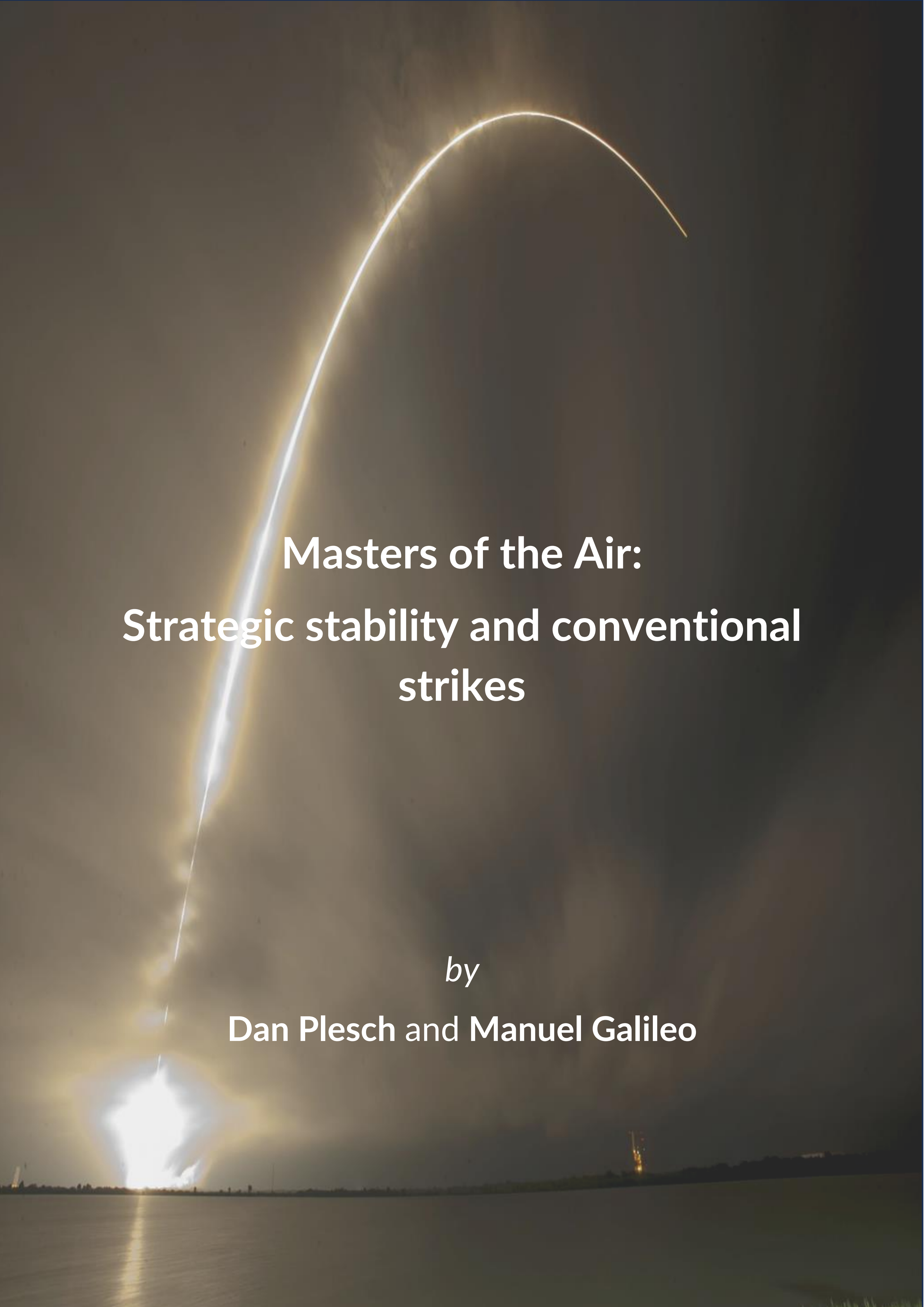

Masters of the Air:

Strategic stability and conventional strikes

by

Dan Plesch and **Manuel Galileo**

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Overview and strategic context

World War is a subject of public debate, currently in the context of Russia's war on Ukraine, as well as possibly arising in the Middle East or the Asia-Pacific. Such a World War is universally assumed to be a nuclear war.

In this study we examine the strategic non-nuclear strike capability of the US and its allies as contributions to deterrence and potential war fighting, if and when decision makers had concluded that war had commenced. Additionally, pre-emptive attack is a strategic policy option in the US.[1] For critics and potential adversaries, the US and allied actions in Iraq and historic examples such as the origins of the US war in Vietnam, support the concept that initiating war is conceivable. Certainly, peer-competitor actions, not least Russian aggression in Ukraine in 2022 and Chinese military expansion in the East and South China Seas, point to an unstable strategic environment where unprovoked attack is a reality.

We look at the potential of the US and its allies to conduct a non-nuclear world war using the "conventional and missile defence capabilities" referred to. This study examines whether the US and allies have the capacity to destroy Russian and Chinese strategic nuclear forces with a non-nuclear pre-emptive attack. We consider how far currently deployed non-nuclear weapons might enable these types of attacks: also known as "first-strike" and "counterforce". We conclude that the supporting evidence is compelling – if not conclusive – and urge the matter be given attention across defence studies.

The expiration of the US-Russian START process in 2025 adds fresh urgency to consider the current state of strategic stability. This analysis combines European and east Asian missile deployments; whereas studies usually focus on, for instance, Germany *or* the South China Sea, but rarely both.

The US and allies' "Rapid Dragon"[2] missile system, the unexpected successes of US missile defence systems, and post-INF land-based missile deployments point to the need to look again at US non-nuclear strategic firepower.

Our analysis questions the normal assumptions in strategic studies that crewed aircraft, cruise missiles, and other non-nuclear weapons are not effective for attacking adversary strategic nuclear weapons. There are four main reasons given for the assumed ineffectiveness of these types of weapons for strategic pre-emption. Firstly, they are too slow, secondly they can be detected by early-warning radars,

[1] Warren, A. (2011). Prevention, pre-emption and the nuclear option: from Bush to Obama. Routledge Studies in US foreign policy. **N.B. All URLs cited were accessed in August 2024 unless stated otherwise.**
[2] Moore, G. (2023). Rapid Dragon: The US military game-changer that could affect conventional and nuclear strategy and arms control negotiations. Bulletin of the Atomic Scientists. // Waltermire, B. (2022). AFSOC conducts live-fire exercise with Rapid Dragon. Air Force. // Dean, S. (2023). Instant bombers: Rapid Dragon lends teeth to cargo aircraft. European Security and Defence.

thirdly they lack the power to destroy targets hardened with concrete, and lastly they cannot be shot down by missile defences after they are fired.

"NATO is a defensive alliance whose members are committed to safeguarding the freedom and security of all Allies, against all threats, from all directions. Deterrence and defence is one of NATO's core tasks. The Alliance deters aggression by maintaining a credible deterrence and defence posture based on an appropriate mix of nuclear, conventional and missile defence capabilities, complemented by space and cyber capabilities. Allies are significantly strengthening the deterrence and defence of the Alliance as the backbone to their Article 5 commitment to defend each other."[3]

NATO is therefore committed to not initiating war, while seeking to prevent one with comprehensive deterrence through credible capacity to wage war if it were to happen.

Below we provide analysis challenging these four assumptions which can be summarised as follows:

First, to challenge the assumption of lack of speed: the Pentagon's Defense Science Board Study on Time Critical Conventional Strike from Strategic Standoff played down the importance of even one-hour flight times in assessing weapons requirements. It stated that in the analysed scenarios between the US and near-peer competitors, "there is no need for one hour, global range delivery ... as there appears to be nothing unique or compelling about one hour [missile strikes]".[4]

Second, to counter the point of early detection: current Russian and Chinese early-warning radars could be seen overall as non-robust especially against NATO stealth weapons, although it should be noted that "China hosts a more varied and geographically extensive Integrated Air Defense System than Russia".[5]

Third, in answer to the lack of power for hardened-concrete targets: contemporary missiles have significant hard-target destruction capacity especially when "earthquake and shockwave effects," and direct strikes are considered.[6]

Lastly, to dispute their inability to be shot down by missile defences after they have been fired: conflicts in the Levant and Ukraine have shown unexpected Ballistic

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[3] NATO (2024). Deterrence and Defence.
[4] Defense Science Board Task Force (2009). Time Critical Conventional Strike from Strategic Standoff. Department of Defense.
[5] Bronk, J. (2020). Modern Russian and Chinese Integrated Air Defence Systems: The nature of the threat, growth trajectory and Western options. RUSI.
[6] RTX (2008). Raytheon Unveils New Bunker-Busting Technology. // Carpaccio, T. (2011). B-2 Bomber gets Boeing's new 30,000-pound bunker-buster bomb. Bloomberg. // Parken, O. (2023). Our best look yet at the massive Ordnance Penetrator Bunker Buster bomb. The Warzone. // Blair, B., Sleight, J. & Foley, E. (2018). The End of Nuclear Warfighting: moving to a deterrence-only posture. Princeton University, Global Zero. Edited on the 17th of September in response to contact by Princeton.

Missile Defence (BMD) effectiveness and a wealth of real-world data for system upgrades.[7]

However, although valid opposing arguments on boost-phase interception appear valid,[8] Vice Admiral John Hill, Director of the US Missile Defence Agency, admitted that intercepting boost-phase missiles "should start to scare you … because it just gets so close to being a strike operation when you think about it."[9]

Rapid Dragon JASSM system

The Rapid Dragon system encompasses the deployment of palletized boxes with AGM-158 JASSM cruise missiles in unmodified cargo planes, namely the C-130 and C-17. As presented by Lockheed Martin,[10] these can be used against land or naval targets, and crucially used with no prior preparation in between transport missions.[11]

C-17 transport aircraft with palletized JASSM missiles

The system has already been successfully trialled with JASSM-ERs against land and sea targets, with strike ranges of 1,000km successfully tested off Norway in 2022.[12]

Russian and Chinese leaders point to US dominance in offensive and defensive non-nuclear systems as undermining strategic stability and so a reason not to engage in negotiations to control nuclear weapons by themselves.[13] In the West, discussing

[7] Stoll, H., Hoehn, J. and Courtney, W. (2024). Air Defense shapes warfighting in Ukraine. RAND Corporation. // Doyle, G. (2024). Missile defense success in Gulf, Ukraine fuel global urgency to acquire systems. Reuters. // Judson, J. (2024). How Patriot proved itself in Ukraine and secured a fresh future. Defense News. // Bowsher, H. (2023). Air denial lessons from Ukraine. US Naval Institute. // Boyd, I. (2023). Israel's Iron Dome air defense system works well - here's how Hamas got around it. Colorado Arts and Sciences Magazine.
[8] Williams, I. & Dahlgren, M. (2022). Boost-Phase Missile Defense - Interrogating the Assumptions. CSIS. // Wilkening, D. (2003). Airborne Boost-Phase Ballistic Missile Defense. Science & Global Security, 12:1-67. // Williams, I. & Dahlgren, M. (2022). As missile threats grow, don't give up on boost-phase defense. Defense News. // Garwin, R. (2000). Boost-Phase Intercept: A Better Alternative. Arms Control Association.
[9] Defense Daily (2020). MDA Director: Boost Phase Intercept Hard And Likely Only For Retaliation, If Possible.
[10] Lockheed Martin (2021). Rapid Dragon. Strategic Development Planning and Experimentation Office (video presentation).
[11] Lockheed Martin (2021). Rapid Dragon Demonstrates Palletized Munition Capability in first C-17 and EC-130 System-Level Demonstrations.
[12] US Spec Ops Europe (2024). 352nd Special Operations Wing successfully test fire a palletized Joint Air to Surface Standoff Missile (JASSM). Accessed on X, 9th November, 2022.
[13] Kremlin (2022). Joint Statement of the Russian Federation and the People's Republic of China on the international relations entering a new era and the global sustainable development. // Fu, C. (2020). Rebuilding

an issue highlighted by Russia and China is to risk being discredited as serving their interests; on the contrary seeking objectivity and understanding adversary perspectives is essential to robust analysis. Indeed, it is precisely the sensitivity of the topic that requires attention.

Where one party is unaware of the threat it is perceived to pose to another this can contribute to unintended conflict – a problem Presidents Joe Biden and Xi Jinping highlighted and pledged to prevent.[14] We contribute this study in that spirit. The US 2024 Threat Assessment itself highlighted Chinese fear of a US first strike as motive for Chinese nuclear arms build-up.[15] In the extreme conditions where, for example, Western leaders saw nuclear war as imminent, a disarming conventional strike to limit an attack without going nuclear might appear the lesser of two evils. Russian public policy emphasises that in a mirror of NATO during the Cold War it would start a nuclear war if it were losing a non-nuclear war.[16] In this context, would Russia or China risk nuclear first use when much of that nuclear force was already destroyed and China has a prominent no first use public policy?[17]

Frank von Hippel describes the risks of unintended consequences: first, history has demonstrated that false warnings occur due to human and equipment error. This is particularly pertinent when hacking capabilities are considerable in 2024.[18] Moreover, "a launch-on-warning posture is indistinguishable from being constantly poised to mount a first strike, which pressures Russia and China to put their missiles on hair trigger as well. The United States would be on the receiving end for any mistaken launch one of them makes."[19] Such "hair trigger" posture is not merely nuclear. We argue that US and allied conventional capabilities are seen by other nations as a further hair trigger.[20]

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mutual trust in arms control, non-proliferation, and disarmament: the way ahead. Speech, EU non-proliferation and disarmament conference, virtual, November 13, 2020.

[14] White House (2023). Readout of President Joe Biden's Meeting with President Xi Jinping of the People's Republic of China. // Ministry of Foreign Affairs of the PRC (2023). Steering the Wheel of China-US Relations and Piloting Asia-Pacific Cooperation.

[15] Office of the Director of National Intelligence (2024). Annual Threat Assessment of the US Intelligence community. p.9.

[16] Seddon, M. & Cook, C. (2024). Leaked Russian military files reveal criteria for nuclear strike. Financial Times. // Williams, H., Hartigan, K., MacKenzie, L., and Younis, R. (2024). Russian nuclear calibration in the war in Ukraine. CSIS.

[17] Zhenqiang, P. (2016). China's No First Use of Nuclear Weapons. Carnegie Endowment for International Peace.

[18] Clarke, R. (2022). The Cyber-Nuclear Threat. NTI. // Futter, A. (2018). Hacking the bomb: cyber threats and nuclear weapons. Georgetown University Press. // Unal, B. and Lewis, P. (2018). Cybersecurity of nuclear weapons systems: threats, vulnerabilities, and consequences. Chatham House.

[19] von Hippel, F. (2021). Biden should end the launch-on-warning option. Bulletin of the Atomic Scientists.

[20] Miasnikov, 2000. Precision Guided Weapons and Strategic Balance. Center for Arms Control at MIPT, Dolgoprudny.

Background to counterforce

The idea of striking opponents before they can fire weapons is not new and has long been a feature of warfare.[21] Since the beginning of the nuclear age, the US and USSR have struggled with this possibility.[22] Almost 50 years ago, Paul Nitze wrote that the US could dispense with nuclear weapons since its non-nuclear forces were able to defeat any potential nuclear enemy.[23] Nitze had been an architect of US air power since WW2 and a key arms-control negotiator with the Soviet Union. Over the last 30 years, nuclear weapons themselves have remained little changed while non-nuclear or conventional strike technologies have become much faster, with longer ranges and significantly more accuracy – especially in the US.[24]

After 9/11, US national policy espoused preventive war and implemented it in Iraq.[25] More recently, US policy documents have emphasised integrated nuclear and conventional deterrence.[26] Similar language has been found in Russian[27] and Chinese[28] literature for more than a decade, and has been discussed by Western scholars.[29] In contrast, Western strategic studies includes numerous papers examining Russian and Chinese forces in regional contexts in Europe, and of China with relation to East and South China Seas. Western analysis of strategic war with Russia and China usually focuses on nuclear weapons without including the non-nuclear dimension.

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[21] Thucydides (1974). History of the Peloponnesian War. Penguin Classics. // Grotius, H. (1625). The Law of War and Peace. Classics of Strategy and Diplomacy. // Clausewitz, C. (1993). On War.
[22] Gray & Payne (1980). Under the nuclear gun: victory is possible.
[23] Nitze, P. (1977). The Relationship of Strategic and Theater Nuclear Forces. International Security, Fall 1977, p.124.
[24] Congressional Research Service (2021). Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues.
[25] Russel, J. & Wirtz, J. (2002). Preventive War against Iraq. Strategic Insight: Center for Contemporary Conflict.
[26] Lopez, C. (2023). Allies, partners central to US integrated deterrence effort. US Department of Defence.

[27] Ven Bruusgaard, K. (2016). Russian Strategic Deterrence. Survival, 58(4), p.7-26. // Kofman, M., Fink, A. & Edmonds, J. (2020). Russian Strategy for Escalation Management: Evolution of Key Concepts. CNA. // Kalinkin, D., Khryapin, A. & Matvichuk, V. (2015). Стратегическое сдерживание в условиях создания США глобальной системы ПРО и средств глобального удара [Strategic Deterrence in the Context of the US Global Ballistic-Missile Defence System and Means for Global Strike]. Voyennaya Mysl [Military Thought], no. 1, January 2015, pp. 18–22. // Akimenko, V. (2021). Russia and Strategic Non-Nuclear Deterrence: Capabilities, Limitations, and Challenges. Chatham House Briefing, 29 July 2021.

[28] Blasko, D. (2009). Military Parades Demonstrate Chinese Concept of Deterrence. China Brief, Vol. 9, No. 8, April 16, 2009. // Cheng, D. (2011). Chinese views on deterrence. Joint Force Quarterly, n.60, 1st Quarter, 2011, p.92-4. // While the official PLA dictionary of military terms does not contain the terminology "integrated strategic deterrence", it covers the concepts of intelligence, campaign, military, and strategic deterrence, with the latter subdivided into categories of defensive, offensive, conventional, nuclear, 'all-out' and limited deterrence. These can be found on the People's Liberation Army Military Terms (2011) 中国解放军军语. Beijing: Military Science Academy Press.
[29] Horschig, D. & Adamopoulos, N. (2023). Conventional-Nuclear Integration to Strengthen Deterrence. CSIS. // Anderson, J. (2021). Deterring, Countering, and Defeating Conventional-Nuclear Integration. Strategic Studies Quarterly, Spring 2021. // Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics (2010). The Nuclear Weapons Effects National Enterprise. Defense Science Board. // Horschig & Adamopoulos (2023). Conventional-Nuclear Integration to Strengthen Deterrence. CSIS. // Jones, S. (2021). The future of competition: US adversaries and the growth of irregular warfare. CSIS.

"Mind the Gap" in strategic analysis

Studies by Podvig,[30] Zhao,[31] and Hoffman[32] recognise the existence of a literature gap on conventional counterforce. This paper explores this gap in research: the contribution of conventional forces to potential first strike (i.e., counterforce) in a strategic confrontation between the US, China, and Russia. The same gap is present in discussions of regional confrontations, for example with Russian first use of nuclear weapons in Ukraine or conventional war in East Asia where the regional analysis rarely includes the global military context. Readers are left to assume that a great-power war would be nuclear.

A silent revolution in military affairs

Ongoing significant incremental upgrades to decades-old non-nuclear missile types enable them to be targeted against the most important strategic adversary weapons and targets. The upgraded weapons include Tomahawk, Advanced Medium-Range Air-to-Air Missiles (AMRAAM), SM-3 and SM-6, Aegis, and JASSM. Upgrades include range, accuracy, smaller profile and weights, greater hard-target penetration, and the sheer volume of production. For example, "generic box launchers"[33] as delivery platforms for Tomahawk and Aegis systems and the Rapid Dragon system that can fire JASSM from unmodified transport planes.[34] Simultaneously, the US has highly capable Global Hawk RQ-4, and RQ-180 drones for tracking mobile nuclear launchers;[35] and strategic bombers, with the B-21 soon entering service.[36]

Accompanying this detection and delivery superiority is the development of the Tandem Warhead System and the Massive Ordnance Penetrator, conventional bunker-busting technologies specifically designed to defeat or incapacitate hardened and deeply-buried bunkers and potentially certain nuclear silos.[37] These technologies

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[30] Podvig, P. (2024). Restoring Russian-US Arms Control. Arms Control Association.

