

ASYMMETRIC WMD THREATS: DPRK NUCLEAR, CYBER, AND BIO-CHEMICAL WEAPONS CAPABILITIES



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SANG HYUN LEE

JANUARY 17 2022

I. INTRODUCTION

In this essay, Sang Hyung Lee assesses the evolution and state of play of DPRK's current asymmetric capabilities. He argues that DPRK's asymmetric forces consisting of increasingly-sophisticated nuclear weapons, ballistic missiles, bio-chemical weapons, and cyberattacks pose an existential threat to the ROK, undermine stability in Northeast Asia and threaten the international community.

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Banner image: Wikipedia, flags of DPRK Army, Navy, Air and Anti-Air, Strategic Rocket and Special Forces; from [here](#); DPRK cyber force graphic from [here](#)

II. NAPSNET SPECIAL REPORT BY SANG HYUN LEE

ASYMMETRIC WMD THREATS: DPRK NUCLEAR, CYBER, AND BIO-CHEMICAL WEAPONS CAPABILITIES

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1. Introduction

The Democratic People's Republic of Korea or DPRK (informally, North Korea) maintains the world's fourth largest armed forces, with nearly 1.3 million active personnel, accounting for about five percent of the total population. More than six hundred thousand others serve as reserve soldiers. The DPRK's military power poses a constant threat to the security of Northeast Asia as well as South Korea, Korea, officially the Republic of Korea (ROK).

The regime spent an average of \$3.6 billion annually on the military between 2007 and 2017, according to the US State Department. Although Pyongyang is outspent by its neighbors and adversaries in dollar-to-dollar comparisons and defense experts say it operates with aging equipment and technology, the regime's forward-deployed military position and missiles aimed at Seoul ensure that Pyongyang's conventional capabilities remain a constant threat to its southern neighbor.^[1] The DPRK is qualitatively inferior to the ROK but has superior conventional forces in number.

The DPRK maintains a readiness posture capable of carrying out a surprise attack at any given time by positioning seventy percent of its ground force south of the Pyongyang-Wonsan line. The forward-deployed 170mm self-propelled guns and 240mm Multiple Rocket Launchers (MRLs), for instance, provide the DPRK with the capability for a large-scale and concentrated surprise fire targeted at the Greater Seoul Metropolitan Area.

More serious than conventional military force are various asymmetric threats posed by the DPRK. In general, asymmetric threats refer to the use of unexpected means and methods to neutralize the opponent's strengths and exploit weaknesses to prevent the other party from retaliating. DPRK's asymmetric threats consist of its active and increasingly-sophisticated nuclear weapons, ballistic missiles, bio-chemical weapons, and cyberattacks.

Since the succession of power in 2011, the DPRK has maintained the stability of the regime through reorganization and reshuffling of the whole state system. The regime is seeking a strategic change by adopting a new strategic line in 2018 by focusing all efforts on building a socialist economy, replacing the 2013 '*byungjin*' policy of simultaneously developing its economy and nuclear weapons.

The DPRK unilaterally withdrew from the Treaty on the Non-Proliferation of Nuclear Weapons in January 2003, is not a party to the Comprehensive Nuclear-Test-Ban Treaty, and has conducted six increasingly sophisticated nuclear tests since 2006. The DPRK is not a party to the Chemical Weapons Convention, and is believed to possess a large chemical weapons program. Despite being a state party to the Biological and Toxin Weapons Convention and the Geneva Protocol, evidence suggests the DPRK may maintain an offensive biological weapons program.[\[2\]](#)

The ROK maintains conventional forces that are qualitatively superior to those of the DPRK, but it cannot avoid relative inferiority in relation to the DPRK's asymmetric force advantages. In particular, it relies entirely on the U.S. nuclear umbrella for nuclear weapons, and Seoul, a densely populated area, is close to the border, making it vulnerable to DPRK's asymmetric threats.

2. DPRK's Asymmetric WMD Capabilities

2.1 Nuclear and Missile Threats

The DPRK declared 'completion of nuclear weapons program' in November 2017, and no nuclear development trend was detected during the reconciliation between the United States and the ROK from the following year. But it is pushing to upgrade its nuclear and missile capabilities again after the Hanoi talks broke down.

The DPRK has nuclear fuel manufacturing and enrichment facilities, nuclear fuel cycle facilities, nuclear reactors such as 5MWe graphite moderated reactors, and nuclear fuel cycle facilities such as a radiochemical laboratory (reprocessing facility) at Yongbyon Nuclear Science Research Center. It conducted a nuclear test at its nuclear test site in Punggye-ri by manufacturing nuclear weapons from plutonium produced at its Yongbyon nuclear facility. In addition to the disclosed Yongbyon nuclear complex and the Punggye-ri nuclear test site, the DPRK is also believed to have a number of unidentified nuclear facilities.

Nuclear weapons development is usually carried out in four stages: acquiring nuclear materials, manufacturing nuclear explosive devices, nuclear tests, and miniaturization of the warheads. First, the DPRK should secure enough fissionable material to produce nuclear weapons. To acquire nuclear fissile materials such as plutonium (Pu) and highly enriched uranium (HEU), plutonium production technology, reprocessing technology, and uranium enrichment technology are required. Second, manufacturing nuclear explosive devices is a step to assemble nuclear materials and detonators, and it is possible to declare nuclear possession at this stage without the need for reliability verification through nuclear tests. The DPRK officially declared its possession of nuclear weapons in February 2005 after the Geneva Agreed Framework was scrapped. Third, nuclear tests are necessary to verify the operation of nuclear explosive devices, improve their performance, such as nuclear fission conditions, and increase their power. To that end, the DPRK conducted six nuclear tests. The fourth stage is to miniaturize and lighten nuclear warheads (diameter less than 90cm, weight less than 1 ton) and secure the reliability of the means of delivery. Currently, it is believed to be at the fourth stage of its nuclear weapons development program. The DPRK regime claimed that it achieved standardization, miniaturization, and lightweight of nuclear warheads after its sixth nuclear test.

Experts estimate that the DPRK is believed to have twenty to sixty nuclear weapons and has recently come close to having ballistic missile capabilities capable of carrying nuclear warheads and striking the US mainland. The exact number of nuclear warheads held by the DPRK varies depending on the evaluation agency and experts, and about twelve additional nuclear warheads are expected to be produced annually. This is based on the production of a nuclear warhead (Pu 8 kg, HEU 20 kg) with an explosive yield of about 20 Kt, and depending on the analyst's choice of desired nuclear weapons

explosive power attributed to the DPRK and the type and design of warhead, a realistic estimate of the DPRK's capacity and quantity of the warheads varies, depending on these assumptions.

