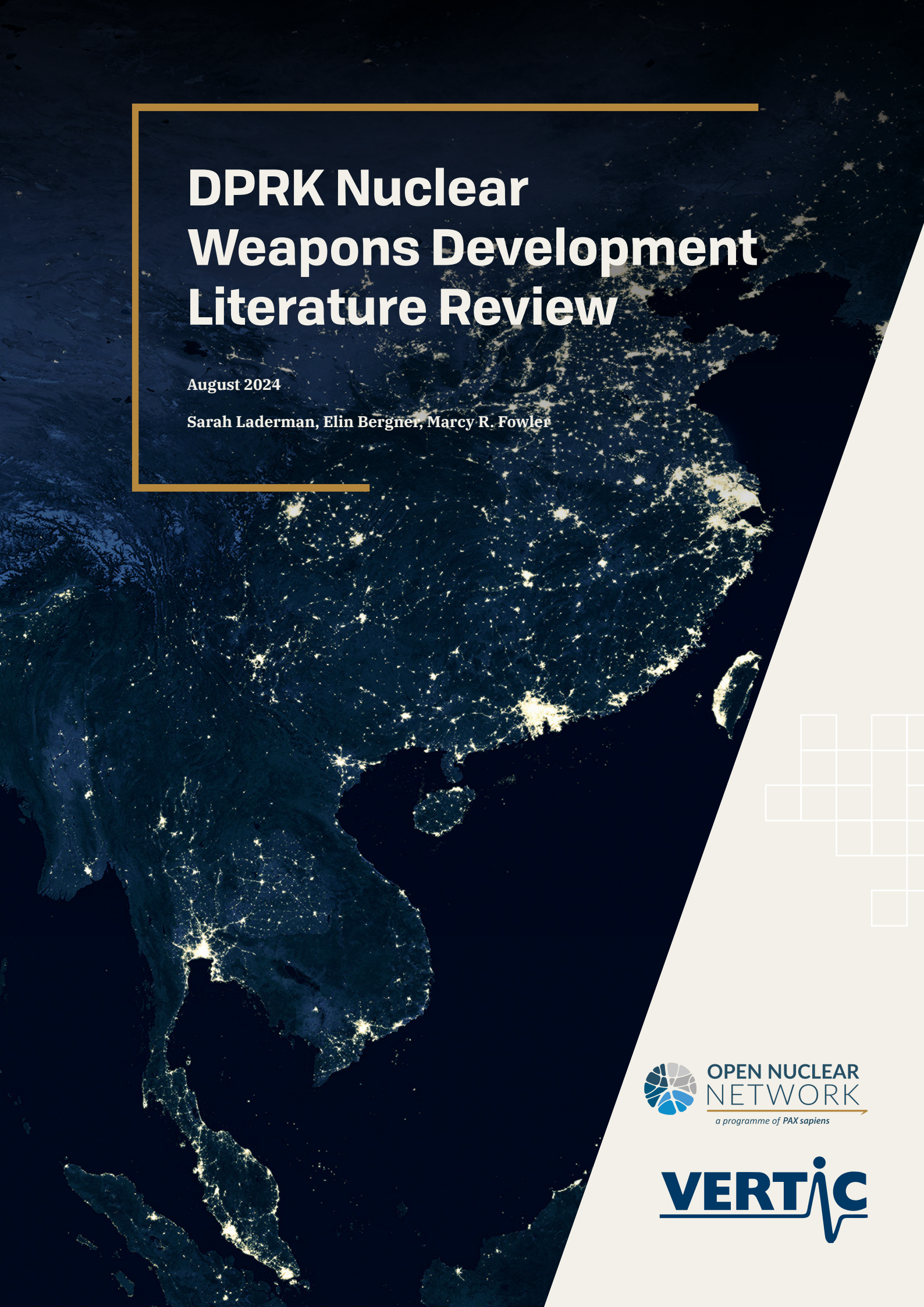

DPRK Nuclear Weapons Development Literature Review

August 2024

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Contents

Introduction

In the course of its research on nuclear issues related to the Democratic People's Republic of Korea (DPRK), Open Nuclear Network (ONN) found that there exists no recent comprehensive literature review related to the DPRK's nuclear weapons development capabilities and associated strategy.

This paper seeks to fill this gap by compiling and summarising all major published analyses released since 2017 (the year of the DPRK's last nuclear test) in the following five areas:

1. Nuclear weapons strategy, focusing on objectives, posture, force structure, targeting, decision making and delivery range.
2. Estimated plutonium (Pu) inventory and production capacity.
3. Estimated highly enriched uranium (HEU) inventory and production capacity.
4. Estimated nuclear weapons stockpile and production capacity.
5. Additional nuclear weapons development relevant capabilities.

