A Study on North Korea's Reconnaissance Satellite Development: Threats Analysis and Suggestion for the South Korean Military

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Abstract

This study aims to assess the threat posed by North Korea's launch of a reconnaissance satellite on November 21, 2023. After examining the current status, purpose, and capabilities of North Korean reconnaissance satellites, we evaluate the threats from spy satellites developed by North Korea and review the countermeasures by the South Korean military. Reconnaissance satellites were initially developed by the United States and the Soviet Union during the Cold War and later in China, Japan, France, and Germany. North Korea successfully launched satellites in 2012 and 2016, while South Korea has been operating its own satellites since the 1990s. North Korea and South Korea have launched and operated spy satellites since 2023, with North Korea claiming the development of spy satellites in response to perceived threats from the United States, Japan, and South Korea. However, given North Korea's capacity for a nuclear attack, the launch of a spy satellite by North Korea could lead to a security crisis. Therefore, South Korea needs to prepare measures for the South Korean military's countermeasures against North Korean spy satellites to ensure peace and security on the Korean Peninsula.

Although analysts have determined that North Korea's satellite technology is in such a rudimentary stage and its satellites may not be capable of performing necessary military functions, it is still important to establish a countermeasure against North Korea's successful launch of a reconnaissance satellite in 2023. This should involve analyzing North Korea's intention to develop a reconnaissance satellite and its military threat; strengthening the joint response capabilities of South Korea, the United States, and Japan against military threats from North Korean reconnaissance satellites; and enhancing South Korea's surveillance and reconnaissance capabilities to gain an upper hand in the competition with North Korea for the development of reconnaissance satellites.

Key Words: *Reconnaissance satellite, Chollima-1 SLV, Malligyong-1 satellite, Target intelligence, ISR*

I. Introduction

North Korea's successful launch of the reconnaissance satellite Malligyong-1 on November 21, 2023 started a new space race on the Korean Peninsula. On December 2, 2023, South Korea successfully launched its first reconnaissance satellite, which was developed as part of the 425 reconnaissance satellite project. North Korean-made Chollima space launch vehicle was used to launch Malligyong-1 from the Dongchang-ri West Sea satellite launch site, while South Korea's launch was assisted by Space X's Falcon 9 space launch vehicle at Vandenberg Space Force Base in California, the United States. North Korea announced that it would launch three more reconnaissance satellites in 2024.[1] South Korea successfully launched its second reconnaissance satellite with a high-performance SAR(Synthetic Aperture Radar) in Florida, the United States, on April 8, 2024.

As the United States and the Soviet Union began developing reconnaissance satellites during the Cold War, they collected information on major military targets such as intercontinental ballistic missile bases in hostile states. In the meantime, China, Japan, France, and Germany successfully developed and launched reconnaissance satellites. North Korea launched Kwangmyongsong satellites in 2012 and 2016. However, they appeared to malfunction and disappeared after entering the atmosphere in June and September 2023, respectively.[2] Until now, North Korea's satellite launch has been regarded as its attempt to develop rocket technology used to build intercontinental ballistic missiles, not for Earth observation purposes. North Korea has insisted on monitoring its enemies such as the United States, Japan, and South Korea with spy satellites. Due to their low performance, in the past, North Korean satellites were not a threat to any of its enemy states. However, North Korea's ability to develop and operate spy satellites in combination with its nuclear attack capabilities can pose a significant threat to the Korean Peninsula and neighboring countries.

Research on North Korea's reconnaissance satellites has been insufficient. Most studies are concerned with North Korea's space power, the North Korean Space Development Act, and the North Korean space policy. Park Sang-joong evaluated North Korea's military space power based on his analysis of the North Korean space organization, the space development process, and the space launch vehicle test and emphasized the importance of establishing South Korea's response strategy.[3] By analyzing North Korea's space development law and improving the

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1) *Rodong Sinmun*, December 31, 2023.

2) https://www.n2yo.com/satellite/?s=39026#results;
https://www.n2yo.com/satellite/?s=41332#results.

3) Park Sang-joong and Cho Hong-je. "Evaluation and implications of North Korea's military space force," *Journal of Aerospace Policy and Law,* Vol 36, no.4 (2021): 245-267.

existing framework that rendered North Korea's justification for developing ballistic missiles, Choi Eun-seok argued that South Korea should induce North Korea to comply with international laws related to space development and seek institutional measures for peaceful space development between the two Koreas.[4] To respond to North Korea's military use of space, Lee Woon-seok called attention to the need for an objective evaluation of North Korea's space capabilities while describing the characteristics surrounding building infrastructure for North Korea's space activities, securing space launch vehicles, and attempting to launch reconnaissance satellites based on chronological analysis of North Korea's space policy.[5]

Previous studies focus on analyzing North Korea's space development program and evaluating North Korea's space capabilities before the successful launch of a reconnaissance satellite in 2023. There is a lack of studies assessing the performance and threats of Pyongyang's reconnaissance satellites and evaluating the countermeasures against them. By examining the concept, activity, and performance of the reconnaissance satellite, this study seeks to analyze the development process and military threat of the North Korean reconnaissance satellite and propose future South Korean military countermeasures.