[31] Zhao, T. (2011). Conventional Counterforce Strike: An Option for Damage Limitation in Conflicts with Nuclear-Armed Adversaries? Routledge. // Zhao, T. & Stefanovich, D. (2023). Missile Defense and the Strategic Relationship among the United States, Russia, and China. American Academy of Arts and Sciences.

[32] Hoffmann, F. (2021). Threat Under the Radar: The Case for Cruise Missile Control in the Next National Security Strategy. The Strategy Bridge. // Hoffmann, F. (2021). Strategic Non-Nuclear Weapons and Strategic Stability – Promoting Trust Through Technical Understanding. Fondation pour la Recherce Stratégique.

[33] Trevithick, J. (2022). Cargo Ships as Missile Carriers is one of the Navy's options to offset cruiser retirements. The Warzone. // Bisht, I. (2023). US Navy tests sea-based containerized missile launcher. The Defense Post. Army Deploys Typhon Missile System To China's Backyard For The First Time (twz.com)

[34] Janes (2023). USSOCOM to trial 'Rapid Dragon' palletised launcher in November. // Dean, S. (2023). Instant bombers: Rapid Dragon lends teeth to transport aircraft. European Security & Defence.

[35] Section edited for clarity on September 16th, 2024. // McKinney, B. (2024). RQ-4 Global Hawk modernised ground segment comes in from the cold. Northrop Grumman. // Losey, S. (2024). Northrop Grumman modifying Global Hawk drones for hypersonic tests. Defense News. // Newdick, T. (2021). Unwanted Global Hawk drones are being transformed to support hypersonic missile tests. The Warzone. // Li, B. (2007). Tracking Chinese strategic mobile missiles. Science and Global Security, 15:1-30. 2007. // Bracken, P. (2020). The hunt for mobile missiles: nuclear weapons, AI, and the new arms race. Foreign Policy Research Institute.

[36] Air Force, 412th Test Wing Public Affairs (2024). B-21 Raider continues flight test, production. // Northrop Grumman (2024). 10 facts about Northrop Grumman's B-21 Raider. // Gunzinger, M. (2023). The case for the B-21 Raider. Air and Space Forces Magazine.

[37] RTX (2008). Raytheon Unveils New Bunker-Busting Technology. // Carpaccio, T. (2011). B-2 Bomber gets Boeing's new 30,000-pound bunker-buster bomb. Bloomberg. // Parken, O. (2023). Our best look yet at the

constitute a quiet revolution in the currently deployed aircraft and missile capability of the US and allies, enabling them to increasingly target adversary strategic systems. In considering such counterforce in US relations with Russia and China, there is a clear geographical disparity that favours the US and allies. Accordingly, we focus on US capabilities vis-à-vis Russia and China. The inherent geographic disparity is based on the fact that Moscow and Beijing have few military assets or allies in the US's vicinity, while the reverse is true: the US has numerous bases and allies close to Russia and China. Indeed, this reality provides some empirical support for these states' rhetoric about encirclement.[38]

Geographic and technological disparities

In a mirror image, US allies, whether in the Baltic or South China Sea, find themselves adjacent to far larger Russia or China, which induces military reliance on the US for their security guarantees. From a simple analytic perspective, where a larger state's actions in respect to a peer are necessarily on a larger scale – they are inevitably overbearing to smaller neighbours. The dynamics of these disparities are themselves hard to reconcile technically, leading to escalating misunderstandings. These misunderstandings are amplified when open debate predominantly overlooks the US and allies' overall strategic preponderance apropos Russia and China, concentrating almost entirely on Western concerns over Russia and China's disparities with one or more of its smaller neighbours.

The estimation of military capabilities in Western literature tends to focus on those of Russia and China, often disregarding the massive capabilities of the US – let alone combined with its allies in Europe and Asia – which still accounts for most of the world's defence spending. The US's $738bn budget remains nearly four times that of China's $193bn and almost six times that of Russia's current wartime budget (which has itself tripled compared to 2021).[39] A discussion of a US non-nuclear war with Russia and China needs to begin with the sheer arithmetic magnitude of capabilities of the US's military assets which are reinforced by a larger budget, technical expertise, and wartime experience. All of these criteria overall outweigh the relative advantages of cheaper personnel costs and technology in Russia and China in purchasing power parity.[40] For as much that Russia and China are arming on various

massive Ordnance Penetrator Bunker Buster bomb. The Warzone. // Feng, H. et al., (2023). Simulation study of the damage effect of tandem warhead on concrete target. ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering, v.10, i.1.

[38] Chang, F. (2016). China's encirclement concerns. Foreign Policy Research Institute. // Nathan, A. & Scobell, A. (2012). How China sees America: the sum of Beijing's fears. Foreign Affairs, v.91, n.5 (September-October, 2012), p.32-47). // Bagshaw, E. (2023). Xi urges officials 'to fight', accuses US of encircling China. Sydney Morning Herald.

[39] Hartung, W. (2023). Reality Checks: Chinese Military Spending in Context. Brown University, Costs of War, Watson Institute of International & Public Affairs. // Peter G.Peterson Foundation (2023). US Defense Spending Compared to Other Countries.

[40] Kofman, M. & Connolly, R. (2019). Why Russian Military Expenditure is Much Higher than Commonly Understood (as is China's). War on the Rocks. // Robertson, P. (2022). The Real Military Balance Review of Income and Wealth.

measures, and reinforcing their strategic capabilities; US commanders have the technical and financial wherewithal – and crucially the geographic advantage – to dominate escalating crises, and counter opposing forces before they can be used.

The following analysis outlines US and allied non-nuclear strike capabilities versus Russian and Chinese strategic nuclear forces.[41] It particularly analyses mobile and deeply-buried missiles, for Russia and China respectively, and deems them the "hardest to reach" strategic targets of the US and its allies.

Throughout the history of nuclear weapons, policymakers and military strategists have continuously explored strategies to utilise these weapons to overcome adversaries, including pre-emptively disarming strikes against opponents armed with nuclear capabilities. However, early challenges hindered the effectiveness of such approaches. The inaccuracy of weapons made it challenging to reliably destroy fortified targets, while concerns about fratricide[42] limited the feasibility of targeting multiple adversaries simultaneously. Additionally, the sheer quantity of targets, coupled with inadequate intelligence on their locations, posed significant obstacles. In sum, conventional weapons proved insufficient for the task, and any attempts at disarming adversaries were anticipated to result in catastrophic loss of life.[43]

The growing advent of counterforce

By 2024, in contrast, highly-accurate conventional weapons appear capable of reaching most types of counterforce targets. The biggest obstacles to effective counterforce remain targeting intelligence, and kinetic and earthquake-induced penetrating capabilities against mobile and deeply-buried targets. Yet, ongoing technological changes are revolutionary.[44] Of the two key strategies that countries like the US, Russia and China have employed since the start of the nuclear age to keep their arsenals safe, the effectiveness of infrastructure hardening has been significantly reduced against conventional missiles, and concealment of nuclear launchers is increasingly under duress due to highly-sensitive radars. Consequently, strategic stability, defined as a reliable retaliatory force, is likewise reduced.

The purpose of counterforce can be summarised as the destruction of the military capabilities of the opponent, including nuclear and non-nuclear forces.[45]

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[41] Federation of American Scientists (2024). Nuclear notebook. // IISS (2024). The Military Balance.

[42] Nuclear fratricide occurs when there is an unintentional destruction of nuclear warheads or their delivery systems by detonations from other warheads from the same attack (e.g., debris cloud, the blast intensity)

[43] Payne, K., Harvey, J., Miller, F. and Soofer, R. (2023). The Rejection of Intentional Population Targeting for 'Tripolar' Deterrence. National Institute Press, v.3, no.9, 2023.

[44] Acton, J. (2013). Conventional Prompt Global Strike and Russia's Nuclear Forces. Carnegie Endowment for International Peace. // Congressional Research Service (2021).Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues. // Bracken, P. (2020). The Hunt for Mobile Missiles: Nuclear Weapons, AI, and the New Arms Race. Foreign Policy Research Institute. // Jamison, B. (2022). The Counterforce Continuum and Tailored Targeting: A New Look at United States Nuclear Targeting Methods and Modern Deterrence. Air Command and Staff College.

[45] von Hippel, F. (1988). Civilian Casualties from Counterforce Attacks. Scientific American, v.259, no.3, September 1988, pg. 36-43.

Since an opponent's strategic forces represent the greatest threat, they are considered to be the highest-priority targets for counterforce missions. Today some analysts argue that Russia and China possess nuclear capabilities that are highly resilient, making pre-emptive strikes against them unlikely to significantly reduce the potential damage the Continental United States (CONUS) would face in a nuclear conflict.[46] Our analysis suggests that this resilience is lesser than expected, and may be deemed non-existent; nonetheless, it increases US-Russia-China tripartite geostrategic instability.

The continuing wars in Ukraine and the Middle East are providing a continuous flow of real-world experience in how weapon systems and their operators act, where all concerned are intent on maximising their own capabilities. Analyst William Arkin argues that contrary to the conventional perspective of Russian superiority, recent data indicates a significant lead for the US and its European allies over Moscow.[47] These continuous operations, known as "persistent heel-to-toe" exercises,[48] involve seamlessly transitioning from one exercise to another, highlighting swift aircraft deployments and dispersals to forward bases. The focus in 2023 primarily revolved around fighter aircraft and bomber dispersals, showcasing Western geographical advantages and the culmination of combined air operations honed over two decades of engagements in the Middle East. We now outline US and allied conventional systems and their incrementally-strengthened capabilities.

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[46] For example: Acton, J. (2023). Two Myths about Counterforce. War on the Rocks. // Brown, G. (2021). Understanding the Risks and Realities of China's Nuclear Forces. Arms Control Association.
[47] Arkin, W. (2020). While the Press and Public Focus on Iran, US Military Prepares for War with Russia. Newsweek Magazine.
[48] Congressional Research Service (2020). Defender Europe 20 Military Exercise, Historical (REFORGER) Exercises, and US Force Posture in Europe.

Bunker busting with earthquake effects

In WW2, the earthquake effect of Tall Boy and Grand Slam bombs dropped alongside, rather than on top of, concrete-hardened targets, destroyed reinforced concrete bunkers of Nazi V-2 ballistic missiles and other types of targets resistant to direct attack.[49] Nevertheless, 80 years later, the norm of analysing the effects of bombs on hardened targets focuses on direct hits and rarely includes this dimension.[50] Any consideration of analysis of weapons going through concrete should be augmented by analysis of the same weapon alongside the target. Consequently, a *lower* explosive and penetrating power may be needed to destroy targets than is often assumed.

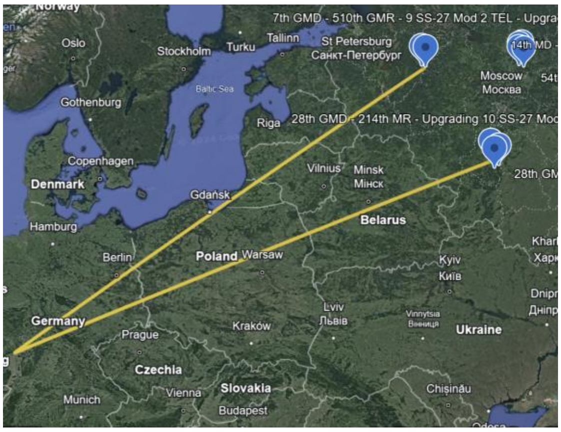
British Tall Boy bomb in WW2. Source: Imperial War Museum, CH15363

In July 2024, the US and Germany agreed to deploy US long-range conventional missiles in Germany by 2026.[51] These conventional missiles include the SM-6 and Tomahawks.[52] This announcement surprised several German politicians, and incited a public debate about the potential consequences,[53] with particular concerns of escalatory risks.[54] These systems will be headquartered at Clay Kaserne in Wiesbaden in southwestern Germany (approximately 1,700km from St. Petersburg and 2,000km from Moscow). The SM-6 has a reported range of around 460km,[55] and the Tomahawk has a range of between 1,600 and 1,900km.

As shown in fig.1, these Tomahawks could reach several silos in western Russia, including the ICBM launchers' headquarters of the 7th GMD at Bologoye (approximately 1,850km away), and the silos in Kozelsk in Kaluga Oblast (approximately 1,900km away).

[49] Multiple primary and secondary sources describe these attacks, for example, Flower, S. (2013). *The Dambusters: An Operational History of Barnes Wallis' Bombs*. Amberley Books. *Also, see the destruction of the bunker La Coupole with Tall Boy bombs.*
[50] Tucker, P. (2022). Pentagon to Launch New Study on How to Get at Hard, Deeply Buried Targets. Defense One. // US Department of Defense (2022). 2022 National Defense Strategy of the USA.
[51] Graef, A. & Thies, T. (2024). Missiles on the move: why US-long range missiles in Germany are just the tip of the iceberg. Bulletin of the Atomic Scientists. // Felstead, P. (2024). Germany agrees to host conventional range US missiles on its territory. // Roque, A. (2024). Germany gives US greenlight to deploy new longer-range weapons inside its borders. Breaking Defense.
[52] White House (July 2024). Joint Statement from US and Germany on Long-range fires deployment in Germany. Press Brief.
[53] DW (2024). Germany split on US stationing long-range cruise missiles.
[54] Goury-Laffont, V. (2024). US Missiles are welcome in Germany, foreign minister says. Politico.
[55] Freedberg, S. (2020). Army picks Tomahawk & SM-6 for Mid-range missiles. Breaking Defense.

Fig.1 Ranges from Germany to western Russian strategic ICBMs



Source: Elaborated by authors from ICBM coordinates by Kristensen et al. (2024)[56]

This US missile deployment in Germany coincides with Berlin's public pursuits to improve its missile defence framework, likely through the US's THAAD,[57] or the recently announced contract – the second in 2024 – by Raytheon totalling $1.2bn for additional Patriot systems in Germany.[58]

Limitations of the study

There are important warnings that should be attached to all analyses of this type, less our discussion of the potential of pre-emptive war against Russia and China be taken as a recommendation. There is a tendency to describe a rational world, apparently devoid of chaos and human psychology, wherein cognitive dissonance is commonplace.[59] General Lee Butler, the first STRATCOM commander, later observed that:

"Elegant theories of deterrence wilt in the crucible of impending nuclear war."[60] He went on to say that "deterrence [is] a dialogue of the blind with the deaf. In the final analysis, it was largely a bargain we in the West made with ourselves... It was premised on a litany of unwanted assumptions, unprovable assertions and logical contradictions. It suspended

[56] Kristensen, H., Korda, M., Johns, E. & Knight, M. (2024). Russian nuclear weapons, 2024. Bulletin of the Atomic Scientists, vol. 80, 2024.
[57] Reuters (2020). Germany looks to buy Israeli or US missile defence system.
[58] RTX (2024). RTX's Raytheon awarded a $1.2 billion contract to provide additional Patriot air and missile defense systems to Germany.
[59] Acharya, A., Blackwell, M. & Sen, M. (2018). Explaining Preferences from Behaviour: A Cognitive Dissonance Approach. Journal of Politics, v.80, no.2, March 1, 2018. // Jervis, R. (1976). Perception and Misperception in International Politics. Princeton University Press.
[60] Butler, L. (1996). General Butler's Speech on Nuclear Weapons. December 4th, 1996. Inside Missile Defense, v.2, no.25, December 11, 1996, pp.17-19.

rational thinking about the ultimate aim of national security to ensure the survival of the nation."[61]

Butler's observations are in tune with civilian analysts such as Carol Cohn,[62] Benoît Pelopidas,[63] or the actualities of Cuba and Able Archer,[64] however all such analyses require contextualisation. Unfortunately, the formulas of strategic studies replicated here all too often drive debate, policy and procurement. For example, the recent US Commission report on the future of US nuclear forces blandly describes the likelihood of vast areas of central US absorbing missile attack.[65]

Additionally, in considering our report's technical analyses, it must be noted that probability calculations from open sources are fraught with unpredictability and reliability. Yet, likewise, prior probability analysis has been highly influential in government analysis despite known flaws.

The study is focused on present systems – rather than latent and emerging issues such as hypersonic, cyber, AI and weapons in space – not least because future potential systems are already the subject of research[66] to the neglect of in-service technologies. Moreover, this study does not analyse drones, which have been impactful in the Russo-Ukrainian war, for instance in bypassing early-warning systems. Despite their capabilities, they can still be deemed as tactical and non-strategic.

Overall, this study can be considered as laying out a further research agenda on the issues analysed. This research agenda encompasses, amongst other areas, analyses on the destruction of hardened silos, the advent of palletized missile systems, and radar capabilities against conventional missiles in their boost phases.

US and allies' current non-nuclear counterforce systems

A quiet evolution in the capability of US and allied non-nuclear weapons systems has taken place this century. This includes their accuracy, stealth, range, flexibility of targeting, and network connectivity with other systems. Our study looks at key current technologies to *Detect* adversary strategic nuclear weapons; to *Defeat* them with missiles and aircraft before they can be launched; and to *Defend* by intercepting

[61] Butler, L. (1998). The Risks of Nuclear Deterrence: From Superpowers to Rogue Leaders.
[62] Cohn, C. (1987). Sex and Death in the Rational World of Defense Intellectuals. University of Chicago Press.
[63] Pelopidas, B. (2017). The unbearable lightness of luck: Three sources of overconfidence in the manageability of nuclear crises. European Journal of International Security, 2017, 2(2), pp.240-262.
[64] National Security Archive (2021). Able Archer war scare "potentially disastrous".
[65] Creedon et al., (2023). America's Strategic Posture: The final report of the Congressional Commission on the strategic posture of the United States. Congressional Commission.
[66] Feldstein, S. (2024). AI in war: can advanced military technologies be tamed before it is too late? Bulletin of the Atomic Scientists. // Authority of the House of Lords (2023). Proceed with Caution: Artificial Intelligence in Weapon Systems. Report of Session 2023-24. // Mueller, B. et al. (2023). Cyber Operations during the Russo-Ukrainian War. CSIS.

incoming strategic nuclear missiles. The study is not intended to cover every system nor to include cyber, AI, or space systems.

Detecting systems include satellites, aircraft and drones (pilotless aircraft). The weapons have three main purposes: to target systems, to defeat adversaries before they can launch, and to defend by shooting down missiles after their launch. Missile defeat weapons include: aircraft, (subsonic) cruise missiles and (super/hypersonic) ballistic missiles. Missile defence systems are supposed to intercept all types of adversary systems.[67] The Appendices and Technological information section provides a summary of all weapon systems discussed below.

