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Western Air Supremacy as One Russian Justification for NSNW

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ABSTRACT

Significant and enduring US/NATO advantages in aircraft and precision-guided munitions drives the Russian need for a varied and large stock of non-strategic nuclear weapons (NSNW). NATO nations, particularly those on the eastern periphery of the alliance, perceive a need for this defensive air combat capability to ensure their security. Russia views events – such as the Kosovo War and Desert Storm – as validating its fear that these capabilities could be used offensively against it. Moreover, for historical and geographical reasons, Russia is apprehensive about threats all along its dynamic European border. Against large numbers of truly fifth-generation F-22s and F-35s, backed by fourth-plus-generation F15EXs and Block III F-18E/Fs, Russian air defenders will likely experience high early attrition rates in a military conflict. The United States is expected to retain this advantage well into the future, as it is already flight testing is latest sixth-generation fighter aircraft. Based on this firm sense of technological and numerical inferiority, Russian political and military leadership perceives the need for a range of nonstrategic nuclear capabilities.

Supportive Russian research into, and presumptive development of, much lower-yield nuclear warheads in the range of tens to hundreds of tons for non-strategic nuclear weapons has reduced the barriers to use. As examples of conventional explosions in this range, we note that ten tons is comparable to the GBU-43/B Massive Ordinance Air Blast bomb dropped in Afghanistan, while a yield of several hundred tons is comparable to the 2020 fertilizer blast in Beirut that killed over 200 people. Underwriting this dependence on NSNW, Russian military analysts perceive a "gap" between NSNW use at some very limited level of violence and the necessary conditions perceived as credible for even a limited strategic nuclear response. **Fundamentally, in this paper, we argue that Russian military planners and political leaders perceive a need for theater range, very- and ultra-low-yield nuclear systems in order to blunt the US/NATO air war that it expects as the inevitable opening gambit of any conflict with the West. Further, this employment of NSNW should be seen as Moscow's most probable pathway across the nuclear threshold.**

Despite a renewal in the bilateral Strategic Stability Dialogue, the "trades" involved in attempting to limit the class of NSNW applicable to the air-superiority issue would be highly asymmetric and would involve weapons on each side that are regarded as fundamental defensive capabilities by their holders
and as highly threatening by the other side.

CONTENT

THE CHALLENGE POSED BY RUSSIA'S NSNW RESPONSE TO US/NATO AIR SUPERIORITY

The US has been trying to limit Russian non-strategic nuclear weapons (NSNWs) since the end of the Cold War, largely unsuccessfully, notably with the non-binding, unilateral Presidential Nuclear Initiatives by both sides in 1991-1992,[1] and a hoped-for follow-on to New START that never came about.[2]

With the renewal of New START until 2026 by Presidents Biden and Putin, the US and Russia have reengaged with a Strategic Stability Dialogue "to lay the groundwork for future arms control and risk reduction measures."[3] Speaking at the September 2021 NATO Conference on WMD Arms Control, Disarmament, and Nonproliferation, Undersecretary of State for Arms Control and International Security Bonnie Jenkins said the US "will seek to address all nuclear warheads, including … so-called non-strategic nuclear weapons."[4]

The challenges in addressing Russian NSNW grows out of Russia's historical fears of the security threat from Europe, exacerbated by the lack of protective land barriers to assault and by the encroachment of NATO from the west, eliminating the protection formerly provided by intervening buffer states.[5] Large differences in population, collective GDP, and technical capability further conspire to create a sense of conventional military inferiority. Ironically, Russian aggression against Georgia and Ukraine has helped to widen the technical divide resulting from Western sanctions.[6,7,8] Under these circumstances, NSNW become the backstop if conventional deterrence and warfighting fail. In the end, we show that post-Cold War reductions in US NSNW in Europe have left the US little direct leverage – trading power – in the attempt to engage Russia on NSNW. Consequently, if the US is to make progress on this front, difficult asymmetric trades may have to be considered or countervailing capabilities developed.

One of the most prominent areas of conventional military asymmetry between the two sides is the enduring superiority of the US and NATO in aircraft and precision-guided munitions,[9,10] which helps drive Russian perceptions of inferiority in ways that strengthen the desire to retain NSNW. In that context, we briefly mention the challenge of trying to find a common ground for arms control negotiations when what each side considers to be its most effective defensive capability – air power for the US and NATO, NSNW for Russia – is simultaneously regarded by the other side as potentially the most dangerous offensive threat it faces.

Qualifier: China's Nuclear Buildup and the Future for Attempting to Limit Russian NSNW

In this paper, we examine the relationship between the significant and enduring US/NATO advantages in aircraft and precision-guided munitions and Russia's perceived need for a large and varied stock of NSNW. We do so under the assumption that any attempt to regulate Russian NSNW will necessarily involve a consideration of asymmetric security relationships, given the limited number of US NSNW as leverage.

