Russia's November 21 Missile Attack on Dnipro:

Experimental Use of a Dual-Capable Missile with Transcontinental Reach

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Cover

Picture: Gradient blue overlay on top of a screenshot of surveillance camera footage of Russia's November 21, 2024, attack on Ukraine's Pivdenmash complex in the city of Dnipro. Source: Missile Matters Substack newsletter, 'Key Takeaways from Russia's Oreshnik Strike' (2025). Retrieved from https://missilematters substack.com/p/key-takeaways-from-russias-oreshnik.

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Summary

Russia's November 21 attack on Ukraine's Pivdenmash complex in the city of Dnipro was significant for the first use of an intermediate-range ballistic missile (IRBM) delivering a hypersonic, non-nuclear payload against a large-area target. The missile, named *Oreshnik*, was linked variously to the *Rubezh* missile by the US DoD and to the *Kedr* developmental missile (or a version thereof) by the Ukrainian intelligence service, both of which were, or are, being developed originally to carry nuclear warheads. Oreshnik carried six warheads, each of which in turn delivered six submunitions that appeared to be purely kinetic, with no explosive load.

Russian claims of a conventional destructive capability rivaling that of very low yield nuclear weapons mark a shift away from nuclear threats to deter US and NATO support for Ukraine. Such a shift eliminates the risk of breaking the so-called nuclear taboo, making the threat more immediate and realizable for front-line NATO nations.

No official damage assessment has been released, so the Russian claims are at least not publicly demonstrable. However, we speculate that the use of a reduced number of individual, large mass projectiles may not be the optimal choice for such an attack. At the hypersonic velocity of the incoming warheads, their kinetic energy density significantly exceeds the chemical energy density of the same mass of conventional high-explosive, making it possible to distribute many lower-mass projectiles with high kinetic energy over wide areas against relatively soft targets. The use of an IRBM makes this a relatively prompt threat, with launch-to-impact times of a couple tens of minutes at intracontinental ranges. Of course, there is also a nuclear component to the threat for a dual-capable system.

The November 11 Attack

In the pre-dawn hours of Thursday, November 21, Russia launched a missile attack with six warheads, each of which dispensed six sub-warheads, on the Pivdenmash[*] complex in the Ukrainian city of Dnipro.[1] Reportedly, the sub-warheads were not loaded with high-explosive, relying instead on their kinetic energy for a destructive effect.[2] US officials were warned of the launch about a half hour prior to launch of the missile.[3]

[*] Formally, the State Factory "Production Union Southern Machine-Building Plant named after O.M. Makarov," formerly known as Yuzhmash.

One group of sub-munitions striking the ground in Dnipro taken from a video recording of the six-warhead (x 6 submunitions per warhead) attack.[4]

In a bit of theater later that day, Russian Foreign Ministry spokesperson Maria Zakharova took a phone call during a press briefing, on a hot microphone, in which she was instructed not to discuss the Dnipro missile attack.[5] Also, on the 21st, Pentagon spokesperson Sabrina Singh confirmed that the US had been warned shortly before the Dnipro attack through nuclear risk reduction channels and stated that it was an experimental use of an intermediate-range missile based on the RS-26 *Rubezh* ICBM.[6] The following day, a release from the Main Intelligence Department of the Ukrainian Ministry of Defense indicated that a different missile "probably" from the *Kedr* complex had been used.[7] That same day, Vladimir Putin named a third missile, *Oreshnik,* that was used in the attack in a launch from Astrakhan Oblast.[8]

What is known of *Rubezh* and *Kedr*?

Putting aside the matter of *Oreshnik*, about which little is known and which may be a variant of the other named missiles, we review *Rubezh* and *Kedr*, two solid-fueled missiles developed by the Moscow Institute of Thermal Technology (MITT). The former was developed first, and we include as an Appendix an unpublished and more extensive report we prepared on that system.

Rubezh was ostensibly to be developed as an ICBM. After an initial failed test in September 2011, it was flight tested from the Plesetsk Cosmodrome to the Kura Missile Test Range on the Kamchatka Peninsula, a distance of 5,700 kilometers, presumably to qualify the system as an ICBM. Four subsequent tests were flown over the 2,000-kilometer test range from Kapustin Yar near Astrakhan to the Sary Shagan Test Range in Kazakhstan between October 2012 and March 2015 to hinder foreign intelligence collection. The tests involved "new combat equipment" and multiple warheads on each missile. For reasons detailed in the Appendix, we believe it possible, if not probable, that the tests involved a unique warhead dispensing mechanism known by the Russian acronym BIR[†] in which each warhead has its own

[†] In Russian, блоками индивидуального разведения, translating to "individual dispersal units."

individual final-stage rocket motor rather than a single bus dispensing all warheads.[9] The questionable ability of the missile to reach ICBM range with multiple warheads would have set up a future debate over whether *Rubezh* was actually an ICBM or an intermediate-range violator of the then-active INF Treaty.

Rubezh was said by most analysts to be based on the three-stage *Yars* ICBM (the SS-27 Mod 2); however, a contract for the transporter pointed to a much smaller and lighter missile than *Yars*, suggesting it was a two-stage missile (plus the individual motors for each warhead). Prior to its first successful launch from a mobile launcher at Plesetsk, one report stated that it was a land-based version of MITT's *Bulava* SLBM.[10] The missile was only to be based in silos, with no mobile version, suggesting that it used a more energetic (and volatile) propellant, similar to that for *Bulava*. The use of a higher energy propellant also pointed to the possibility that that the missile might employ a so-called "depressed trajectory" with a lowered maximum altitude during flight and a reduced flight time to target that required more energy. The combination of the BIR warhead dispensing technology and employment of a depressed trajectory were meant to help confound missile defenses.

The end of the *Rubezh* program was signaled by a series of events.

- An unnamed source on the Russian General Staff indicated in July of 2014 that *Rubezh* was to be deployed to one of Russia's farthest east ICBM divisions near Irkutsk in 2015; however, in 2015 another unnamed source in Russia's Military-Industrial Complex (or VPK) said that deployment would occur in 2016.
- An exhibition of *Rubezh* as a new ICBM accountable under the terms of New START was announced in March 2015, then postponed in November 2015 and never rescheduled.
- In January 2018, *Rubezh* was to be included in the State Armament Plan running to 2017. In late March of that year, though, an unnamed source in the VPK stated that *Rubezh* had been pulled from the plan in favor of the *Avangard* hypersonic glide vehicle carried by the SS-19 Mod 4 when the funds were insufficient to cover both.

At that time, two more test launches were reportedly planned, for 2016 and 2017. That same reporting indicated that, counter to earlier statement, the termination of *Rubezh* was not solely for financial reasons. One possibility was to avoid a confrontation with the US over a possible INF Treaty violation by the multiple warhead version of the missile.[11]

In February 2021, *Kedr* appeared in a TASS article,[12] claiming it was in the early scientific research stage.[‡] A more extensive discussion appeared in *VPK News* in May 2021 indicated that by 2030, the missile would replace *Yars* and *Topol-M* with a more effective system, while *Sarmat* would replace the SS-18 Mod 5 and SS-19 Mod 4, the latter as the carrier of hypersonic glide vehicles. The article mentioned the depressed trajectory capability of *Yars*, as well as the BIR warhead deployment concept reportedly tested for *Rubezh* and a version of *Yars*.[13] Unlike *Rubezh*, *Kedr* is to have mobile and silo-based versions.