The defeat of hard-to-reach mobile and concealed missiles can be conducted by aircraft with bombs and short-range missiles, and cruise and ballistic missiles. Cruise missiles include the JASSM-ER and -XR, Tomahawk, AMRAAM, SM-3 and SM-6, fired from stealth bombers and other aircraft, vessels, and land bases. The *Zumwalt*-class destroyer, originally designed for land attack using Tomahawk missiles, is being retrofitted with hypersonic missiles.[68]

1) Aircraft and missile detection

A traditional reason for rejecting the pre-emptive role of cruise missiles and aircraft is that they can be detected. Russia and China have made significant advancements in their radar capabilities against US stealth,[69] although analysts still deem it insufficient to fully negate US-stealth superiority.[70] For instance, despite greater Chinese Airborne Early-Warning and Control (AEW&C) systems,[71] the US still appears to be able to circumvent China's A2/AD zone through a combination of advanced stealth, sensor, and longer-range missile capabilities.[72] Although Russia seems to have had some success in detecting stealth fighters, targeting them appears a more challenging task,[73] particularly given that some Ukrainian military successes have degraded Russia's radar capability.[74]

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[67] Reif, K. (2019). Missile Defense Systems at a Glance. Arms Control Association. // On cost and value calculation of missile defence, see Rumbaugh, W. (2024). Cost and Value in Air and Missile Defense Intercepts. CSIS.
[68] Sutton, H. (2022). US Navy's hypersonic missile will give Zumwalt class new capability. Naval News.
[69] Stefanovich, D. (2019). Russia to help China develop early warning system. The Diplomat. // Tirpak, J. (2021). New Stealth Aircraft and Capabilities in China's Air Arms Eroding US Advantages.
[70] Majumdar, D. (2014). Chinese and Russian radars on track to see through US stealth. USNI News. // Suciu, P. (2021). Can China really track the stealth F-35 and the F-22? The National Interest.
[71] Newdick, T. & Rupprecht, A. (2023). China's massive fleet of radar planes and the strategy behind it. The Warzone. // Palve, S. (2024). China modernises AWACS flying radars to counter US military; draws critical lessons from Ukraine conflict. Eurasian Times.
[72] Sawant, M. (2021). Why China cannot challenge the US military primacy. Air University. // Swaine et al. (2013). China's military and the US-Japan Alliance in 2030: A strategic net assessment. Carnegie Endowment for International Peace. // Kass, H. (2023). Stealth: The military technology Russia, China, and America Crave. The National Interest. // Decker, A. (2024). China's new stealth bomber nowhere near as good as US's, intel official says. Defense One.
[73] Hollings, A. (2022). How effective is Russia's Nebo-M counter-stealth radar? Sandboxx.
[74] Brugen, I. (2024). Russia's newest state-of-the-art radar destroyed in rare Ukraine footage. Newsweek.

Weapons detection has been conducted by reconnaissance aircraft and satellites since the mid-20th century. For decades, the most important challenge has been to locate mobile and concealed targets. A current core system appears to be the RQ-180 stealth drone. The RQ-180 is a US stealth drone in service since 2015 with a range in excess of the 16,000km of the Global Hawk (RQ-4) system and the SR-71 it has replaced.[75] The capability of the RQ-180 is unclear, but what is clear is that the US has deemed it a suitable replacement for highly-capable target acquisition systems and that its existence partly answers the academic and think tank discussion of alleged gaps in such US satellites' capabilities.[76] The RQ-180 should be considered as part of US and allied reconnaissance systems, including satellites and radars located on land, aircraft and ships.[77] In 2024, the US began fielding a new suite of missile-detecting satellite technologies.[78] Today these systems can detect chemical emissions, heat, radio-wave communications and the varying density of materials. Civilian applications for environmental use or archaeology give some sense of the military capabilities.

In our project's volume "Open Source Investigations in the Age of Google," civilian analysts concerned with on-the-ground and digital research across the spectrum – from human rights abuse to the type of strategic weapons – are considered here. Our illustrative prototype Weapons Tracking Portal[79] is designed as a pointer to the potential for a public service.

The end of arms control and disarmament treaties – notably the Intermediate Nuclear Forces Treaty,[80] the OSCE Vienna document on conventional armed forces in Europe,[81] and possibly START[82] – mean that government-classified National Technical Means and Open-Source investigations will be at a premium.

2) Missile defeat

This part of the study is concerned with weapons delivered by crewed aircraft as well as cruise missiles launched from any platform. While the prior discussion questions whether Russia and China can detect a non-nuclear attack, we now consider whether

[75] Baghai, C. (2023). The RQ-180: The Secret Spy Drone that can fly higher and farther than any other. Medium. // Naoum, K. (2024). The RQ-180 Drone - Northrop Grumman's Advanced (and Secret) Surveillance Aircraft. Thomas Net.
[76] Acton, J. (2013). Conventional Prompt Global Strike and Russia's Nuclear Forces. Carnegie Endowment for International Peace. // Insinna, V. (2022). Air Force's RQ-4 Global Hawk drones headed for retirement in FY27. Breaking Defense. // Trevithick, J. (2022). Global Hawk Retirement Points Again to RQ-180 Waiting in the Wings. The Warzone. // Bronk, J. (2017). The future of Air C2 and AEW: E-3 Sentry, threat technologies and future replacement options. RUSI. // Losey, S. (2023). US Air Force pursues major retirements in 2024. Defense News.
[77] Naoum, K. (2024). The RQ-180 Drone - Northrop Grumman's advanced (and secret) surveillance aircraft. Thomas Net.
[78] Clark, S. (2023). US military begins launching satellites to counter hypersonic missile threat. Spaceflight Now.
[79] SCRAP Weapons (2024). Global Weapons Tracking Portal.
[80] Kimball, D. (2024). The Intermediate-Range Nuclear Forces (INF) Treaty at a Glance. Arms Control Association.
[81] OSCE (2024). Treaty on Conventional Armed Forces in Europe.
[82] US Department of State (2023). New START Treaty.

the speed and other capabilities of non-nuclear systems render them ineffective for strategic pre-emption. It appears that in effect "slow" means flight times of up to two hours assuming launch from outside adversary airspace, but considerably less if launched in wartime from supersonic fighters and bombers or stealth bombers. Against a robust and alert adversary two hours is a long time. While against a lesser-equipped peer-adversary, two hours is very little time at all.

US Defense Science Board Time Critical Conventional Strike from Strategic Standoff[83]

• *"The solution to "time critical" is not necessarily weapon speed.*

• *None of the scenarios exposed a need for "one hour, global-range delivery." There appears to be nothing unique or compelling about one hour.*

• *Covert, loitering strike-systems enabled by: robust target tracking, Intelligence, Surveillance, and Reconnaissance (ISR); Command, Control and Communication (C3); and fire-control capabilities would revolutionise global strike for both the long war and for deterrence of rogue and near-peer nations.*

• *The most cost-effective enhancements to current capabilities appear to come from: two new types of munitions and warheads (those designed to destroy hardened structures), strike-delivery platforms focused on non-stationary targets, and enhancements to ISR capabilities".*

Crewed aircraft

US and allied air force strike forces include bombers and fighters with ranges from a few hundred kilometres to thousands and add to the 1,800-km range of a JASSM XR, giving all such planes the potential of long-range strike capability. The US Air Force possesses B-52, B-1, B-2 and now B-21 bombers.[84] The B-2 and B-21 are strategic stealth bombers, meaning that they are constructed to be difficult to detect by radar.

There are a wide variety of fighters and other aircraft. Calculations of the force structure of strategic missile-capable aircraft should now potentially include all US and allied transport aircraft. This is because the introduction of the Rapid Dragon JASSM system enables such aircraft to carry out missile missions with no prior preparation,[85] being used as an "end-to-end … palletized strike mission, from rolling missile pallets onto an aircraft to in-flight missile release".[86] This development eliminates the need for aircraft modifications and enables rapid fielding as a roll-

[83] Defense Science Board (2009). Time Critical Conventional Strike from Strategic Standoff. Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics.
[84] IISS (2024). The Military Balance.
[85] AFRL. Rapid Dragon Delivers Palletized Effects from Cargo Aircraft.
[86] Lockheed Martin (2021). Rapid Dragon Demonstrates Palletized Munition Capability in first C-17 and EC-130 System-Level Demonstrations.

on/roll-off system.[87] Fighters in service with the US and allies are also capable of carrying JASSM-XR as well as shorter-range missiles and bombs.[88]

Cruise missiles

- **Joint Air-to-Surface Missile (JASSM)**

The JASSM with ranges of up to 1,800km from planes or surface locations exemplifies the evolution of a missile type's capability. The JASSM has been in service for 20 years, initially with a range of ~400km similar to the Franco-British *Storm Shadow* and German *Taurus*; however, today it is up to 1,800km for the JASSM-XR.[89]

The US and its allies already have thousands of JASSM of various ranges and are buying thousands more (for allied stockpiles, see Appendix). For example, Japan is purchasing 50 JASSM-ER, and Poland is purchasing 821 JASSM-ER.[90] Japan is intending to fit them in pallets into its C-2 cargo fleet,[91] using the Rapid Dragon technology.[92] The US Navy has fitted a JASSM variant, the Long-Range Air to Surface Missile (LRASM) to its F-18 planes aboard aircraft carriers which have capability against both moving naval vessels and land targets.[93]

- **Tomahawk**

Well known since the 1980s, the Tomahawk is ubiquitous in the US Navy and is carried by some 89 ships and 53 submarines. The same Mk 41 Box launcher that fires the Aegis defence missile can also fire Tomahawk and is now based in Romania.[94] US and UK submarines can fire Tomahawks undetected before launch from close to the coast of adversaries, many of whose forces – especially air and sea bases – can be reached in a few minutes.

The Intermediate Nuclear Forces Treaty of 1987, which ended in 2019,[95] had prohibited the US and Russia from having ground-launched missiles with ranges of 500 to 5,500km. Now unconstrained, Russia and the US are deploying and developing such systems.[96]

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[87] AFRL (op.cit)
[88] Citadel (2024). US Air Force's Joint Air-to-Surface Standoff Missile goes extreme on range. // Sato, D. (2024). Japan Approves JASSM-ER missile purchase for its F-15J Jets.
[89] CSIS Missile Defense Project (2021). JASSM/JASSM ER. CSIS Missile Threat. // Global Security (2021). AGM-158D JASSM-D/JASSM-XR "Extreme Range".
[90] Adamowski, J. (2024). Poland Buys Missiles for Hitting Targets Spotted by Radar Baloons. Defense News.
[91] Waldron, G. (2023). Tokyo Considers Long-Range Strike Role for C-2 Transport. Flight Global.
[92] Williams, L. (2024). Japan arms cargo planes with missiles and bombs to counter China. Warrior Maven.
[93] Vavasseur, X. (2019). LRASM to achieve EOC with US Navy's F-18. Naval News.
[94] Department of Defense (2012). Establishment of US Aegis Ashore Missile Defense System, Romania, Devesulu, Romania. Department of the Navy, Office of the Chief of Naval Operations.
[95] Kimball, D. (2024). The INF Treaty at a Glance.
[96] Associated Press (2024). Putin calls for resuming production of intermediate missiles after scrapping of treaty with US. // Wright, T. (2024). The return of long-range US missiles to Europe. IISS. // Kimball, D. (2019). The Intermediate-Range Nuclear Forces (INF) Treaty at a Glance. Arms Control Association.

3) Missile defence

The traditional perspective on missile defence is that its advocates see it as effective and indispensable; while opponents as a futile, gross waste of money. For decades, there has been a vigorous debate in the West between supporters and opponents of missile-defence systems on issues including strategic stability, and the effectiveness, or not, of the systems.[97] Our analysis indicates that taken together with defeat systems, defence does has effect if faced with a small number of missiles surviving an attack. Moreover from a stability perspective Russian and Chinese planners will necessarily assume higher levels of effectiveness.[98]

The US and allies have today some potential to shoot down Russian and Chinese ICBMs using the Aegis system as well as in the boost phase of a few minutes after launch using air-to-air missiles.[99] This is despite significant expenditures over the last 40 years.[100] The priority therefore remains missile defeat, with missile defence tasked with intercepting remaining adversary missiles.

The missile defence systems described below are considered separately, although planners and commanders would seek to use them in combination with each other and with the above systems for missile defeat.[101] The systems with anti-missile capabilities analysed are air-to-air systems in the boost phase (AMRAAM, air-Launched SM-3 and SM-6), Patriot, THAAD, and Aegis, though the capacity of Patriot and THAAD are very limited against ICBMs. The Ground-based Midcourse Defence system in the continental US also appears very limited, and in need of a "major update".[102]

In 2023/24 several Russian hypersonic missiles including the *Zircon* were purportedly destroyed by Allied equipment.[103] Which exact system can be linked to this destruction is presently unknown, but the Patriot has been speculated as being responsible for destroying *Kinzhal* missiles.[104]

Richard Garwin espoused the attractiveness of boost-phase interception (BPI) a generation ago.[105] CSIS's 2022 study examines some of the assumptions behind

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[97] Hitchens, T. (2022). No US missile defense system proven capable against 'realistic' ICBM threats:Study. Breaking Defense. // See original February 9th, 2022 report at APS, POPA Reports.
[98] von Hippel, F. (2021). Biden should end the launch-on-warning option. Bulletin of the Atomic Scientists.
[99] Alcazar, V. (2018). Exploiting Airpower's Missile Defense Advantage: The Case for Aerial Boost Phase Interception. Mitchel Institute for Aerospace Studies. // Insinna, V. (2019). Pentagon considers an ICBM-killing weapon for the F-35, but is it affordable? Defense News. // Freedberg, S. (2018). F-35 ready for missile defense by 2025: MDA chief. Breaking Defense.
[100] O'Rourke, R. (2023). Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress. Congressional Research Service.
[101] Congressional Research Service (2024). Defense Primer: Ballistic Missile Defense.
[102] Williams, I. & Dahlgren, M. (2022, p.4). Boost-phase missile defense - Interrogating the Assumptions. CSIS.
[103] Militarnyi (2024). Ukrainian Air Defense Shoots Down Russian Zircon Hypersonic Missile.
[104] Franks, J. (2024). US-Built Patriot System Destroys Russian Hypersonic Missiles in Ukraine. Warrior Maven: Center for Military Modernization.
[105] Garwin, R. (2000). Boost-Phase Intercept: A Better Alternative. Arms Control Association.

boost-phase interceptions;[106] however, it does not discuss boost-phase defeat with respect to Russia and China in the context of counterforce. AMRAAM in the boost phase and Aegis in mid- and terminal-phases of ICBMs have some capability,[107] demonstrated through successful testing,[108] although not fully representing "real-world conditions".[109]

- **Air-to-air missiles for boost-phase interception**

It is important to keep an open mind on the capacity of US air-to-air missiles to destroy adversary ICBMs in the extreme conditions discussed here. In circumstances where the US was determined to defeat adversary missiles prior to launch, it is illogical to preclude the attempt to saturate the missile fields with fast-stealth fighters armed with air-to-air missiles of a speed and range offering capacity to degrade missiles launched under attack. Below we outline some simple arithmetic to illustrate that fielding large numbers of aircraft carrying such weapons is well within US inventories. Unsurprisingly, the industry-funded Missile Defense Advocacy Alliance has no doubt as to AMRAAM's effectiveness as a boost-phase interceptor.[110]

AMRAAM is the predominant US system used as air superiority against peer rivals.[111] The 160-km range AMRAAM AIM-120D-3[112] variant appears to have some capability to shoot down ballistic missiles in their one- to five-minute boost phase after launch where its Mach 4 speed enables it to reach out to 100km in little over a minute (83 km/min). In war, one can assume that there would be a high priority to supplementing strikes with a loitering capacity to intercept ICBM launches in their one- to five- minute boost phase.[113]

The closest public analysis of this challenge concerns the DPRK; a recent CSIS study spoke of the "sensitivity" of discussing the type of scenario sketched above.[114] Some analysts see this as a present day capability against ICBMs,[115] with the

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[106] Williams, I. & Dahlgren, M. (2022). Boost-Phase Missile Defense: Interrogating the Assumptions. CSIS.
[107] National Research Council (2012). Making Sense of Ballistic Missile Defense: An Assessment of Concepts and Systems for US Boost-Phase Missile Defense in Comparison to Other Alternatives. National Academies Press.
[108] US Department of Defense (2020). US successfully conducts SM-3 Block IIA intercept test against an Intercontinental ballistic Missile Target.
[109] Hitchens (op.cit)
[110] MDAA (2023). Do the Math. Missile Defense Advocacy Alliance. Accessed Jan 2024. Offline as of August 2024.
[111] Born, E. (2020). Ensuring US Air Superiority in a Conflict with China: Requirements to supplement fifth generation assets with counterair remotely piloted aircraft. USMC Command and Staff College. // Raytheon (2024). AMRAAM Missile. // Newdick, T. (2021). Latest AMRAAM Air-to-Air Missile Aims to Keep Pace with China. The Warzone.
[112] Trimble, S. (2017). New Long-Range Missile Project Emerges in US Budget. Flight Global.
[113] Missile Defense Advocacy (2017). Capitol Hill Briefing on "Boost Phase Missile Defense". Transcript from Briefing. *See briefing video* here. // Alcazar, V. & Schanz, M. (2018). Exploiting Airpower's Missile Defense Advantage: The Case for Aerial Boost Phase Interception. The Mitchell Forum: Mitchell Institute for Aerospace Studies. // National Research Council (2012). Making Sense of Ballistic Missile Defense: An Assessment of Concepts and Systems for US Boost-Phase Missile Defense in Comparison to Other Alternatives.
[114] Williams, I. & Dahlgren, M. (2022). Boost-Phase Missile Defense: Interrogating the Assumptions. CSIS.
[115] Osborn, K. (2022). Can US missile interceptors destroy an attacking ICBM? The National Interest. // Osborn, K. (2023). Could Navy ships track, intercept, and destroy a Chinese or North Korean ICBM? Warrior Maven: Center

technical development trail going back more than a decade.[116] For the US and its adversaries considering strategic military action, the ability, or lack of it, to shoot down missiles in their boost phase is a high priority.[117] Open source information shows that the US has some capability in this area today,[118] whereas most public analysis does not include this possibility.

It is reported that AMRAAM can "safely hold at standoff ranges and provide boost-phase missile defence with unprecedented effectiveness".[119] Moreover, these types of "long-range cheap kinetic interceptor missiles can become a pivotal strategy of neutralising ICBM threats in their nascent [boost] stages".[120] Lastly, AMRAAMS can "provide boost-phase missile defense with unprecedented effectiveness and cost efficiency" that was argued to be able to disrupt, for example, North Korea's ICBMs according to its advocates.[121]

- **Air-launched SM-6 and possible classified programme**

The SM-6 is a hit-to-kill missile based on the Aegis SM-3 offering extended range.[122] It offers greater options for boost-phase interception from US aircraft over adversary missile fields, and there are reports of another similar system designed to be carried inside stealth aircraft.[123]

The US Navy recently deployed the missile SM-6 on carrier-launched aircrafts in the Indo-Pacific; analysts argue that this could outrange China's forces.[124] The SM-6 possesses three advantages: it can fly farther, with a range of 400km versus the AMRAAM's 150-km range; it does not require new production lines; and is compatible with planes deployed by at least another ally: Australia.[125] Crucially, the SM-6 outranges China's PL-15 missile, meaning that US aircraft carrier groups with F-18s and F-35s can strike Chinese targets from further distances.

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for Military Modernisation. // Karako, T. in Larter, D. (2020). US Navy destroyer shoots down an ICBM in milestone test. Defense News.

[116] Missile Defense Agency (2008). Aegis Ballistic Missile Defense: Status, Integration and Interoperability, May 6, 2008. // Hicks, A. (2005). Aegis Ballistic Missile Defense (BMD) System. Washington Roundtable of Science and Public Policy, George C. Marshall Institute, December 19, 2005. // Mostly Missile Defense (2016). Strategic Capabilities of SM3 Block IIA Interceptors.

[117] Missile Defense Advocacy (2017). Capitol Hill Briefing on "Boost Phase Missile Defense". Transcript from Briefing. See briefing video here.

[118] Larter, D. (op.cit).

[119] MDAA (2023). Do the Math. Missile Defense Advocacy Alliance. Accessed Jan 2024. Offline as of August 2024.

[120] ibid

[121] ibid

[122] Reif, K. (2019). Current US Missile Defense Programs at a Glance. Arms Control Association.

[123] Freedberg, S. (2014). Non-Standard: Navy SM-6 Kills Cruise Missiles Deep Inland. Breaking Defense.

[124] Doyle, G. (2024). US Navy's Newest Air-to-Air Missile Could Tilt Balance in South China Sea. Reuters.

[125] ibid // Newdick, T. (2024). Navy's SM-6 Missile Used in Combat: Report. The Warzone.

