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EMERGING CAPABILITIES? THE UNFLOWN SLBMS OF THE DPRK

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EMERGING CAPABILITIES? THE UNFLOWN SLBMS OF THE DPRK

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In its October 2020, January 2021 and April 2022 military parades, the DPRK displayed three types of large submarine-launched ballistic missiles (SLBMs): the Pukguksong-4[△], the Pukguksong-5[△] and an unnamed SLBM, respectively. To date, none of these SLBMs have been flight tested and their developmental status remains unclear.

In an effort to better understand these missiles and the programme that they may represent, this paper examines the visible characteristics of these SLBMs and evaluates their potential capabilities. It also offers an assessment of whether they represent a serious development effort by looking at the technical challenges that such a programme would face. On that basis, ONN offers the following conclusions:

- It is likely that the SLBMs that have been showcased since 2020 represent a mid- to long-term development plan.
- It is likely that the DPRK will start testing such SLBMs, which are potentially of intercontinental range, before the end of the five year plan (2021 to 2025), although delays and setbacks of the programme are possible.
- Uncertainties continue to exist with respect to the DPRK's shipbuilding industry and whether it is capable of building submarines large enough to accommodate large SLBMs such as the one displayed during the April 2022 military parade.

CONTENTS

I.	SLBM CHARACTERISTICS.....	1
II.	SLBM DEVELOPMENT.....	6
	A. Motor Casings	6
	B. Attitude Control System	7
	C. Simplified Development Routes.....	7
	D. Launch Platforms.....	7
III.	SLBM AUTHENTICITY ASSESSMENT	8
	A. Past Examples.....	8
	B. Official Statements.....	10
IV.	CONCLUSIONS	11
V.	APPENDIX A: MENSURATION	12
	A. Method	12
	B. References	13
VI.	APPENDIX B: KCNA REPORT	14
	ENDNOTES.....	15

I. SLBM CHARACTERISTICS

In order to understand the possible potential of the previously unflown SLBMs displayed by the DPRK, ONN made measurements based on publicly available images of the DPRK's parades and developed estimates of the dimensions of the SLBMs (the methods and references for these measurements are detailed in Appendices A and B).

The photos used to measure the diameter of the Pukguksong-4^λ, Pukguksong-5^λ and the unnamed SLBM are shown in Figure 1.

Using the measured diameter of the Pukguksong-4^λ and the Pukguksong-5^λ and the wheelbase of the truck, the approximate lengths of the Pukguksong-4^λ, the Pukguksong-5^λ and the unnamed SLBM were calculated (Figure 2, 3, 4).

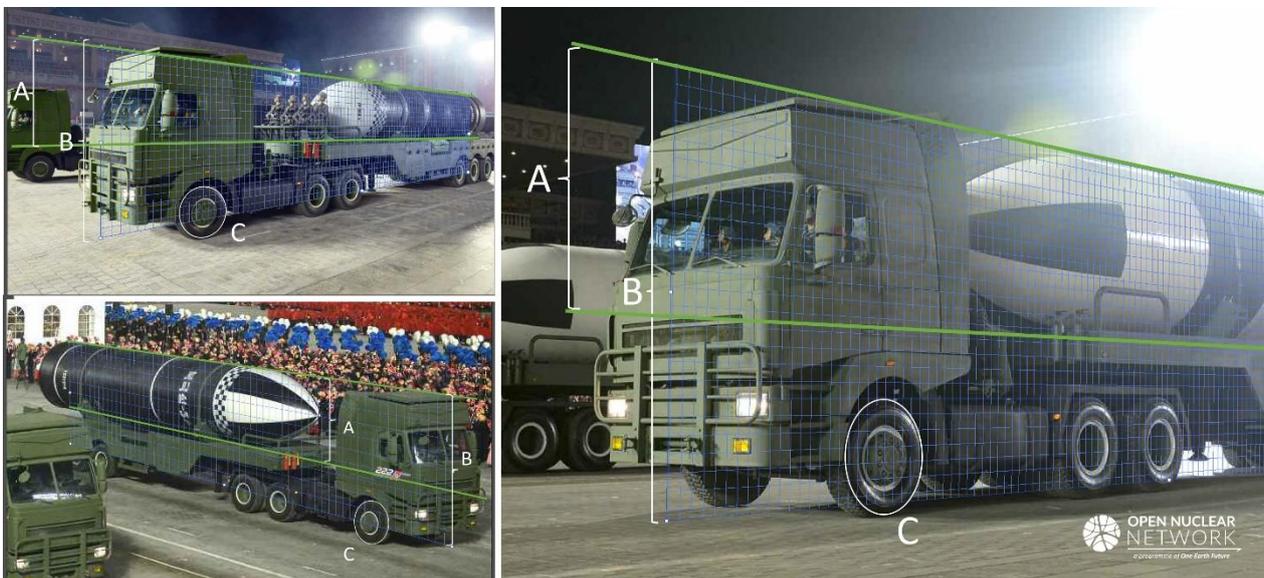


Figure 1. Example measurement of the diameter (marked as A) of the Pukguksong-4^λ (top left), the Pukguksong-5 (bottom left) and the unnamed SLBM (right), using the approximate height of the truck (B) and the diameter of the wheel (C) as references. The grid shows the vertical plane on which the measurement was made.