However, recent revelations of the construction of hundreds of new ICBM silos in China[a,b,c,d] raise questions about how exactly to proceed with nuclear arms control in a way that enhances the security of all parties. In any event, we judge that the issues addressed here will be germane in any attempt to try to rein in NSNW.

a. Joby Warrick, "China is building more than 100 new missile silos in its western desert, analysts say," Washington Post, 30 June 2021, https://www.washingtonpost.com/national-security/china-nuclear-missilesilos/2021/06/30/0fa8debc-d9c2-11eb-bb9e-70fda8c37057_story.html.
b. Jeffrey Lewis and Decker Eveleth, "Chinese ICBM Silos," Arms Control Wonk, 2 July 2021, https://www.armscontrolwonk.com/archive/1212340/chinese-icbm-silos/.
c. Matt Korda and Hans Kristensen, "China Is Building A Second Nuclear Missile Silo Field," 26 July 2021, https://fas.org/blogs/security/2021/07/china-is-building-a-second-nuclear-missile-silo-field/.
d. Rod Lee, "PLA Likely Begins Construction of an Intercontinental Ballistic Missile Silo Site near Hanggin Banner," China Aerospace Studies Institute, 12 August 2021, https://www.airuniversity.af.edu/CASI/Display/Article/2729781/pla-likely-begins-construction-of-anintercontinental-ballistic-missile-silo-si/.

In the following, we first discuss the US and NATO superiority in aircraft and precision-guided munitions (PGMs). Then we consider Russia's expectations and concerns in the event conflict with NATO breaks out, Russia's escalation philosophy and strategy, and information indicating Russia's interest in very-lowand ultra-low-yield nuclear weapons (yields in the range of hundreds to tens of tons). We then turn to Russia's concept of active defense and how it would be employed against a NATO air assault. This treatment includes the analysis of the types of situations that could cause a transition to nuclear use and examine the types of dual-capable weapons that could be used as NSNW to blunt the NATO air war. Finally, we close with a short summary of the results of our analysis.

THE US-NATO AIR AND PRECISION-GUIDED MUNITION ADVANTAGE

The F-22 and the F-35 are currently the world's only truly 5th-generation combat aircraft, underpinning US/NATO air superiority (see the text box, with references i-vi in the box listed under Ref. 11 in the endnotes). These aircraft are distinguished by the following features:

- Stealth: specific design features reduce the range at which hostile radars and other sensors can detect, track, and engage them, which include limiting engine exhaust and electronic signals.[12]
- Enhanced situational awareness: the integrated avionics on these aircraft can fuse data from their advanced multi-spectral sensors and off-board data to provide a real time operating picture of the battlespace. The F-35 has active and passive sensors than can see in all directions and at night.[13]
- Electronic warfare: a suite of offensive and defensive capabilities enable: detecting hostile emitters; geolocating them and identifying the threats; and jamming, degrading, or avoiding them.[14]
- Advanced engine performance: the Pratt & Whitney F135 engine developed for the F-35, the most powerful fighter engine ever built, includes features such as low-observable exhaust and thermal management.[15]
- Networking: the F-35 can gather, exploit, and move information from aircraft to aircraft, even in a widely-spaced formation of aircraft, enabling a complete, real-time view of the battle space. This ability to collect, synthesize, and share information is at the heart of a radical change in combat tactics. The F-35 will be the "quarterback" of modern aerial combat, directing individual aircraft to specific targets in real time as the battlespace unfolds.[16]

NATO is well positioned to achieve air dominance over Russia fairly quickly in combat

NATO has a 3.4:1 advantage in combat aircraft and an even greater 4:1 advantage in such aircraft with a primary air-to-air mission.[i]

NATO currently has over 700 5th-generation fighters, the USAF F-22 and the F-35, the world's most capable fighters. The F-35 is the only 5th-generation fighter currently in production.[i,ii]

While somewhat affected by COVID-19, projections indicate NATO will have over 1,700 5th-generation fighters by the end of this decade.[iii]

Russia currently has no 5th-generation aircraft and may not have any at the end of this decade.[iv]

The US Air Force announced in 2019 they had built and flown a prototype 6th-generation fighter.[v] The US Navy also has a program to develop a 6th-generation fighter, and both services have reported they hope to begin production by the end of this decade.[vi]

Stealth, as an example of one of these features, confers enormous relative advantage, offering first look, first shot, first kill capability. Look involves the F-35's APG-81 Actively Electronically Scanned Array (AESA) low-probability-of-intercept radar for air-to-air and advanced air-to-ground application, as well as high-resolution mapping, multiple ground moving target identification and track, electronic warfare, and ultra-high bandwidth communications.[17,18] Shoot and kill involves the AIM-120 Advanced MediumRange Air-to-Air Missile (AMRAAM), an active-radar-guided, medium-range, supersonic air-to-air missile. The latest version, AIM-120D with a range of about 90 miles,[19,20] offers improved range, GPS-assisted guidance, updated data links, and jam resistance, in addition to greater lethality. In 2019, the Air Force announced it is developing the AIM-260 Joint Air Tactical Missile (JATM)[21] with the Navy to replace AMRAAM with a longer-range (possibly up to 180 miles), more capable weapon to counter high-end threats. Initial operating capability is expected in 2022. The Air Force refers to the weapon as the next air-to-air dominance weapon.

