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Classification of Types of Nuclear Weapons and Systematization of Knowledge about them with a Focus on Nonproliferation in Modern Age

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From the first use of nuclear weapons in the battlefield to the present day, eight decades have passed. Due to its destructive power, this type of weapon has never been used in warfare again. However, the fear that this weapon will be used again has never disappeared. On the contrary, all states possessing this type of armament have not abandoned it but have modernized it to such an extent that it seems that just one wrong move by a statesman could bring this world to the brink of extinction. This paper systematically reviews knowledge about nuclear weapons and classifies them according to various criteria. Throughout history, there have been various efforts to abolish this weapon, and with the development of different types of nuclear armaments, new agreements have emerged aiming to reduce specific types of projectiles. The paper demonstrates the impact of these agreements on the signatories and the reduction of certain types of weapons.

Key words: **Nuclear Weapons; Tests; Classification; A-Bomb; H-Bomb.**

Introduction

SINCE the invention of nuclear weapons until today, a considerable amount of time has passed. The dire predictions regarding the use of these weapons have not hindered their rapid development. Exactly nine countries now possess this type of weaponry. It is assumed that significant international pressure and numerous agreements have influenced the number of nuclear-armed states not to be drastically higher [1].

Certain studies, both older [2] and more recent [3, 4], demonstrate the catastrophic consequences that would ensue in the event of a nuclear war, and consequently, a nuclear winter that would follow. On the other hand, as nuclear terrorism has become a significant threat today, there are numerous studies focused on mitigating the consequences [5] and preventing the outcomes that could result from this type of activity [6].

Although there are certain mechanisms for monitoring situations related to nuclear testing [7], North Korea still occasionally conducts nuclear weapon tests [8]. These tests have a serious impact on the environment [9] and human health [10], which is the main reason why the entire international community has historically strived to abolish all types of nuclear tests. This effort eventually resulted in the Comprehensive Nuclear-Test-Ban Treaty and the mechanisms to monitor its implementation [11].

In this paper, the classification of nuclear weapons and the systematization of knowledge about them will be carried out. This is important so that the wider scientific community and the general public have an insight into what is the domain of nuclear physics and engineering, when it comes to weaponry, and what crosses over into the domain of rocket engineering. This is essential to understand the historical and overall significance of each of the nuclear security regimes that serve the goal of non-proliferation, as well as to understand the regimes themselves. This means the text of the agreement, the implementation mechanism, as well as the need to introduce that regime. Namely, many of them, especially the bilateral ones between the USA and Russia, tend to limit the development of a certain type of missile or weapon system, even though those missiles or systems do not necessarily have to carry a nuclear warhead, regardless of whether this is logical considering the incomparable difference in the power of these warheads. In order to be able to fully explain this, it is also necessary to carry out a certain systematization of knowledge about nuclear weapons from their inception to the present day.

Systematization of Knowledge about Nuclear Weapons

Nuclear warheads can be classified into two categories: fission bombs and fusion bombs. The first to be developed was the fission bomb, which was originally called the atomic bomb or A-bomb [12, 13]. Later, when the fusion bomb appeared, it was named the thermonuclear or Hydrogen bomb (H-bomb). In fact, neither can function without a fission reaction, but unlike the A-bomb, the H-bomb, in addition to the fission reaction, operates on the principle of fusion. A more detailed explanation follows in the text below. To fully understand all the details that follow, it is necessary to have

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some knowledge of the basics of nuclear physics. To understand the principle of operation of nuclear explosive devices, it is necessary to have a complete understanding of the principle of fission and the principle of fusion. These nuclear reactions are based on the concepts of mass defect and binding energy, as well as on the Einstein's equation that attributes a certain energy equivalent to mass:

$$E = m\,c^2. \tag{1}$$

It is also necessary to understand the empirical graph of the dependence of the specific binding energy ($f = E_v/A$) on the mass number (A). These information are available even in high school physics textbooks for higher grades.