Images: Rodong Sinmun [1]



Figure 2. The Pukguksong-5 λ is almost as long as the trailer that carries it.
Images: KCTV [2]

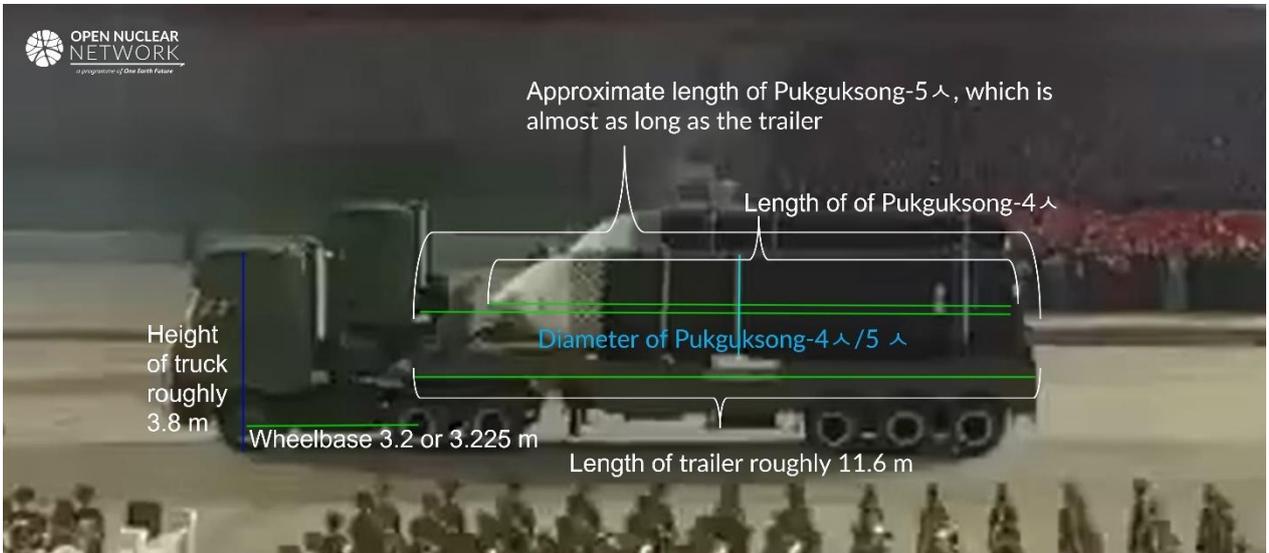


Figure 3. A rough measurement of the length of the Pukguksong-4 λ and the Pukguksong-5 λ . Due to the limited availability of images, a more precise measurement could not be made.
Image: KCTV [3]