To enhance its strategic attack capabilities, the DPRK has continuously developed nuclear weapons. It first gained access to nuclear materials in the 1980s after operating the 5MWe reactor located in the Yongbyon Nuclear Complex by reprocessing spent fuel rods. It is estimated to possess around 50kg of weapon-grade plutonium obtained from several rounds of reprocessing spent fuel rods. The DPRK is also believed to possess a substantial amount of highly enriched uranium (HEU), and its ability to miniaturize nuclear weapons seems to have reached a considerable level. The amount of enriched uranium that can be produced at the Yongbyon nuclear facility in 2010 is about two tons per year for 3.5 percent low-enriched uranium, and 40 kilograms per year for weapons-grade, highly enriched uranium, which can be used to fabricate two small nuclear weapons. However, assuming that the DPRK is hiding additional uranium enrichment facilities, the production capacity of highly enriched uranium increases further. As of the end of 2018, a reasonable estimate of the maximum North Korean HEU production capacity and inventory amounts to 200 kilograms and 980 kilograms per year, respectively.[3]

Table 1. DPRK's Nuclear Tests

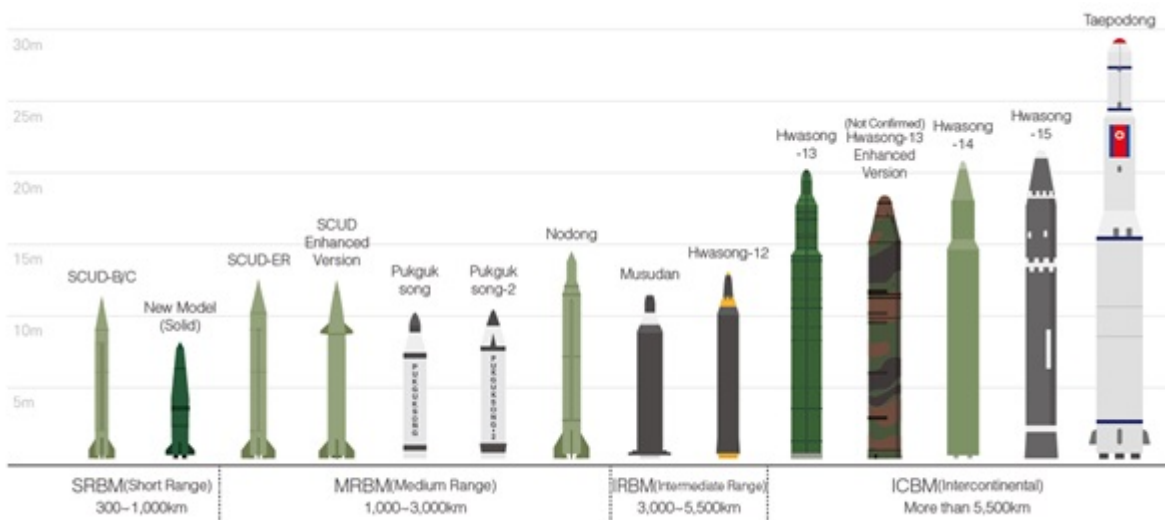
Sequence	Date	Location	Est. Yield
1	9 October 2006	Punggye-ri Test Site	0.7 - 2 kt
2	25 May 2009	Punggye-ri Test Site	2 - 5.4 kt
3	12 February 2013	Punggye-ri Test Site	6 - 16 kt
4	6 January 2016	Punggye-ri Test Site	7 - 16.5 kt
5	9 September 2016	Punggye-ri Test Site	15 - 25 kt
6	3 September 2017	Punggye-ri Test Site	70 - 280 kt

The DPRK's progression from the nuclear threshold to a heavily armed nuclear state with intercontinental reach is doing serious damage to the foundations of strategic stability in Northeast Asia by eroding confidence in the ability and will of the United States to fulfill its security guarantees to the ROK and Japan. While working for denuclearization, the United States, ROK, and Japan have also been working to adapt and strengthen deterrence so as to stay ahead of the emerging threat. The US nuclear umbrella, which was designed in very different security environments in 1991 and 2010, is increasingly outdated for the purpose of deterring the DPRK's nuclear threats. Hence, it must be modified to enable improved signaling of collective resolve to stand up to the DPRK's nuclear bullying. Some experts suggest that we should move toward a more NATO-like posture which is based on 'nuclear sharing' in Northeast Asia. At the same time, it is important to maintain an appropriate mix of nuclear and non-nuclear capabilities for deterrence, including missile defense.[4]

The DPRK has been focusing on strengthening its ballistic missile capabilities since it announced the completion of its nuclear weapons construction. After beginning the ballistic missile developments in the 1970s, it produced and fielded the Scud-B and Scud-C missiles with ranges of 300km and 500km, respectively, in the mid-1980s. In the late 1990s, it fielded the Rodong missile with a range of 1,300km and, later, the Scud-ER, which are Scud missiles with an extended range. In 2007, the DPRK fielded the Musudan missile with a minimum range of 3,000km without a test launch. Through these successive additions to its missile inventory, the DPRK has gained direct strike capabilities

against the ROK and the surrounding countries of the Korean Peninsula.[5]

Figure 1. DPRK's Missiles in Inventory or Under Development[6]



The DPRK's nuclear and missile capabilities are rapidly growing. The regime seems to be risking its national survival on nuclear and missile development, especially after the succession of power to Kim Jong-un.

Since the collapse of the Hanoi summit, the DPRK has intensively tested short-range missiles with a range of less than 1,000 kilometers on a total of sixteen occasions from May 2019 to August 2020. The KN-23 has a pull-up function that makes it move up again in the final stage of the flight, which is considered similar to the Russian Iskander missile, and is estimated to have a range of up to 600 kilometers. The KN-24, called the North Korean version of ATCAMS, can fire continuously and hit the entire Korean Peninsula with a range of up to 400 kilometers. KN-25 and KN-09, although the DPRK called them multiple rocket launchers, are considered to be short-range missiles in the sense that it is equipped with guided technology and shows ballistic missile flight trajectories. Unlike conventional Scuds and Rodong missiles, the KN-23 and KN-24 used solid fuel to enhance surprise attack capabilities and significantly improve the accuracy of target strikes. The liquid-fueled Scud and Rodong missiles are likely to be exposed by US intelligence assets before the launch, but KN-23 and KN-24 can be launched immediately, significantly improving their survivability and surprise launch capabilities. The DPRK's new guided weapons are also considered more difficult to intercept through the ROK-US missile defense system.

