Bursting the Bubble

Russian A2/AD in the Baltic Sea Region: Capabilities, Countermeasures, and Implications

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Sammanfattning

Stater som har förmågan att använda en kombination av sensorer och långdistansrobotar för att hindra antagonister från att operera inom en exkluderingszon, eller "bubbla", i anslutning till sitt territorium sägs besitta avreglingsförmåga (eng. anti-access/area denial, A2/AD). Denna studie analyserar Rysslands avreglingsförmåga och dess implikationer för Östersjöregionen. Rysslands förbättrade förmågor, samt dess påverkan på Natos möjligheter att förstärka och försvara de sårbara baltiska staterna i händelse av kris eller krig, har väckt mycket uppmärksamhet på senare år. Denna studie visar dock att denna förmåga inte är tillnärmelsevis lika oöverstiglig som den ibland framställs, i synnerhet när möjliga motåtgärder inkluderas i analysen. Särskilt markbaserade luftvärnssystem skapar i nuläget en mer begränsad exkluderingszon än vad som ofta antas och flera motåtgärder är möjliga. Erfarenheter från Syrien väcker också frågor om systemens faktiska förmåga i fält, jämfört med dess nominella förmågor. Sjömåls- och markmålsrobotar utgör ett större hot, men även här finns flera möjliga motåtgärder. Dynamiken i detta säkerhetskomplex påverkar även Sverige direkt och indirekt och är en av de huvudsakliga orsakerna till varför Sveriges säkerhet i ökande grad är sammanvävd med våra grannländers, och med den transatlantiska alliansen Nato.

Nyckelord: Avreglingsförmåga; A2/AD; Baltikum; Nato; Ryssland; sjömål; markmål; luftmål; radar; motmedel; skenmål; Iskander; S-400; Bastion

Summary

States with the ability to use a combination of sensors and long-range missiles to prevent adversaries from operating in an exclusion zone, or "bubble", adjacent to their territory are said to possess anti-access/area denial (A2/AD) capabilities. This study examines Russia's A2/AD systems and their implications for the Baltic Sea region. Much has in recent years been made of Russia's new capabilities and the impact they might have on the ability of NATO member states to reinforce or defend the vulnerable Baltic states in case of crisis or war. On closer inspection, however, Russia's capabilities are not quite as daunting, especially if potential countermeasures are factored in. In particular, surface-to-air missile systems currently create much smaller A2/AD bubbles than is often assumed and a number of countermeasures are possible. Experiences from Syria also raise questions about the actual capabilities of such systems in combat, relative to their nominal capabilities. Anti-ship and anti-land systems pose a greater threat but, here too, countermeasures are available. The dynamics of this strategic vortex affect Sweden directly and indirectly. This is one of the reasons why Sweden's security is increasingly interlocked with that of its neighbours and of the transatlantic alliance.

Keywords: A2/AD; The Baltic Sea Region; NATO; Russia; air defense; anti-ship missiles; radar; decoy targets; Iskander; S-400; Bastion

Acronyms

A2/AD	Anti-Access/ Area Denial
ASW	Anti-Submarine Warfare
ATO	Air Tasking Order
AWACS	Airborne Warning and Control System
C2	Command and Control
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CSAR	Combat Search and Rescue
CIWS	Close-in Weapons Systems
eFP	Enhanced Forward Presence
ERI	European Reassurance Initiative
FOFA	Follow-on Forces Attack
GBAD	Ground-Based Air defences
IAF	Israeli Air Force
IFF	Identification Friend or Foe
IIR	Imaging Infrared
INF	Intermediate-Range Nuclear Forces
IR	Infrared
NRFA	NATO-Russia Founding Act
OTH	Over the Horizon
PGM	Precision-Guided Munitions
RCS	Radar Cross-Section
SAM	Surface-to-Air Missile
SEAD	Suppression of Enemy Air Defences
SLOC	Sea-Lines of Communications
STRATCOM	Strategic Communications

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Preface

The Defence Policy Studies Project at FOI analyzes selected issues affecting Swedish defence policy under contract from the Ministry of Defence. These issues currently include actual operational capabilities, military intelligence, civil defense, deterrence and threat analysis, as well as nuclear issues. For the present study, the project has been commissioned by the Ministry of Defence to analyze Russian A2/AD capabilities and NATO's possible countermeasures, and their impact on the strategic dynamics in the Baltic Sea Region. In so doing, we have sought to produce an introductory overview of the subject, aimed primarily at non-specialist security professionals. The fact that FOI has a wide range of technical experts with deep knowledge of their subjects has been an incredible asset in this endeavor, allowing us to anchor an essentially politico-military analysis in a solid understanding of physical realities.

The authors would like to express their gratitude to Erik Berglund for reviewing the manuscript and to Per Wikström for designing the maps used throughout the report. Furthermore, we are very grateful to a number of colleagues who have provided very valuable feedback on various drafts of the report, including Andreas Hörnedal, Jan Frelin, Jonas Kjellén, Bo Tarras Wahlberg, and Fredrik Westerlund. Similarly, we wish to thank Brett Bourne and Anders Enström from the Swedish Defence University for their helpful feedback. Finally, we wish to thank Lena Engelmark for very quickly and ably helping us with the layout of the report.

Stockholm, March 2019

Michael Jonsson
Head of Project, FOI Defence Policy Studies

Executive summary

Russia's potential to create "keep-out zones" or anti-access/area-denial (A2/AD) "bubbles" in its near abroad has become a hot topic and a source of concern in recent years. In a land-grab operation against a weak neighbour, it is feared, Russia could keep help from reaching the victim in time by cordoning off the area of operations with a combination of long-range sensors and missiles. Soon, notions of nearly impregnable Russian A2/AD-barriers or bubbles extending far beyond its territory became widespread in the West, as did maps with large circles indicating areas out of bounds.

The possible implications of such a capability have been most acutely felt in the Baltic region, where reinforcements to Estonia, Latvia and Lithuania might be cut off by long-range missiles based in the Kaliningrad exclave. Similarly, the application of Western airpower to the region might be stymied by long-range air defence systems. In Sweden, concerns have grown that Russia, in a crisis or war, might grab the island of Gotland and forward-deploy air-defence systems there in order to close the A2/AD-ring around the Baltic states, and thus seal their fate.

The annexation of Crimea in February-March 2014 was a rude awakening for many in the West, and the assessment of Russia quickly shifted from prickly but peaceful partner to aggressive adversary. This hurried shift most probably also caused the Western assessment of Russia's military capabilities to overshoot, helped along by the Kremlin's propaganda highlighting of its military and technical prowess.

Five years after Crimea, it is time to undertake a more sober and realistic assessment of Russia's A2/AD-capabilities and their implications for the region, for NATO, and for Sweden. Do these barriers or bubbles exist? If so, how big are they, how dangerous are they, what weaknesses do they have and how can they be dealt with? FOI has launched a series of studies of these issues, drawing on both our politico-military and technical expertise. A selection of the findings is presented in this report, which seeks to provide an introductory overview of these issues intended for non-specialist security and policy professionals. Since these topics are complex and extensive, this means that not every segment of the study has been afforded the level of granular analysis it might otherwise deserve.

While Russia has a long pedigree of using long-range missiles to keep airborne or shipborne adversaries out, or hitting targets on land, the recent claims of far-reaching A2/AD-capabilities are mainly based on three fairly new systems: the S-400 anti-aircraft system, the Bastion anti-ship system, and the Iskander ballistic missile system for use against land targets. Most of the rather alarmist accounts of Russia's A2/AD-capabilities in recent years have been based on uncritical acceptance of Russian claims concerning the range and performance of these systems. Besides uncritically taking Russian data at face value, the three cardinal sins have been:

(i) confusing the maximal nominal range of missiles with the effective range of the systems;
(ii) disregarding the inherent problems of seeing and hitting a moving target at a distance, especially targets below the horizon; and
(iii) underestimating the potential for countermeasures against A2/AD-systems.

The S-400 anti-aircraft system is often said to have a 400-km range and be capable of intercepting a gamut of targets, from lumbering transport aircraft to agile fighter jets and cruise missiles, and even ballistic missiles. In fact, the missile with a purported 400-km range, the 40N6, is not yet operational and has been plagued by problems in development and testing. In its current configuration, the S-400 system should mainly be considered a threat to large high-value aircraft such as AWACS or transport aircraft at medium to high altitudes, out to a range of 200-250 km. In contrast, the effective range against agile fighter jets and cruise missiles operating at low altitudes can be as little 20-35 km. Moreover, despite its sophistication, an S-400 battery is dependent on a single engagement radar and has a limited number of firing platforms. It is thus vulnerable both to munitions targeting its engagement radar and to saturation attacks. If and when the 40N6 missile goes online, its 400-km technical range cannot be effectively exploited against targets below approximately 3000 meters unless target data can be provided and updated during the missile's flight by airborne or forward-deployed radars. Such a capability – often known as Cooperative Engagement – has only recently been successfully achieved by the U.S. Navy, and is a highly complex and demanding endeavour that Russia should not be expected to master within 10-15 years.

The Bastion-P anti-ship missile system can constitute a threat to high-value surface targets, such as aircraft carriers, landing ships, and transports out to a 300-km range. But since conventional ground-based radars cannot see beyond the horizon (approximately 40 km at sea level), due to the curvature of the Earth, airborne or forward-placed radars are again needed to provide and update targeting data at extended ranges. This, however, is a less demanding task when the target is a ship and a Russian capability can be expected within 5-10 years.

The capabilities of Russia's showcase anti-land missile system, the Iskander-M ballistic missile, has probably not been hyped to the same extent as the S-400 and Bastion have been, but its military impact has probably been overrated. While clearly a danger to fixed and movable (but not mobile) high-value ground targets within a 500-km range (in the future perhaps 700 km), the number of missiles deployed in Kaliningrad is still small when compared to the number of potential targets, especially when the need to hold some missiles back as a reserve for nuclear use is factored in. While still a significant threat to high-value land targets, the threat to ground targets from Iskander-M pales in comparison to the threat from cruise missiles, especially as the INF-treaty is about to expire.

A net assessment of the threat from Russian A2/AD-capabilities should also take into account the wide-ranging menu of countermeasures potentially available to NATO. The alliance could take *indirect countermeasures* if it prepositioned more forces to the Baltic states in peacetime or chose less vulnerable routes of transportation, not least through Sweden. It could also discourage Russia from using its A2/AD-assets in Kaliningrad through deterrence, that is, by holding the exclave itself at risk. Moreover, NATO could take *direct countermeasures* of a *passive* or *active* kind. Camouflaging and fortification belong in the former group. The use of decoys, electronic jamming, hacking, and head-on strikes against the missile, the firing unit, its radar, or other support vehicles constitute countermeasures in the latter group. None of this is easy however, and all these options require concerted efforts to rebuild NATO capabilities, spanning from procurement, to training and planning, via tactics, techniques and procedures, to joint and multi-national exercises. Since many of the required assets are American, European allies should also acquire greater capabilities, which beyond F-35s would require add-on systems, such as radar-homing missiles and precision-guided munitions with a long stand-off range.

All in all, this demonstrates that Russia's "A2/AD bubble" is smaller than often thought, not impenetrable, and probably even burstable. The main implication of this is that the prospects for defending or resupplying the Baltic states in a crisis or war are not as bleak as is often claimed. The challenges can probably be handled, provided there is political and military will and that the commensurate resources are allocated. Another implication is that the dynamics of this contest of long-range capabilities will almost inevitably have an impact on all the states in the region, regardless of whether they are a primary party to the conflict or not. For Sweden, this has arguably already contributed to the acquisition of Patriot air defence systems and the deployment of troops to Gotland.

1 The scope and context of the study

1.1 Aim and scope

This study aims to provide an estimate of the challenge posed by Russia's A2/AD-capabilities in the Baltic Sea region, by realistically assessing Russia's A2/AD-capabilities and NATO's possible countermeasures with an eye to their impact on the correlation of forces and strategic dynamics in the Baltic Sea region. The study proceeds in four steps: (a) briefly mapping Russia's geopolitical goals vis-à-vis the West; (b) assessing the capabilities of its A2/AD systems in the Baltic Sea region; (c) taking stock of the countermeasures available to NATO; and (d) briefly reviewing the implications for NATO, as well as for Sweden.

The study argues that the threat from Russian A2/AD capabilities, and the problems these could cause for NATO and its partners in the Baltic Sea region, have so far been exaggerated. Specifically, the assumed 400-km "exclusion zone" so often cited is on closer inspection much smaller, and the systems are more vulnerable to countermeasures. Russian claims regarding their capabilities should also be understood as strategic communication rather than simple statements of fact.