This paper is focused solely on the part of the DPRK's nuclear weapons programme that begins with weapons-grade fissile material; nuclear fuel cycle and fissile material production analysis is outside the scope of this literature review.

For the numerical fissile material and weapons estimates, only original, independent assessments are included. There are a number of publications, primarily news reports, which repeat the assessments made by other analysts to report or build on their findings; these repetitions are not included.

Nuclear weapons strategy

The literature posits that nuclear weapons are a central component of the DPRK's defence strategy with three primary objectives: regime survival; assuring territorial integrity; achieving dominance on the peninsula; and deterring external aggression through becoming a regional great power. It further shows that these weapons are likely designed to target Japan, the Republic of Korea (ROK) and the United States and their respective military bases in the Asia-Pacific region, but that the DPRK's ability to deliver nuclear warheads on intercontinental ballistic missiles (ICBMs) remains contested. Finally, the review suggested that the DPRK may attempt first use through an asymmetric escalation strategy, although the cases for such use are the subject of speculation.

Overall nuclear objectives and posture

A 2024 US intelligence assessment[1] concluded that Kim Jong Un relies on his nuclear arsenal to secure his rule and "almost certainly" will never denuclearise. The assessment also concluded that nuclear weapons are the "centerpiece" of the DPRK defence strategy and that the state sees them as a source of great national pride.

A 2021 RAND study[2] concluded that the DPRK nuclear arsenal has three primary objectives: "ensure regime survival"; "achieve peninsula dominance"; and "make North Korea a regional great power." In addition to these, the study found the DPRK's secondary nuclear arsenal objectives to be: "decouple the ROK-US alliance"; "enhance coercive diplomacy"; and "augment warfighting capability." A 2019 Norwegian Defence Research Establishment (FFI) assessment[3] identified three similar primary objectives of the DPRK nuclear arsenal: "regime survival"; "securing territorial integrity"; and "deterring military aggression," including forced reunification with the ROK.

The 2021 RAND study[4] also assessed that the DPRK has been evolving from a more defence-oriented posture to one with aggressive, asymmetrical escalation capabilities: "Pyongyang's continuing development of nuclear and missile programs beyond the necessary requirements for deterrence suggests that the regime strives for a true regional dominance strategy, including warfighting if necessary."

Force structure, targeting and decision-making

The argument was made in January 2024 by Robert L. Carlin and Siegfried S. Hecker[5] that "Kim Jong Un has made a strategic decision to go to war." They assert that as part of that decision, Kim Jong Un could elect to use the DPRK's nuclear arsenal.

A 2023 study from the Korea Institute for Defense Analyses (KIDA)[6] concluded that the DPRK would need 100–300 nuclear weapons "in the long term" to achieve its military objectives. The study also quoted the 2022 DPRK nuclear law, which stipulates that the DPRK may use nuclear weapons in response to a conventional attack. KIDA additionally stated that:

> "There is room for North Korea to misjudge that it can achieve the goal of limited occupation if it overcomes the limitations of conventional military power against South Korea with asymmetric power and succeeds in deterring U.S. military intervention with nuclear weapons. The strategy is to induce an early end to the war by taking away the opportunity to counterattack and blocking external intervention through 'speed warfare.' There is also concern about an offensive strategy to maximize the surprise effect at the beginning of the war through nuclear electromagnetic pulse (EMP) attacks."

1. *Annual Threat Assessment of the U.S. Intelligence Community* (Office of the Director of National Intelligence, 5 February 2024) <https://www.dni.gov/files/ODNI/documents/assessments/ATA-2024-Unclassified-Report.pdf>.
2. Bruce W. Bennett, Kang Choi, Myong-Hyun Go, Bruce E. Bechtol, Jr., Jiyoung Park, Bruce Klingner, and Du-Hyeong Cha, *Countering the Risks of North Korean Nuclear Weapons* (RAND Corporation, April 2021) <https://www.rand.org/pubs/perspectives/PEA1015-1.html>.
3. Halvor Kippe, *Nuclear Weapons Capabilities and Doctrines in North Korea* (Norwegian Defence Research Establishment (FFI), 18 February 2019) <https://www.ffi.no/en/publications-archive/nuclear-weapons-capabilities-and-doctrines-in-north-korea>.
4. Bennett and others, Countering the Risks of North Korean Nuclear Weapons.
5. Robert L. Carlin and Siegfried S. Hecker, 'Is Kim Jong Un Preparing for War?', *38 North*, 11 January 2024 <https://www.38north.org/2024/01/is-kim-jong-un-preparing-for-war/>.
6. Sangkyu Lee and Yonghan Park, *'북한의 핵탄두 수량 추계와 전망'* [North Korea's Warhead Quantity Estimation and Forecast] (Korea Institute for Defense Analyses (KIDA), 11 January 2023) <https://www.kida.re.kr/frt/board/frtNormalBoardDetail.do?sidx=2184&idx=818&depth=2>.

