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THE MIRVED MISSILE: THE TECHNOLOGY AND ITS RATIONALE DURING THE COLD WAR

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I wish I had thought through the implications of a MIRVed world.

—Henry Kissinger[1]

With the beginning of the nuclear age in 1945, the world saw a change in the means of warfare. Making bombs was not sufficient. With time, it was realised that their delivery would define the future course of deterrence. The first mode of delivery of nuclear bombs was the aircraft. After the Hiroshima and Nagasaki attacks, the United States (US) military began working on the miniaturisation of the bomb and shielding it sufficiently to enable it to travel to a distant target on a missile. However, it was difficult to make a nuclear weapon small enough to fit inside a missile's nose cone and be able to endure intense gravitational forces created by extremely high speeds.

For the US, even after acquiring the bomb, it took a decade to develop a missile that could carry a single warhead. The successful launch of the Sputnik by the USSR in 1957 was a major turning point. It proved that if a satellite could be put into orbit, then a nuclear warhead could, in theory,

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1. Henry A Kissinger, *Nuclear Weapons and Foreign Policy* (Routledge, 1984).

MIRV is a 'missile bus', whose passengers are nuclear bombs. It facilitates a single booster to deliver bombs to different targets. A MIRV increases the capacity of striking because its payload contains several warheads, and each warhead can hit a different target.

be delivered to any target on earth. By the 1960s, both the US and USSR began fielding Intercontinental Ballistic Missiles (ICBMs) with single warheads. Gradually, they were able to put more than one warhead on each missile. Thus began the race for the Multiple Independently Targetable Reentry Vehicle (MIRVed) missiles. In this context, this paper traces the development and deployment of MIRVed missiles by the US, Russia, United Kingdom (UK) and France, and their current status. It also analyses the impact of MIRVs on nuclear deterrence and strategic stability, and how arms control measures have affected their deployment.

WHAT ARE MIRVs: HOW ARE THEY DIFFERENT FROM MaRVS?

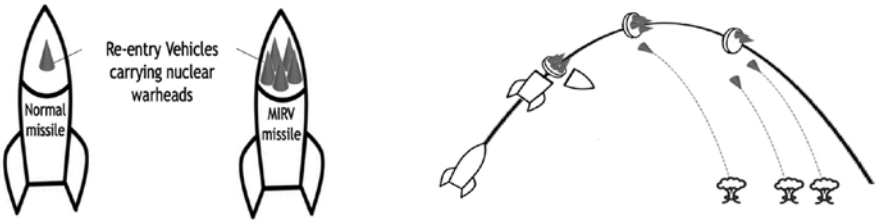
In general, a MIRV is a 'missile bus', whose passengers are nuclear bombs. It facilitates a single booster to deliver bombs to different targets. A MIRV increases the capacity of striking because its payload contains several warheads, and each warhead can hit a different target. In a MIRV, technically, a post booster vehicle is propelled into a free-flight suborbital ballistic flight path by the main rocket. The bus manoeuvres after the boost phase with the help of small on-board rocket motors and a computerised inertial navigation system. It adopts a ballistic trajectory that delivers a reentry vehicle to the target. Then it shifts to a new trajectory, releasing another warhead, and continues the process for all the warheads.[2]

A Reentry Vehicle (RV) is similar to a small spacecraft with sufficient shielding to survive the intense heat and stress associated with entering the

2. Matthew Bunn, *Technology of Ballistic Missile Reentry Vehicles* (Cambridge, MA: Program in Science & Technology for International Security, Massachusetts Institute of Technology, 3/1984), at https://scholar.harvard.edu/files/bunn_tech_of_ballastic_missle_reentry_vehicles.pdf. Accessed on July 15, 2021.

earth's atmosphere at high velocity. In the case of nuclear ballistic missiles, the RV contains a nuclear warhead. As the RV passes through the atmosphere, ground-based radars can access not only its ballistic coefficient but its weight too. Thus, to protect the RV all the way to the ground, a penetration aid would have to be as heavy as the RV itself.[3]

Fig 1: Normal Missile vs MIRVed Missile



Source: armscontrolcenter.org[4]

The two most common types of RVs are the ballistic and manoeuvrable vehicles. As it falls through the atmosphere, a ballistic RV is not guided or controlled. On the other hand, a Manoeuvrable Reentry Vehicle (MaRV) is guided during reentry and, therefore, can change direction instead of falling straight through the atmosphere. MaRVs are heavier, more complex and more expensive than MIRVs, and performing manoeuvres is their *raison d'etre.* For this, they require more advanced technologies beyond ballistic vehicles. Accuracy remains highly relevant for MaRVs because they are designed to successfully evade the Anti-Ballistic Missile (ABM) system.[5] In a MaRVed missile, not only does the bus that fires individual RVs have a guidance system, but the RVs themselves have their own little guidance systems.[6]

3. Ibid.
4. Centre for Arms Control and Non-Proliferation, "Multiple Independently-Targetable Reentry Vehicles (MIRVs)", at https://armscontrolcenter.org/wp-content/uploads/2017/08/MIRV-graphic.pdf. Accessed on July 30, 2021.
5. Bunn, n. 2.
6. D. Shapley, "Technology Creep and the Arms Race: ICBM Problem a Sleeper", *Science*, vol. 201, no. 4361, 1978, p. 1104.

In the early phase of the competition, ICBMs were large and inaccurate, with single warheads, and were deployed above ground which made them highly vulnerable to the enemy's preemptive attack.

UNITED STATES' MIRVs: PATTERN OF DEVELOPMENT AND DEPLOYMENT

The successful launch of the Sputnik satellite by the Soviet Union on October 4, 1957, became a major concern for the United States. It created a 'Pearl Harbour atmosphere' throughout the US because it triggered the thought that if the USSR could launch a satellite into space, it could easily target a nuclear warhead on any place on earth.[7] The missile used for this launch was the R-7/ SS-6 Sapwood or R-7 Semyorka also known as the world's first ICBM.[8]

The US acquired atomic bombs in 1945, but it developed the MGR-1 Honest John, which was the first nuclear surface-to-surface rocket in 1953. It was primitive and clumsy, with a speed of Mach 1.5 and was unguided. It had the capability of carrying 680 kg high explosive or a 5/25 kiloton nuclear warhead.[9] In the early phase of the competition, ICBMs were large and inaccurate, with single warheads, and were deployed above ground which made them highly vulnerable to the enemy's preemptive attack. The "missile gap" between the US and Soviet Union in the early phase was seen as the "window of vulnerability", therefore, at that time ICBMs politicised the presidential debates.[10]

Since 1959, the US has fielded more than 3,000 ICBMs of four types, namely, the Atlas, Titan, Minuteman, and Peacekeeper MX, with nearly eight types of warheads with varying yields from 170 kilotons to more than 9 megatons. Initially, all missiles were capable of carrying only one warhead.

7. National Park Service, "The Shock of Sputnik", at https://www.nps.gov/articles/mimiarmsrace-01.htm. Accessed on August 15, 2021.
8. Federation of American Scientists, "R-7 - SS-6 Sapwood", at https://nuke.fas.org/guide/russia/icbm/r-7.htm. Accessed on August 21, 2021.
9. History of War, "MGR-1 'Honest John' Missile System", at http://www.historyofwar.org/articles/weapons_mgr-1_honest_john.html. Accessed on August 20, 2021.
10. Robert S. Norris and Hans M. Kristensen, "Nuclear U.S. and Soviet/ Russian Intercontinental Ballistic Missiles, 1959-2008", *Bulletin of the Atomic Scientists*, vol. 65, no. 1, 2009, pp. 62-69, at https://www.tandfonline.com/doi/pdf/10.2968/065001008. Accessed on December 12, 2021.

Table 1: US ICBMs and SLBMs* till 2008

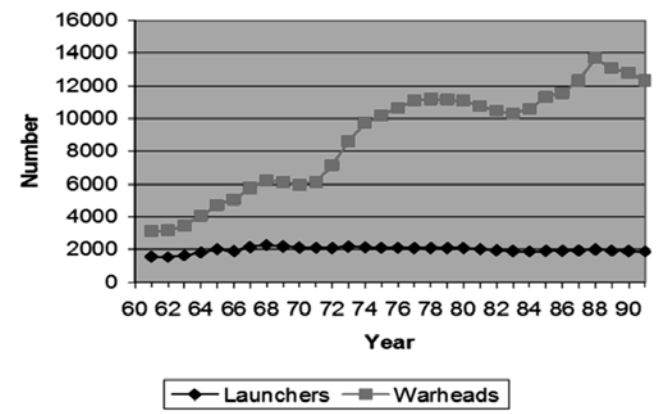
Designation	Dates Deployed	Warheads
Atlas D	1959-1963	1
Atlas E	1961-1964	1
Atlas F	1962-1964	1
Titan I	1962-1964	1
Titan II	1963-1986	1
Minuteman I (ICBM)	1962-1974	1
Minuteman II (ICBM))	1966-1990	1
Minuteman III (ICBM)	1970-2008	Up to 1-3
MX/Peacekeeper (ICBM)	1986-2005	Up to 10
Poseidon (SLBM)	1971-1991	Up to 10-14
Trident I (SLBM)	1979-2005	Up to 8

Source: Prepared by the author from the *Bulletin of the Atomic Scientists*, Federation of American Scientists.[11]
Note: *SLBM: Submarine Launched Ballistic Missile.