The intended audience for this report is primarily non-specialist security professionals and policy professionals who take an interest in the Baltic Sea region, or in A2/AD. The study does not aim to provide definitive or exhaustive answers, but rather an introductory overview of the subject, and does not cover submarines or sea-mines, or the potential for hybrid warfare, which have been covered elsewhere.[1] Nor does it really try to assess the Russia's capabilities in electronic warfare. For those readers who are not familiar with technical or tactical matters, an explanation of the basics in terms understandable to the lay-person is provided in Appendix 2.

[1] Cf. Kathleen Hicks, Andrew Metrick, Lisa Sawyer Samp, Kathleen Weinberger, *Undersea Warfare in Northern Europe* (Washington D.C.: CSIS, 2016); Martin Murphy, Frank Hoffman, Gary Schaub, *Hybrid Maritime Warfare and the Baltic Sea Region* (Copenhagen: Centre for Military Studies, 2016); Jonas Kjellén, *Russian Electronic Warfare. The role of Electronic Warfare in the Russian Armed Forces* FOI-R--4625--SE (Stockholm: FOI, 2018).

1.2 The strategic context

Ever since Russian troops annexed Crimea and conducted quasi-covert warfare in Donbas, NATO has been forced to revise its threat perceptions and force posture. With its actions in Crimea, Russia definitively made itself a revisionist power intent on creating its own sphere of interest.[2] After the first tranche of former Warsaw Pact states were admitted to NATO in the late 1990s, the alliance assumed that there would be no further need for a forward presence to defend against Russia. In the unlikely event that such a need should re-emerge, it was assumed that this task could be handled by rapid reinforcement of the eastern NATO member states.[3]

Following Russia's confrontational signals in 2007 and its attack on Georgia in 2008, the first of these assumptions began to look questionable.[4] In 2009, the then president of Russia, Dmitry Medvedev, officially confirmed that Russia was seeking to replace the post-Cold War security order with an order granting Russia special privileges as a great power.[5] Russia's audacious *coup d'annection* in Crimea in 2014 and its follow-up intervention in Donbas showed that such claims should be taken seriously. It could no longer be safely assumed that eastern NATO members would be protected simply through their membership. This has put the spotlight on Estonia, Latvia and Lithuania as NATO's most exposed and vulnerable members, and also as the possible next victims of Russia's yearning for greatness.[6]

The Baltic Sea region has thus become a geopolitical focal point in the face-off between Russia and the West. State-controlled Russian media often question the Baltic nations' claims to statehood and emphasize their "fascist" past or "oppressive" policies towards Russian-speakers, thereby raising the spectre of

[2] Ronald Asmus, "Renegotiating European Security", *Washington Post*, 13 Dec. 2008; Ivan Krastev, "Russian Revisionism", *Foreign Affairs*, 3 March, 2014; Lisa Sawyer Samp, CSIS, "Statement before the House Foreign Affairs Committee, Subcommittee on Europe, Eurasia and emerging threats, U.S Policy toward the Baltic States", March 22, 2017; Gudrun Persson, ed., *Russian Military Capability in a Ten-Year Perspective – 2016*, FOI-R--4326--SE, (Stockholm: FOI, 2016).

[3] *Founding Act on Mutual Relations, Cooperation and Security between NATO and the Russian Federations, signed in Paris, France*, 27 May 1997; William Alburque, *'Substantial Combat Forces' in the Context of NATO-Russia Relations*, Research Paper Nr 131, June 2016 (Rome: NATO Defence College, 2016).

[4] Robert Larsson, ed., *Det kaukasiska lackmustestet: Konsekvenser och lärdomar av det rysk-georgiska kriget i augusti 2008* FOI-R--2563--SE, (Stockholm: FOI, 2008).

[5] President of Russia, "Interview given by Dmitry Medvedev to Television Channels Channel One, Rossia, NTV", 31 August 2008; See also Andrew Kramer, "Russia Claims its Sphere of Influence in the World", *New York Times*, 31 August 2008.

[6] Eric Schmitt "US Lending Support to Baltic States Fearing Russia" *New York Times*, 1 January, 2017.

Russian revanchism.[7] Further emphasizing the gravity of the situation, the military geography of the Baltic states and the balance of forces in the region look far from beneficial for those intent on defending their sovereignty.[8] A widely quoted RAND report from 2016 concludes that Russia could overrun the defences of the Baltic states in 60 hours or less, which would present NATO with an unpalatable choice between accepting defeat or launching a campaign of reconquest against a major nuclear power.[9] Either way, NATO and the Trans-atlantic link would be in jeopardy, raising the spectres of a nuclear war, or a transition to a Hobbesian Europe in which Russia would dominate its near abroad.

Troublingly, in spite of the article 5 guarantees of the North Atlantic Treaty, at least part of the US political spectrum sees the dedication to safeguarding all NATO member states as far from given. On the subject of defending Estonia, for instance, Newt Gingrich, a political ally of US President Donald J. Trump, infamously stated in 2016 that he was "not sure that he would risk a nuclear war over some place which is [in] the suburbs of St Petersburg".[10]

Moreover, when NATO began to refocus on beefing up its capabilities for rapid reinforcement of threatened members, it also discovered that Russia had significantly improved its capability to interdict such reinforcements.[11] In particular, it was feared that new Russian long-range anti-aircraft and anti-ship missiles forward-based in the Kaliningrad exclave might make reinforcement of the Baltic states a costly and time-consuming endeavour.[12] In combination with new and more capable ballistic missiles and cruise missiles for use against ground targets, these systems and capabilities threatened to create a wide zone in Russia's near abroad where NATO forces could not (or would not) enter or operate, and where

[7] Mike Winnerstig "The Baltic Sea Area: a New Geopolitical Focal Point", in Cecilia Hull Wiklund, Daniel Faria, Bengt Johansson and Josefin Öhrn-Lundin (eds.), *"Perspectives on national security in a new security environment"*, Strategic Outlook 7, FOI-R--4456--SE, (Stockholm: FOI, 2017); Mike Winnerstig, ed., *Tools of Destabilization – Russian Soft Power and Non-Military Influence in the Baltic States*, FOI-R--3990--SE, (Stockholm: FOI, 2014).

[8] Robert Dalsjö *Brännpunkt Baltikum* FOI-R--4278--SE, (Stockholm: FOI, 2016).

[9] David Shlapak and Michael Johnson, *Reinforcing Deterrence on NATO's Eastern Flank: Wargaming the Defense of the Baltics*, RR-1253-A, (Santa Monica, CA.: RAND, 2016).

[10] Andrew Stuttaford, "Estonia, Newt Gingrich and Strategy", *National Review*, 23 July 2016.

[11] Nato, *Wales Summit Declaration: Issued by the Heads of State and Government participating in the meeting of the North Atlantic Council in Wales*, 5 September, 2014.

[12] Gulia Paravicini, "'New chess game between West and Russia'", *Politico*, 1 July, 2016; Stephan Frühling and Guillaume Lasconjarias, "NATO, A2/AD and the Kaliningrad Challenge", *Survival*, April-May 2016; Martin Zapfe, Michael Carl Haas, "Access for Allies? NATO, Russia and the Baltics", *RUSI Journal* June/July 2016.

Russia would thus have a free hand.[13] In military jargon, such capabilities are nowadays known as anti-access/area-denial (A2/AD), a term first coined 15 years ago by US analysts to describe China's emerging capabilities to keep the US Navy away from its coastal waters. Anti-access (A2) refers to the ability to deny access to a region (e.g. to aircraft or ships entering a region), while area-denial (AD) refers to the ability to make it dangerous to remain in the same region.[14]

While the term is rather new, and some of the instruments used are modern and hi-tech in nature, the idea of using long-range weapons to keep an adversary's naval and air forces away from vital or vulnerable areas is far from new. For example, during the Cold War the Soviet Union planned to use air- and ship-launched missiles to keep Western aircraft carriers away from adjacent waters and built so-called bastions to protect its naval bases and strategic submarines.[15]

Nonetheless, after Crimea both the news media and professional journals soon overflowed with claims regarding the capabilities of new Russian systems, including maps of "A2/AD bubbles" creating no-go zones reaching 400 km from Kaliningrad or from islands in the Baltic Sea, and thus shutting off the region to Western aircraft and ships.[16] If true – or just believed to be true – this could have major consequences not only militarily, but also politically, as NATO might be

[13] Richard Fontaine and Julianne Smith, "Anti-Access/Area Denial Isn't Just for Asia Anymore", *Defence One*, 2April, 2015; Luis Simón, "The 'Third' US Offset Strategy and Europe's 'Anti-access Challenge'", *Journal of Strategic Studies*, Vol 39, No 3, 2016. Old hands at military or politico-military analysis might see A2/AD as a reverse form of the 1980s concept of Follow-On Forces Attack (FOFA). FOFA aimed to block the Soviet second echelon of forces from reaching the front in Germany by using high-tech sensors and weaponry to strike at massed manoeuvre forces and logistics nodes in the rear.

[14] In the mid-1990s, a rising and increasingly self-confident China was frustrated by being held in *check* in East Asia by US air and naval forces. China thus started work on a panoply of systems and capabilities – including long-range missiles capable of hitting fixed and mobile targets – intended to prevent US forces from projecting power in the waters off China and from coming to the aid of Taiwan and other US allies in the region. Searching for a term to describe this mounting geopolitical challenge, US analysts settled on "anti-access/area denial" or "A2/AD" capabilities. Andrew Krepinevich, Barry Watts, and Robert Work, *Meeting the Anti-Acess and Area Denial Challenge* (Washington D.C.: CSBA, 2003); Robert Dalsjö, "Air-Sea Battle: Ett amerikanskt concept för att hantera A2/AD-hotet" in Robert Dalsjö, Kaan Korkmaz and Gudrun Persson, *Örnen, Björnen och Draken: Militärt tänkande i tre stormakter*, FOI-R--4103--SE (Stockholm: FOI, 2015).; "What is Anti Access Area Denial", *Defence Matters*, 11 September 2016.

[15] Cf. Milan Vego, *Soviet Naval Tactics* (Annapolis, MD: USNI, 1992), Ch. 1, 20.

[16] Bret Perry, "Entering the Bear's Lair: Russia's A2/AD Bubble in the Baltic Sea", *The Buzz/The National Interest*, 20 September, 2016; Tobias Oder, "The Dimensions of Russian Sea Denial in the Baltic Sea", *Center for International and Maritime Security-website* (cimsec.org), January 4, 2018; Loc Burton, "Bubble Trouble: Russia's A2/AD Capabilities", *Foreign Policy Association-website*, 25October, 2016; Robbie Gramer, "This Interactive Map Shows the High Stakes Missile Stand-Off Between NATO and Russia", *Foreign Policy*, 12 January, 2017.

unable to protect its weakest and most exposed members from Russian provocations, meddling or aggression. Such a perception would have consequences even in peacetime, which would imply that Russia has an interest in portraying its capabilities in the most formidable light possible as an end in and of itself.

Moreover, if the claims of extensive and impenetrable A2/AD bubbles were true, they would act as sanctuaries for Russian air and naval forces, which could then sally forth at a time of their choosing to harass or attack NATO units or lines of communications.