More recently, a posting in the *Dzen* news aggregator (formerly *Yandeks*) indicated that *Kedr* had been included in the State Armament Plan to 2027, and that it was to move to engineering development[§] in 2023.[14] Ukrainian Defense Intelligence claims that *Kedr* was test-flown twice from Kapustin Yar, in in October 2023 and June 2024.[15] However, aggregate reporting of Russian missile flight testing might more accurate point to tests in April of 2023 and 2024 conducted on the Sary-Shagan/Kapustin-Yar range

[‡] A defined stage in the Russian development process, Научно-исследовательская работа, or transliterated, NIR.
[§] Another defined stage in the Russian development process, to follow NIR: Опытно-конструкторская работа, or OKR in transliteration.

by a missile designated *Yars-E* (E presumably standing for "experimental") apparently carrying a single warhead.[16]

Oreshnik: New Missile or New Development?

Whether *Oreshnik* is a modification of *Rubezh* or *Kedr,* according to Vladimir Putin it is a new missile that is not a "weapon of mass destruction," but rather a conventionally armed missile dispensing submunitions with an effect similar to that of a nuclear weapon, presumably at the low end of nuclear yields.[17] He said the missile has entered serial production and that several of them are already available for use. The missile is said to have an intermediate range that can cover much of Europe.[18]

It would not be surprising if *Oreshnik* incorporates features of both *Rubezh* and *Kedr*. The former was most likely a two-stage missile, while the latter, which is intended to replace *Yars* as an ICBM, is likely a three-stage missile. As discussed in the Appendix, *Rubezh* was intended to be silo-based, with no mobile version, suggesting to us that it might have used a higher-energy but more volatile propellant, like the *Bulava* SLBM (and all of these are MITT missiles). One piece of the wreckage of the missile was identified as having been used on *Bulava*, recalling the report that *Rubezh* was based on *Bulava*, although, as mentioned, the same design and development organization, MITT, also was behind Russia's solid-fueled ICBMs.[19]

Could *Oreshnik* have been a modification of either missile, modified at least in changing out the original payload for a six-warhead payload with each warhead distributing six submunitions? In the case of *Rubezh*, one more flight test from Kapustin Yar may have been planned, while another missile may have been planned for use in the New START exhibition. Beyond that, because the missile was to be deployed to the Irkutsk ICBM base, it may be possible that additional missiles were in a state of full or partial assembly to employ in this instance. In the case of *Kedr,* since flight testing was reported to have begun, there may have been additional missiles available for the Dnipro attack, possibly even a two-stage modification for the shorter range of the attack.

Whether *Oreshnik* was based on *Rubezh* or *Kedr,* it could have incorporated the BIR warhead dispersal technology and could have flown a depressed trajectory to help evade missile defenses, if that was desired. Also, both were designed to carry nuclear warheads, so *Oreshnik* could carry a nuclear payload if desired. And its use certainly makes the point that Russia now has land-based nuclear delivery capability covering much of Europe with delivery times from launch to impact measured in a couple of tens of minutes or less. To this point, however, Russia could achieve similar coverage with Kalibr 3M-14 land-attack cruise missiles launched from either the Black or Norwegian Seas, or Kh-101 (conventional)/Kh-102 (nuclear) air-launched cruise missiles carried by strategic Blackjack or Bear-H bombers, although both are subsonic flight systems. If hypersonic flight is the distinguishing feature, the *Kinzhal* rocket launched from a tactical bomber is available.

With regard to these details, *Janes* analysis notes the SPY-1 radars of NATO's Aegis Ashore facilities in Redzikowo, Poland, and Deveselu, Romania should have observed the missile's flight, as well as radars on US destroyers in the eastern Mediterranean.[20] NATO airborne collection assets were also active during this time, which may also have detected the trajectory.

Implications

The attack with *Oreshnik* on the Pivdenmash plant in Dnipro should likely be viewed first and foremost as part of a larger retaliation for Ukrainian attacks on Russian territory with long-range ATACMS and Storm Shadow missiles.

The attack also represents a new level of conventional strategic attack, employing a more penetrable intermediate-range system with high kinetic energy submunitions that could be engineered to carry high explosive.[**] In principle, the large Pivdenmash plant was well-suited to attack with such a weapon, presuming that at least some of the buildings had sheet metal roofs penetrable by sufficiently high kinetic-energy projectiles. The missile is likely a rather expensive delivery vehicle, so that its use would presumably be directed toward high-value targets of strategic significance. The Pivdenmash facility has long been a missile production site, going back to Soviet times as the source of the SS-18 family of missiles. Recently, Lithuania signed a €10M contract to support the factory in building new *Palianytsia* missile drones.[21]

So far, there appears to be limited reliable reporting assessing the effectiveness of this single-missile, multiple-warhead attack. Vladimir Putin compared the effect of a conventional *Oreshnik* strike to that of a nuclear weapon, albeit without the use of an actual nuclear warhead.[22]

On the other hand, reporting in the UK *Daily Mail* five days after the attack indicated that the damage was not as extensive as the Russians had hoped.[23] Ukrainian press reporting is similarly dismissive. The *Kyiv Post* reported that satellite imagery did not show the expected damage and recounted Russian war blogger expressions of disappointment or disbelief of the Russian official claims.[24] US and NATO experts are said to be investigating the site, but no statements have been released yet.[25,26]

To scope the military effectiveness of such a system, we first consider the kinetic energy of a mass moving at a speed of Mach 11, which is 3,740 meters/second at sea level. The specific kinetic energy of such a mass, with units of joules/kilogram, is about 7 MJ/kg, which is 2/3 greater than the specific chemical energy of TNT, which is about 4.2 MJ/kg. If we now consider a mass of 800 kilograms moving at Mach 11, it has a kinetic energy equivalent to the chemical energy of about 1.8 tons of TNT. The destructive mechanism is different, of course.

We note that the choice of using a number of individual, large mass projectiles dispersed from the independent warheads may not have been the optimal choice for such an attack. We hypothesize that time constraints and technological difficulties prevented the use of a more effective conventional kinetic energy weapon based on scattering fragments over a larger target area. Such systems have been researched and tested by the United States.[27] They have been described as a “big shotgun shell.”[28] By using controlled conventional explosives to scatter fragments, one can place a desired fragment pattern on a target by selecting a height of burst appropriate to the incoming speed of the warhead and the expected fragment sizes. Consider two examples.

First, if one creates fragments of about 50 grams each (roughly equivalent to the mass of a .50 caliber bullet, but with 17 times greater kinetic energy), the number of fragments expected from an 800 kg warhead would be 16,000. If one sets the height of burst to have 1 fragment per square meter, then the radius of the "shotgun" pattern is about 70 meters. Consequently, such a fully fragmented warhead can theoretically saturate about 4 acres in one shot, which might probably have had far more devasting effects on the Privdenmash complex, a relatively soft target.