In 1967, the number of delivery vehicles was maximum but the number of warheads on these delivery vehicles surged exponentially through 1975 and peaked in 1987, as illustrated in Fig 2. This increase reflects the deployment of ICBMs and SLBMs with MIRVs. In 1970, the US started to deploy the Minuteman III, the first MIRVed ICBM with three warheads on each missile. In 1971, it deployed the Poseidon, the first MIRVed SLBM which had the capability of carrying up to 10 warheads on each missile. In the mid-1980s, the increase in warheads can be attributed to the Peacekeeper (MX) ICBM, which was able to carry 10 warheads on each missile.[12]

11. Ibid. Also see, Hans M. Kristensen and Matt Korda, "United States Nuclear Weapons, 2021", *Bulletin of the Atomic Scientists*, vol. 77, no. 1, 2021, pp. 43-63; and Amy F. Woolf, "U.S. Strategic Nuclear Forces: Background, Developments, and Issues", Congressional Research Service (CRS), Federation of American Scientists, CRS Report RL33640, 2021, p. 4, at https://sgp.fas.org/crs/nuke/RL33640.pdf. Accessed on September 1, 2021.
12. Woolf, n. 11.

Fig 2: US Strategic Nuclear Weapons, 1960-1990

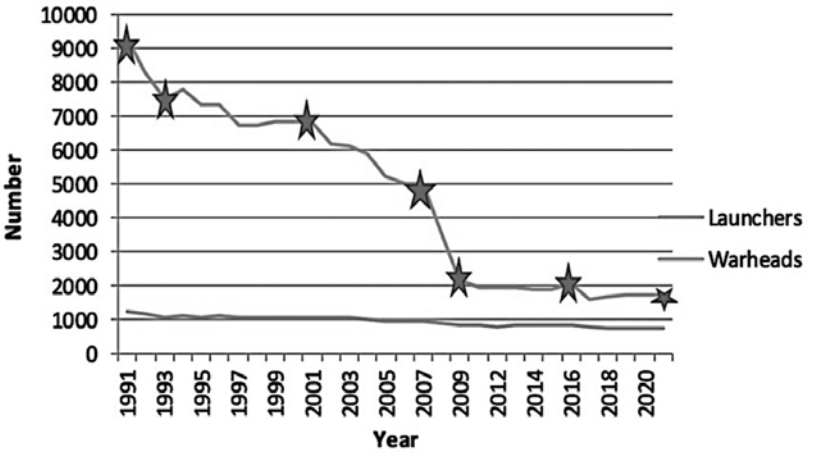


Source: Federation of American Scientists.[13]

The MIRVs enabled the deployment of more warheads on the same number of ICBM launchers. In 1990, it is estimated that the United States deployed approximately 12,304 warheads on its ICBMs, SLBMs, and heavy bombers. The then ICBMs force comprised "single-warhead Minuteman II missiles, 3-warhead Minuteman III missiles, and 10-warhead Peacekeeper (MX) missiles, for a total force of 2,450 warheads on 1,000 missiles".[14] The submarine force consisted of Poseidon submarines with the Poseidon C-3 and Trident I (C-4) missiles and the Ohio class Trident submarines with the Trident I and some Trident II (D-5) missiles. The total force consisted of 5,216 warheads on around 600 missiles.[15] After the New Strategic Arms Reduction Treaty 1 (START 1) of 1991, the United States reduced the numbers and types of weapons in its strategic nuclear arsenal while maintaining its nuclear triad of strategic forces with multiple warheads. Retaining the triad with MIRVed missiles was seen to provide "a range of capabilities and flexibility in nuclear planning" and was able to complicate the adversary's attack planning. The added benefit was that it also acted as a hedge against any unexpected problem in any single delivery system.[16]

13. Ibid., p. 3.
14. Ibid., p. 4.
15. Ibid.
16. Ibid.

Fig 3: US Strategic Nuclear Forces, 1991-2020

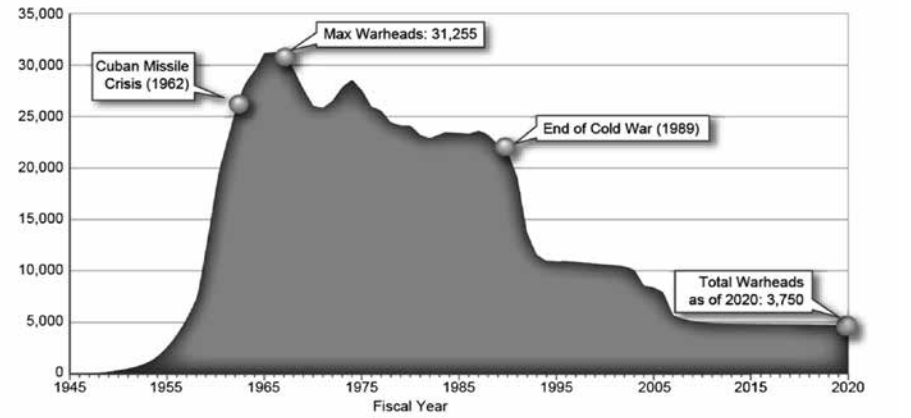


Source: Federation of American Scientists.17

The basic terms of the 1991 START Treaty included the maximum 1,600 deployed Strategic Nuclear Delivery Vehicles (SNDVs) such as ICBMs, SLBMs and heavy bombers, and 6,000 accountable warheads on ICBMs, SLBMs, and heavy bombers, of which no more than 4,900 could be on ICBMs and SLBMs (ballistic missile warheads) and 1,100 on mobile ICBMs.[18] As of September 2020, the US stockpile of nuclear warheads consisted of 3,750 warheads. The US land-based ballistic missile force (ICBMs) consisted of nearly 400 land-based Minuteman III ICBMs, each deployed with one warhead, spread among a total of 450 operational launchers which is in accordance with the New START Treaty.[19]

17. Ibid.
18. Daryl Kimball, "START I at a Glance", Arms Control Association, at https://www.armscontrol.org/factsheets/start1. Accessed on August 30, 2021.
19. Woolf, n. 11.

Fig 4: 2020 US Nuclear Warhead Stockpile



Source: US Department of State.[20]

Table 2: MIRVs Deployment under New START, March 2021

US MIRVs		Warheads	Deployed Launchers
Minuteman III (active)	ICBM	Up to 1-3 warheads	399/400
Trident II D5 (active)	SLBM	Up to 8-14 warheads	206
Poseidon (retired)	SLBM	Up to 10-14 warheads	-
Trident I (retired)	SLBM	Up to 8 warheads	-
Peacekeeper MX (retired)	ICBM	Up to 10 warheads	-

Source: Compiled by the author from the Bulletin of the Atomic Scientists.[21]

The second leg of the triad, the US ballistic missile submarine fleet, consists of 14 Trident submarines. Each can carry 20 Trident II (D-5) missiles—a reduction from 24 missiles per submarine. In general, these Trident II missiles

20. US Department of State, "Transparency in the U.S. Nuclear Weapons Stockpile", October 5, 2021, at https://www.state.gov/transparency-in-the-u-s-nuclear-weapons-stockpile/. Accessed on October 9, 2021.
21. Kristensen and Korda, n. 11, pp. 43-63 and Woolf, n. 11, p. 4.

can carry up to 8-12 reentry vehicles but under the New START Treaty, the limit is up to eight.[22]

LGM-118 Peacekeeper (MX)/Peacekeeper

The Peacekeeper missile, when under development, was known as the Missile-X for Missile-eXperimental. It was a solid-fuelled ICBM to attack hardened military targets. The Peacekeeper programme began in 1971 to increase US counter-strike capabilities. It employed an advanced guidance system and a MIRV system of approximately a dozen warheads, along with a cold launch system which was unique to the Peacekeeper. Till 1988, 114 missiles were produced. The Peacekeeper had a range of 9,600 km and the capacity to carry up to 10 MIRV warheads. It functioned as a complement to the Minuteman series. Peacekeepers were in operation from 1987 through 2005. In the late 1980s, the US deployed 50 Peacekeeper ICBMs, each with 10 warheads.[23]

The Peacekeeper had a range of 9,600 km and the capacity to carry up to 10 MIRV warheads. It functioned as a complement to the Minuteman series. Peacekeepers were in operation from 1987 through 2005.

The Strategic Arms Reduction Treaty II (START II) of 1993 would have successfully eliminated these missiles. In anticipation of the implementation of this treaty, the US decided to eliminate them. In 1994, the budget was increased by the air force for this elimination. But in 1998, Congress stopped the then Clinton Administration from "spending any money on the deactivation or retirement of these missiles until START II entered into force".[24] Later, work on missile retirement was initiated by the Bush Administration with a $14 million budget in October 2002 and was completed by September 2005. It is believed that financial considerations comprised one of the reasons for the US retiring the Peacekeeper missiles.[25]

22. Missile Threat, "Trident D5", at https://missilethreat.csis.org/missile/trident/. Accessed on July 30, 2021.
23. Missile Threat, "LGM-118 Peacekeeper (MX)", at https://missilethreat.csis.org/missile/lgm-118-peacekeeper-mx..Accessed on August 8, 2021.
24. Woolf, n. 11, p. 10.
25. Ibid.