The US military relies on PGMs to execute military operations. These guided munitions are intended to destroy a point target and minimize collateral damage. PGMs include air- and ship-launched missiles, multiple launched rockets, and guided bombs. Russia's large and sophisticated anti-access/area denial (A2/AD) systems are likely to increase the value of PGMs. Using advanced guidance systems, PGMs can be launched at long ranges to attack an enemy without risking US forces. As a result, DOD has argued it requires and is procuring longer-range munitions to meet these and other new threats.[22] We highlight a few in the following paragraph.

The Joint Air-to-Surface Standoff Missile (**JASSM**) is a stealthy, precision-guided cruise missile designed to defeat defended high-value targets, including enemy air defenses. There are several configurations of the JASSM: AGM-158A (JASSM), AGM-158B (JASSM-ER), and the AGM-158D (JASSM-XR), with ranges of 230, 620, and 1120 miles, respectively.[23,24,25,26] There is also AGM-158C, or the Long-Range Anti-Ship Missile (**LRASM**).[2]7 For suppression of enemy air defenses, the AGM-88G is an extended-range version of the current High-Speed Anti-Radiation Missile (**HARM**), which is already in production and service. Improvements include a more lethal warhead, more advanced seekers, a classified range extension, and networking capability.[28,29,30] The Air Force is also using the AGM-88G as the basis for its next generation Stand-in Attack Weapon (**SiAW**) to equip the F-35A with full-up Suppression/Destruction of Enemy Air Defense (SEAD/DEAD) capability.[31] As final examples, the GBU-39 **Small Diameter Bomb I** and the GBU53 **STORMBREAKER** are precision-guided munitions with explosive armament of the order of roughly 100 pounds or less capable of striking targets in all-weather from up to 46 miles away. The GBU-39 is designed to attack fixed targets while the GBU-53 can attack moving targets. Their small size allows them to be carried in fighter aircraft internal weapon bays or to increase overall load-out to enable more independent strikes per sortie.[32] Eight of these weapons will fit internally on the F-35A.[33] The bombs are retargetable after release.[34] The range of these glide bombs allows them to attack modern Russian surface-to-air missile systems (SAMs) comfortably outside the range the radar can track an F-35.

RUSSIA'S EXPECTATIONS AND CONCERNS

According to Michael Kofman, if fighting breaks out with NATO, the Russian military will "expect a US aerospace blitzkrieg which cannot be blocked at the outset."[35] Assuming "that the initial period of war will be decisive," Russia will move rapidly to deflect, attrit, and disorganize the US response with the goals of undermining US political will and disrupting the allied plan of operations or creating enough pain to cause the attackers to deescalate. And if Russia fails to achieve those goals conventionally, Koffman adds, "… there is always theater employment of non-strategic nuclear weapons, an area where Russia does not suffer credibility problems."

Russia has taken two notable actions to respond with urgency to the NATO air assault. One is the 2015 creation of the Aerospace Forces military branch, on a par with the Ground Forces and Navy, which aggregates the Russian Air Force (which includes both Long-Range Aviation and the Air Forces and Air Defense commands that are functionally subordinated to the regional military commanders), the Aerospace and Missile Defense Forces (which includes the Moscow ABM system and the missile attack space sensors and early-warning radars), and the Space Forces. The other is the recognition that given the expectation of a rapidly developing situation, fully staffed and equipped permanent readiness troops are required in these units.[36,37]

Given Russia's expectation of holding a weak conventional military hand, Russian military writers anticipate the need to employ asymmetric responses.[38] This approach is similar to that anticipated over 50 years earlier by Herman Kahn, who recognized that for a technologically and economically inferior Soviet Union, "possessing large numbers of tactical nuclear weapons" was the equalizer.[39]

RUSSIA'S ESCALATION PHILOSOPHY AND STRATEGY

We expect that conflict between Russia and NATO would lie on the cusp of what Russian analysts characterize as regional and large-scale conflict, depending on the degree to which NATO and the US strike into Russia and the potential for Russian strikes on the US in response.[40] Russian military analysts do seem to believe there is an escalatory "gap" between the use of NSNW and the circumstances that create a strategic nuclear exchange.[41] This gap is likely widened even further by Russian research into, and we judge likely inclusion of, very-low- and ultra-low-yield NSNW (see following text box). Such weapons, combined with highly-accurate Russian PGMs, would create a very potent and usable combination that would increase the down-time of stricken airfields and dramatically increase the number of high-priority NATO targets, to include possible NSNW launchers and launch sites.

