

China's New Multiple Independent Re-entry Vehicle (MIRV) ICBM the DF-41

On 24 July 2012 China is reported to have tested its DF-41 long range ICBM. Some images of this missile, presumably taken by Chinese bystanders with cell phone cameras were put out on the Internet.

There are four images of the missile that are making the rounds on the Internet.¹ Apart from these there is another image which provides some details and perspectives on the DF-41 including a plan view of the canisterised missile. The plan view could be used for a guesstimate of the dimensions of the three stages of the missile and the warhead. Taken together the images and the conceptual diagram could provide some indication of the size of the missile from which it would be possible to estimate the range.²

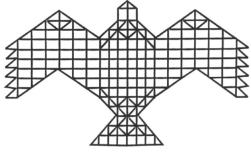
In image 1, the canister ends are seen to be flat and in image 2, the ends are dished. However, the internet refers to both of them as DF-41. For want of any better information these images are used for deriving the length and diameter of the missile.

The first image reproduced as Figure 1 below provides an image of a missile being carried on a vehicle. Though the image is tilted the details available in the image makes it possible to measure the length. ³ The length of the missile including its canister works out to be about 24.4 metres.

¹ These images can be found at http://www.china.org.cn/china/2012-08/22/content_26307167.htm

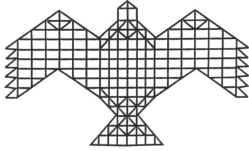
² Though not a substitute for more reliable data the approach adopted will provide useful knowledge on the DF-41. In any case this is the best that can be done with open source information.

³ It is likely that the transporter carrying the missile is a Russian MAZ 543 derivative. If this were so from published information the MAZ 543 wheel base – the distance between the centre of the wheels is 2.2 m



The second image used in sizing the missile's diameter is shown below as Figure 2





Our measurements suggest that the canister diameter is between 2.33 and 2.45 m.

Our earlier measurements on some of the DF-31 canister images⁴ suggested a canister diameter between 2.2 and 2.4 m. The canister for the DF-41 appears to be fairly close to this. So it is likely that both the DF-31 and the presumed DF-41⁵ use the same generic solid rocket booster.⁶

Our view is that the diameter of the solid rocket motors for both the DF-31 as well as the presumed DF-41 missile is the same and that this diameter would be about 2 m. This would be housed inside a canister whose diameter would be around 2.4 metres. The diameter is in line with other solid fuel based contemporary ICBM's like 2.10 m of the Peacekeeper, 2.3 m of the Trident D5 and 1.9 m of Topol.

Our earlier study on China's ballistic and cruise missile specifically addressed the question of whether the DF-31 and its variants could carry an MIRV payload.⁷ In that earlier report we had identified two possible configurations for achieving an MIRV capability.

In the first option, to contain the overall missile length for accommodation within the submarine launch tube, the multiple reentry vehicles were housed around a smaller diameter third stage. The Post Boost Control Vehicle (PBCV) is placed below the MIRV platform in an annular fashion.⁸ We referred to this design as the *submerged option*⁹. Such a configuration utilizes the limited volume available for housing the third stage and the MIRV/PBCV combination optimally, but renders the third stage separation to be a complicated operation.

The Second option that we had considered was what we had termed *the tandem configuration*. In this option the PBCV and MIRV combination is mounted on top of the third stage. This option is equivalent to adding a fourth stage to the missile and is easier to engineer. This arrangement would however, result in an increased length of the missile which may not be suitable for a submarine installation. The available information from the **DF-41 image and the measurements on its length and diameter is indicative of such an arrangement for the stages and PBCV/MIRV combination**

⁴ S. Chandrashekar et al, "An Assessment of China's Ballistic and Cruise Missiles", NIAS Study Report R4-07, 2007.

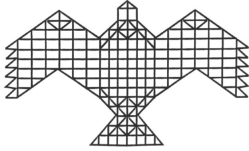
⁵ Some US sources have reported that the development of the DF-41 had been terminated. The most recent DOD report only talks of an MIRV DF-31 A with a range of over 7000 Km.

⁶ The diameter would be the same though the lengths could vary.

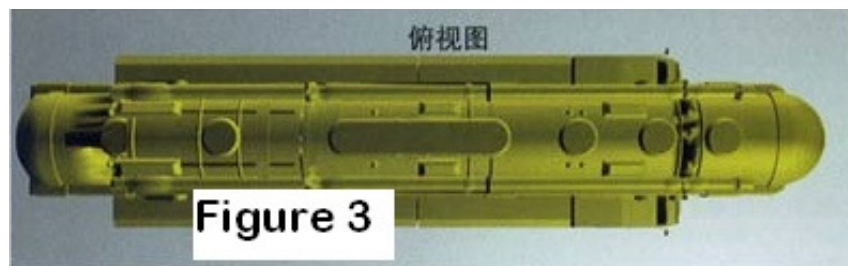
⁷ S. Chandrashekar et al, "An Assessment of China's Ballistic and Cruise Missiles", NIAS Study Report R4-07, 2007, pp 122-129

⁸ In our earlier studies we had looked at a range of smaller diameters for the third stage of the DF-31

⁹ The US Trident SLBM has a similar design. It represents possibly the state-of art currently.



We then attempted to estimate the performance of this missile. For this it is necessary to get an idea of the length of the three stages of the missile and the stage performance parameters. It is impossible to identify the three stages of the missile from images 1 and 2 and get some estimate of their lengths. However there is one additional conceptual diagram and write-up from which the individual stage dimensions can be estimated. The plan view of the canisterised missile being carried on its TEL shown in figure 3 can be used for roughly guessing the stage lengths.