There is a debate on how the Peacekeepers were affecting the nuclear balance. One school of thought advocated deployment of Peacekeepers as a stability enhancer and believed that the US developed MIRVs as a reaction to the ABM defence of the Soviet Union. This missile enhanced the deterrence capability of the United States because it was a mobile, rail-based system which could stay on the move in periods of heightened tension. Admiral Turner stated that the "MX added to the capability of our existing ICBMs—it would give us the potential for a surprise attack on Soviet ICBMs, it would make the Russians nervous, their fingers too, would have been on the trigger … we must commit ourselves to a doctrine of assured retaliation".[26]

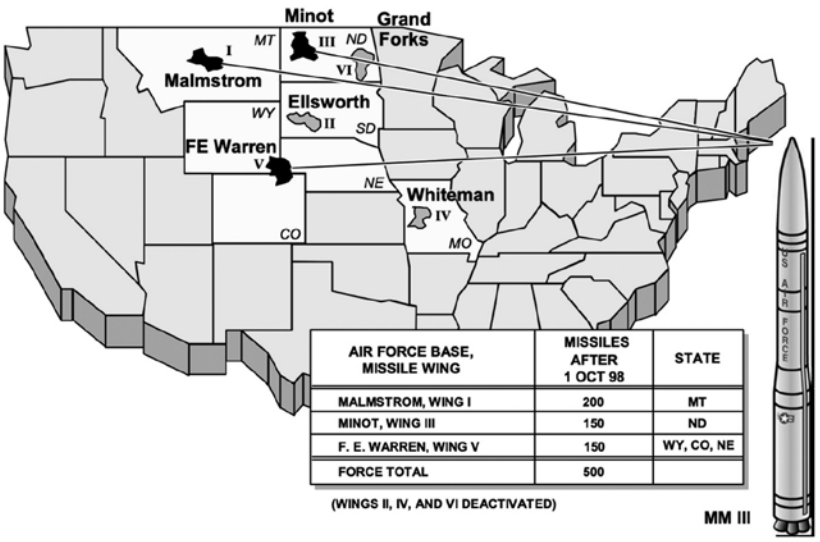
The other school of thought viewed the Peacekeeper as destabilising because of its capabilities which could potentially mount a counter-strike against the Soviet Union. It believed that the MX Peacekeeper could trigger a 'use it or lose it' dilemma in the Soviet strategic thinking. This could lead to a Soviet first strike.

Minuteman III

Currently, the LGM-30G Minuteman III is the sole land-based component of the US nuclear triad. It is a three-stage, solid-fuelled, intercontinental-range ballistic missile. It was the first MIRVed missile of the United States. Since the 1960s, the Minuteman has been the backbone of the US land-based nuclear strategic forces. The development of the Minuteman III began in 1960 and it entered into service with a force of 550 missiles.[27]

26. n. 23.
27. Missile Threat, "Minuteman III", at https://missilethreat.csis.org/missile/minuteman-iii/. Accessed on September 2, 2021.

Fig 5: Minuteman Weapon System Deployment



Source: minutemanmissile.com[28]

Currently, the US "Minuteman III ICBMS are located at three air force bases: F.E. Warren Air Force Base (AFB) in Wyoming, Malmstrom AFB in Montana, and Minot AFB in North Dakota. Each base supports 150 missile silos, but only 400 of the 450 silos currently hold operational missiles".[29]

These originally carried a 170 kiloton (kT) yield Mark 12 RV and, later, a 300 to 350 kT Mark 12A RV. Now it is speculated that they are equipped to carry the larger and more accurate single 300 to 475 kT Mark 21 RV.[30]

In 2006, the US planned to reduce the number of deployed Minuteman III ballistic missiles from 500 to 450. The US deactivated the missiles in Malmstrom's 564th Missile Squadron, which was known as the "odd squad".

28. Minuteman Missile, "Minuteman Weapon System: History and Description," at https://minutemanmissile.com/documents/MinutemanWeaponSystemHistoryAndDescription.pdf. Accessed on August 7, 2021.
29. Woolf, n. 11, p. 10.
30. n. 27.

On September 8, 2020, the US Air Force awarded Northrop Grumman Corporation a US$ 13.3 billion contract to develop a new nuclear missile, the Ground-Based Strategic Deterrent (GBSD) which will replace the Minuteman III ICBMs.

By 2008, the squadron was deactivated, all reentry vehicles and missiles were removed by the end of July 2008 and the squadron was deactivated by the end of August 2008.[31]

In 2014, the Obama Administration announced a report on the planned force structure under the New START. According to this, the air force would retain 400 deployed Minuteman III ICBMs within a total force of 450 deployed and non-deployed launchers. This provided the option to deactivate the missiles in the silos "that have been damaged by water intrusion, repair those silos, and return the missiles to them at a later date while it repaired additional silos".[32] Thus, the air force now has 400 silos loaded with operational missiles and 50 empty silos that are counted as "non-deployed" under the New START. The important point is that the US has not altered the "front end of the missiles or removed the old bulkhead". Therefore, the US retains the options to restore warheads to its ICBM force if the international security environment changes.[33]

On September 8, 2020, the US Air Force awarded Northrop Grumman Corporation a US$ 13.3 billion contract to develop a new nuclear missile, the Ground-Based Strategic Deterrent (GBSD) which will replace the Minuteman III ICBMs. The GBSD is also known as a 21st century deterrent. It will have a modular design and open architecture which allows for the replacement of ageing and outdated components. This modular approach would reduce the life-cycle cost of the GBSD and also provide flexibility for improvements throughout the life of the weapon system. It will also have improved security,

31. Global Security Newswire, "U.S. Deactivates 50 Strategic Missiles", August 4, 2008, as cited in Woolf, n. 11, pp. 10-11.
32. Gabe Starosta, "On New START, Timing Begins to Limit Force-Structure Alternatives," InsideDefense.com, May 14, 2013, quoted in Woolf, n. 11, p. 3.
33. Woolf, n. 11, p. 13.

potential manpower savings and improved throw-weight.[34]

MIRVed Submarine-Launched Ballistic Missiles

In total, as stated earlier, the US fleet of ballistic missile submarines consists of 14 Trident (Ohio class) submarines. These submarines were originally equipped to carry 24 Trident missiles. But, currently, as two submarines are in overhaul, there are 12 operational submarines that are carrying around 1,100 warheads. Under the New START limitations, to comply with launcher limits, each submarine can now carry only 20 missiles. Therefore, the four empty launch tubes have been removed.

The Nuclear Posture Review (NPR) of 2010 also endorsed a fleet of 14 Trident submarines and each submarine would be fitted with 20 missiles for the New START Treaty requirements.

To see the pattern of deployment, if we go back to 1990, the US deployed 18 Trident ballistic missile submarines (SSBNs). These were able to carry 24 Trident missiles. These 24 Trident missiles had the capability of carrying 8 warheads. Eight of these submarines were deployed at Bangor and were fitted with the older Trident I missiles. The other 10 submarines were equipped with the Trident II missiles at Kings Bay, GA. The Clinton Administration, in 1994, decided to keep a 14-submarine fleet and 4 submarines were planned to be "backfitted" to carry the Trident II missiles. In 2001, the Bush Administration decided to backfit 4 other Trident submarines with the Trident II missiles. Now all these submarines were carrying Trident II missiles. And instead of retiring 4 submarines, the US decided to convert them to carry conventional weapons and, thus, they were named as "guided missile" submarines (SSGNs). The Nuclear Posture Review (NPR) of 2010 also endorsed a fleet of 14 Trident submarines and each submarine would be fitted with 20 missiles for the New START Treaty requirements.[35]

34. Congressional Research Service, "Defense Primer: Ground Based Strategic Deterrent (GBSD) Capabilities", at https://sgp.fas.org/crs/natsec/IF11681.pdf. Accessed on August 29, 2021.
35. Woolf, n. 11, pp. 24-26.

The plan of backfitting 4 Trident submarines with the Trident II (D-5) missiles helped in replacing the ageing C-4 missiles. It increased accuracy and the capability of carrying a larger payload. These submarines provided the US with secure second-strike capability and, thus, enhanced strategic stability.[36] Of the 8 submarines that were in Bangor, WA, 4 were part of the backfit programme. The USS *Alaska*, USS *Nevada*, USS *Henry M. Jackson*, and USS *Alabama* were part of this backfit programme. The USS *Alaska* and USS *Nevada* completed their backfit programme and joined the fleet in 2002. The *Henry M. Jackson* and *Alabama* completed their engineering overhaul and backfit and entered in 2007 and 2008. All the Trident submarines in the US fleet now carry the Trident II missiles.[37]

The Trident II (D-5) can carry up to 8 warheads, but the US has continued to reduce the total number of warheads on its Trident missiles to comply with the New START Treaty. The point worth mentioning is that unlike the START that "attributed the same number of warheads to each missile of a given type, regardless of whether some of the missiles carried fewer warheads, the United States can deploy different numbers of warheads on different missiles and count only the actual warheads deployed on the force".[38] This leads to the possibility of each missile being tailored according to the mission assigned to that particular missile.[39]

The US Navy has scheduled a 48 years' service for the Trident submarines. Also, a life extension of the D-5 missiles, known as the D5LE (D-5 Life Extension) is planned, so that their reliability can be ensured for 42 years of the submarines' life. They will also be the initial missiles of the new Columbia class submarine.[40] The second life extension programme for the Trident II missile (D5LE2) was also planned in 2019. It was to ensure the reliability of the missile through the life of the Columbia class submarines. This second

36. Ibid.
37. Ibid.
38. Ibid., p. 27.
39. Hans M. Kristensen and Robert S. Norris, "United States Nuclear Forces, 2017", *Bulletin of the Atomic Scientists*, December 2016, p. 52.
40. Hans M. Kristensen and Robert S. Norris, "U.S. Nuclear Forces, 2018," *Bulletin of the Atomic Scientists*, March 2018, at https://www.tandfonline.com/doi/pdf/10.1080/00963402.2018.1438219?needAccess=true. Accessed on August 27, 2021.

life extension programme will ensure multiple benefits and will keep the Trident II missiles as a credible force in volatile threat environments.[41]

RUSSIA'S MIRVs: PATTERN OF DEVELOPMENT AND DEPLOYMENT

On August 29, 1949, the Soviet Union conducted its first nuclear device test. It tested the first thermonuclear bomb in 1953. The SS-3 or R-5 Pobeda was the first ballistic missile of the Soviet Union with a nuclear warhead which was tested in 1956 but it was a short-range missile. Subsequently, by 1959, it tested and deployed the SS-4 Sandal or R-12 Dvina, a theatre ballistic missile that became the central point of the 1962 Cuban missile crisis. It was capable of delivering a megaton-class nuclear warhead at medium range. Then with the SS-5 Skean or R-14 Chusovaya, the Soviet missile range was further extended because it was an intermediate-range ballistic missile. The SS-6 Sapwood or R-7 Semyorka was first successfully tested on August 21, 1957, and became the world's first ICBM. It was capable of delivering nuclear warheads to US targets. On October 4, 1957, the Soviet Union launched the Sputnik 1, the first artificial satellite into space. Since 1960, the Soviet Union began producing a large number of ICBMs and by 2010, it had built around 5,000 ICBMs.