Adding the SM-6 to the US Navy, even if not yet in sufficiently large numbers, may change the calculus of a regional conflict given that it "keeps China's high-value aircraft way back".[126]

- **Patriot**

The Patriot system has a very limited capacity against ICBMs but has a demonstrated capacity against Russian air-launched hypersonic missiles. It is highly mobile and modular, with three operational functions, namely: surveillance, tracking, and engagement all in one unit. It is capable of defeating aircraft, cruise missiles, and ballistic/hypersonic missiles. The US operates 16 Patriot battalions with 50 Patriot batteries across more than 1,200 deployed interceptors.[127]

In 1991, it was reported that only 9% of Iraqi Scuds were intercepted by the Patriot system – although it has since been upgraded.[128] Yet, Raytheon, the manufacturer of the system, rebutted these seemingly low interception rates.[129] Indeed, Saudi Arabia and Israel have reported interception rates of 70% and 40%, respectively.[130] Some consider Patriot's potential as having the capacity to protect against missile threats from China in the Asia-Pacific region.[131]

Engagements by Patriot in the Russo-Ukrainian War included the defeat of a Russian Kh-47 *Kinzhal* aeroballistic missile over Kyiv. The Ukrainian Air Force claimed it used Patriot to defeat a salvo of six *Kinzhal* missiles over Kyiv on May 16, 2023.[132] Further, it appears that Russia lost one *Kinzhal* that was trying to destroy one of Ukraine's Patriot launchers.[133] These engagements likely involved the PAC-3 CRI interceptor. Although the Patriot radar only covers a 120-degree sector, unlike the Russian S-300 and S-400's 360-degree coverage, the next generational upgrade, the LTAMDS, is planned to solve this.[134]

- **THAAD**

THAAD provides regional defence to intercept short-, medium- and intermediate-range ballistic missiles in the terminal phase of flight[135] and can defend targets at a range of 150-200 km.[136] There are currently seven THAAD batteries fielded and

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[126] Layton, P. (2024) interviewed by Doyle, G. (op.cit).
[127] Hollings, A. (2023). Who has the world's best air defense system? The National Interest.
[128] PBS Frontline (1994). Mim-104 Patriot.
[129] Raytheon (1996). Raytheon's Response to WGBH Frontline.
[130] Hollings, A. (op.cit)
[131] Freedberg, S. (2018). Missile Defense vs. China, Russia: Decentralise, Disperse, and Hide. Breaking Defense.
[132] Missile Defense Project (2023). Patriot. Missile Threat, Center for Strategic and International Studies.
[133] Slayton, N. (2023). Russia lost a hypersonic missile trying to destroy one of Ukraine's Patriot missiles. Task and Purpose.
[134] Keller, J. (2022). Raytheon to upgrade LTAMDS missile-defense radar to handle advanced threats like hypersonic munitions. Military and Aerospace Electronics.
[135] CSIS Missile Defense Project (2021). Terminal High Altitude Area Defense. CSIS Missile Threat.
[136] Reuters (2017). THAAD Missile Defense System. / CSIS Missile Defense Project (op.cit)

assigned to the US Army pertinent to Russia and China: one to South Korea, one in Guam, one in Hawaii and one to Romania.[137]

THAAD complements the "lower-tier Patriot system and the upper-tier Aegis BMD system," providing a middle-tier system that can engage ballistic missiles in the endo- and exo-atmosphere (i.e., <100km and 500-1,000km of altitude, respectively). THAAD covers a larger defended area than the Patriot, while serving as an underlay for the exo-atmospheric Aegis BMD.[138] Simultaneously, THAAD can accept target cues for acquisition of threat missiles from Aegis BMD, showing their systemic complementarity.

THAAD defeated a separating intermediate-range ballistic missile (IRBM) in a flight test in July 2017 in Alaska.[139] It was also successfully tested in August 2019 against a complex medium-range ballistic missile (MRBM) re-entry vehicle at a low-end atmospheric altitude (i.e., <100km). Following tests, THAAD may have the ability to "discriminate and intercept an RV from a separating MRBM target with countermeasures at such altitude".[140]

THAAD's radar, the AN-TPY-2, has an operational range of 1,000km.[141] This radar can be deployable in two modes: a forward-based mode, where it detects missiles in the ascent/boost phase to cue other BMDs elements; and a terminal mode, where it provides tracking and engagement data for THAAD engagements during the terminal phase.[142] Hence, it can be deduced that THAAD tracks in the boost phase at a range of 150-200km and can destroy threat missiles in the terminal phase. When this radar connects to the larger "Command, Control, Battle Management, and Communications" (C2BMC) network,[143] THAAD can exchange tracking data with Aegis and Patriot missile defence. A THAAD-cued Patriot intercept was successfully tested in 2020.[144]

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[137] Reif, K. (2019). Current US Missile Defense Programs at a glance. Arms Control Association.
[138] ibid
[139] Director Operational Test and Evaluation (2017). Terminal High-Altitude Area Defense (THAAD). DOTE.
[140] ibid
[141] CSIS Missile Defense Project (op.cit).
[142] Headquarters Department of the Army (2019). Ground-based Midcourse Defense Operations. Army Publishing.
[143] CSIS Missile Defense Project (2021). Command and Control, Battle Management, and Communications. CSIS Missile Threat. // Director Operational Test and Evaluation (2010). C2BMC System. DOTE.
[144] Judson, J. (2020). MDA and Army see successful Patriot and THAAD test after failure. Defense News.

Source: FT, 2017[146]

THAAD active deployment in South Korea

The present deployment location of THAAD in South Korea can cover most of eastern China and Russia's far east military capabilities. There was a strong reaction from China to the long-range anti-missile radars deployed by South Korea in 2017 that reached mainland China and could better track China's ballistic launches.[145]

- **GMD (Ground-based Midcourse Defence system)**

According to its manufacturer: "the Ground-based Midcourse Defense system is the US's only operationally deployed missile defence program capable of defending the entire US homeland (including Alaska and Hawaii) against long-range ballistic missile attacks. GMD is designed to detect, intercept and defeat long-range ballistic missiles during their midcourse phase of flight. The system provides early detection and tracking during the boost and midcourse phase, as well as target discrimination, precision intercept and destruction of the target through force of collision. GMD is an integral element of the US Missile Defense Agency's layered ballistic missile defence architecture. As prime contractor, Boeing designs, produces, integrates, tests and sustains all GMD components deployed across 15 time zones."[147]

Despite these alleged capabilities, the system's number of interceptors is small and there are only two operating sites. It has been suggested that, beyond the current ongoing major upgrades needed for the GMD, "US policymakers should consider the relative costs and benefits of adding a boost-phase layer alongside other prospective augments to homeland missile defense".[148]

- **Aegis SM-3 Afloat and Ashore (and now in the air)**[149]

Aegis uses a ballistic missile interceptor in post-boost phase and prior to re-entry; and has been assessed as more likely to penetrate Russian air-defence systems.[150] First

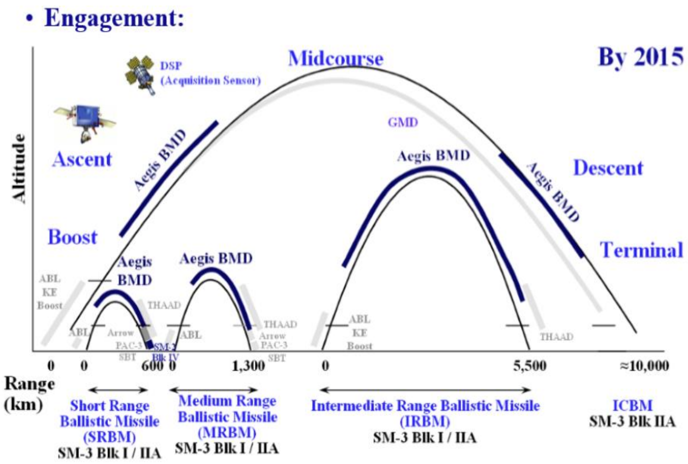
145 Zelleke, A. (2019). In the eye of a geopolitical storm: South Korea's Lotte Group, China and the US THAAD Missile Defense System.
146 Financial Times (2017). US Missile Shield Drives Wedge between South Korea and China.
147 Boeing (2024). Ground-Based Midcourse Defense (GMD).
148 Williams, I. & Dahlgren, M. (2022, pg.4). Boost-Phase Missile Defense - Interrogating the Assumptions. CSIS.
149 Missile Defense Project, "Aegis Ballistic Missile Defense," Missile Threat, Center for Strategic and International Studies, June 14, 2018.
150 Wilkening, D. (2004). Airborne Boost-Phase Ballistic Missile Defense. Science and Global Security, 12:1-67, 2004.

deployed in the 1980s, the Aegis system has been repeatedly upgraded from an ant–aircraft system to one also capable of shooting down missiles.[151] Aegis successfully destroyed a disabled American spy satellite in orbital space in 2007[152] and the newest SM-3 Block IIA interceptor was used to destroy one ICBM in 2020.[153] Co-developed with Japan's Mitsubishi Heavy Industries, it was specifically developed to "destroy short-to intermediate-range ballistic missiles"[154] through sheer impact force, and can be launched from land or sea.[155] However, "it was not an operational test, and it was executed under highly favourable conditions".[156] In a realistic environment against peer rivals with countermeasures, the system's effectiveness is expected to be reduced.[157]

Conducted off Hawaii, a 2023 multi-sensor test successfully shows that Aegis tracked, discriminated, and defeated two short-range ballistic missiles and two subsonic anti-ship cruise missiles.[158] A further test successfully demonstrated that Aegis discriminated against a complex MRBM target with countermeasures.[159] Most recently, in January 2024, Aegis successfully shot down Houthi ballistic, cruise and drone missiles on the Red Sea.[160] The systematic interconnectedness between Aegis, THAAD and Patriot was noted by US Admiral Jon Hill, as "all these assets are linked together by our Command and Control Battle Management and Communications system".[161] The systems are intended to work in tandem to defeat ICBMs.[162] The Aegis system is carried by over 40 US ships, along with the Spanish Navy's F100 class, and by Japan's Maritime Self-Defense Force (on four Kongo-, two Atago-, and two Maya-class guided-missile destroyers).[163]

[151] O'Rourke, R. (2024). Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress. Congressional Research Service.
[152] Polmar, N. (2008). US Navy: Aegis scores a 'space kill'. US Naval Institute.
[153] Government Accountability Office, Missile Defense [2020] Fiscal Year 2020 Delivery and Testing Progressed, but Annual Goals Unmet, GAO 21-314, April 2021, p. 24. // Franks, J. (2024). The US Navy's SM-3 Block IIA can hit ICBMs and satellites. Warrior Maven.
[154] Raytheon (2024). SM-3 Interceptor: Beating ballistic missiles on land and at sea.
[155] Raytheon (2020). A new layer of homeland defense. // Osborn, K. (2021). The Navy's SM-3IIA missile is bigger and badder than ever. National Interest.
[156] Government Accountability Office, Missile Defense[:] Fiscal Year 2020 Delivery and Testing Progressed, but Annual Goals Unmet, GAO 21-314, April 2021, p. 24. // Judson, J. (2021) "Watchdog Expresses Concern over Using US Navy Interceptor for Homeland Missile Defense," Defense News, April 29, 2021. // With video - Larter, D. (2020). US Navy destroyer shoots down an ICBM in milestone test. Defense News.
[157] Union of Concerned Scientists. The SM-3 Block IIA Interceptor.
[158] US Navy. US Navy and MDA successfully intercept multiple targets in integrated air and missile defense test. Defense-Aerospace.
[159] Jones-Bonbrest, N. (2024). Missile Defense Agency and US Navy Successfully Demonstrate Aegis Weapon System Capabilities against Advanced Countermeasure Missile Target. Defense Visual Information Distribution Service. // Fabey, M. (2024). MDA and USN report successful Aegis test against advanced countermeasure missile target. Janes.
[160] Eckstein, M. (2024). US Navy making Aegis updates, training changes based on Houthi attacks. Defense News.
[161] Hill, J., Missile Defense Agency (2023). Missile Defense Agency officials hold a press briefing on President Biden's Fiscal 2024 Missile Defense Budget. US Department of Defense.
[162] Lockheed Martin (2013). THAAD and Aegis BMD successfully engage multiple targets during integrated ballistic missile defence system test. // Center for Arms Control and Non-Proliferation (2023). US Ballistic Missile Defense. // Judson, J. (2022). Missile Defense Agency fires Patriot missile from THAAD system. Defense News.
[163] Nagashima, A. (2021). A Closer Look at the Operational Concept for 'Aegis System-equipped Vessels'. Konrad Adenauer Stiftung.

The Aegis platform uses two high supersonic missile variants: the SM-3 Block IIA and the SM-2ER Block IV,[164] which have an operational range of 200km and 400km, respectively. The SM-3 Block IIA intercepts in post-boost phase and prior to re-entry, making it theoretically more likely to penetrate Russian air defence systems.[165] The Aegis Afloat BMD and Aegis Ashore work in tandem.[166] In the early 1990s, an Aegis-type system was designed to provide future defence of the continental US using Ground-Based Interceptors (GBIs from Aegis Ashore) based in Alaska and California.[167] The Aegis interception of ICBMs in ascending and descending phases is schematised below.



Source: Missile Defense Agency (2008)[168]

The inventory of SM-3 Block IIA interceptors is projected to be over **400**, and their stockpile numbers highly classified.[169] It has been estimated that the actively deployed inventory of these interceptors in 2013 was comparable to the total number of ICBMs fielded by China (60) and Russia (312).[170] The Department of Defense FY2025's request includes 12 SM-3 Block IIA interceptors, compared to 39

[164] Missile Defense Project, "Aegis Ballistic Missile Defense," Missile Threat, Center for Strategic and International Studies, June 14, 2018.
[165] Wilkening, D. (2004). Airborne Boost-Phase Ballistic Missile Defense. Science and Global Security, 12:1-67, 2004.
[166] Lockheed Martin Corporation (2003). Aegis Ashore: supporting phased adaptive approach for layered missile defence.
[167] Reif, K. (2019). US and Allied Ballistic Missile Defenses in the Asia-Pacific Region.
[168] Missile Defense Agency (2008). Aegis Ballistic Missile Defense: Status, Integration and Interoperability, May 6, 2008. N.B. As the briefing from 2008 shows, the Block IIA was expected to begin deployment in 2015. By 2020,the Block IIA successfully intercepted an ICBM in a controlled environment. See: US Department of Defense (2020). US successfully conducts SM-3 Block IIA Intercept Test against an ICBM Target.
[169] Government Accountability Office (GAO). 2016. Missile defense: Ballistic missile defense system testing delays affect delivery of capabilities. GAO-16-339R. Washington, DC. April 28. // Eaglen, M. (2024). The US Navy's missile production problem looks dire. American Enterprise Institute.
[170] Patton, T., Podvig, P. and Schell, P. (2013). A new START model for transparency in nuclear disarmament. UNIDIR, Geneva.

in FY 2024.[171] Further, the FY2025 proposed funding aims to pivot and discontinue the SM-3 Block IB procurements in favour of the SM-3 Block IIA and the SM-6 missiles, although serving different purposes.[172] While the SM-3 is designed for Aegis ballistic missile defense, the SM-6 was originally designed for air defense and land-attack missions.[173] Yet, it will be used as an interceptor missile in Aegis vessels, including the Ticonderoga Class Aegis Cruisers and by the Arleigh Burke Class Aegis Destroyers. [174] The procurement for SM-6 missiles in 2024 totals 125 missiles, a significantly greater request, with the "factory operating at maximum production rate".[175] The current estimate of US SM-6 stockpile is of 1,500 missiles.[176] In the latest press release from the Department of Defense regarding Aegis, it was confirmed that precise numbers of stockpiles cannot be disclosed, but the Global Force Management is acquainted with the SM-3 Block IIA, being "deployed across the fleet today. And the sailors are trained to use them".[177]

Japan announced that in 2027 two new exclusively-designed Aegis vessels: the Aegis System Equipped Vessels (ASEV) will be operational.[178] These could negate China's ICBM trajectories against CONUS, while two operational Aegis Ashore systems in Poland and Romania could do the same for Russian trajectories.[179] After the Obama administration's approval in 2009, the Aegis Ashore system was deployed in Romania in 2016.[180] A containerised and portable version with Aegis was tested in 2021,[181] unmanned surface vessels have been tested to transport shipping containers hiding guided-missile launchers, the SM-6 was tested in October 2023, [182] and the SM-3 missile was launched from a containerised vertical launching system aboard a US Navy vessel during the Pacific Dragon 2024 ballistic missile defense exercise.[183]

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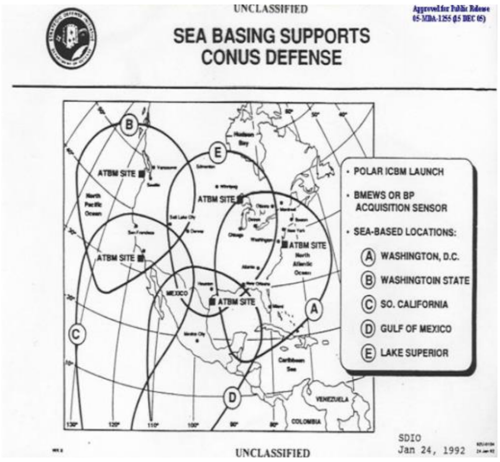
[171] US Department of Defense (2024). Fiscal Year 2025 Budget Request. Office of the Under Secretary of Defense (Comptroller)/Chief Financial Officer. // Fabey, M. (2024). Pentagon Budget 2025: Aegis BMD cut slightly in USN request. Janes. // Hill, J., Missile Defense Agency (op.cit). // Department of Defense (2024). Fiscal Year 2025 Budget Estimates. Missile Defense Agency. // Altman, H. (2024). More SM-3 interceptors needed after downing Iranian ballistic missiles: Navy Secretary. The Warzone.
[172] ibid
[173] Reif, K. (2019). Current US missile defense programs at a glance. Arms Control Association.
[174] O'Rourke, R. (2024). Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress. Congressional Research Service.
[175] Department of Defense (2024, pp. 5.17). Program Acquisition Cost by Weapon System: Fiscal Year 2025 Budget Request.
[176] Department of Defense (2024). Fiscal year 2025 Budget Estimates. Department of the Navy.
[177] ibid
[178] Honrada, G. (2023). Japan pouring billions into sea-based missile defense. Asia Times. // Mahadzir, D. (2023). Japan Locks in Funding for 2 New Aegis Destroyers. USNI News. // Japan's Ministry of Defense (2024). Missile Defense: Ballistic Missile Defense. // US DoD (2024). Contracts for January 12, 2024. Missile Defense Agency. // Japan's Ministry of Defense (2023). Annual White Paper.
[179] Lockheed Martin (2018). Next Generation Aegis Ashore Solution.
[180] Lagrone, S. (2013). Inside Aegis Ashore. USNI News. // Harvey, C. (2009). Obama shifts gears on missile defense. Arms Control Association.
[181] Lagrone, S. (2024). Navy Rapid capabilities process can now deploy new weapons faster. USNI News.
[182] ibid
[183] Johnston, C. (2024). SM-3 Launched from Containerised VLS for the first time. Naval News. Edited on the 17th of September.

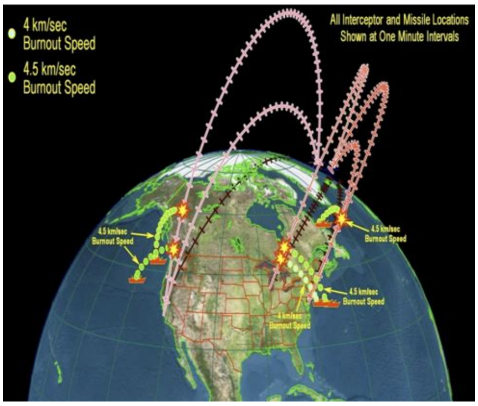
Aegis Afloat and Ashore give the US considerable, but not fully comprehensive, coverage of adversary missile launch sites and missile trajectories. There are widely differing views across the US military, academia and think tanks as to the effectiveness of Aegis against ICBMs. A 20th-century sketch map from the Pentagon illustrates the maximalist view of its potential.