Beyond the Russian assessment of a gap between regional NSNW use and a strategic exchange, the evidence also indicates that the Russian military has less aversion to the use of NSNW, especially with VLY and ULY warheads, than NATO and the US. We point to the very wide variety of dual-capable systems available to Russia (a point to which we shall return, in part). In this regard, we believe it highly unlikely that there is a nuclear warhead for every dual-capable weapon; however, we also believe it highly likely that there are at least some nuclear warheads for every type of theater-range weapon system. Building the warheads is not a challenge for Russia, provided Houston Hawkins' 2014 estimate of 1000 plutonium pits per year in Russia is comparable to warheads per year.[42] As noted by Mark Schneider, assuming this also means 1000 warheads can be built every year, that implies the production complex could support up to 10,000-20,000 total warheads, depending on warhead lifetime.[43]

Russia has some advantages over the US in managing escalation into the nuclear realm – in part a question of each side's capacity to inflict and accept pain, as well as determining if the prize is worth the price – beyond the availability of a large number of NSNW. These advantages, or asymmetries, include, first, the fact that Russia has a host of "escalatory targets" in the European theater without having to strike highly escalatory targets outside the region (i.e. US territory) and run the risk of escalating from a regional to a large-scale conflict. In comparison, NATO and the US have a paucity of regional escalatory targets outside Russia, so that strikes against the Russian homeland are almost required, opening up the US to retaliation, a situation that could leave the US self-deterred. Second, Russia has designed a force of VLY and ULY nuclear weapons to discriminately cause psycho-social pain and perhaps achieve certain military advantage while limiting collateral damage and casualties to suppress retaliation. On the other hand, NATO and the US have relinquished almost all capability for assured, proportionate, in-kind response to nuclear "pin-pricks," which are nonetheless very effective operationally.

Russia's use of NSNW would also act as a substantial jolt to the NATO alliance, straining political fracture lines, depending of course on the reasons for a conflict. Trans-conflict fractures could be operationally determinative, while post-conflict fractures could constitute an acceptable outcome for Russia, even under status quo ante conditions. Potential fracture lines themselves can be outlined as a set of questions, among which are the following:

- Are Southern members who are geographically removed from conflict "all in?"
- Are Allies hosting nuclear weapons prepared to accept "prime target" status?
- Is the threat posed by Russia assessed similarly by all Allies?
- Is the territorial integrity of every member state equally valuable to all of its Allies?

Returning to a point, Russia's measured and discrete use of NSNW allows Moscow to "dial in" the pressure on the alliance, exploiting the varying tolerances of each member state. The goal would be to find the right level of shock and/or pain to cause the other side to deescalate or desist without going so far that nuclear use galvanizes the alliance into mounting an even a stronger response.

Russian Very-Low-Yield (VLY) and Ultra-Low-Yield (ULY) Nuclear Weapons

Declassified CIA analysis of August 2000 stated, "… the need for subkiloton nuclear weapons with minimal long-term contamination had been argued in the media by senior Ministry of Atomic Energy (Minatom) officials, nuclear weapons scientists, and military academics since the mid1990s…."[a] Unnamed Russian advocates were said to "cite clean, very-low-yield weapons as an 'asymmetric response' to US superiority in conventional weapons." This analysis followed a 30 April 1999 meeting of the Russian Federation Security Council that according to then Council Secretary Vladimir Putin dealt with a concept for the use of nuclear weapons, including tactical nuclear weapons.[b] Investigative journalist Pavel Felgengauer, reporting in Segodnya, stated that this included a plan to develop a new, low-yield nuclear warhead.[c]

According to DIA, as of May 2019, "Russia's stockpile of nonstrategic nuclear weapons, already large and diverse, [was] being modernized with an eye towards greater accuracy, longer ranges, and lower yields to suit their potential war-fighting role."[d]

In our work, VLY weapons are those with nuclear yields of the order of hundreds of tons, which is comparable in explosive yield to the 2020 ammonium-nitrate explosion in Beirut that killed over 200 people. We regard ULY weapons as those with nuclear yields of the order of tens of tons, comparable to the GBU-43/B Massive Ordinance Air Blast bomb dropped in Afghanistan.

