

Open Nuclear Network's

SIZE ESTIMATES OF DPRK'S NUCLEAR DEVICES

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KEY TAKEAWAYS

- The DPRK nuclear warheads showcased before 2023 have a maximum diameter of around 600 mm and were likely intended to be delivered by ballistic missiles.
- The Hwasan-31 nuclear warhead, newly revealed in late March 2023, has a reduced diameter of around 460 mm, suggesting advances in miniaturization.
- Assuming the Hwasan-31 has not been tested before, the DPRK is likely to conduct a seventh nuclear test to validate its parameters before it enters full production, in furtherance of DPRK leader Kim Jong Un's order for exponential expansion of the State's nuclear arsenal.

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I. INTRODUCTION

On 27 March 2023, DPRK leader Kim Jong Un reportedly inspected the country's nuclear weapons. A nuclear warhead called "Hwasan-31" - intended to be used for several different nuclear delivery systems - was revealed during this inspection.

The 27 March inspection was possibly the fourth known occasion in which a DPRK nuclear weapon was shown to the outside

world. The images released offer more data that can be used in estimating the size of the DPRK's nuclear warheads.

This article presents estimates of the size of all DPRK nuclear warheads showcased to date, including the most recently displayed Hwasan-31, with the aim to provide more data for understanding the DPRK's nuclear weapons development and programme.

II. METHODOLOGY

Mensuration of ground photos is a technique used to estimate the dimensions of objects in photos, and in this case can be utilized to estimate the size of the nuclear warheads shown in DPRK State media images. The method used for the mensuration is to (1) find suitable references (objects of a known size that can be used for measuring the size of another object) and (2) find a relatively suitable plane for measurement so that errors caused by perspective distortion can be minimized. Less accurate references, photos taken with unfavourable angles, low resolution images or distortion caused by

camera lenses all result in higher margins of error. Sometimes conversion of references, for example, measuring the size of an object in one photo so that the same object could be used as a reference in another photo, can be used. Such conversions also increase the inaccuracies of the measurement due to accumulation of errors.

The measurements are made on the basis of the assumption that all nuclear warheads or their mockups presented by the DPRK State media represent the real size of the physical nuclear packages used by the DPRK.

III. SUMMARY OF MENSURATION RESULTS

As information on nuclear weapons is closely controlled, the images of nuclear warheads released by the DPRK for propaganda purposes are not necessarily amenable to mensuration. Measurement confidence levels are impacted by (1) the quality of the reference for the purpose of measurement and (2) how aligned a reference is placed for

the purpose of measurement in relation to the object being measured. Therefore, the measurements of the DPRK's nuclear weapons, as listed in Table 1 below, do not all share the same level of confidence.¹

A more detailed explanation of each measurement made for this article is available in Appendix I.

Nuclear device being measured	Date of Kim Jong Un / Kim Jong Il inspection	Approximate maximum diameter (range of measured results)	Confidence level
A suspected implosion device	Before 2012	~ 600 mm	Low
A purported implosion device	8 March 2016	~ 600 mm (578 to 615 mm)	Medium to high
A purported two-stage thermonuclear device	3 September 2017	Primary: ~ 620 mm (581 to 642 mm) Secondary: ~ 460 mm (436 to 481 mm)	Low to medium
Hwasan-31 nuclear warhead	27 March 2023	~ 460 mm (450 to 463 mm)	High

Table 1. Size estimates of showcased DPRK nuclear devices.

IV. IMPLICATIONS

In a previous ONN publication on the six nuclear tests conducted by the DPRK to date,² it was assessed that by 2017 the DPRK's nuclear weapon programme had: (1) tested a relatively compact device; (2) increased the yield-to-weight ratio of its nuclear device; and (3) detonated a two-stage thermonuclear device.

The measurements made for this report suggest that between 2006 and 2017, the size of the DPRK's atomic bombs, or the size of the primary in the case of the sixth nuclear test, has remained largely unchanged. While this article focuses on the measurement of the nuclear devices showcased by the DPRK, the measured size of these devices is generally compatible with the size of reentry vehicles of the DPRK's ballistic missiles. For example, the body diameter of the Hwasong-7 (Rodong) ballistic missile is ~125 cm.³ Longer-range missiles, such as the Hwasong-12, have a wider body. A fission bomb with a diameter of around 600 mm would be able to fit in a re-entry vehicle on top of these missiles.