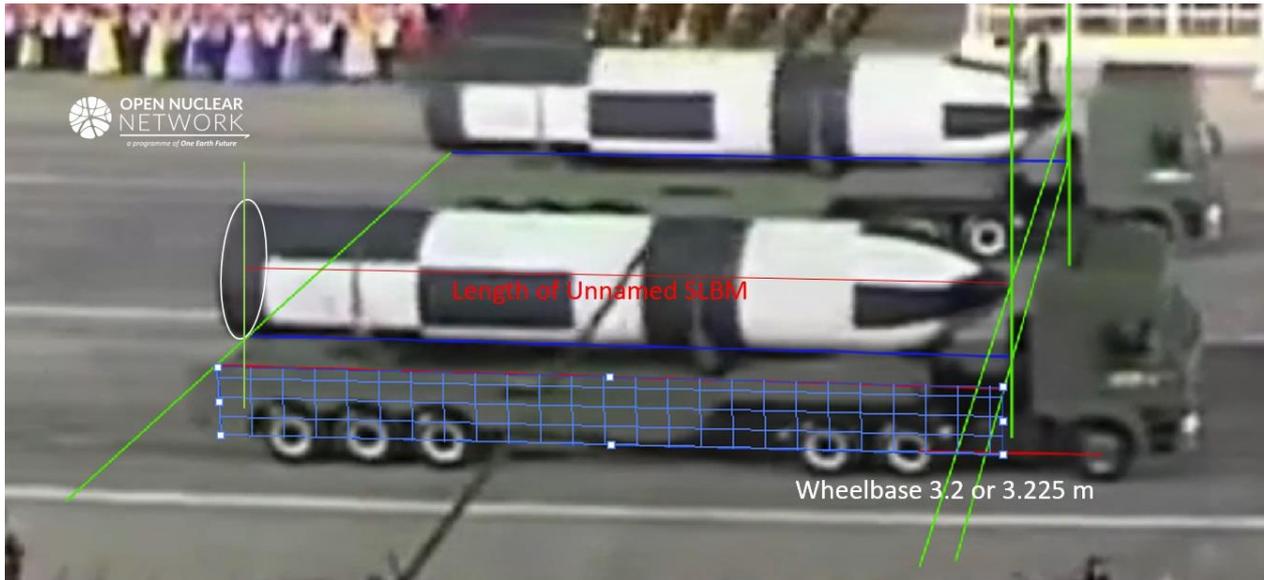


Figure 4. Measuring the length of the unnamed SLBM displayed in April 2022. The grid represents the vertical plane from which the measurement was made. Image: KCTV [4]

The results of all measurements are compiled in Table 1 below.

	Reference 1 Tire of the truck	Reference 2 Wheelbase/height of truck
Pukguksong-4 Δ (Oct 2020 parade)	~2 m diameter ~10 m length	~2.1 m diameter ~9.8 m length
Pukguksong-5 Δ (Jan 2021 parade)	~2 m diameter ~11.86 m length	~2.1 m diameter ~11.3 m length
Unnamed SLBM (Apr 2022 parade)	~2.16 m wide	~2.26 m diameter ~13.2 m long

Table 1. Measurement of diameter of DPRK SLBMs using different references.

Based on these estimated measurements, the SLBMs displayed by the DPRK, in particular the unnamed SLBM showcased in the military parade in April 2022, have dimensions comparable to solid-propellant SLBMs with intercontinental range [5] that are currently deployed by the nuclear-weapon States (Table 2), most of which are highly compact, three-stage missiles armed with multiple independent re-entry vehicles (MIRVs).

While the Pukguksong-4⁴ and the Pukguksong-5⁵ appear to have two stages, the unnamed SLBM appears likely to have a three-stage design, as the shroud appears to be of sufficient length to accommodate both a smaller diameter third stage and the warhead (Figure 5). An SLBM with such a design and estimated dimensions would potentially have an intercontinental range.

	Approximate or average size	Number of stages	Number of warheads
Pukguksong-4 ⁴ (Oct 2020 parade)	Diameter ~2.05 m Length ~9.9 m	2	Unknown
Pukguksong-5 ⁵ (Jan 2021 parade)	Diameter ~2.05 m Length ~11.6 m	Possibly 2	Unknown
Unnamed SLBM (Apr 2022 parade)	Diameter ~2.21 m Length ~13.2 m	Possibly 3	Unknown
US Trident II D5, also deployed by the UK	Diameter 2.11 m Length 13.42 m ⁶	3 + post boost vehicle (PBV) or "bus" to dispense MIRVs	Up to 8 ⁷
France M51 ⁸	Diameter ~2.35 m Length ~13 m	3 + PBV	Possibly up to 6
Russia RSM-56 Bulava ⁹	Diameter ~2 m Length ~12 to ~13 m	3 + PBV	Possibly up to 10
Chinese JL-2	Diameter ~2 m Length ~13 m ¹⁰	3, possibly no PBV	1 ¹¹

Table 2. Comparison of DPRK SLBMs and solid-propellant SLBMs with intercontinental range deployed by the nuclear-weapon States.



Figure 5. The cable raceway is indicative of the length of each stage of the unnamed SLBM because the cables could not be placed inside the propellant. The shroud seems to have enough length and volume to accommodate a third stage and the warhead.

Images: KCTV [12], Rodong Sinmun [13]

II. SLBM DEVELOPMENT

It is difficult to assess how long it would take the DPRK to produce solid motors with a diameter of two metres or above because (1) different countries have different development and manufacturing capabilities, and (2) the resources and priorities allocated to missile programmes also vary from country to country. For example, the time between China's flight test of its first solid-propellant medium-range ballistic missile and the flight test of its first solid-propellant ICBM is 19 years (1981 to 1999), while the USA only took three years to complete this process (1958 to 1961). [14]

Building a solid-propellant SLBM of intercontinental-range is a significant design and manufacturing challenge. These missiles normally require composite materials [15] for the production of their large-diameter and lightweight airframe, as well as for their high performance solid-propellant and lightweight attitude control mechanisms, to increase their payload/range capabilities.