Naval-based missile defense of CONUS

The figure shows coverage of CONUS by a Block IIA-like interceptor, envisioned in 1992, by Rear Admiral A. Brad Hicks.[184] Essentially, the proposal is an Aegis missile defence bubble for CONUS from Aegis vessels. This concept is further shown, with the coverage of CONUS by Block IIA interceptors with a speed of about 4.5 km/s against potential Russian ICBMs.[185]

Source: Hicks, A. (2005)





Intercept geometries for Block IIA-like missiles by vessels against Russian ICBMs

This concept of naval-based Aegis as a defence shield against ICBMs appears to have been revitalised recently in 2020. Raytheon, the manufacturer, stated that Aegis was designed and had the potential to destroy ICBMs in mid-course (*video in source*).[186]

Source: Butt and Postol (2011, p.24)[187]

[184] Hicks, A. (2005). Aegis Ballistic Missile Defense (BMD) System. Washington Roundtable of Science and Public Policy, George C. Marshall Institute, December 19, 2005. // Mostly Missile Defense (2016). Strategic Capabilities of SM3 Block IIA Interceptors.
[185] Freedberg, S. (2015). Aegis Ashore: Navy Needs Relief from Land. Breaking Defense.
[186] Lartner, D. (2020). US Navy Destroyer shoots down an ICBM in milestone test. Defense News.
[187] Butt, Y. & Postol, T. (2011). Upsetting the Reset: The Technical Basis of Russian Concern over NATO Missile Defense. Federation of American Scientists, Special Report, no. 1, September, 2011.

Russian and Chinese detection of missile attack: fighting blind?

Russia has operated highly-capable ground-based radar arrays for missile warning, characterisation and tracking since the 1990s.[188] Despite these apparent capabilities, there has been a systemic and long-term degradation trend of Russian satellite reconnaissance, as comprehensively analysed by Elena Grossfeld.[189] Some of these systems have been recently destroyed by Ukraine.[190] Taken together, Russia cannot be considered to presently possess a reliable system of "bubble defence" to detect and defeat missile attacks; having to rely on a combination of other intelligence sources or a policy of "launch-under-attack," akin to the "sword of Damocles".[191] Moreover, unlike often assumed, Russia does not seek to possess an "Area Denial/Anti-Access" doctrine (i.e., A2/AD), like China.[192] Instead, Russian missile defence is not strictly defensive; it is based on a symbiosis of offensive/defensive strategic operations, and is underpinned by attrition, disorganisation, and deflection of incoming missiles.[193]

The Russian over-the-horizon radar *Kontayner* (29B6) is located deep inside Russia and can monitor most of Europe's airspace at a 3,000-km range, with the publicised potential to track cruise and hypersonic missiles.[194] A *Kontayner* radar has been under construction since 2019 in Kaliningrad to cover most of Europe and the UK.[195] There is no in-depth open source investigation on the radar's capabilities against NATO. Nonetheless, the ongoing war in Ukraine demonstrates that Russian air defence systems like the S-300 have suffered losses by both Ukraine and Russia alike.[196] Indeed, some Russian early-warning radars were destroyed by Ukraine with tactical drones in May 2024.[197] Following this logic, conventional kinetic missiles are likely to be launched with drone swarm attacks to "overload" early-warning systems.

China is developing early-warning ground and satellite missile-detection systems which optimistic analysis sees as capable against US and allied medium-range ballistic missiles.[198] However, Beijing has not yet developed a full ground-based radar or

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[188] Podvig, P. (2002). History and the Current Status of the Russian Early-Warning System. Science and Global Security 10(1):21-60. // National Academy of Sciences (2021). Regional Ballistic Missile Defense in the Context of Strategic Stability.
[189] Grossfeld, E. (2022). What does the war in Ukraine tell us about Russian Intelligence?
[190] Cook, E. (2024). Critical $100m Russian Radar System 'Nebo-U' Destroyed: Kyiv. Newsweek.
[191] Montoya, N. & Kemp, R. (2023). Launch under attack: A sword of Damocles. War on the Rocks.
[192] Simon, L. (2017). Demystifying the A2/AD buzz. War on the Rocks.
[193] Koffman, M. (2020). Russian A2/AD: It is not overrated, just poorly understood. Russian Military Analysis. // Kofman, M. (2019). It's time to talk about A2/AD: Rethinking the Russian military challenge. War on the Rocks. // Jacob, L. (2017). Limiting Russia's Anti-Access/Area-Denial Strategy in the Baltic Sea. NATO Association.
[194] Kofman, M. (2020, op.cit).
[195] TASS (2020). Russia's advanced radar in Kaliningrad to monitor entire territory of Europe.
[196] Axe, D. (2022). Ukraine is losing several S-300 anti-air launchers a week. But it still has hundreds left. Forbes.
[197] Liang, X. (2024). Ukraine strikes Russian early-warning radars. Arms Control Association. // Reuters (2024). Ukraine drone targets second Russian long-range military radar.
[198] Swope, C. (2024). No place to hide: a look into China' geosynchronous surveillance capabilities. CSIS.

space-based system for detecting missile attack like Russia, which is assisting China to develop its own early-warning system.[199] Overall, it appears that both Russia and China have no obvious superiority in early warning against potential US conventional missiles, especially if paired with drone swarm attacks, as shown in Ukraine and in the Levant.

Russian and Chinese strategic nuclear naval forces

Russia operates 11 submarines with Submarine Launched Ballistic Missiles (SLBMs) capable of reaching CONUS. These are under continuous monitoring by the US and its allies.[200] However, not all submarines can be tracked at all times with full certainty,[201] even though NATO has greatly strengthened its anti-submarine warfare in the last decade.[202] Russian submarines can be deemed overall as vulnerable to attack, as despite their relative technological parity,[203] they suffer from inferior port geographic conditions when compared to the US.[204] Since the end of the Cold War, US and allied anti-submarine forces have continued to improve;[205] whereas on leaving their homeports, Russian submarines could be tracked by multiple submarine and surface vessels. In a crisis, any launch would be vulnerable in its boost phase to Aegis missile defences in US vessels.[206]

Russia has 992 actively-deployed naval strategic warheads on 12 submarines, even though not all these submarines are fully operational.[207] Russian SLBMs may be vulnerable to allied-attack submarines which have shown capability to shadow them from port.[208] Moreover, the Sound Surveillance System using hydrophones that was introduced in 1954 has proven relatively successful in tracking Russian submarines. It has been refined over time, culminating into the current Integrated Undersea Surveillance System (IUSS).[209] Although Russian submarines' stealth capabilities are

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[199] US Department of Defense (2023). Military and security developments involving the PRC. Annual Report to Congress. // Shu, H. (2021). China's Missile Defense Capability. Report on the Defense Technology Trend Assessment. // Harpley, U. (2023). China's Anti-Satellite Weapons are 'compounding problem we have to figure out'. Air and Space Forces Magazine. // Stefanovich, D. (2019). Russia to help China develop early warning system. The Diplomat.
[200] Kaushal, S. & Balletta, R. (2024). An asymmetric approach to the use of NATO's maritime forces in competing with Russia. RUSI.
[201] Cook, E. (2023). NATO has a Russian Submarine problem. Newsweek. // Navy Lookout (2023). Has the Russian submarine threat been diminished by the Ukrainian war?
[202] Alleslev, L. (2019). NATO Anti-submarine warfare: rebuilding capability, preparing for the future. Science and Technology Committee.
[203] Lagrone, S. (2023). Russia close to persistent nuclear cruise missile attack sub presence off US coasts. USNI News.
[204] McKinzie, M. (2001). The US Nuclear War Plan: A Time for Change. NRDC.
[205] Clark, B. et al., (2017). A new fleet architecture for the US Navy. Center for Strategic and Budgetary Assessments.
[206] Landis, M. (2001). Overview of the fire control loop process for Aegis LEAP Intercept.
[207] Kristensen, H., Korda, M., Johns, E., and Knight, M. (2024). Russian nuclear weapons, 2024. Bulletin of the Atomic Scientists, 80:2, 118-145.
[208] Trevithick, J. (2024). Russian Naval Group Shadowed Off Florida by US Allies. The Warzone.
[209] Brock, J. (2023). US revives Cold War submarine spy program to counter China. Reuters.

comparable to that of NATO,[210] the US has a relative advantage in processing power. This enables the US to better analyse underwater data (i.e., submarine noise) by using unmanned vessels, and consequently better track them in their disadvantageous ports' geography.[211] Thus, the geographic disparity remains, as US and allies' naval bases effectively reduce Russian and Chinese potential for submarines to exit port, despite their present stealth capabilities.[212] While the submarines have been made stealthier due to new materials, they have simultaneously increased their acoustic silhouette, by increasing their noise emission.[213] Vitally, in the few minutes of boost phase after launched missiles were to emerge from the sea undetected, they appear vulnerable to defeat by Aegis surface vessels when covering their area of projection.[214] The submarine inventories of both nations are now presented.

Table 1: Russian naval strategic nuclear forces, 2024[215]

Total actively-deployed warheads by submarines = 992	
Launcher type	**Number**
Delta IV class	5
Borei class	7
Total strategic submarines	12

To be noted, not all of these are fully operational, and the warhead loading on some of the missiles may have been reduced for Russia to stay below the New START treaty limit on deployed warheads. The Russian navy is also developing a nuclear-powered, intercontinental-range, nuclear-armed torpedo called *Poseidon*. The weapon is scheduled for delivery to the navy in 2027, and its capabilities are unknown.[216]

China possesses 72 actively-deployed naval-strategic warheads. Presently, Chinese SSBNs are more vulnerable to anti-submarine warfare than their Russian counterparts,[217] although there is much discussion of future systems.[218] China

[210] Majumdar, D. (2017). US Navy on Russia's Stealth submarines. National Interest.
[211] Navy Lookout (2024). The Royal Navy's Future Vision for the Underwater Battlespace.
[212] Dibb, P. & Brabin-Smith, R. (2024). Why the US will stay dominant in undersea warfare. ASPI. // Chan, R. (2024). US nuclear submarine surfaces in China's backyard. Newsweek. // Palmer, A., Carroll, H. and Velazquez, N. (2024). Unpacking China's naval buildup. CSIS. // Collins, G., Erickson, A., Goldstein, L. and Murray, W. (2008). Chinese evaluations of the US Navy submarine force. Naval War College Review, v.61, no.1 Winter.
[213] Sutton, H. (2020). The Chinese Navy's most powerful attack submarine: the Type-093A. Naval News.
[214] Landis, M. (2001). Overview of the fire control loop process for Aegis LEAP Intercept.
[215] Adapted from Kristensen et al. (2024). Russian Nuclear Weapons, 2024. Bulletin of the Atomic Scientists.
[216] TASS (2023). Submarine Force Armed with Poseidon Torpedoes to Come into Operation in Kamchatka in 2025." April 3, 2023.
[217] Lewis, J. (2009). China's Noisy New Boomer. Arms Control Wonk. // Kristensen, H. (2009). China's Noisy Nuclear Submarines. Federation of American Scientists. // NTI (2023). China Submarine Capabilities. Submarine Proliferation Resource Collection.
[218] NTI (2023). China Submarine Capabilities.

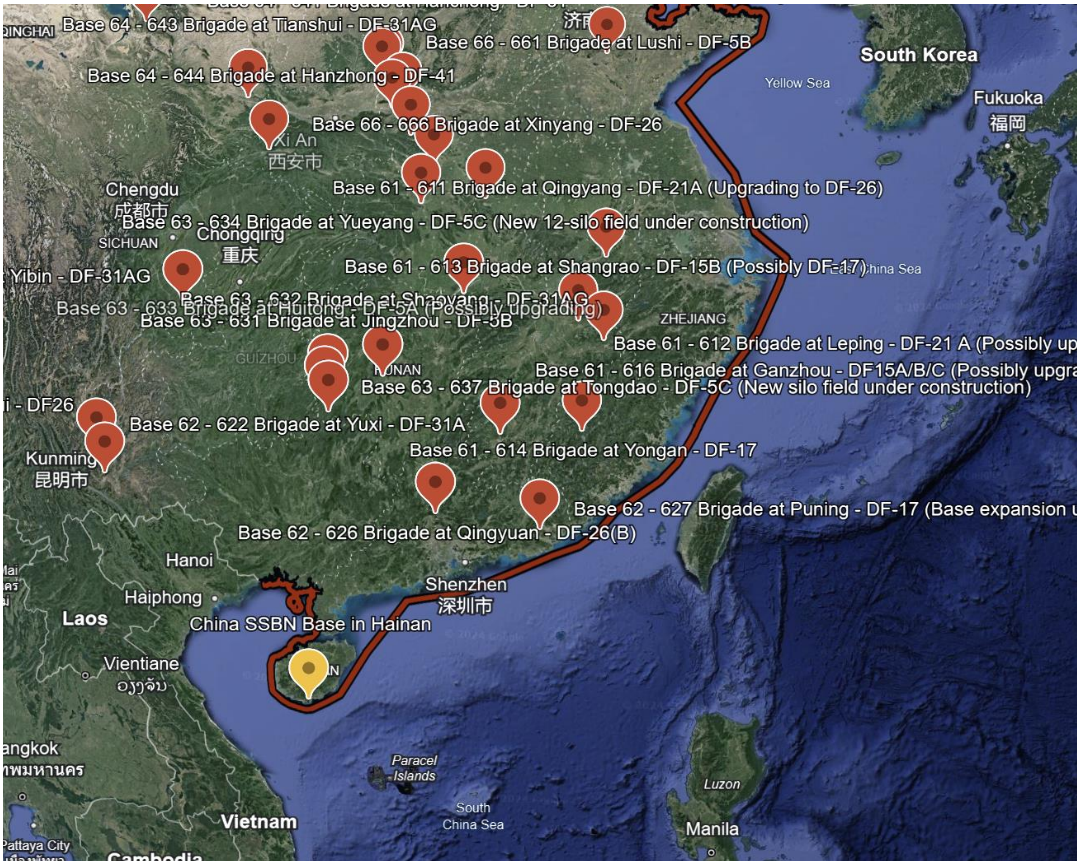
possesses six nuclear-powered ballistic missile submarines (SSBNs) *Jin-class* with ICBMs capable of reaching CONUS.[219]

Table 2: Chinese naval strategic nuclear forces, 2024[220]

Total actively-deployed warheads by submarines = 72	
Launcher type	**Number**
JL-2 class	0[221]
JL-3 class	72
Total strategic submarines	72

These submarines are stationed at the Longposan naval base near Yulin on Hainan Island, shown in yellow below.

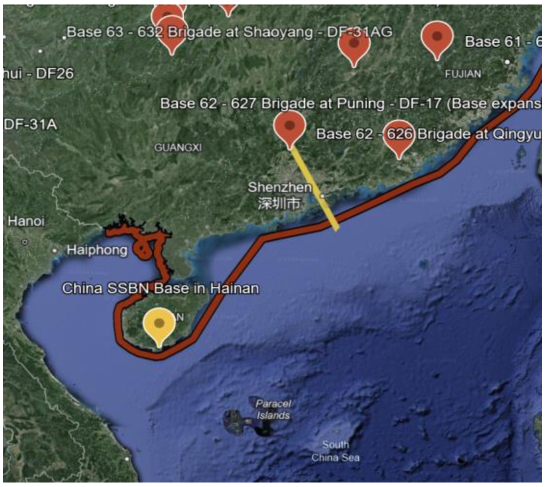
Fig.2. Location of China's SSBN base and 12nm EEZ delineation



[219] NTI (2023). China submarine capabilities.
[220] Adapted from Kristensen et al. (2024). Chinese Nuclear Weapons, 2024. Bulletin of the Atomic Scientists, 80:1, 49-72.
[221] In November 2022, Admiral Samuel Paparo, Commander of the US Pacific Fleet, stated publicly that Beijing had replaced all its JL-2 SLBMs with JL-3s. However, the 2023 DOD report describes the SSBNs as upgrading to the JL-3.

China's "easy to reach" coastal ICBMs

As an example, from the outside of China's EEZ domestic area of 12nm, the distance is only 270km to Puning DF-17 Base, well within range of conventional US missiles. Indeed, the majority of China's nuclear strategic forces are within <1,200km of their coast, and are henceforth deemed as "easy to reach".



Source: elaborated by authors from coordinates from Kristensen et al. (2024).[222]

Russian and Chinese strategic nuclear air forces

Russian strategic air forces are overall outdated compared to the US, and greatly depleted post-2022.[223] Most TU-95MS "Bear" turboprop-powered strategic bombers are headquartered in bases near Engels in Saratov Oblast. This is well within range of NATO conventional strike systems (approximately 1,000km).[224] Moreover, they are outranged by NATO fighters' missiles with any fighter escorts that these Russian bombers may have.[225] Vulnerable and slow as they are, they nevertheless carry nuclear missiles that would have a devastating effect if launched and not intercepted. Current Russian strategic air forces are presented below.

Table 3: Russian strategic air nuclear forces[226]

[222] Kristensen, H., Korda, M., Johns, E. and Knight, M. (2024). Chinese nuclear weapons, 2024. Bulletin of the Atomic Scientists, v.80, 2024.

[223] Dalsjö, R., Jonsson, M. & Norberg, J. (2022). A brutal examination: Russian military capability in light of the Ukraine War. Global Politics and Strategy, vol. 64, 2022, issue 3. // Axe, D. (2022). The Russian Air Force is losing its best jets over Ukraine. Forbes. // Bronk, J. (2023). Russian combat air strengths and limitations: lessons from Ukraine. CNA. // Bronk, J. (2022). Getting serious about SEAD: European Air Forces must learn from the failure of the Russian Air Force over Ukraine. RUSI. // Bronk, J. (2022). Is the Russian Air Force actually incapable of complex air operations? RUSI. // Barrie, D. & Mizio, G. (2024). Moscow's Aerospace Forces: No Air of Superiority. IISS. // Kindsvater, S. (2024). Russian Air Force report: dismal, could do better. CEPA. // Dmytriieva, D. (2024). Critical loss of TU-22M3 Bombers: Russia's ageing fleet faces challenges. RBC. // Melkozerova, V. (2024). Ukraine successfully shoots down first Russian strategic bomber. Politico.

[224] Janes (2023). Russia relocates bombers to Far East as Ukraine targets Western bases. // von Brugen, I. (2024). Satellite images show Russian TU-95 strategic bombers at drone-hit airbase. Newsweek. // See Russian strategic air bases here by Lasserre, F. (2016). Throughout the Russo-Ukrainian War, Russian strategic bombers have been relocated from Engels to Ukrainka base in the Far East.

[225] Giles et al. (2022). Myths and Misconceptions around Russian Military Intent. Chatham House.

[226] Adapted from Kristensen et al. (2024). Russian Nuclear Weapons, 2024. Bulletin of the Atomic Scientists.

Total actively-deployed warheads by strategic bombers = 586	
Launcher type	**Number**
TU-95MS "Bear"	52
TU-160/M "White Swan"	15
Total air launchers	67

Four TU-160/M "White Swan" strategic bombers (considerably faster than the TU-95MS) appear to have been destroyed by Ukrainian drones in Russia's Engels base in the Saratov region.[227] Even inside Russia, these bombers were destroyed by American-supplied systems. The capabilities of the TU-160 bomber attacking CONUS by surprise are nearly null, as they are surpassed by American radar and air-to-air capabilities.[228] Yet, it should be noted that this is not a Russian specific weakness per se; the American equivalent strategic bombers like the B-52, or even the stealth B-1 bomber, have been tracked by Russia. However, in contrast to Russia, US systems presently appear better supported by ground attack and air defence fighters, especially when supported by its allies.[229]

Compared to Russia, China presently lacks strategic range bombers capable of reaching CONUS (around 11,000km), but possesses bombers with ranges of around 6,000km, as below.[230] Only in 2016 did mid-air refuelling planes enter service with the People's Liberation Army Air Force (PLAAF), which are required for strategic missions against CONUS.[231]

Table 4: Chinese strategic air nuclear forces[232]

[227] GDC (2024). Ukraine's Kamikaze Drones Destroy TU-160 Blackjack at Engels Air Base. // Shcherbak, S. (2024). Ukraine drones attack Russian strategic airfield in Engels. Defense Express. // See first hand accounts here in Russian from Telegram.
[228] Roblin, S. (2021). Russia's TU-160 Bomber: Can it strike America or sink an aircraft carrier? 19fortyfive. // Gorbachevskiy, A. (2018). [in Russian]. TU-160. Should I resume production? Answer to critics.
[229] Eurasian Times (2023). Invisible Aircraft. How Russian Radars Busted the Myth of Stealth Fighters. // US European Command (2024). US strategic bombers complete first Bomber Task Force deployment under Large Scale Global Exercise 2024. // US European Command. (2023). US Air Force bombers integrate with UK 5th gen fighters in pre-planned mission. // Kim, J. (2024). US strategic bomber drops precision weapon in drills with South Korean fighters. Reuters. // Dean, S. (2022). Strategic bombers: still relevant? European Security & Defence.
[230] Office of the Secretary of Defense (2018). Military and Security Developments Involving the PRC 2018. Department of Defense.
[231] Trevithick, J. (2021). China's new YU-20 Tanker joined dozens of other warplanes flying near Taiwan. The Warzone. // Osborn, K. (2023). Chinese YU-20 Tanker refuels carrier-based J-15, massively increases Pacific threat. Warrior Maven.
[232] Adapted from Kristensen et al. (2024). Chinese Nuclear Weapons, 2024.