The 2022 ROK Defense White Paper similarly stated that the DPRK is likely to attempt a surprise attack based on asymmetric power in case of emergency, to "end the war early."[7]

The 2021 RAND study[8] concluded that the DPRK would need 40–60 nuclear weapons for a surprise attack to disrupt ROK and US missile defences. A 2019 RAND study[9] assessed:

> "The DPRK's growing arsenal will provide its regime with multiple options to employ its nuclear weapons. With an arsenal of up to 100 weapons, the DPRK could explode one or more early in a conflict as a warning, while reserving a salvo of 20–60 weapons to attack military targets like troop concentrations, airbases, and seaports. This would leave enough for a final salvo of 30–40 weapons to threaten attacks against cities in South Korea, Japan, China, Russia, and—if they develop the delivery means—targets in the United States."

A 2017 European Council on Foreign Relations policy brief[10] compiled a list from DPRK sources of 16 potential nuclear strike targets/groups of targets, which includes:

- ***The United States:*** Manhattan, the White House, the Pentagon, "US mainland," "Major American cities";
- ***Asia-Pacific:*** Guam, Hawaii, "US military bases in the operational theatres in the Pacific," "US nuclear aircraft carrier";
- ***The ROK:*** Seoul, the Blue House, Osan, Gunsan, Busan, Pyeongtaek, Jungwon, Daegu, Gyeryongdae, "reactionary governmental agencies," "US military bases in South Korea," "targets in the operation theatres of South Korea"; and
- ***Japan:*** Tokyo, Osaka, Yokohama, Nagoya, Kyoto, Yokosuka, Misawa, Okinawa, "Japanese mainland," "US military bases in Japan and Okinawa."

Nuclear delivery range

In January 2024, Carlin and Hecker[11] assessed that the DPRK's arsenal could reach the ROK, Guam and most of Japan.

In the Stockholm International Peace Research Institute (SIPRI) 2024 Yearbook,[12] it was assessed that the DPRK "has used only a small portion of its HEU for thermonuclear weapons and has probably used the majority for a larger number of fission-only single-stage weapons deliverable by medium-range ballistic missiles (MRBMs) or possibly by intermediate-range ballistic missiles (IRBMs)." The assessment also noted that there is no conclusive evidence in open sources that the DPRK has the capability to deliver nuclear warheads on ICBMs.

While the Washington Post in 2017[13] reported that the US intelligence community assessed that the DPRK had produced nuclear weapons for delivery on ICBMs, it was not explicitly assessed that they could be successfully delivered on ICBMs.

The 2019 FFI assessment[14] stated that the DPRK had made progress towards "an assured, regional second-strike capability," but it required more development and testing for credibility. FFI additionally assessed that the DPRK did have, however, "first-strike uncertainty" as an adversary could not be certain that it would destroy the entirety of the DPRK's second-strike capability.

7. '2022년 국방백서"' [2022 *Defense White Paper*] (Ministry of National Defense, ROK, February 2023) <https://www.mnd.go.kr/user/mnd/upload/pblictn/PBLICTNEBOOK_20230217021922467O.pdf>.
8. Bennett and others, *Countering the Risks of North Korean Nuclear Weapons*.
9. Gian Gentile, Yvonne K. Crane, Dan Madden, Timothy M. Bonds, Bruce W. Bennett, Michael J. Mazarr, and Andrew Scobell, *Four Problems on the Korean Peninsula: North Korea's Expanding Nuclear Capabilities Drive a Complex Set of Problems* (RAND Corporation, 2019) <https://www.rand.org/pubs/tools/TL271.html>.
10. Léonie Allard, Mathieu Duchâtel, and François Godement, *Pre-empting Defeat: In Search of North Korea's Nuclear Doctrine* (European Council on Foreign Relations (ECFR), November 2017) <https://ecfr.eu/wp-content/uploads/ECFR-237-In_search_of_North_Koreas_nuclear_doctrine.pdf>.
11. Carlin and Hecker, 'Is Kim Jong Un Preparing for War?'.
12. Hans M. Kristensen and Matt Korda, '7. World Nuclear Forces', in *SIPRI Yearbook 2024: Armaments, Disarmament and International Security* (SIPRI, 2024) <https://www.sipri.org/sites/default/files/YB24%2007%20WNF.pdf>.
13. Joby Warrick, Ellen Nakashima, and Anna Fifield, 'North Korea Now Making Missile-Ready Nuclear Weapons, US Analysts Say', *The Washington Post*, 8 August 2017 <https://www.washingtonpost.com/world/national-security/north-korea-now-making-missile-ready-nuclear-weapons-us-analysts-say/2017/08/08/e14b882a-7b6b-11e7-9d08-b79f191668ed_story.html>.
14. Kippe, *Nuclear Weapons Capabilities and Doctrines in North Korea.*