II. Concepts of Reconnaissance Satellites and Analysis Methods

1. The concept of a spy satellite

As a satellite that observes ground facilities from space above an altitude of 100 km, a reconnaissance satellite operates for military purposes and uses the obtained imagery information to support military operations or the determination of the national command.

During the Cold War, the United States and the Soviet Union developed reconnaissance satellites to observe major military facilities and major targets in other countries and continuously improved the performance of reconnaissance cameras. The United States operated photographic reconnaissance satellites in the early days of the Cold War to identify the military weapons development activities of the Soviet Union and China. From the early 1960s to the mid-1980s, photographic reconnaissance satellites were indispensable for the United States to obtain critical information about the Soviet nuclear threats and weapons

4) Choi Eun-seok and Um Jung-sik, " Inter Korea's perceptions and legal analysis of North Korea's space development," *International Regional Studies*, volume 27, no. 3 (2023): pp. 117-141.

5) Lee Woo-suk and Jung Young-jin, "A study of North Korea's space policy during the Kim Jong-un period - focusing on the five-year national space development plan," *Journal of Aerospace Policy and Law*, Vol 38, no. 2 (2023): pp. 119-147.

development.[6] Thanks to the development of Electro-Optical(EO) cameras from the KH-11 reconnaissance satellite program in 1976, it takes only mere minutes compared to the film-recovery-type satellite to receive images, which used to take weeks to a month.[7]

In addition, based on the collected information on the Soviet strategic missile storage, the United States was able to proceed with the US-Russian strategic arms control agreement.[8]

The main payloads of reconnaissance satellites include Electro-Optical/Infrared (EO/IR) sensors and SAR. EO/IR cameras use visible or infrared sensors to photograph targets and have high precision, although they are greatly affected by weather conditions such as clouds. The SAR payload emits radar waves to map the Earth's surface and creates images by receiving signals reflected from the surface. It can acquire all-weather satellite images regardless of the weather. Signal intelligence (SIGINT) satellites collect communication intelligence (COMINT) and electronic intelligence (ELINT). A missile-warning satellite contributes to missile defense and response operations as a major monitoring means by detecting the heat source of launches such as intercontinental ballistic missiles of enemy countries in space and quickly alerting our allies.

<Table 1> Types and characteristics of major sensors of spy satellites

Category	EO/IR	SAR	SIGINT	Missile Warning
Key Features	Electro Optical (Day) Infrared (Night)	It transmits radar radio waves and receives and processes reflected signals	COMINT, ELINT	Detects an ICBM heat source and provides an early warning
	Influenced by weather restrictions such as precipitation and clouds	Operational day and night, and it's possible to operate in bad weather		
	Good readability	Professional imagery analyst is needed and vulnerable to jamming		

6) Historical Data on the Development of U.S. Reconnaissance Satellites, National Museum of the United States Air Force, https://www.nationalmuseum.af.mil/Visit/Museum-Exhibits/Fact-Sheets/Display/Article/195923/cold-war-in-space-top-secret-reconnaissance-satellites-revealed/; film-return capsule system (accessed on April 26, 2024).

7) AU-18, *Space Primer*, (Maxwell AFB, AL: Air University Press, 2009), p. 172.

8) Wawrzyniec Muszyński-Sulima, "Cold War in Space: Reconnaissance Satellites and US-Soviet Security Competition," *European journal of American studies*, 18-2, 2023.

2. Development of Reconnaissance Satellites in Developed Countries

The development and operation of reconnaissance satellites dates back to the Cold War era characterized by competition between the Union of Soviet and the United States. The Soviet Union's 1960 shootdown of an American U-2 aircraft with a surface-to-air missile in Soviet airspace made it impossible to operate a reconnaissance aircraft and collect information from the airspace of other countries. The incident prompted the United States to replace reconnaissance aircraft with satellites to continue reconnaissance on Soviet territory. Surveillance and reconnaissance were possible in outer space, which allowed one to monitor enemies without the risk of airspace invasion.[9)]

Early reconnaissance satellites used a film recovery method in which targets were photographed, their images were stored in a film, and film containers were dropped to the ground. Since the 1990s, the development of Electro-Optical (EO) cameras has allowed image information to be transmitted to ground stations using radio waves, while SAR has been used to provide all weather radar imaging.

Reconnaissance satellites can conduct missions safely due to no risk of being shot down by surface-to-air missiles and are capable of surveillance and reconnaissance over large areas over a long period of time.[10)]

The United States operates the largest number of spy satellites in the world. The United States operates five KeyHole-12 electro-optical reconnaissance satellites and a Lacrosse SAR satellite, while Russia has two Persona optical reconnaissance satellites and a Kondo radar satellite.[11)] China operates 30 Yaogan reconnaissance satellites with SAR, EO, and ELINT sensors,[12)] and Japan operates 15 IGS (Information Gathering Satellite) EO/SAR satellites. Other countries include France with Helios and Germany operating SAR-Lupe reconnaissance satellites.