Total actively-deployed warheads by strategic bombers = 20	
Launcher type	**Number**
H-6K	10
H-6N	10
Total air launchers	20

Russian "easy to reach" land-based strategic nuclear forces

- "Easy to reach" conveys southern and eastern Russia targets, encompassing silos, or road-mobile "headquarters" or their logistic hubs.

Russia has around 90 ICBM silos in western Russia[233] and an additional 81 that are road-mobile (i.e., transporter erector launcher, or TEL) according to the START Treaty. The entirety of actively-deployed Russian nuclear forces are shown below.

Table 5: Russian land-based strategic nuclear forces capable of reaching CONUS[234]

Actively-deployed land launchers (silos and road-mobile) = 326 Actively-deployed warheads by land launchers = 1,244		
Launcher type	**Number of launchers**	**Number of warheads**
SS-18 M6 Satan	34	340
SS-19 M4	10	10
SS-27 Mod 1 (mobile)	18	18
SS-27 Mod 1 (silo)	60	60
SS-27 Mod 2 (mobile)	180	720
SS-27 Mod 2 (silo)	24	96
SS-29 (silo)	- deploying in 2024	- unknown
Total land-based launchers	**326**	**1,244**

[233] These are located at Kozelsk, Tatischevo, Teykovo, Vypolsovo, and Yoshkar-Ola. All these targets are those not those bordering Kazakhstan and in Siberia.
[234] Adapted and estimated from Kristensen et al., (2024) and UNIDIR (2013). Russian Federation: New START Report.

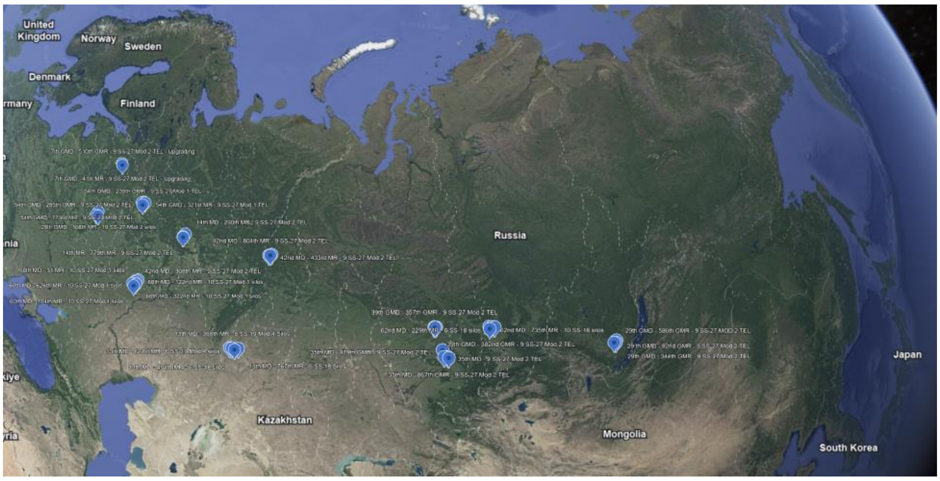
N.B. There are 999 strategic warheads in storage (storage and activation time frame is unknown). Moreover, warhead numbers come with significant uncertainty due to limited transparency of Russian nuclear forces.

Russian strategic nuclear forces are organised under the Strategic Rocket Forces in three missile armies, totalling 12 divisions, consisting of 40 missile regiments with ~50,000 personnel. Their status (i.e., reserve or deployed) and location are presented below.

Table 6: Status of Russian land-based ICBM forces[235]

Locations	Divisions	Regiments (Coordinates)	Launchers*	Status
Barnaul	35th MD	307th MR (53.3128, 84.5080)	9 SS-27 Mod 2 TEL[a]	Active
		479th GMR (53.7709, 83.9580)	9 SS-27 Mod 2 TEL	Active
		480th MR (53.3054, 84.1459)	9 SS-27 Mod 2 TEL	Active
		867th GMR (53.2255, 84.6706)	9 SS-27 Mod 2 TEL	Active
Dombarovsky	13th MD[b]	368th MR (51.0934, 59.8446)	(6 SS-19 Mod 4 silos)	Upgrading, 1 silos completed[c]
		494th MR (51.0628, 60.2119)	6 SS-18 silos	Active
		621st MR (51.0618, 59.6081)	6 SS-19 Mod 4 silos	Active
		767th MR (51.2411, 60.6069)	6 SS-18 silos	Active
Irkutsk	29th GMD	92nd GMR (52.5085, 104.3933)	9 SS-27 Mod 2 TEL	Active
		344th GMR (52.6694, 104.5199)	9 SS-27 Mod 2 TEL	Active
		586th GMR (52.5505, 104.1584)	9 SS-27 Mod 2 TEL	Active
Kozelsk	28th GMD	74th MR (53.7982, 35.8039)	10 SS-27 Mod 2 silos	Active
		168th MR (54.0278, 35.4589)	10 SS-27 Mod 2 silos	Active
		214th MR (53.7641, 35.4866)	(10 SS-27 Mod 2 silos)	Upgrading, 2 silos completed
Novosibirsk	39th GMD	357th GMR (55.3270, 82.9417)	9 SS-27 Mod 2 TEL	Active
		382nd GMR (55.3181, 83.1676)	9 SS-27 Mod 2 TEL	Active
		428th GMR (55.3134, 83.0291)	9 SS-27 Mod 2 TEL	Active
Nizhny Tagil	42nd MD	308th MR (58.2298, 60.6773)	9 SS-27 Mod 2 TEL	Active
		433rd MR (58.1015, 60.3592)	9 SS-27 Mod 2 TEL	Active
		804th MR (58.1372, 60.5366)	9 SS-27 Mod 2 TEL	Active
Tatishchevo	60th MD[d]	31st MR (51.8792, 45.3368)	10 SS-27 Mod 1 silos	Active
		104th MR (51.6108, 45.4970)	10 SS-27 Mod 1 silos	Active
		122nd MR (52.1589, 45.6404)	10 SS-27 Mod 1 silos	Active
		165th MR (51.8062, 45.6550)	10 SS-27 Mod 1 silos	Active
		322nd MR (52.0449, 45.4458)	10 SS-27 Mod 1 silos	Active
		626th MR (51.7146, 45.2278)	10 SS-27 Mod 1 silos	Active
Teykovo	54th GMD	235th GMR (56.7041, 40.4403)	9 SS-27 Mod 1 TEL	Active
		285th GMR (56.8091, 40.1710)	9 SS-27 Mod 2 TEL	Active
		321st MR (56.9324, 40.5440)	9 SS-27 Mod 1 TEL	Active
		773rd MR (56.9167, 40.3087)	9 SS-27 Mod 2 TEL	Active
Uzhur[e]	62nd MD	229th MR (55.2453, 89.9194)	6 SS-18 silos	Active
		269th MR (55.2077, 90.2526)	6 SS-18 silos	Active
		302nd MR (55.1147, 89.6311)	(6 SS-29 silos)	Upgrading
		735th MR (55.2720, 89.5783)	10 SS-18 silos	Active
Vypolsovo	7th GMD	41st MR (57.8620, 33.6500)	(9 SS-27 Mod 2 TEL)	Upgrading[f]
		510th GMR (57.7889, 33.8660)	(9 SS-27 Mod 2 TEL)	Upgrading
Yoshkar-Ola	14th MD	290th MR (56.8328, 48.2370)[g]	9 SS-27 Mod 2 TEL	Active
		697th MR (56.5601, 48.2144)	9 SS-27 Mod 2 TEL	Active
		779th MR (56.5821, 48.1550)[h]	9 SS-27 Mod 2 TEL	Active
11 Nuclear ICBM Divisions		**39 regiments**	**312 ICBMs**[i]	
Yurya	8th MD	76th MR (59.21946, 49.4256)	9 Sirena-M/SS-27 Mod 2 TEL[j]	Active; non-nuclear
12 Total ICBM Divisions		**40 regiments**	**321 ICBMs**	

Fig.3. Location of Russian silo-based ICBM launcher forces[236]



235 Kristensen, H., Korda, M., Johns, E. & Knight, M. (2024). Russian Nuclear Weapons, 2024: Nuclear Notebook.
236 Compiled and mapped by the authors from Kristensen, H., Korda, M., Johns, E. & Knight, M. (2024). Russian Nuclear Weapons, 2024: Nuclear Notebook. Available from the authors on Google Earth.

Amongst these, the estimated 90 ICBM silos[237] in western Russia are "easy to reach" by NATO forces with a combination of conventional weapons held by fighter jets, bombers, and air- and sea-launched missiles; many of which have the accuracy and speed to destroy their targets in under an hour from outside Russian air space. We are not considering early-warning systems, but as previously explained, the US would likely swarm Russia's radar system using drones – as Ukraine did – with relative success. Consequently, it can be assumed that some Russian land-based ICBMs located in western Russia are relatively vulnerable to pre-emptive attack, as are shorter-range missiles that are not the subject of this study. This is because allied inventories of such assets appear more than adequate and numerous to assign several weapons to each target.

For example, in Kozelsk, Kaluga Oblast (closest to Moscow), the regional silo cluster is only 812km from NATO territory in Riga, Latvia. Therefore, the duration of flight for:

- A JASSM-ER AGM-158D missile is **53 minutes**.
- A Tomahawk Block Vb missile is **53 minutes**.
- An Aegis RIM-156 SM-2ER Block IV is **12 minutes.**

In Tatischevo, Saratov Oblast, the regional silo cluster is 1,800km from international waters in the Barents Sea. Therefore, the duration of flight for:

- A JASSM-XR missile is **2 hours**.
- A Tomahawk Block Vb missile is **2 hours.**
- An Aegis RIM-156 SM-2ER Block IV missile is **26 minutes.**

As discussed above; Finland, Germany, the Netherlands and Poland are all purchasing the JASSM-ER in a combined quantity of **1,216**,[238] more than enough to cover most Russian silos.

Russian "hard to reach" strategic nuclear forces

- "Hard to reach" means silos or road-mobile missiles and bases in headquarters of central Russia and Russian-central Asia.

Road-mobile

Around 20% of Russia's 1,050 land-based strategic nuclear warheads are deployed on mobile launchers, or 210 TEL ICBMs, organised in 12 divisions.[239]

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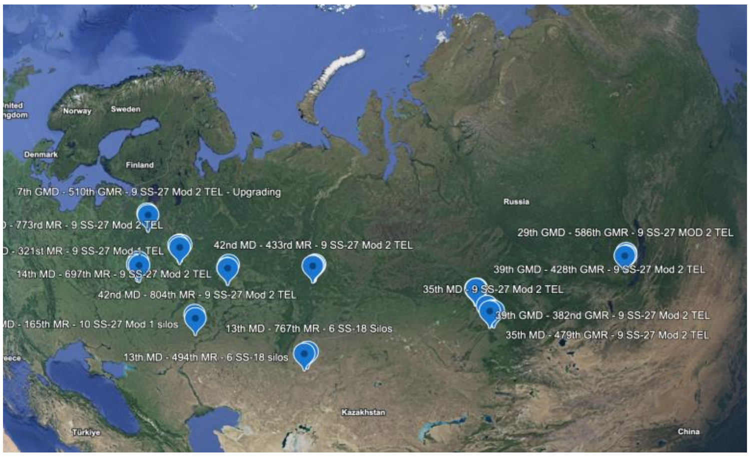
[237] Kristensen, H., Korda, M., Johns, E. & Knight, M. (2024). Russian Nuclear Weapons, 2024: Nuclear Notebook.
[238] 200 by Finland, 75 by Germany, 120 by The Netherlands, and 821 by Poland.
[239] Kristensen et al. (op.cit)

There are around 207 actively-deployed Russian TELs:[240]

- **18** TELs of SS-27 Mod 1
- **189** TELs SS-27 Mod 2

Crucially, although these TELs are highly versatile they are also restricted by fuel and logistics; and are often headquartered in 10 logistic "cluster" hubs throughout Russia, as below.

Fig.4. Location of Russian road-launcher bases[241]



N.B. There are 10 logistic "cluster" hubs for mobile ICBMs

Silo-based

These "hard to reach" Russian silos with ICBMs capable of reaching CONUS are mapped below, along with their warhead yields.

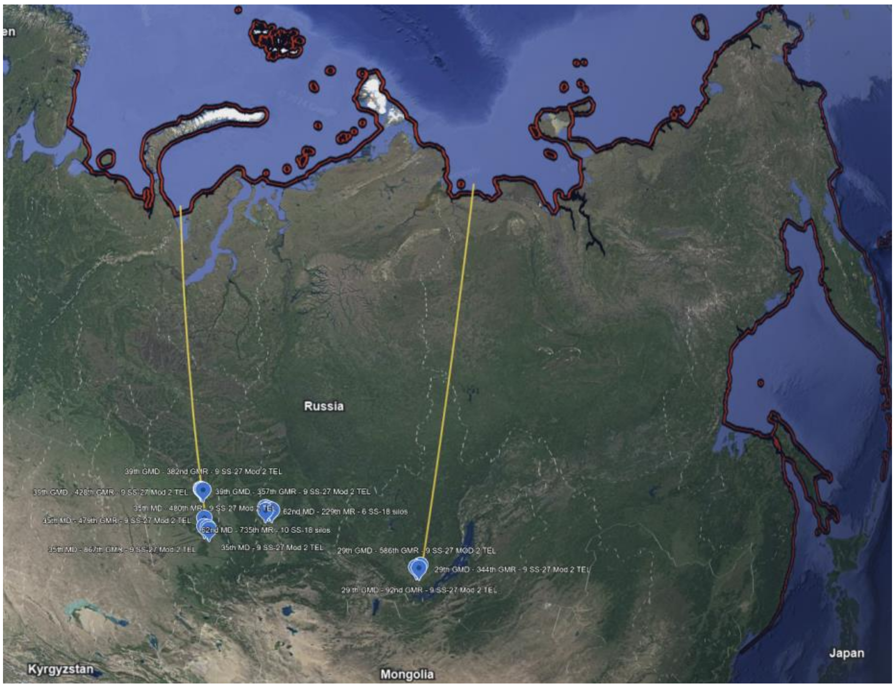
- 34 silos of SS-18 (*Satan*), with ranges of 11,000km, and warhead yield ranging from 550-750 kT, with decoys and penetration aids
- 12 silos of SS-19 Mod 4 (*Stiletto*), with ranges of 10,000km, and warhead yield ranging from 600-750 kT
- 78 silos of SS-27 Mod 1 (*Sickle*), with ranges of 11,000km, and warhead yield of 1Mt
- 30 silos of SS-27 Mod 2 (*Yars*), with ranges from 11,000-12,000km, and warhead yield from 400-500 kT

The furthest strategic Russian silos from the edge of Russian airspace (12nm accounting for sea coast) are located at Barnaul, the headquarters of the 35th GMD,

[240] ibid
[241] Compiled by authors from data by Kristensen et al. (2024) & UNIDIR (2013). Russian Federation: New START Report.

at a distance of **2,200km**, and Irkutsk, headquarters of the 29th GMD, at a distance of **2,400km**, as below.

Fig.5. Location of furthest Russian silo clusters



These targets are at greater ranges with potentially longer warning times of attack. However, US subsonic aircraft and missiles are in around a two-hour flight time from these targets. Indeed, it is found that time is not the only variable for a successful delivery capability, but also "target type and mobility of target, geography, and possible adversary response".[242] If launched, Russian land-based ICBMs would be devastating for the US.[243] For Russian planners, full survivability of these strategic targets is not expected.[244] These US non-nuclear first-strike capabilities, for instance, even in Russia's most theoretically safeguarded silos have been publicly raised by both Russia and China through a 2022 joint statement, emphasising that "US advancements in… non-nuclear weapons for disarming strikes and other strategic objectives [are matters of concern]".[245]

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[242] DoD (2009). Time Critical Conventional Strike from Strategic Standoff. Report of the Defense Science Board Task Force.
[243] Lowther, A. and Williams, D. (2023). Why America has a launch on attack option. War on the Rocks. // Congressional Research Service (2024). Russia's nuclear weapons. // Bivens, M. (2022). Nuclear famine. IPPNW.
[244] Cook, C. & Seddon, M. (2024). Leaked Russian military files reveal criteria for nuclear strike. FT. // Pifer, S. (2023). Russia, nuclear threats, and nuclear signalling. Brookings. // Alberque, W. (2024). Russian Military Thought and Doctrine Related to Non-Strategic Nuclear Weapons: Change and Continuity. IISS. // Johnson, D. (2021). Russia's Deceptive Nuclear Policy; chapter in Survival June-July 2021: Ending Endless Wars? IISS.
[245] Kremlin (2022). Joint Statement of the Russian Federation and the People's Republic of China on the international relations entering a new era and the global sustainable development.

Chinese "easy to reach" land-based strategic nuclear forces

- "Easy to reach" means road-mobile or silo-based missiles in eastern/coastal China.

Road-mobile

Mainland Chinese nuclear forces with ranges reaching its neighbours and CONUS exist in large quantities and are rapidly increasing.[246] China's ICBM launchers capable of reaching CONUS are expanding significantly, and the introduction of the DF-41 (*Dongfeng*) carrying up to 10 warheads with a range of 15,000km, greatly expands China's mobile strategic arsenal.[247] However, China's geography significantly constrains strategic ambitions and power projection, particularly given that there are competitor powers in its periphery.[248]

The assumption is that US regional forces in the Indo-Pacific Command and those of US allies, particularly Japan, would have prime responsibility for suppressing these weapons. Japan alone is acquiring 400 Tomahawks and 50 JASSM-ER, fitting JASSM to its airfleet of F-15J aircraft, and acquiring two new Aegis destroyers.[249]

The Chinese road-mobile nuclear launchers' headquarters in coastal regions are within ranges of most advanced cruise missiles. For instance, Base 62 at Yuxi holding DF-31A ICBM road-mobile launchers is only 670km from the outside of China's 12nm EEZ and adjacent to Vietnam's EEZ. This is a distance covered by JASSM-ER, Tomahawks, or SM-3s.