The ICBMs of Russia can be traced by categorising these into six periods. The first period can be bracketed from 1959-65. In this period, the ICBMs were deployed above ground and were vulnerable. They were also not very accurate and took long hours to get ready for launch. The second period was from 1965 to 1973, when extensive deployment of the SS-9, SS-11 and SS-13 was done in underground silos. The third period was seen from 1973 to 1985 and was the most crucial one for the MIRVed missiles of the Soviet Union. In this period, a dramatic increase in the number of warheads can be attributed to the deployment of MIRVs. This was the time when the Soviet Union started deploying the SS-17 ICBM with up to 4 warheads. This was

41. Richard R. Burgess, "Navy's SSP Admiral: New Missile Planned for Introduction on 9th Columbia SSBN," *Seapower Magazine*, June 10, 2021, at https://seapowermagazine.org/navys-ssp-admiral-new-missile-planned-for- introduction-on-9th-columbia-ssbn/. Accessed on August 29, 2021.

the first MIRVed missile whose deployment began on December 30, 1975. It was soon followed by the SS-18 ICBMs with up to 10 warheads and the SS-19 ICBM with 6 warheads.[42] In the fourth period from 1985-91, new silo-based and mobile ICBMs were introduced which increased survivability and accuracy. The fifth period was from 1991 to 2008 in which Russia reduced its strategic forces after signing the START I. It reduced these from 1,398 ICBMs with more than 6,600 warheads in 1991 to 415 ICBMs with 1,422 warheads in 2008.[43] The sixth period was after 2008, with Russia continuously modernising its forces.

Table 3: Russian ICBMs

NATO Designation	Russian Designation	Period (Approximately)	Warheads (Approximately)
SS-6 Sapwood	R-7	1960-1967	1
SS-7 Saddler	R-16	1961-1977	1
SS-8 Sasin	R-9	1963-1977	1
SS-9 Scarp M1	R-36	1966-1979	1
SS-9 Scarp M2	R-36	1967-1978	1
SS-9 Scarp M3	R-36	1969-1979	1
SS-9 Scarp M4	R-36	1970-1977	Up to 3 (MRV)
SS-11 Sego M1	UR-100	1965-1979	1
SS-11 Sego M2	UR-100K	1973-1990	1
SS-11 Sego M3	UR-100K	1975-1990	Up to 3 (MRV)
SS-11 Sego M4	UR-100U	1975-1979	Up to 6 (MRV)
SS-13 Savage M1	RT-2	1969-1979	1
SS-13 Savage M2	RT-2P	1975-1983	1
SS-17 Spanker M1	MR UR-100/RS-16 A	1975-1990	Up to 4

42. Federation of American Scientists, "UR-100MR/SS-17 Spanker", at https://nuke.fas.org/guide/russia/icbm/ur-100mr.htm. Accessed on April 2, 2022.
43. Though the Multiple Reentry Vehicle (MRV) deploys multiple warheads, they are not individually targetable. Norris and Kristensen, n. 10, pp. 66-68.

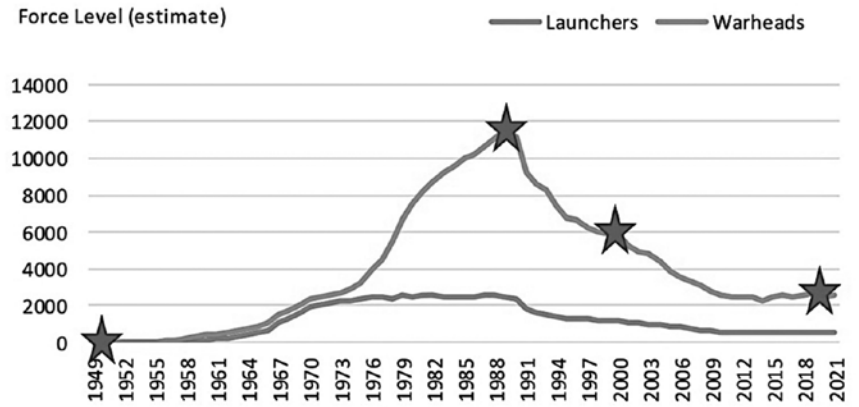
SS-17 Spanker M 2	MR-UR-100 UTTH/RS-16 A	1975-1990	1
SS-17 Spanker M 3	MR-UR-100 UTTKh/100U/ RS-16B	1978- 1990	Up to 4
SS-18 Satan M1	R-36M	1974-1983	1
SS-18 Satan M2	R-36M	1975-1980	Up to 8
SS-18 Satan M3	R-36M UTTkh	1979-1986	1
SS-18 Satan M4	R-36 MUTTH	1979-2005	Up to 10
SS-18 Satan M5	R-36 MUTTH	1986-2009	1
SS-18 Satan M6	R-36M2/RS20V	1988-present	Up to 10
SS-19 Stilleto M1	UR-100N	1975-1983	Up to 6
SS-19 Stilleto M2	UR-100N	1977-1982	1
SS-19 Stiletto M3	UR-100NUTTH/ RS-18	1980-present	Up to 6
SS-19 M4	? (Avangard)	2019	1 HGV
SS-24 Scalpel M1	RT-23UTTH	1987-2005	Up to 10
SS-24 Scalpel M2	RT-23UTTH	1988-2000	Up to 10
SS-25 Sickle	RT-2PM Topol/ RS-12 M	1988	Up to 4
SS-27 Mod 1(mobile)	RS-12M1/ Topol-M	2006	1
SS-27 Mod 1 (silo)	RS-12M1/ Topol-M	1997	1
SS-27 Mod 2 (mobile)	RS-24 (Yars)	2010	Up to 4
SS-27 Mod 2 (silo)	RS-24 (Yars)	2014	Up to 4
SS-X-29	RS-28 (Sarmat)	2022	Up to 10

Source: Table compiled by the author, based on data available from the *Bulletin of the Atomic Scientists* and CSIS Missile Defence Project.[44]

44. Norris and Kristensen, n. 10. Also see, Hans M. Kristensen and Matt Korda, "Russian Nuclear Weapons", *Bulletin of the Atomic Scientists*, February 25, 2022, at https://www.tandfonline.com/doi/full/10.1080/00963402.2022.2038907. Accessed on April 21, 2022; and Missile Threat, "RT-2PM2 Topol-M (SS-27 Mod 1" Sickle B), at https://missilethreat.csis.org/missile/ss-27/. Accessed on May 15, 2022.

Throughout the 1960s and 1970s, the Soviet stockpile of nuclear warheads increased exponentially and peaked in 1986 when it had more than 40,000 warheads. Amongst these, around 10,700 warheads were carried by long-range delivery systems. Like the United States, the Soviet Union also succeeded in developing a triad of nuclear forces by the 1960s. It consisted of land-based ICBMs, SLBMs and heavy bombers.[45]

Fig 6: Estimates of Soviet/Russian Strategic Forces



Source: Federation of American Scientists.[46]

Fortunately, by the end of the 1960s, both the US and Soviet Union initiated negotiations for arms control. The Strategic Arms Limitation Talks I (SALT I), signed in 1972,[47] and was considered the crowning achievement of the Nixon-Kissinger strategy of détente. Though it capped the construction and size of ICBM silo launchers and limited the number of launchers for SLBMs, it did not pose any limit on the nuclear warheads that could be carried by the ICBMs or SLBMs. Thus, throughout the 1970s, the Soviet Union continued with its programme

45. Amy F. Woolf, "Russia's Nuclear Weapons: Doctrine, Forces, and Modernization", Congressional Research Service Report R45861, 2020, at https://sgp.fas.org/crs/nuke/R45861.pdf. Accessed on September 5, 2021.
46. Ibid., p. 11.
47. US Department of Defence, "Strategic Arms Limitations Talks/ Treaty (SALT) I and II, at https://history.state.gov/milestones/1969-1976/salt. Accessed on August 29, 2021.

of modernising and expanding its nuclear forces. During this time, it commissioned numerous "Delta-class strategic missiles submarines, armed with single-warhead, intercontinental-range SS-N-8 SLBMs; it developed the Tu-22M Backfire intermediate-range bomber aircraft; also began to develop a new supersonic strategic heavy bomber, the Tu-160 Blackjack, and deployed the SS-20 intermediate-range ballistic missile in 1976 which, along with other missiles of its class, was eliminated in the 1987 INF Treaty".[48] In 1991, Russia inherited the nuclear triad of the Soviet Union. Its undersea leg consisted of the Delta and Typhoon class submarines with MIRVed SLBMs and its ICBM leg consisted of the SS-18, SS-19, and SS-25 MIRVed missiles.