South Korea has developed satellites since the 1990s. Generally, reconnaissance satellites must have a resolution of less than 1 meter. South Korea's KOMPSAT 3 had a resolution of 0.7 meters in 2012; its KOMPSAT 3A boasted a resolution of 0.55 meters in 2015. In order to monitor North Korea's ballistic and nuclear missile attacks, South Korea successfully launched a reconnaissance satellite with a

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9) Kim Sung-bae, Shin Hyun-in. " The status and acquisition strategy of world spy satellites." *Defense Policy Study,* No. 51 (2000.12), pp. 89-90.

10) Lee Young-sang, Kim Woo-sang. " The impact of the alliance's possession of reconnaissance satellites on the deterrence of expansion," *East-West Study,* Vol. 35, No. 2 (2023), p. 64.

11) Mark Krutov and Sergei Dobrynin, "In Russia's War On Ukraine, Effective Satellites Are Few And Far Between," April 11, 2022, https://www.rferl.org/a/russia-satellites-ukraine-war-gps/31797618.html(accessed on April 26, 2024).

12) Junnosuke Kobara, "China and India lead Asia race to expand spy satellite networks," January 18, 2024, *Nikkei Asia, https://asia.nikkei.com/Politics/Defense/China-and-India-lead-Asia-*race-to-expand-spy-satellite-networks(accessedonApril26,2024).;DIA,"Challengestosecurity inspace,"pp.22-23.

0.3-meter resolution in 2023.

3. Scope and Target of Reconnaissance Satellite Research

North Korea's development and launch of a reconnaissance satellite boosted by the Chollima Space Launch Vehicle marked the onset of competition on the Korean Peninsula for the development of reconnaissance satellites. After analyzing the causes of the failure of the first and second reconnaissance satellites, North Korea finally succeeded in launching the third reconnaissance satellite. After the successful launch of the North Korean reconnaissance satellite, there were reports that Russia provided technical assistance to North Korea, such as the provision of spy satellite blueprints and data analysis results in return for North Korea's provision of conventional weapons to Russia during the Russia-Ukraine War.[13] North Korea's successful launch of the reconnaissance satellites with its own Chollima space launch vehicle calls attention to the gravity of evaluating North Korea's capability of developing reconnaissance satellites and urgency of devising countermeasures for South Korea's security.

To assess and analyze the threat posed by North Korea's spy satellite development, this study proposes three assessment factors: the goal of developing a North Korean spy satellite, the capability of a North Korean spy satellite, and the military threats of a North Korean spy satellite.

First, we investigate why North Korea aims to develop a reconnaissance satellite. After launching a satellite in 2016, North Korea did not launch a satellite until 2022. At the 8th Party Congress in 2021, North Korea announced a plan to develop a military reconnaissance satellite in the five key tasks of the five-year defense capability strengthening plan.[14] A satellite launched in 2016 also deviated from orbit in June 2023 and disappeared in the atmosphere after failing to carry out its satellite mission. North Korea successfully developed nuclear and ICBM capabilities in 2017. For its regime survival, North Korea must deem it necessary to monitor threats posed by the United States and South Korea, which North Korea recognizes as enemies; promote the Kim Jong-un regime's scientific and technological advancement; inspire patriotism; create tension through increased security threats on the Korean Peninsula; and strengthen external bargaining power.

Second, we take into consideration the capability of North Korean spy satellites. For a spy satellite, its resolution is the most important technology. The resolution of the reconnaissance satellite launched by North Korea in 2023 was estimated to be 3 meters based on the data its cameras collected in international waters during the first

13) Kim Min-seo, "The situation of providing satellite blueprint and data analysis to Russia, North Korea," *Chosun Ilbo*, November 24, 2023, https://www.chosun.com/politics/north_korea/2023/11/24/RY6IUMNKTBGTZL7NQRZQRXULWQ/(accessed on April 26, 2024).

14) *Rodong Sinmun*, January 13, 2021.

launch, and it had no military effect.[15] To be considered as a reconnaissance satellite, a satellite must have a resolution of less than 1 meter, which is a sub-meter class. Although it is difficult to determine the exact capability of the reconnaissance satellite, it must be a low-level reconnaissance satellite since North Korea has not released the images of the reconnaissance satellite in 2023. Recently, North Korea was reported to have received Russian technology for its provision of military supplies to Russia in the Ukraine-Russia war. However, since a drastic improvement in satellite resolution within a short period of time is unfeasible, the resolution of images taken by the North Korean reconnaissance satellites will likely to remain low. Although it is difficult to determine the exact capabilities of North Korean reconnaissance satellites due to the lack of detailed analysis results, With limited data available, this study will evaluate the capabilities of North Korean reconnaissance satellites.