Finland and Sweden, no longer neutral but not yet in NATO, face the prospect of operating in the shadow of Russia's current A2/AD capabilities, as well as the possibility that in a crisis Moscow might move its systems forward to their islands of Åland or Gotland, respectively. This would of course draw Sweden and/or Finland into the conflict.[17] Similarly, Sweden could be drawn in because of NATO's need to use its airspace or territory in order to circumvent a Russian missile threat from the Kaliningrad exclave.[18] Sweden has already taken a number of steps to adapt to the threat from Russia's new A2/AD capabilities, including putting a garrison on the island of Gotland, dispersing aircraft at peacetime bases, purchasing the Patriot air defence system and forming closer defence ties with the United States.[19]

However, many of the sensationalist claims about Russia's A2/AD capabilities – of bubbles as no-go zones, and on their ripple effects – are clearly overblown and do not stand up to closer or professional scrutiny.[20] For example, hardly any of these stories take account of the fact that the Earth is round while radar beams normally travel in a straight line. This means that the effective range of radar is

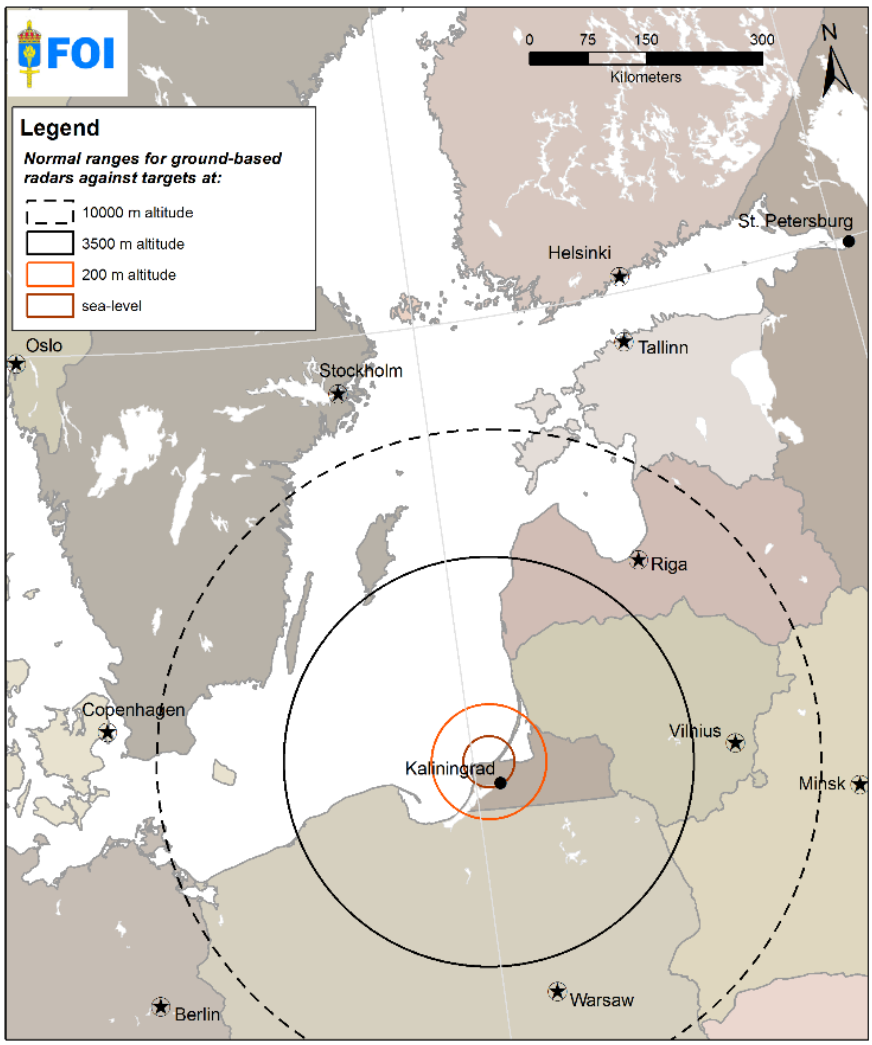
[17] Swedish Ministry of Defence, "Sweden's Defence Policy 2016 to 2020", press release June 1 2015; Regeringen, *Prop 2014/15: 109 Försvarspolitisk inriktning – Sveriges försvar 2016-2020*; Försvarsberedningen, *Motståndskraft: Inriktningen av totalförsvaret och utformningen av det civila försvaret 2021–2025*, Ds 2017:66 (Stockholm: Försvarsdepartementet, 2017); Försvarsmakten, *Tillväxt för ett starkare försvar: Slutredovisning av Försvarsmaktens perspektivstudie* 2016-2018, FM2015-13192:15, 22 February 2018; Statsrådets kansli *Statsrådets säkerhets- och utrikespolitiska redogörelse* Statsrådets kanslis publikationsserie 8/2016 (Helsingfors: Statsrådets kansli, 2016).

[18] Shlapak and Johnson, *Reinforcing Deterrence…;* Försvarsmakten, *Tillväxt för ett starkare försvar…*

[19] For details and references, see chapter 5. John Granlund, "ÖB: Försvaret omgrupperar flygstridskrafter efter ryskt robotdrag", *Aftonbladet*, 16 October, 2016.

[20] This has been pointed out i.a. by Jyri Raitasalo, "It is time to burst the western A2/AD bubble", on the blog *Defence and Security*, published digitally by the Royal Swedish Academy of War Sciences, 16 June, 2017.

usually limited to a “horizon”, much in the same way that the human eye is. This effect is most pronounced for radars located at ground level searching for objects at the same level or at low altitude. In such cases, the range is normally 40 km or less, while the radar horizon widens considerably if either the radar or the target is airborne and particularly at higher altitude (see Map 1 below and Appendix 2).



Map 1: Ranges for ground-based radars against targets at different altitudes.

The S-400 air defence system is often claimed to have a 400-km range, but FOI’s technical experts estimate that the effective range against maneuvering targets at low altitude is much less, even down to 20 km for smaller targets hugging the

terrain.[21] Russian specialists have estimated the effective range of the S-400 against old and un-stealthy Tomahawk cruise missiles to be 24–36 km in mixed terrain.[22] At low altitudes, the masking effect of terrain, trees and buildings can cause a diagram of the effective range to resemble a Rorschach-blot rather than a neat circle. The S-400 system also has limitations when dealing with a large number of targets that appear within a short space of time, such as a swarm of cruise missiles.[23]

When the West considered intervening with airstrikes in the Syrian civil war in 2011 and 2013, the strong Russian-supplied air defence system was said to be a factor militating against this course as losses might be heavy.[24] However, these assessments failed to take account of the fact that the Israeli Air Force (IAF) has been operating in Syrian airspace with near impunity for more than 30 years.[25] Moreover, although recently reinforced by Iranian air defence units, Syrian air-defences have hardly managed to make a dent in US, French, British or Israeli strikes against targets in Syria, while a large proportion of Syrian and Iranian assets have been obliterated.[26]

Russian air defence units are also present in Syria, including with modern S-400 and S-300 V4 batteries, but these are probably primarily intended for the protection of Russian bases in Syria. Furthermore, a mechanism for deconfliction of the airspace between Russia and the US exists, most probably also between Russia and Israel. As Western and Israeli air forces have largely avoided targets and airspace in immediate proximity to these Russian bases, and as the

[21] Erik Berglund, Martin Hagström, Anders Lennartsson, "The Long-range Weapon Threat", in Hull Wiklund et al., *Perspectives on national…* .

[22] Roger McDermott, "Russian Air Defenses and the US Strike on Al-Shayrat", *Eurasia Daily Monitor* Volume 14, Issue 50, 11 April, 2017.

[23] Justin Bronk, "Russia's Air Defence Challenge in Syria", *RUSI Defence Systems*, 29 June 2017.

[24] "NATO General Worried About Russian Military Build-Up In Syria", *Defense News*, 28 September 2015.

[25] The February 2018 downing of an Israeli F-16, hit in Syrian airspace but which crashed in Israel, was the first downing by Syrian forces since the early 1980s. It was apparently the result of a trap set by Iran to draw Israel into an air defence ambush, but which did not work too well. Moreover, the IAF claims that they destroyed more than half of the air defences in follow-up raids, including the most modern units, such as SA-22 Pantsir. Amos Harel, "Israel believes Syria strike took out nearly half of Assad's air defences", *Haaretz*, 14 February, 2018. This lack of success need not only be due to shortcomings in the Russian-supplied missile systems, but could also be due to deficiencies in crew training or morale, to a lack of cueing from command and control networks, or to a decision not to engage. The latter two factors however seem unlikely in the case of an air defence ambush. "Syria shoots down Israeli warplane as conflict escalates", *BBC News*, 10 February 2018; Tom Cooper, "The February 2018 Air War between Israel, Syria and Iran Was Brief and Violent", *National Interest*, 26 February 2018; Sebastien Roblin, "Israeli's Deadly Air Force Has Been Destroying Syria's Russian-Built Air Defense Systems", *National Interest*, 21 May 2018).

[26] "Allies dispute Russian and Syrian claims of shot-down missiles", *Guardian*, 14 April 2018.

mechanisms for deconfliction have been used, there are as of yet no reports of firefights between Western/Israeli aircraft and Russian-operated air defences.[27]

The fact that Russian-supplied A2/AD-systems operated by Syrians, including very modern systems such as Pantsir, have repeatedly come up short in Syria does not mean that some of the new capabilities that Russia is deploying at home are not real or not a source for concern. But the track record of actual operations should still give pause for thought; the laws of physics still apply, the Earth is still round and hitting a moving target over long distances is still both complicated and demanding.

Conceivably, the problems stemming from the Earth's curvature could be bypassed by having a separate and forward-placed or elevated radar supply target data and handle target illumination – a process known as Cooperative Engagement. However, there are no indications that Russia currently has such a capability. While such a capability against ships may be within fairly easy reach, achieving it against aircraft or missiles is an entirely different matter. It took the US Navy almost two decades of high-tech efforts before it finally succeeded, and electronics is not the Russian defence industry's strongest card. It is notable that some of the most talked about Russian systems or capabilities of recent years – such as the stealth fighter PAK-FA/Su-57 or the 400-km range active-seeker 40N6 missile for the S-400 air defence system – have been plagued by developmental problems and are not yet operational or even in series production.

Despite numerous claims to the contrary from Russian sources over several years, the 40N6 missile had not been deployed or even entered series production by the summer of 2018. Reportedly, this has been due to problems with the active seeker. In the autumn of 2018 Russia claimed again that the missile had been successfully tested and approved for production, but this remains to be seen.[28] Similarly, the Su-57 has underperformed in tests and only has an interim type of engine, so production has been limited to 12 aircraft for the foreseeable future.[29]

Moreover, as demonstrated in Syria, a wide range of countermeasures are available that could mitigate or even eliminate some or most A2/AD threats.[30]

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[27] Eric Schmitt, "In Syria's Skies, Closed Calls With Russian Warplanes", *New York Times*, 8 December 2017.

[28] Franz-Stefan Gady, "New Long-Range Missile for Russia's S-400 Air Defense System Accepted Into Service", *Diplomat*, 23 October, 2018.

[29] Dave Majumdar, "Why Russia's New Su-57 Stealth Fighter Might Be a Giant Waste of Time: And Moscow is only buying 12 of them", *The National Interest*, July 31, 2017.

[30] Cf. John Richardson, "Chief of Naval Operations Adm. John Richardson: Deconstructing A2AD", *The National Interest*, Oct 3, 2016. However, the CNO's message downplaying the threat from A2/AD should probably be seen in the light of service interests, not least related to aircraft carriers.

It should be obvious by now that the flurry of announcements in recent years about the new Russian *Wunderwaffen*, as well as the interventions and demonstrations in Ukraine and Syria, are part of a strategic communications (Stratcom) campaign on a massive scale. This campaign is aimed at both domestic audiences and the near and far abroad. Domestically, the master message is that President Putin has made Russia great again, as a strong and powerful military actor that dares to stand up for its interests and to challenge the West. To the states in the near abroad, the message is that Russia is a ruthless and powerful great power, and small neighbours had better show it proper respect.[31] Moreover, small neighbours should not trust guarantees from their friends in the West, because they would not be able to help out in a crisis.[32] To states in the far abroad, comfortably west of Russia's immediate reach, the message has a slightly different flavour: Don't meddle in our backyard.[33]

In the West, uncritical acceptance and dissemination of far-reaching claims regarding the capabilities of Russia's A2/AD system and their implications for Western freedom of action could feed into these Russian narratives and magnify their effect. Thus, a sense may be fostered of it being futile to try to defend the Eastern European NATO member states, or to reinforce and resupply them in a crisis. Such an impression could have military consequences, in the form of a reluctance to plan for more than symbolic steps to defend or to reinforce exposed members, or an acceptance of inflated assumptions as a basis for planning. It could also have political consequences in peacetime, as a sense of vulnerability and of being out of reach for help might foster defeatism or accommodation to the wishes of the mighty neighbour.[34]

Thus, there is ample reason to conduct a sober assessment of Russia's A2/AD capabilities and the extent of the problems they could create in case of crisis or war in the Baltic Sea region. Critically, such an analysis should also take into account the countermeasures the West might put in place to reduce or mitigate the impact of A2/AD. Furthermore, for a Swedish research institute it is also natural to consider the possible implications not only for NATO and for the wider region, but also for Sweden and its armed forces.

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[31] On Russia's emphasis on "respect", see e.g. Keir Giles, *Moscow Rules: What Drives Russia to Confront the West?* (London: Chatham House, 2019), 18-21.

[32] This was clearly the message sent by the cross-border kidnapping of the Estonian security officer Eston Kohver, two days after Obama had been in Tallinn and declared that the Baltic states were safe, as the USA was protecting them. "Russians Open a New Front after Estonian Official is Captured in 'Cross-Border Raid', *Guardian*, 8 September, 2014.

[33] Persson (ed) *Russian Military Capability…;* Dalsjö, *Brännpunkt Baltikum*.

[34] An analogous reasoning for the Middle East is provided in Jonathan Altman, "Russian A2/AD in the Eastern Mediterranean", *Naval War College Review*, Winter 2016.