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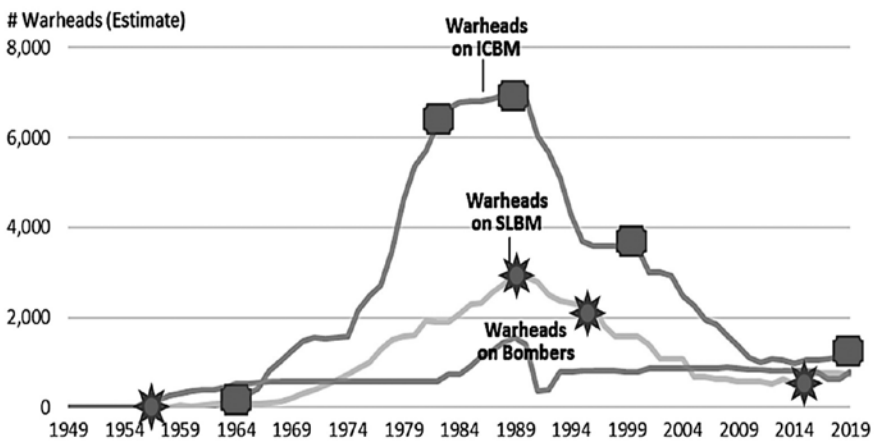
Fig 7: Estimates of Warheads on Soviet/ Russian Strategic Nuclear Forces



Source: Federation of American Scientists.[49]

48. Woolf, n. 45, p. 13.
49. Ibid., p. 14.

Gradually, the strategic forces began to decline because of the 1991 START Treaty, the 2002 Strategic Offensive Reductions Treaty and the 2010 New START Treaty.[50] Currently, the remaining Soviet era ICBMs are the SS-18, SS-19 and SS-25. The SS-18 is a 10-warhead heavy ICBM and was first deployed in 1988; it is now reaching the end of its life and is being replaced by the SS-29 (Sarmat or RS-28). The SS-19 came into service in 1980 and may be replaced by the SS-27 Mod 2 (RS-24). Russia is also retiring its SS-25 (RS-12 M or Topol) missile and is replacing it with the SS-27 Mod 2 (RS-24). The SS-27 has two versions, Mods 1 and 2. These two variants could carry more warheads than all of the SS-18s.[51]

Fig 8: Bases for Russian Strategic Forces

Source: Map from Congressional Research Service (CRS).[52]

The SS-27 Mod 1 is a single warhead missile known as the Topol-M in Russia. Its deployment was completed in 2012 with 78 missiles. Currently,

50. Nuclear Threat Initiative, "Russia", at https://www.nti.org/learn/countries/russia/. Accessed on July 8, 2021.
51. Hans M. Kristensen and Matt Korda, "Russian Nuclear Forces, 2020", *Bulletin of the Atomic Scientists*, vol 76, no. 2, 2020, pp. 105-107, at https://www.tandfonline.com/doi/pdf/10.1080/00963402.2020.1728985. Accessed on July 14, 2021.
52. Woolf, n. 45, p. 17.

Russia is focussing on the SS-27 Mod 2, also known as the RS-24 (Yars). It is a modified SS-27 Mod 1 or Topol-M, and can carry up to four MIRVs. It was first deployed in 2010 and Russia now has 140 Yars.[53] According to the Russian Defence Ministry, preparations have been going on for the Yars bases across the country, and were to be completed by 2021.[54]

UR-100 MR/SS-17 Spanker

This was amongst the first MIRVed ICBMs of the Soviet Union. It had three variants. The SS-17 Mod-1 was the initial version which had the capability of carrying up to four MIRV warheads. Its deployment began in 1975. The SS-17 Mod-2 was able to carry only one warhead. The SS Mod-3 was also able to carry up to four MIRV warheads.[55] They were all gradually removed from the inventory.

Table 4: UR-100MR/SS-17 Spanker/MR-UR-100 Sotka

Variants	Type of Warhead	Warheads	Deployed
SS-17 Mod-1/ Spanker/ RS-16A/ MR-UR-100	MIRV	Up to 4	1975-1990
SS-17 Mod-2/ Spanker/ MR-UR-100 UTTH	MIRV	1	1975-1990
SS-17 Mod-3/ Spanker/ MR-UR-100kh/100U	MIRV	Up to 4	1980-1990

Source: Table compiled by the author, based on data available from the Federation of American Scientists.[56]

R-36M/SS-18 Satan

The R-36 ICBMs were initially developed by the Soviet Union, now the Russian Federation. There were six versions, with only the Mod-6 still in

53. Ibid., p. 107.
54. TASS, "The Regiment with the Yars-S Complex Will Begin Combat Duty in Barnaul in November 2019", at https://tass.ru/armiya-i-opk/7016703. Accessed on July 15, 2021.
55. Federation of American Scientists, "UR-100 MR/SS-17 Spanker", at https://nuke.fas.org/guide/russia/icbm/ur-100mr.htm. Accessed on October 10, 2021.
56. Ibid.

Currently, only the Mod 6 is in operation and can house 10 MIRVs. Till the time the SS-X-30 (RS-28 Sarmat) comes into operation, the SS-18 Mod-6s are expected to remain in operation.

operation. Development of the SS-18 began in 1964. Deployment began from December 30, 1975. Over time, the previous versions of the SS-18 such as the SS-18 Mod-1/2/3 missiles were removed, and replaced by the Mod-4. The Mod-4 had the capability to carry around up 8 to 10 MIRVs. In 1988, the replacement of the Mod-4 began by the single warhead Mod-5 and multiple warhead Mod-6. Currently, only the Mod 6 is in operation and can house 10 MIRVs. Till the time the SS-X-30 (RS-28 Sarmat) comes into operation, the SS-18 Mod-6s are expected to remain in operation.[57] After the successful flight test of the Sarmat missile in April 2022, these missiles will be retired.

Table 5: Family of R-36M/SS-18 Satan

R-36M / SS-18 Satan Variants	Type of Warhead	Warheads	Maximum Deployed Numbers (approx.)	Deployment
R-36M/ SS-18 Mod 1/Satan/ RS-20A	Single	Up to 1	148	1974-1983 (approx.)
R-36M/ SS18 Mod 2/Satan/ RS-20A	MIRV	Up to 8	10	1975-1980 (approx.)
R-36M UTTkh/ SS-18 Mod 3/Satan/ RS-20A	Single	1	30	1979-1986 (approx.)
R-36MU UTTKh/ SS-18 Mod 4/Satan/ RS-20B	MIRV	Up to 10	278	1979-2005 (approx.)

57. Missile Defense Project, "R-36 (SS-18 "Satan")," Missile Threat, Centre for Strategic and International Studies, August 10, 2016. Last modified August 2, 2021, at https://missilethreat.csis.org/missile/ss-18/. Accessed on April 20, 2022.

R-36M2/ SS-18 Mod 5/Satan/ RS-20V	Single	1	104	1986-2009
R-36M2/ SS-18 Mod 6/Satan/ RS-20V	MIRV	Up to 10	58	1988-present

Source: Table compiled by the author, based on data available from the Federation of American Scientists.[58]

By 1975, the R-36 ICBMs had opened a "window of vulnerability". It was speculated that only a few of the Minuteman could survive a Soviet attack. This "window of vulnerability" of US land-based strategic missiles became a major debate in the US strategic circles in the 1970s and 1980s. The R-36/SS-18 was the main focus of arms control initiatives in the Bush and Reagan Administrations. It was seen as a destabilising first strike weapon, and because of its enormous threat to the balance of power, the START II Treaty specifically tried to ban land-based MIRV systems.[59]

UR-100/SS-19 "Stiletto"/RS-18/UR-100NUTTH

This ICBM was also amongst the first Soviet missiles to be equipped with MIRV warheads along with the SS-17 and SS-18. There have been three SS-19 models: Mod-1 was in service from 1975-83, Mod-2 was in service from 1977-82, and Mod-3 from 1980 to the present. The Avangard hypersonic glide vehicle is presently "fielded on a UR-100 booster and emplaced in existing UR-100 silos". This is also known as the SS-19 Mod-4.[60]

58. Federation of American Scientists, "R-36M/SS-18 Satan", at https://nuke.fas.org/guide/russia/icbm/r-36m.htm. Accessed on October 10, 2021. Also see, Missile Threat CSIS Missile Defense Project, "R-36 (SS-18 'Satan'), at https://missilethreat.csis.org/missile/ss-18/. Accessed on April 30, 2022.
59. Ibid.
60. Ibid.

Table 6: UR-100/SS-19 "Stiletto"/RS-18/UR-100NUTTH

RS-18/ SS-19/ Stiletto	Type of Warhead	Warheads	Deployment
SS-19 Mod-1/ Stiletto Mod-1/ UR-100N	MIRV	Up to 6	1975-1983
SS-19 Mod-2/ Stiletto Mod-2/ UR-100N	Single	1	1977-1982
SS-19 Mod-3/ Stiletto Mod-3/ UR-100NUTTH	MIRV	Up to 6	1980-present
SS-19 Mod-4	Avangard	1 HGV	2019-present

Source: CSIS Missile Defence Project.[61]

SS-27 Mod-2/RS-24 Yars/SS-29

This ICBM can carry up to four MIRVs and has been in service since 2010. It has an RV of a newer design which allows it to manoeuvre in space and also during reentry.[62]

SS-X-29/RS-28 (Sarmat)

This MIRVed ICBM is designed to replace the ageing SS-18 Satan. On April 20, 2022, Russia conducted the first flight test of the RS-28 Sarmat ICBM. It can reportedly carry up to 10 large warheads and 16 smaller ones, and also a combination of warheads and counter-measures or hypersonic glide vehicles.[63] The media has dubbed the SS-29 as the "Son of Satan" because "it is a follow-on to the SS-18, which the United States and North Atlantic Treaty Organization (NATO) designated 'Satan'—presumably to reflect its extraordinary destructive capability".[64] The SS-29 will be "installed in a total of 46 silos of the three regiments at the Dombarovsky missile field".[65]

61. Ibid.
62. Missile Threat CSIS Missile Defense Project, "RS-24 Yars (SS-27 Mod-2)", at https://missilethreat.csis.org/missile/rs-24/. Accessed on October 10, 2021.
63. Missile Defense Project, "RS-28 Sarmat," Missile Threat, Centre for Strategic and International Studies, May 17, 2017. Last modified July 31, 2021, at https://missilethreat.csis.org/missile/rs-28-sarmat/. Accessed on October 10, 2021.
64. Kristensen and Korda, n. 51, p.108.
65. Ibid.