Third, we assess the military threat from North Korean spy satellites. It is imperative to predict the future military operation of reconnaissance satellites developed by North Korea. Studying the operational concepts and forecasting the threat level of North Korean reconnaissance satellites will help analyze their impact on South Korea's national security and establish South Korea's military countermeasures. North Korea will likely continue to develop and operate reconnaissance satellites in space orbit. Thus, we seek to analyze the development process and military threats to suggest future countermeasures for the South Korean

<Table 2> The Scope and Target of Analysis of the Threat of North Korea's Spy Satellite Development

Category	Criteria for Determining Threats	Details
Judgment of Threats of Spy Satellite Development	Purpose of developing spy satellites	Monitoring major military activities of enemies, enhancing national status, and strengthening national defense capabilities through the development of advanced space technology
	Reconnaissance satellite capability	Reconnaissance satellite resolution, orbit maintenance, imaging capability, ground station transmission/reception activity, revisit time
	Military threats of spy satellites	Military Operations of Reconnaissance Satellites, space attack, space weapons development (Provide precision target information when operating nuclear missiles)

15) Ministry of National Defense, “Reports on the results of North Korea's reconnaissance satellite salvage analysis,” July 5, 2023.

military. Below, we present criteria used to analyze the threats of North Korean reconnaissance satellites.

III. Threats of North Korea's Reconnaissance Satellite Development

1. Milestones in North Korea's Reconnaissance Satellite Development

(1) First Reconnaissance Satellite Launch (May 30, 2023)

At 6:27 a.m. on May 30, 2023, North Korea launched its first reconnaissance satellite Malligyong-1 with its new satellite launch vehicle Chollima-1 from the West satellite launch sites, which is located in Dongchang-ri, Cholsan County, North Pyongan Province. It crashed into the West Sea due to a second-phase engine failure. The North's National Space Development Administration (NADA) announced that it would proceed with the second launch as soon as possible after the failed launch.[16] At the plenary session of the Central Committee of the North Korean Workers' Party on June 16, Kim Jong-un noted the launch failure of a military reconnaissance satellite, the most important strategic project in space development, as the most consequential setback and ordered investigation of the possible causes of the failure and another launch of a reconnaissance satellite as soon as possible.[17]

The South Korean military recovered and analyzed the debris of the Cheollima rocket that crashed in the West Sea and revealed the specifics of the North Korean spy satellite. The Ministry of National Defense determined that the North Korean spy satellite, equipped with an electronic optical camera, can only picture targets during the daytime with a 3-meter resolution and has no military effect.[18]

(2) Second Reconnaissance Satellite Launch (August 24, 2023)

North Korea has been conducting intensive engine combustion tests since July to verify the reliability of the space launch vehicle and solve the problem with the first reconnaissance satellite that failed to launch.[19] North Korea notified the Japanese government and the International Maritime Organization (IMO) of the satellite launch plan, which specified the duration of the satellite launch and the danger zone where rocket debris would fall. North Korea attempted to launch a second spy satellite on Aug. 24, 2023. At 3:50 a.m., the space launch vehicle carrying the spy satellite Malligyong 1 launched from the launch site in the West Sea.[20] The

16) Korean Central News Agency, 2023.5.31.

17) Korean Central News Agency, 2023.6.19.

18) Noh Seok-jo, "North reconnaissance satellite named 'Manli-kyung', level of the telescope when opened," *Chosun Ilbo,* 2024.7.6. https://www.chosun.com/politics/diplomacy-defense/2023/07/06/H4243ES3KFBONO3MGCVNXYTXN4/(accessed on April 26, 2024).

19) National Intelligence Service, *National Assembly Intelligence Committee report,* 2024.8.17.

Chollima rocket flew normally in both stages 1 and 2. However, the second reconnaissance satellite launch failed due to an error in the emergency explosion system during the third stage of the flight. North Korea announced that it would launch a third reconnaissance satellite in October after quickly identifying the causes of the second failure.[21] North Korea's first and second reconnaissance satellites failed to enter space orbit due to problems with the engine and system of the space launch vehicle.