2 Russia's geopolitical ambitions

The strategic goals of foreign states are difficult to assess. Academics and experts have come to at least three different conclusions regarding Russia's objectives on its Western front.[35] Regardless of its underlying strategic motives, Russia's actions and stated aims are incompatible with the post-Cold War security order in Europe.[36] Unless Western states recognize Russia's claims to a sphere of "privileged interests" or abandon their efforts to promote the democratic aspirations of nations in the post-Soviet space – or both – the clash of interests already under way risks becoming a clash of arms.[37] This can be inferred from Russia's 2014 military doctrine, which highlights NATO's presence in states "near the borders of the Russian Federation", and the rise of hostile political "regimes" inside these countries, as constituting a threat to Russia.[38]

In keeping with the narrative that Russia is a victim of political subversion and encirclement by the West, the Kremlin has expanded its tool-box of tactics. In 2012, Putin coined the term "managed chaos".[39] Soon thereafter, the Chief of General Staff, in what erroneously became known as the Gerasimov Doctrine, posited that "the rules of war have changed" since a blurring of the lines between war and peace rendered "non-military means of achieving political and strategic goals" evermore important.[40] Vladislav Surkov, Putin's close adviser, conceptualized this as a turn to "non-linear" warfare.[41]

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[35] Elias Götz "Russia, the West, and the Ukraine crisis: three contending perspectives", *Journal of Contemporary Politics*, June 2016. For some examples of these, see John Mearsheimer, "Why the Ukraine Crisis Is the West's Fault", *Foreign Affairs*, September/ October 2014; Stephen Walt, "Why Arming Kiev Is a Really, Really Bad Idea", *Foreign Policy*, 9 February, 2015; David Kramer, "On the Situation in Ukraine", *Freedom House*, 7 April, 2014*;* Dmitry Gorenburg, "Russia Isn't Chasing After Empire in Ukraine", *Moscow Times*, 23 September, 2014; Stephen Blank, "Russia's Vladimir Putin clearly wants to dominate all of Europe", *Washington Times*, 28 December, 2014*;* Alexander Motyl, "Arm Ukraine Now", *Atlantic Council*, 15 February, 2017

[36] George H. W. Bush, "A Europe Whole and Free", *Remarks to the Citizens in Mainz*, 31 May, 1989.

[37] Andrew Kramer, "Russia Claims Its Sphere of Influence in the World", *New York Times*, 31 August, 2008

[38] The Embassy of the Russian Federation to the United Kingdom of Great Britain and Northern Ireland, *The Military Doctrine of the Russian Federation*, 25 December, 2014

[39] Vladimir Putin, "To be strong: national security guarantees for Russia", *Rossiyskaya Gazeta*, 20 February, 2012.

[40] Mark Galeotti, "The 'Gerasimov Doctrine' and Russian Non-Linear War", *In Moscow's Shadows,* 27 February, 2013; Mark Galeotti, "I'm Sorry for Creating the 'Gerasimov Doctrine'", *Foreign Policy*, 4 March, 2018.

[41] Nathan Dubovitsky [a nom de plume for Vladislav Surkov], "Bez Neba", *Russkiy Pioneer*, 12 March 2014. Russian officials also accuse the US, the UK, Poland, the Baltic States, and Sweden of spearheading this hybrid war against Russia see TASS, "Нарышкин отмечает угрозу переноса активности террористов в Центральную Азию и РФ", 19 December 2017.

In spite of Russia's much-discussed use of non-military means of influence, the country has by no means abandoned its reliance on conventional arms and capabilities. Since the mid-2000s, Russia has also gone to great lengths, and allotted huge sums, to the development of long-range missiles.[42] These supplement the nuclear deterrent, discouraging adversaries from entering the Russian heartland and – should this fail – offering space and time for defensive mobilization.[43] The range of these systems also affords protection to forces conducting offensive operations beyond their own borders but within the larger "keep-out zone" and can be used as a means of coercion.[44] Russia's long-range missiles therefore add not only to its strategic depth, but also to its leverage over neighbours such as the Baltic states, Poland and Finland.

Western strategists suspect that Russia's posture – while purportedly defensive – is in fact designed to support offensive aims.[45] All three Baltic states have small armies and lack an air force of their own. Their defence has been boosted through the US European Reassurance Initiative (ERI) and NATO's enhanced Forward Presence (eFP) programs. The Western battlegroups put in place in the Baltic states, however, serve as little more than a tripwire.[46] Lacking the resources to repel an assault on their own, the Baltic states, and the Western troops stationed there, might find themselves in a hopeless position unless heavier reinforcements come to their rapid rescue.[47]

Regardless of whether the underlying assumptions of and details in the RAND study are indisputable, its verdict that Russia could overrun the Baltic states in 60 hours or less has taken on a life of its own, much as the so-called Gerasimov doctrine has, and is now often taken as a given.[48]

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[42] U.S. Asymmetric Warfare Group, *Russian New Generation Warfare Handbook*, 1 December, 2016.

[43] Andrei Afanasevich Kokoshin, "Strategic nuclear and nonnuclear deterrence: Modern priorities", *Herald of the Russian Academy of Sciences*, March 2014, Volume 84.

[44] Guillaume Lasconjarias and Allessandra Marrone, *How to Respond to Anti-Access/Area-Denial (A2/AD)? Toward a NATO Counter –A2/AD Strategy*, NDC Conference Report No 01/16 (Rome: NDC, 2016).

[45] Sergey Sukhankin, "Russia's Changing Military-Strategic Perceptions of Kaliningrad Oblast Between 2013 and 2017", *Eurasia Daily Monitor*, Volume: 14 Issue: 140, 1 November, 2017

[46] Mark Cancian, "The European Reassurance Initiative", *Center for Strategic & International Studies*-website, 9 February, 2016; NATO, "Boosting NATO's presence in the east and southeast", 2 March, 2018.

[47] Fabrice Pothier, "An Area-Access Strategy for NATO", *Survival*, June-July 2017. Shlapak and Johnson, *Reinforcing Deterrence*…; for a slightly different view, see Robert Dalsjö, "Baltikum", in Krister Pallin, ed., *Västlig militär förmåga: En analys av Nordeuropa 2017* FOI-R--4563--SE (Stockholm. FOI, 2018).

[48] Shlapak and Johnson, *Reinforcing Deterrence*…; cf. Dalsjö, "Baltikum".

While Russian officials seldom use the term A2/AD, General Gerasimov has acknowledged the role of long-range missiles in asserting control over the strategic Baltic Sea region. With their help, Russia can project power over states in its near abroad.[49] By eroding NATO's access to frontline states, it can also put the collective defence assurance at the heart of the alliance to the test.[50] Some members might decide that their forces would confront intolerable risks by entering the theatre of conflict. Their willingness to trigger article 5 might further diminish if Russia used "non-linear" means to make it appear that the victims of aggression are culpable for their own misfortune.[51] Should serious doubts arise as to whether NATO's collective defence guarantees can really be trusted, the West could soon face the geopolitical equivalent of a run on the bank.[52]

Such a scenario is not too far-fetched as it reflects the modus operandi of Russian warfare in recent conflicts. Mindful of its weaknesses in protracted conflicts with advanced antagonists, Russian tacticians favour offensive action and stress the need to reach operational objectives in the earliest days of a campaign through the coordinated use of forces across all the relevant domains of warfare. This involves softening up the target through the disruption of communications, the use of irregular forces and deception to sow confusion, and the use of conventional forces not part of the attacking force to deter large-scale countermeasures by the opponent. In the meantime, a strong umbrella of ground-based air defences (GBAD) and indirect fire would allow the attacking force to hit hard and move fast to establish facts on the ground, before turning to the consolidation of gains.[53] If, however, the A2/AD bubble is not as impenetrable as is often claimed, the strategic calculus might be less favourable to Russia.[54]

Sweden remains outside of NATO but is realizing that it would find itself caught in the cross-fire in case of a shooting conflict in the neighbourhood, not least because its territories and airspace would be valuable for parties intent on controlling the Baltic Sea region. Making matters worse, between the end of the Cold War and the Russian aggression of 2014, neither NATO nor Sweden prepared for a conflict with advanced state-based adversaries. Since 2014 some

[49] Valery Gerasimov, *Remarks by Chief of General Staff of the Russian Federation General of the Army Valery Gerasimov, Russian Defence Ministry's board session, November 7, 2017*.

[50] Constance Baroudos, "Why NATO Should Fear Russia's A2/AD Capabilities (And How to Respond)", *National Interest*, 21 September, 2016.

[51] Luis Simón "The'Third' US Offset Strategy and Europe's 'Anti-access' Challenge", *Journal of Strategic Studies*. Vol 39, 2016; For an analysis of Russian "hybrid" or non-linear tactics in the lead-up to the 2008 war in Georgia, see Niklas Nilsson *Russian Hybrid Tactics in Georgia* Silk Road Studies Paper, January 2018.

[52] Martin Zapfe Michael Carl Haas, "Access for Allies? NATO, Russia and the Baltics", *RUSI Journal*, Vol 161, No 3, June/July 2016.

[53] Scott Boston and Dara Massicot, *The Russian Way of Warfare: A primer* (Santa Monica, CA: RAND, 2017).

[54] Cf. Raitasalo, "It is time to burst…".

steps have been taken to reshape structures, capabilities and postures to the reality of the Russian threat, but there is still a very long way to go. As part of this adjustment, it will be necessary for those with a stake in the status quo to familiarize themselves with Russia's A2/AD capabilities, and to realistically assess their possible impact.

Correctly evaluating the threat that Russia's A2/AD systems pose to the Baltic states, and to Western abilities to reinforce, resupply or defend them in times of crisis or war, requires more than just an assessment of the genuine range of Russia's long-range missiles. The radars, sensors, data links and other support systems that help missiles to detect, trace and incapacitate chosen targets must also be factored in. In addition, account must be taken of the fact that some targets are more vulnerable than others. These factors tend to be lost in public debates. All too often, accounts even in the specialist press depart from the stated maximum range of a missile system – represented in the form of a circle on a map – and suggest that all operations inside this exclusion zone are impossible or at least highly risky.[55] That this may be the impression that Russia wants to convey – "don't mess in Russia's backyard" – does not always seem to have been considered.

[55] Bret Perry, "Entering the Bear's Lair: Russia's A2/AD Bubble in the Baltic Sea", *The National Interest – Blogs – The Buzz,* 20 September, 2016; Robert Beckhusen, "Interactive Missile Map Reveals How Messy a NATO-Russia War Would Be", *The National Interest – Blogs – The Buzz,* 15 January, 2017

3 Russia's capabilities in the Baltic Sea Region

Traditionally a land power, Russia is predisposed to think of both power and protection in territorial terms. Thus, Russia – in its various guises – has sought to expand its territories and to maintain an outer string of vassal states as both a sign of its power-status and as a protective glacis, perhaps also as a jumping-off point for further conquests.[56] When faced with adversaries predominantly strong in the naval or air domains, such as the UK, Japan or the US, Russia has striven to deny these adversaries access to Russia through the sea or through the air.[57] During the Cold War, Soviet Russia tried to complement the glacis against ground threats provided by the captive states of the Warsaw Pact with a strong air defence based on radars, missiles and fighters, and by building a capability for denying the naval forces of the Western allies access to the seas adjacent to it.

In the 1950s and 1960s, when the nuclear air offensive (which included a sizable contribution from aircraft carriers) was the West's primary weapon in case of Soviet aggression, the Soviet Union built an extensive and elaborate defensive system, which in many ways can be considered a forerunner of today's A2/AD-concepts.

Thus, Russia inherited an air defence doctrine of using integrated overlapping radars and multiple missile systems, which helped cover the entire altitude envelope in great depth. In the West such a comprehensive system is today called an Integrated Air Defence System (IADS) or an Integrated Air and Missile Defence system (IAMD). This kind of system had been elaborated in East Germany and Poland to shield Warsaw Pact forces from Western air power. When Soviet/Russian troops were withdrawn from Eastern Europe after the collapse of communism, however, this system was dismantled and Kaliningrad and St Petersburg became military outposts.[58] In the past decade, Russia has upgraded its posture in these areas.

[56] Cf. Giles, *Moscow Rules…*

[57] E.g. by building a fort on the Åland islands in the 1850s, or by building strong coast-artillery positions on both sides of the Gulf of Finland in the early 1900s. Cf. Johan Tunberger and Robert Dalsjö, "Strategic developments and the impact of naval arms control in the Baltic region", in Andreas Fürst, Volker Heise and Steven E. Miller, eds., *Europe and Naval Arms Control in the Gorbachev Era* (Oxford: Oxford U.P./SIPRI, 1992).

[58] Frühling and Lasconjarias, "NATO, A2/AD…"; Pothier, "An Area-Access Strategy; Adrian Hyde-Price, *Nato and the Baltic Sea Region: Towards Regional Security Governance?,* NATO Research Fellowship Scheme 1998-2000.