A. Motor Casings

It remains unclear whether the DPRK has manufactured any large motor casings with a diameter of two metres or above. However, since 2016, the DPRK has demonstrated technological advances in the manufacturing of relatively large solid-propellant motors up to 1.5 m in diameter. [16] It has also publicly displayed lightweight composite material airframes made with filament winding techniques (Figure 6). In fact, the UN Panel of Experts reported that the solid motor casing of the Pukguksong-2 land-based mid-range ballistic missile, with an approximate diameter of 1.5 m [17], was built with composite materials. [18]

The DPRK reportedly has been expanding its solid propellant motor research and production facilities that are located in Hamhung. [20] The US government has also alleged that the DPRK is continuing its efforts to procure goods with missile applications (including materials for the manufacture of solid-propellant motors) and knowledge related to solid-propellant mixtures. [21]



Figure 6. Kim Jong Un inspects a composite casing at the Chemical Material Institute at Hamhung in August 2017. Image: Rodong Sinmun [19]

B. Attitude Control System

Uncertainties also exist with respect to the attitude control system, as there has been no evidence to indicate that the DPRK has applied lightweight attitude control mechanisms on its solid-propellant motors. According to publicly available images, the solid-propellant ballistic missiles of the DPRK rely on aerodynamic surfaces and jet vanes (rudders that deflect the plumes) to control their flight (Figure 7). Jet vanes are simple control mechanisms but they increase the deadweight a missile has to carry, and thus are less suitable for intermediate range and intercontinental ballistic missiles, especially for the second and third stages of such missiles.

C. Simplified Development Routes

The number of nuclear warheads a ballistic missile is able to carry is determined by the payload capacity of the missile and the level of warhead miniaturisation. With a limited payload capacity, and without significant miniaturisation, increasing the number of warheads could quickly exceed what the SLBM could carry. A single warhead, by contrast, could reduce the need for miniaturisation and pose fewer technical challenges, potentially allowing for the use of less advanced materials and less energetic propellant for solid rocket motors.

Considering such potential payload limitations, it is possible that an intercontinental-range SLBM of the DPRK might initially carry only one warhead. According to publicly available information, China appears to have achieved initial intercontinental-range SLBM capabilities by designing its JL-2 SLBM to carry fewer warheads (possibly only one [23]) than intercontinental-range SLBMs developed by other nuclear-weapon States.

Conversely, as it has been assessed that the DPRK has finished preparations for a possible seventh nuclear weapon test, [24] a successful test of a further miniaturised device could lower the payload requirement for an SLBM with intercontinental range.

D. Launch Platforms

The DPRK's development of ballistic missile submarines that could house these missiles appears to be lagging behind. To date, only one small experimental ballistic missile submarine is in limited use for testing purposes. The status of a larger, more capable ballistic missile submarine that was converted from a Chinese Type 033 submarine remains unknown. [25] It is also unclear if this converted Type 033 submarine is large enough to handle large SLBMs such as the one displayed during the April 2022 military parade.



Figure 7. Kim Jong Un inspects the test of a solid motor with jet vanes in March 2016.

Images: Rodong Sinmun [22]

III. SLBM AUTHENTICITY ASSESSMENT

A. Past Examples

Considering the lack of flight testing for the displayed SLBMs and the challenges in developing intercontinental-range SLBMs, it is possible that the SLBMs referred to above are simply display models. The fact that (1) the Pukguksong-5 is almost as long as the display trailer, and (2) the unnamed SLBM is roughly as long as the distance from the back of the truck cabin to the rear end of the

display trailer may also indicate that the dimensions of the SLBMs were dictated by the display trailer.

The DPRK has in the past showcased items that are not authentic for their purported purpose. For example, during the October 2020 parade, a launcher carrying five rounds of “super-large calibre multiple rocket launchers (MRLs)” was showcased. This vehicle was later shown to actually carry land-attack cruise missiles (Figure 8).



Figure 8. Left: Parade vehicles carry models of five model rounds of “super-large calibre multiple rocket launchers (MRLs)” during the October 2020 parade. Right: Same launcher with parade configurations fires a land-attack cruise missile from one of its five launch canisters. Images: KCTV [26]

In a military parade in April 2017, two types of missile transporter-erector-launchers (TELs) with previously unseen large canisters were displayed (Figure 9). The two displayed missile systems shared some resemblance to Chinese and Russian solid-propellant ICBMs. As the two DPRK missile systems have not to date been seen again, it remains unclear whether they represented early concepts of solid-propellant long-range ballistic missiles or were purely for display during the parade.