Fission Bomb

From its inception to the present, there are two common types of nuclear explosive devices: gun-type bombs [14] and implosion-type bombs [15]. These are the models initially established for fission warhead designs, as these bombs were the first to be produced. However, since the operating principle of the Hydrogen bomb is the same, which will be discussed later, it is clear that these bombs also use one of these two construction principles.

The operating principle of either of these devices (gun-type and implosion), and therefore of any nuclear warhead, relies on a nuclear chain reaction [16]. For a nuclear chain reaction to occur, the bomb's core, consisting of nuclear fuel (most commonly ^{235}U or ^{239}Pu), must have a critical mass necessary for the development of this reaction. Since the initiator of fission, and thus the factor for maintaining the chain reaction, is the neutron, it is essential to know how many neutrons will be produced from a given mass of fuel and whether this number is sufficient for the reaction to be a sustainable chain reaction. In fact, it is necessary to know the rate of production of a certain number of neutrons because the number of fission reactions occurring per unit time is crucial for the chain reaction [17].

The shape in which the fuel should be is a sphere because this shape has minimal potential energy compared to others. A sphere of certain dimensions has a precisely determined value of critical mass, which is conditioned by the density that leads to a chain reaction. Changing the parameters also changes the value of the critical mass because changing parameters (e.g., temperature or pressure) also changes the density of the fuel [16-18].

The gun-type bomb is constructed in a simple manner. It can actually be realized in several different ways, which essentially come down to the same thing, which is that the core of critical mass is divided into parts, usually two, and these parts are physically separated. The separation can be achieved with a barrier or simply by keeping the parts apart. When it is necessary for the reaction to occur, the parts are combined to form a sphere of a certain radius and mass that corresponds to the critical mass for those radiuses under given conditions. The parts are brought together by means of a conventional explosive explosion. Usually, a part is removed from the sphere and fired from a barrel, resembling a gun barrel, towards the rest of the sphere; hence this method is called gun-type [14].

The implosion-type bomb is based on the principle of implosion. A sphere of a certain mass occupies dimensions corresponding to a much larger critical mass. This sphere is then in a so-called sub-critical condition. It is surrounded by conventional explosives on all sides. When it is necessary for the chain reaction to occur, all the conventional explosives are activated simultaneously. The explosion causes the sphere to compress to smaller dimensions. The dimensions of this sphere are now such that the mass it has is actually the critical mass under the given conditions [15].

In both cases, it is necessary to have an initiator of the chain reaction, which is actually a neutron emitter. It emits neutrons that are necessary to start the first fission reaction at the beginning of the chain.

H-bomb

The hydrogen, or thermonuclear bomb [19, 20], cannot simply be called a fusion bomb; the most accurate term would be a fission-fusion-fission bomb. The reason is that for a nuclear reaction involving the fusion of nuclei, since they are positively charged and repel each other with Coulomb forces, a large amount of energy is needed to bring these nuclei close enough to each other for the strong interaction to take effect. In other words, the nuclei must move at high speeds toward each other to overcome the repulsive Coulomb barrier. This is achieved by raising the temperature to the extreme levels. High temperatures increase the kinetic energy of the nuclei because this type of energy depends on the temperature. Such temperatures cannot be achieved on the Earth except through a fission reaction [21]. Therefore, to initiate the fusion process, at least for now [22, 23], fission must first occur [21]. This bomb uses the fission reaction to create a large amount of thermal energy, which is used to propel the nuclei to overcome the potential barrier during fusion, and then the remaining energy from the fusion is used to initiate another fission process [21].

This bomb consists of two segments. The first part is a sphere that is in a sub-critical condition and is made of some fission fuel. This sphere is compressed by implosion. When, after the implosion, a chain reaction occurs, the temperature rises sharply. It affects the fusion fuel located in the second part of the warhead as the second segment. A fusion reaction occurs within this part. In the core of this part, there is usually additional fission material that is activated after the fusion [24, 25].