The Soviet Union had also worked to make its adjacent waters, including the North Sea and the Norwegian seas, unsafe for NATO aircraft carriers, through a combination of submarines, long-range anti-ship missiles, and land-based strike aircraft.[59] Later, these protective zones also served as "bastions" for strategic missile submarines.

Today, the Kaliningrad exclave, squeezed between the NATO member states Lithuania and Poland, is the home of Russia's Baltic Fleet. The exclave is thought to host multiple reinforcing A2/AD resources: the S-400, S-300 and Pantsir-S surface-to-air missile (SAM) systems, Bastion-P coast defence systems using supersonic Oniks anti-ship cruise missiles, Bal coastal defence systems, Iskander-M ballistic missiles combined with Iskander-K land attack cruise missiles, and the ship-based Kalibr cruise missile, which exists in an anti-ship and a land-attack version.[60]

St Petersburg and its vicinity (formerly known as Ingria) is of obvious importance as a major city, a former capital, an industrial area and the home of many military units and formations, including the Western Joint Strategic Command. There is less information available in the public domain on Russian A2/AD assets in the St Petersburg region than about those in Kaliningrad, but the Petersburg region was the first in the Western direction to receive the Iskander missile system on permanent deployment, in 2010.[61] The region is also known to contain several air defence units equipped with S-300 and S-400 SAM systems and the concomitant Pantsir point defence system, probably both south and north of St Petersburg.

There are no reports of coastal defence missiles in the area but as the Baltic Fleet has its traditional homeport in Kronstadt just outside St Petersburg, it would make sense to at least detach a battery of Bal missiles to the area.

Finally, it should be kept in mind that the Russian army units in the Baltic Sea region contain organic air defence and rocket artillery assets that may become relevant in a conflict, such as the Tor (SA-15) and Buk (SA-11/17) short/medium-range air defence missile systems, and the Smerch rocket artillery system with a reported range of 90 km.[62]

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[59] Cf. Vego, *Soviet Naval…*

[60] Fredrik Westerlund, *Russia's Military Strategy and Force Structure in Kaliningrad*, FOI Memo 6060, (Stockholm: FOI, 2017); Persson, ed., *Russian Military Capability….*

[61] Stefan Forss, *The Russian Operational-Tactical Iskander Missile System*, National Defence University, Department of Strategic and Defence Studies. Series 4: Working Paper No 42 (Helsinki: NDU, 2012).

[62] Tor and Buk are intended for the defence of army manoeuvre units (battalion combat teams, brigades) against air attacks. Tor has a range of only 12 km while Buk has a range of 35-45 km. It

3.1 Anti-air systems

According to unclassified Russian sources, the Kaliningrad exclave has two air defence regiments, the 183rd and the 1545th. The 183rd is reported to have two battalions (four batteries) equipped with the S-400-system and four battalions (seven batteries) of the older S-300 PS-system (SA-10 Grumble). This regiment also has six firing-units of Pantsir (SA-22 Greyhound) for self-defence.[63] The 1545th air defence regiment has two battalions equipped with the newer system S-300V4 (SA-23 Giant/Gladiator).[64]

The S-400 is a heavy but mobile SAM system, known as Triumf in Russia and the SA-21 Growler by NATO.[65] It is marketed as being close to omnipotent against almost all kinds of flying targets, from ballistic missiles and strategic aircraft, to stealth aircraft, cruise missiles and precision guided munitions (PGMs).[66] In reality, the system is probably optimized for the interception of ballistic missiles and large high-value aircraft at high altitudes, with an ancillary function against smaller targets at lower altitudes.

Said to be one of the best air-defence systems currently in production, it entered service with the Russian Armed Forces in 2007 but did not become operational in Kaliningrad until 2012 and near St Petersburg until 2016.[67] The S-400 system is meant to utilize different kinds of missiles, which differ in speed, range and guidance[68], much like the US Patriot system can use different missiles for different targets and purposes:

- A large, very long-range (400 km) high-speed missile with active radar guidance, known as the 40N6, is intended primarily for use against large high-value targets. This missile is the basis for the oft-repeated claim

was a Buk that shot down the Malaysian airliner over Ukraine in 2014. Johan Abramson, *Ryska luftvärnssystem*, FMV Teknisk Und Orienterar 13FMV55-1:1 (Stockholm: FMV, 2013).

[63] According to the respected analyst Carlo Kopp, S-300PS batteries are equipped with the engagement radar 5N63S Flap Lid B, which can engage maximum six targets simultaneously. Carlo Kopp, "Almaz S-300P/PT/PS/PMU/PMU1/PMU2 Almaz-Antey S-400 Triumf SA-10/20/21 Grumble/Gargoyle Technical Report APA-TR-2006-1201", *Air Power Australia*.

[64] "BF", Milkavkaz com; "VKS", Milkavkaz com.

[65] Franz-Stefan Gady, "A2/AD Threat: Russian Army Adds 2nd S-400 Regiment in 2016", *Diplomat*, 23 September, 2016; Kopp, "Almaz S-300P/PT/PS/PMU/PMU1/PMU2…"*;* Abramson, *Ryska…* .

[66] Adam Muspratt, "How capable is the S-400 missile system?", *Defence IQ*, 21 November 2018; Rajat Pandit, "India moves towards acquiring Russian S-400 missile systems despite US opposition", *Times of India*, 1 July 2018.

[67] "Brothers in arms Turkey and Russia cosy up over missiles", *Economist*, 4 May, 2017; "Baltic Fleet Receives S-400 Air Defense Missile Systems", *Rusnavy com*, 9 April, 2012; "Russia moves missiles to Finnish border", *Independent Barents Observer*, 26 September, 2016.

[68] Kopp, "Almaz S-300P/PT/PS/PMU/PMU1/PMU2*…";* Abramson*, Ryska…* . These missiles often exist in special export versions, and those have an E added to the designation, e.g. 9M96E.

that the S-400 has a range of 400 km, but has repeatedly failed in tests and is not yet in series production or operational.[69] However, Moscow has recently claimed that it has now been cleared for production.[70]

- A large, long-range (200–250 km) high-speed missile with semi-active guidance, known as the 48N6, is probably intended for the same types of targets. This is a slightly enhanced version of the missile used in the older S-300 family of systems, known as SA-10 Grumble and SA-20 Gargoyle by NATO.
- A highly agile short- to medium-range (two versions exist, 40 and 120 km) missile with active radar guidance, known as the 9M96 and 9M96DM, is intended for use against tactical aircraft, PGMs and ballistic missile warheads. This missile is primarily for self-defence of the S-400 units and any Russian high-value targets close to it.

An S-400 battalion consists of two batteries, each with a command centre, one surveillance/target acquisition radar, one fire control and engagement radar (92N6 known as Grave Stone by NATO) and four launch trucks (formally called transporter-erector-launcher vehicles, TEL) each carrying four large or 16 small missiles, plus vehicles for auxiliary functions such as reloading and power supply. Other types of search radars or target acquisition radars can be added, such as mast-mounted or with alleged capabilities against stealth aircraft. Two battalions make up a regiment and the battalion is normally connected to additional sensors and command functions at the regimental level, as well as to territorial search radars, electronic listening stations and the air defence command-and-control network. All the main functions are mounted on large multi-axle trucks. These can be airlifted, but only on very large transport aircraft.[71]

[69] Keir Giles, *Russian Ballistic Missile Defense: Rethoric and Reality* (Carlisle, PA: US Army War College Press, 2015); Bronk, "Russia's Air Defence Challenge…"; Guy Plopsky, *Russia's Air Defenses in Syria: More Politics than Punch*, BESA Center Perspectives Paper No 618, 18 October, 2017.

[70] Karl Soper and Neil Gibson, "40N6 missile for S-400 system could enter service 'soon'", *Jane's 360*, 8 April 2018; Gady, "New Long-Range Missile…". It is possible that the problems with the seeker that have plagued the 40N6 missile have now been solved, but it is also possible that Moscow simply cleared it for production – despite lingering problems – because of outstanding contracts for export to China, India and Turkey.

[71] Kopp, "Almaz S-300P/PT/PS/PMU/PMU1/PMU2…"; Giles, *"Russian Ballistic Missile…;* "Kaliningrad and the Suwałki Gap: a look from the other side", *Corporal Frisk*, 11 August 2016.

Figure 1: S-400 engagement radar on the left, transporter-erector-launch vehicle on the right. Photo: Wikimedia Commons/Mil.ru

The S-400 is by all accounts a potent air defence system, but is still far from the 400-km range menace to all things flying that it is often made out to be.[72] Since the most potent long-range missile is still not operational, the currently fielded system uses the same long-range semi-active missile as the later versions of the older S-300-system, thus limiting range and performance against all targets but large aircraft at high altitude.[73] Until the 40N6-missile is actually fielded, the main new features of the S-400 system is that its more modern radar is able to handle a greater number of targets simultaneously, and that its agile short- to medium-range active missiles have capabilities against low-flying and maneuvering targets and against incoming PGMs.[74]

However, the comparatively short range of these agile missiles, in combination with the inherent problems of acquiring low-flying objects, limits the effective range of the S-400 against maneuvering targets at low altitude – such as cruise missiles or fighter aircraft. Against such targets its effective range may be as little as 20-35 km, or even less depending on the terrain.[75] This means – at least until

[72] Cf. Muspratt, "How capable…".
[73] Plopsky, *Russia's Air Defenses in…*
[74] Kopp, "Almaz S-300P/PT/PS/PMU/PMU1/PMU2… "; Frühling and Lasconjarias, "NATO, A2/AD…"; Abramson, *Ryska…* .
[75] Berglund, Hagström, and Lennartsson, "The Long-range Weapon…" McDermott, "Russian Air Defenses…"

the 40N6 missile becomes operational – that the much-vaunted S-400 far from establishes a 'no-go-zone' over the southern Baltic. It should mainly be seen as a threat to tankers, transports, and other large aircraft flying at high to medium altitudes within 200–250 km, and against fighter aircraft or PGMs directly attacking the S-400 battery or objects in its immediate vicinity.

Moreover, if and when the 40N6 missile becomes operational, in order to fully exploit its range against targets between 3 000 and 10 000 metres altitude, it will be necessary to connect the S-400 battery to an external (airborne or forward-placed) radar that can see the target and provide usable target data for the missile battery. Using an external and forward-placed sensor to provide target data so that a "shooter" (launch unit) positioned further back can fire on a target beyond the horizon is often called a Cooperative Engagement Capability (CEC). When applied to airborne targets capable of moving in three dimensions at high speed, this is a demanding task involving a lot of high-tech engineering and integration, which the US Navy has only recently mastered after decades of effort. [76] Given the problems in Russia's defence industries, perhaps particularly defence electronics, it seems unlikely that Russia will be able to do this anytime soon.[77]

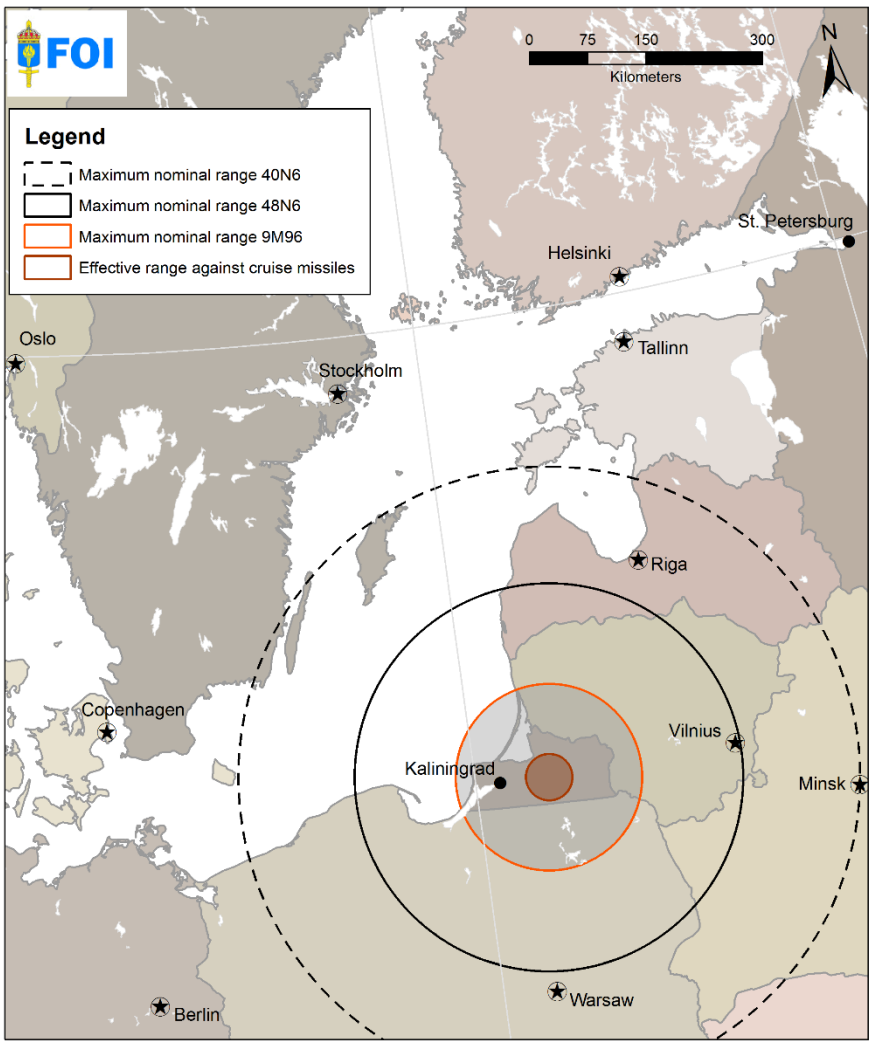
So, while still posing a threat to transport aircraft in the air corridors over the Baltic, or to aircraft landing or taking off from airfields in western Lithuania, any "offensive" impact that S-400 systems in the Kaliningrad region might have on NATO's freedom of action would appear to be somewhat limited. When calculated in terms of the area effectively covered by air defence, these limitations appear even more dramatic.