Submarine Launched Ballistic Missiles

The sea-based leg of the Soviet Union was built in the 1960s with the deployment of SLBMs on the Golf, Hotel, and Yankee classes submarines. Though these submarines carried intermediate-range missiles, their mobility allowed them to successfully threaten Europe, and, to some extent, the US. Currently, Russia's Strategic Naval Forces have mainly 10 strategic submarines of three different types: the Delta, Typhoon, and Borei. The Delta and Borei submarines have the capability to carry 16 SLBMs with multiple warheads on a missile. Under the New START, the submarine fleet can carry 600 warheads. Most of the submarines in Russia are the older Delta class. These include the Delta III submarine and 6 Delta IV submarines. The last of these Delta class submarines were built in 1992. They are now based in Russia's Northern Fleet. Delta submarines were deployed with the three-warhead SS-N-18 missile, and the Delta IV submarines carry the four-warhead SS-N-23 missile. The Sineva system is an upgraded version of this and entered service in 2007.[66] Another modification known as the Liner could reportedly carry up to 10 warheads.[67]

Table 7: Russia's SLBMs

SLBMs	Year	Warheads
SS-N-18 M1 Stingray/ RSM-50/	1978	Up to 3 (MIRV)
SS-N-23 M2/3/RSM-54 (Sineva/Layner)	2007	Up to 4 (MIRV)
SS-NX-32/RSM-56/Bulava	2018	Up to 6 (MIRV)

Source: *Bulletin of the Atomic Scientists*.[68]

66. Woolf, n. 45, p. 19.
67. Pavel Podvig, "Strategic Fleet: Russian Strategic Nuclear Forces", June 2017, at http://russianforces.org/navy/. Accessed on August 29, 2021.
68. Hans M. Kristensen and Matt Korda, " Nuclear Notebook: How Many Nuclear Weapons does Russia have in 2022", *Bulletin of the Atomic Scientists*, February 23, 2022, at https://thebulletin.org/premium/2022-02/nuclear-notebook-how-many-nuclear-weapons-does-russia-have-in-2022/. Accessed on March 30, 2021.

Each deployed Trident II D-5 missile is capable of carrying 12 warheads. It means that each Vanguard class submarine is capable of carrying up to 192 warheads.

Construction of Russia's Borei class SSBN began in 1996. It joined the Northern Fleet in 2013. It is speculated that Russia will deploy 10 Borei class submarines, with 5 in the Pacific Fleet. Three submarines are currently in service, all in the Northern Fleet, and 5 more are in different stage of construction. The latter 5 submarines will be improved versions, known as the Borei-A/II. Russia plans to complete the "first eight ships by 2023 and to finish the last two by 2027. Borei class submarines can carry 16 of the SS-N-32 Bulava missiles; each missile can carry six warheads. The Bulava missile began development in the late 1990s. It experienced numerous test failures before it entered service in 2018."[69] Russia deploys mainly three types of SLBMs: the R-29 R (North Atlantic Treaty Organisation (NATO): SS-N-18 also known as the Stingray); the second one is the R-29 RM Sineva (NATO: SS-N-23 'Skiff'); and the third is the R-30 Bulava (NATO: SS-NX-32).[70]

The R-29-R is the first sea-based Soviet ballistic missile, carrying 3 to 7 MIRVs with a range of 6,500 to 8,000 km.

UNITED KINGDOM'S MIRVs: PATTERN OF DEVELOPMENT AND DEPLOYMENT

The UK's strategic nuclear deterrence relies only on its nuclear-powered ballistic missile submarines (SSBNs), the Vanguards, for its nuclear deterrent and the warheads deployed are the Trident Holbrooks which are based on the United States' W76 warhead.[71] Each deployed Trident II D-5 missile is capable of carrying 12 warheads. It means that each Vanguard class submarine is capable of carrying up to 192 warheads.

69. Woolf, n. 45, p. 19.
70. Nuclear Threat Initiative, "Russia", at https://www.nti.org/learn/countries/russia/delivery-systems/. Accessed on July 8, 2021.
71. Centre for Arms Control and Non-Proliferation, "Fact Sheet: The United Kingdom's Nuclear Inventory", at https://armscontrolcenter.org/fact-sheet-the-united-kingdoms-nuclear-arsenal/. Accessed on August 17, 2021.

Currently, according to the Nuclear Notebook of 2021, the UK has a stockpile of "approximately 225 nuclear warheads of which up to 120 are operationally available for deployment on four Vanguard class nuclear-powered SSBNs".[72] Each of these SSBNs has 16 missile tubes. One of the four SSBNs remains deployed at sea at all times. This is known as the Continuous At-Sea Deterrent (CASD) posture. This posture ensures a second-strike capability in the event of a nuclear attack. Of the remaining submarines, two remain in port and can be deployed at short notice, while the fourth remains in overhaul and cannot be quickly deployed, if at all.

The United Kingdom's nuclear history is intertwined with the United States from the days of World War II. In October 1952, the UK tested its first nuclear device. In 1958, the US and UK signed the "Mutual Agreement for Cooperation on the Uses of Atomic Energy for Mutual Defence Purposes" which is also known as the Mutual Defence Agreement.

Table 8: UK's MIRVed SLBMs

Designation	No.	Year Deployed	Range	Warheads	Total Available Warheads
Trident II D5	48	1994	>10,000	Up to 8	225

Source: *Bulletin of the Atomic Scientists*.[73]

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72. Hans M. Kristensen and Matt Korda, "United Kingdom Nuclear Weapons, 2021", *Bulletin of the Atomic Scientists*, vol. 77, no. 3, 2021, p. 153, at https://www.tandfonline.com/doi/citedby/10.1080/00963402.2021.1912309?scroll=top&needAccess=true. Accessed on October 9, 2021.
73. Ibid., p. 154.

which is also known as the Mutual Defence Agreement. This agreement is the cornerstone of the UK's nuclear programme because it allows for sharing classified information to develop nuclear power.[74]

Between 1974-81 the UK's stockpile peaked at approximately 500 warheads. By 1998, the Trident was left as the only nuclear weapon system of the UK. The total warhead stockpile was reduced by 20 per cent and the number of operationally available warheads fell from 400 in the 1980s to 300.[75] In 1998, the Strategic Defence Review (SDR) prescribed that the UK should maintain a minimum nuclear deterrent force structure in which, although each Trident was capable of carrying 12 warheads, it was stipulated that no more than three warheads would be fitted to each missile.[76]

Fig 9: Estimated United Kingdom's Nuclear Weapons Stockpile, 1953-2025

Source: *Bulletin of the Atomic Scientists*.[77]

Since 1998, the UK has maintained a "minimal deterrent with the smallest deployed nuclear arsenal of the nuclear weapon states".[78] In October 2010,

74. United Kingdom Parliament, "The UK's Strategic Nuclear Deterrent", at https://publications.parliament.uk/pa/cm200506/cmselect/cmdfence/986/98605.htm. Accessed on August 18, 2021.
75. Ibid.
76. Ibid.
77. Kristensen and Korda, n. 72, p. 155.
78. Centre for Arms Control and Non-Proliferation, "Fact Sheet: The United Kingdom's Nuclear Inventory", at https://armscontrolcenter.org/fact-sheet-the-united-kingdoms-nuclear-arsenal/. Accessed on August 17, 2021.

the Strategic Defence and Security Review (SDSR) announced that the United Kingdom would reduce its overall nuclear weapon stockpile to no more than 180 by the mid-2020s. The UK government pledged to reduce the number of warheads on-board each submarine. In 2015, the SDSR reaffirmed its statement of reducing the size of the nuclear stockpile. By then, the number of operationally available nuclear warheads had already been reduced from fewer than 160 to no more than 120, After showing the grit to reduce the size of its nuclear stockpile for two decades, in 2021, the UK government reversed the commitment to gradual disarmament, backtracked, and declared a "significant increase in the upper limit of the United Kingdom's nuclear inventory, up to no more than 260 warheads".[79]

In the upcoming pattern of deployment, the UK has committed to replace its current fleet of Vanguard class SSBNs with the new Dreadnought class SSBNs, which may enter service in the early 2030s and can have a service life of 30 years. The four boats will be named *Dreadnought, Valiant, Warspite* and *King George VI*.[80] The Dreadnought class SSBNs will have new "Quad Pack" common missile compartments which will hold four launch tubes. Each Dreadnought class SSBN will have three Quad Packs on-board for a planned total of 12 launch tubes which is a reduction from the 16 launch tubes that are currently carried by the UK's Vanguard class submarines.[81] Currently, the UK is upgrading its warheads. The *Nukewatch* stated that in 2020 "two SSBNs had been loaded with Mk4A-upgraded warheads".[82]

79. HM Government, "Global Britain in a Competitive Age the Integrated Review of Security, Defence, Development and Foreign Policy", 2021, at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/975077/Global_Britain_in_a_Competitive_Age-_the_Integrated_Review_of_Security__Defence__Development_and_Foreign_Policy.pdf#page=78. Accessed on July 31, 2021.
80. UK Ministry of Defence, "Defence Secretary Praises 50 Years of Nuclear Service as New Submarine Is Named", Press Release. May 3, 2019, at https://www.gov.uk/government/news/defence-secretary-praises-50-years-of-nuclearservice-as-new-submarine-is-named. Accessed on August 2, 2021.
81. Kristensen and Korda, n. 72, p. 155.
82. Nukewatch, "Warhead Convoy Movements Summary 2020", at https://www.nukewatch.org.uk/wp-content /uploads/2021/01/Convoy-log-2020.pdf. Accessed on September 7, 2021.