However, in other cases, new systems first revealed during military parades were eventually flight tested and deployed by the military. Therefore, new items displayed during DPRK military parades could be:

- special items made for display or posturing;
- models made to represent real projects that are still under development; or
- models that represent long-term ambitions.



Figure 9. Left and right: Two types of ballistic missile systems, possibly of solid-propellant type, displayed during a military parade in April 2017. The missiles on the left are also towed by HOWO T7H trucks.

Images: KCTV [27]

B. Official Statements

According to DPRK state media, on 11 January 2022, in connection with a hypersonic missile test, Kim Jong Un reportedly said that developing hypersonic weapons was one of the “five core tasks of the five-year plan [2021-2025] for building up the national defence capability” established at the 8th Congress. While the official list of “five core tasks” is not publicly known, solid-propellant SLBMs appears to be part of the “core plan and strategic tasks in developing and strengthening national defence industry”, as referred to in the KCNA report on the 8th Party Congress (Appendix B), which are summarised as follows:

1. producing tactical nuclear warheads and large, high yield nuclear warheads;
2. raising strategic striking distance up to 15000 km;
3. developing and deploying hypersonic glide vehicles (HGVs) within a short time;
4. developing ground- and sea-based solid-propellant ballistic missiles of intercontinental range; and
5. possessing nuclear-powered submarines and an underwater-launched nuclear strategic weapon.

Since the 8th Congress, the DPRK has made progress in tactical nuclear weapon systems, [28] 15000 km range ICBMs [29] and HGVs. [30] Visible progress on the remaining tasks have yet to be demonstrated. In this regard, the displayed SLBMs represent at least mid-to long-term ambitions of the DPRK leadership. To what extent “ground- and sea-based solid-propellant ballistic missiles of intercontinental range” share commonalities in technologies remains unclear.

However, directives of the DPRK’s Supreme Leader are not always fulfilled and are subject to delays and changes. For example, during a liquid engine ground test in September 2016, Kim Jong Un stated that the DPRK would turn into “a possessor of geostationary satellites in a couple of years to come”, [31] as of July 2022, this order had not been fulfilled. [32] During the 8th Congress, there were no public references to geo-stationary satellites. Instead, orders were given to develop military reconnaissance satellites, [33] most of which do not use geo-stationary orbit. It would appear likely, then, that this order has been abandoned with no public announcement of such change.

IV. CONCLUSIONS

On the basis of the characteristics of the displayed SLBMs, technical assessment of the potential capabilities and an evaluation of the authenticity of the displayed SLBMs, the following conclusions can be drawn:

- It is likely that the SLBMs that have been showcased since 2020 represent a mid- to long-term development plan.
- It is likely that the DPRK will start testing such SLBMs, which are potentially of intercontinental range, before the end of the five year plan (2021 to 2025), although

delays and setbacks of the programme are possible.

- Uncertainties continue to exist in the DPRK's shipbuilding industry. It is unclear if the DPRK is able to build submarines large enough to accommodate large SLBMs such as the unnamed one displayed during the April 2022 military parade.

V. APPENDIX A: MENSURATION

A. Method

The method used for measurement of these missiles was to (1) find suitable references and (2) build a three dimensional space (Figure 10) in the photos so that margins of error caused by perspectives could be

minimised. With ideal angle and high-resolution images, the margins of error could be reduced within a reasonable range (Figure 11). Less accurate references, photos taken with less favourable angles and low resolution images result in higher margins of error.



Figure 10. Forming a three-dimensional space in a photo.
Image: KCTV [34]