Although it is not yet certain whether these new short-range missiles can deliver nuclear warheads, experts say that it may be possible enough. Jeffrey Lewis, a US missile expert, evaluates that the KN-23 can be equipped with nuclear warheads. Another expert, Michael Elleman, estimates that the KN-24 is 700 to 850 mm in diameter and is capable of mounting a 60-centimeter diameter nuclear warhead.[7]

The DPRK's rapid progress on intercontinental ballistic missile (ICBM) and submarine-launched ballistic missile (SLBM) capabilities is also alarming. It unveiled new missile capabilities during its military parade on October 10, 2020, marking the 75th anniversary of the founding of the Korean Workers Party. In particular, the two newly introduced strategic weapons attracted the attention of experts. One is the 'Hwasong-16' ICBM and the other is the 'Pukguksong-4' SLBM. Hwasong-16, appears to be approximately 25-26 m long and 2.5-2.9 m in diameter—about 4-4.5 m longer and about 0.5 m larger in diameter than the DPRK's Hwasong-15 ICBM flight tested once in November 2017. Indeed, the new missile has been correctly characterized as the world's largest mobile

ICBM—in part because countries with ICBMs generally seek to make their road-mobile ICBMs smaller so they can be more mobile and concealable. It is estimated that the new missile's launch weight at roughly 100,000-150,000 kg, compared to some 80,000 kg for the Chinese DF-41 solid-propellant, road-mobile ICBM and about 104,000 kg for the former Soviet SS-24 rail-mobile solid ICBM.[8]

The DPRK, which began developing SLBM in earnest in 2014, successfully test-fired the Pukguksong-1 and 3. It unveiled Pukguksong-4 at the military parade in October 2020 and introduced Pukguksong-5 at the military parade in January 2021. Although the Pukguksong-4 and 5 have not yet been tested, it is estimated that they will be deployed on a mid-sized submarine or a nuclear-powered submarine planned for the future. The DPRK's mid-sized submarines, which were unveiled in July 2019, are expected to be able to carry at least 3-4 SLBMs, given the volume of drainage and the shape of the bridge's renovation.[9]

Although this is a new progress in the DPRK's overall capabilities, some analysts say that these SLBM missiles could provide only a marginal addition to the threat posed by the DPRK's much larger, increasingly longer range and much more survivable land-based ballistic missile force. When The DPRK revealed a new type of conventionally powered ballistic missile submarine (SSB), many media sources termed this a 'game changer' and their reaction verged on a hysterical atmosphere of fear. But, in fact, the DPRK's construction of a new-type SSB is far from new. We do not know either whether the DPRK will build SSB force of at least several boats, which would be required for a true second strike capability. The new SSB appears to be based on the 1950s-vintage Soviet ROMEO-class diesel-electric submarine which are very noisy boats that are thus highly susceptible to acoustic detection while having only a limited ability to know that they are being tracked by enemy submarines. The new-type SSB almost certainly is substantially less survivable than the DPRK's land-mobile ballistic missile force, and it would be even more vulnerable if it were to be forward-deployed against the US West Coast or Hawaii. In this sense, the DPRK's new SSB is not an "existential threat" nor a "most menacing weapons" Kim Jong-un has that can get pretty close to the continental United States.[10]

The last hurdle that the DPRK has to overcome is to complete an ICBM that can strike the US mainland using atmospheric reentry vehicle technology. Advanced technologies such as ultra-precision flight posture control and composite materials are required to withstand the high heat (more than 7,000 degrees) and pressure caused by the warhead falling at a speed of more than Mach 20. In March 2016, the DPRK revealed the status of a test for a reentry vehicle, but from what is known by observers, it seems that they have not yet completed the technology. Another technology the DPRK is trying to strengthen its ICBM capability is multiple independently-targetable reentry vehicles (MIRVs). When the DPRK revealed Hwasong-16 during its October 10 military parade, many experts speculated that this missile, which is considerably larger than the Hwasong--, may be designed to carry multiple warheads and decoys to ensure the penetrability of America's missile defenses. Hwasong-16 will need to undergo flight trials conducted over a couple of years to validate its performance and reliability. Nevertheless, there is circumstantial evidence that the DPRK is developing MIRV technology. For example, it is likely that Hwasong-12, given the fact that it separated in three pieces as it entered the atmosphere in August 2017, was a post-boost vehicle (PBV) engine test, an important part of MIRV development.

Table 2. DPRK's Major Missile Inventory[11]

Category	Name	Range	Remarks
IRMBs, ICBMs	Musudan	3,000+ km~	Operational since 2016
	Hwasong-12	5,000+ km~	Test launch, May 2017
	Hwasong-14	10,000+ km~	Test launch, July 2017
	Hwasong-15	13,000 km	Test launch, Nov. 2017
	Hwasong-16	13,000+ km~	Revealed, Oct. 2020 parade
SLBMs, Submarines	Pukguksong-1	1,000km	Test launch, August 2016
	Pukguksong-3	2,000km	Test launch on a barge, Oct. 2019
	Pukguksong-4	2,000km	Revealed, Oct. 2020 parade
	Pukguksong-5	3,000km	Revealed, Jan. 2021 parade
	Sinpo class submarine, also called the <i>Gorae</i> (whale)	1,800ton displacement	Loaded with 1 SLBM, operational
	Mid-size submarine	3,000ton displacement	Loaded with 3-4 SLBMs, Shaft assembly complete
	Nuclear submarine	5,000+ ton displacement	SLBM capacity unknown, design phase
New Tactical (short-range) missiles	KN-23	600km	Test launch, May 2019, aka North Korean <i>Iskander</i>
	KN-24	400km	Test launch, Aug. 2019, aka North Korean <i>ATCAMS</i>
	KN-25	400km	Operational since July 2019, 'Super-large' multiple launch

So, what will be the future expectations? It is highly likely that the DPRK will no longer pursue underground nuclear tests after six nuclear tests. It has not been confirmed whether there are more underground nuclear test sites other than Punggye-ri. But arguably the DPRK's 200kT nuclear test already reached and perhaps exceeded the limit on the size of a nuclear test underground, however, the possibility of an atmospheric nuclear test on land or at sea cannot be ruled out. While the first five nuclear tests were relatively small, the sixth one was more powerful than all the previous ones combined. Given these circumstances, it would be reasonable to say that the DPRK's nuclear development is now nearing completion.[\[12\]](#)

2.2 Cyber Threats

The DPRK's continuing economic difficulties have caused not only a lack of conventional war capability, but also a lax military discipline. It is difficult to maintain offensive conventional military capabilities against the ROK's superior armed forces. To overcome these difficulties, the DPRK has focused on developing North Korean-style strategies, tactics, and weapons systems, and among them, its cyber capabilities are potentially as potent as its nuclear and missile capabilities.