Aftermath of the Beirut explosion of August 2020, with an explosive yield of roughly 300 tons. Note the water-filled crater at right. (Reuters, Mohamed Azakir)

a. Intelligence Memorandum, CIA/Office of Transnational Issues, "Evidence of Russian Development of New Subkiloton Nuclear Warheads," 30 Aug 2000 (redacted for release).
b. "Documents adopted at the meeting of the Security Council on the development of nuclear forces," Interfaks, 29 April 1999.
c. Pavel Felgengauer, "Limited Nuclear War? Why Not!" Segodnya, 6 May 1999, pp. 1, 2.
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RUSSIA'S CONCEPT OF ACTIVE DEFENSE IN RESPONSE TO NATO AIR SUPERIORITY

Consider the three integral elements of Russia's active defense against aerospace attack:[44]

- Air defense systems for strategically important targets and forward army units that are in the process of being integrated with new bistatic over-the-horizon radars and a network of radars covering the Barents Sea.
- Missile defense of the Moscow area integrated with ballistic missile early warning radars ringing the country and launch-warning satellites in space.
- Theater strike systems to degrade or defeat US and NATO attack systems, including airfields, command and control nodes, radar systems, and supporting infrastructure.

Russia is in the process of overhauling its ballistic missile and air attack early warning radars, replacing older systems, some of which were placed on the territory of formerly Soviet republics. To reduce cost, Russia has designed and has built or is building twelve new modular ballistic-missile warning radars of the Voronezh type, with models operating in the meter and decameter wavelength ranges.[45] These radars ring the country from sites at Lekhtusi (near St. Petersburg),[46] Olenegorsk,[47] Vorkuta,[48] Pechora (a Cold-War radar in the process of being replaced),[49] Yeniseysk,[50] Mishelevka (a two-radar site near Irkutsk),[51] Barnaul,[52] Orsk,[53] Armavir (a two-radar site),[54] and Pionersky (in Kaliningrad).[55] The hardware cost alone for those radars is roughly 55B rubles, which is comparable to the cost of two to three BoreiA SSBNs (a 2012 contract for five such submarines totaled 100B rubles). Two additional radars of the new Yakhroma type are to be built in Crimea[56] and on the Chukchi Sea.[57]

New Konteiner bistatic,* over-the-horizon radars are to be built for early warning of aircraft, cruise missile, and short- to intermediate-range ballistic missile attack. The first such radar was built and deployed in December 2019 with a transmitter near Gorodets and a receiver near Kovylkino.[58] Construction of a second such radar has begun near Zeya in the Far Eastern Amur region, although completion seems to be delayed.[59,60] A third is planned for Kaliningrad,[61] and a fourth may be built at an undisclosed location in the Arctic.[62] These radars cost about 10B rubles each. Another type of over-thehorizon radar, claimed to have enhanced ability to detect stealthy and hypersonic targets, the RezonansN, has been deployed at five locations located around the Barents Sea to protect that SSBN launch bastion as well as the Northern Fleet and other defense facilities.[63]

These radars will be available for networking with Russia's mobile missile defense units. The main longrange systems are the S-300 series (S-300P type for air defense units, S-300V to protect Ground Forces units, and S-300F mounted on ships);[64] S-350 with smaller, more maneuverable missiles;[65] S-400, a more capable successor to the S-300P and S-300F series;[66] and the even more capable S-500 to be used for air and missile defense,[67] and possibly in an anti-satellite role.[68] Each of these systems consists of a missile launcher carrying cannisterized missiles sealed at the factory; reload missiles on a vehicle with a loading crane; long-range

* "Bistatic" meaning the transmitter and receiver are separated by distances of ten to hundreds of kilometers

detection and shorter-range targeting radars; and a control vehicle. As an example, for the S-400, each launcher can carry four missiles, each control vehicle can control up to twelve launchers, and each 12-launcher unit can be networked with five others (for a total of six units) spaced at distances of tens of kilometers or more.[69] The new S-500 system will be capable of networking with other S-500s, as well as S-400s and -300s.[70] Different types of missiles can be loaded with each system, and depending on the range of the missiles – as well as the radar cross section of the target and its elevation, so the defense radar can see it over the horizon – the S-300V4 has a maximum range of about 400 km for a large target like an AWACS, about the same range as S-400 with its longest-range missiles. Russia's air defense is multi-layered as well, with shorter-range Buk missiles and the Pantsir system for protection at shorter range.[71] In **Figure 1**, we show a deployment map for Russia's air-defense units.[72] Note the concentrations near Moscow and St. Petersburg; in the Arctic, Far East, Black Sea, and Kaliningrad; and at strategic locations related to strategic air, ICBM bases, and SLBM bases.