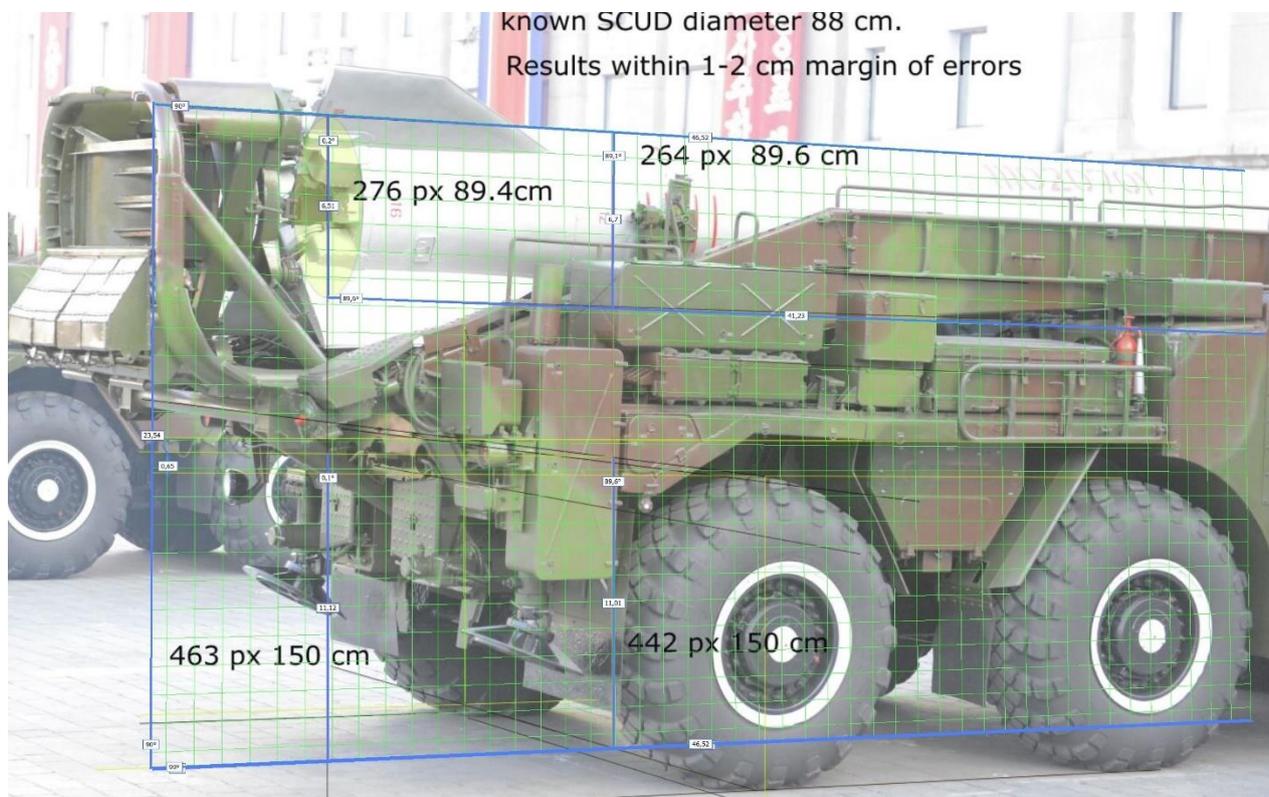


Figure 11. The SCUD missile is known to have a diameter of 88 cm. The error margin of this measurement is ~1.5 cm. The grid is a vertical plane where the measurement is made. The reference is the wheel diameter of the MAZ-543 truck.
Image: Tianran Xu

B. References

The primary reference used for the measurement of the SLBMs was the wheel diameter of the display trucks. The display trucks of all three SLBMs are likely to be HOWO T7H, a Chinese commercial tractor truck (Figure 12). A standard version HOWO T7H runs on 295/80R22.5 or 1200R20 tires, [35] which have an overall diameter of 1.044 m and 1.125 m, respectively. [36]

Measurement results based on the 1200R20 tire as a reference are not in accordance with reality (making the missile too long and thick than circumstances allow).

Thus, the measurement results based on 1200R20 tires are excluded from this report as the measurements confirmed that 295/80R22.5 tires are the ones used during the parades.

The secondary references for measuring the SLBMs were the wheelbase and height of the truck. As the DPRK has modified the truck cabin, the height of the original T7H truck could not be used directly as a reference. However, the approximate height of the truck could be estimated on the basis of the wheelbase (between first axle and second axle), which is known to be 3.225 m or 3.2 m long. [39] The measured height of the truck head is in general agreement with the height of a standard T7H truck head (Figure 13).



Figure 12. The accessories of the trucks seen in the parades are identical to that of the HOWO T7H commercial trucks. The truck cabins seen in DPRK parades have been modified.

Images: KCTV [37], Sinotruck [38]