The DPRK has expanded its cyber capabilities, as manifested by the intensification of state-sponsored attacks from the DPRK or its agents that the world has witnessed in the last decade. Amongst the most blatant offensive cyber-attacks allegedly linked to North Korean-originated hacker groups are the Sony Pictures attack, the WannaCry attack, and the DarkSeoul attack, although the DPRK consistently denies any involvement with these attacks, or the damage suffered by them. The DPRK's cyber army consists of approximately 7,000 hackers, performing a wide range of activities including theft, denial of service (DDoS), espionage and sabotage.

In fact, the DPRK's cyber capabilities, including hacking, are considered world-class. Kim Jong-un had earlier stressed that "cyber warfare, along with nuclear weapons and missiles, is an all-round sword that guarantees the merciless striking capability of the Korean People's Army." This was revealed during the National Assembly intelligence committee audit hearing by National Intelligence Service chief Nam Jae-joon.[\[13\]](#)

The DPRK's illegal cyber activities pose a serious security threat not only to the ROK but also to the international community. The DPRK does not hesitate to launch cyberattacks to secure cash as its long-standing sanctions have deepened its international isolation.

While the DPRK's illegal cyber activities in the past focused mainly on the theft of sensitive information, the DPRK's behavior has recently changed to cyber-financial theft. To this end, the DPRK has constructed cyberattack capabilities in more diverse and creative ways to generate revenues for regime survival, in addition to military and strategic purposes. Two main shifts in Pyongyang's cyber operations are observed: first, an increase in cyber-attacks aimed at financial gain; and second, a decrease in the visibility of cyber operations at espionage and information gathering.[\[14\]](#) The DPRK is very interested in cyber foreign currency earnings through hacking. It is difficult for the ROK to even calculate the amount of damage it suffered from the DPRK's cyberattacks.

After the hacking of Sony Pictures in November 2014, the DPRK's cyberattacks have expanded into political, military, and strategic targets, as well as seeking financial gains at the same time. The 2016 hacking cost Bangladesh Bank 81 million dollars and Chile National Bank 10 million dollars in 2019. The group that attacked the banks was identified as a hacker group called the Lazarus Group in the DPRK. Cyber security firm FireEye referred to Lazarus as 'Advanced Persistent Threats (APT)-38' and confirmed Lazarus was linked to the DPRK government or government-backed military units. Lazarus recently led the hacking of cryptocurrency, which resulted in losses of more than \$500 million. It is suspected that in 2017 and 2018, it hacked mainly Korean bitcoin exchanges (Bithumb, Coinness, Yobit, and Yapizon) and attacked Japan's exchange stations, CoinCheck.[\[15\]](#)

A US internet security company Recorded Future analyzed in February 2020 that in the DPRK, where public internet access is prohibited, internet usage has increased by about 300 percent over the past three years. The report analyzed that the DPRK is making all-out efforts to mine, steal, and produce cryptocurrency such as Bitcoin, Litecoin, and Moreno. In particular, the DPRK is believed to have mined more than ten times compared to the previous year by concentrating on Moreno. Moreno is known to be more anonymous than Bitcoin, and is easier to mine than Bitcoin, which is almost impossible to mine new.[\[16\]](#)

The DPRK reacts violently whenever reports of hacking and stealing of the DPRK's cryptocurrency are reported. Despite the DPRK's strong denials, it is almost certain that it uses the stolen cryptocurrency as a means of avoiding sanctions. It is clear that the DPRK, which has narrow channels of earning foreign currency due to sanctions, will strengthen its activities to earn foreign currency through hacking attacks on financial institutions around the world or taking away cryptocurrency. It is always possible however improbable that the DPRK will actually use nuclear weapons or short or intermediate range missiles against the ROK. But its cyber operations are far more effective and profitable. The DPRK is training a number of excellent hackers at very low cost who are able to exploit the huge and porous attack surfaces presented by its leading adversaries with their open societies and poor cyber-security practices. The DPRK's cyberattack capabilities present a far more realistic and immediate threat than its strategic asymmetric weapons such as nuclear and missile programs, with their massive research, development and deployment costs, or its conventional military, which requires enormous resources simply to maintain. In short, cyber forces are actually the DPRK's all-around, most effective asymmetric arsenal.

It is true that North Korean hackers can't do more direct damage than a nuclear weapon. However, the DPRK can unleash its hackers, even in peacetime, while keeping its nuclear-tipped arsenal in wait. It is also true that the DPRK isn't the only country that uses cyberattack capabilities for its national interest. In comparison with other US adversaries like Iran, Russia, and China, the DPRK's propensity to use its hackers for crime—robbing banks and emptying cryptocurrency wallets, according to US Department of Justice—is outstanding. For example, Iran used cyber capabilities to take aim at Saudi Arabia's oil production, and Russia has used cyber capabilities to unsettle states in its orbit, especially Georgia and Baltic states. Analysts indicate that Russia and Iran will do some disruptive cyber-attacks but less cyber-crime. China's cyber-warriors also overlap with cyber-criminal groups but have not done as much in the way of cyber disruption. The DPRK, in contrast, doesn't seem to respect those boundaries. It launched several disruptive attacks against the ROK, including a huge theft of military secrets of ROK's armed forces. The DPRK is also believed to be involved in the WannaCry ransomware attack, which infected tens of thousands of computers and sent several UK hospitals offline in 2017. Pyongyang's willingness to mix crime with state-directed cyberthreats makes it almost uniquely problematic.[\[17\]](#)

