

A study on North Korea's Hypersonic Missile Development: Threat Analysis and Suggestions for the South Korean Military

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Abstract

This paper attempts to assess the threats from North Korea's first Hwasung-8 hypersonic missile test in 2021 and another hypersonic missile test undertaken in January 2022. Through examination of the current status, purpose, and capability of North Korea's hypersonic missile development, we evaluate the current status and threat of North Korea's hypersonic missile development and review the countermeasures of the South Korean military.

Hypersonic missiles constitute a new weapon system currently being developed in some technologically advanced countries, including the United States, Russia, and China. They are dubbed a game-changer of war because it is impossible to defend them with a general ballistic missile defense system. Thus, North Korea's hypersonic missile test was a big shock to South Korea. North Korea's development of hypersonic missiles should be established through objective evaluation of South Korea's missile defense system. Since hypersonic missiles are different from ordinary ballistic missiles in terms of their capabilities, such as speed and maneuver, it is difficult to establish a counter-defense weapon system. North Korea's development of hypersonic missiles poses a threat to South Korea's peace and security; thus, a response is needed. First, South Korea should analyze North Korea's intentions behind developing hypersonic missiles and its threats. Second, South Korea should strengthen its missile capabilities to cope with military threats from North Korea's development of hypersonic missile technology. Lastly, South Korea should surpass North Korea in the hypersonic missile development.

This study is meaningful in that it analyzed the North's hypersonic missile development and test process and its threats to South Korea and neighboring countries. It also studied countermeasures of the South Korean military. Access to information such as North Korea's hypersonic missile flight data was restricted; hence, analysis of North Korea's hypersonic missile capability was limited. Nonetheless, this study will provide substantial grounds to encourage in-depth research on North Korea's supersonic missile development in the future.

Keywords: Hypersonic missile, Hwasung-8, HGV, HCM, Missile provocation

I. Introduction

On September 28, 2021, North Korea's hypersonic missile test-launch shocked South Korea. North Korea reported that it had succeeded in the development of hypersonic weapons systems with the most strategic significance among the five key tasks proposed in the Five-Year Plan for Defense Science and Technology and Weapon System Development at the 8th Party Conference in January 2021.¹⁾ North Korea announced that it would develop North Korea's advanced defense science and technology, improve defense capabilities, and strengthen national self-power while conducting a hypersonic missile development project. In addition, in January 2022, two hypersonic missile tests and five missile provocations heightened the crisis on the Korean Peninsula. Beijing Winter Olympics and South Korea's presidential election were scheduled to be held; yet, North Korea had no interest in negotiating with the United States and continued with missile provocations to draw attention from the international community, including the United States. North Korea's missile provocations are expected to increase further as major national events such as Kim Il-sung's birthday are planned in 2022.

It is critical that we study why North Korea decided to develop hypersonic missiles. The technology required to develop hypersonic missiles is difficult to acquire, and North Korea was under international economic sanctions after its previous missile tests. The U.S., China, and Russia are currently securing technology and continue to develop hypersonic missile technology. Since 2017, North Korea has been threatening the Korean Peninsula and neighboring countries as its missile performance has improved so much that it can complete the advancement of nuclear power and project missiles into North Korea's attack targets. North Korea's missiles were known for their poor accuracy in the past. However, North Korea's advanced missile system is considered a grave military threat to South Korea. Hypersonic missiles are dubbed a game-changer because they are difficult to intercept with the existing missile defense system. North Korea's development of hypersonic missiles is expected to escalate military threats to South Korea.

Many studies have been undertaken on North Korea's nuclear and missile threats. Yet, studies on hypersonic missiles recently developed by North Korea are still rare. Most works on North Korea's development of hypersonic missiles are conducted by the Korea Institute for Defense Analysis. The recent report on North Korea's launch of a new ballistic missile compared the warhead of North Korea's hypersonic missile with that of other countries' missiles in order to assess North Korea's hypersonic missile capability.²⁾ There was a study that evaluated South Korea's response system

1) Rodong Newspaper, January 11, 2022.

2) Shin Seunggi, "Evaluation and implications of North Korea's new ballistic missile test launch." *Northeast Asia Security Situation Analysis*, Feb 9, 2022.

and military countermeasures by analyzing North Korea's intention behind developing the hypersonic missile system and its threats to the neighboring countries including South Korea.³⁾ The study suggested that South Korea should analyze the development of North Korea's strategic weapons, dubbed a game-changer, and establish countermeasures.⁴⁾

To analyze the process of North Korea's hypersonic missile development and assess the gravity of its military threats, this study will discuss the nature of hypersonic missiles and examine the activities and performance of North Korea's hypersonic missile development.

II. The concept and analysis method of hypersonic missiles

1. Hypersonic missile concept and preliminary research review

The Hypersonic Missile is a threatening weapon system called a game-changer in the modern war as it flies at a high speed of more than 6,120 km/h (Mach 5 or higher). Hypersonic missiles are mounted on a hypersonic glide vehicle (HGV) on the booster propulsion system of the ballistic missile. Once they are fired, they leave the atmosphere, reach their peak altitude, and then enter the atmosphere as they are separated from the booster rocket. Hypersonic missiles operate in the atmosphere differently from existing ballistic missiles flying at an altitude; they are not easy to detect and intercept due to anomalous maneuvers. Due to the high flight speed, they can target and reach any object on Earth within two hours, and it is difficult to defend oneself from them with the existing missile defense system.⁵⁾ The United States, Russia, and China have previously acquired hypersonic missile technology. Yet, the news that North Korea had tested hypersonic missiles was a big shock to South Korea. The fact that North Korea tested hypersonic missiles poses a grave threat to South Korea's national security.