Second, for a fragment about 100 grams (the mass of a 25-mm cannon armor-piercing round penetrator), the kinetic energy for an IRBM-delivered 100-gram fragment is about seven times larger than a cannon fired round, which is just shy of 0.1 MJ. Given the larger mass per fragment, the area covered by such a system for the same total payload mass and distribution of fragments would be about 1 acre. The point is that at the high terminal velocity quoted for *Oreshnik*, Mach 11, fragment energies delivered by IRBM

[**] It appeared that the submunitions in the Dnipro attack were not armed with high explosive.

will in most every case deposit significantly more energy than similarly sized munitions fired from rifles and cannons. Such energies raise the likely prospect of even penetrating ceilings and floors to vulnerable basement spaces.

The point here is not to delve too deeply into warhead details but to show that this conventional attack could have been more effective and possibly approached damages that, per Mr. Putin's assertion, might be expected from an ultra-low-yield nuclear weapon (10s of tons), but without the political baggage associated with nuclear effects and breaking the "nuclear taboo." It strikes us that the use of this weapon was to push the boundaries of Russia's conventional capabilities and expand the deterrence and capability maneuver space without going nuclear. Russia has long feared western dominance in conventional, integrated, and stealthy capabilities. Having a conventional ballistic missile conventional capability is relevant to ongoing discussions of nuclear-conventional integration in operational scenarios and in force design for deterrence. It certainly seems to expand the space for assignment of conventional weaponry to distant and defended softer targets. It remains to be seen if more effective conventional warheads reduce the chance of crossing the nuclear threshold. Also debatable is whether, despite their complexity, modern conventional warheads offer cost-efficient military options. It seems clear to us that Russia is first and foremost trying to expand their conventional options to enable playing along the escalation ladder without going nuclear. It is a convenient bonus for them to retain the clear possibility of nuclear use in a dual-capable *Oreshnik*-like system. Nevertheless, the system used in this conventional attack was not optimal and certainly could have done more damage had they possessed a specifically designed kinetic energy warhead optimized by fragment size and height of burst for the intended target.

Appendix: The Mystery of RS-26 (*Rubezh*). Did Russia – Will Russia -- Develop an IRBM?

9 March 2021

A TOPOL'-E mobile missile launch from Launch Complex 107 at Sary Shagan. From TV Zvezda, https://tvzvezda.ru/news/vstrane_i_mire/content/201405202353-cnun.htm.

Over the period 2011 to 2015, Russia conducted five successful flight tests of a missile designated R-29 and known by the project name *Rubezh*. After an initial flight to ICBM range, succeeding tests were conducted over the roughly 2000-kilometer path between the Kapustin Yar and Sary Shagan test ranges, ostensibly to develop new "combat equipment" (warheads) away from the prying eyes of Western intelligence. Although the project was eliminated in 2018 from the State Armament Plan that runs to 2027 – reportedly losing the battle for funding priority to the *Avangard* system with a hypersonic glide vehicle on top of an SS-19 booster – it remains an option that must be taken into account in negotiating a successor to New START, in the event it, or something with similar features, reappears in the next State Armament Plan. The features to bear in mind are a missile of limited intercontinental reach that exploits ambiguities in the definition of an ICBM to provide a very capable intermediate-range nuclear delivery system that evades missile defense more effectively and is appropriate to deterrence in Northeast Asia and Europe.

The Short Story of Rubezh

On 27 September 2011,[29] Russia began a flight test series for a new and unique solid-fueled missile from the Moscow Institute of Thermal Technology (MITT) known as RS-26 or by the project name *Rubezh*.††

†† The missile's GRAU index, for the designator applied by the Russian Main Missile and Artillery Directorate of the Ministry of Defense, was 15Zh67. This distinguishes it from the *Yars* ICBM, designated 15Zh55M and

Although that initial test was a failure – allegedly the missile struck the launcher during takeoff and crashed less than 10 kilometers down range[30,31] – by the end of the program of five subsequent successful flights, the last on 17 March 2015, the Ministry of Defense announced a planned exhibition of this new ICBM at the Votkinsk Machine Building Plant under the terms of New START.[32,33] Also at that time, an unnamed source from the Russian General Staff indicated that following a final successful flight test, the missile would begin service in the Irkutsk Guards Missile Division‡‡ sometime in 2015.[34] That time frame shifted to 2016 in later reporting from an unnamed source in the military-industrial complex (VPK).[35]

The missile exhibition for US observers never occurred; it was postponed in November 2015 and not rescheduled.[36] Funding issues began to appear: the final test that was supposed to precede deployment was delayed by funding shortfalls from December 2014 to March 2015 according to a statement from the VPK.[37] After that sixth test of the missile, according to reporting by *TASS*, "a decision will be made."

The final act for *Rubezh* – at least until 2027 or later – played out in the first quarter of 2018 in two accounts of the finalization of the State Armament Plan (known by the Russian acronym GPV) for the period 2018 to 2027. As of January 2018, *Rubezh* was in the GPV running to 2027.[38] By late March 2018, however, an unnamed source in the VPK stated that *Rubezh* had been pulled from the plan in favor of the *Avangard* hypersonic glide vehicle carried by the SS-19 Mod 4 missile.[39] The source indicated that while the original plan was to fund both *Rubezh* and *Avangard*, in the end only one could be funded, and *Avangard* was judged to be more important for the nation's defense.

The Technical Significance of *Rubezh*

Whether it returns or not at the end of the decade, Rubezh featured significant developments from the standpoints of missile technology; policy, internally to Russia and externally in the deterrence relationships with the US and China; and nuclear arms control. To place these developments in context, the flight test series for *Rubezh* is shown in **Table 1**.

Date	Launch	Impact	Range	Comments
27 Sep 2011	Plesetsk, LC 167	Kura Test Range	(failed)	
23 May 2012	Plesetsk, LC 167	Kura Test Range	5700 km	Mass-equivalent blank?[40]
24 Oct 2012	Kapustin Yar, LC 107	Sary Shagan	2000 km	Inert missile whd[41,42]
6 Jun 2013	Kapustin Yar, LC 107	Sary Shagan	2000 km	New combat equipment tested[43,44]
18 Dec 2013	Kapustin Yar, LC 107	Sary Shagan	2000 km	New combat equipment, multiple whds[45]
17 Mar 2015	Kapustin Yar, LC 107	Sary Shagan	2000 km	Whd hit target with "given accuracy"[46]

Table 1. Test flights of the RS-16, *Rubezh*, missile. LC is the abbreviation for "launch complex."

At the top level, Russia conducted a first test with what was claimed to be a mass mockup of a warhead (some warhead, but we judge not necessarily the only warhead option, or even an intended warhead option) to Kamchatka at a range that possibly intended to qualify the missile as an ICBM under the terms of New START,§§ a point frequently emphasized in subsequent Russian commentary. The subsequent four test flights all occurred on the roughly 2000-kilometer internal test range between the Kapustin Yar Missile Test Range in southern Russia to the Sary Shagan Test Range in Kazakhstan. The stated reason

15Zh65M for the road-mobile and silo-based versions of the missile, or the *Yard-M*, which appeared later, with designators 15Zh80 and 15Zh81 for the road-mobile and silo-based versions. In every case, the prefix 15Zh indicates a solid-propellant missile.

‡‡ The 29th Guards Missile Division of the 33rd Guards Missile Army.