If the S-400 did have an effective range of 400 km, as is often claimed, it would cover slightly more than 500 000 km^2 of airspace. If the range is reduced to 250 km, however, the area covered shrinks to slightly less that 200 000 km^2, or to 39 per cent of the area claimed. If the range is further reduced to 120 km, the area covered becomes only 9 per cent of the maximum, and if the range is only 20 km, the effective 'no-go-zone' shrinks to 0.25 per cent of what has been claimed. Furthermore, the S-400 system is vulnerable on a number of fronts, such as the single engagement radar or the limited number of long-range missiles that can be fired without reloading. These vulnerabilities can be exploited by an adversary.[78]

[76] The USN/USMC version of CEC is called Naval Integrated Fire Control – Counter Air (NIFC – CA); Erik Berglund et al., *Strid med system i samverkan: Teknisk förstudie*. FOI-R--4055--SE (Stockholm: FOI, 2015).

[77] The fact that the Syrian air defence – which is supposedly fully integrated with Russia's –shot down a Russian airborne radar aircraft instead of shooting down Israeli F-16s testifies to this. Barbara Starr and Ryan Browne, "Syrian regime accidentally shoots down Russian military plane", *CNN*, 18 September 2018.

[78] Bronk, "Russia's Air Defence Challenge…".



Map 2: Ranges for the different missiles of the S-400 system.

The S-400 was developed on the basis of the older S-300 family of air defence systems that remain in service in Russia and abroad. The first S-300s were fielded in the late 1970s, and were known as the SA-10 Grumble by NATO. The system has since been updated and modified to achieve better effects, primarily against stealthy objects, cruise missiles and ballistic missiles. Later versions of the system, such as the S-300PMU-1/2, known as the SA-20 Gargoyle by NATO, or the S-300V4, known as the SA-23 Gladiator by NATO, have nearly the same

capabilities as the S-400 and almost the same set of missiles. The SA-20 Gargoyle is often favourably compared to the US Patriot air defence system.[79]

Naturally, capable SAM-systems such as the S-400 and S-300 would be a priority target for enemy air forces early on in any war. In the Gulf War of 1991 the US-led coalition air forces wreaked havoc on Iraq's air defence systems in the first days of the air campaign, using highly effective air-launched missiles that homed in on radar signals. To guard against this threat, S-400 and S-300 batteries are often complemented by short-range air defence systems for point defence. The most modern short-range system in Russian service is the Pantsir S1, known as the SA-22 Greyhound by NATO, which combines 30-mm guns and short-range ground-to-air missiles with radar and optronic fire direction in a single package mounted on a truck.[80] Supposedly powerful and modern, it has nonetheless repeatedly come up short against Israeli F-16s armed with Delilah missiles in Syria.[81]

3.2 Anti-ship systems

Russia's capabilities to intercept Western ships in the Baltic Sea have been increased recently by the deployment of the Bastion-P heavy coastal anti-ship system to Kaliningrad. Bastion-P has been in service with the Russian Armed Forces since 2015. It appeared near St Petersburg in August 2016 and its presence near Kaliningrad was officially announced in November 2016.[82] Following this deployment, Russian analysts claimed that Russia could not only hit targets in Germany, Poland and the Baltic states, but also block access to the Baltic Sea from the Atlantic.[83]

The modern and supersonic Bastion system is intended for use against large, high-value surface targets, such as aircraft carriers, and in the Baltic might be

[79] For example in Kopp, "Almaz S-300P/PT/PS/PMU/PMU1/…". The S-300V4 is sometimes reported to have a 400-km range, but this probably relates to the range of the radar when used against ballistic missiles. Cf. "S-300V4", *Deagel com*-website.

[80] Carlo Kopp, "KBP 2K22/2K22M/M1 Tunguska SA-19 Grison /96K6 Pantsir S1 / SA-22 Greyhound SPAAGM2" Technical Report APA-TR-2009-0703, *Air Power Australia;* Abramson, *Ryska….*

[81] Daniel Brown, "Russian air defenses were caught on video getting beaten badly by Israeli forces in Syria - here are Russia's excuses", *Business Insider*, 14 May 2018; Judah Ari Gross, "IDF says it bombed Iran arms caches, intel sites, bases, and Syrian air defenses", *Times of Israel*, 21 January, 2019.

[82] Dylan Malyasov, "Russia deploys Bastion-P coastal defence missile system near border with the Baltics", *Defence Blog,* 12 August, 2016; "Russia Deploys Bastion Missile System in Kaliningrad Region, *Moscow Times*, 21 November, 2016.

[83] Aleksandr Golts, "The Bastion Missile System: A Symbol of Power and Foreign Policy Tool", *Eurasia Daily Monitor*, Vol 13 issue 190, 5 December 2016.

used against larger surface combatants, large landing ships or transports. With a 300-km range and a supersonic approach, when based in Kaliningrad this system presents a threat to Western freedom of operation in the Baltic, including to NATO sea lines of communications (SLOCs) to the Baltic states and to Poland.[84]

Figure 2: A Bastion-P launch truck (or more formally a TEL). Photo: Shutterstock

Bastion-P, labelled the SS-C-5 Stooge in NATO reporting, is a mobile system with cruise missiles loaded on to launch trucks and controlled from command and support vehicles, making it easier to move and to hide. A Bastion-P battery contains up to four launch trucks with two missiles each, a matching number of reloading trucks with three missiles each, and one or two command post vehicles equipped with a target acquisition radar.[85] A missile battalion consists of two batteries.[86]

The cruise missiles fired by Bastion-P are very different from the familiar US Tomahawk and its Russian analogues, Kalibr and Kh101/102. Bastion-P uses larger ramjet-powered P-800 Oniks missiles (marketed as Yakhont in the export version) that have a much shorter range (up to 350 km with a high-low trajectory,

[84] "Bastion-P: Costal defense missile system", *Military Today*.
[85] "Bastion P", *Daegel com.*
[86] "Russia sets up 3K55 Bastion Coastal Defense Missile Systems on Kuril Islands", *Navy-recognition com.*

less with a low-low trajectory).[87] After launch, the missile ascends to up to 14 000 meters in order to acquire the target with its active radar seeker and to fly economically. It then descends to sea level for the final approach. As the ramjet gives the missile a speed of Mach 2.5, this makes it difficult for the target to detect an incoming missile early enough to take countermeasures.[88] There are also reports of the missile being equipped with a data link that allows a single missile flying at high altitude to relay target data to other missiles flying at sea level. [89]

Russia has also deployed the somewhat older and lighter Bal coastal defence missile system in Kaliningrad. Bal uses the sea-skimming Uran Kh-35 missile (SS-N-25 Switchblade) which has an active radar seeker supported by inertial navigation. It is reported to have a range of 130 km, which makes it analogous to the Western Exocet or Otomat systems from the 1980s. It is mainly a threat to somewhat smaller vessels, such as frigates, closer to the shore. An updated version, the Kh-35U, is claimed to have twice the range, satellite navigation and a better radar seeker, making it more of a threat to vessels further out. A Bal battery is organized in the same manner as a Bastion battery, the major difference being that the launch vehicles each carry eight missiles.[90]

While Russia wants to project the image that it has the capacity to hit ships in the Danish straits or near the western shore of the Baltic, the organic fire control radar of the Bastion-P cannot see beyond the radar horizon (normally 40 km at sea level).[91] This limits the effective range of the system unless an external (airborne or forward-based) sensor can be used. During the Cold War, Soviet naval doctrine called for maritime reconnaissance aircraft to provide targeting data and mid-course guidance for anti-ship missiles launched by other platforms.[92] Nowadays, with the emphasis on operations closer to home shores, this service is mainly provided by radars mounted on Ka-32 helicopters. In the not too distant future it could probably also be provided by less vulnerable drones.[93]

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[87] A high-low trajectory means that a missile first ascends to a high altitude and remains there for much of the journey, but descends to a low altitude for the final approach to the target. Such a trajectory is more fuel-efficient than a low-low trajectory and allows an active radar seeker to acquire the target, but also means that the missile can be spotted by radars while at high altitude.

[88] "SS-N-26 'Strobile' (P-800 Oniks)/ Yakhont / Yakhont-M / Bastion (launch systems)", *CSIS Missile Defense Project*-website.

[89] "Bastion P", *Daegel com*-website.

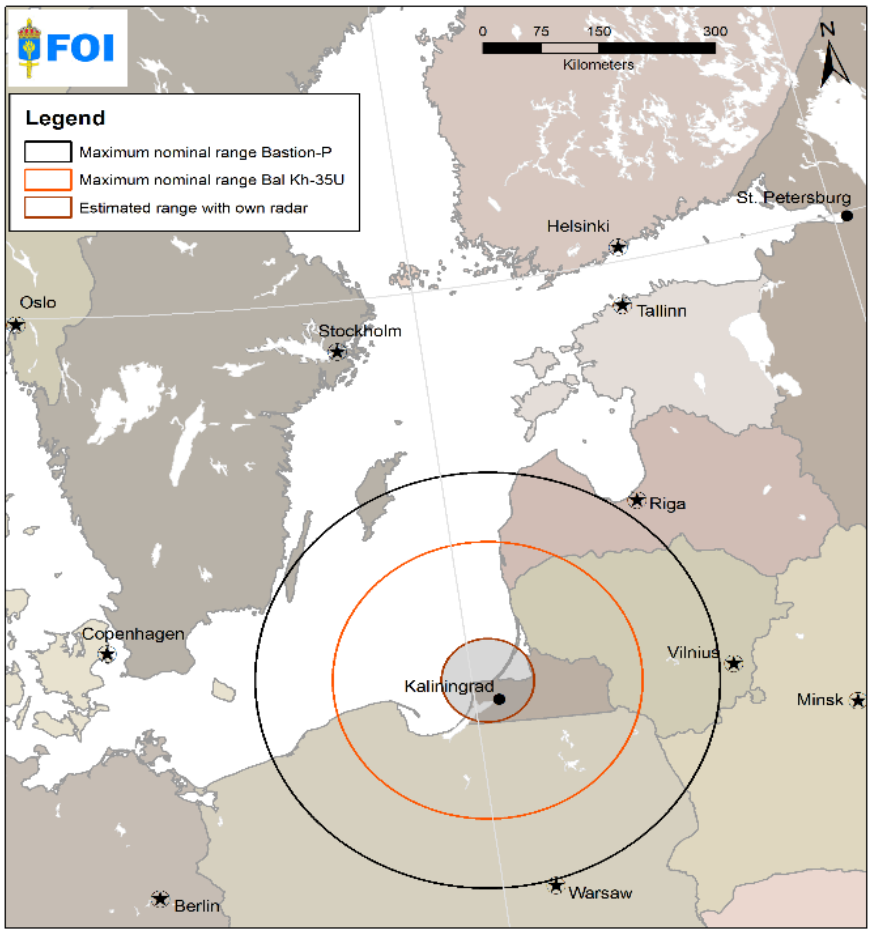
[90] "Bal: Coastal defense missile system", *Military Today*-website.

[91] "Служу на Балтике, служу России", *Vesti Kaliningrad,* 18 August, 2018.

[92] Vego, *Soviet Naval*…; 82. The authors' are grateful to Mats Nordin for pointing this out.

[93] "Bastion-P: Costal defense missile system", *Military Today*-website. While Russia has made great strides in the manufacture and use of drones in the last ten years, possibly with the help of Israel, this has so far been limited to short-range drones for tactical target-spotting. The lack of longer-range drones makes it unlikely that Russia has already fielded a capability to detect and to target-spot ships at greater distances far beyond the horizon.