However, the Hwasan-31 nuclear warhead, newly revealed in late March 2023, has a significantly smaller diameter of around 460 mm, suggesting further miniaturization. The reduced size allows the warhead to be carried by a wider range of weapon systems,

providing a basis for potentially more widespread use on the battlefield in accordance with Kim Jong Un's instruction to apply the State's war deterrence to control and manage the security on the Korean peninsula.⁴

The Hwasan-31's yield potential is unclear. The DPRK State media has claimed that missiles that are supposed to carry the Hwasan-31 warheads have simulated airbursts at altitudes of 500, 600 and 800 metres, respectively.⁵ For comparison, in 1966, China detonated a 12 kt atomic bomb, delivered over the target area by a DF-2A ballistic missile, at an altitude of 569 metres.⁶ The similar detonation altitude may suggest that the designed yield of the Hwasan-31 is also in the 10 kt class, though the detonation altitude could be associated with the nature of the intended targets.⁷

If the Hwasan-31 nuclear warhead represents a new design that has not been tested before, the DPRK is likely to conduct a seventh nuclear test to validate its performance before it enters production, in furtherance of DPRK leader Kim Jong Un's orders for the exponential expansion of the State's nuclear arsenal.⁸ Moreover, if the Hwasan-31 has been previously tested and validated, it may already be in production.

APPENDIX 1: MENSURATION PROCESS

A. Suspected Implosion Device (before 2012)

In December 2017, KCTV reported on a meeting in celebration of the development of the State's nuclear armed forces. In that programme, KCTV showed Kim Jong Il inspecting a spherical object (Figure 1) hanging on one of the walls of the meeting venue. Considering the main theme of the meeting, and that other photos displayed during the meeting were relevant to the State's missile and nuclear weapon

programmes (Figure 2), the photo might depict Kim Jong Il's inspection of a purported implosion device.¹⁰

This photo may be the only publicly-available image of an DPRK implosion device that was taken before the Kim Jong Un era. Thus, this picture is used as a possible reference for the size of the DPRK's early implosion devices. However, due to the small size of the relevant part of the video, only a rough estimate of the size of the spherical object, using the height of Kim Jong Il as reference, was made (Figure 3).



Figure 1. Kim Jong Il inspecting a spherical item, shown during a December 2017 meeting celebrating the State's development of nuclear armed forces.

Image: KCTV⁹



Figure 2. Kim Jong Il inspecting a spherical object - possibly two pictures away from the one of Kim Jong Un inspecting a purported two-stage thermonuclear device.
Image: KCTV¹¹



Figure 3. Left: Kim Jong Il inspecting a spherical object processed with Photoshop's perspective warp in order to show a better view. Right: Another photo of Kim Jong Il, full-body height, overlaid on the original photo as a rough reference,¹² the spherical object has a diameter of roughly ~600 mm.
Images: KCTV,¹³ Kim Jong Il Looking at things¹⁴

B. Purported Implosion Device (2016)

The DPRK unambiguously showcased its nuclear weapons for the first time in March 2016, when Kim Jong Un conducted his first publicly-reported inspection of the DPRK's nuclear weapons, which took place between the State's fourth and fifth nuclear tests in January and September 2016, respectively.¹⁵

During this visit, Kim inspected a purported implosion device with visible explosive lenses, and he reportedly said that "it was gratifying to see the nuclear warheads with the Korean-style structure of mixed charge adequate for prompt thermo-nuclear reaction".¹⁶

1. Measurement 1

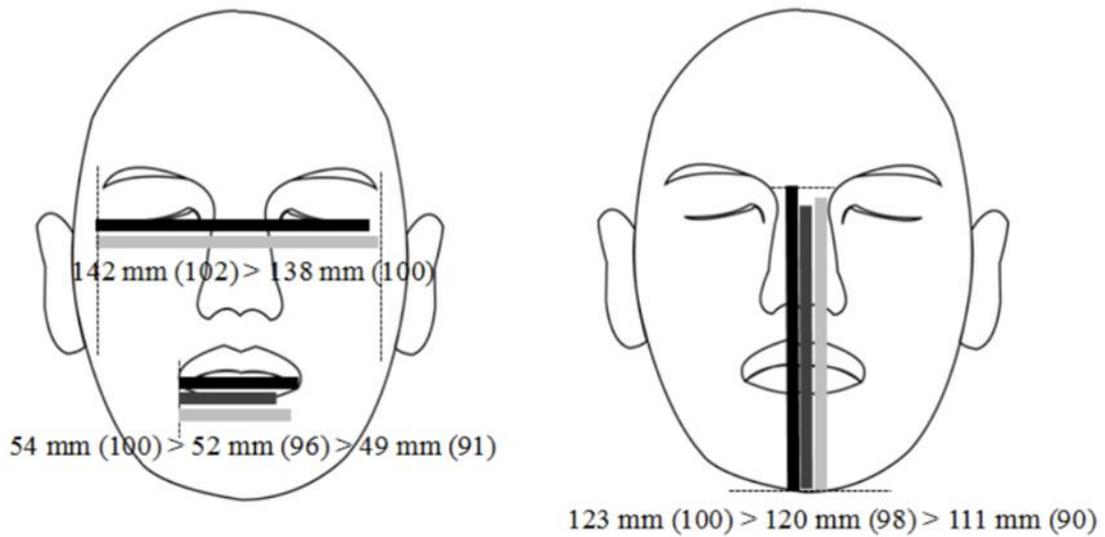
To measure the diameter of this device, the first reference used is the face length (length from eyes to chin) of Hong Sung Mu, a key figure in the DPRK's nuclear weapon development and currently the first vice department director of the Central Committee of the Workers' Party of Korea (Figure 4).