§§ The Treaty Between the United States of America and the Russian Federation on Further Reduction and Limitation of Strategic Offensive Arms, which is the same name given to New START.

for this test strategy was to conceal the development of the system from foreign intelligence collection efforts, especially from intelligence-collection ships monitoring the Kamchatka test range.[47,48]

The use of the interior test range may have been meant to conceal the application of a unique warhead deployment method involving the use of individual liquid-fueled engines and guidance systems in the final stage to deploy the missile's reentry vehicles (RVs), as opposed to the typical method of dispensing RVs from a common bus with a single propulsion system.[49] In a January 2011 interview with *RT*, Yuriy Solomonov, the General Designer of MITT, said that the concept had been tested a year earlier.[50]

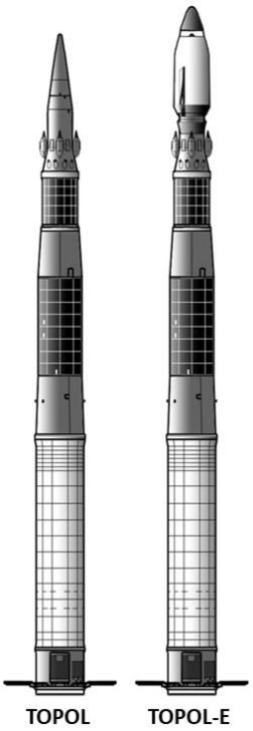

Figure 1. The *Topol* and *Topol-E* missiles.[51]

Roughly a year before Solomonov's interview, on 10 December 2009, a *Topol-E* missile – the version of the SS-25 *Topol* missile used for experiments (see **Figure 1**) – flew from Kapustin Yar to Sary Shagan.[52] This was a "GCh" test, presumably standing for "golovnaya chast'," the term for the "head end" of an ICBM containing the RVs and associated equipment. A spokesman for the Strategic Missile Forces said that the flight included a successful test of the "combat equipment" of ICBMs.[53] A flight with all the same signatures also took place on 5 December 2010.[54]

Following the first *Rubezh* test flight from Kapustin Yar on 24 Oct 2012, the official representative of the SRF told the press that the purpose of the launch was "to … test elements of a new combat payload of the ICBM."[55] Similarly, following the next test, on 6 June 2013, the chief of the Main Operations Directorate of the General Staff of the Russian Armed Forces, said that "new combat equipment" had been tested, adding that the new missile under development "will have significantly expanded capabilities and increased maneuverability compared to existing systems…."After the 18 December 2013 test, the head of the Strategic Missile Troops added that the missile had multiple warheads.[56]

One analyst did find a treatment of the warhead deployment concept possibly employed on *Rubezh*, apparently known by the Russian acronym BIR, in a textbook from the Bauman Institute (see **Figure 2**).[57]

Beyond the unique warhead deployment method, *Rubezh* employed more energetic solid propellant, closer in character, if not the same as, that employed in the *Bulava* SLBM,[58,59,60] and the missile was considerably lighter and smaller than *Yars*, from which it was said to be derived. Together, the two significantly reduced the time of booster burn required to get the missile up to speed.

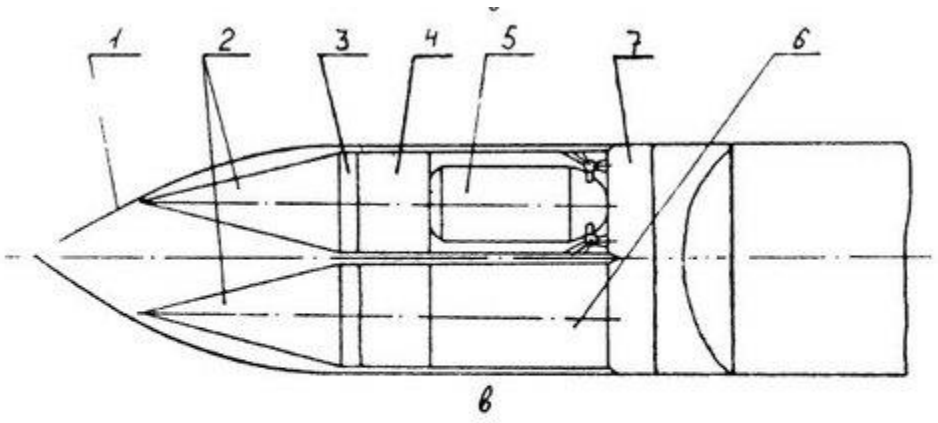

Рис. 2.2. Компоновочные схемы передней части ракеты с РГЧ: а, б - с последовательным разведением; в - с индивидуальным (параллельным) разведением; I - обтекатель; 2 - боеголовка; 3 - платформа ГЧ; 4 - приборный отсек; 5 - ДУ БС; 6 - модульная ГЧ (БИР); 7 - платформа модульных ГЧ (БИР)

Figure 2. Translation of the Bauman Institute text: Layout diagrams of the front of the rocket with MIRV: a, b - with sequential dilution; c - with individual (parallel) breeding; 1 - fairing; 2 - warhead; 3 - MS platform; 4 - instrument compartment; 5 - DU VS; 6 - modular warhead (BIR); 7 - platform modular MS (BIR)

The more energetic propellant is also more susceptible to unwanted ignition. This is reportedly the reason why there is no silo-based version of the missile. Ironically, the softer basing modes – submarine, road-mobile launcher – are less likely to suffer the shocks that a silo-based missile would feel from a near-hit by an attacking missile.

The mass and smaller size can be inferred indirectly. In 2008, a contract between MITT and the Minsk Wheel Tractor Plant (MZKT) called for development of the MZKT 72921 transporter for the new mobile missile, a 12-wheeled vehicle considerably smaller than the 16-wheel MZKT 79221 used to carry the mobile versions of *Topol-M* and *Yars*.[61] It also carried less weight than the larger vehicle, 50 tons versus 80, which was said to imply a missile mass of 32 tons. This is much less than the mass and length of *Yars*, almost 50 tons and 23 meters, but comparable to *Bulava's* 37 tons and 12.1 meters.

Given the greater size of the warhead deployment systems, it was speculated that Rubezh might have only two stages, plus the independent motors for the individual RVs.[62] On the other hand, Russian journalist Ivan Safronov offered that *Rubezh* had the same three stages as *Bulava*.[63]

The Political-Military Significance of *Rubezh*

The first question that arises relates to the military purpose of *Rubezh*. The use of energetic fuel to shorten the boost-stage operation of the missile as well as the maneuverability of the RVs after deployment from the missile were apparently aimed at achieving even greater ability to evade missile-defense interceptors. More than one Russian article pointed to the much greater numbers of interceptors required to guarantee kill of the new missile, relative to the older *Yars*.[64,65] Other writers suggested that *Rubezh* was intended as a counter to missile-defense interceptors, especially in Europe. In this regard, one author suggested that the shorter Kapustin-Yar/Sary-Shagan flight range might have been used to evaluate so-called "depressed trajectory" flights.[66,67] Such flights involve more energy-consuming trajectories with reduced apogee (the highest altitude reached by the missile) and much shorter flight times to target. However, in addition to

requiring more fuel to fly the same range, RVs delivered by this method typically have much increased CEP[***] at the target, which could require much larger yields to achieve the same target kill.[68] Given the sources of the CEP increase, though, the use of a non-ballistic, guided RV might reduce some of the error.