Hypersonic missiles can be largely divided into two categories: Hypersonic Glide Vehicle (HGV) and Hypersonic Cruise Missile (HCM).⁶⁾ Launched by rocket, HGVs are separated from the booster rocket at an altitude of 50 to 100 km. They fly at high speed to the target above the atmosphere with anomalous maneuvers such as ascending and descending maneuvers and skipping. In general, a HGV is

3) Lee Sunhee, "Intent and implications for the development of a hypersonic glide in North Korea." *Defense Foundation*, no. 1884, Feb 10, 2022.

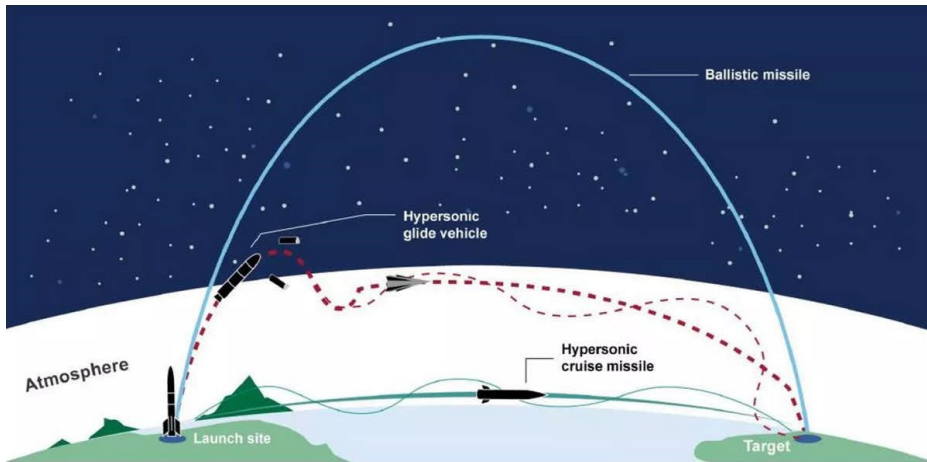
4) Kim Kangnyeong, "North Korea's development of game changer strategic weapons and South Korea's response." *South Korea and the world*, Volume 3, No. 1, 2021.

5) Richard H. Speier, George Nacouzi, Carrie A. Lee, Richard M. Moore, 2017. *Hypersonic Missile Nonproliferation*, Santa Monica: Rand corporation, p. 12.

6) NASA, "Welcome to the NASA's Guide to Hypersonics."
<https://www.grc.nasa.gov/www/BGH/index.html> (accessed : Feb 8, 2022)

wedge-shaped.⁷⁾ HGVs can set various attack directions and flight paths depending on the target, making it difficult to ascertain expected targets because they do not follow a typical flight trajectory of ballistic missiles.⁸⁾ Due to the nature of these hypersonic missiles, the prediction of the intended targets is nearly impossible, and, thus, hypersonic missiles pose a greater threat than do those with hypersonic but low maneuvering capability ballistic missiles. As shown in Figure 1, a HGV does not have a ballistic trajectory like a ballistic missile. Its anomalous trajectory limits air defense units' ability to intercept the missile and can improve the viability of hypersonic glide vehicles in case of target changes during the flight.

<Figure 1> Comparing the flight trajectories of hypersonic glide vehicle (HGV) and ballistic missile reentry vehicle



Source: The Economist, "Gliding missiles that fly faster than Mach 5 are coming," April 6th, 2019, <https://www.economist.com/science-and-technology/2019/04/06/gliding-missiles-that-fly-faster-than-mach-5-are-coming> (assessed: April 20, 2022).

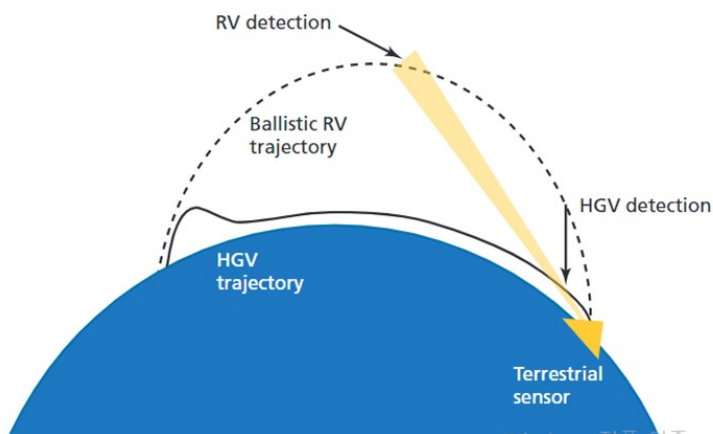
The hypersonic cruise missile (HCM) is the fastest existing cruise missile, equipped with a high-speed jet engine such as a rocket or a scramjet, flying to the target. Typical cruise missiles boast a subsonic speed of less than Mach 1 and excellent maneuvering capability but have the disadvantage of being intercepted due to their relatively low speed.⁹⁾ The high speed of HCMs can neutralize the opponent's missile defense system

7) Richard H. Speier, George Nacouzi, Carrie A. Lee, Richard M. Moore, 2017. *Hypersonic Missile Nonproliferation*, Santa Monica: Rand corporation, p. 1.