The result shows that the face length of Hong Sung Mu is roughly 122.4–126 mm long, which is in general alignment with a 2011 ROK study on facial anthropometrics (Figure 5).

Using the face length of Hong as a reference, a rough measurement of the diameter of the implosion device showcased in March 2016 was made (Figure 6, measurement result see Table 2).



Figure 4. Using the 600 mm multiple rocket launcher round as reference, the face length of both Kim Jong Un and Hong Sung Mu have been measured for later use.
Image: KCTV¹⁷



Korean Male Pilots
 Korean Male Civilians
 US Air Force

Figure 5. A study shows that South Korean male pilots have an average face length of 123 mm, and South Korean male civilians have an average face length of 120 mm.

Image: Jeong Rim Jeong¹⁸



Figure 6. Hong at a relatively favourable position for measuring diameter of purported implosion device. Inset depicts approximate spatial relationship of photo setting.

Image: KCNA/Chosun.com¹⁹

2. Measurement 2

According to the photos and videos released by the State media, the warhead showcased in 2016 was most certainly intended to be carried by the three-stage variant of the Hwasong-13 intercontinental ballistic missile. A blurred diagram showing the re-entry vehicle of the Hwasong-13 containing this warhead was also shown to Kim Jong Un. Thus, the second reference used for measuring the nuclear device is the base diameter of the re-entry vehicle.

The truck carrying the Hwasong-13 is used as the reference to measure the base diameter of the Hwasong-13's re-entry vehicle. According to the United Nations panel of experts, the Chinese WS51200 was the carrier truck of the Hwasong-13.²⁰ The

vehicle is known to have a length of 20.11 m.²² The missile could be measured as having a length of around 19.27 m (Figure 7),²³ and the base diameter of its re-entry vehicle is around 1.34 m.²⁴ In turn, the diameter of the implosion device in the diagram could be deduced (Figure 8, measurement result see Table 2).

The measurement results for the purported implosion device displayed in 2016 are shown in Table 2 below. The quality of references depends on how accurate and aligned the reference is for the purpose of measurement. The confidence level of the measurements depends on the quality of the references and whether the photo being worked on was taken with an angle favourable for the measurement.



Figure 7. Using stated length of WS51200 truck as reference, approximate length of the missile and base diameter of its re-entry vehicle could be measured.