The main problem in the production of nuclear weapons does not actually lie in the construction of the bombs, whether atomic or hydrogen. The main problem is the separation of certain isotopes that can be used as nuclear fuel in these bombs. The process of separating uranium-235 from natural ore is called enrichment. It is very complicated, especially considering that the presence of isotope 235 in natural uranium is almost negligible compared to isotope 238, which is much more stable [26]. The enrichment process is achieved by centrifuging the natural ore (GCIS – Gas Centrifuge Isotope Separation) or by separation by laser (LIS – Laser Isotope Separation) [27, 28].

Effects of a Nuclear Explosions

The effects of a nuclear warhead explosion are divided into three stages, excluding the primary and secondary effects of nuclear radiation [25]. These are: thermal radiation, blast wave, and electromagnetic pulse (EMP) [29]. Naturally, these effects are more pronounced in case of a thermonuclear device explosion compared to those resulting from an atomic bomb explosion [25, 29].

Any nuclear explosion is measured in terms of the equivalent of a certain amount of TNT explosive. Of course, enormous amounts of TNT are required to match the effect of any nuclear weapon. Accordingly, the yield of fission bombs is measured in kilotons (kt) of TNT. They typically have a yield in the range of several tens of kilotons of TNT. In contrast, thermonuclear devices have a destructive power that is 1000 times greater and is measured in megatons (Mt) of TNT [29, 30]. Most commonly, bombs have yields of several tens of megatons of TNT. The most powerful bomb ever tested was the Tsar Bomb, tested by the USSR in 1961 [31].

Classification of Nuclear Weapons according to Various Criteria

It is very difficult to classify nuclear weapons, as throughout history, from the inception of this weapon, through the Cold War period, to the present day, the most diverse types of these weapons have appeared. Many of them were extremely interesting, although the idea of where and how they could be used was indeed unusual, to say the least. Therefore, the classification will be carried out according to various criteria, strictly taking into account the historical moment in which the weapon was created and the role envisioned by its creators.

Nuclear weapons can be classified in several ways. The most widespread classification of these weapons is into strategic and tactical nuclear weapons. Next is the classification according to the delivery method to the target location. Then follows the classification by range.

Finally, there is the classification by power, which has already been done. It is clear that there is a difference between the two categories of nuclear bombs: those of lesser power – fission bombs (measured in kilotons of TNT) and those with far greater destructive power – thermonuclear bombs (measured in megatons of TNT).

Classification into Strategic and Tactical Weapons

Strategic nuclear weapons include all types of nuclear explosive devices designed to completely retaliate against the enemy, i.e. to destroy vital points and significant objects with the power of the explosion or to intimidate and deter them from a potential attack [32].

Unlike strategic nuclear weapons, which are designed to deter the enemy from a potential attack or to destroy a large area of enemy territory to force the opponent into surrender, tactical or non-strategic nuclear weapons are designed to destroy a large number of enemy military targets at the same time. These targets include aircraft, artillery units, and sometimes even infantry formations, but primarily formations of tanks and other armoured vehicles [32]. Typically, tactical missiles carry warheads of low yield, very often sub-kiloton devices.

There is no clear boundary between tactical and strategic nuclear weapons, although there are different definitions for both subtypes of these weapons. This ambiguity is generally true for all classifications of nuclear weapons according to any criterion. The boundaries are unclear because they vary from one author to another. Classifications are most easily made when reading international agreements aimed at halting the proliferation of nuclear weapons or bilateral nuclear agreements between the USA and the Russian Federation. For example, by studying any of the START (Strategic Arms Reduction Treaty) bilateral agreements, it can be concluded that all weapons not covered by these agreements are considered tactical nuclear weapons.

Classification by Delivery Method to the Target (Launcher-Target Position)

According to the delivery method to the target, missiles are divided into: surface-to-surface missiles, surface-to-sea missiles, surface-to-air missiles, air-to-air missiles, air-to-surface missiles, air-to-sea missiles, sea-to-surface missiles, sea-to-air missiles, and sea-to-sea missiles [33].