In response to increasing the DPRK's cybercrimes, US Department of Justice charged three North Korean individuals for stealing and extorting more than \$1.3 billion in cash and cryptocurrency from banks and business around the world. According to the indictment filed in December 8, 2020, three defendants—Jon Chang Hyok, Kim Il, And Park Jin Hyok—work for the Reconnaissance General Bureau, the DPRK's military intelligence agency. The agency houses hacking units known by various names, including Lazarus Group and Advanced Persistent Threat 38 (APT38). The DPRK has previously denied being involved in hacking operations. The indictment builds upon 2018 charges brought against one of the alleged hackers in connection with the 2014 cyberattacks on Sony Pictures Entertainment. Three North Koreans, operating under several pseudonyms, were charged for conspiracy to commit wire fraud and bank fraud including destructive cyberattacks on entertainment companies, bank cyber-enabled heists, cryptocurrency heists, and ATM cash-outs. The indictment shows the degree to which the DPRK relies on cybertheft to obtain hard currency under the continuing United Nations and US sanctions, further isolated by a self-imposed coronavirus blockade. According to prosecutors, the hackers managed to steal at least \$190 million, although nobody knows exactly how much was stolen. Prosecutors said the North Koreans were unable to get at least \$1 billion of the \$1.3 billion they targeted, mostly in banks.[\[18\]](#)

As the coronavirus situation worsens around the world, the DPRK is even attempting to hack into coronavirus information. It attempted to steal Covid-19 vaccine technology from the US pharmaceutical company Pfizer, according to South Korean intelligence officials. It is currently unclear what, if any, data was stolen. The ROK's National Intelligence Service reportedly briefed lawmakers about the alleged attack. According to the NIS briefing, the DPRK attempted to hack the servers of an ROK drug manufacturer to obtain technology information on the company's coronavirus vaccine and treatment.[\[19\]](#) In November 2020, Microsoft said at least nine health organizations including Pfizer had been targeted by state-backed organizations in the DPRK and Russia. It said North Korean groups dubbed Zinc and Cerium, and a Russian group nicknamed Fancy Bear, were responsible. While many of the break-in attempts failed, Microsoft warned at the time that some had been successful.[\[20\]](#) The DPRK closed its borders in January 2020 soon after the virus began to emerge in China; since then it has yet to report a single case of coronavirus.[\[21\]](#) But many public health specialists believe the DPRK is highly vulnerable to the pandemic and that it is desperately seeking zero cost ways to obtain vaccines so that it may resume domestic economic activity.

There is much evidence that the DPRK is engaged in various illegal activities in cyberspace. As long as the coronavirus pandemic continues and the DPRK's economic difficulties continue, the

cyberattacks will also continue.

2.3 Biological and Chemical Threats

The ROK government maintains the DPRK began producing chemical weapons in the 1980s and currently holds a stockpile of an estimated 2,500–5,000T of chemical weapons. The ROK Ministry of Defense asserts that the DPRK is capable of cultivating and producing various types of biological agents, such as anthrax, smallpox, and pests.^[22] In fact, not much is known about the DPRK's biological and chemical weapons programs. There have been no reports of transactions or proliferation of biological and chemical weapons involving the DPRK in recent years.

One strong reason to believe that the DPRK may still maintain a chemical weapons program is the assassination of Kim Jong-nam, the eldest son of deceased North Korean leader Kim Jong-il and the half-brother of Kim Jong-un. Kim Jong-nam was killed on 13 February 2017 when he was attacked with VX nerve agent at Kuala Lumpur International Airport, Malaysia. Four North Korean suspects left the airport shortly after the assassination and reached Pyongyang without being arrested. Other North Koreans were arrested but were released without charge. Two women, one Vietnamese, the other Indonesian, were charged with murder. They claimed they thought it was part of a TV show program. DPRK was relisted as a state sponsor of terrorism by the United States on 20 November 2017, with the assassination cited as one of the reasons.

As for the DPRK's biological weapons program, known information is even more limited. Many of the terms used by the US government in discussing the possibility that the DPRK and other countries are developing or possessing biological weapons are highly ambiguous. Also, there is a high degree of uncertainty about what the purported North Korean biological weapons program actually entails. There is a lack of consistency in the public assessments of the US and South Korean governments or between the assessments and the policy responses of those governments.

In the final analysis, the DPRK may once have had and may still be pursuing a biological weapons capability. It is also possible that it never moved beyond research and development of biological agents and the establishment of a biotechnical infrastructure that could support future biological weapons production. It is also possible that the DPRK program never moved beyond planning or, whatever its previous nature, the program has essentially ended. But one thing seems clear – nothing in the official public record to date indicates that the DPRK has an advanced biological weapons program, notwithstanding media reports to the contrary.^[23]

Although there is a lack of recent evidence regarding the DPRK's biological and chemical weapons, we cannot rule out the possibility that it might use them in the worst-case scenario. In particular, the ROK's greatest threat is the attack from DPRK long-range artillery deployed along the DMZ with biological and chemical agent payloads. In fact, this case is more threatening than nuclear weapons or ballistic missiles. ROK plans to use artillery radar to identify and destroy the source of the threat if the DPRK fires a long-range artillery, but there are fundamental limitations.

3. DPRK's Asymmetric Threats: Real or Contrived?

The DPRK claims that it has developed nuclear weapons because of the US hostile policy toward the DPRK and will continue to strengthen its nuclear deterrent capability to prevent the United States from invading the DPRK. In traditional nuclear deterrence theory, deterrence usually refers to the practice of discouraging or restraining other states from taking unwanted actions, such as an armed attack. It involves an effort to stop or prevent an action, as opposed to the closely related but distinct concept of 'compellence,' which is an effort to force an actor to do something—including stopping something that they are already doing.

The classic literature distinguishes between two fundamental approaches to deterrence. Deterrence by denial strategies seek to deter an action by making it infeasible or unlikely to succeed, thus denying a potential aggressor confidence in attaining its objectives—deploying sufficient local military forces to defeat an invasion, for example. Deterrence by punishment, on the other hand, threatens severe penalties, such as nuclear escalation or severe economic sanctions, if an attack occurs. These penalties are connected to the local fight and the wider world. The focus of deterrence by punishment is not the direct defense of the contested commitment but rather threats of wider punishment that would raise the cost of an attack.[24] This concept of deterrence can be applied mainly to strategic relations between powerful countries, but it is difficult to apply it to nuclear strategies of weak countries such as the DPRK. For this reason, various analyses have been made on the DPRK's intentions and postures related to its nuclear weapons.