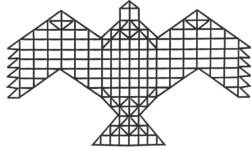
The rough translation of the Chinese write-up¹⁰ seems to suggest that this is a brochure put out by Song Rong from the MW Design Office that is responsible for the design of China's future weapons for land, air and sea. The performance of the missile is separately provided in a box. The text in the box identifies the missile as the DF-41 with a range of 12000 km, a CEP of 300 m and capable of carrying six MIRV's. The guidance for the missiles is provided by a Shuanxing Positioning System.¹¹

Based on these dimensions and a diameter of 2 metres the propellant and stage masses for the three stages have been estimated. ¹² Using typical values of burn time and thrust for solid rocket motors of this diameter, the maximum range of the DF-41 missile was estimated using the trajectory software developed at NIAS. Some optimization of the third stage mass was also carried out so as to arrive at suitable configuration for an MIRV payload. An initial value of 2000 kg was used for the MIRV payload.

¹⁰ We acknowledge the help of Prof. Sonika Gupta of the China centre of IIT Madras for help with the translation

¹¹ Possibly this is the Chinese equivalent of the GPS.

¹² The ratio of the propellant masses for the first second and third stages is not too different from the same ratios for other ICBMs such as the Peacekeeper, Minuteman, and Topol.



The configuration we have analyzed in some detail has a first stage mass of 37.9 tonnes, a second stage mass of 15.8 tonnes and a third stage mass of 4.7 tonnes. The total liftoff mass with a payload of 2 tonnes is about 60 tonnes.¹³ The performance of this missile for different warhead weights is provided in Table below.¹⁴

Range Vs Warhead Weight for the DF-41

MIRV Warhead Mass Kg	Range Km	Burnout Velocity Km / sec	Time of Flight Sec
2000 Kg	7273 Km	6.258 Km / sec	1603 seconds
1800 Kg	8239 Km	6.528 Km / sec	1724 seconds
1600 Kg	9592 Km	6.848 Km / sec	1883 seconds
1400 Kg	11815 Km	7.260 Km / sec	2107 seconds
1200 Kg	19016 Km	7.795 Km / sec	3062 seconds

As per the details provided in the write-up associated with these images the range of the DF-41 is 12000 Km. If this is true the MIRV warhead weight from Table above would be about 1400 Kg.

Other information available puts the range of the DF-41 with 6 MIRV as 14000 Km.¹⁵ If this were the case the mass of the MIRV warhead would be about 1300 Kg.

An MIRV warhead mass of between 1300 Kg and 1400 Kg is in reasonable agreement with the images put out. Both the configuration of the missile as well as its estimated performance is consistent with a land-based MIRV DF-41 ICBM.

The related question to ask is whether the capabilities of the presumed DF-41 missile are consistent with the carriage of six MIRV warheads.¹⁶

The SS-18 carries 8-10 MIRV's and the throw weight (PBCV+MIRV's) is indicated as 7260 kg¹⁷. Assuming half the mass goes for the PBCV, the mass of individual MIRV will work out to 363 kg.

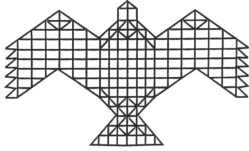
¹³ This is a conservative estimate and includes provision for the length taken away by the canister.

¹⁴ The MIRV warhead weight would depend on the number of independent warheads carried. These could range from three to about 10 and more carried on the US Trident SLBM. Chinese publications including the one we have used suggest 6 MIRV in the DF-41.

¹⁵ Information from Chinese language sources on the DF-41 provided by Ms. Rukmani Gupta of IDSA.

¹⁶ The PBCV will also carry decoys that will behave like real warheads. Whether the number of MIRV specified includes some warheads and some decoys is not clear.

¹⁷ *Case Study 3, The Origin of MIRV*, <http://www.fas.org/man/eprint/leitenberg/mirv.pdf> accessed on 22/09/2012



The W-88¹⁸ warhead with a yield of 475 kT is used in the Trident D-5. It is stated to be 0.55 m in diameter and 1.75 m long. Its mass is indicated to be around 362 kg. If we use 360 kg as the mass of MIRV based on the Russian and US MIRV data, the 6 MIRV's on DF-41 will weigh 2160 kg. The throw weight after adding the PBCV mass will be nearly 4000 kg. Consequently one could surmise that the DF-41 range with 6 MIRV's will be considerably lower or for a 12000 km range they will be flying with fewer—maybe 3 MIRV's.

Alternately, it is possible, that the Chinese may have optimized the MIRV mass to be lighter. Even if this were so managing 6 MIRV's + PBCV in a total mass of 1300-1400 kg is doubtful.

On balance it would appear that though the parameters of the presumed DF-41 are consistent with a long range MIRV ICBM the number of MIRV that could be carried on the DF-41 may be not more than three.

The information and the images put out also seem to suggest that the Chinese want the world to know what they possess. The data provided is such that with some knowledge, Chinese capabilities can be inferred. These conclusions may be very similar for different groups looking at this issue across the world. In spite of this there is still sufficient ambiguity in the information being put out by them that precludes a complete assessment of the true capabilities of their newer missiles. This deliberate ambiguity seems to be a part of their grand strategy.

Our analysis also suggests that the Chinese can use this missile to place a medium sized payload of 800 to 1000 Kg in near earth orbit.

¹⁸ <http://nuclearweaponarchive.org/Usa/Weapons/W88.html> accessed on 22/09/2012