Besides these delivery methods, there is also direct delivery to the target by infantry. More about this will be discussed in the following text.

Classification by Range

According to range, nuclear missiles are divided into three categories: short-range missiles, intermediate-range missiles, and long-range missiles.

Considering the INF Treaty (Intermediate-range Nuclear Forces Treaty) between the USA and the Russian Federation, short-range missiles [34] are those with a range of up to 500 km, intermediate-range missiles [35] cover those with a range from 500 km to 5500 km, while long-range missiles [36] are those with a range greater than 5500 km.

Types of Nuclear Weapons and Their Categorization

The first nuclear bombs, the so-called atomic bombs, dropped on Hiroshima and Nagasaki in 1945, were named Little Boy and Fat Man, with yields of 16 kt TNT and 21 kt TNT, respectively [37]. Based on this, it could be concluded that these are two nuclear devices of relatively small yield, falling under the category of tactical nuclear weapons. However, since this was the first use of such a weapon on the battlefield, aimed to intimidate the opponent and achieve that goal, it can be safely said that this was by definition the first strategic nuclear weapon ever used. According to other criteria, this weapon could also be classified as short-range, given that it was dropped from an aircraft at an altitude of 10 km [38], and by its air-to-surface delivery method, as it was released from the air to the ground. However, these types of bombs are most commonly called gravity bombs, as they are not actually missiles. They are the precursors of strategic bombs carried by strategic bombers [39].

As the further text mainly pertains to missiles, it should be noted that what has been mentioned so far actually falls under nuclear physics and nuclear engineering. The following discussion primarily revolves around rocket physics, as all these missiles and types of weapons to be discussed later do not necessarily have to carry a nuclear warhead but can carry conventional explosives. Therefore, the story related to nuclear armament is not so simple because within it, nuclear physics intertwines with other branches of physics and engineering. In other words, nuclear weapons are what is explained in the sections on fission and thermonuclear bombs, and if nuclear armament could be divided into broad and narrow senses, this would be nuclear weapons in the narrow sense, expanding when terms from rocket physics, which follow, are introduced.

Ballistic Missiles encompass a group of missiles whose flight consists of three parts: the initial phase using jet engine propulsion, the free-flight phase, and the re-entry phase into the atmosphere [39, 40]. They are usually classified into four categories based on range: Short-range Ballistic Missiles (SRBM, 70 – 1000 km), Medium-range Ballistic Missiles (MRBM, 1000 – 3000 km), Intermediate-range Ballistic Missiles or Long-range Ballistic Missiles (IRBM or LRBM, 3000 – 5500 km), and Intercontinental Ballistic Missiles (ICBM, more than 5500 km) [41]. Based on the launch method, these missiles are divided into three categories: Air-launched Ballistic Missiles (ALBM) [41], Submarine-launched Ballistic Missiles (SLBM) [41], and Land-based Ballistic Missiles [42], which are launched from the ground and housed in silos or on mobile platforms [42]. Classification is also performed based on the application of Ballistic

Missiles [43]. According to this criterion, Ballistic Missiles are divided into two categories: Offensive Ballistic Missiles [43] and Defensive Ballistic Missiles, also known as Anti-Ballistic Missiles (ABM) [44], which are part of Anti-Ballistic Missiles Defence (ABMD) or Theatre Ballistic Missiles Defence (TBDD) [45-47]. Today, Multiple Independently Targetable Re-entry Vehicle (MIRV) is in use. They carry a large number of warheads, each capable of hitting a different target. Ballistic Missiles are generally classified as strategic weapons because they serve to deter an opponent from potential attack. Both offensive and defensive Ballistic Missiles serve as deterrents, so both are considered strategic armament. However, those Ballistic Missiles with shorter ranges than ICBMs are used as tactical weapons, but since these missiles are much more expensive than Cruise Missiles, Cruise Missiles are generally preferred for tactical purposes.