Assessing the DPRK's nuclear threats, there are two kinds of threats posed by its nuclear weapons. One is the intended threat posed by the offensive nuclear doctrine, and the other is an unintended threat, such as a sudden collapse of the DPRK regime or preemptive use of nuclear weapons by misjudgment.

According to Vipin Narang, an expert on nuclear strategy, new nuclear weapons states are generally likely to choose one of three types of nuclear strategies. The first is the strategy of using nuclear weapons for 'catalytic' purposes. This is when a new nuclear power uses nuclear weapons to bring its existing benefactor closer to its side. A state which adopts this posture has a small number of nuclear weapons but uses them to get a superpower—usually the United States—to intervene on its behalf. In this sense, the weapons are the catalyst that forces the stronger states to smooth over regional conflicts. It's a political strategy that's designed to strengthen the reliability of a superpower patron in a conflict to help the state and is only available to the regional powers.

The second is the 'asymmetric escalation' strategy. It refers to the use of nuclear weapons preemptively to force an end to a crisis or conflict or to gain political advantage. In this posture, a state deploys a nuclear arsenal to present a credible threat of a first nuclear strike, in response to a conventional, non-nuclear attack. This is explicitly designed to deter conventional conflict. Countries with this posture tend to delegate authority for a strike to certain military leaders—which may present problems for the rest of the world, since the procedures for using nuclear weapons may not involve many safeguards. The challenge is really command and control, safely managing its nuclear arsenal.

The third is the 'assured retaliation' strategy. It is a case in which a nuclear weapon is operated with the aim of avoiding a pre-emptive nuclear strike and ensuring a second nuclear strike with a surviving nuclear weapon. This posture exists when a state develops a sufficiently large and dispersed arsenal to be able to retaliate if it is the victim of a nuclear attack. This is the classic nuclear strategy where the state is developing nuclear weapons basically to assure the existence of the state. This strategy is exemplified by China and India. Having a secure second-strike capability is designed to deter nuclear use and coercion. The strategic drawback to this posture is that it sacrifices some deterrent power against conventional conflict. Enemies may assume that limited conventional battles are very unlikely to escalate and involve nuclear arms.[25]

There are mixed analyses on the DPRK's nuclear posture. The country is likely to threaten the use of nuclear weapons for catalytic purposes to induce China to intervene in the event of a serious regime threat from outside. The DPRK's nuclear strategy, however, is believed to be evolving toward securing a viable second-strike capability.

It is believed that the DPRK is struggling to develop SLBMs also to secure the ability for a survivable second-strike capability. It has conducted several rounds of cold-launching test of an SLBM.

Whether successful or not, these efforts mean that the DPRK is trying to diversify its missile capabilities, threaten Japan beyond the ROK, protect missiles from the US first-strike attacks, and expand the foundation for retaliatory attacks on the ROK and Japan.

Given the power and number of warheads that the DPRK is developing, it is unlikely to opt for a strategy to concentrate all of its nuclear forces in the early stages of the war. It will pursue a strategy to strengthen its nuclear capability enough to withstand retaliation by the ROK-US combined forces after a limited surprise attack, thereby taking the initiative in the process of developing the situation and ending the situation in an advantageous position. Its most logical strategy is to end escalation by using nuclear threats after it caused considerable damage to the ROK with a surprise conventional attack and before the situation goes to next stage of escalation.[\[26\]](#)

Whatever the DPRK's intention is to use nuclear weapons, the DPRK's nuclear weapons pose a serious security threat not only to the ROK but also to all states in Northeast Asia. The ROK has no means of responding to the DPRK's nuclear weapons except for relying on the US nuclear umbrella. There is little possibility of developing nuclear weapons independently, at least in the foreseeable future. In this sense, the DPRK's nuclear program is an existential risk to ROK's security.

On the DPRK's threat perception, the United States shares a similar view. According to a report published by US Congress, House Armed Services Committee, the DPRK continues its unabated march toward full nuclearization under the leadership of Kim Jong-un. In July 2017, the DPRK successfully launched its first intercontinental ballistic missile, which is likely capable of striking the United States. Since then, it has continued to build and test increasingly sophisticated nuclear weapons and missiles, even as it suffers heavy sanctions by the international community. Of further concern, especially to US security partners ROK and Japan, is the DPRK's significant production and stockpile of biological and chemical weapons. It also maintains an exceptionally large conventional military force, a significant threat to regional allies and US forces in the Pacific.[\[27\]](#)

On October 10, 2020, the DPRK celebrated the 75th anniversary of the founding of the Workers' Party of Korea (WPK), the country's ruling party. The occasion was celebrated in a grand way, with an unprecedented pre-dawn military parade. Thousands of uniformed military personnel marched through Pyongyang's renovated Kim Il-sung Square in perfect unison, trailed by scores of heavy military vehicles. Kim said that his nuclear weapons "will never be abused or used as a means for preemptive strike. He clarified, however, that if "any forces infringe upon the security of our state and attempt to have recourse to military force against us, I will enlist all our most powerful offensive strength in advance to punish them." This was a restatement of the DPRK's offensively oriented nuclear strategy, which reserves the right for nuclear first use to deter adverse military action against its territory or leadership.[\[28\]](#)

Regarding denuclearization talks, the DPRK's position is straightforward. It has consistently used the term "denuclearization of the Korean Peninsula" instead of "denuclearization of the North." It argues that the United States should completely eliminate its nuclear threat to the DPRK before removing the DPRK's nuclear threat. The elimination of the US nuclear threat directly refers to the dismantlement of its nuclear umbrella pledge. This leads to a ban on the import of strategic assets such as strategic bombers that fly to the Korean Peninsula every time the DPRK provokes a missile, and a suspension of ROK-US joint military drills. This is ultimately a demand that leads to the withdrawal of US troops from the ROK. Unless these demands are met, it seems improbable that the DPRK will ever denuclearize itself alone. For this reason, denuclearization negotiations between the United States and the DPRK are expected to be very difficult.

Regarding the DPRK's cyber threats, a tentative conclusion is that although its cyber operations are rather unsophisticated and of relatively rudimentary nature, it is rapidly becoming a real and

existential threat to the international community. The DPRK's cyber capabilities are evolving and adapting day-by-day. Numerous government and private institutions around the world have been hit hard by North Korean hacking. The DPRK's cyberattacks have become more frequent in general as international isolation has intensified due to international sanctions.