8) Richard H. Speier, George Nacouzi, Carrie A. Lee, Richard M. Moore, 2017. *Hypersonic Missile Nonproliferation*, Santa Monica: Rand corporation, p. 2.

while overcoming typical cruise missiles' vulnerability to the air defense system due to their low speed.¹⁰⁾

<Figure 2> The characteristics of radar detection of hypersonic missiles (HGVs) and ballistic missiles



Source: Richard H. Speier, 2017. *Hypersonic Missile Nonproliferation*, Santa Monica: Rand Corporation, p.11.

Since hypersonic missiles do not fly at an altitude similar to that of ordinary ballistic missiles; missile warning times may be reduced, limiting missile defense operations. Countries like South Korea that do not have missile warning satellites in space mainly operate ground-based air defense networks. Ballistic missiles can be detected in advance and warn of threats, but hypersonic missiles fly less than 50 km as shown in Figure 2 above, making it difficult to detect by radar early; thus, they are bound to be vulnerable to air defense operations. According to a study by the RAND Corporation, re-entry of the 3,000km range can be detected by the ground radar 12 minutes prior to the target collision, but hypersonic missiles powered at low altitude reduced the radar's detection ability to 6 minutes prior to the target collision.¹¹⁾ It can be a major obstacle to the operation of air defense assets because the radar detection

9) Richard H. Speier, George Nacouzi, Carrie A. Lee, Richard M. Moore, 2017. *Hypersonic Missile Nonproliferation*, Santa Monica: Rand corporation, p. 7.

10) Lee Sunhee, "Intent and implications for the development of a hypersonic glide in North Korea." *KIDA Defense Issues and Analyses*, no. 1884, Feb 10, 2022, p. 3.

11) Richard H. Speier, George Nacouzi, Carrie A. Lee, Richard M. Moore, 2017. *Hypersonic Missile Nonproliferation*, Santa Monica: Rand corporation, p. 11.

system installed on the ground is limited, not being able to issue a warning of hypersonic missile attacks in advance.

Studies on North Korea's development of hypersonic missiles are rare. In September 2021, North Korea conducted the first hypersonic missile test. Due to the limited collection of detailed flight data, there were not many studies and analyses on missile test activities. Shin Seung-gi postulates that, based on its activities in 2021, North Korea's hypersonic missile development is in the early stage and that it will take a long time for the North to be able to electrify the Korean Peninsula.¹²⁾ Based on his analysis and comparison of the hypersonic missile launch in January 2022 with the September 2021 launch, Shin concludes that the North Korean hypersonic missile was an improved MaRV with improved performance that could neutralize the ROK-US joint missile defense system.¹³⁾ Lee Sun-hee determines North Korea's hypersonic missile development as a challenge to the South Korea-U.S. missile defense system, which limits the allocation of missile batteries due to their high speed and maneuvering capability. Thus, she argues that they should perform hypersonic missile defense missions.¹⁴⁾ While existing studies reviewed above reveal the current state of North Korea's hypersonic missile development and the gravity of its threats, in-depth studies that assess North Korea's ability to develop hypersonic missiles, analyze its threats systematically, and propose countermeasures against military threats are needed.

2. Hypersonic missile development and international control regime

Russia and China have succeeded in developing weapons systems with hypersonic missile technology. Russia has Avangard glide-type hypersonic missiles deployed in 2019 and Chiron vessels and submarine-launched hypersonic cruise missiles deployed in November 2020. Before Russia's recent invasion of Ukraine, it threatened to fire hypersonic missiles as a show of force. Recently, Russia fired a Kinzhal hypersonic missile to strike a Ukraine weapons depot. China's typical hypersonic missile is DF(Dong Feng)-17, which was operatively deployed in 2020 and can speed up to Mach 10. The United States is developing hypersonic weapons in the Army, Navy, and Air Force and plans to deploy them in 2023. However, due to the recent test failure of the U.S. hypersonic missile, there are strong concerns about the United States trailing far behind China and Russia that possess advanced hypersonic missile technology.¹⁵⁾

North Korea's recent claim that it tested hypersonic missiles necessitates an effective mechanism to control over the transfer of hypersonic missile technology.

12) Shin Seung Gi, "It is related to the evaluation of North Korea's Mars-8 type and new anti-aircraft missile test launch." *Northeast Asia Strategic Analysis*, Oct. 26(2021).

13) Shin Seunggi, "Evaluation and implications of North Korea's new ballistic missile test launch." *Northeast Asia Strategic Analysis*, Feb 9(2022).

14) Lee Sunhee, "Intent and implications for the development of a hypersonic glide in North Korea." *KIDA Defense Issues and Analyses*, no. 1884, Feb 10(2022).

15) Yoo Yong-won, *Chosun Ilbo*, "Hypersonic missile." (2022.1.7).