Cruise Missiles represent tactical nuclear weapons if they carry nuclear explosives. The difference between these missiles and Ballistic Missiles is that Cruise Missiles are powered by an engine throughout the flight, and unlike Ballistic Missiles, they do not discard parts during flight but instead, the entire missile body hits the target [48, 49]. They differ mainly based on the type and position of the launcher from which they are fired, as well as the speed they reach during flight. Based on the speed, they are divided into Subsonic Cruise Missiles [50], Supersonic Cruise Missiles [51], and Hypersonic Cruise Missiles [52]. The range of these missiles is generally several hundred kilometres, but there are also those designed to fly over several thousands of kilometres.

In addition to this type of tactical nuclear devices, during the Cold War, Unguided air-to-air nuclear missiles [53, 54], Medium Atomic Demolition Munition (MADM) [55], Special Atomic Demolition Munition (SADM) [55], and, believe it or not, some sort of Land Mines was also made [56]. Unguided air-to-air missiles were jointly developed by the USA and Canada from 1957 to 1985. The missile developed by these two countries was called AIR-2 Genie and carried a 1.5 kt TNT warhead. The purpose of this missile was to destroy incoming Ballistic Missiles or formations of enemy aircraft, primarily nuclear strategic bombers. It is considered the precursor to Anti-Ballistic Missiles [53]. MADM represents nuclear artillery shells and mines, which were potentially intended to cause significant damage to enemy formations, primarily tanks and other armoured vehicles, but also to demolish bridges and tunnels. The warhead had a yield of up to 15 kt, and there are hints that a nuclear bazooka was even developed. The smallest weapon of this type ever tested was called Davy Crockett, after the American hero. It was a tactical recoilless rifle that fired a projectile with a W54 warhead, with a yield below 10 kt, weighing 23 kg, and exceptionally small dimensions for a nuclear weapon [57, 58]. SADM weapons were conceived as nuclear warheads carried by two men in a backpack. They would infiltrate an enemy harbour, place the nuclear device at the designated location, and retreat to safety with the help of a submarine waiting nearby. Little is known about nuclear-type Land Mines. Many are just urban legends. However, it is believed that there was a weapon called Blue Peacock, created by the British in the 1950s. Huge amounts of nuclear explosives were housed within a mountain in northern Germany. This explosive was connected to a number of land mines, which the Soviets were supposed to trigger in the event of a deeper breakthrough into the Western Europe. The idea was for the mountain to collapse on them when they reached this point [56].

Discussion and Conclusion

There are numerous nuclear agreements initiated by the UN and multilateral ones – Non-Proliferation Treaty (NPT, 1970), The Partial Nuclear Test Ban Treaty (PTBT, 1963) as a previous agreement and Comprehensive Nuclear-Test-Ban Treaty (CTBT, 1996) as a successor, International Convention for the Suppression of Acts of Nuclear Terrorism (CNT, 2005), The Antarctic Treaty (1959), The Outer Space Treaty (1967), Seabed Treaty (1971), Moon Agreement (1979), The Nuclear-Weapons-Free Zones (NWFZ group agreements, 1967-2006), The Treaty on Prohibition of Nuclear Weapons (TPNW, 2017). Also, there are bilateral agreements initiated by the USA and the USSR (now the Russian Federation) – Strategic Arms Limitation Talks (SALT I, 1972; SALT II, 1979), Anti-Ballistic Missile Treaty (ABMT, 1972), Threshold Test Ban Treaty (TTBT, 1974), Intermediate-range Nuclear Forces Treaty (INF, 1987), Strategic Arms Reduction Treaty (START I, 1991; START II, 1993; New START, 2010), Strategic Offensive Reductions Treaty (SORT, 2002) [1]. These have enormous historical significance as they involve the two largest nuclear forces in the world, guiding most other nuclear-armed states as well [59]. All of these nuclear weapon agreements or nuclear security regimes as a whole were and they still are the attempts to reduce the number of nuclear weapons. Some of them are the attempts to reduce or prohibit any kind of nuclear weapons, when others have goal in reducing some specific kind of nuclear weapon. For example, SALT agreement was making limitations in the field of strategic weapons, and ABMT followed that agreement, because there were fears that defensive strategic weapons could be used offensively and that under the guise of producing defensive weapons, offensive weapons could actually be developed and increased in number. On the other hand, the INF Treaty, limited the development of intermediate-range ballistic missiles. Of all the agreements, the only one currently taken seriously and almost fully adhered to is the Comprehensive Nuclear-Test-Ban Treaty. Since its adoption in 1996, the number of nuclear tests has dropped to single digits, which is significant given that the number was about 2000 until that point[1]. Both bilateral and multilateral agreements are generally not fully implemented because almost none of them, including the one that somehow forms the basis for halting the spread of nuclear weapons – the Non-Proliferation Treaty (NPT), have been ratified by all the signatories. They are somewhat adhered to but are not entirely binding. The trend of decreasing nuclear warheads worldwide is evident [1], but it should be noted that this decline has been ongoing for over a decade, mainly because the USA and RF are reducing their numbers by decommissioning outdated warheads, while the numbers in other nuclear-armed states remain stagnant or even it is in increasing (in China for example). However, it is also important to note that since the onset of the war in Ukraine (2022), the situation has drastically intensified. All nuclear powers are increasingly upgrading their arsenals and deploying strategic missiles, which was not previously the case [59]. By summing up the figures relating to the total number of warheads in the world over the last five years, Table 1 was obtained [59-63].