The intended basing of the missile stated in the press suggested an intended use of the missile against both European and Chinese targets.[69] The most explicit statement was that the first deployed *Rubezh* missiles would go the mobile-missile bases near Irkutsk, which are among Russia's most easterly missile bases, from which a 6000-kilometer-range missile could more than cover all of China. The threat to China was not lost on Chinese analysts.[70] After Irkutsk, *Rubezh* was to replace outdated SS-25s,[71] which possibly suggests the 7th Missile Division of the 27th Missile Army[72] in Vypolzovo.[73]

Under the circumstances, a controversy arose with regard to whether or not *Rubezh* was an intermediate-range missile in violation of the INF Treaty. To Russian apologists the answer was obvious: the missile had flown to ICBM range, and Russia appeared at one point to be preparing to exhibit the missile to US inspectors under the terms of New START. Therefore, the missile was an ICBM. Further, if it had been deployed, to Irkutsk or Vypolzovo or both, it would have counted against the Russian allocation of operationally-deployed nuclear weapon systems under the treaty.[†††]

We argue here, though, that the wrong questions are being asked in the previous paragraph. To be sure, a missile with a particular warhead mass mockup flew to greater than ICBM range from Plesetsk to the Kura Test Range on Kamchatka. The proper question to ask is this: will that same missile, carrying multiple, independently-propelled and -guided warheads, be capable of flying to ICBM range? In other words, one payload's ICBM may be different payload's IRBM. We suggest that this issue would result in endless arguments between the Russian and US side unless it is recognized during negotiations, and treaty language is developed to disambiguate such a situation in the future.

What Happened to *Rubezh*?

The simple answer to this question is that Russia ran out of money to fund all of the items in the State Armaments Plan from 2018 to 2027, and *Rubezh* was bumped by the higher-priority *Avangard* system with the missile-defense-evading hypersonic glide vehicle. The issue of the Russian economy and defense budget is a topic beyond our scope here, but a piece in the Belarussian news magazine site *Belrynok* argued that Russia's defense budget problems are real and of long standing.[74] The author pointed to the 2011 dispute between then-President Dmitry Medvedev and then-Finance Minister Alexei Kudrin over Medvedev's desire to increase defense spending and Kudrin's warning that the increase was unaffordable. The result was the resignation of Kudrin and the approval of the spending increase. Those were the days of $100-per-barrel oil. By 2015, with oil at half the price and Russia under sanctions for the 2014 annexation of Crimea, well-known Russian economist Sergei Guriev was arguing that the level of Russian defense spending was simply unsustainable.

Rubezh was not the only 2018 casualty of funding shortfalls. A case in point is the SSBN, the BOREI-B, the follow-on to the BOREI-A submarines now under construction. In December 2017, in an article carrying the qualifier that there was no official confirmation for the information, *TASS* reported that development work on BOREI-B was to begin in 2018, with delivery to the fleet scheduled for 2026.[75] By May 2018, however, BOREI-B was out.[76] According to an unnamed source in the VPK, "After analyzing

[***] Circular Error Probable (CEP) is a measure of RV accuracy defined by the radius of a circle centered on the target sized so that one-half of incoming RVs impact within the circle, and one-half impact outside.
[†††] The fine points of treaty accountability are discussed by Pavel Podvig, "RS-26 and other intermediate-range ICBMs," 18 July 2017, http://russianforces.org/blog/2017/07/rs-26_and_other_intermediate-r.shtml.

the proposals for the creation of the BOREI-B nuclear submarine, it was decided to abandon them, since the project for the construction of these submarines does not meet the cost-effectiveness criterion. Instead, BOREI-A was included in the final version of the state armament program until 2027."

This rejection of the new in favor of the familiar had an analog in the case of *Rubezh*. Two developments were planned for 2016. First, the exhibition of the missile to US inspectors under the terms of New START was postponed from November 2015 to an undetermined date in 2016. Second, in February 2016, according to a source in the VPK, there was a seventh flight test of *Rubezh* planned for the second quarter of 2016 in order to evaluate the combat equipment.[77] Neither took place.

However, despite the halt on *Rubezh* development, the technology of independently propelled and guided RVs reappeared in a version of *Yars*, called *Yars-M*,[78] for which the first flight test occurred on 25 August 2016.[79] That flight, and the succeeding three flight tests for the silo-based and road-mobile versions of *Yars-M*,[‡‡‡] all were conducted from the Plesetsk Cosmodrome to the Kura Test Range over ICBM ranges, reportedly with each missile carrying two warheads. A treatment of the development effort is beyond the scope of this report, but we emphasize that *Rubezh* and *Yars-M* are different missiles. Much was made of a 2015 statement by former Strategic Missile Troops Commander Viktor Yesin, who conflated the two, saying in part, "… the *Yars-M* mobile missile system, sometimes called the *Rubezh* with the RS-26 missile …."[80] However, the two missiles have distinctively different GRAU indices: 15Zh67 for Rubezh, and 15Zh80 and 15Zh81 for the silo-based and road-mobile versions of *Yars-M*, respectively. Because the latter missile has a silo-based version, we judge it likely uses the less energetic propellant of most ICBMs, rather than the more energetic propellant of *Bulava* and *Rubezh*.

Continuation of flight testing of a missile with a payload consisting of independently propelled and guided RVs may be connected to some unfinished business in the development of the combat equipment for *Rubezh*. Following the final March 2015 flight test, an unnamed source told *TASS* that while the completion of that test was sufficient to go forward with deployment, additional flights would continue into 2016 to test options for the combat equipment.[81] The source explained further that *Rubezh* was to have "multivariate combat equipment" and carry a maximum of four warheads. Consistent with the observations about additional flight tests, we recall the planned 2016 flight test of *Rubezh*, which was intended as a test of combat equipment.[82]

The mention of "multivariate combat equipment" suggests a line of development observed for Russian missiles. The subject is beyond our scope, but it deserves mention that *Yars* appears in three versions distinguished at least by the payload, or combat equipment: *Yars*, with lower-yield-class warheads;[§§§] *Yars-S* with medium-yield-class warheads, and more recently the aforementioned *Yars-M*. Similarly, the *Layner* version of the SS-N-23 SLBM on DELTA IV SSBNs can carry a variety of warhead loads, from four middle-yield-class warheads to ten lower-yield-class warheads, as well as certain intermediate combinations.[83] Press reports also indicate that a different yield-class warhead is being developed for *Bulava*.[84]

The failure of *Rubezh* to make the cut in 2018 was, for want of a better word, a surprise, after the five successful flight tests, the scheduling of the treaty-related missile exhibition, and the public mention of deployment to missile units near Irkutsk and possibly Vypolzovo. In April 2015, following the final *Rubezh* flight test, in an article qualified by the statement, "*TASS* has no official confirmation of this

[‡‡‡] Flight tests conducted 12 September 2017, 19 June 2018, and 6 February 2019.
[§§§] When we refer to "lower-yield-class" we mean nuclear warheads with a yield of roughly 100 kilotons, while "middle-yield-class" implies a nuclear warhead with a yield in roughly the range 300-500 kilotons.

information yet," an unnamed source in the VPK said that serial production of the missile was to begin in late 2015 or early 2016.[85]

However, there were signs of financial stresses and competition for funding. For example, the final *Rubezh* flight test was postponed from December 2014 to March 2015 because of funding shortages.[86] Earlier on, following the first successful flight test in 2012, Yevgeny Myasnikov, director of the Center for Arms Control Studies, stated that simultaneous development of *Rubezh*, the *Bulava* SLBM, and *Sarmat* – the liquid-fueled, heavy missile replacement for the SS-18 Mod 5 – was extremely costly and economically unjustifiable.[87]

Will *Rubezh* Return, Post-2027?