Although Japan is also developing hypersonic missiles, North Korea's actual test activities have made waves. Concerns that North Korea may have secured hypersonic technology increased because it is difficult for North Korea to import strategic materials and transfer technology due to COVID-19 and U.N. Security Council economic sanctions. It is not easy for North Korea to produce its own hypersonic missile development technology, and there is a high possibility of technical support from China or Russia. Some media outlets have reported that North Korea secured hypersonic missile technology through hacking.¹⁶⁾ Rogue states and terrorist groups can pose a grave threat to international security if they acquire hypersonic missile technology.

The hypersonic missile technology is controlled by the MTCR. However, since hypersonic missiles are a new weapon system that surpasses the existing concept of war, it is necessary to discuss the transfer of hypersonic missiles for peace. Among the developed countries, the United States, China, and Russia possess hypersonic missile technology. Australia, Japan, India, France, and Germany are currently developing hypersonic missile technology, while Iran, Israel, and South Korea are known to conduct basic research. North Korea's hypersonic missile development was announced as a paramount development project of a weapon system at the 8th Party Congress in January 2021. However, it is considered a grave threat to the security of the Korean Peninsula as North Korea undertook three hypersonic missile tests in September 2021 and January 2022. It is unclear whether or not North Korea has developed its own hypersonic missile technology. Nonetheless, North Korea's threat should not be underestimated because it has acquired and tested the world's best weapon technology.

3. Research Scope and Subject

When North Korea test-launched a hypersonic missile, the most asked question was whether or not it was a hypersonic missile. At the time of the 2021 test launch, the maximum missile speed was measured as Mach 3. Thus, assuming North Korea's hypersonic missile test failed, South Korea surmised that it could intercept North Korea's hypersonic missile with South Korea's missile defense system. However, at the time of the 2022 test launch, the missile flew at a high speed of Mach 10 and broke through hypersonic speeds, raising concerns over whether South Korea could defend itself from North Korea's hypersonic missiles. Therefore, it is imperative that the South Korean government should evaluate North Korea's hypersonic missile development activities and devise countermeasures for its national security.

To assess North Korea's threats systemically, this study selects three evaluation factors: the purpose of North Korea's hypersonic missile development; the capability of North Korea's hypersonic missiles; and the military threat of hypersonic missiles. First,

16) Nils Weisensee. 『NKNEWS』 .“Hackers likely helped North Korea build hypersonic missile: UN report”, February 8, 2022, <https://www.nknews.org/2022/02/hackers-likely-helped-north-korea-build-hypersonic-missile-un-report/> (accessed : Feb 28, 2022).

given that North Korea launched hypersonic missiles after North Korea's declaration of nuclear advancement, the purpose of hypersonic missile development could be to provide a reliable weapon system that can carry North Korea's nuclear weapons. North Korea began developing missiles in the 1980s and has operated a number of Scud and No Dong missiles. Over three decades, North Korea has noticed many shortcomings of conventional missiles as a delivery vehicle of nuclear weapons. In addition, North Korea was aware that the ROK-US joint missile defense system could intercept its missiles. Thus, it can be assumed that these reasons motivated North Korea to develop hypersonic missile technology that could change flight routes to address the shortcomings of such missile operations.

Second, it seems that North Korea developed hypersonic missiles, which boast excellent maneuvering capability and shorten the detection time by the ROK-US radar system, in order to carry out successful attacks on the South Korean, Japanese, and U.S. military bases. Although the speed of the first test launch in 2021 fell short of the hypersonic speed, it showed hypersonic maneuver during the test launch activity in 2022. While the lack of detailed flight data and analysis of North Korea's hypersonic missiles limits the evaluation of hypersonic missiles, based on data collected during the tests of North Korea's hypersonic missiles so far, this study will evaluate the characteristics and capability of the missiles.

Lastly, it is critical that the South Korean government should gauge how North Korea's hypersonic missiles could be used for military purposes in the future. By studying the nature and threat of North Korea's hypersonic missile operation, the South Korea government must update its missile defense operation system so that it could utilize it efficiently against North Korea's hypersonic missiles. Assuming that North Korea builds hypersonic missiles to strengthen its nuclear missile capabilities, this study intends to propose countermeasures for the South Korean military by examining the process of North Korea's hypersonic missile development and analyzing missile

<Table 1> North Korea's hypersonic missile threats research range and subject

Category	Judging threat analysis	Examples
Judgment on the threat of the development of hypersonic missiles	The purpose of developing hypersonic missiles	Enhance national status and strengthen national defense capabilities through advanced nuclear missile capabilities, domestic control, and development of advanced technologies.
	Hypersonic missile capability	Status and capability of hypersonic missile design/test launch
	Military operation of hypersonic missiles	Hypersonic Missiles Military Threats and Military Management Measures

capabilities and military threats. The threat of North Korea's development of hypersonic missiles is analyzed in the following manner. Table 1 shows the ranges and subjects of the research on North Korea's hypersonic missile threats.