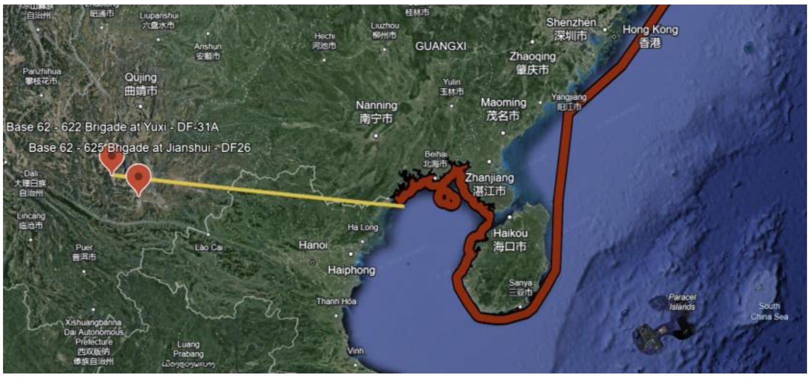


Fig.6. Example of "easy to reach" targets near the Chinese coast

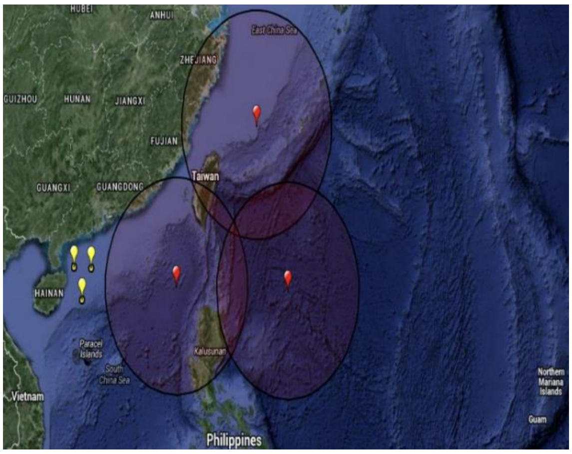
[246] Kristensen, H., Korda, M., Johns, E. & Knight, M. (2024). Chinese nuclear weapons, 2024. Bulletin of the Atomic Scientists, vol. 80, issue 1.
[247] Helfrich, E. (2023). China has now more ICBM launchers than the United States. The Warzone.
[248] Heath, T. (2023). Why is China strengthening its military? It's not all about war. RAND Corporation. // Nolt, J. (2024). Geography limits China's possibilities as a sea power. China-US Focus.
[249] Takahashi, K. (2024). Japan Inks $1.7 billion contract with the US for 400 Tomahawks. Naval News. // Defense Security Cooperation Agency (2023). Japan Joint - Air to Surface Standoff Missiles with Extended Range. Press Release, 23-60. // Fellstead, P. (2023). US State Department Approves Japanese JASSM-ER Purchase. European Security & Defence. // Takahashi, K. (2024). Japan's MoD unveils latest image of Aegis System Equipped Vessel (ASEV). Naval News. // Mahadzir, D. (2023). Japan locks in funding for 2 new Aegis destroyers. USNI News.

China's A2/AD (Anti-Access/Area Denial) strategy: How effective is China's answer to US power projection?

Despite the aforementioned Chinese geographic weaknesses, making several of its strategic targets "easy to reach," China has sought to extend the range of US naval and air systems through its A2/AD strategy. Essentially, it seeks to keep competitors' power projection at bay.

However, US and allied capability to target Chinese strategic nuclear forces does not appear to be overall negated by the considerable activity of China's military reach to the east and south of its land borders with island development for air and naval forces.[250] The reason being that the US and allied systems have ranges long enough to reach deep into China regardless. Nevertheless, shorter-range systems such as carrier-based planes without standoff missiles now encounter improving Chinese capabilities, for instance the YJ-18. It was built to counter Aegis-enabled carriers. Literature calls it the "Chinese Aegis"[251] and similar to Russia's supersonic 3M-54E (*Kalibr*).[252] It is subsonic in boost phase, or 966km/h, and accelerates to supersonic in post-boost phase, or 3,700km/h. Its range is 540km following a sea-skimming flight path. The YJ-18s are usable by submarines, surface ships, and standard sea containers.[253]

YJ-18 and YJ-82 A2/AD "threat ring" capabilities



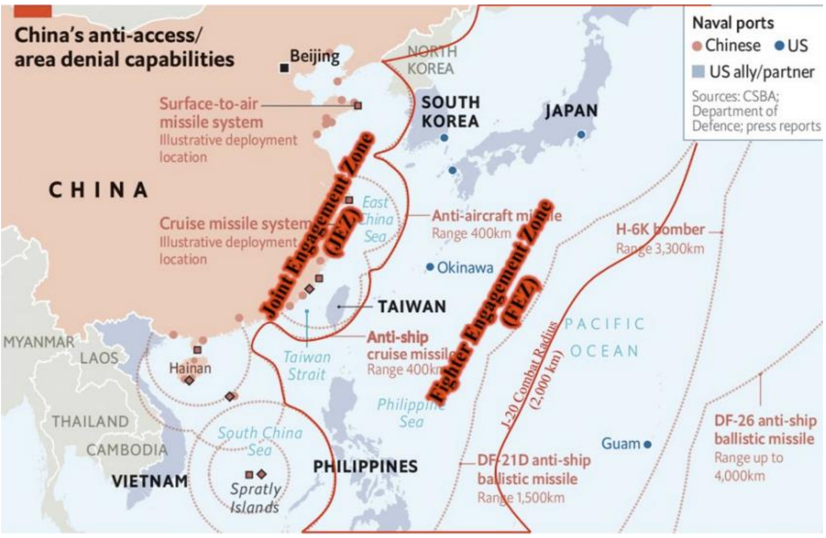
Source: Pilger, M. (2015)[254]

There is a potential overlapping of "threat rings" from three YJ-18-carrying submarines (shown in red markers), and potential "threat rings" of three YJ-82 submarines (yellow markers), thus forming a type of A2/AD "bubble" in the South and East China Seas.

[250] US DoD (2022). Military and security developments involving the People's Republic of China.
[251] Keck, Z. (2014). 'Chinese Aegis' Leads A2/AD Drill in South China Sea. The Diplomat.
[252] Missile Threat (2021). YJ-18 Eagle Strike. // Pilger, M. (2015). China's New YH-18 Antiship Cruise Missile: Capabilities and Implications for US Forces in the Western Pacific. US-China Economic and Security Review Commission. // Gormley, D., Erickson, A. and Yuan, J. (2014). A Low-Visibility Force Multiplier: Assessing China's Cruise Missile Ambitions. National Defense University Press.
[253] Missile Threat (op.cit).
[254] Pilger, M. (op.cit)

China's JEZ and FEZ zones

The combination of these A2/AD rings encompass China's Joint Engagement Zone (JEZ) in the nation's maritime vicinity which are complemented with a further Fighter Engagement Zone (FEZ), greatly extending the tactical and strategic manoeuvrability of Chinese naval and air forces.



Source: Osborn, E. (2021)[255]

Despite significant technological advancements seeking to extend the US missile ranges, the US is no longer prevented by treaties from land-based missiles of unlimited range located in allied territory. The US Army's deployment of THAAD in South Korea is a case in point, greatly increasing monitoring, defence, and potential defeat of Chinese missiles.

Would Chinese capabilities be able to push back these technologies and make them hard to reach rather than easy to reach? Significant Chinese technological and political capital has been invested in its A2/AD strategy intended to keep the US "at bay" from mainland China.[256] The strategy's effectiveness has attracted much debate.[257] However, the range and capabilities of US and allied tactical weapon systems in the region appear more than sufficient to permit strategic conventional strikes far into the mainland (>2,200km), even though this dimension is not often discussed.

[255] Osborn, E. (2021). US air superiority in a conflict with China: Requirements to supplement fifth generation assets with counterair remotely piloted aircraft. USMC Command and Staff College.

[256] Meraner, F. (2023). China's Anti-Access/Area-Denial Strategy. The Defence Horizon Journal. // Beckley, M. (2017). The Emerging Military Balance in East Asia. International Security, 2017, 42(2). // Weichert, B. (2024). Why China's missile arsenal could outmanoeuvre US military might. The National Interest.

[257] Wagemann, J. (2014). Chinese Grand Strategy: How A2/AD Fits in China's Plan. Air University. // Yevtodyeva, M. (2022). Development of the Chinese A2/AD system in the context of US-China relations. Her. Russ. Acad. Sci.92(Suppl 6), S534-S542 (2022). // Missile Defense Advocacy Alliance (2018). China's Anti-Access Area Denial.

The East and South China Seas

Is China creating an effective "archipelagic defense"[258] against US and allied strategic conventional forces through its huge investment in A2/AD?

Unfortunately for China, US long-range anti-ship and anti-surface weapons detailed in this study will always outrange Chinese naval and land-based systems because the US has the strategic depth of the Pacific as well as numerous launch points around mainland China. The US and allied 2,200-km systems launched from aircraft can still be expected to reach into central Asia. This study presumes launches outside adversary territory; however a key driver of weapon systems development is to be able to operate in hostile environments.

Discussions of A2/AD systems need a greater technical focus on their capability to prevent US strategic non-nuclear attack and defences.

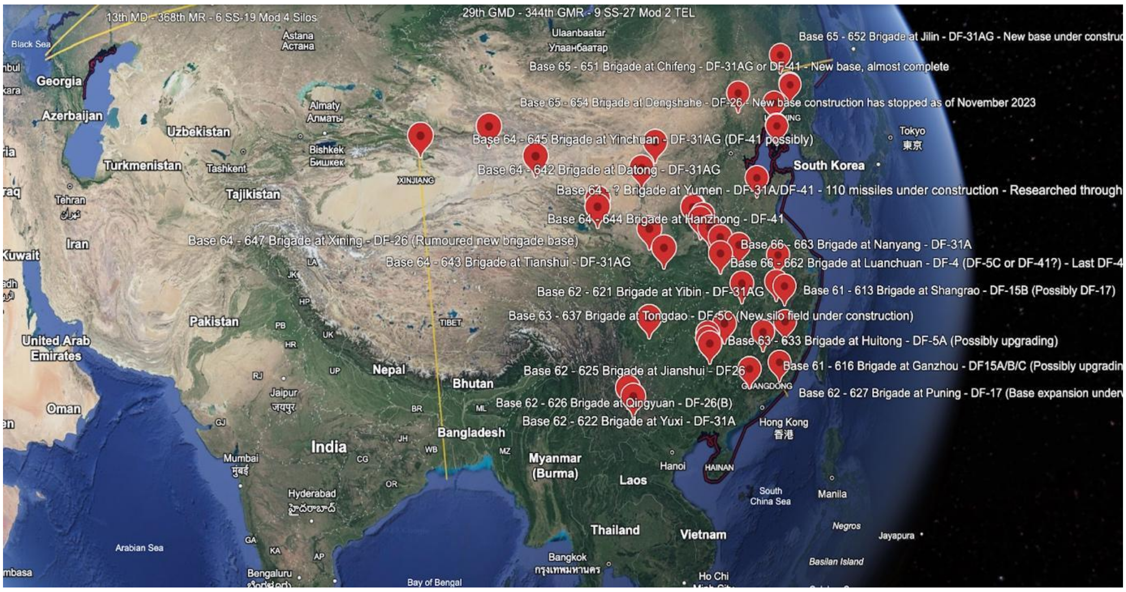
- As per Pilger,[259] the YJ-18's wide deployment and long-range "increases China's ability to launch standoff multi-axis, multi-missile attacks against US Navy surface ships that would carry Tomahawks and Aegis and carrier groups, hence providing China a multilayered anti-access/area denial capability in its near seas and beyond".[260]
- As per Gormley et al.,[261] "China's increasing ASCM (anti-ship cruise missiles) inventory has increasing potential to saturate US Navy defences".
- Taking Pilger's analysis, "the assessed 537-km range creates a threat ring covering 906,180km^2. The US must greatly expand its monitoring area against the PLA Navy submarine activity. Even though most of these submarines are relatively noisy, detecting and engaging these will complicate the task of defending US Navy surface ships from cruise missile attacks".[262]
- As also proposed by Pilger, Chinese *Shang*- and *Yuan*-class submarines with YJ-18 "could impede progress of a carrier-strike group in the western Pacific".[263]

Silo-based ICBMs

The Chinese silo-based locations are shown below.

[258] Krepinevich, A. (2017). Archipelagic Defense. Sasakawa Peace Foundation.
[259] Pilger, M. (2015). China's new YJ-18 anti-ship cruise missile: capabilities and implications for US forces in the western Pacific. US-China Economic and Security Review Commission.
[260] ibid
[261] Gormley et al. (op.cit, p.77)
[262] Pilger (op.cit) // Chan, M. (2015). China's Pirate Patrol Submarine is Too Noisy, Say Naval Experts. SCMP.
[263] Pilger (ibid)

Fig.7. Location of Chinese ICBM silos



Source: Elaborated by authors from data by Kristensen et al. (2024)[264]

The furthest silos inside China accessible by the Bay of Bengal are those in Xinjiang, at a straight-line distance of approximately 2,500km.

Chinese “hard to reach” strategic nuclear forces

- We define “hard to reach” as the road-mobile headquarters and silos in north western China

Road-mobile

The PRC’s ICBM forces encompass around 320 road-mobile ICBMs and some 60 in silos.[265] China's road-mobile ICBMs include the solid-fuelled DF-31 and DF-41 variants. The CSS-20 has enhanced range and accuracy compared to older solid-fuelled ICBMs and is equipped with a maximum of three warheads per missile, each with a range of 11,000km. The DF-41 ICBM system has been operationally deployed since 2019.[266] For US planners, these 400 actual targets are the key focus of detect/defeat/defend capabilities.[267] As a benchmark, doubtless troubling to Beijing, is that the US alone can count on approximately 5,000 cruise missiles[268] with 2,000-km ranges to allocate to the task, and to which can be added shorter-range air launch

[264] Kristensen, H., Korda, M., Johns, E. and Knight, M. (2024). Chinese nuclear weapons, 2024. Bulletin of the Atomic Scientists, v.80, 2024.
[265] Kristensen, H., Korda, M., Johns, E. & Knight, M. (2024). Chinese nuclear weapons, 2024. Bulletin of the Atomic Scientists, 80:1, 49-72.
[266] Missile Threat: CSIS Missile Defense Project (2024). DF-41 Dong Feng-41/CSS-X-20.
[267] US DoD (2023). Military and security developments involving the People’s Republic of China.
[268] IISS (2024). The Military Balance, 2024.

systems. This creates an uncertain and highly complex combination of competing forces that support the need for our continuing study agenda, but which nevertheless needs infusing across discussions of tripartite US, China, and Russian strategic affairs.

Wack-A-Mole:[269] The issue of deeply-buried missile silos

China is reorienting its nuclear posture for strategic rivalry with the US because its leaders have concluded that their current capabilities are insufficient.[270] Besides the pursuit of geopolitical leverage, Beijing worries that bilateral tension, US nuclear modernization, and the PLA's advancing conventional capabilities have *increased* the likelihood of a US first strike.[271] Beijing does not appear interested in agreements that restrict its plans, and will not agree to negotiations that lock-in US or Russian advantages.[272] Beijing's heightened confidence in its nuclear deterrent, driven by a large-scale construction of new ICBM silos, is simultaneously likely to bolster its resolve in conventional conflicts.[273]

According to the 2022 Pentagon Report, China's arsenal of "operational" nuclear warheads has exceeded 400 and is anticipated to grow to approximately 1,500 warheads by 2035.[274] Senior Colonel Tan Kefei, spokesperson for China's Ministry of National Defense, rebuked the report, alleging it misrepresented China's defence policy and military strategy, emphasising that China is committed to maintaining peace and stability in the region as a "builder of world peace".[275] Despite uncertainties surrounding China's nuclear plans, expansion remains evident, notably with the construction of three extensive missile silo fields. Even the augmentation of the mobile ICBM force represents an unprecedented move.[276]

A non-nuclear first strike might be implied in this US threat assessment, and the following analysis illuminates such possibilities with currently-deployed US and allied technologies focused on missile attacks on the entrance to extensive Chinese

269 A well-known game called Wack-a-Mole.
270 Boyd et al., (2023). PLA sharpens nuclear and conventional capabilities but still has work to do, US says. IISS. // Zhao, T. (2024). The real motives for China's nuclear expansion. Foreign Affairs.
271 Kremlin (2022). Joint Statement of the Russian Federation and the People's Republic of China on the international relations entering a new era and the global sustainable development. // Fravel et al. (2023). China's misunderstood nuclear expansion. How US strategy is fueling Beijing's growing arsenal. Foreign Affairs.
272 Ying, F. (2016). How China sees Russia: Beijing and Moscow are close, but not allies. Foreign Affairs, vol.95, no.1, January/February 2016, pp.96-105. Council on Foreign Relations. // Fraser, C. (2024). Russia and China: the true nature of their cooperation. RUSI. // Morris, L. (2023). Unease, not confidence, defines China's 'partnership' with Russia. Asia Society Policy Institute. // Fong, C. & Maizland, L. (2024). China and Russia: Exploring Ties. Council on Foreign Relations. // Saradzhyan, S. (2020). Why Russia's alliance with China is improbable, but not impossible. The Foundation for Strategic Research 13, 2020.
273 Office of the Director of National Intelligence (2023:7-8). Annual Threat Assessment of the US Intelligence Community.
274 US Department of Defence (2023, p.94). Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2022. Office of the Secretary of Defense, November 29.
275 Chenglong, J. (2022). Ministry Slams US Report on Chinese Military. China Daily.
276 Kristensen, H., Korda, M., Johns, E. & Knight, M. (2024). Russian Nuclear Weapons, 2024: Nuclear Notebook.

tunnel systems hiding their ICBMs near mountainous regions, the so-called "Great Wall".[277] Despite these challenges, the rationale from a US planner would likely not be to reach and/or destroy the missiles themselves, deep inside a mountain, but rather to block potential launch openings.[278] This entails a relatively less challenging task – although difficult to analyse from public sources – even if it involves some hundreds of aim points. In 2008, Raytheon unveiled new conventional bunker-busting technology designed to defeat hardened and deeply-buried bunkers, called the Tandem Warhead System, whereby a 450-kg warhead penetrated 5.7m out of a 6-m, 330-ton steel reinforced concrete block rated at 87 MN/m^2 (12,600 PSI).[279]

However, this direct-hit proposition begs the question of earthquake effects – a principle used to great effect to circumvent the concrete that Adolph Hitler used to protect his favoured bunkers and submarine pens as discussed above. Thus, the Tandem Warhead System could demonstrate greater earthquake effects which deserves a technical comparison to the Tall Boy and Grand Slam bombs used in WW2 by the British.

The Pentagon's projections suggest China may intend to equip the new silos with missiles capable of carrying multiple independently-targetable re-entry vehicles (MIRVs). However, critical uncertainties persist; firstly, it is unclear how many of the new silos will be operational. China might construct more silos than necessary to employ a tactic resembling a "shell game," complicating adversaries' targeting efforts.[280] Secondly, the number of missiles equipped with MIRVs and the warhead count remain unknown. While each DF-5 ICBMs can carry up to five warheads, the Pentagon anticipates the DF-41 ICBM will likely carry no more than three MIRVs.[281] The primary objective of the extensive silo construction likely aims to preserve China's retaliatory capability against a pre-emptive strike, while the MIRV program likely focuses on ensuring penetration of US missile defences rather than maximising warhead capacity. Drawing from literature, it becomes evident that China's ongoing silo construction initiatives and the expansion of its mobile ICBM forces suggest the potential for China to surpass either Russia and the US in ICBM capabilities within the

[277] Zhao, T. (2011). Conventional Counterforce Strike: An option for damage limitation in conflicts with nuclear-armed adversaries? The Technical Basis for Arms Control, Disarmament, and Non-Proliferation Initiatives, volume 19, 2011, issue 3. // Zhao, T. (2011). Deterrence meets Great Wall. The Diplomat. // Holmes, J. (2011). China's underground Great Wall. The Diplomat. // Zhang, H. (2012). China's underground Great Wall: Subterranean Ballistic Missiles. Harvard Belfer Center for Science and International Affairs.
[278] US Department of Defense (2001). Report to Congress on the defeat of hard and deeply buried targets. // Union of Concerned Scientists (2005). Earth-penetrating weapons. // Bunn, M. & Tsipis, K. (1983). The Uncertainties of a preemptive nuclear attack. Scientific American, v.249, no.5, November 1983, pp.38-47.
[279] RTX (2008). Raytheon Unveils New Bunker-Busting Technology.
[280] Hiim, H., Fravel, M. & Trøan, M. (2023). The dynamics of an entangled security dilemma: China's changing nuclear posture. International Security, 47(4), 147-187. // Trachtenberg, D. (2021). Back to the future: a misguided understanding of China's nuclear intent. Real Clear Defense.
[281] US DoD (2023). Military and Security Developments Involving the PRC. Annual Report to Congress.

next decade.[282] The targets that these new weapons present will generate new US weapons requirements. Such is the logic of arms races.[283]

Findings

- The US and its allies may threaten even the most buried and mobile strategic forces of Russia and China.
- Only Russian mobile and Chinese deeply-buried (i.e., underground "Great Wall") strategic systems may be considered at all survivable in the face of conventional missile attacks. They appear far more vulnerable than usually considered given US and allies' technological and numerical advantages in conventional missiles and delivery systems.
- The US and allies have the task of defeating or defending against some 70 Chinese and 150 Russian launchers in eastern central Asia. Against these, there are 4,400 Tomahawks and 3,500 JASSM missiles. Arithmetically, the numbers favour the US and allies.
- Mobile and deeply-buried strategic systems face the challenge of reliable launch-under-attack. US and allied conventional missiles and missile-carrying aircraft are highly accurate, relatively hard to detect with radar systems, and have subsonic speeds close to 914 km/h. The furthest targets are at ranges of 2,400km for Russia and 2,500km for China from outside their borders.
- Formidable and increasing Russian and Chinese conventional land forces do not have a comparable ability to reach into the continental United States.