In the absence of official statements about the future of *Rubezh* or a missile like it, we observe that the unique features of *Rubezh* are the use of a high-energy propellant on a land-based missile – which precludes the inclusion of a silo-based version of the missile – in a compact, reduced-mass booster that burns quickly in delivering warheads with independent engines that provide additional capability to evade or attack missile defenses. The initial base locations for *Rubezh* may provide additional information: the Irkutsk missile bases are the closest Russia has to the military facilities and major Chinese cities of the eastern region of the country. Similarly, the Vypolzovo bases are among the closest to NATO's military bases and Europe's major cities. This suggests the possibility that *Rubezh* could have been intended to provide a missile of limited intercontinental reach with superior intermediate range capability and the possibility of operation in a depressed-trajectory mode.

Timing is also potentially an issue. The maximum five-year extension allowed for negotiation of a successor treaty to New START expires in 2026. Russia's next State Armament Plan begins in 2027. This makes it imperative that negotiation of a successor treaty anticipate the possibility that Russia could deploy a very capable intermediate-range nuclear missile during the period covered by this New START successor.

Rubezh may return, or it may be overtaken by another, newer missile. On 28 February 2021, *TASS* carried the announcement of a new Russian research project (at a state of development known by the Russian acronym NIR) named *Kedr* aimed at the development of a new missile. No further information is yet available.[88]

References

[1] Joe Simonetti, Lauren Minore, Yulia Drozd and Natasha Popova, Kyiv says Russian ICBM strikes Ukraine, but US official says it was experimental medium-range ballistic missile, *ABC News*, November 21, 2024, accessed at *Everett Post*, https://www.everettpost.com/local-news/kyiv-says-russian-icbm-strikes-ukraine-but-us-official-says-it-was-experimental-medium-range-ballistic-missile.

[2] Chloé Hoorman, Benjamin Quénelle and Elise Vincent, Russia fires medium-range ballistic missile at Ukraine in warning to West, *Le Monde*, November 22, 2024, accessed November 27, 2024, via https://www.lemonde.fr/en/international/article/20)24/11/22/russia-fires-medium-range-ballistic-missile-at-ukraine-in-warning-to-west_6733702_4.html.

[3] Mathias Hammer, Russia informed US of ballistic missile attack on Ukraine, US official confirms, *Semafor*, November 21, 2024, https://www.semafor.com/article/11/21/2024/russia-informed-us-of-incoming-ballistic-missile-attack-on-ukraine-us-official-confirms.

[4] Olga Ostrovskaya, Why Russia's Irresistible Rocket Was Called "Nut Tree:" From Biblical Wisdom to the Grapes of Wrath, *KP.RU*, November 22, 2024, https://www.kp.ru/daily/27664.5/5014935/.

[5] Russian press conference interrupted by call ordering silence on ballistic missiles – video, *The Guardian*, November 21, 2024, https://www.theguardian.com/world/video/2024/nov/21/russian-press-conference-interrupted-by-call-ordering-silence-on-ballistic-missiles-video.

[6] Pentagon Says Russia Notified U.S. Before Ballistic Missile Strike on Ukraine, clip of Defense Department briefing, *C-SPAN*, November 21, 2024, https://www.c-span.org/video/?c5142975/pentagon-russia-notified-us-ballistic-missile-strike-ukraine.
[7] The "Kedr" complex - details about the new ballistics that terrorist Russia used to strike the Dnieper, Main Department of Intelligence of the Ministry of Defense of Ukraine, *Telegram*, November 22, 2024, https://t.me/DIUkraine/4878.
[8] Maya Mehrara and John Feng, What Is "Oreshnik?" Putin's New Medium Range Ballistic Missile Hit Ukraine, *Newsweek*, November 22, 2024, https://www.newsweek.com/what-oreshnik-putins-new-medium-range-ballistic-missile-hit-ukraine-1989974.
[9] We note, however, that apparent tests of BIR on Yars-M, as opposed to Yars, have been with fewer warheads per missile, possibly suggesting a mass and/or volume penalty; see Jonathan C. McDowell, Jonathan's Space Report, JSR Launch Vehicle Database, TOPOL family, https://planet4589.org/space/gcat/data/launch/Topol.html.
[10] Ivan Safronov, "Bulava" surfaced in Plesetsk – What kind of rocket was actually launched in Russia yesterday, *Kommersant*, no. 92, p. 1, May 24, 2012, https://www.kommersant.ru/doc/1941514.
[11] Vladimir Tuchkov, "Kedr" nowhere to plant; Why the Strategic Missile Forces change missiles like gloves, *VPK News*, no. 19, p. 882, May 25, 2021, https://vpk-news.ru/articles/62271.
[12] Russia is developing a new strategic missile system "Kedr," *TASS*, February 21, 2021, https://tass.ru/armiya-i-opk/10801813.
[13] Vladimir Tuchkov, "Kedr" nowhere to plant; Why the Strategic Missile Forces change missiles like gloves, *VPK News*, no. 19, p. 882, May 25, 2021, https://vpk-news.ru/articles/62271.
[14] Even the strongest enemy will be overtaken by the inevitable nuclear logging: The newest ICBM "Kedr" is not a fiction, but a reality, *Dzen/Patriot*, October 21, 2022, https://dzen.ru/a/Y1LKn6oBhzo_lseN.
[15] Vaslentyna Romanenko, Ukraine's Defence Intelligence unveils details of new ballistic missiles used in Russian attack on Dnipro, *Ukraïnska Pravda*, November 22, 2024, https://www.pravda.com.ua/eng/news/2024/11/22/7485828/.
[16] See Jonathan C. McDowell, Jonathan's Space Report, JSR Launch Vehicle Database, TOPOL family, https://planet4589.org/space/gcat/data/launch/Topol.html.
[17] Varvara Koshechkina, "At the epicenter of the explosion, everything turns to dust," Putin told what will happen during a massive strike by "Oreshniki," *Lenta.ru*, November 28, 2024, https://lenta.ru/news/2024/11/28/v-epitsentre-vzryva-vse-prevraschaetsya-v-pyl-putin-rasskazal-chto-budet-pri-massirovannom-udare-oreshnikami/.
[18] Maya Mehrara and John Feng, What Is "Oreshnik?" Putin's New Medium Range Ballistic Missile Hit Ukraine," *Newsweek*, November 22, 2024, https://www.newsweek.com/what-oreshnik-putins-new-medium-range-ballistic-missile-hit-ukraine-1989974.
[19] Mark Krutov, posted on X, November 21, 2024, https://x.com/kromark/status/1859656550857703897.
[20] Meredith Roaten, Nicholas Fiorenza, and Nick Brown, Ukraine conflict: Russia fires 'experimental' missile for first time, *Janes*, November 25, 2024, https://www.janes.com/osint-insights/defence-and-national-security-analysis/post/ukraine-conflict-russia-fires-experimental-missile-for-first-time.
[21] 10 million euros for "Palyanytsia": Ukraine offered Lithuania a mechanism for financing the production of a drone missile, *Ukrainian Ministry of Defense*, October 23, 2024, https://mod.gov.ua/en/news/10-million-euros-for-palyanytsia-ukraine-offered-lithuania-a-mechanism-for-financing-the-production-of-a-drone-missile.
[22] Varvara Koshechkina, "At the epicenter of the explosion, everything turns to dust," Putin told what will happen during a massive strike by "Oreshniki," *Lenta.ru*, November 28, 2024, https://lenta.ru/news/2024/11/28/v-epitsentre-vzryva-vse-prevraschaetsya-v-pyl-putin-rasskazal-chto-budet-pri-massirovannom-udare-oreshnikami/.
[23] Will Stewart, Russian shock as satellite images suggest Putin's new "wonder weapon" missile "caused little damage" after he unleashed it on Ukraine, *Daily Mail*, November 26, 2024, https://www.dailymail.co.uk/news/article-14126817/Russia-satellite-images-Putin-new-weapon-missile-little-damage-Ukraine.html.
[24] Oreshnik missile strike on Dnipro: Satellite images show surprising lack of destruction," *Kyiv Post*, November 25, 2024, https://tvpworld.com/83667483/russian-military-bloggers-underwhelmed-by-putins-new-missile.
[25] Pentagon not yet assessed damage caused by use of Russia's newest Oreshnik missile, *TASS*, November 25, 2024, https://tass.com/world/1877421.
[26] NATO spies study damage from Oreshnik at Yuzhmash — expert, *TASS*, November 25, 2024, https://tass.com/defense/1877061.
[27] Tyrone C. Marshall Jr., Livermore team successfully leads important test of a conventional warhead for the DoD, *Lawrence Livermore National Laboratory*, October 29. 2013, https://www.llnl.gov/article/39436/livermore-team-successfully-leads-important-test-conventional-warhead-dod.