III. Threat Analysis of North Korea's Hypersonic Missile Development

1. North Korea's hypersonic missiles development

With the success of the sixth nuclear test, North Korea conducted a test launch of a Hwasung-12 Intermediate-range ballistic missile (IRBM) with a range of 4,500 to 5,500 km in May and November 2017, and exhibited North Korea's missile capability in November 2017. In January 2021, the 8th Worker's Party Congress set forth major tasks pertaining to the development of the defense industry and announced that it would develop hypersonic missiles, tactical nuclear weapons, nuclear submarines, and military reconnaissance satellites.¹⁷⁾ At the time, it was questionable whether or not North Korea could develop hypersonic missiles. Nonetheless, South Korea was shocked to learn of North Korea's test launch of a hypersonic missile in September 2021. We will analyze North Korea's three hypersonic missile tests.

(1) The first hypersonic missile test (September 28, 2021)

On September 28, 2021, North Korea launched a Hwasung -8 hypersonic missile from Yonglim-gun, Jagang-do. North Korea claimed that the hypersonic missile test launch was carried out to fulfill one of the top five tasks, the development of hypersonic missiles, in the Defense Science Development and Weapon System Development Plan announced at the 8th Party Conference in January 2021. Kim Jong-un mentioned North Korea's preparation for the production of hypersonic missile tests in the 8th Worker's Party Congress project report.

Korea Central News Agency reported that the National Defense Research Institute conducted a test launch of the newly developed hypersonic missile Hwasung-8. Defense scientists corroborated the flight control and stability of the missile in the active section and confirmed technical indicators, including the induction maneuvering capability and glide flight characteristics of the separated hypersonic active flight combat unit. They confirmed the stability of the ampoule missile fuel system and actuator introduced for the first time, and all technical indicators aimed at the test were satisfied with the design needs.¹⁸⁾

17) Jeon Seong-hoon, "Northern ultrasonic missile, the decisive version of the 10-year nuclear advancement of Kim Jong-un," *Kookmin Ilbo*, October 11, 2021, <https://www.donga.com/news/article/all/20211011/109641872/1> (accessed: February 26, 2022).

18) Korea Central News Agency, September 28, 2021.

North Korea's first hypersonic missile test fell short of the speed of Mach 5, and, thus, South Korea evaluated that North Korea's missile test could not be considered a hypersonic missile test. Based on its analysis, the South Korean government determined that it was not a threat because North Korea's hypersonic missile technology was still in the early stage of development.¹⁹⁾ Detailed flight data and analysis data on the first hypersonic test launch were not released; thus, North Korea's initial test launch of hypersonic missiles received little attention. It seems that North Korea inspected the basic hypersonic missile flight performance and lowered the difficulty of the test evaluation when it first tested and fired hypersonic missiles.²⁰⁾ The first test is evaluated as an initial test launch to develop hypersonic missiles while additional functions such as precise guidance of hypersonic missiles, stable flight, and extended ranges are expected to be tested in the future.²¹⁾ North Korea continues to develop weapon systems to improve the efficiency and viability of ballistic missile operations using ampoule-type fuels to prevent a prolonged liquid-fuel injection and shorten the operation time of missile launches.

(2) The second Hypersonic Missile Test Launch (January 5, 2022)

North Korea claimed to have conducted the second hypersonic missile test on January 5, 2022. The shape of the warhead of the hypersonic missile claimed by North Korea is different from that of the Hwasong-8 launched in September 2021. Yet, the propulsion system was the same and was determined to be the MaRV with improved performance.²²⁾ MaRV has relatively fewer technical demands than hypersonic missiles. The Ministry of National Defense announced that North Korea's second hypersonic test hit a target with a maximum speed of Mach 6 or less and an altitude of 50 kilometers apart, but there was no technological advance compared to the first test. It added that it was a ballistic missile with a MaRV.²³⁾ It is speculated that the liquid fuel ampoule was used, and weapon system development activities were carried out to improve viability by being fired from a mobile launch vehicle.

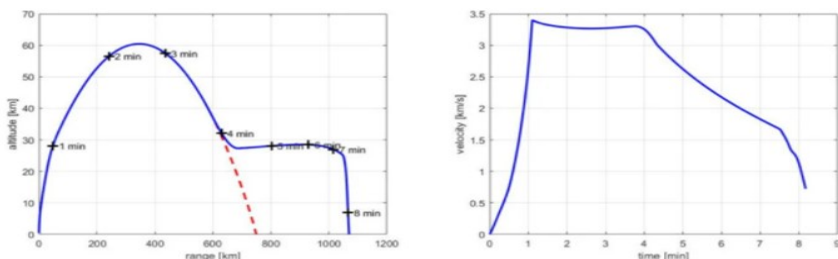
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- 19) Kim Yong-rae, Yonhap News Agency, "It falls short of North Korea's hypersonic missile, Mach 5..." "Technology beginner stage", 2021.11.24., <https://www.yna.co.kr/view/AKR20211124085100504?input=1195m> (accessed: February 26, 2022).
- 20) Shin Seung Gi, "It is related to the evaluation of North Korea's Mars-8 type and new anti-aircraft missile test launch." *Northeast Asia Strategic Analysis*, Oct. 26, 2021, p.9.
- 21) Lee Sang-heon, Yonhap News, Game Changer's competition to develop hypersonic missiles is heating up...North Korea also joins, on October 19, 2021, <https://www.yna.co.kr/view/AKR20211019035800071?input=1195m> (accessed: February 26, 2022).
- 22) Shin Seung Gi, "It is related to the evaluation of North Korea's Mars-8 type and new anti-aircraft missile test launch." *Northeast Asia Strategic Analysis*, Oct. 26, 2021, p.3
- 23) Ministry of National Defense press briefing, January 7, 2022.