Conclusions

Strategic non-nuclear forces have a demonstrable impact on strategic weapons stability between the US and its allies on the one hand and Russia and China on the other. Preventing miscalculation leading to nuclear war should be the highest priority of government and civil society. Yet, there is an extremely dangerous dynamic in the interaction of nuclear and non-nuclear strike forces that is compounded by the extraordinarily low level of awareness of the problem across stakeholding communities.

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[282] Kristensen et al. (2024). Chinese Nuclear Weapons. Federation of American Scientists. // Zhao, T. (2020). Narrowing the US-China gap on missile defence. Carnegie Endowment for International Peace. // Korda, M. & Kristensen, H. (2021). China is Building a Second Nuclear Missile Silo Field. Federation of American Scientists. // Hadley, G. (2023). China now has more ICBM launchers than the US. Air & Space Forces Magazine. / US Department of Defense (2022). Military and Security Developments Involving the People's Republic of China. Annual Report to Congress. // Newdick, T. (2021). China increasing its ICBM silos by a factor of ten. The Warzone.

[283] Butler, G. (1999). Ending the Nuclear Madness. Nuclear Age Peace Foundation.

Our analysis reveals that the US and allies have a plausible present day capacity with non-nuclear forces to pre-empt Russian and Chinese nuclear forces by Detecting, Defeating and Defending against them. Piecing together weapon systems and geographic concerns that are usually considered as independent elements and unconnected continents provides a compelling picture of US and allied current non-nuclear strategic superiority.

The sheer quantity of US and allied long-range, accurate missiles, within two hours of the hardest-to-reach Russian and Chinese strategic weapons threatens to overwhelm them, not least given Russia and China's overall lesser detection capabilities and incrementally improving US missile defences. Allied conventional capabilities may seem more plausible to Russia and China than to US decision makers;[284] however, across the spectrum from peacetime diplomacy to crisis at the brink of war, this advent of non-nuclear counterforce capabilities deserves greater attention than has so far been given.

In a major power crisis, decision makers should be expected to ask their commanders, "what non-nuclear options do I have?" This study begins to sketch out what US commanders might tell the President about current non-nuclear capacity to pre-empt and defend against Russian and Chinese strategic nuclear forces.[285] In a crisis, and assuming that Western aircraft are inside Russian air space, there is a very different circumstance. Take the ubiquitous F-35: its radars designed to find and attack ground targets have a diameter of 300km on each aircraft, and are equipped with JASSM and other missiles and bombs. In addition, the F35 and other aircraft carry the latest air-to-air missiles. Again, these AMRAAM have an operational radius of some 150km on each aircraft due to its AN/APG-81 radar.[286] This highly sensitive radar is capable of detecting targets with a radar cross section of $1m^2$ at a range up to 110km.[287] This is particularly relevant when considering that such an AMRAAM system may have the capacity to shoot down ICBMs in their boost phase.[288] Indeed, as former US Representative Duncan Hunter claimed, research facilities at Los Alamos and Livermore are attempting to "shoot AMRAAMSs off F-35s in the first 300 seconds [of boost-phase] that it takes a missile to go up in the air".[289] These

[284] Kremlin (2022). Joint Statement of the Russian Federation and the People's Republic of China on the international relations entering a new era and the global sustainable development.
[285] Creedon et al. (2023). America's Strategic Posture: Final Report of the Congressional Commission on the Strategic Posture of the United States. House.gov.
[286] Department of Defense (2015). F-35 Joint Strike Fighter (JSF). Office of the Director, Operational Test and Evaluation.
[287] Nikolov, B. (2023). F-35's radar detects a Russian SU-57, but within a certain range. Bulgarianmilitary.com // Jenn, D. (2011). RCS Reduction: Radar & Laser cross section. Naval Postgraduate School, Monterey, California.
[288] Alcazar, V. & Schanz, M. (2018). Exploiting Airpower's Missile Defense Advantage: The Case for Aerial Boost Phase Interception. The Mitchell Forum: Mitchell Institute for Aerospace Studies. // National Research Council (2012). Making Sense of Ballistic Missile Defense: An Assessment of Concepts and Systems for US Boost-Phase Missile Defense in Comparison to Other Alternatives.
[289] Missile Defense Advocacy (2017). Capitol Hill Briefing on "Boost Phase Missile Defense". Transcript from Briefing. See briefing video here.

incremental technological developments that this study seeks to uncover are highly pertinent to the current geopolitical situation. US NATO members and allies like Poland, the Netherlands, and Japan have substantially increased their JASSM-ER stockpiles.[290] This further demonstrates the sheer asymmetry between allied non-nuclear capabilities and Russia's defence systems, which are not keeping up with recent allied conventional developments.[291]

The US and its allies can threaten even the most buried and mobile strategic forces of Russia and China. Our analysis predicts that only Russian mobile and Chinese deeply-buried strategic systems may be considered at all survivable in the face of conventional missile attacks and are far more vulnerable than usually considered. Indeed, their unexamined invulnerability is a basis of assumed strategic stability. For instance, the US and allies have the task of defeating or defending against, at present, around 70 Chinese and 150 Russian targets in central Asia. Against these, there are 3,500 JASSM and 4,400 Tomahawks missiles. In this presumed environment, the US would be flying fighters equipped with air-to-air AMRAAM missiles with an interception diameter of 200km. An indicative but obviously oversimplified analysis might assume 200 surviving missile launches requiring some 10 AMRAAM per missile from 40 US fighter aircraft, a plausible and realistic number. Mobile and deeply-buried strategic systems face the challenge of reliable launch under attack. US and allied conventional missiles and missile-carrying aircraft are highly accurate, relatively hard to detect with radar systems, and have subsonic speeds close to 914km/h. Their hardest to reach targets are at a range of around 2,400km for Russia and 2,500km for China from outside their borders. That is a nominal launch-to-target time of two hours. Prudent planners would need to assume that surprise and stealth characteristics and ability to launch from within Chinese and Russian air space would eat into or eliminate warning time.

As discussed in the introduction, any real world war will be extremely hazardous. And yet, in framing the need for new US nuclear forces, the US Congress's study[292] includes the supposed vulnerability of existing US land-based systems to attack, or various scenarios around a US-China regional conflict. A narrow technological analysis and a rhetoric analysis of adversaries is commonplace in shaping policy, as well as procurement and deployment of weapons. In that style of

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[290] Osborne, T. (2024). Poland Plans Missile Buildup with JASSM, Amraam, Sidewinder Buys. Aviation Week Network. // Defense Security Cooperation Agency (2024). The Netherlands - Joint Air-to-Surface Standoff missiles with extended range. // Defense Security Cooperation Agency (2023). Japan Air-to-Surface Standoff missiles with extended range.

[291] Starchak, M. (2023). Sanctions further delay Russian missile early warning program in space. Defense News. // Janes (2022). Hammer and Shield: Russia's modernised radar and early warning systems. // Kofman, M. (2020). Russian maritime A2/AD: Strengths and weaknesses. Russian Military Analysis.

[292] Creedon, M. et al. (2023, pg.8 and pg.91). America's Strategic Posture. Final Report of the Congressional Commission on the Strategic Posture of the United States.

analysis, the following should be considered important considerations for Russian and Chinese planners, along with Western policy makers, civil society, and media.

Any decision to fire nuclear weapons in response to a non-nuclear attack has a credibility problem for any assumed deterrent. Regardless of statements, for example by Russia, that an attack on its core interests would be met with a nuclear strike, it is hard to see how this would be rational if it then invited a nuclear attack on any forces that had survived a conventional counterforce strike.

Ultimately, the incremental and largely unnoticed technological developments analysed in our study appear to strengthen the argument that conventional first-strike capabilities may carry a similar effect on opponents' strategic planning as do orthodox first-strike nuclear capabilities. That is to say, non-nuclear pre-emption might work.

Implications and further research

- US global conventional firepower is underestimated, which threatens both the realities and the perceptions of strategic stability.
- The considerations in this study serve as a baseline for studies of new technologies such as hypersonic missiles, AI, and the related issues of cyber, space and electronic warfare. This is not usual in present studies of such issues.
- The global perspective presented here can be added to regional strategic studies, specifically in Europe, the Middle East, and the East and South China Seas to provide the necessary holistic approach required in a militarily-globalised world.
- What are the implications of the capabilities described here for deterrence and Western policy? What are the implications for deterrence of leaving out such an important, large-scale conventional capacity? If no one knows, how can it deter? Would wider understanding encourage aggressive attitudes in Western publics? Can these capabilities, as Paul Nitze considered,[293] allow substantial Western nuclear reductions? These are among the matters arising from this study.
- The present study is only concerned with non-nuclear weapons; it clearly begs the question of the potential for integrated nuclear and non-nuclear weapons use. Does such a mix represent the US concept of "integrated deterrence" with the dimension of non- or "less nuclear" coercive diplomacy? Do Russia and China have comparable policy?

[293] Nitze, P. (1977). The Relationship of Strategic and Theater Nuclear Forces. International Security, Fall 1977, p.124.

- The risks of war from the arms race described here require a "soft landing" approach of arms control and disarmament as, for example, discussed in the SOAS project on the Strategic Concept for the Removal of Arms and Proliferation at www.scrapweapons.com. Particularly, the proposals for "Zero Missiles," for annual extended meetings of the UN General Assembly on Disarmament like a Special Session on Disarmament (SSOD-IV),[294] and for open source tools to boost multilateral confidence and verification.
- Generally, ongoing deterrence studies would benefit from integrating strategic non-nuclear systems into their analyses.
- Realistically, the unrecognised and unstable integration of strategic conventional and nuclear forces is unprecedented and provides a further imperative for nuclear weapons elimination and generalised weapons controls. To this end, an SSOD-IV at the UN General Assembly is a necessary - if insufficient - short term objective.

This report should be seen as **a scoping study for a wider research agenda.** For example, risk and cost-benefit analyses, calculations of effectiveness of destruction of Russian and Chinese targets, survivability rates of NATO systems against peer competitors, and incapacitation or partial destruction of hardened silos through non-nuclear bunker buster missiles.

[294] United Nations (2023, pg.31). Our Common Agenda Policy Brief 9: A New Agenda for Peace. // United Nations (2024). Secretary-General Urges Conference on Disarmament to Move Humanity Closer to Peace. // United Nations (2024). Pact for the Future: Rev.2, 17 July 2024. See Action 27 (a): "We decide to: (a) Revitalise the role of the United Nations in the field of disarmament, including by recommending that the General Assembly hold a fourth special session devoted to disarmament (SSOD-IV)".

Appendices/Technological information

Presented below is a 2024 snapshot of the inventory and known orders (of the last two years). US and allied Air Systems capable of conventional counterforce (i.e., carrying JASSM, AMRAAM, and Tomahawk missiles). The following military inventories are sourced from the IISS Military Balance 2024.[295]

Allied actively-deployed conventional missiles

- **JASSM**

Actively-deployed allied JASSM missiles ~2,000	
Type	**Operational range (km)**
JASSM AGM-158A	370
JASSM AGM-158B (ER)	1,000
JASSM AGM-158D (XR)	1,800

Note: all JASSM variants have a maximum subsonic speed of 914km/h (Mach 0.74)

Stockpiles of JASSM variants by nation	
AGM-158A JASSM	US: 2,000 – 2,100 Australia: 150 – 200
AGM-158B JASSM-ER	US: 1,200 – 1,300 Australia: 80
Total held by allied nations	**3,555**

- **Tomahawk**

Actively-deployed allied Tomahawk missiles	
Tomahawk variants	**Operational range (km)**
Block II TLAM-A	2,500
Block III TLAM-C	1,700
Block IV	1,600
Block Vb	> 1,666 (classified)

[295] IISS (2024). The Military Balance.

Stockpiles of all Tomahawk variants by nation
USA: 4,000
UK: >150
Australia: 200
Total: 4,350

Note: all Tomahawk variants have a maximum subsonic speed of 914km/h (Mach 0.74)

Actively-deployed US Air Fighters

Actively-deployed US Air fighters = 1,476		
Type	**Number**	**Loadings per fighter (estimate from weightings)**
F-15E	218	16/22 air-to-air missiles
F-16C	441	6 Tomahawks. 5 JASSMs deployed in 2021[296]
F-16D	108	6 Tomahawks. 5 JASSMs deployed.
F/A-18	227	2 JASSMs, 8 AMRAAMs
F-35A Lighting II	450	4 AMRAAM internally, 4 AMRAAM externally. 2 JASSM externally
F-35B Lighting II	32	4 AMRAAM internally, 4 AMRAAM externally. 2 JASSM externally

[296] Newdick, T. (2021). Five JASSM Stealth Missiles have been loaded on a Strike Eagle for the First Time. The Warzone.

Actively-deployed US bombers		
Type	**Number**	**Loadings per bomber (estimate from weightings)**
B-1B Lancer	62	24 ASSM internally, with additional 12 missiles externally through Boeing's Load Adaptable Modular pylon (LAM).[297] Total of 36 JASSM-ER internally and externally.
B-2	20	16
B-52	58	20
Total	**140**	(62 x 36) + (20 x 16) + (58 x 20) = **3,712**

Navy systems armed with conventional missiles

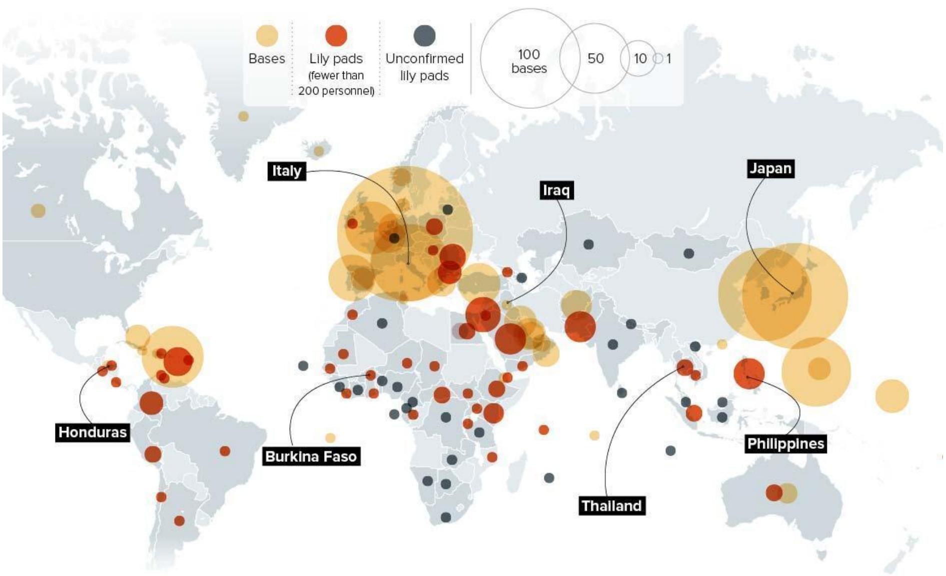
US Naval vessels capable of carrying Tomahawks = 89	
Cruiser type	**Number**
Ticonderoga	17
Arleigh Burke Flight IIA	42
Arleigh Burke Flight I/II	28
Zumwalt	2

Aegis-enabled US Naval vessels = 87	
Cruiser type	**Number**
Ticonderoga	17
Arleigh Burke Flight IIA	42
Arleigh Burke Flight I/II	28

[297] Air Force Global Strike Command (2016). B-1B Lancer. // Tirpak, J. (2023). New Boeing pylon could shift hypersonics testing to B-1, add bomb capacity. Air & Space Forces Magazine. // Keller, J. (2023). The Air Force wants to load up the B-1B Lancer with more bombs than ever before. Task and Purpose.

US submarines capable of carrying Tomahawks = 53		
Submarine type	**Number**	**Loadings per submarine**
Ohio	4	22 tubes, each with 7 Tomahawks = **154**
Los Angeles Flight II	4	25 tubes, each with 7 Tomahawks = **175**
Los Angeles Flight III	22	25 tubes, each with 7 Tomahawks = 175 + 12 dedicated VLS tubes for one Tomahawk each. 175 + 12 = **187**
Virginia Flight I/II	10	12 tubes, each with 7 Tomahawks = **84**
Virginia Flight III	8	12 tubes, each with 7 Tomahawks = **84**
Virginia Flight IV	3	12 tubes, each with 7 Tomahawks = **84**
Seawolf	2	**50**

Location of US military bases overseas as of 2015



Source: Vine, D. (2015). Politico.

This report was written by Dan Plesch and Manuel Galileo. It was edited by Roxanne Mackey, Martin Butcher, Zahraa Kapasi, and Eloisa Romani.

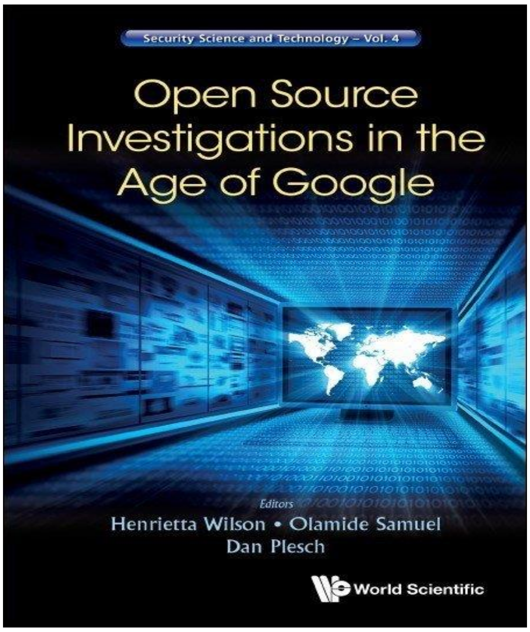
This report is developed from Dan Plesch's piece *Could the US win WWIII without using nuclear weapons?*[298]

"Masters of the Air" is a term coined by Winston Churchill to describe Allied air forces in WW2, and the title of an Apple TV+ series.

The report forms part of the project on a Strategic Concept for the Removal of Arms and Proliferation led by Professor Plesch at SOAS University of London, www.scrapweapons.com. The research is supported by the Marmot Trust and the Joseph Rowntree Charitable Trust.

A focus of the project is on the need, as outlined by UN Secretary-General António Guterres in his New Agenda for Peace from July 2023,[299] for a new annual special session of the UN General Assembly on Disarmament and on examples and prototypes to implement general arms control and disarmament.

To donate to support the research agenda of this report please contact Professor Dan Plesch at dp27@soas.ac.uk with Donation in the subject line. Independent funding for the type of research presented here is in extremely short supply. In contrast, as Benoit Pelopîdas and Egeland Kjølv Egeland have demonstrated,[300] industry funding of independent research centres is the norm.



298 Plesch, D. (2018). Could the US win World War III without using nuclear weapons? The Conversation.
299 United Nations (2023, pg.31). Our Common Agenda Policy Brief 9: A New Agenda for Peace. // United Nations (2024). Secretary-General Urges Conference on Disarmament to Move Humanity Closer to Peace. // United Nations (2024). Pact for the Future: Rev.2, 17 July 2024. *See* Action 27 (a): "We decide to: (a) Revitalise the role of the United Nations in the field of disarmament, including by recommending that the General Assembly hold a fourth special session devoted to disarmament (SSOD-IV)".
300 Pelopidas, B. and Egeland, K. (2022). No such thing as a free donation? Research funding and conflicts of interest in nuclear weapons policy analysis. HAL Open Science, Sciences Po.