Image: KCNA/US Navy Institute²¹

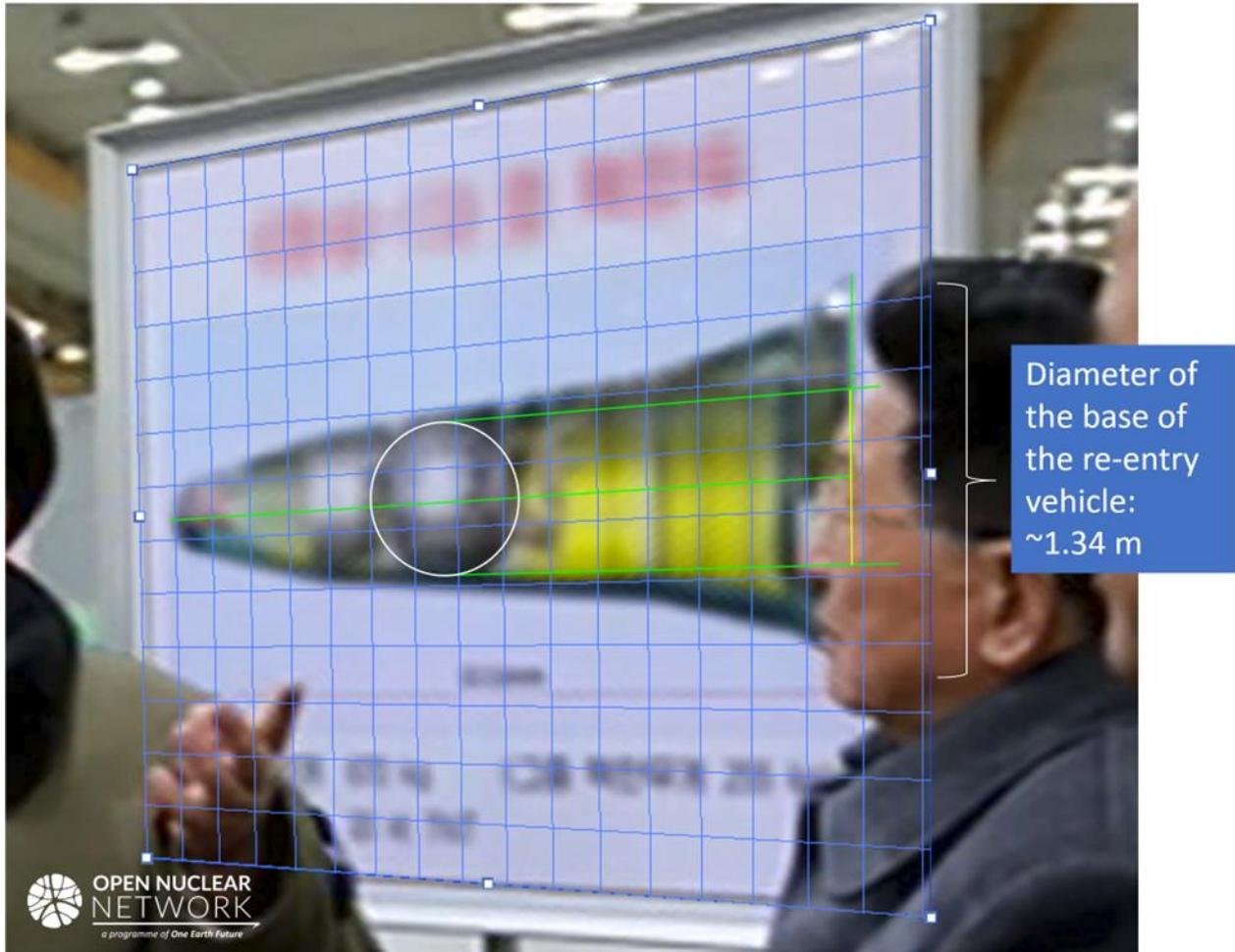


Figure 8. Using approximate diameter of base of warhead as reference, implosion device depicted in blurred diagram has approximate diameter of below 600 mm.

Image: KCTV/RogueStatesMedia²⁵

	References	Quality of references	Result	Angle for measurement	Confidence level
Measurement 1	Face length of Hong Sung Mu	Medium	~597-615 mm	Relatively favourable	Medium to high
Measurement 2	Base diameter of re-entry vehicle	Medium	~578 mm	Relatively favourable	Medium to high

Table 2. Size estimates of purported implosion device showcased by DPRK in March 2016

C. Purported Two-Stage Thermonuclear Device (2017)

On the day of the DPRK's sixth nuclear test on 3 September 2017, the DPRK State media released photos of Kim Jong Un inspecting a purported two-stage thermonuclear device.²⁶ This is the second time Kim Jong Un conducted a publicly-reported inspection of nuclear weapons.

1. Measurements 1 to 3

None of the photos contains ideal objects for referencing, nor were they taken with ideal angles for measurement. Two photos taken from relatively useful angles were selected to measure the diameter of the primary and secondary of the purported two-stage thermonuclear device, using the measured face length of Hong Sung Mu and Kim Jong Un as reference (Figure 4, Figure 9, Figure 10 and Figure 11).



Figure 9. Former ROK president Moon Jae-in stated that he was ~1.72 m tall.²⁷ Accordingly, face length of Kim Jong Un in photo would be ~126.5 mm. Images: AFP/DailyMail²⁸

According to the diagram of a re-entry vehicle containing this two-stage thermonuclear device (Figure 12), the diameter of the secondary is roughly 75% of

the diameter of the primary. Using this ratio, the diameter of the primary and secondary in the two images can also be deduced (Table 3).