(3) The third hypersonic missile test launch (January 11, 2022).

On January 11, 2022, North Korea conducted its third hypersonic missile test launch under the observation of Kim Jong-un. In the third missile test launch, the missile flight distance was more than 700 km, the flight altitude was up to 60 km, and the maximum flight speed surpassed Mach 10. In the face of South Korea which concluded that the missile North Korea test-launched for the second time was not hypersonic, North Korea showed off its achievements in developing hypersonic missiles that surpassed Mach 10 in its third launch. The two hypersonic missile test launches conducted in January 2022 are Maneuverable Reentry Vehicles (MaRV).

Some argue that it can attack by bypassing the southern region of the Korean Peninsula and Japan from the interview with the Deputy Director of Missile Defense Project, the Center for Strategic and International Studies.²⁴⁾ In addition, as a result of the simulation of the hypersonic missile test launch on January 15, unlike ordinary ballistic missiles, the flight trajectory was horizontally descending at an altitude of 60 km or less. Its speed exceeded 3 km per second, flying at hypersonic speed. North Korea's third test launch is presumed to be of a hypersonic missile. Given the missile range, attacks on U.S. military bases in Japan are possible.²⁵⁾

<Figure 3> Hypersonic missile flight altitude-distance, speed-time analysis results



Simulation results: altitude versus range (left) and velocity as a function of time (right). (Savelsberg/Kawaguchi)

Source: Ralph Savelsberg and Tomohiko Kawaguchi, "North Korea's hypersonic missile claims are credible, exclusive analysis shows," February 16, 2022, <https://breakingdefense.com/2022/02/north-koreas-hypersonic-missile-claims-are-credible-exclusive-analysis-shows/> (accessed: 2022.2.27.)

24) Brad Lendon and Yoonjung Seo, "North Korea claims to be testing the world's most advanced weapon. Experts are doubtful", CNN, January 6, 2022, <https://edition.cnn.com/2022/01/06/asia/north-korea-missile-test-explained-intl-hnk-ml/index.html> (accessed: Feb. 27, 2021).

25) Ralph Savelsberg and Tomohiko Kawaguchi, "North Korea's hypersonic missile claims are credible, exclusive analysis shows" February 16, 2022, <https://breakingdefense.com/2022/02/north-koreas-hypersonic-missile-claims-are-credible-exclusive-analysis-shows/> (accessed: Feb. 27, 2022).

It is not easy to intercept hypersonic missiles like the one that North Korea test-fired over Mach 5 due to high-speed flights and anomalous maneuvers. In South Korea's missile defense system, Patriot and THAAD are usually responsible for intercepting ballistic missiles. More than likely, North Korea will analyze the operational range of Patriot and THAAD and their weakness and operate hypersonic missiles at altitudes and areas where Patriots and THAAD cannot intercept them.

2. Analysis and evaluation of North Korea's threat to develop hypersonic missiles

(1) The military purpose of developing hypersonic missiles

North Korea is strengthening its nuclear and missile power to defend itself against the invasion of hostile countries and unify the Korean Peninsula by strengthening its defense power. It also demands that South Korea and the United States lift economic sanctions on North Korea while strengthening internal control and solidarity within its territory. North Korea is recognized as a nuclear powerhouse and continues to develop the latest missiles, including the development of hypersonic missiles, the North Korean version of Iskander (KN-23), the North Korean version of ATACMS (KN-24), and the new long-range cruise missiles. North Korea also launched 11 missiles in January 2022, escalating the security crisis on the Korean Peninsula according to its strategy regardless of the Beijing Winter Olympics and South Korea's presidential election. North Korea claims that missile development is part of its efforts to strengthen its peaceful defense system against U.S. aggression. North Korea also strongly opposes the U.S.-South Korea joint exercises and steps up criticism for practicing invasion of North Korea even in small-scale military exercises.

North Korea's missile launches in the name of strengthening its nuclear and missile defense capabilities are drawing criticism from the international community. Yet, North Korea continues to develop missiles despite the UN Security Council's resolution to impose sanctions on North Korea. North Korea continues to strive to complete new missile systems, including hypersonic missiles, to defend itself from the U.S. attack and maintain internal control over North Koreans. It also highlights the Kim Jong-un regime's performance in strengthening its defense capabilities. In addition, after the success of the sixth nuclear test, North Korea has completed various nuclear weapons delivery systems. Following the successful development of mid- to long-range ballistic missiles and intercontinental ballistic missiles, North Korea is advancing missile technology that will neutralize the South Korea-U.S. missile defense system.

In his 2017 New Year's address, Kim Jong-un expressed confidence in the development of ICBM, claiming that the plan to prepare for the intercontinental ballistic missile (ICBM) test was in its final stage. Then, he declared the

completion of the national nuclear force with the success of the Hwasung-15 ICBM launch in November 2017. Kim Jong-un aims to improve nuclear missile technology by strengthening missile power in order to block U.S. intervention in the event of a war on the Korean Peninsula.²⁶⁾ Taking into account North Korea's threat to develop hypersonic missiles and violations of U.N. Security Council resolutions, South Korean and U.S. authorities should toughen economic sanctions and pay attention to the dangers of North Korea's hypersonic missiles.