Pu inventory and production capacity

The literature estimates that the DPRK's Pu inventory ranges from 18 to 81 kg, which could increase further by 2030 to a top estimate of 123 kg (summarised in Table 1). Only two estimates included annual production capacity, ranging from 6 to 7.4 kg per year. A graph showing the inventory estimates from Table 1 over time is provided in Figure 1 below.

Source of the estimate	Date the estimate was made	Pu inventory (kg)	Annual Pu production capacity (kg/year)
Kristensen, et al. (BAS)[15]	July 2024	66–81	
IPFM[16]	April 2024	40 (as of 2023)	
Albright (ISIS)[17]	April 2023	56–70	
Kristensen & Korda (SIPRI)[18]	January 2023	40	
Lee & Park (KIDA)[19]	January 2023	68–78 107–123 (by 2030)	7.4
ROK White Paper[20]	December 2022	70	
CENESS-IISS[21]	September 2020	18–30	6
ROK White Paper[22]	2020	50	
Fedchenko & Kelley (Janes)[23]	December 2019	52	
Hecker[24]	December 2017	20–40	

Table 1. Independent estimates made since 2017 of the DPRK's weapons-grade Pu inventory and production capacity, ordered by most recent estimate. All inventory estimates are as of the date they were made, except where otherwise noted.

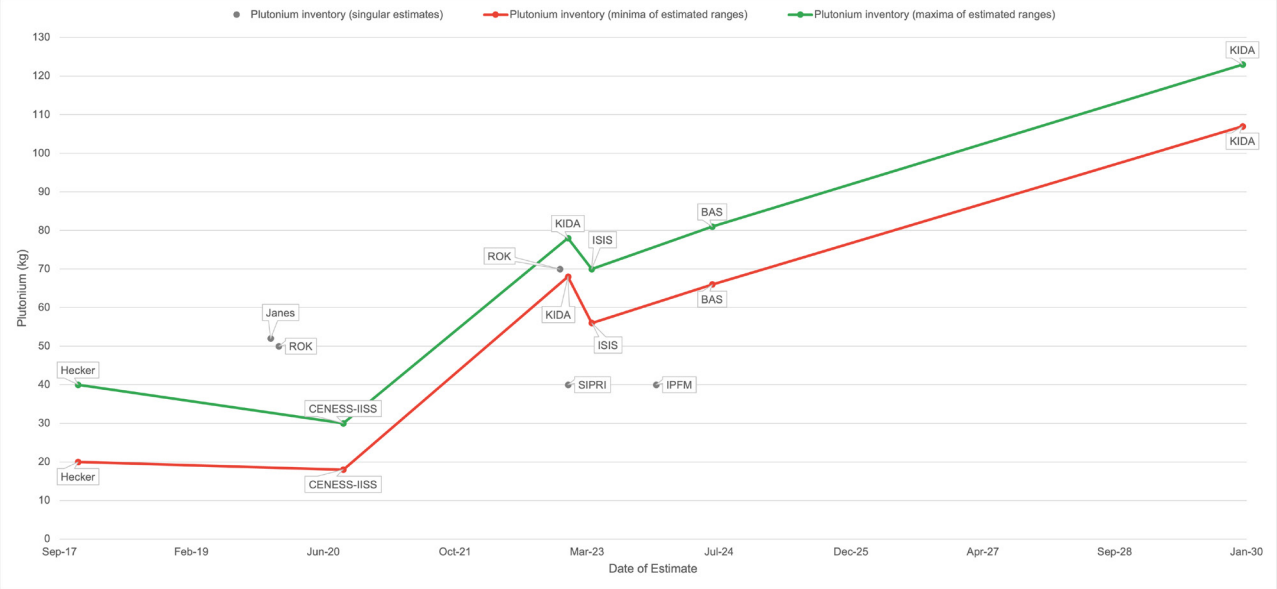

Figure 1. Independent estimates made since 2017 of the DPRK's weapons-grade Pu inventory, from data in Table 1. Data points in grey show where authors provided a singular estimate. When authors provided a range of values in their estimates, the upper bound was plotted on the chart in green and the lower bound in red.