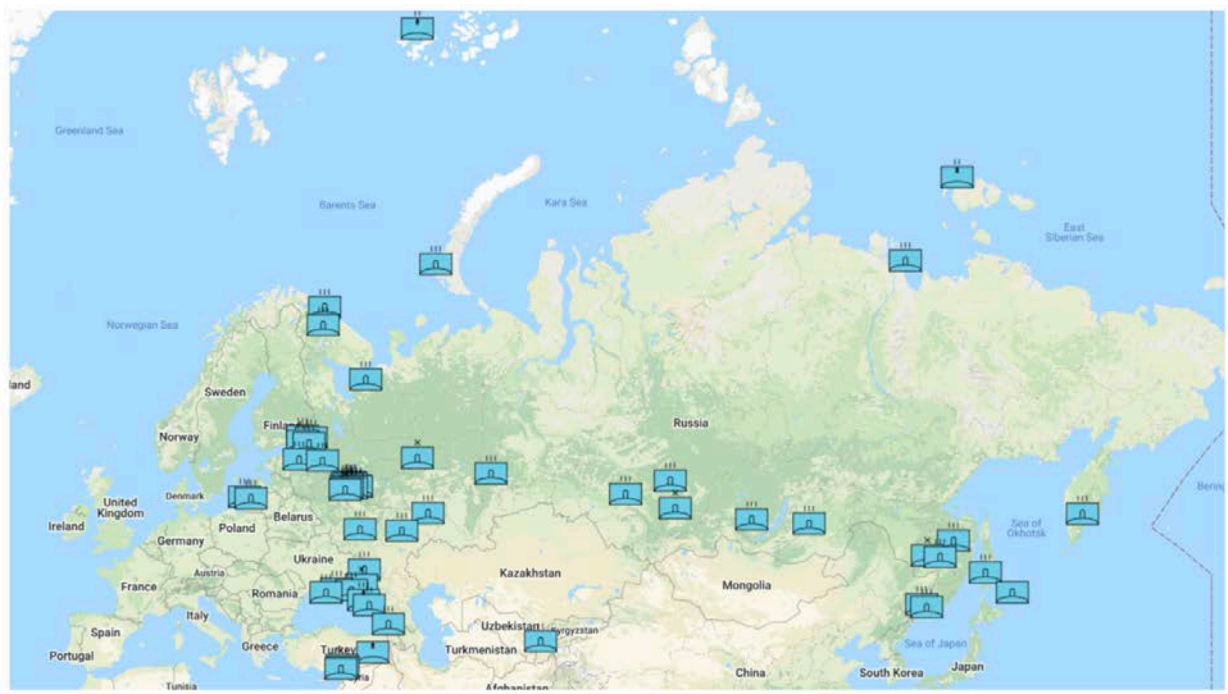

Figure 1. Locations of deployed air-defense units in Russia and nearby.

The problem for Russia is the detectability of low-flying stealthy cruise missiles and stealthy US and NATO aircraft that can attack the targeting and perhaps long-range detection radars before the aircraft are even detected.[73] A possible mitigating factor playing in Russia's favor is the strength of the network of warning radars and networked air-defense radars, as well as Russia's electronic-warfare capabilities, both topics beyond our scope.

As mentioned, active defense for Russia also includes a strike element aimed at disrupting and reducing the ability of the other side to mount air attacks. Our initial analysis of Russia's options, limiting ourselves largely to long-range strike systems to avoid NATO air power, is illustrated in **Figure 2**. Russia can cover much of NATO with 2500-km-range Kalibr land-attack cruise missiles (the SS-N-30A)[74] fired from submarines in the Black and Norwegian Seas, as well as the 9M729 ground-launched cruise missile (the SSC-8) launched from bases at Shuya and Voronezh, for which we assume a 2500-km range.[75,76] We also show a 500-km range ring for an Iskander-M (SS-26)[77] launched from Kaliningrad. Several other systems not shown in the figure include the following. The ship-launched hypersonic Tsirkon (SS-N-33) missile has a range of about 1000 km,[78] which is the same range as the modified Kh-32 launched from a Backfire bomber.[79] Depending on the point of launch, the hypersonic air-launched Kinzhal (Kh-37M2), with a range 2000 to 3000 km for launch from the MiG-31K or Backfire bomber,[80] respectively, or the long-range Kh-101/-102 air-launched cruise missiles from strategic Bear-H or Blackjack bombers[81] can cover all of Europe.