North Korea emphasized cooperation and peaceful exchanges for denuclearization at six-party talks, the Pyeongchang Winter Olympics, three inter-Korean summits, and Kim Jong-un and Trump's historic summit. However, it should recognize historical lessons to simply avoid risks of pressure on North Korea and U.S. military response.²⁷⁾ On multiple occasions, North Korea has promised to comply with the international community norms, while participating in dialogues through diplomatic channels, only to break the promise once the situation improved. Thus, North Korea's hypersonic missile development strategy should be clearly recognized and countered by similar military strategies.

North Korea's large-scale national budget investment in missile development in the midst of economic difficulties and international sanctions shows how desperately North Korea seeks to strengthen its nuclear missile power and enhance its external bargaining power with the U.S. and South Korea. Provided that there are only three countries in the world with hypersonic missile technology, the United States, China, and Russia, North Korea's success in testing hypersonic missiles could boost North Koreans' pride in and loyalty to the North Korean regime and, ultimately, contribute to strengthening Kim Jong-un's power.²⁸⁾

(2) Hypersonic missile capability.

North Korea has conducted three hypersonic test launches since September 2021. North Korea's launch of hypersonic missiles is a big shock to South Korea, which is still undergoing basic research on hypersonic missiles. North Korea's hypersonic missile is operated as a mobile launcher and can be deployed at any launch point and fired at any time, avoiding the ROK-US joint surveillance network in advance. In addition, by using an ampoule type of liquid fuel equipped with a sealed liquid-fuel tank, North Korea seems to have found a solution to the existing long-term fuel injection time and information monitoring system and

26) Jeong Sung-jang, "North Korea's ICBM test launch and prospects for U.S.-North Korea relations." *Sejong review*, no. 333, 2017, p. 2.

27) Park Siyoung, "The reversal of North Korea's perception and preference of threats before and after the declaration of completion of nuclear force." *Defense Research*, Volume 62, No. 1, 2019, p. 26.

28) Jeong Sung-jang, "The background of North Korea's consecutive missile launches and the outlook for the situation on the Korean Peninsula." *The situation and policy*, 2022-Feb No.10.

enabled rapid missile launch. The capabilities of North Korea's hypersonic missiles require precise analysis and research on test activities. Overseas research institutes report various analyses of North Korea's claims of hypersonic missiles. Based on the test launch data so far, it is difficult to intercept hypersonic missiles with missile defense assets because it has a range of more than 700 km with a peak altitude of 50 to 60 km, a maximum speed of Mach 10, and high-speed flight and maneuver at an altitude of 50 km.

The International Institute for Strategic Studies (IISS), a British think tank, recently identified North Korea's hypersonic missile as a mobile re-entry (MaRV) ballistic missile and compared it to the Hwasung -8, which was launched in September 2021, the booster of the Hwasung-12 medium-long-range ballistic missile.²⁹⁾ North Korea's hypersonic missiles have yet to be technically completed. However, North Korea ordered priority investment in strengthening its defense capabilities and developing weapons systems at the 8th Party Conference in January 2021. Since the party and Kim Jong-un focus the national power on developing a defense weapon system, the South Korean government should proactively implement its military missile defense operation and response weapon system.

(3) Hypersonic missiles for military operations.

North Korea's hypersonic missiles are expected to have a range of more than 700 kilometers and are estimated to fly within 60 kilometers of their peak altitude. They boast high-speed flight performance, flying below the peak altitude of Mach 5, and maneuvering capability that allows changes of flight routes, making it difficult to intercept if they fly below the lowest effective altitude of 40 km of the THAAD interception system. The interception altitude of the High Altitude Missile Defense System (THAAD) ranges from 40 to 150 km, the range is 200 km, the new Patriot Missile (PAC-3 MSE) is 40 km, the range is 100 km, and the medium-range surface-to-air guided weapon (M-SAM) is 15 to 20 km, and the range is 40 km.

North Korea can establish and operate flight routes and find operational restrictions based on its previous research on non-imperceptible areas of South Korea's missile defense system. Rather than presuming that North Korea's hypersonic missile technology level is primitive and cannot pose a threat to South Korea's security, the South Korean government should establish countermeasures in advance to respond to the advancement of North Korea's hypersonic missile technology.

29) Tom Karako, Masao Dahlgren, CSIS Missile Defense Project, *Complex Air Defense: Countering the Hypersonic Missile Threat*, February 7, 2022, <https://www.csis.org/analysis/complex-air-defense-countering-hypersonic-missile-threat> (accessed: Feb.26, 2022).

IV. The South Korean military's countermeasures

North Korea continues to develop various ballistic missiles to strengthen its nuclear missile capabilities and step up its R&D activities to neutralize the South Korea-U.S. missile defense system. North Korea's recent development of hypersonic missiles poses a grave security threat to the Korean Peninsula because only a few countries around the world possess such technology. North Korea's launch of hypersonic missiles and ballistic missiles is a violation of the UN resolution. The South Korean government should strengthen its military readiness by utilizing the ROK-US joint missile defense system while demanding tougher sanctions from the international community. In response to the increase in North Korea's threat of hypersonic development, we propose that the South Korean military adopt the following measures.