Table 1. Nuclear Warheads Growth Trend in Last 5 years

	2020.	2021.	2022.	2023.	2024.
Total	13400	13080	12705	12512	12121
Operational	/	/	9440	9576	9585

The situation with deployed warheads is somewhat different and is presented in Table 2 [59-63]. The number of deployed nuclear warheads fluctuates and it can even be said that the number has drastically increased in 2024, which is undoubtedly a result of the heightened tensions due to the ongoing war in Ukraine. Additionally, the number of missiles on high alert status has increased this year, following three years of stagnation.

Table 2. Deployed Nuclear Warheads Growth Trend in Last 5 years

	2020.	2021.	2022.	2023.	2024.
Deployed	3720	3825	3732	3844	3904
In High Operational Alert	1800	2000	2000	2000	2100

Throughout history, starting from 1972, the USA and the RF have signed a series of bilateral nuclear arms agreements. These agreements addressed the limitation of nuclear weapons use, reduction of certain capabilities related to the use of these weapons, freezing of specific conditions regarding the number of nuclear warheads used by particular (mostly strategic) weapons, and halting the development of certain missile programs or systems designed to carry nuclear warheads [1]. Although both sides have historically hidden their intentions and secretly developed various programs, they have always aimed to adhere to these agreements as much as possible to avoid compromising national security. Some agreements that involved the reduction of certain types of weapons for specific periods were extended, and new deadlines for compliance were set. The INF Treaty is one of the few agreements that came into force and was allegedly adhered to by both sides for 31 years until the United States withdrew, accusing Russia of non-compliance [64]. In addition to this treaty, the ABM Treaty was also in effect for 30 years. It is believed that this treaty prevented the proliferation of nuclear weapons into space. The USA withdrew from it in 2002 [65]. Given that Russia exited the New START treaty in 2023 due to U.S. involvement in the Ukraine war, none of the agreements between these two parties are currently in force [66].

Table 3. Nuclear Forces of RF, US and China, 2024

	Strategic Offensive	Tactical & Defensive	Total Operational	Retired	Σ
Russia	2822	1558	4380	1200	5580
USA	3508	200	3708	1336	5044
China	310	128	438	/	500*

Note: * - have some in production

In Table 3, a detailed overview of the number of warheads by type for the two largest nuclear powers (the USA and the Russian Federation), as well as for China, is provided. This overview takes into account China's status as an economic power and its announcement to modernize its nuclear capabilities [59, 67-69]. It is interesting that projections about the Chinese nuclear forces are very pessimistic. Asymptotes of these projections talking that the China nuclear forces will have 750 minimum or 1500 maximum nuclear warheads in 2035 [69].