[28] Jared Keller, The Pentagon's New Super Weapon Is Basically A Weaponized Meteor Strike, *Task and Purpose*, updated January 11, 2021, https://taskandpurpose.com/news/kinetic-bombardment-kep-weaponry/.
[29] The wreckage of the rocket found at the cosmodrome: The newest ICBM flew only 8 km, *Kommersant*, no. 182, p. 2, September 29, 2011, https://www.kommersant.ru/doc/1783440?from=doc_vrez.
[30] An intercontinental missile was launched from the Kapustin Yar test site, *Interfaks*, October 4, 2011, https://www.interfax.ru/russia/210607.
[31] Ivan Safronov, "Bulava" surfaced in Plesetsk – What kind of rocket was actually launched in Russia yesterday, *Kommersant*, no. 92, p. 1, May 24,2012, https://www.kommersant.ru/doc/1941514.
[32] Anton Mardasov, "Killer of American missile defense" will be sent to Irkutsk," *Svobodnaya Pressa*, September 23, 2015, https://svpressa.ru/war21/article/132431/.
[33] Prototype of new RS-26 ICBM to be shown to US side by year end, Prototype of new RS-26 ICBM to be shown to US side by year end, *TASS*, April 29, 2015, http://tass.ru/en/russia/790581.
[34] The latest ballistic missile RS-26 will enter service with the Irkutsk Strategic Missile Forces Division, *TASS*, July 1, 2014, https://tass.ru/politika/1290469.
[35] Source: the newest ICBM RS-26 will enter service with the Irkutsk Strategic Missile Forces Division in 2016, *TASS*, September 16, 2015, https://tass.ru/armiya-i-opk/2265803.
[36] Source: demonstration of the new RS-26 ballistic missile to the Americans postponed until 2016, *TASS*, November 18, 2015, https://tass.ru/armiya-i-opk/2448395.
[37] Test launch of the latest ballistic missile based on Yars postponed, *TASS*, January 16, 2015, https://tass.ru/armiya-i-opk/1701232.
[38] "Armats," "Sarmatians," and "Zircons": what are the priorities of the state armament program until 2027, *TASS*, January 30, 2018, https://tass.ru/armiya-i-opk/4911274.
[39] Source: the Avangard complex replaced the Rubezh in the state armament program until 2027, *TASS*, March 22, 2018, https://tass.ru/armiya-i-opk/5055517?utm_source=twitter.com&utm_medium=social&utm_campaign=smm_social_share.
[40] Ivan Safronov, "Bulava" surfaced in Plesetsk – What kind of rocket was actually launched in Russia yesterday, *Kommersant*, no. 92, p. 1, May 24, 2012, https://www.kommersant.ru/doc/1941514.
[41] An intercontinental missile was launched from the Kapustin Yar test site, *Lenta*, October 25, 2012, https://lenta.ru/news/2012/10/25/kapustin/.
[42] Pavel Podvig, New ICBM tested in Kapustin Yar, *Russian Strategic Nuclear Forces*, October 24, 2012, http://russianforces.org/blog/2012/10/new_icbm_tested_in_kapustin_ya.shtml.
[43] The new Rubezh missile system will be put on duty by the end of the year, *RIA Novosti*, June 7, 2013, https://ria.ru/20130607/942136785.html.
[44] Alexey Mikhailov and Dmitry Balburov, Russia will test the strategic missile "Avangard," *Izvestiya*, December 7, 2012, https://iz.ru/news/541042#ixzz3mZGrQgOm.
[45] Complex with ICBM RS-26 is planned to be put on duty in 2015, *RIA Novosti*, December 18, 2013, updated March 1, 2020, https://ria.ru/20131218/984844440.html.
[46] Ivan Safronov, "Frontier" of foreign use: Russia has successfully completed testing of a new missile and is ready to begin its deployment, *Kommersant*, no. 52, p. 1, March 26, 2015, https://www.kommersant.ru/doc/2694449.
[47] Strategic Mission Complex RS-26 "Rubezh," January 17, 2015, http://bastion-karpenko.ru/rubeg/.
[48] Ivan Safronov, "Frontier" of foreign use: Russia has successfully completed testing of a new missile and is ready to begin its deployment, *Kommersant*, no. 52, p. 1, March 26, 2015, https://www.kommersant.ru/doc/2694449.
[49] Sergey Ketonov, Long-range universal, *VPK*, # 28 (546), August 5, 2014, https://vpk.name/news/114891_dalnoboinaya_universalnaya.html.
[50] The ultimate warhead puts end to discussions, *RT*, January 27, 2011, https://www.rt.com/news/warhead-ultimate-missile-system/.
[51] RS-12M Topol, missile RT-2PM / 15Zh58 – SS-25 SICKLE, *Military Russia*, created March 11, 2011, changed November 24, 2019, http://militaryrussia.ru/blog/topic-600.htm.
[52] See Jonathan C. McDowell, Jonathan's Space Report, JSR Launch Vehicle Database, 2019 Nov 18 Edition, TOPOL family, https://planet4589.org/space/lvdb/launch/Topol.
[53] Test launch of Topol ballistic missile was successful – MOD, *RIA Novosti*, December 10, 2009, https://ria.ru/20091210/198457442.html.
[54] See Jonathan C. McDowell, Jonathan's Space Report, JSR Launch Vehicle Database, 2019 Nov 18 Edition, TOPOL family, https://planet4589.org/space/lvdb/launch/Topol.
[55] Pavel Podvig, New ICBM tested in Kapustin Yar, *Russian Strategic Nuclear Forces*, October 24, 2012, http://russianforces.org/blog/2012/10/new_icbm_tested_in_kapustin_ya.shtml.