Ships are much slower than aircraft, and move in only two dimensions, and there is no need for illumination of the target. It is therefore considerably easier to achieve a Cooperative Engagement Capability against ships than against aircraft.



Map 3: Ranges for different missiles in the Bastion-P system.

It is also possible that other long-range sensors, such as signals intelligence, passive sonar or optical observation from aircraft or submarines, could provide data on the target's position, course and speed, but in a crowed environment relying on such data would increase the risk of hitting the wrong target. Using data from satellites is of course also an option. Russia has precious few radar-satellites for finding ships at sea (Rorsat), but if it is daylight and not cloudy it might be possible to find and identify ships with proprietary optical or electro-

optical satellites. In addition, the use of data from commercially available electro-optical or radar-satellites should not be ruled out.[94]

Finally, firing more or less blindly at ships beyond the horizon is of course also a possibility for missiles that have an active seeker, and this tactic was used by the Iraqis during the tanker war of 1980s, using both Exocets and Russian- or Chinese-made missiles. However, while the Iraqis hit many ships in this way, the hits were not always on the Iranian tankers they intended, but often third party vessels, such as the USS Stark. Furthermore, the Iraqis never managed to stop Iranian oil exports, which was the intention.[95] This indicates that while firing blindly in the absence of targeting data, or on unidentified radar echoes, might suffice for harassment purposes, it is insufficient if the aim is to hit specific ships or to stop traffic.

3.3 Anti-land systems

Clearly, the most written-about Russian land-attack missile in recent years must be the Iskander ballistic missile. By providing hints and reminders about the Iskander, and deploying it on exercises to the Kaliningrad exclave, Russia has successfully demonstrated its military power to countries in the Baltic Sea region. The Iskander system actually consists of two different missiles: the Iskander-M ballistic missile and the Iskander-K cruise missile.

Iskander-M is an advanced ballistic missile, mounted in pairs on TEL launch trucks, and is referred to as the SS-26 Stone in NATO parlance. Iskanders are normally deployed in brigades, of which there is one at Chernyakhovks in Kaliningrad and one at Luga, south-west of St Petersburg. A missile brigade is made up of three battalions, each of which has eight missiles on launch trucks and as many again on reload vehicles. A brigade thus has 24 ready missiles that can be fired in a salvo, and 24 reloads that can be fired 30–60 minutes later. Iskander-M is replacing the 1970s-vintage SS-21 Tochka in Russian missile brigades. It has been in service with the Russian Armed Forces since 2006 and was first used in the war against Georgia, albeit with mixed results.[96]

[94] Interview with Christer Andersson, FOI, 13 February 2019.

[95] Despite destroying some 40 ships and causing more than 300 casualties during eight years of war, these attacks affected only 1 or 2 percent of shipping in the Persian Gulf. See Ronald O'Rourke, "The Tanker War", *U.S. Naval Institute Proceedings*, May 1988; Anthony Cordesman and Abraham Wagner, *The Lessons of Modern War Part II: The Iran-Iraq War* (Westview, 1990).

[96] Forss, *The Russian Operational-Tactical…*; Veli-Pekka Kivimäki and Jeffrey Lewis, "Russia Depoys the Iskander to Kaliningrad", *Arms Control Wonk*, 11 December, 2016.

Figure 3: Iskander-M launch truck to the right, and transport-reload vehicle to the left. Photo: Shutterstock

The first permanent operational deployment of the Iskander missile system in the Baltic Sea region took place in 2010, at a base in Luga, half way between St Petersburg and Pskov.[97] Assuming the nominal 450-km range, from Luga the Iskander-M could cover targets in all of Estonia, most of Latvia and part of Lithuania, as well as targets in southern Finland up to Mikkeli. If the missile can be equipped with a lighter warhead, giving it a 700-km range, it would cover all of the Baltic states, all of Finland south of Lapland, as well as the area around Stockholm and Uppsala in Sweden. Moreover, these missiles are highly mobile.

In 2016, officials confirmed its transfer to Kaliningrad as "part of routine drills", but Iskander-M will probably remain in the exclave as this would complete the rearmament of the missile brigades with SS-26s.[98] The SS-26 reaches a speed of Mach 6 after burn-out, which gives it a range of 400–500 km if fitted with a 700-kg warhead and up to 750 km if fitted with a lighter warhead.[99] Several different warheads are reported to be available, probably including nuclear warheads. It is

[97] Stratfor, "Russian Missiles on NATO's Border", *Strafor*-website, 30 November, 2010.

[98] "Russia moves nuclear-capable missiles into Kaliningrad", *Reuters*, 8 October, 2016; Andrew Osborn, "Russia seen putting new nuclear-capable missile along NATO borders by 2019", *Reuters*, 23 June, 2016.

[99] A range above 500 km would contravene the spirit of the INF-treaty, but as long as the missile had not been tested at those ranges, it would not technically be a violation.

reported that – at least for some warheads – targeting data can be updated in-flight via a datalink, and the warhead's basic inertial and satellite navigation can be augmented by electro-optical terminal guidance, providing high levels of accuracy.[100]

Moreover, Iskander-M has a quasi-ballistic trajectory and is reported to be capable of evasive maneuvering at high speed, making it hard to hit with defensive missiles.[101] With a flight-time of 10 minutes or less, Iskander-M thus poses a danger to fixed and movable (but not mobile) ground targets in the Baltic Sea region, including sites in south-eastern and perhaps eastern Sweden.[102]

The Iskander-M missile has a less well known sibling, the ground-launched cruise missile Iskander-K, which seems to have been fielded in the missile brigades without any fanfare. Much less is known about the presence of Iskander-K in the region but assuming an equal number of ready missiles and reloads (24 + 24) in a brigade, this would increase the regional threat to land targets.

Guidance, propulsion and performance are probably analogous to the better known Kalibr cruise missile (see below), but its range-potential is probably less than Kalibr's, as the missile's body is one meter shorter and thus has less room for fuel. It is also possible that the range of the Iskander-K has been artificially reduced to less than 500 km in order to comply with the INF Treaty. If so, this is something that could be easily rectified, perhaps by a software change and by topping up the fuel tanks.

[100] It is not known for certain whether all of these variants have actually been fielded. Electro-optical scene-matching guidance means that the missile has stored an image of the target before launch (or possibly in flight using a datalink) and when the missile reaches the vicinity of the target, it starts looking (using a camera or radar) for features that match the stored image, and then homes in on them. Forss, *The Russian Operational-Tactical Iskander*…

[101] Forss, *The Russian Operational-Tactical Iskander*…; Dave Majumdar, "Introducing the Iskander: The Russian Missile NATO Fears", *National Interest*, 1 April, 2016.

[102] Berglund, Hagström, Lennartsson, "The Long-range…"; "Iskander Tactical Ballistic Missile System", *Army Technology*.

Russian A2/AD-assets in the Baltic region now also include the Kalibr sea-launched cruise missile, which made its combat debut in October 2015 in a spectacular strike launched from small ships in the Caspian Sea to hit targets in Syria.[103]

Map 4: Range of Iskander-M missiles from Kaliningrad.

Kalibr is actually a family of cruise missiles very similar to the now classic US Tomahawk cruise missile, first fielded in the 1980s. Like the Tomahawk, the

[103] Air-launched long-range cruise missiles, such as the KH-101/102, are not covered by this study. While highly relevant in some respects, their 3000-km range and the fact that they are launched from strategic bombers puts them in a league above the regional or A2/AD-contexts.

Kalibr exists in different versions (land-attack and anti-ship) and can be launched from different types of platforms, such as surface ships and submarines. The land-attack version is designated the 3M14 in Russia and the SS-N-30 by NATO, while the anti-ship version is known as the 3M54 in Russia and the SS-N-27 Sizzler by NATO.

Like the Tomahawk, Kalibr 3M14 land-attack missiles fly at low altitude and at subsonic speed using small wings. The wings, the moderate speed and the use of a turbojet engine mean that the range can be impressive, at more than 1650 km for the Kalibr.[104] Guidance is probably also similar to the Tomahawk, with a combination of inertial and satellite navigation augmented by electro-optical terminal guidance, resulting in an accuracy measured in single digit meters.

The fact that the Kalibr can be launched from compact vertical tubes means that the system can be fitted to ships as small as corvettes, providing a quantum leap in the precision long-range land-attack fire power of the Russian Navy and giving it a capability hitherto only possessed by the US Navy.[105]

The 3M14 entered service with the Russian Armed Forces in 2012, but arrived in the Baltic Sea in October 2016, when two missile corvettes – heavily armed despite their small size – joined Russia's Baltic Fleet. A third similar vessel has since joined them. Each vessel can carry eight missiles, and the number of such corvettes is planned to increase to five in the coming years.[106] When based in the Baltic, small ships armed with Kalibr land-attack missiles are capable of striking ground targets all over Northern Europe.

Somewhat less is known about the 3M54 anti-ship missile. It has a much shorter range (about 300 km) and makes a supersonic dash, switching on active guidance features when approaching the target.[107]

Kalibr missiles are also manufactured in export variants, often with reduced range, and marketed under the name of Club or Klub. One version has a complete launch system fitted inside civilian shipping containers, making it very easy to hide.[108] If produced also for the Russian Armed Forces, this might greatly complicate NATO targeting.

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[104] Persson, ed, *Russian Military Capability…,* 89.

[105] Discounting a dozen or so land-attack Tomahawks on Royal Navy submarines.

[106] Andrew Osborn, and Simon Johnson, "Russia beefs up Baltic Fleet amid NATO tensions: reports", *Reuters*, 26 October, 2016; Sebastien Roblin, "Why Russia's Enemies Fear the Kalibr Cruise Missile", *National Interest*, 22 January, 2017; DFRLab, "Missile Misdirection: Is Russia shipping nuclear-capable cruise missiles to the Baltic while saying they're headed for the Mediterranean?", *Medium*, 23 October 2016;, "SS-N-30A (3M-14 Kalibr)", *CSIS Missile Defense Project*-website.

[107] "SS-N-27 "Sizzler", *CSIS Missile Defense Project*-website.

[108] "Club-K: Container missile system", *Rosoboronexport.*

Finally, the Oniks/Yakhont missile can also be used against land targets, although the advantages of this are not evident if other means are available. It is possible that the recent use of this system against land targets in Syria was a case of marketing and showcasing strategic communications.[109]

Map 5: Estimated range of Kalibr (3M14) from Kaliningrad.

[109] Sputnik News, "This is How Russia Could Use Bastion Systems Against Land Targets in Syria", *Sputnik News*, 15 November, 2016

3.4 Other systems and forces

The designated Russian A2/AD capabilities delineated above are backed up or augmented by general purpose air and naval forces deployed in the region. The Baltic Fleet in Kaliningrad and St Petersburg nominally has eight guided missile destroyers or frigates, 2–3 submarines and 12 missile boats or attack corvettes, as well as naval aviation consisting of one squadron of fighters and one squadron of strike aircraft.[110] How many of these are serviceable at a given time is another matter, as the Baltic Fleet has been underperforming for some time leading to the dismissal of its commander and some 50 officers.[111] Currently, among the major surface ships it seems that one Sovremenny-class destroyer and one Neustrashimy-class frigate can be considered as operational, to which can be added four Steregushy-class larger corvettes and the three small corvettes armed with Kalibr.