South Korea, the United States, and the United Nations strongly condemned North Korea's launch of a spy satellite. U.N. Secretary-General António Guterres denounced North Korea's attempt to launch a military satellite, stressing that all missile launches using ballistic missile technology would violate relevant Security Council resolutions.[22]

(3) Third Reconnaissance Satellite Launch (November 21, 2023)

At 10:42 p.m. on November 21, 2023, 89 days after the second failed launch of a reconnaissance satellite, North Korea launched the third Malligyong satellite. It informed the Japanese government beforehand that it would launch the satellite between midnight on November 22 and midnight on December 1. However, North Korea launched the satellite about an hour earlier than the scheduled launch time. Given the launch time, the reconnaissance satellite seemed to be sent off earlier than scheduled to avoid the intensive surveillance time of the South Korea-U.S. reconnaissance assets. However, it is more likely that the reconnaissance satellite was instructed to be launched before the pre-announced launch time by the satellite launch window calculation program and weather conditions such as upper wind and rainfall at the West Sea satellite launch site.[23] The Chollima rocket was separated from the first stage, the fairing, the second stage, and the third stage before successfully entering orbit at 10:54 p.m. After the successful satellite launch, North Korea claimed that the launch of a reconnaissance satellite was North Korea's exercise of its legitimate right to strengthen its self-defense and that it would respond to military threats from its enemies and enhance its readiness for war.[24] Kim Jong-un celebrated the success of the reconnaissance satellite launch, claiming that the country fulfilled its resolution of the 8th Party Congress of the North Korean Workers' Party was achieved most accurately.

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20) Korean Central News Agency, 2023.8.22.

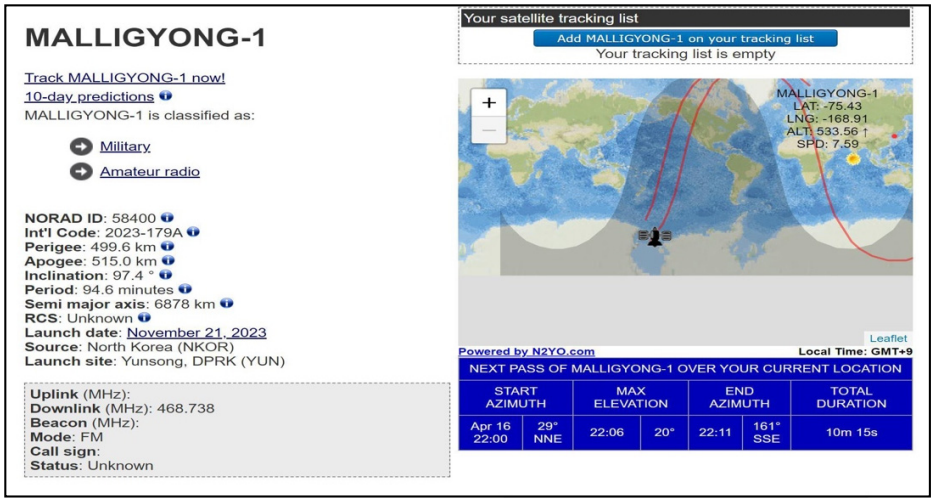
21) Korean Central News Agency, 2023.8.24.

22) UN News, UN chief strongly condemns DPRK spy satellite launch, May 31, 2024, https://news.un.org/en/story/2023/05/1137192(accessed on April 26, 2024).

23) The Malligyong1 reconnaissance satellite was calculated as 23:05 for the descending node and 10:17 for the ascending node during the period from November 21 to 30. https://launchwindow.barnazagoni.com.

24) Korean Central News Agency, 2023.11.22.

<Figure 1> Specifics of Malligyong-1 satellite



Source: https://www.n2yo.com/satellite/?s=58400#results(accessed on April 26, 2024).

As shown in Figure 1, the North Korean reconnaissance satellite Malligyong 1 was assigned an ID of 58400 by NORAD with a perigee of 499.6 km and an apogee of 515 km. The orbital inclination angle is 97.4 degrees, and the period of orbiting Earth is 94.6 minutes.

<Table 3> 5−Day Prediction for Malligyong-1 at Pyongyang Ground Station

Start	Max Altitude	End	Remark
Nov 24, 11:19 pm	11:25 pm	11:31 pm	Night
Nov 25, 09:56 am	10:02 am	10:08 am	Day
Nov 25, 11:00 pm	11:06 pm	11:12 pm	Night
Nov 26, 09:38 am	09:43 am	09:49 am	Day
Nov 26, 11:12 am	11:17 am	11:22 am	Day
Nov 26, 10:41 pm	10:47 pm	10:53 pm	Night

Source : https://www.orbtrack.org/# (accessed on Nov. 23, 2023).

As shown in <Table 3>, the North Korean reconnaissance satellite Malligyong 1 orbits the Earth at the north-south pole and visits the Korean Peninsula two to four times a day. At this time, it may communicate with the Pyongyang satellite control center for about 12 minutes. It may undertake reconnaissance of the major

targets in South Korea once or twice a day due to the nature of electronic optical cameras.

The average altitude of the satellite was lowered to 510 km, but in February 2023, the Malligyong 1 conducted five maneuvers to increase the altitude to 512 km.[25] This means that North Korea's Malligyong1 satellite has gradually increased its altitude using a propulsion jet to offset the drop in altitude due to atmospheric drag, and satellite command and control are being performed between the Pyongyang Satellite Control Center ground station and the reconnaissance satellite.[26]

Unlike in the past, when North Korean satellites were in orbit but there was no practical activity due to the inability to control their posture, the Malligyong 1 uses satellite control and thrusters to control its attitude, which indicates that Malligyong is communicating with the ground station. However, it may suggest that there are limitations in imagery transmission and reception because the radio waves used to transmit images by spy satellites to the Pyongyang ground station are not identified.