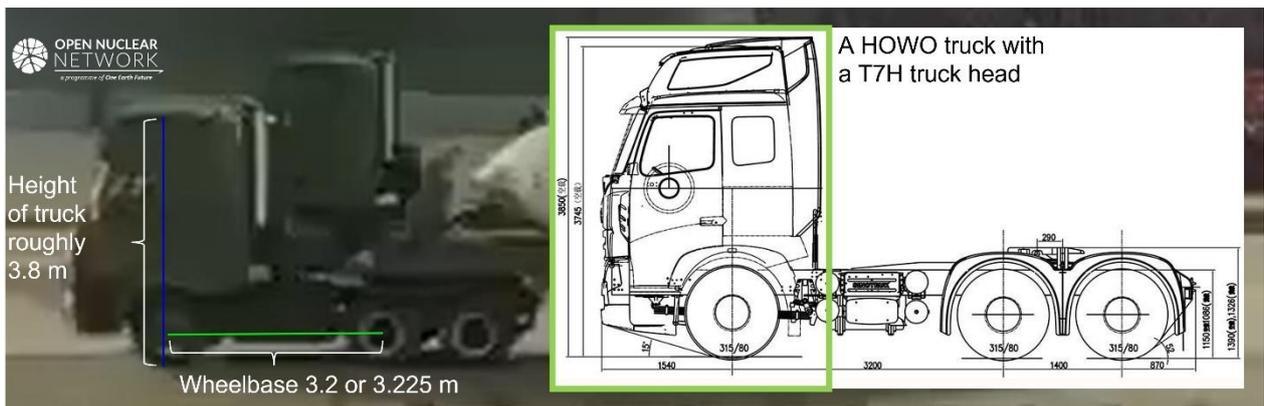


Figure 13. Height of the trucks towing the SLBMs. Inset image: dimension of a T7H truck head.

Images: KCTV [40], Sinotruck [41]

VI. APPENDIX B: KCNA REPORT

Excerpt from KCNA article on “Report Made by Supreme Leader Kim Jong Un at 8th Congress of WPK”, 10 January 2021

The report mentioned the core plan and strategic tasks of crucial importance in rapidly developing and strengthening the national defence industry.

It is necessary to develop the nuclear technology to a higher level and make nuclear weapons smaller and lighter for more tactical uses. This will make it possible to develop tactical nuclear weapons to be used as various means according to the purposes of operational duty and targets of strike in modern warfare, and continuously push ahead with the production of super-sized nuclear warheads. In this way we will be able to thoroughly contain, control and handle on our own initiative various military threats on the Korean peninsula, which are inevitably accompanied the nuclear threat.

The report also set a goal of attaining an advanced capability for making a preemptive and retaliatory nuclear strike by further raising the rate of precision good enough to strike and annihilate any strategic targets within a range of 15 000 kilometres with pinpoint accuracy.

And the tasks were brought up to develop and introduce hypersonic gliding flight warheads in a short period, push ahead with the development of solid-fuel engine-propelled inter-continental underwater and ground ballistic rockets as scheduled, and possess a nuclear-powered submarine and an underwater-launch nuclear strategic weapon which will be of great importance in raising the long-range nuclear striking capability.

The report also referred to the need to secure the ability of reconnaissance and information gathering based on operation of a military reconnaissance satellite in the near future, and conduct in real earnest the most important research to develop reconnaissance drones and other means of reconnaissance capable of precisely reconnoitring up to 500 km deep into the front.

ENDNOTES

- [1] Rodong Sinmun, 10 October 2020, 15 January 2021, 26 April 2022, available at: <http://www.korea-copy.com>
- [2] Military parade for the 8th Party Congress, KCTV, 15 January 2021, available at: https://www.youtube.com/watch?v=cYbnjxjKNf8&t=4350s&ab_channel=dprknow
- [3] Military Parade for the 75th founding anniversary of the Workers' Party of Korea, KCTV, 10 October 2020, available at: https://www.youtube.com/watch?v=jFp1K1VKWHg&t=843s&ab_channel=WeirdNKvideoarchive
- [4] Military parade for the 90th founding anniversary of the Korean People's Revolution Army, KCTV, 27 April 2022, available at: https://www.youtube.com/watch?v=F96t1k_a-pU&t=7222s&ab_channel=dprknow
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- [6] Trident II (D5) Missile, US Navy, 22 September 2021, available at: <https://www.navy.mil/Resources/Fact-Files/Display-FactFiles/Article/2169285/trident-ii-d5-missile/>
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- [12] Military parade for the 90th founding anniversary of the Korean People's Revolution Army, KCTV, 27 April 2022, available at: https://www.youtube.com/watch?v=F96t1k_a-pU&t=7222s&ab_channel=dprknow
- [13] Rodong Sinmun, 24 April 2022, available at: <http://www.korea-copy.com>