15. Hans M. Kristensen, Matt Korda, Eliana Johns, and Mackenzie Knight, 'North Korean Nuclear Weapons, 2024', *Bulletin of the Atomic Scientists (BAS)*, 80:4 (15 July 2024), pp. 251–271, <https://doi.org/10.1080/00963402.2024.2365013>.
16. 'Countries: North Korea' (International Panel on Fissile Materials (IPFM), 13 April 2024) <https://fissilematerials.org/countries/north_korea.html>.
17. David Albright, *North Korean Nuclear Weapons Arsenal: New Estimates of Its Size and Configuration* (Institute for Science and International Security (ISIS), 10 April 2023) <https://isis-online.org/isis-reports/detail/2023-north-korean-nuclear-weapons-arsenal-new-estimates>.
18. Kristensen and Korda, '7. World Nuclear Forces'. Note that the estimates in the 2024 Yearbook still reflect January 2023 estimates.
19. Lee and Park, '북한의 핵탄두 수량 추계와 전망' [North Korea's Warhead Quantity Estimation and Forecast].
20. '2022년 국방백서' [2022 Defense White Paper], ROK Ministry of National Defense.
21. *DPRK Strategic Capabilities and Security on the Korean Peninsula: Looking Ahead* (Center for Energy and Security Studies–International Institute for Strategic Studies (CENESS–IISS), 14 July 2021) <https://www.iiss.org/blogs/research-paper/2021/07/dprk-strategic-capabilities-security-korean-peninsula>.
22. Jeongmin Kim, 'Seoul Estimates North Korea Has Processed More Plutonium for Nukes', *NK News*, 16 February 2023 <https://www.nknews.org/2023/02/seoul-estimates-north-korea-has-processed-more-plutonium-for-nukes/>.
23. Vitaly Fedchenko and Robert Kelley, 'New Methodology Offers Estimates for North Korean Thermonuclear Stockpile', *Janes*, 30 July 2020 <https://www.janes.com/new-methodology-offers-estimates-for-north-korean-thermonuclear-stockpile>.
24. Siegfried S. Hecker, 'What We Really Know About North Korea's Nuclear Weapons', *Foreign Affairs*, 4 December 2017 <https://www.foreignaffairs.com/articles/north-korea/2017-12-04/what-we-really-know-about-north-koreas-nuclear-weapons>.

HEU inventory and production capacity

The literature provides a wide range of estimates for the DPRK's current inventory of HEU (summarised in Table 2), ranging from 180 to 2,185 kg, which could further increase to a top estimate of 3,408 kg by 2030. Three estimates suggested an annual production capacity ranging from 80 to 170 kg per year. A graph showing the inventory estimates from Table 2 over time is provided in Figure 2 below.

Source of the estimate	Date the estimate was made	HEU inventory (kg)	Annual HEU production capacity (kg/year)
Kristensen, et al. (BAS)[25]	July 2024	1,000–1,800	
Kristensen & Korda (SIPRI)[26]	June 2024	280–1,500	
IPFM[27]	April 2024	280–1,500	
Albright (ISIS)[28]	April 2023	1,425–2,185	
Lee & Park (KIDA)[29]	January 2023	2,044 3,408 (by 2030)	170
CENESS-IISS[30]	September 2020	180–810	100
Fedchenko & Kelley (Janes)[31]	December 2019	180–850	
Hecker[32]	December 2017	250–500	80

Table 2. Independent estimates made since 2017 of the DPRK's HEU inventory and production capacity, ordered by most recent estimate. All inventory estimates are as of the date they were made, except where otherwise noted.