All of these weapons are dual-capable.[82] Similarly, certain missiles for the S-300P series and S-400, as well as likely the S-500, have had nuclear warheads designed for them.[83,84] In addition, TASS reports that at least some missiles carried by S-400 can be used in a surface-to-surface mode.[85]

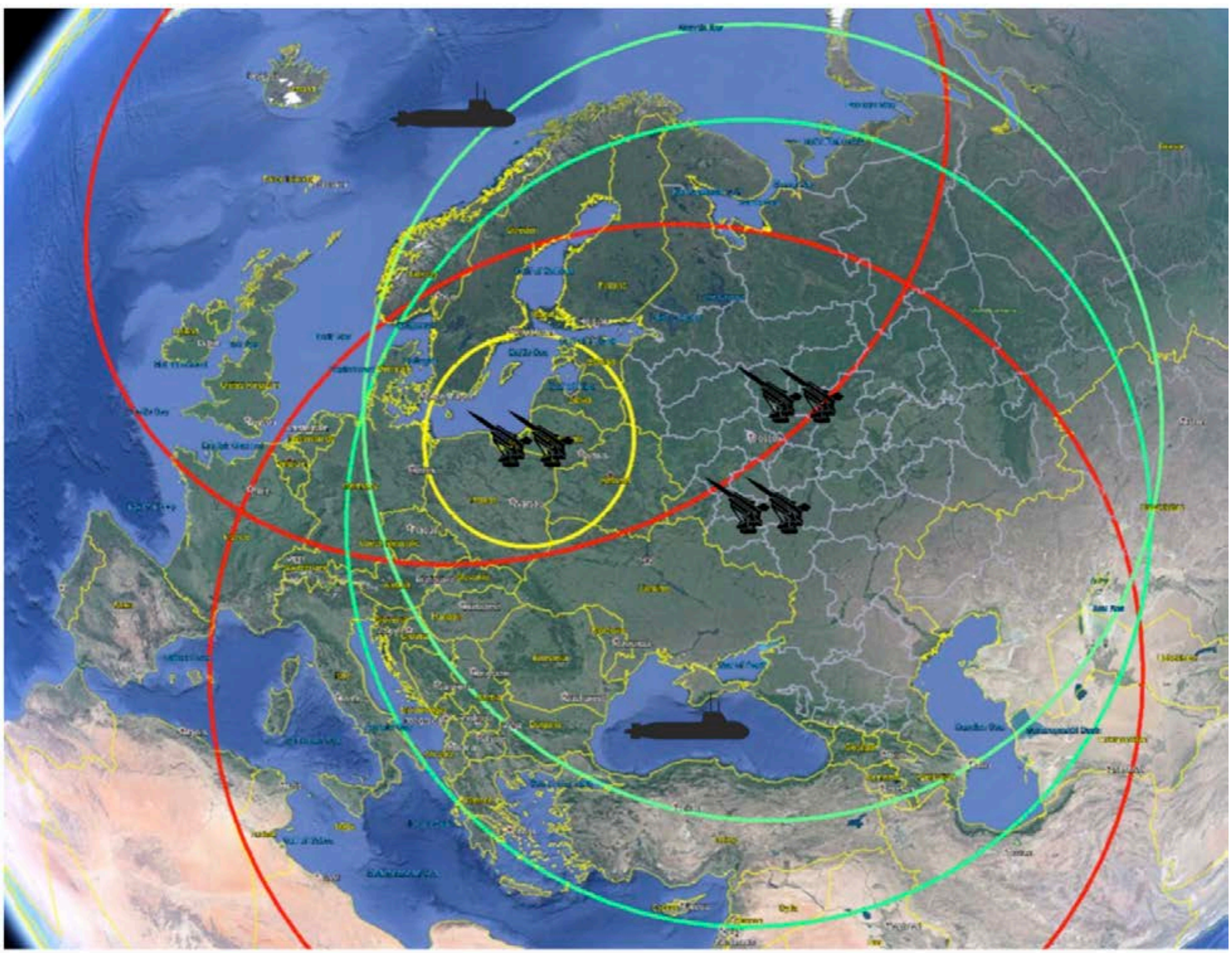

Figure 2. Range rings for SS-N-30A land-attack cruise missiles (red); SSC-08 ground-launched cruise missiles (green); and SS-26 short-range ballistic missiles (yellow).

The limitation on collateral damage from low-yield air-to-air missiles or VLY and ULY warheads is perhaps not fully appreciated. In "Ground Zero Population 5," a video made in 1957 at the Nevada Test Site, five officers and a cameraman stand under a 2-kiloton explosion from an air-to-air missile at 18,500 feet above them. No one was injured, and all participants in that test apparently had normal lifespans.[86]

In a separate context, one of the authors used the publicly available computer code NUKEMAP[87] to explore the effect of a series of 20-ton blasts detonated at a minimum-fallout height of burst a means of disabling the port of Bremerhaven, shown in **Figure 3**, which could be used to move personnel and materiel from the US to Europe in the event of a conflict. That analysis indicated that 15 ULY strikes could destroy 10 ships and leave the port nonoperational, with as few as about 300 killed and 1200 injured, although those casualties could grow depending on the number of personnel on the ships.