Given these realities, how should the ROK respond to the DPRK's asymmetric threats? There are not many options for the ROK and the future prospects are not very bright. The DPRK is expected to continue to strengthen all of its possible military capabilities. In a report at the 8th Workers' Party Congress, Kim Jong-un ordered the DPRK's conventional military power to become more "high-tech, intelligent, precise, unmanned, high-performance, and lightweight." Regarding nuclear and missile power, Chairman Kim stressed the need to further strengthen nuclear power so that the DPRK can take more initiative in curbing its nuclear war. Kim Jong-un has disclosed the list of weapons he wanted: multiple independently targetable reentry vehicles (MIRV), hypersonic missiles, nuclear submarines, SLBMs, and military reconnaissance satellites—weapons being competitively developed by the United States, China, and Russia or being developed or bought by the ROK.^[29] Given the long timelines—some of them decadal—of some of these objectives, one may infer that Kim Jong-un is planning to keep the nuclear arsenal for at least as long as his own leadership might last.

It is not easy to analyze the DPRK's intentions based on the asymmetric threat it poses. This is because it not only has standard WMD arsenals such as chemical, biological and nuclear capabilities, but also a cyberforce of real substance. It may not be appropriate, therefore, for the international community (including the United States) to apply to the DPRK lessons learned from negotiations dealing with various nuclear, cyber, and biochemical threats in other parts of the world. This inapplicability arises because the DPRK is a very unusual system. The DPRK which is ruled by Kim dynasty is *sui generis*. It is not like Iraq or Iran.

In late January 2021 US Defense Secretary Lloyd Austin stated that "Even as we address accelerating competition by China, we will ensure that we remain fully ready to respond to and effectively deter nation-state threats emanating from Russia, Iran, and the DPRK."^[30] He also noted that the DPRK is one of only a handful of countries that pose threats to the United States and its allies.

Austin explained, "We will seek to impose cost where necessary, while using all of our tools to lower the risk of escalation with our adversaries and respond to challenges below the level of armed conflict. We will continue to maintain credible deterrence against advanced threats, and we will right-size our mission around the world in a transparent and principled manner."^[31] His remark is standard boilerplate, especially useless when applied to Pyongyang.^[32]

Given these evidences, we can cautiously conclude that the DPRK's nuclear doctrine can be summed up as seeking minimum deterrence against the US while seeking deterrence by punishment that discourages provocative military actions through threats to impose unaffordable retaliation on its counterpart. Minimum deterrence requires securing a second strike capability that allows meaningful retaliation with residual nuclear power after a preemptive strike by the enemy. For this goal, strategic nuclear weapons should be able to destroy large cities and industrial facilities in the other country, so the key is to maintain the viability and retaliatory capability of early nuclear weapons. This posture is similar to the 'assured retaliation' posture, which, according to the Vipin Narang's classification, allows direct retaliation against adversaries—that is, the United States. For a strategy of minimum deterrence or assured retaliation to be established, the survival of the DPRK's nuclear arsenal and its ability to strike the US mainland are key, and its recent series of actions support this view. Although the DPRK declared 'completion of the construction of nuclear weapons' in late 2017, one cannot say that it has established a firm retaliation capacity against the United States in terms of nuclear military power. Therefore, the DPRK is expected to make

continuous efforts to upgrade its nuclear and missile capabilities, at least for the time being.

4. Conclusions

The asymmetrical threats posed by the DPRK are not only existential threats to the ROK, but they also undermine stability in Northeast Asia and pose global threats to the entire international community. The DPRK's nuclear capability is estimated to be near completion, with only the stage of weaponization remaining. As a means of delivering nuclear weapons, various ballistic missile capabilities are rapidly advancing. Cyber threat capabilities are mainly focused recently on cash extortion through illegal cyber activities as the DPRK's economic difficulties and international isolation deepens due to the spread of COVID-19 pandemic. However, cybercriminal capacity may also be deployed in cyberwarfare, and pose a real threat to US, ROK, and allied forces operating in Korea. In the case of biochemical weapons, there has been no clear activity or evidence recently, but there is also no evidence that the DPRK has scrapped these weapons programs. Thus, due to its extraordinary opacity, it poses a real threat to both nuclear and missile, cyber and biochemical weapons.

As time goes by, the DPRK will upgrade its nuclear and missile capabilities, and its nuclear threats will expand beyond the Korean Peninsula to a level that challenges regional and global security. The DPRK is unlikely to give up its nuclear program, which it believes is the best means to ensure the survival of its regime. It is also difficult to resolve the issue peacefully through dialogue and negotiations. If this conclusion is correct, then we should devise and implement strategies for the DPRK on the premise that the conflict will last a long time.

The DPRK will give up only if the cost of possessing nuclear weapons threatens the survival of its regime. Incentives such as economic aid and a peace treaty alone cannot induce nuclear renunciation. While leaving open the possibility of dialogue with the DPRK, the realistic response is to approach the DPRK with the premise that only omnidirectional and active pressure will change the DPRK's strategic calculus. A new strategy should be developed, therefore, to make the DPRK pay more and make it regret missed opportunities for dialogue and to prepare the way for further talks aimed at least at slowing if not reversing its accrual of WMD.

If the DPRK's nuclear capability is enhanced and its threatening rhetoric is further heightened, ROK's dependence on US strategic assets will further increase. As geopolitical conditions on the Korean Peninsula make it difficult to guarantee ROK's absolute security from DPRK attacks, it seems inevitable that the ROK will upgrade its offensive and defensive military capabilities while making full use of various US strategic assets—such as multi-layered missile defense networks, strategic bombers, Aegis destroyers, nuclear submarines, and nuclear aircraft carriers.

Regarding cyber threats, the ROK must keep a close watch on espionage activities to correctly estimate the DPRK's cyber capabilities. It must continuously adapt and build up capabilities to counter rapidly evolving cyber threats not only in the technical domain, but also through devising common responses with international partners.

The ROK could benefit from establishing closer collaboration, both on a bilateral and multilateral level, with countries that have experienced or become the victims of the DPRK cyber-attacks. Intelligence sharing can help all parties involved to overcome their security problems by addressing each other's cyber system weaknesses. Also, sharing the lessons the ROK has learned from its past with different countries will enhance its position in the international arena as an 'issue specific' security provider.[\[33\]](#)

It is very important to seek a military response to the asymmetric threat posed by the DPRK, but that

is not enough. The ROK should strengthen its efforts to induce the DPRK into becoming a normal state in Northeast Asia via a peace process on the Korean Peninsula in the long run. While easing military tensions on the Korean peninsula, efforts should be made to build trust between the DPRK and its neighbors. In the end, the best way is to make it realize that threatening the ROK or neighboring countries with asymmetric threats will not pay off but will only hasten the end of the Kim regime.