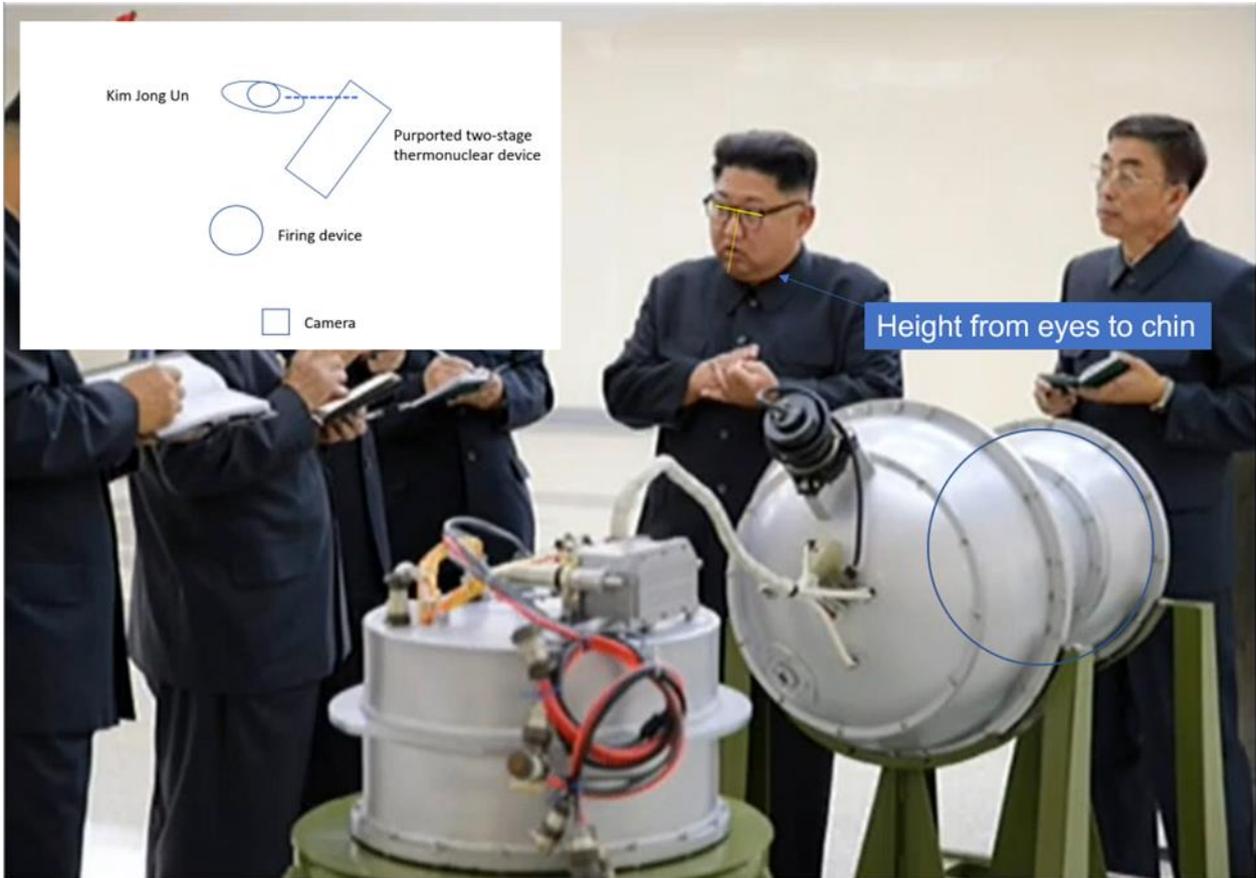


Figure 10. Measuring diameter of secondary of purported two-stage thermonuclear device with face length of Kim Jong Un as reference measured in two different images (Figure 4 and Figure 9). The inset image shows the approximate spatial relationship of the photo setting.
Image: KCTV²⁹



Figure 11. Measuring diameter of primary of purported thermonuclear device with face length of Hong Sung Mu as a reference. Inset shows approximate spatial relationship of the photo setting.