According to the Two Line Element (TLE) report of the Malligyong Reconnaissance Satellite, it is possible to check the communication time of the Pyongyang control station and the possible photographing time around the Korean Peninsula. Since the Malligyong Reconnaissance Satellite cannot photograph at night, it may photograph images of the Korean Peninsula around 10 o'clock, which is usually the daytime. Given that the frequency of 468 MHz UHF used for basic-level Cube satellite communication was collected from the Malligyong Reconnaissance Satellite so far, it seems that the reconnaissance satellite has not photographed and transmitted images to the ground station, and the satellite imagery has not been high resolution.

2. Analysis and Evaluation of the Threats of North Korea's Reconnaissance Satellite Development

(1) The purpose of developing spy satellites

North Korea claims to have developed reconnaissance satellites to monitor the military activities of its enemies while strengthening its nuclear and missile capabilities to defend against aggression from hostile countries and unify the Korean Peninsula.

All countries have the right to use space peacefully, but North Korea continues

25) Marco Lanbroek, "A North Korean satelliteshowing sign of life," The Space Review, March 4, 2024 (accessed on April 26, 2024).

26) Josh Smith, "North Korea's first spy satellite is 'alive', can maneuver, expert says" Reuters, February 29, 2024, https://www.reuters.com/technology/space/north-koreas-first-spy-satellite-is-alive-can-manoeuvre-expert-says-2024-02-28/(accessed on April 26, 2024).

to develop ICBMs using ballistic missile technology. The U.N. Security Council has banned North Korea from launching ICBM missiles since 2006. Because Pyongyang's reconnaissance satellite technology can be used for intercontinental ballistic missiles, its claim of peaceful space development is hard to accept.[27)]

After the successful launch of the Hwasong-15 ICBM in November 2017, North Korea declared the completion of its national nuclear force. After the breakdown of denuclearization negotiations between the U.S. and North Korea in 2019, it resumed its pursuit of the advancement of its nuclear and missile capabilities.[28)] On September 8, 2022, North Korea adopted the North's nuclear force policy decree to justify a preemptive nuclear attack on South Korea.[29)] North Korea has justified that it can preemptively attack nuclear weapons if an attack by a hostile state is imminent or if it is deemed operatively inevitable.

In the 1960s, China developed hydrogen bombs, atomic bombs, and satellites surveilling enemies through the Two Bombs, One Satellite project.[30)] However, even after completing its nuclear armament, North Korea was unable to monitor its adversaries. North Korea launched a reconnaissance satellite in May 2023 because South Korea planned to launch its first reconnaissance satellite in December 2023.

To ensure the success of a nuclear attack, North Korea must be capable of proactively spying on major targets in the United States, US military bases in Japan, and South Korea. As a result, North Korea is concentrating its efforts on developing reconnaissance satellites, a major mission in the space sector. Additionally, North Korea seems to seek to build reconnaissance satellites, which use a sizable national budget, to threaten neighboring countries and enhance its bargaining position in denuclearization negotiations as its nuclear and missile capabilities advance.

Since the Kim Il-sung and Kim Jong-il administrations were unable to develop and operate spy satellites, the success of the North Korean spy satellite launch will contribute to strengthening the power of the young leader, Kim Jong-un, by giving North Koreans pride in the North Korean regime and promoting the achievements of North Korea's space science and technology.

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27) Cho Sang-jin, "Department of Defense Pursues Korea-U.S. Space Force Exercise, North Korea's Space Launch Is Illegal" *VOA News*, April 19, 2024, https://www.voakorea.com/a/7575970.html(accessed on April 26, 2024).

28) Jeong Jang-jang, *Why should we become a nuclear power*, Seoul: Medici Media, 2023, p. 21.

29) *Rodong Sinmun*, September 9, 2022.

30) Liu Yanqiong, “Chinese Academy of Sciences and Project of Two Bombs, One Satellite," *Bulletin of Chinese Academy of Sciences*, vol 34, September 2019, https://bulletinofcas.researchcommons.org/cgi/viewcontent.cgi?article=1359&context=journal(accessed on April 28, 2024).

(2) Reconnaissance satellite development capability

In 2023, North Korea launched three reconnaissance satellites with its own space launch vehicles using technology acquired during the development of intercontinental ballistic missiles. South Korea, on the other hand, has been utilizing foreign launch vehicles since 1999 to launch a multi-purpose satellite called KOMPSAT in orbit. While North Korea's successful launch of its own reconnaissance satellite is a noteworthy achievement, it is important to note that the resolution is inferior to that of standard reconnaissance satellites. Furthermore, there is no evidence of transmitted satellite images to ground stations or public disclosure. This raises questions about the actual capabilities of North Korea's reconnaissance satellite.