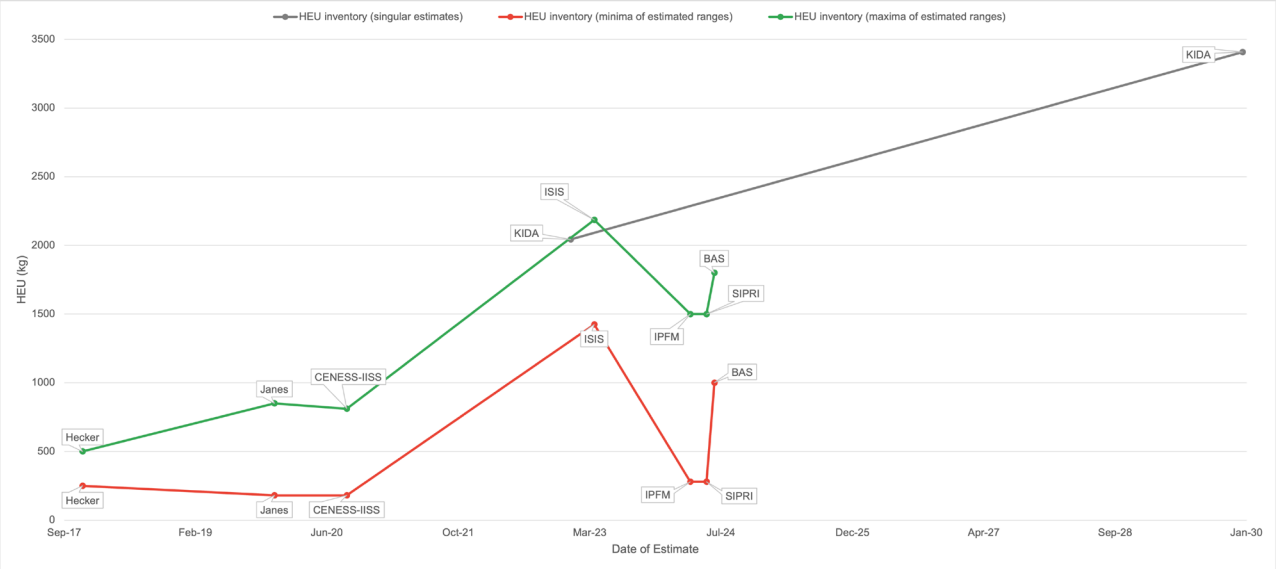

Figure 2. Independent estimates made since 2017 of the DPRK's HEU inventory, from data in Table 2. Data points and trend line in grey shows where authors provided a singular estimate. When authors provided a range of values in their estimates, the upper bound was plotted on the chart in green and the lower bound in red.

25. Kristensen, et al., 'North Korean nuclear weapons, 2024'. While the BAS and SIPRI pieces have many of the same authors, the estimates vary based on differing assumptions used in the two publications.
26. Kristensen and Korda, '7. World Nuclear Forces'. While the BAS and SIPRI pieces have many of the same authors, the estimates vary based on differing assumptions used in the two publications.
27. 'Countries: North Korea', IPFM.
28. Albright, *North Korean Nuclear Weapons Arsenal: New Estimates*.
29. Lee and Park, '북한의 핵탄두 수량 추계와 전망' [*North Korea's Warhead Quantity Estimation and Forecast*].
30. *DPRK Strategic Capabilities and Security on the Korean Peninsula*, CENESS-IISS.
31. Fedchenko and Kelley, 'New Methodology Offers Estimates for North Korean Thermonuclear Stockpile'.
32. Hecker, 'What We Really Know About North Korea's Nuclear Weapons'.

Nuclear weapons stockpile and production capacity

The literature provides a broad range of estimates for the DPRK's current nuclear weapons stockpile (summarised in Table 3), from 10 to 100 weapons, which could further increase to a stockpile of 80 to 200 weapons by 2030. Of these, some estimates were further sub-divided into Pu and HEU weapons, including a range of 4–19 Pu weapons (up to 30 by 2030) and 9–81 HEU weapons (up to 136 by 2030). Three estimates suggested an annual production capacity of 6–7 weapons. A graph showing the total weapons inventory estimates from Table 3 over time is provided in Figure 3 below.

Source of the estimate	Date the estimate was made	Pu weapons	HEU weapons	Total weapons	Annual weapons production capacity
Kristensen, et al. (BAS)[33]	July 2024			50–90 130 (by 2030)	
Kristensen & Korda (SIPRI)[34]	June 2024			50–90	
IPFM[35]	April 2024			10–60	
Carlin & Hecker (38 North)[36]	January 2024			50–60	
Albright (ISIS)[37]	April 2023			17–96	
Lee & Park (KIDA)[38]	January 2023	17–19 26–30 (by 2030)	81 136 (by 2030)	80–90 162–166 (by 2030)	
Hecker[39]	2023			65 (by 2024)	
ROK White Paper[40]	December 2022	12			
RAND[41]	April 2021			50–100 200 (by 2027)	
CENESS-IISS[42]	September 2020	4–7	9–40	13–47	
US Army[43]	2020			20–60	6
Fedchenko & Kelley (Janes)[44]	December 2019	5–13 (assumes only Pu weapons)	15–70 (assumes only HEU weapons)	14–40 (assumes both Pu and HEU weapons)	
RAND[45]	2019			15–60 30–100 (by 2020)	
Hecker[46]	December 2017	4–8	12–24	25–30	6–7
US DIA[47]	July 2017			60	

Table 3. Independent estimates made since 2017 of the DPRK's nuclear weapons stockpile and production capacity, ordered by most recent estimate. All inventory estimates are as of the date they were made, except where otherwise noted.