III. ENDNOTES

[1] Eleanor Albert, "North Korea's Military Capabilities," Council on Foreign Relations, Backgrounder, updated November 16, 2020, <https://www.cfr.org/backgrounder/north-korea-military-capabilities>

[2] Nuclear Threat Initiative, <https://www.nti.org/learn/countries/north-korea/>

[3] Korea Institute of Nuclear Nonproliferation and Control (KINAC), *North Korean Nuclear Almanac 2020* (in Korean, 2020), pp. 39-41.

[4] Brad Roberts, "Living with a Nuclear-Arming North Korea: Deterrence Decisions in a Deteriorating Threat Environment," Stimson Center, 38 North Special Report, November 2020, pp. 14-15.

[5] Ministry of National Defense, Republic of Korea, *2018 Defense White Paper* (2018), pp. 32-33.

[6] Ministry of National Defense, Republic of Korea, *2018 Defense White Paper* (2018), p. 34.

[7] Jeffrey Lewis, "Preliminary Analysis: KN-23 SRBM," June 5, 2019, James Martin Center for Nonproliferation Studies, <https://nonproliferation.org/preliminary-analysis-kn-23-srbm/>; Michael Elleman, "Preliminary Assessment of the KN-24 Missile Launches," 38 North, March 25, 2020, <https://www.38north.org/2020/03/melleman032520/>

[8] Vann H. Van Diepen and Michael Elleman, "North Korea Unveils Two New Strategic Missiles in October 10 Parade," 38 North, October 10, 2020, <https://www.38north.org/2020/10/vdiepenmelleman101020/>

[9] Michael Elleman, "North Korea's Newest Submarine-Launched Ballistic Missiles, Same as the Old One?" 38 North, January 15, 2021, <https://www.38north.org/2021/01/north-koreas-newest-submarine-launched-ballistic-missile-same-as-the-old-one/>

[10] Vann H. Van Diepen, "Cutting Through the Hype About the North Korean Ballistic Missile Submarine Threat," 38 North, September 6, 2019, <https://www.38north.org/2019/09/vvandiepen090619/>

[11] Rearranged from Jungsup Kim, "North Korea's Tactical and Strategic Weapons Development: Recent Trends, Evolution of Doctrines, and Their Implications," Sejong Institute, *Sejong Policy Brief* (in Korean), March 23, 2021; other related information was collected from various sources by the author.

[12] Korea Institute of Nuclear Nonproliferation and Control (KINAC), *North Korean Nuclear Almanac 2020* (in Korean, 2020), pp. 19-20.

[13] *Joongang Daily*, November 5, 2013, <https://news.joins.com/article/13048072>

- [14] Chong Woo Kim and Carolina Polito, "The Evolution of North Korean Cyber Threats," The Asan Institute for Policy Studies, Issue Brief, February 2019, p. 2.
- [15] Sang-ho Lee, "North Korea's Cyberattack Capabilities and Cyber Fundraising," *Monthly North Korea* (), 2020.
- [16] Ibid.
- [17] Morten Soendergaard Larsen, "While North Korean Missiles Sit in Storage, Their Hackers Go Rampant," *Foreign Policy*, March 15, 2021, <https://foreignpolicy.com/2021/03/15/north-kore-missiles-cyberattack-hacker-armies-crime/>
- [18] Ellen Nakashima, "U.S. accuses three North Koreans of conspiring to steal more than \$1.3 billion in cash and cryptocurrency," *The Washington Post*, February 18, 2021.
- [19] "N. Korea attempted to steal COVID-19 vaccine, treatment technology via hacking: NIS," *Yonhap News Agency*, February 16, 2021, <https://en.yna.co.kr/view/AEN20210216008451315>
- [20] "North Korea accused of hacking Pfizer for Covid-19 vaccine data," *BBC*, February 16, 2021, <https://www.bbc.com/news/technology-56084575>
- [21] "North Korea again claims zero COVID-19 cases after testing roughly 24,500 people," *NK News*, December 4, 2021, <https://www.nknews.org/2021/04/north-korea-again-claims-zero-covid-1-cases-after-testing-roughly-24500-people/>
- [22] Ministry of National Defense, Republic of Korea, *2018 Defense White Paper* (2018), p. 34.
- [23] Elisa D. Harris, "North Korea and Biological Weapons: Assessing the Evidence," 38 North Special Report, November 2020, pp. 5-6.
- [24] Michael Mazarr, "Understanding Deterrence," RAND Corporation, 2018 https://www.rand.org/content/dam/rand/pubs/perspectives/PE200/PE295/RAND_PE295.pdf, pp. 2-3.
- [25] Vipin Narang, *Nuclear Strategy in the Modern Era: Regional Powers and International Conflict* (Princeton: Princeton University Press, 2014).
- [26] Kang Choi, "North Korea's Nuclear Threats: Challenges and Responses," Asan Institute for Policy Studies, Asan Report, September 2016, pp. 79-84.
- [27] U.S. Congress, House Armed Services Committee, "Future of Defense Task Force Report 2020," September 23, 2020, p. 25
- [28] Ankit Panda, "A Nuclear North Korea's Wake-up Call," *The Diplomat*, October 13, 2020, <https://thediplomat.com/2020/10/a-nuclear-north-koreas-wake-up-call/>
- [29] Min Hong, "Analysis of the 8th Party Congress of WPK in North Korea (1): Strategic Basis," Korea Institute for National Unification, *Online Series*, January 15, 2021, <https://www.kinu.or.kr/pyxis-api/1/digital-files/1d2bb338-30e8-4fe8-99f3-26640c01fc86>
- [30] "U.S. defense chief shortlists N. Korea as 'nation-state threat'," *Yonhap News Agency*, March 5, 2021, <https://en.yna.co.kr/view/AEN20210305000600325>
- [31] Ibid.

[32] Doug Bandow, “Does North Korea Keep Lloyd Austin Up at Night?” *The National Interest*, March 20, 2021, <https://nationalinterest.org/print/feature/does-north-korea-keep-lloyd-austin-night-180585>

[33] Chong Woo Kim and Carolina Polito, “The Evolution of North Korean Cyber Threats,” The Asan Institute for Policy Studies, Issue Brief, February 2019, pp. 9-10.

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