FRANCE'S MIRVs: PATTERN OF DEVELOPMENT AND DEPLOYMENT

France has approximately 290-300 nuclear weapons comprising both strategic and tactical nuclear capabilities. Nearly 280 of them are deployed. It also has fighter aircraft as deterrents.[83] SLBMs constitute the backbone of the French nuclear deterrent. The sea leg consists of four Le Triomphant-class SSBNs—*Le Triomphant* (hull number S616), *Le Temeraire* (S617), *Le Vigilant* (S618) and *Le Terrible* (S619).[84] Of these submarines, one remains deployed at all times. Each submarine is capable of carrying a set of 16 M51 domestically manufactured SLBMs that can carry up to 5-6 warheads.[85]

The French Navy has transitioned from the M45 SLBMs to the newer M51s. The last M45 was offloaded in late 2016. The M51 has better range and accuracy than the M45 and can carry up to six 100-kiloton TN75 MIRV warheads. Also, the M51.2 which is an upgraded version of the M51.1, was flight tested on July 1, 2016, and was declared operational in 2017.[86] The M51.2 which carries a new warhead the "*tete nucleaire oceanique* or TNO", has since been added to the *Le Temeraire*.[87] A third iteration of the M51.3 is in development and will be completed by 2025: it will ensure more accuracy and increased range.[88]

83. Hans M. Kristensen and Matt Korda, "French Nuclear Forces, 2019", *Bulletin of the Atomic Scientists*, vol. 75, no. 1, 2019, pp. 51-55, at https://www.tandfonline.com/doi/full/10.1080/00963402.2019.1556003. Accessed on July 7, 2021.
84. Ibid.
85. Nuclear Threat Initiative, "France", at https://www.nti.org/learn/countries/france/nuclear/. Accessed on August 20, 2021.
86. F. Parly, "Madame Florence Parly, Ministre des armées, Visite de l'usine des Mureaux: Ariane Group." [Florence Parly, Minister of the Armed Forces, Visit to the Mureaux Factory: Ariane Group.], French Ministry of the Armed Forces, Mureaux, December 14, 2017, at https://www.defense.gouv.fr/actualites/communaute-defense/discours-de-florence-parly-ministre-des-armees-prononce-a-l-usine-des-mureaux-arianegroup-le-14-decembre-2017. Accessed on July 30, 2021.
87. L. Willett, "Ballistic Trajectory: French SLBM Technology Developments Boost Operational Output", *Jane's International Defence Review*, 2018, at https://janes.ihs.com/Janes/Display/FG_1080227-IDR. Accessed on July 30, 2021.
88. Kristensen and Korda, n. 83, p. 52.

Table 9: France's MIRVed SLBMs

Designation	Year Deployed	Warheads
M51.1	2010	Up to 4-6
M51.2	2017	Up to 4-6
M51.3	in development	
M51.4	in development	

Source: Compiled from the *Bulletin of the Atomic Scientists*.[89]

By 2030, the Triomphant class SSBNs will also be on the verge of being retired. Therefore, development of a third generation SSBNs is going on. The new submarine class known as the SNLE-3G is also associated with the M51.4 SLBM and will start entering operational service by 2035. It is expected to have a longer hull and advanced stealth features.[90]

IMPACT OF MIRVs ON NUCLEAR DETERRENCE AND STRATEGIC STABILITY

By the mid-1960s, both superpowers had achieved an invulnerable deterrence posture. There was general stability at the strategic level. But the advent of the Anti-Ballistic Missile (ABM) system combined with MIRVs changed the situation. There are generally two schools of thoughts on the impact of MIRVs on nuclear deterrence and strategic stability. One argues that MIRVs are stabilising as they ensure a second-strike capability and increase deterrence; the other school argues that MIRVs are destabilising because they tend to increase the possibility of a first strike, can overwhelm the ABM system, lead to miscalculations and misunderstandings, and they are also hard to negotiate for in arms control.

During the 1960s and 1970s, some American strategists argued that MIRVs, along with a nuclear triad, would increase deterrence and discourage a

89. Ibid.
90. X. Vavasseur, "Here Is the First Image of the French Navy Next Generation SSBN-SNLE 3G," *Navy Recognition*, October 3, 2018, at http://www.navyrecognition.com/index.php/news/defence-news/2018/october-2018-navy-naval-defense-news/6538-here-is-the-first-image-of-the-french-navy-next-generation-ssbn-snle-3g.html. Accessed on October 9, 2021. Also see, Timothy Wright, "Counting the Cost of Deterrence: France's Nuclear Recapitalisation", 2021, at https://www.iiss.org/blogs/military-balance/2021/05/france-nuclear-recapitalisation. Accessed on September 5, 2021.

MIRVed ICBMs tend to increase the possibility of a first strike because of their higher accuracy, fast response time and multiple warheads which can destroy several targets at the same time.

Soviet first strike, because they would complicate the Soviet Union's attack planning and ensure the survivability of US forces in the case of a Soviet first strike. Moreover, the accuracy of MIRVed ICBMs, with the ability to respond promptly at hardened targets such as the Soviet Union's command posts and silos would also increase deterrence. MIRVed SLBMs also would complicate Soviet efforts to launch a disarming first strike and to retaliate if such an attack was ever attempted. In other words, MIRVs have been defended for being a "cost-effective means to cover increased Soviet targets, a hedge against Soviet ABM designs".[91] As in deterrence, interestingly, "offensive weapons are those that provide defense", MIRVs are good in enhancing counter-force capabilities.[92] And they also improve the first strike capability, which has important military strategic significance.

On the other side of the debate, the precise fact that MIRVs tend to increase the first strike possibility makes them extremely destabilising. Once they are installed on existing missiles, MIRVs immensely increase the available number of deliverable warheads. The military advantage with this development comes in the understanding that the possessor would try to strike first. With reasonable confidence in the precision of its warheads, the possessor could consider itself capable of "almost completely disarming its opponents' land-based missile force by saturating it with a skillfully planned MIRV barrage".[93] Therefore, MIRVed ICBMs tend to increase the possibility of a first strike because of their higher accuracy, fast response time and multiple warheads which can destroy several targets at the same time.

In other words, MIRVed missiles disrupted the stability that favoured the earlier nuclear math in the 1970s. The United States began deploying

91. W. C. Potter, "Coping with MIRV in a MAD World", *Journal of Conflict Resolution*, vol. 22, no. 4, 1978, pp. 599-626.
92. Robert Jervis, "Cooperation under the Security Dilemma", in Barry Buzan and Lane Hansen (eds), *The Cold War and Nuclear Deterrence,* International Security, vol 1, 2007, p. 159.
93. B. S. Lambeth, "Deterrence in the MIRV Era", *World Politics*, vol. 24, no. 02, 1972, pp. 224-225.

MIRVs on Minuteman III ICBMs with 3 warheads and Poseidon SLBMs which had more than 10 warheads. The Soviets also started deploying the SS-18 Satan which had 8-10 warheads and SS-19 Stilleto which had 6 warheads. MIRVs can destroy multiple adversary targets. This means that by shooting first, an attacker with MIRVed missiles could eliminate the adversary's ground-based forces and still be left with a winning situation and its own terms for peace. This was obviously bad for strategic stability because the party that is threatened by MIRVed missiles would also have a strong incentive to attack first.

ABM systems came into place to counter single warheads from ICBMs. The concept was simple, and the economic cost was also low because the cost of an ICBM launching a warhead was always more than that of the smaller interceptor missile that would be used to destroy the incoming ICBM. Therefore, this equation favoured defence.

Also, there was the logic of "cost-exchange ratios favour shooting first at a MIRVed force because a smaller number of attacking missiles could preemptively destroy a much larger part of the MIRVed adversary's total nuclear arsenal".[94] And with both parties being aware of this logic, they had the "use it or lose it" dilemma: shoot first or face loss and damage. This was also beneficial for the attacker because then there would be no requirement of increasing the number of missiles and launch facilities to cause destruction. While one warhead missile can target only one area, in a MIRVed missile, the post-boost stage or bus stage acts as a dispenser of warheads at different areas.

MIRVs also overwhelm ABM systems and reduce their effectiveness without even increasing the size of the missile fleet. ABM systems came into place to counter single warheads from ICBMs. The concept was simple, and the economic cost was also low because the cost of an ICBM launching a warhead was always more than that of the smaller interceptor missile that

94. Dakota S Rudesill, "MIRVs Matter: Banning Hydra-Headed Missiles in a New START II Treaty", *Stanford Journal of International Law,* vol. 54, 2018, p. 92.

would be used to destroy the incoming ICBM. Therefore, this equation favoured defence. Increase in missiles can be countered by increasing the interceptors, but MIRVs changed this balance. Now each missile became capable of carrying multiple warheads, including decoys. This created the need for more interceptor missiles for each warhead to cover a large geographical area. On the one hand, a MIRVed missile can have multiple warheads, while, on the other, interceptors can have only one warhead per missile. Therefore, a MIRVed missile made attack easier than defence. Earlier one defensive missile was able to destroy one offensive missile, but if, for example, one offensive missile has 10 warheads, then 10 defensive missiles would be needed for each single offensive missile.

Also decoy reentry vehicles could further confuse and evade interception. This led to a heavy cost-exchange ratio biased in favour of the attacker. This greatly enhanced the cost of defence. Thus, the ABM system became extremely costly, as defence became more costly than offence.

Daniel Buchonnet (1976) postulated that MIRVs contributed to "escalation of the arms race" to the extent that the Soviet Union viewed "U.S. MIRV systems … as strengthening the U.S. counterforce capability (high accuracy of low yields) and improving the first-strike capability (large number of warheads)".[95] The ABM system deployed by the Soviet Union caused the United States to deploy MIRVs in order to be able to penetrate any expanded Soviet ABM.

Alexander de Volpi, in an interview in 1970 explained that there are generally four destabilising implications of MIRVs: first, MIRVs tend to "perpetuate the action-reaction cycle of military hardware"; second, MIRVs can escalate the arms race to a higher magnitude; third, MIRVs foster a "first strike psychology which contagiously infects both major powers"; and fourth, MIRVs increase the probability of an accidental launch of a "nuclear-armed missile in peacetime".[96]

95. "Multiple Independently Targetable Reentry Vehicles (MIRVs)", at https://nsarchive2.gwu.edu/nsa/NC/mirv/mirv.html
96. Alexander De Volpi, "Expectations From SALT", *Bulletin of the Atomic Scientists*, vol. 26, no. 4, 1970, p. 6.