[56] Complex with ICBM RS-26 is planned to be put on duty in 2015, *RIA Novosti*, December 18, 2013, updated March 1, 2020, https://ria.ru/20131218/984844440.html.
[57] See Pavel Podvig, Yars launch in September tested parallel deployment of warheads, *Russian Strategic Nuclear Forces*, October 4, 2017, http://russianforces.org/blog/2017/10/yars_launch_in_september_teste.shtml, which contained a figure showing the concept from a Twitter account.
[58] Sergey Ketonov, Long-range universal, *VPK*, # 28 (546), August 6, 2014, https://vpk.name/news/114891_dalnoboinaya_universalnaya.html.
[59] Anton Mardasov, "Killer of American missile defense" will be sent to Irkutsk, *Svobodnaya Pressa*, September 23, 2015, https://svpressa.ru/war21/article/132431/.
[60] Ivan Safronov, "Bulava" surfaced in Plesetsk – What kind of rocket was actually launched in Russia yesterday, *Kommersant*, no. 92, p. 1, May 24, 2012, https://www.kommersant.ru/doc/1941514.
[61] Sergey Ketonov, Long-range universal, *VPK*, # 28 (546), August 6, 2014, https://vpk.name/news/114891_dalnoboinaya_universalnaya.html.
[62] The development of the RS-26 strategic missile is one of the retaliatory steps to the deployment of the US missile defense system - a source at the Russian Defense Ministry, *Interfaks -AVN*, March 26, 2015, https://www.militarynews.ru/story.asp?rid=1&nid=370944&lang=RU
[63] Ivan Safronov, "Bulava" surfaced in Plesetsk – What kind of rocket was actually launched in Russia yesterday, *Kommersant*, no. 92, p. 1, May 24, 2012, https://www.kommersant.ru/doc/1941514.
[64] Alexey Mikhailov and Dmitry Balburov, Russia will test the strategic missile "Avangard," *Izvestiya*, December 7, 2012, https://iz.ru/news/541042#ixzz3mZGrQgOm.
[65] Anton Mardasov, "Killer of American missile defense" will be sent to Irkutsk," *Svobodnaya Pressa*, September 23, 2015, https://svpressa.ru/war21/article/132431/.
[66] Sergey Ketonov, Long-range universal, *VPK*, # 28 (546), August 6, 2014, https://vpk.name/news/114891_dalnoboinaya_universalnaya.html.
[67] Alexander Alesin, Strategic weapons: Russia surrenders "Rubezh," *Belrynok*, May 4, 2018, https://www.belrynok.by/2018/04/05/strategicheskie-vooruzheniya-rossiya-sdaet-rubezh/.
[68] Lisbeth Gronlund and David C. Wright, Depressed Trajectory SLBMs: A Technical Evaluation and Arms Control Possibilities, *Science & Global Security*, Vol. 3, pp.101-15, 1992.
[69] Anton Mardasov, "Killer of American missile defense" will be sent to Irkutsk, *Svobodnaya Pressa*, September 23, 2015, https://svpressa.ru/war21/article/132431/.
[70] See https://www.youtube.com/watch?v=iGF18cLxoWg which was translated to Russian.
[71] ICBM RS-26 "Rubezh" will soon go into mass production, *I-Mash*, April 15, 2015, http://www.i-mash.ru/news/nov_otrasl/65295-mbr-rs-26-rubezh-skoro-otpravitsja-v-serijjnoe.html.
[72] Sergey Ketonov, Long-range universal, *VPK*, # 28 (546), August 6, 2014, https://vpk.name/news/114891_dalnoboinaya_universalnaya.html.
[73] 7th Guards Rezhitskaya Red Banner Missile Division, http://www.ww2.dk/new/rvsn/7gvmd.htm.
[74] Alexander Alesin, Strategic weapons: Russia surrenders "Rubezh," *Belrynok*, May 4, 2018, https://www.belrynok.by/2018/04/05/strategicheskie-vooruzheniya-rossiya-sdaet-rubezh/.
[75] Source: the delivery of the first submarine of the Borey-B type to the Navy is scheduled for 2026, *TASS*, December 25, 2017, https://tass.ru/armiya-i-opk/4840412.
[76] Source: Russia will build six more Borei-A-class nuclear-powered strategic submarines, *TASS*, May 21, 2018, https://tass.ru/armiya-i-opk/5218417.
[77] Source: Strategic Missile Forces will launch a new RS-26 missile in the second quarter of 2016, *TASS*, February 20, 2016, https://tass.ru/armiya-i-opk/2686054.
[78] Ankit Panda, Revealed: Russia's New Experimental ICBM Warheads, *The Diplomat*, October 4, 2017, https://thediplomat.com/2017/10/revealed-russias-new-experimental-icbm-warheads/.
[79] See Jonathan C. McDowell, Jonathan's Space Report, JSR Launch Vehicle Database, 2019 Nov 18 Edition, TOPOL family, https://planet4589.org/space/lvdb/launch/Topol.
[80] Ministry of Defense: it is planned to re-equip all divisions of the Strategic Missile Forces with Yars and RS-26 in 2021, *TASS*, July 21, 2015, https://tass.ru/armiya-i-opk/2132865.
[81] The *TASS* reporting was recounted in ICBM RS-26 "Rubezh" will soon go into mass production, *I-Mash*, April 15, 2015, http://www.i-mash.ru/news/nov_otrasl/65295-mbr-rs-26-rubezh-skoro-otpravitsja-v-serijjnoe.html.
[82] Source: Strategic Missile Forces will launch a new RS-26 missile in the second quarter of 2016, *TASS*, February 20, 2016, https://tass.ru/armiya-i-opk/2686054.
[83] Development Work "Liner," *Joint-stock company State Missile Center named after academician V.P. Makeeva*, http://makeyev.ru/activities/missile-systems/Narubegevekov/Lainer/

[84] The source reported on the differences between the upgraded version of the Bulava missile, *Lenta.ru*, January 23, 2017, https://lenta.ru/news/2017/01/23/bulava/.
[85] Russia's new RS-26 missile to enter batch production in 2015-early 2016 — source, *TASS*, April 15, 2015, https://tass.com/russia/789383?_ga=2.130247755.598343688.1613923772-1091491743.1613923772.
[86] Test launch of the latest ballistic missile based on Yars postponed, *TASS*, January 16, 2015, https://tass.ru/armiya-i-opk/1701232.
[87] Ivan Safronov, "Bulava" surfaced in Plesetsk – What kind of rocket was actually launched in Russia yesterday, *Kommersant*, no. 92, p. 1, May 24, 2012, https://www.kommersant.ru/doc/1941514.
[88] Russia is developing a new strategic missile system "Kedr," *TASS*, February 28, 2021, https://tass.ru/armiya-i-opk/10801813.

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