The Most Advanced Nuclear Missiles – Consequences of Power Imbalances

Nuclear security regimes in preventing the spread of nuclear weapons have, over time, shown a large number of weaknesses. As a result, this type of weaponry has spread, but an even more serious indicator of distrust is the constant improvement of nuclear combat systems. The results are reflected in the fact that there is a large number of advanced weapons systems. The importance of the systematization and categorization of nuclear weapons and missiles is that they indicate how far everything has come in terms of the development of nuclear combat systems, which is actually a real indicator of the weaknesses of most international bilateral and multilateral agreements. On the other hand, for the fight against something to be successful, knowledge of it must be at the highest level.

Whether the mistrust arose due to the existence of secret nuclear programs in these states, or whether these programs are a consequence of mistrust, or if trust never existed at all, is currently irrelevant. The consequence of non-compliance with the agreement is that today there is a large number of powerful missiles of various types and purposes, some of which travel at hypersonic speeds.

Here are the characteristics of some Russian missiles that the Russian Federation has publicly announced. It is also known that China has developed some missiles of this type, including the JL-2 and DF-41 [70].

Sarmat is a Russian ICBM with liquid fuel, classified as a MIRV missile. Unlike older Russian ICBMs with a range of around 11000 km, Sarmat has an unlimited range (16000+ km), making it the only missile capable of targeting both the northern and southern poles. This is very important because if it operates via the southern pole, it bypasses the American missile defence shield. Due to its short-boost-phase engine, tracking and verifying its launch are difficult. It carries 10 to 16 warheads with a total yield of 8 Mt TNT, and these warheads can vary in design, with one of them possibly being a hypersonic Avangard missile. It is believed to be able to hit targets anywhere on the planet within a few minutes of launch [71].

Kinzhal is a Russian hypersonic ballistic missile with a medium range, up to 2000 km. It uses solid fuel and carries a conventional or nuclear warhead. It is launched from a modified interceptor jet (MiG-31 or Tu-22M3) and travels at speeds of Mach 5 to 10 (about 6000 – 12000 km/h). It has fins that provide some degree of manoeuvrability, but its trajectory is aero-ballistic. It is primarily intended to counter attacks on missile defence systems and carrier groups [71, 72].

Avangard is a hypersonic boost-glide vehicle that can be deployed on the Sarmat ICBM. In tests conducted in 2018, it reached speeds of over Mach 20 (about 24000 km/h) and travelled over 6000 km. It is made of composites, so it is not damaged by high temperatures resulting from such high speeds. It is expected to carry a warhead with a yield of 150 kt, possibly even larger. It is designed to strike targets that require bypassing defences and are located at great distances, i.e. strategic range [71].

Poseidon is a Russian nuclear weapon with strategic range. It is a nuclear-powered torpedo used to target distant coastal infrastructures or carrier groups. It operates at depths of 1000 km and travels at the speed of 111 km/h, targeting objects at distances greater than 5000 km. It carries a nuclear warhead with a yield of 2 Mt and is difficult to detect or intercept. It is mounted on two special-purpose submarines: the Belgorod and Khabarovsk-class [71].

Burevestnik is a Russian subsonic nuclear-powered cruise missile with a nuclear warhead. Its range is 23000 km. It is projected to enter service in 2025. This would be the first strategic nuclear-powered cruise missile [71].