Image: KCNA/CNN³⁰

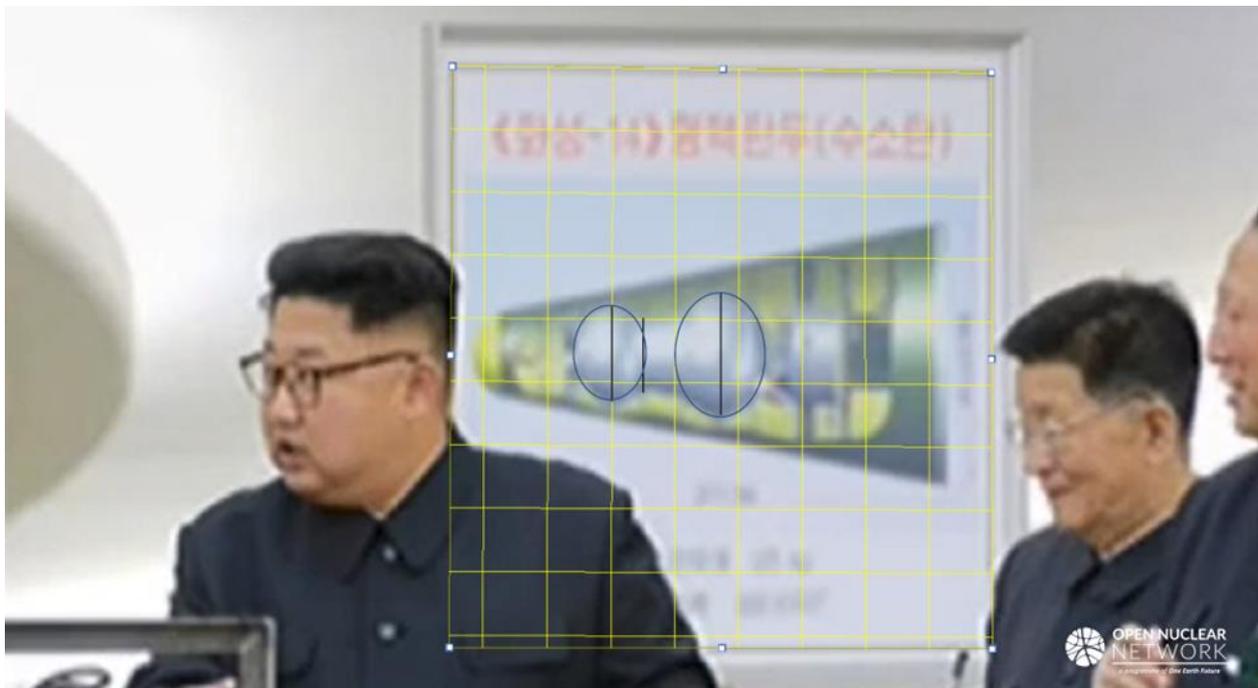


Figure 12. Diagram of re-entry vehicle shown to Kim Jong Un during his inspection.

Image: KCTV³¹

2. Measurement 4

On 10 September 2017, DPRK State media reported on a concert celebrating its sixth nuclear test. During the concert, several frames showing the assembly of the purported two-stage thermonuclear device were displayed (Figure 13). A rough estimate of the size of this device was also made using these frames. However, as the head breadth of the staff shown in the short clip is unknown, the measurement could be made only with the average head breadth of a ROK civilian (Figure 14, result see Table 3).

The measurement results of the purported two-stage thermonuclear device are shown in

Table 3 below. The quality of references depends on how accurate and aligned the reference is for the purpose of measurement. The confidence level of the measurements depends on the quality of the references and whether the photo in question was taken from an angle favourable for the measurement.

Considering that the time interval between the March 2016 and September 2017 inspections was relatively short, and that the two nuclear devices seem to have a similar firing device, it is possible that the primary of the two-stage thermonuclear device showcased in 2017 is similar to the implosion device showcased in 2016.



Figure 13. Concert celebrating sixth nuclear test displaying short clip of assembly of purported two-stage thermonuclear device.

Image: KCVT/Arirang News³²

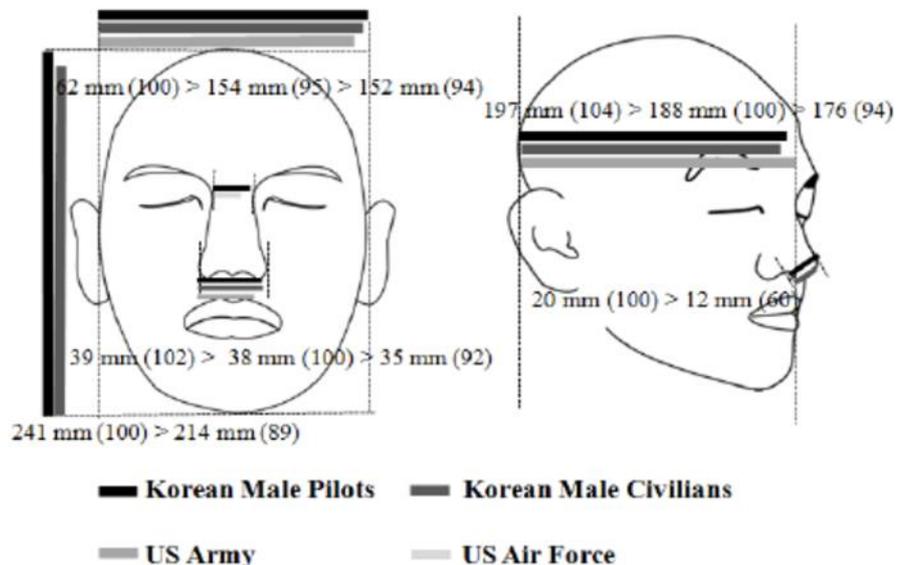


Figure 14. Average head breadth of South Korean civilians is 154 mm. Image: Jeong Rim Jeong³³