- [14] Scott LaFoy, How close is North Korea to testing an ICBM?, NKnews, 21 April 2017, available at: <https://www.nknews.org/pro/how-close-is-north-korea-to-testing-an-icbm/?t=1656935268>
- [15] Early ICBMs have used more traditional materials for the construction of their motor casings. However, composite materials have become more common as they can increase a missile's throw weight and/or range through reduction of structure mass. For example, the first and second stage motor casings of the US Minuteman I/II/III ICBMs are made of steel and titanium, respectively; Kevlar-based composite material was used on all three stages of the US Trident I C4 SLBM. The weight of the Trident II D5 was reduced by replacing a kevlar-based composite material with graphite-based composite material. See: Minuteman weapon system: history and description, ICBM Prime Team, TRW Systems, July 2001, available at: <https://minutemanmissile.com/documents/MinutemanWeaponSystemHistoryAndDescription.pdf>; Rocket motor cases: high-performance lightweight composite motor cases, General Dynamics, November 2017, available at: <https://www.gd-ots.com/wp-content/uploads/2017/11/Rocket-Motor-Cases.pdf>; Trident II D-5 Fleet Ballistic Missile, Federation of American Scientists, 1 May 1998, available at: <https://nuke.fas.org/guide/usa/slbm/d-5.htm>
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- [24] Lee Haye-ah, N. Korea tests nuclear detonation device: presidential office, Yonhap News Agency, 25 May 2022, available at: <https://en.yna.co.kr/view/AEN20220525008952315?section=nk/nk>
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- [29] Tianran Xu, 24 March 2022 DPRK ICBM Test, ONN, 25 March 2022, available at: <https://opennuclear.org/publication/24-march-2022-dprk-icbm-test>
- [30] While it is possible that the HGV could carry either a conventional or a nuclear payload, in the context of this list, it is likely referring to a nuclear capable vehicle. For more, see: Tianran Xu, Analysis of the 11 January 2022 Hypersonic Missile Test of the DPRK, ONN, 14 January 2022, available at: <https://opennuclear.org/publication/analysis-11-january-2022-hypersonic-missile-test-dprk>
- [31] Kim Jong Un reportedly said that “the successful manufacture of the engine provided a firm scientific and technological guarantee for developing and completing the carrier rocket for geo-stationary satellite during the 5-year program for national aerospace development” and that the National Aerospace Development Administration (NADA) should turn the DPRK “into a possessor of geostationary satellites in a couple of years to come.” See: Kim Jong Un Guides Ground Jet Test of New-type High-Power Engine, KCNA, 19 September 2016

- [32] According to the Yonhap News Agency of the Republic of Korea, the DPRK's first 5-year program for national aerospace development started in 2012 and ended in 2015. Thus the (second) 5-year program referred to by Kim Jong Un (footnote 26) possibly lasted from 2016 to 2020. See: Yi Wonju, N.K. pushing for five-year space development program purely for peaceful purposes: state media, Yonhap News Agency, 2 April 2020, available at: <https://en.yna.co.kr/view/AEN20200402005600325>. Even assuming the first 5-year program ended at the end of 2016, the DPRK still failed to complete the carrier rocket for geo-stationary orbit in the second 5-year program (2017 to 2021).
- [33] Report Made by Supreme Leader Kim Jong Un at 8th Congress of WPK, 10 January 2021.
- [34] Hwasong-14 ICBM launch, KCTV, 4 July 2017, available at: https://www.youtube.com/watch?v=MYGsPZRFIWA&ab_channel=songunbg
- [35] HOWO T7H, Sinotruk, accessed on 29 June 2022, available at: <http://en.sinotruk.com/View/zt/howot7h/cs.aspx>
- [36] China 1200R20 chengshan brand CST27 new rubber truck tire, Alibaba, accessed on 29 June 2022, available at: https://www.alibaba.com/product-detail/china-1200R20-chengshan-brand-CST27-new_60123130034.html?spm=a2700.7724838.0.0.VL6YFj
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- [38] SINOTRUK HOWO T7H MAN Engine Tractor Truck 6X4 Euro 3 / 4 440 HP ZZ4257V324HD1B, Sinotruk, accessed on 29 June 2022, available at: <http://turkish.sinotruk-international.com/sale-9449645-sinotruk-howo-t7h-man-engine-tractor-truck-6x4-euro-3-4-440-hp-zz4257v324hd1b.html>
- [39] HOWO T7H, Sinotruk, accessed on 29 June 2022, available at: <http://en.sinotruk.com/View/zt/howot7h/cs.aspx>. Sinotruk HOWO T7h 6X4 Euro III 390HP Heavy Duty Truck, Made-In-China, accessed on 29 June 2022, available at: <https://sinotruk-huawin.en.made-in-china.com/product/mBEQvqRXZwkM/China-Sinotruk-HOWO-T7h-6X4-Euro-III-390HP-Heavy-Duty-Truck.html>
- [40] Military Parade for the 75th founding anniversary of the Workers' Party of Korea, KCTV, 10 October 2020, available at: https://www.youtube.com/watch?v=jFp1K1VKWHg&t=843s&ab_channel=WeirdNKvideoarchive
- [41] Procurement manual, Sinotruk, accessed on 29 June 2022, available at: <https://www.sinotruks.cn/m/pageinfo-9.html>

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