33. Kristensen, et al., 'North Korean nuclear weapons, 2024'.
34. Kristensen and Korda, '7. World Nuclear Forces'.
35. 'Countries: North Korea', IPFM.
36. Carlin and Hecker, 'Is Kim Jong Un Preparing for War?'
37. Albright, *North Korean Nuclear Weapons Arsenal: New Estimates.*
38. Lee and Park, *'북한의 핵탄두 수량 추계와 전망'* [*North Korea's Warhead Quantity Estimation and Forecast*].
39. Siegfried S. Hecker, *Hinge Points: An Inside Look at North Korea's Nuclear Program* (Stanford University Press, 2023).
40. '2022년 국방백서' [*2022 Defense White Paper*], ROK Ministry of National Defense.
41. Bennett and others, *Countering the Risks of North Korean Nuclear Weapons.*
42. *DPRK Strategic Capabilities and Security on the Korean Peninsula*, CENESS-IISS.
43. *North Korean Tactics* (US Department of the Army, 24 July 2020) ATP 7-100 <https://irp.fas.org/doddir/army/atp7-100-2.pdf>.
44. Fedchenko and Kelley, 'New Methodology Offers Estimates for North Korean Thermonuclear Stockpile'.
45. Gentile and others, *Four Problems on the Korean Peninsula.*
46. Hecker, 'What We Really Know About North Korea's Nuclear Weapons'.
47. Warrick, Nakashima, and Fifield, 'North Korea Now Making Missile-Ready Nuclear Weapons'.

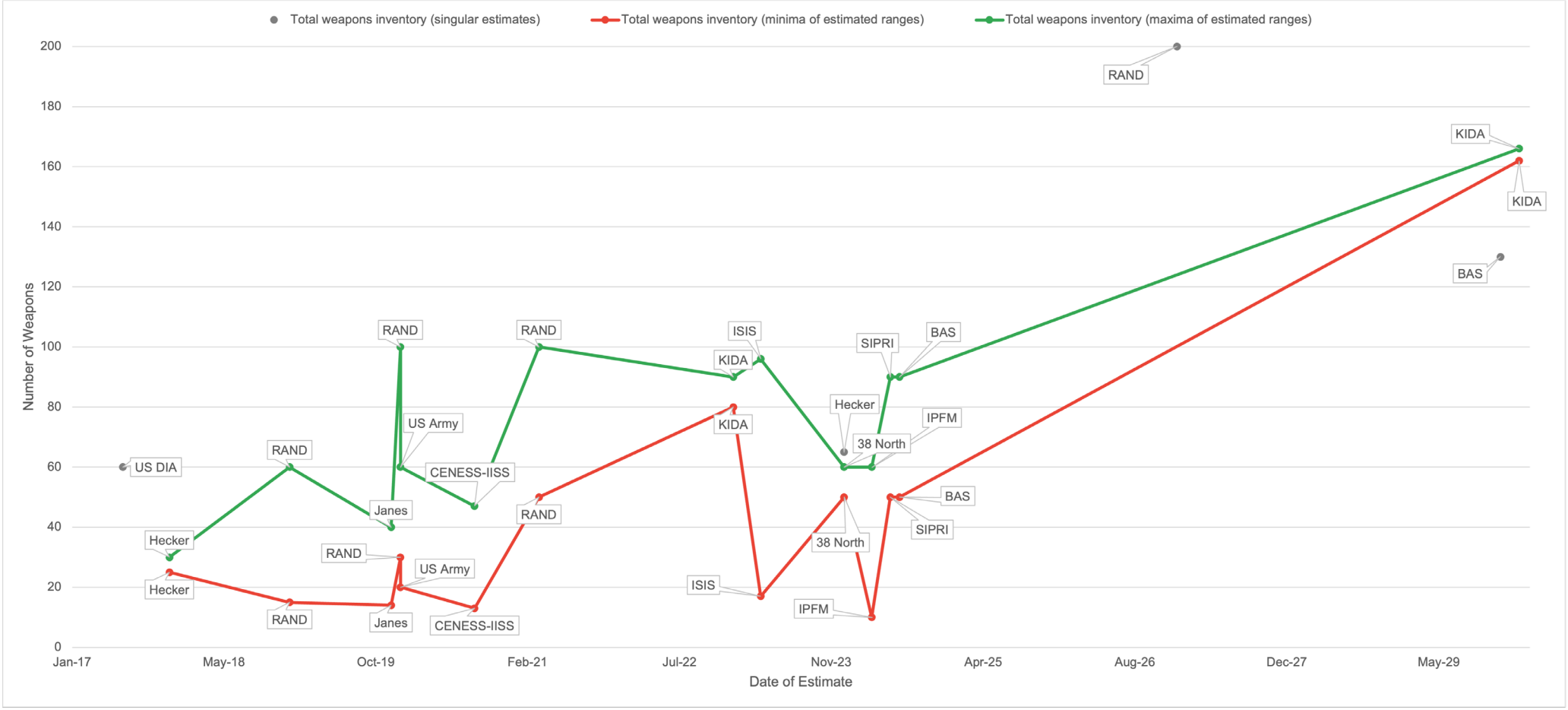

Figure 3. Independent estimates made since 2017 of the DPRK's total weapons inventory, from data in Table 3. Data points in grey show where authors provided a singular estimate. When authors provided a range of values in their estimates, the upper bound was plotted on the chart in green and the lower bound in red.