First, the South Korean military must analyze North Korea's intentions of developing hypersonic missiles and its threats. The hypersonic missile test-launched by North Korea for the first time failed to exceed Mach 5, which indicates that it was not a hypersonic missile. However, the missiles in the subsequent launches in 2022 performed various anomalous maneuvers and surpassed Mach 10, heightening the threat of North Korea's hypersonic missiles. The fact that North Korea's new weapons system development plan announced at the 8th Party Congress in 2021 was tested and evaluated in the second half of 2021 should be recognized that unlike South Korea's weapons system development, it is developing weapons systems with all the nation's capabilities. It is dangerous to judge early that the threat will be small because the North's hypersonic weapons system is low in technology and can be defended with existing missile defense systems. North Korea will also recognize that it will become a game-changer in the war by using hypersonic missiles to attack major targets and military command posts in South Korea's metropolitan area. An objective threat analysis should be conducted on North Korea's hypersonic development activities.

Second, South Korea must devise countermeasures against North Korea's hypersonic missile military threat and develop combined countermeasures technologies and equipment. To maintain South Korea's security, it is imperative that South Korea builds an effective military response system to North Korea's hypersonic missile development. North Korea's hypersonic missiles are in the early stages of development; it is not certain whether or not such missiles would be complete. However, unlike South Korea's weapons system, North Korea's hypersonic missiles may be developed quickly and deployed early. South Korea needs to reinforce its military plans for hypersonic missile defense. South Korea and the U.S. missile military experts, who have established a South Korea-U.S. joint operation plan, should study together how to respond to North Korea's hypersonic missiles. In January 2022, the U.S. and Japan agreed to joint research

on the threat of hypersonic missiles by North Korea and China after a meeting of foreign and defense ministers. South Korea should also participate in the Japan-U.S. cooperation system to jointly respond to North Korea's hypersonic threats and establish measures to strengthen South Korea's missile defense capabilities by working with the US military.

Third, South Korea should surpass North Korea in the hypersonic missile development and strengthen the development of South Korean missile capabilities to counteract the hypersonic missile development. The Ministry of National Defense has decided the requirement for hypersonic guided missiles in 2020. The Agency for Defense Development (ADD) has key technologies and plans to develop hypersonic cruise missiles. The development of hypersonic cruise missiles will strengthen the ability to accurately strike North Korean key targets by surprise attack in the air.

South Korea is vulnerable to North Korea's hypersonic missiles with the South Korea-U.S. current missile defense weapons system. It may be reasonable to develop a weapon system that can defend against North Korea's hypersonic missiles. However, it takes a long time to initiate and conduct basic research, produce prototypes, and evaluate weapons tests. According to a close analysis of Korea's current missile defense system, countermeasures should be established through objective threat evaluation. North Korea's hypersonic missiles are also in the development stage. However, if development activities are terminated early, it is also necessary to purchase and deploy a new weapon system that can respond to them. Raytheon's new Glide Phase Interceptor (GPI) and SM-6 missile defense systems are adopted by the U.S. Missile Defense Agency. It needs to consider introducing and operating interceptors through cooperation between South Korea and the U.S. For South Korea to gain a military advantage in response to various North Korean missile-attack weapons systems, it is imperative that South Korea introduces a counter-weapon system and builds the technology required for a counter-weapon system.

V. Conclusion

This paper analyzed North Korea's hypersonic missiles in political and military aspects. North Korea is continuing to develop the latest weapons systems, including hypersonic missiles, to defend against external aggression and strengthen its defense capabilities. However, North Korea's hypersonic missiles are not developed for defense purposes but for military attacks against neighboring countries. Despite COVID-19 and economic sanctions against North Korea, it continues to build new missile weapons systems with large budgets. North Korea is strengthening its nuclear and missile capabilities by developing hypersonic

missiles and new weapons systems to maintain internal control of its people and promote the achievements of the Kim Jong Un regime. Also, as a nuclear power, North Korea is trying to tilt the scale on the situation on the Korean Peninsula in its favor, strengthening its foreign negotiating power on the Korean Peninsula issues. Since hypersonic missiles have emerged as a new weapon system on the Korean Peninsula, existing studies are rare. Most of the analyses are of the United States, China, and Russia, which have secured hypersonic missile technology and are developing weapon systems. Through this study, academia's interest in North Korea's hypersonic missile development and understanding of the development of state-of-the-art weapons systems were enhanced by deriving South Korean military countermeasures through research on North Korea's hypersonic missile development process.

It is very important to analyze North Korea's hypersonic missile development and assess threats through an objective analysis of North Korea's media reports on North Korea's hypersonic missile test launch. Analysis by experts in South Korea and the United States could help evaluate the intention and threat of North Korea's hypersonic missile development.

If North Korea's hypersonic missile capabilities are advanced in the future, it is necessary to establish countermeasures against North Korea's use of hypersonic missiles as an asymmetric strategy through research in advance on how they will operate in missile operations. In the future, comparisons of hypersonic missile development between the two Koreas, detailed analysis of North Korea's hypersonic missile power, and scientific analysis and in-depth research on the military impact of North Korea's hypersonic missile on security on the Korean Peninsula should continue.

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