Thus, analyzing detailed data collected by North Korean spy satellites is necessary to assess North Korean spy satellites' capabilities. For example, the North Korean spy satellite increased the altitude five times between February 19 and February 24, 2024. It is speculated that this altitude adjustment was controlled by thrusters that counteracted the effects of low-orbit atmospheric drag and that ground stations transmitted commands to the Malligyong spy satellite.[31] Kwangmyongsong satellites launched by North Korea in 2012 and 2016 failed in their mission due to problems with altitude control. However, it is anticipated that the reconnaissance satellite launched in 2023 may be capable of maintaining control and extending the lifespan of orbiting satellites through attitude control and altitude adjustments using thrusters. It is important to note that North Korean reconnaissance satellites lack IR sensors, limiting them to daily missions.

In terms of satellite resolution, South Korea has a 0.3-meter resolution, which is 10 times higher than North Korea's 3-meter resolution. This difference may be attributed to the fact that North Korea develops space launch vehicles and reconnaissance satellites utilizing similar rocket technology used for intercontinental ballistic missiles.

At the 8th Party Congress in January 2021, North Korea announced its plans to strengthen its defense capabilities and develop weapons.[32] To successfully develop a defense weapons system, North Korea is anticipated to concentrate its national power and strengthen its diplomatic relations with Russia during the Russia-Ukraine War to acquire cutting-edge aerospace technology. As Pyongyang improves its space science and technology capabilities, including the development of reconnaissance satellites, Seoul should establish military response operations and enhance its surveillance capabilities against its counterpart.

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31) Marco Langbroek, "A North Korean satellite starts showing signs of life," *The SpaceReview*, March 4, 2024, https://www.thespacereview.com/article/4753/1(accessed on April 28, 2024).

32) Korean Central News Agency, 2021.1.9.

(3) Military threats of reconnaissance satellites

Kim Jong-un celebrated acquiring the country's reconnaissance satellite capability indigenously developed after the third launch of the reconnaissance satellite, boasting that Pyongyang could surveil enemies from a distance and use nuclear force to attack distant enemies.[33] However, North Korea's reconnaissance satellites may not be as threatening as it has claimed due to the satellite's low resolution. Although North Korea has a low ability to collect and produce information on the main targets, its nuclear missile attack should raise significant concerns among its adversaries. A nuclear missile is different from a Joing Direct Attack Munition(JDAM), a precision-guided munition fired from a fighter jet carrying out a precision attack. A wide range of attacks on military and civilian targets can also cause significant casualties. By using its own target coordinates on its own intercontinental ballistic missiles, North Korea will be able to carry out more effective attacks on its main targets. Furthermore, it will be possible to increase the reliability of target information for attack by obtaining data that can be used for military targets rather than simple geographical coordinates from Internet map information.

North Korea successfully launched a reconnaissance satellite and announced that it would continue to launch more reconnaissance satellites in 2024.[34] If North Korea builds and operates satellite constellations consisting of reconnaissance satellites in the future, it could pose a military threat to its adversaries as such constellations would enhance its capability of surveillance of its major targets on the Korean Peninsula, Japan, and the United States. North Korea will be able to advance space weapons technology by developing reconnaissance satellites and operating them. Fractional Orbital Bombardment System(FOBS), developed by the Soviet Union during the Cold War, is a weapon system that can fly in orbit, go off track to attack major military targets on the ground, and then descend to destroy enemy facilities. North Korea may attempt to acquire space technology that can build FOBS missiles in the future through the development of spy satellites.[35]

Although North Korea's current spy satellite functionality is lacking, anticipating North Korea's future improved satellite development capabilities,

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33) SOZAKI Atsuhito, "North Korea's 'Successful' Spy Satellite Launch," January 04, 2024, https://thediplomat.com/2024/01/north-koreas-successful-spy-satellite-launch/(accessed on April 28, 2024).

34) *Rodong Sinmun*, December 31, 2023.

35) Koo Hyun-mo, "The meaning of confirming the self-pulling and control of North Korea's 'Manli-kyung-1," *World Daily,* March 26, 2024, https://www.segye.com/newsView/20240325513876 (accessed on April 28, 2024).; Fractional Orbital Bombardment System, Since the Cold War era, Russia has shown keen interest in developing a partial orbital bombardment system. FOBS is a system that rotates the orbit like a satellite, not a ballistic missile like an ICBM, sprays a decelerating rocket close to a target point, and then enters the atmosphere to bomb it.

South Korea must establish and implement military response measures sooner rather than later.

IV. South Korea's Response Plan

While developing a variety of ballistic missiles to strengthen its nuclear and missile capabilities, North Korea will be able to strengthen surveillance of its enemies through the development of reconnaissance satellites and produce detailed target information on major military targets required in advance in case of a nuclear attack.