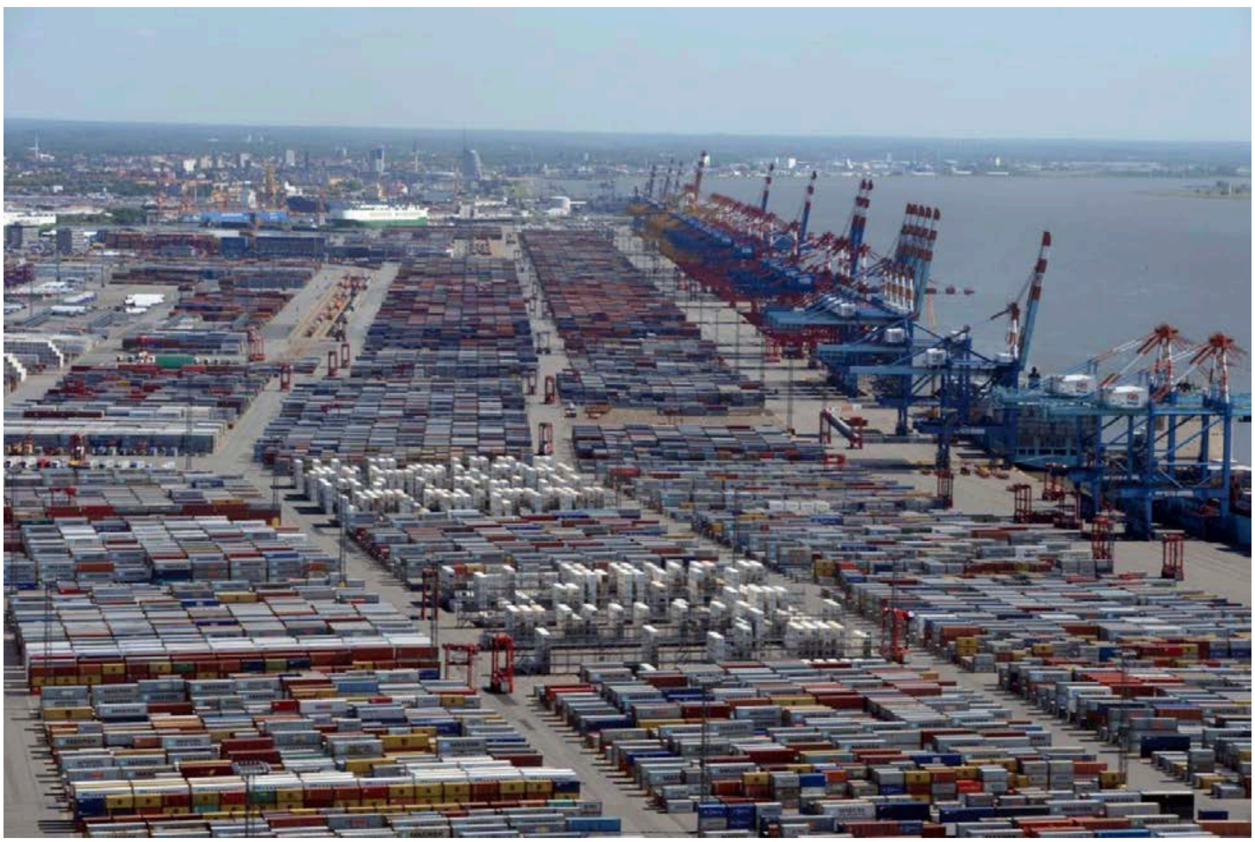

Figure 3. The port of Bremerhaven.

THE DETERRENCE AND OPERATIONAL RELATIONSHIPS BETWEEN NATO AIR SUPERIORITY AND RUSSIAN NSNW

We acknowledge that the nature of war is changing in some fundamental ways, including what constitutes "onset of conflict" and the growth in the number of domains in which war can be fought. Nevertheless, Russia retains substantial NSNW forces, and there are circumstances under which it almost certainly has developed plans to use them. We particularly highlight the likelihood of ULY and VLY nuclear strikes by theater systems in an effort to counter NATO air and PGM superiority and blunt the expected aerospace blitzkrieg. We further expect this to be an enduring element of Russian planning, since: (1) the technological asymmetry between the NATO and US on one side and Russia on the other will continue and likely grow; (2) it is very difficult to envision the economic and population asymmetries between the two sides changing markedly in the coming decades; and (3) the asymmetries have been exacerbated by Russian actions in Ukraine that poisoned relations with NATO members.

One must bear in mind that Russian use of NSNW in a European conflict would inflict potentially intolerable stresses on the NATO alliance. To date, the alliance has withstood any number of rather obvious threats of nuclear use from Russia. An arms control push on NSNW, even a protracted push or continuing good-faith dialogue on this very difficult issue, may provide important support for the maintenance of NATO.

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