	References	Quality of references	Result	Angle for measurement	Confidence level
Measurement 1	Face length of Hong Sung Mu	Medium	Primary diameter: 618–636 mm Secondary diameter: 463–477 mm	Less favourable	Low to medium
Measurement 2	Face length of Kim Jong Un	Medium	Primary diameter: 581–609 mm Secondary diameter: 436–457 mm	Less favourable	Low to medium
Measurement 3	Face length of Kim Jong Un	Medium	Primary: 616 mm Secondary: 462 mm	Less favourable	Low to medium
Measurement 4	Face breadth of a staff	Low	Primary diameter: 642 mm Secondary diameter: 481 mm	Relatively favourable, but image quality is poor	Low to medium

Table 3. Size estimates of purported two-stage thermonuclear device showcased by DPRK in 2017. Measurements 2 and 3 are made with face length of Kim Jong Un as reference measured in two different images (Figure 4 and Figure 9).

D. Hwasan-31 Nuclear Warhead (2023)

On 28 March 2023, DPRK State media reported on DPRK leader Kim Jong Un's 27 March 2023 inspection of nuclear weapons. A nuclear warhead referred to as

the "Hwasan-31" was revealed during the inspection, and described as intended to be used in several nuclear delivery systems. The 27 March inspection is the third time for Kim Jong Un to conduct a publicly-reported inspection of nuclear weapons.



Figure 15. As Hwasan-31 nuclear warhead has casing presumably to realize "interchangeability with different weapon systems,"³⁴ it is possible to measure only maximum diameter of casing. Image: KCNA³⁵

1. Measurement 1

Using the 600 mm diameter multiple rocket launcher (MRL) round as a reference, the

maximum diameter of the casing of the Hwasan-31 nuclear warhead could be measured (Figure 16).



Figure 16. Measurement of maximum diameter of casing of Hwasan-31.
Image: KCTV³⁶

2. Measurement 2

Blurred diagrams of different weapon systems intended to carry the Hwasan-31 were also shown to Kim Jong Un during his visit. These diagrams do not illustrate the whole contour of the Hwasan-31 inside these weapons; nonetheless, measurements were made on diagrams of the 600 mm MRL round and a cruise missile to provide a rough range of the diameter of the Hwasan-31 (Figure 17).

The measurement results are shown in Table 4 below. The quality of references depends on how accurate and aligned the reference is for the purpose of measurement. The confidence level of the measurements depends on the quality of the references and whether the photo in question was taken from a favourable angle for the measurement.

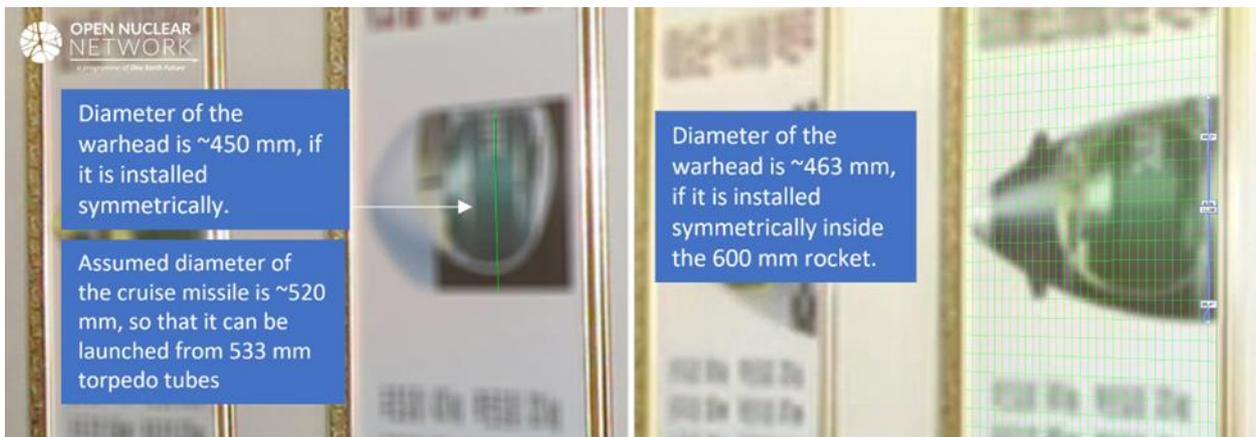


Figure 17. Rough measurements made on diagram of 600 mm MRL rocket and cruise missile likely to have diameter of around 520 mm.³⁷