North Korea violated U.N. resolutions concerning ballistic missile tests by developing and launching reconnaissance satellites into space. South Korea must strengthen its military readiness by utilizing the South Korea-U.S.-Japan defense system while demanding North Korea's compliance with international law. This study recommends the following three countermeasures the South Korean military should consider against North Korea's reconnaissance satellite development.

First, South Korea should analyze North Korea's intention to develop a reconnaissance satellite and assess its military threat. The satellite cameras collected in the West Sea after North Korea’s first failed reconnaissance satellite launch have a low resolution of 3 meters. The camera resolution determines the quality of performance of reconnaissance satellites. However, although North Korea’s satellites have low resolution, they can still monitor important military and national sites in the United States, Japan, and South Korea. A high resolution is necessary to precisely identify targets for coordinating missile strikes during air force operations. However, nuclear attacks may not require high resolution as the goal is often to cause widespread damage through nuclear missiles.

If a reconnaissance satellite gathers data on targets for North Korea's nuclear missiles and then shares that target information with the same geographical coordinate system as the North Korean military’s nuclear missiles operations, it could potentially enhance the accuracy of targeted strikes (CEP, Circular Error Probability) during nuclear missile attacks.

It is imperative to take the potential threat of North Korea's reconnaissance satellite seriously, despite the low resolution of the current satellites. South Korea must acknowledge the possibility of these satellites being used to target major national assets and military command centers in the South Korean metropolitan area. A more comprehensive and objective threat analysis of the military applications of North Korean reconnaissance satellites should be conducted.

Second, to enhance their collective response capabilities, South Korea, the United States, and Japan should collaborate on developing strategies to counter military threats in space posed by North Korea's reconnaissance satellites. At

present, the three allies promptly share information on North Korea's reconnaissance satellite launches and ICBM launches and engage in combined space exercises. Through these combined space exercises, they should establish a plan for combined space operations to address various space threats from North Korea and enhance their collective space operation capabilities.

North Korea is obtaining advanced military technology from Russia in exchange for supplying Russia with conventional weapons in the ongoing Russia-Ukraine war. Russia's support will enable North Korea to acquire crucial technologies to bolster its nuclear weapons operational capabilities, such as miniaturization of nuclear weapons and reentry technologies, and other key technologies related to the development of reconnaissance satellites.[36] As North Korea's nuclear attack capabilities and intelligence surveillance capabilities could further improve, it is essential for South Korea, the United States, and Japan to strengthen their joint responses to North Korea's growing nuclear and space threats.

Third, in order to gain a military advantage over North Korea, South Korea must focus on developing its reconnaissance satellite capabilities and enhancing its surveillance and reconnaissance abilities, both of which are key elements of Kill Chain. On December 2, 2023, South Korea launched its first reconnaissance satellite, an electro-optical satellite with a resolution of 30 centimeters, as part of the 425 project aimed at developing a military reconnaissance satellite. This satellite, which surpasses North Korea's capabilities, will provide crucial information for the South Korean military's Kill Chain and KAMD operations by detecting provocative movements of the North Korean military and issuing early warnings of potential threats. To further solidify its military advantage, South Korea should prioritize the development and operation of reconnaissance satellite, improvement of space surveillance capabilities, training of professional space personnel, and advancement of defense space technology.

V. Conclusion

This paper explores North Korea's development of reconnaissance satellite from political and military perspectives. North Korea claims that it is building reconnaissance satellites to monitor hostile countries, defend against external aggression, and strengthen its defense capabilities. Despite economic difficulties and international sanctions, North Korea has developed reconnaissance satellites to gather target information for nuclear and missile attacks. Additionally, North

36) Christy Lee, "Analysts: US, South Korea Should Be Ready for Russia-North Korea Alliance," *VOA*, Jan. 24, 2024, https://www.voanews.com/a/analysts-us-south-korea-should-be-ready-for-russia-north-korea-alliance/7456346.html(accessed on April 28, 2024).

Korea is also focusing on the development of reconnaissance satellites to reinforce the Kim Jong-un regime's governance, tighten internal control, and showcase the Kim Jong-un regime's scientific and technological achievements.

This study emphasizes the need for more attention to North Korean reconnaissance satellite development and understanding of their technical evaluation. It also highlights the urgency of devising countermeasures by the South Korean military to address the capabilities and threats posed by North Korea's reconnaissance satellites.

It is crucial to conduct a detailed analysis of the operation of North Korea's reconnaissance satellites to objectively determine potential threats. Satellite experts from South Korea, the United States, and Japan need to analyze the mission operation and orbit of North Korea's reconnaissance satellites to understand their intentions and potential threats.

It is important to establish countermeasures against North Korea's reconnaissance satellite operations in the event of their capability improvement, particularly for nuclear and missile operations. Furthermore, a comparative study between the reconnaissance satellites of the two Koreas, focusing on their development, capabilities, and military impacts, is essential, and more research in this area is needed.

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