Nuclear weapons development relevant capabilities

The literature in the area of nuclear weapons development capabilities is sparse due to the secrecy surrounding weapons-sensitive items and compounded by the generally relatively low amount of information regarding the DPRK. However, what ONN did find suggests that the DPRK may have had external assistance in accessing nuclear weapons design information. The literature further suggests that the final stages of nuclear warhead development may be taking place in a different facility outside the Yongbyon complex, and that the DPRK possesses the ability to produce several nuclear weapons-related materials beyond the fissile materials discussed above.

Design assistance

At least three sources assert that the A.Q. Khan network might have assisted in providing nuclear weapons design information, specifically for an implosion-based weapon. It is suspected that this design was based on the Chinese CHIC-4 as Khan is known to have designs for this weapon, although it is assessed that the DPRK would have needed to adapt it for use with Pu instead of HEU.[48]

Machining

Hecker wrote in 2023 that he suspects Pu casting and final warhead component machining is performed outside of the Yongbyon nuclear complex, as he did not see sufficiently large furnaces during his 2007 visit.[49]

Other materials

It has been assessed by numerous sources that the DPRK has the capability to produce several nuclear weapons-related materials: beryllium, lithium-6, lithium deuteride, deuterium and tritium.[50] A 2021 joint study from the Center for Energy and Security Studies (CENESS) and the International Institute for Strategic Studies (IISS) further assessed that the DPRK had a tritium stockpile of 7–8 g as of September 2020.[51]

48. Bennett and others, *Countering the Risks of North Korean Nuclear Weapons; Kippe, Nuclear Weapons Capabilities and Doctrines in North Korea*; Hecker, *Hinge Points*, p. 89, 156.
49. Hecker, *Hinge Points*, p. 178.
50. *DPRK Strategic Capabilities and Security on the Korean Peninsula*, CENESS-IISS; Hecker, 'What We Really Know About North Korea's Nuclear Weapons'; David Albright, Sarah Burkhard, Mark Gorwitz, and Allison Lach, *North Korea's Lithium 6 Production for Nuclear Weapons* (ISIS, 17 March 2017) <https://isis-online.org/uploads/isis-reports/documents/North_Korea_Lithium_6_17Mar2017_Final.pdf>; Sulgiye Park, Terence P. McNulty, and Rodney C. Ewing, 'Critical Metal Resources in Democratic People's Republic of Korea', *International Geology Review* (20 November 2022) DOI: <https://doi.org/10.1080/00206814.2022.2151049>.
51. *DPRK Strategic Capabilities and Security on the Korean Peninsula*, CENESS-IISS.

Key takeaways

A significant conclusion drawn from this literature review is that there is a scarcity of independent assessments regarding the DPRK's stockpiles of weapons-grade Pu, HEU and nuclear weapons. A large amount of open-source information (analysis, reporting, assessments) on the DPRK's nuclear weapons programme thus draws from a small number of truly independent analyses.

Estimates of Pu stockpiles are largely harmonious due both to information made previously available to the International Atomic Energy Agency and the ability of the international community to remotely monitor reactor operations and therefore estimate Pu production. However, estimated amounts of HEU and nuclear weapons using HEU vary significantly, likely in large part due to the relative scarcity of data. This lack of information may have a major impact on the ability of foreign nations to understand and develop strategies related to the DPRK's nuclear weapons programme.

Notably, there are differences in the literature in the level of transparency of the underlying assumptions for each assessment, occasionally impacting the understandability of the data, its credibility and the ability to compare the information with other open-source data.

Moving forward, the community could work to address current gaps in the literature, including those related to:

- Additional nuclear weapons development relevant capabilities, such as:
  - Lithium, tritium and beryllium;
  - High-explosives manufacturing and testing;
  - Modelling and simulation capabilities; and
  - Potential foreign assistance.
- Specific nuclear strategy considerations, such as:
  - Targeting;
  - Interoperability;
  - Gas boosting; and
  - Tactical weapons use.

Ultimately, despite information restrictions, the expert community and civil society have demonstrated an impressive ability to conduct rigorous, open-source assessments on the DPRK's nuclear weapons programme. By working to fill the identified remaining knowledge gaps, we can continue deepening and broadening the knowledge of the field, enhancing the international community's ability to respond to challenges posed by the DPRK's nuclear programme, ultimately contributing to the reduction of global nuclear risk.