Mechanisms for Action Towards Non-Proliferation and Considerations for Improving the Implementation of the Agreement in the Future

Despite all the weaknesses of nuclear security regimes, and despite numerous pessimistic forecasts regarding the growth of nuclear warheads, there are still studies that point to the importance of all these agreements in stopping the spread of nuclear weapons [73]. The fact is that the complete abolition of nuclear weapons is not in sight, but at least their further spread has been stopped. This is due to various types of political influences, such as primarily sanctions against states that seek to develop nuclear weapons [74]. Also, stopping the spread of nuclear weapons would not be possible without the technological tools that are applied to detect activities aimed at developing prohibited fissile materials, as well as testing nuclear weapons. The first category uses various forensic methods, including nuclear forensics methods, monitoring, but also those related to conventional forensics [75]. This category also includes methods used by IAEA safeguards, which aim to find traces of the production and use of unauthorized nuclear materials [76]. For that purpose, even using AI in future is in consideration [77]. One of the most usual methods that IAEA safeguards are using is Environmental sampling data for safeguards (ES) [78]. The second category, which is about nuclear testing, includes seismic monitoring in purpose of control implementation of CTBT [79]. There are also some newer methods such as using hydrophone stations [80].

From all that has been said so far, it is clear that nuclear security regimes are not all-mighty. So far, they have shown a large number of weaknesses, primarily towards those states that already possess this type of weapon. In order to avoid a confrontation between the declared nuclear-armed states (the five provided by the NPT) and the remaining four states that possess nuclear weapons (which are not recognized by this treaty as declared nuclear-armed), these nuclear states have also been tacitly recognized as such and no further pressure is exerted on them without reason. Perhaps this is the first mistake that was made in the past. If there were serious will in the international community, perhaps this should be the path to take. Namely, perhaps the world should first be returned to the conditions when there were only five nuclear forces. It is much easier said than done, but it is certain that those nuclear-armed states that have not declared would not have obtained this type of weapon if they had not had the help of one of the allies that belongs to the group of five declared nuclear-armed states. Perhaps it would be possible somehow, at an opportune moment, to carry out the inverse process and to get rid those four states of nuclear weapons with firm guarantees that this will not come back to haunt them. After that, to slowly move towards the abolition of weapons among the declared nuclear-armed states as well. Certainly, at this moment, everything mentioned in the previous few sentences seems like a fairy tale, because the situation in the world is not good at all. The large number of war zones and constant tension between nuclear states, and the figures that we presented in the previous 3 tables, create the impression that the world is on the edge of the abyss.

However, not everything is as black as it seems. Certain regimes have slowed down the development of certain types of weapons. Some of them, such as The Antarctic Treaty, The Outer Space Treaty, The Seabed Treaty, The Moon Agreement and The Nuclear-Weapons-Free Zones, are all very much adhered to for now. Also, some that are not in force, but have been in force for many years, such as ABMT and INF, have yielded tangible results in the years behind us. The first indirectly stopped the proliferation into space, while the second slowed down the development of intermediate-range ballistic missiles. The combined efforts of the scientific community and all those committed to non-proliferation have resulted in only nine states possessing nuclear weapons. The prediction is that this number would be drastically higher, which was discussed earlier, if there was no regime.

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Klasifikacija tipova nuklearnog oružja i sistematizacija znanja o njima sa fokusom na neproliferaciju u savremenom dobu

Od prve upotrebe nuklearnog oružja na bojnom polju do danas prošlo je osam decenija. Zbog svoje razorne moći, ova vrsta oružja nikada više nije korišćena u ratnim sukobima. Međutim, strah od njegove ponovne upotrebe nikada nije nestao. Naprotiv, sve države koje poseduju ovu vrstu naoružanja nisu ga napustile, već su ga modernizovale do te mere da se čini kako bi samo jedan pogrešan potez nekog državnika mogao dovesti svet na ivicu uništenja. Ovaj rad sistematski razmatra saznanja o nuklearnom oružju i vrši njegovu klasifikaciju prema različitim kriterijumima. Tokom istorije postojali su brojni pokušaji da se ovo oružje ukine, a sa razvojem različitih tipova nuklearnog naoružanja pojavili su se i novi sporazumi usmereni na smanjenje određenih vrsta projektila. Rad prikazuje uticaj ovih sporazuma na države potpisnice, kao i smanjenje pojedinih tipova naoružanja.

Ključne reči: **nuklearno oružje; testiranja; klasifikacija; atomska bomba; hidrogenska bomba.**