Images: KCNA³⁸

	References	Quality of references	Maximum casing diameter	Angle for measurement	Confidence level
Measurement 1	600 mm rocket	High	~460 mm	Relatively favourable	High
Measurement 2	Diagrams of 600 mm rocket and cruise missile	High	450-463 mm	Relatively favourable, though images do not show the whole of the warhead and are also blurred.	High

Table 4. Size estimates of Hwasan-31 nuclear warhead showcased by DPRK in March 2023.

ENDNOTES

- 1 Confidence level is defined by the quality of a reference used and how aligned the reference is positioned for the purpose of measurement in relation to the object being measured. For example, a good quality reference that is favourably aligned with the object being measured would yield a high confidence measurement; a medium quality reference that is favourably aligned with the object being measured would yield a medium to high confidence measurement; a medium quality reference that is less favourably aligned with the object being measured would result in a low to medium level measurement; and a rough reference that is less favourably aligned with the object being measured would yield a low confidence measurement.

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- 4 6th Enlarged Meeting of 8th Central Military Commission of WPK Held, KCNA, 11 April 2023, available at: <http://kcna.kp/en/article/q/e087e06ef298d82aef6643aae6299c47.kcmsf>

- 5 Nuclear Counterattack Simulation Drill Conducted in DPRK, KCNA, 20 March 2023, available at: <http://www.kcna.kp/en/article/q/34d6735ae393854a9d2e9b8f94b0fa59.kcmsf>. Important Weapon Test and Firing Drill Conducted in DPRK, KCNA, 24 March 2023, available at: <http://www.kcna.kp/en/article/q/8f6050fdcdec7876cc135c0378202bf2.kcmsf>. Army Unit in Charge of Important Operation Task in Central Front Conducts Missile Firing Drill, KCNA, 28 March 2023, available at: <http://www.kcna.kp/en/article/q/d7ccd96c7ee88f969f035d0f7b3edce5.kcmsf>

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12 Kim Jong Il was believed to be 1.60 m tall, and it is reported that in his late years (at least since 2009), he no longer wore high-heeled shoes in public out of health considerations. This article uses 1.65 m as his whole-body height taking consideration of hair length and height of shoe soles. See: Kim Sue-young, N. Korean Leader Kim Jong-il Chooses Sneakers Over High-Heeled Shoes, The Korea Times, 26 June 2009, available at:

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35 Respected Comrade Kim Jong Un Guides Work for Mounting Nuclear Warheads on Ballistic Missiles, KCNA, 28 March 2028, available at:

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36 敬愛する金正恩同志が核武器兵器化事業を指導された [*Respected comrade Kim Jong Un guides weaponization of nuclear weapons*], DPRKknow, 28 March 2023, available at:

https://www.youtube.com/watch?v=Mh3jV4yORdU&t=177s&ab_channel=dprknow

37 The DPRK has reportedly launched cruise missiles from submarines. Submarine-launched torpedoes with 533 mm caliber are the most commonly used in the world. The DPRK is known to operate 533 mm torpedoes on its Chinese Type 033 (Romeo) class submarines and locally built small and midget submarines. The ROK also alleged that a DPRK-made 533 mm torpedo fired by a DPRK midget submarine sank the ROK corvette Cheonan in 2010. See: Joint Investigative Report - On the Attack against ROK Ship Cheonan, ROK Ministry of National Defense, September 2010, available at: <http://nautilus.org/wp-content/uploads/2012/01/Cheonan.pdf>. The cruise missile should have a diameter smaller than 533 mm as it possibly needs a canister for its brief travel underwater. This article assumes the DPRK cruise missile has a diameter of around 520 mm, similar to that of the US Tomahawk cruise missile, which can be launched from 533 mm torpedo tubes. See: Carlo Kopp, Tomahawk Cruise Missile Variants, Air Power Australia, 27 January 2014, available at: <https://www.ausairpower.net/Tomahawk-Subtypes.html>

38 敬愛する金正恩同志が核武器兵器化事業を指導された [*Respected comrade Kim Jong Un guides weaponization of nuclear weapons*], DPRKknow, 28 March 2023, available at:

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