As MIRV ambiguity increases the possibility of a first strike, Ralph E. Lapp opined that the technology of MIRVs

> ... tends to perpetuate a certain degree of ambiguity in any strategic arms limitation agreement, unless a system of verification is adopted to determine the number of warheads each ICBM carries. How verification of warheads on a missile can be carried out without onsite inspection, which the USSR traditionally rejected, has eluded negotiators for years. Even with the strategic arms limitation agreement on missiles, which can be verified by reconnaissance from the air or from orbit, the MIRV ambiguity will continue to feed the fear of a first strike.[97]

As MIRVs do not comprise a single warhead, the multiple warheads, introduce "ambiguity in the calculus of strategic strength". Therefore, arms control measures find it difficult to verify the numerical strength of MIRVs. Moreover, states have "operational, cost-efficiency and prestige related reasons for relying on MIRVs", therefore, it becomes difficult to negotiate about them in arms control negotiations.[98] For instance, in June 1992, a follow-on accord to the START I was agreed between the leaders of both nations and was signed in 1993. The START II accord called for reducing deployed strategic arsenals to 3,000-3,500 warheads and banned the deployment of MIRVed missiles. It was the only drafted treaty that was focussed on banning the MIRVs on ICBMs. Therefore, it was also known as the de-MIRVing Agreement. Though the negotiations took place, unfortunately, the agreement never came into force. It was ratified by the US in 1996. Russia also ratified it in 2000 but as the US withdrew from the ABM Treaty in 2002, in response Russia also withdrew from the START II accord in 2002. Therefore, the START II was shelved and never entered into force.[99]

97. Ralph E. Lapp, "Salt, Mirv and First-Strike", *Bulletin of the Atomic Scientists*, vol. 28, no. 3, 1972, p. 21.
98. Ibid., p. 83.
99. Miroslav Tüma, "Will the Validity of the Last US-Russia Arms-Control Treaty, The New START Treaty, be Extended?", Institute of International Relations Prague, Policy Publications,

MIRVs IN ARMS CONTROL NEGOTIATIONS

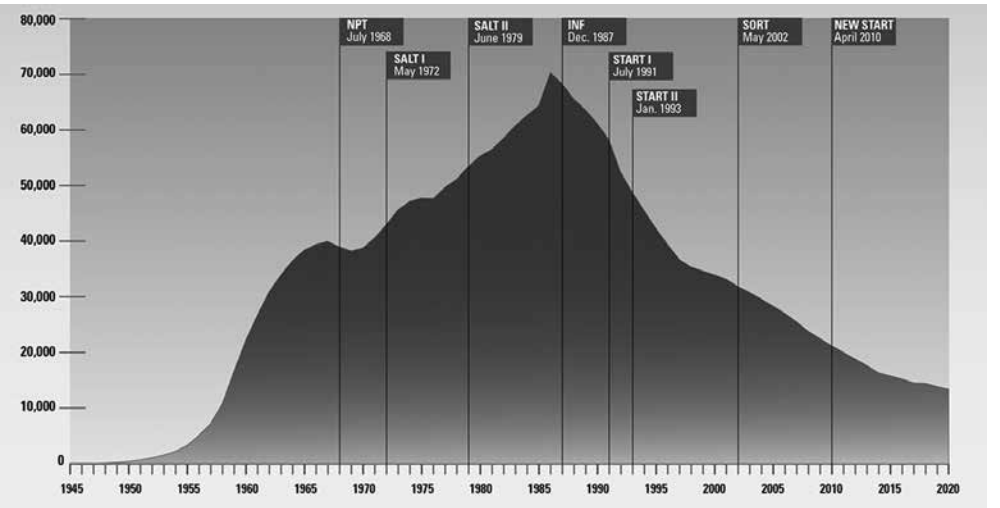
Nuclear MIRVed missiles are generally known as the "unfinished business of bilateral arms control regime".[100] Since the Cold War days, restraining MIRVs has been a major focus, but arms control treaties could not address this issue properly. In the Cold War, as both powers were developing ICBMs and SLBMs with MIRVs, it was also getting clear that both would not survive a nuclear war in a MIRVed world. By the 1970s, the strategists were trying to abandon the "counter-value doctrines" that "deterred by targeting populations, industries and institutions" and vouched for developing "counter-force" war-fighting plans that were based on MIRVs targeting the nuclear forces of the adversary.[101] Advanced MIRV development was leading to thinking about whether it was possible to cross the nuclear threshold preemptively. Any use of nuclear weapons would lead to escalation and bring about the apocalypse. This led to the realisation of détente in which the goals were to achieve peace and chart a path for arms reduction. Therefore, the bilateral arms control became a major achievement of détente.[102]

Thus, a number of negotiations such as the SALT I, SALT II, START I, START II, Strategic Offensive Reductions Treaty (SORT) and New START Treaty were negotiated for arms control. The SALT I negotiations began in 1969 and by 1972, produced the Anti-Ballistic Missile (ABM) Treaty. Though this treaty focussed on ICBM and SLBM forces, it ignored warhead numbers. Therefore, both sides were able to enlarge their forces by deploying MIRVs.[103] The SALT II Treaty limited the ICBM and SLBM numbers, but the 1979 invasion of Afghanistan by the Soviet Union cancelled the treaty. The START I also tried to reduce the number of delivery vehicles to 1,600, with no more than 6,000 warheads. This treaty too expired in 2009.

June 25, 2019, at https://www.iir.cz/en/bude-prodlouzena-platnost-posledni-kontrolne-zbrojni-americko-ruske-smlouvy-new-start-2. Accessed on August 25, 2021.

100. Rudesill, n. 94, p. 83.
101. Ibid., p. 92.
102. Ibid., p. 90.
103. Arms Control Association, "U.S.-Russian Nuclear Arms Control Agreements at a Glance", at https://www.armscontrol.org/factsheets/USRussiaNuclearAgreements. Accessed on July 7, 2021.

Fig 10: Estimated Global Nuclear Warhead Inventories, 1945-2020



Source: armscontrol.org.[104]

As stated earlier, the June 1992 START II Treaty was the only accord that called for banning the deployment of MIRVed missiles. It was also known as the de-MIRVing Agreement. Unfortunately, this treaty never came into force.[105] The SORT (Moscow Treaty) was signed in 2002. The limit on warheads was reduced to 1,700-2,200 warheads each. The SORT was replaced by the New START in February 2011. MIRVs were allowed in the SORT (2002) and New START Treaty of 2010.[106] On February 3, 2021, both parties agreed to extend the New START by five years until February 5, 2026.[107] At present, the New START Treaty is the only arms control arrangement that is in force between the United States and Russia, and it places "verifiable

104. Arms Control, "Estimated Global Nuclear Warhead Inventories 1945-2020", at https://www.armscontrol.org/sites/default/files/images/Factsheets/WarheadInventories_1945-2020.png. Accessed on May 15, 2022.
105. Tüma, n. 99.
106. "Moscow Treaty", at https://media.nti.org/documents/sort_moscow_treaty.pdf; https://2009- 2017.state.gov/documents/organization/140035.pdf. Accessed on July 7, 2021.
107. Arms Control Association, "New START at a Glance", at https://www.armscontrol.org/factsheets/NewSTART. Accessed on July 15, 2021.

Under the New START Treaty, "both sides will exchange lists of the number of warheads deployed on individual missiles"; also, in "Type One" inspections, each side can choose one ICBM or SLBM to inspect on short notice and count the warheads.

limits on all deployed intercontinental- range nuclear weapons by the USA and Russia".[108] The New START Treaty limits both sides to a maximum of 700 deployed ICBMs, SLBMs and heavy bombers, and no more than 1,550 for warheads on deployed ICBMs, SLBMs and heavy bombers.[109] Under the New START Treaty, "both sides will exchange lists of the number of warheads deployed on individual missiles"; also, in "Type One" inspections, each side can choose one ICBM or SLBM to inspect on short notice and count the warheads. In this, the "reentry vehicles can be covered by the host nation to protect sensitive information, but the actual number of RVs must be evident to the inspectors". These inspections are helpful in deterring both sides from deploying a missile with more than its declared number of warheads.[110]

CONCLUSION

The advent of MIRVs exacerbated the competition for developing more such missiles. This race continued throughout the Cold War period and even after that. In this context, this article has traced the development and deployment of MIRVed missiles by the United States, Russia, United Kingdom and France from the Cold War to the present times. Second, this article has also delved into the impact of MIRVs on nuclear deterrence and strategic stability. Third, this article has investigated the effects of arms control measures on MIRV development and deployment.

This article demonstrates that nations first tried to develop and deploy MIRVed missiles to enhance deterrence and second strike capability, but

108. Journals of India, "New START Treaty", at https://journalsofindia.com/new-start-treaty-3/. Accessed on July 25, 2021.
109. US Department of State, "New START: Treaty Text", at https://2009-2017.state.gov/t/avc/newstart/c44126.htm. Accessed on July 25, 2021.
110. n. 107.

MIRVed missiles were also destabilising as they changed the equation of strategic stability, enhanced the logic of striking first, overwhelmed the ABM system, disrupted the cost-exchange ratio, created misunderstanding and were extremely hard to negotiate about for arms control.

In this age, proliferation of MIRVs is being witnessed in new regions. This can also be attributed to the adoption of the Cold War thinking and prestige considerations. The new states that are resorting to developing MIRV missiles should carefully observe the whole movement of MIRVs during and after the Cold War and the endlessness of it, because once these weapons come into being, it is difficult to reverse their existence.

Nations first tried to develop and deploy MIRVed missiles to enhance deterrence and second strike capability, but MIRVed missiles were also destabilising as they changed the equation of strategic stability, enhanced the logic of striking first, overwhelmed the ABM system, disrupted the cost-exchange ratio, created misunderstanding and were extremely hard to negotiate about for arms control.