The Sovremenny-class ships are equipped with eight 1980s vintage ramjet-powered anti-ship missiles (SS-N-22 Sunburn, basically a forerunner of P-800 Oniks) while the Neustrashimy frigates and the Steregushy corvettes carry eight Kh-35 missiles each. As for air defence the older ships carry navalized versions of the Tor or Buk systems with a maximum range of 12 and 30 km respectively, while the more modern Steregushy corvettes carry the Redut air defence system with 12 of the 40 km-range missiles (9M96) used in the S-400 system.[112]

If allowed to leave port, these surface combatants could constitute a mobile threat to NATO shipping within range of their missiles and sensors, but their air defence assets are mainly for self-defence because of their short range. Although under-water capabilities lie outside the remit of this report, the two or three operational Kilo/Lada submarines, plus sea mines and other underwater assets in the Baltic, add to the capabilities to interfere with NATO shipping, as does suspected capability for navalized hybrid warfare.[113]

In the vicinity of St Petersburg can also be found 5–15 combat air squadrons assigned to Russia's Western Military District.[114] A few years ago there was much made in the West of the threat to Western forces emanating from Russia's first fifth-generation stealth fighter aircraft. Dubbed PAK-FA or T-50, this was

[110] IISS, *The Military Balance 2018* (London: IISS, 2018).
[111] "New Commander Appointed Amid Russia's Baltic Fleet Shake-Up", *Moscow Times*, 1 July, 2016.
[112] "Sovremenny-class destroyer", *Wikipedia org* –website; "Neustrashimyy-class frigate", *Wikipedia org* –website¸ "Steregushchiy-class corvette", *Wikipedia org* –website; Abramson, *Ryska luftvärnssystem*.
[113] Cf. Hicks et. al., *Undersea Warfare…*; Murphy, Hoffman, and Schaub, *Hybrid Maritime Warfare…* ; Niklas Granholm, "The Return of Naval Warfare to the Baltic Sea region. Grey-Zone Confrontation and High-end Conflict" (forthcoming).
[114] Persson, ed., *Russian Military Capability…* .

touted as the equivalent of an F-22 or F-35 and as a menace to Western air forces as soon as 2020. However, it has since become apparent that the Su-57 (as it is now known) is severely underperforming and will not enter series production anytime soon, if ever.[115]

3.5 Taking stock of capabilities

This type of account – domain-by-domain, system-by-system – is likely to understate actual Russian A2/AD-capabilities in the Baltic region. This is, first, because it overlooks ancillary capabilities and systems, such as surveillance sensors, infrastructure or general-purpose forces (including submarines and sea-mines); and, second, because it does not factor in the mutually reinforcing effect of having a multitude of systems and capabilities permanently installed in a rather small area. Moreover, when compared with the multinational NATO alliance, Russia has the advantage of only having national command lines and forces, which should allow for simpler and speedier decision making. Thus, the totality of Russian A2/AD-assets in the Baltic region is probably somewhat more capable and more resilient than surmised here.

That said, the picture that emerges of Russia's actual A2/AD-capabilities in the region, including its capability to interfere with NATO airpower or reinforcements for the Baltic states, seems considerably less impressive than the impenetrable 400-km bubble many widely-disseminated accounts would have us believe.

While Russian engineers are skilled at building missiles that fly far and fast, the problems of first finding and identifying, and then hitting small moving targets beyond the horizon are still formidable. This applies not only to the inherent problems of hitting a moving object from a distance, but also very much to the problems of achieving situational awareness and performing targeting, which are exacerbated by the lack of a Cooperative Engagement Capability. Here, the short-comings of Russian defence electronics combine with the laws of physics and an unfavourable geography to make the so-called bubbles much smaller and less impenetrable than is often claimed.

As a result, the estimated effective range of anti-aircraft or anti-ship missile system are often considerably less than the maximum nominal range touted in the press. Similarly, the probability of achieving a hit on the target – if engaged – shrinks as the distance to the target increases. This difference between nominal range and effective range is most striking when it comes to anti-air systems, and

[115] Sebastien Roblin, "The Russian Military's Greatest Enemy (And Its Not America)", *National Interest*, 9 September, 2017.

especially against small manoeuvring targets at low altitudes, less so against large targets flying straight at medium or high altitudes.[116] Anti-ship missiles with active radar seekers are not as dependent on frequent updates of target data during their flight, but are still dependent on being given the target's position, course and speed before launch. Thus, the capability to selectively engage targets beyond the radar-horizon is dependent on target data being provided by a sensor placed forward or in an elevated position, while firing more or less blindly for the purpose of harassment would still be possible at greater ranges. These weaknesses do not, however, generally apply to missiles targeting fixed or movable targets on land.

So, summing up, it might be useful for pedagogic purposes to divide the A2/AD moniker into its two components, anti-access (A2) and area-denial (AD). Russia does not currently, and with its current basing in the Kaliningrad and St Petersburg regions, have the full capability for A2, that is, to deny NATO access to the Baltic region or to the Baltic states. It does however have a capability for AD, that is, to make it dangerous for an adversary to loiter or remain, albeit primarily within a smaller area closer to Russia's bases.[117]

[116] It remains to be seen whether the impending fielding of the active-seeker long-range 40N6 missile gives reason to revise this assessment.

[117] The authors are grateful to Fredrik Westerlund for suggesting this distinction.

4 NATO's menu of countermeasures

When the specter of Russian A2/AD bubbles blocking access to exposed NATO member states in Europe first arose in the wake of the annexation of Crimea, there was a tendency to see such bubbles as large and absolute no-go zones. This first phase has been labelled the "Oh shit!" phase by a US airpower guru. Four years later, we are well into the next phase, which he dubbed the "Well, what do we do about it then?" phase.

Focus has thus shifted away from maximalist interpretations of the capabilities of Russian systems, and of their impact on Western freedom of operation, to more sober assessments of Russia's actual capabilities and to taking an inventory of the countermeasures available to the West. This process has been facilitated by increased skepticism about the torrent of Russian claims about its new weapons and their capabilities, which are correctly seen – at least in part – as a combination of braggadocio aimed at underpinning Russia's claim to great-power status and marketing statements to boost Russian arms exports. In addition, you do not have to be a rocket scientist or an electronics engineer to understand that Russian or Russian-produced air defence systems have so far failed miserably against Western and Israeli air forces in Syria.[118] At times, the disparity between Russian/Syrian claims about aircraft and missiles successfully shot down, and Western after-action reports have been so glaring as to be reminiscent of Baghdad Bob.[119]

On the other hand, after 25 years of operating with virtual impunity in the air- and naval domains, and meeting mainly irregular low-tech adversaries on the ground, Western armed forces had lost interest in many of the skills and capabilities needed for operations against a near-peer opponent, such as camouflage and dispersal, emission control or suppression of enemy air defences (SEAD). The latter was a key capability in the Gulf wars of 1991 and 2003, paving the way to victory in the air and later also on the ground. The US advantage in SEAD in these wars was so great, however, that supremacy came to be taken for granted. Hence, capabilities were cut, there was no investment in

[118] Whether this is due to technical shortcomings in the systems, underperformance by the crews manning them, a decision not to act, or the cunning of Western and Israeli air forces is currently an open question. For references, see appendix 2 on air operations in Syria.

[119] Peter Beaumont and Andrew Roth, "Russia claims Syria air defences shot down 71 of 103 missiles", *Guardian,* 14 April, 2018; Ewen MacAskill and Julian Borger, "Allies dispute Russian and Syrian claims of shot-down missiles", *Guardian*, 14 April, 2018; Gareth Davies, "Syria fired 40 missiles 'at nothing' after allied strikes destroyed three Assad chemical sites*", Daily Telegraph*, 14 April, 2018. An amusing account of a similar situation is offered in the Soviet air force's after-action report on the 1986 US raid on Libya (see, "Information from Air Force Marshall Koldunov on Issues Related to US Aggression Against Libya", available at the *Parallel History Project's* website.)

modernized equipment, such as specialized aircraft or missiles that home in on radars, and the skills of specialized pilots declined because they were not in demand. This has since started to change and the SEAD mission is now given a lot more attention than it was five years ago.[120]

The menu of conceivable countermeasures to Russia's A2/AD capabilities in the Baltic Sea region is quite wide and varied. The objective of this chapter is not to provide an exhaustive taxonomy of countermeasures, and even less to provide an assessment of what they might entail or of their effectiveness. It is simply to present some examples of possible countermeasures and how they might work. If warranted, this menu can also serve as a point of departure for further analysis.

4.1 Indirect countermeasures

Countermeasures can be direct or indirect; that is, they can either attack the problem head-on or go around it. Examples of indirect countermeasures to Russia's A2/AD capabilities in the Baltic Sea region might be:

- to reduce the need for early reinforcement or resupply by stationing more forces and materiel forward in peacetime;
- to choose less vulnerable routes or means of transportation, such as flight paths beyond the range of radar or missiles;
- to increase the capacity and speed of logistics;
- to rely more on deterrence by punishment – irregular, conventional or nuclear.[121]

4.2 Direct countermeasures

Direct countermeasures aim to break one or more links in the opponent's kill chain, which is find, fix, track, target, engage and assess. It is often sufficient to break or disrupt a single link in this chain in order to cause it to malfunction. Links that are both vulnerable and hard to replace, such as airborne radars or

[120] Robert Hawson, "The need for SEAD", *Jane's Defence Weekly*, 19 October 2011; Mike Pietrucha, "The Need for SEAD Part I: The Nature of SEAD", *War on the Rocks*, 17 May, 2016; Mike Pietrucha, "The Need for SEAD Part II: The Evolving Threat", *War on the Rocks*, 7 June, 2016

[121] NATO Public Diplomacy Division (PDD), *NATO's Enhanced Forward Presence*, Factsheet, May 2017; Elbridge Colby and Jonathan Solomon, "Facing Russia: Conventional Defence and Deterrence in Europe", *Survival* Dec 2015–Jan 2016; Shlapak and Johnson, *Reinforcing Deterrence…*;"NATO in Europe needs 'military Schengen' to rival Russian mobility" *Deutsche Welle*, 12 September 2017; Carol Matlack, "Swift Justice: One Way to Make Putin Howl", *Bloomberg Business News*, 4 September, 2014; Frühling and Lasconjarias, NATO, A2/AD…".

datalinks, thus become high-value targets – if the enemy cannot find or identify you, or pass that information on, then he cannot hit you.[122]

Direct countermeasures can be subdivided into passive or active.

4.2.1 Passive countermeasures

Passive countermeasures can include camouflage for land units or stealth technology for aircraft and ships, making it harder for the enemy to find, fix or track units. Valuable mobile assets such as aircraft, ships, headquarters can also be dispersed so that they do not present too tempting a target, or hidden among civilian objects, or moved around in a manner that complicates an adversary's targeting.

Another kind of passive countermeasure is fortification of fixed installations and infrastructure, or redundant systems, making it harder for the enemy to render a target or function inoperable even if it is hit. Emission control, which means not transmitting electronic signals, dispersal and mobility can also be counted in this category, as can flying at low altitude and thus hiding behind natural features or under a radar's horizon.

4.2.2 Active countermeasures

Active countermeasures can be further subdivided into soft-kill or hard-kill, often nowadays misleadingly labelled "non-kinetic" and "kinetic".[123]

4.2.2.1 Soft-kill countermeasures

Soft-kill countermeasures are a wide panoply of tools that include: (a) active electronic jamming of search radars, engagement radars or command-and-control networks; (b) physical or electronic decoys that act as false targets and thus trick radars on the ground or radars on missiles; (c) the hacking of computerized surveillance or command-and-control systems; and (d) old-fashioned evasive action.[124]

Back in the days when the primary task of the US Air Force was to send bombers into the Soviet homeland, or when NATO member state air forces were intended to strike Warsaw Pact forces in Eastern Europe, the latest versions of electronic

[122] Jonathan Greenert and Mark Welsh, "Breaking the Kill-Chain", *Foreign Policy*, 17 May, 2013.
[123] Misleading because in most cases it is the chemical energy of an explosive compound that does the job of destroying the target. There are truly kinetic weapons, such as a rifle bullet, but they are in a distinct minority.
[124] Greenert and Welsh, "Breaking the…".

countermeasures were closely guarded secrets, and were not used on deployments or in "minor" wars, such as Vietnam.[125] The USA devoted considerable resources to the types of electronic warfare known as escort jamming and stand-off jamming. The USA, and to some extent other NATO member state air forces, had special aircraft dedicated to these tasks, such as the EF-111 Raven or the EA-6B Prowler.

After the end of the Cold War and the first Gulf War, such capabilities were judged superfluous. Capabilities were consequently cut or axed, except in the US Navy and Marine Corps and some NATO member state air forces.[126] The US Navy today uses the EF-18G Growler, while Marine Corps squadrons still fly the venerable Prowler, which has been used frequently in Syria.[127]

Escort jammers should be considered separately from the self-defence jammers that most aircraft that go into harm's way should carry. While escort jammers can put out a large electronic cloud capable of masking a squadron of aircraft, or jam command networks or the data-links between a missile and its ground station, the purpose of self-defence jammers is to make it hard for a tracking radar or a missile to get a lock-on to that particular aircraft.

Countermeasures – such as thin strips of aluminium foil, known as chaff, or flares – are usually fired by aircraft or ships under missile attack to spoof the missile in its terminal phase.

More substantial decoys that mimic aircraft can also be deployed at an earlier stage of combat in order to mislead enemy air defences, goad radars to start transmitting or trick missile crews into firing at ghosts. On the opening night of Desert Storm, US Navy F-18s had great success dropping a large number of cheap glider decoys that prompted the Iraqi air defence to light up their radars, whereupon they became visible and could be attacked with radar-homing missiles.[128] A more capable – but also more expensive – version of the same concept adds an engine for range, navigation equipment and electronics able to mimic the radar signature of most Western aircraft. Some versions also carry a jammer.[129]

[125] Email correspondence to author, 2 August 2018. The difference is that escort jammers follow the bombers or strike aircraft into enemy-controlled airspace, while stand-off jammers remain well back.
[126] Italy and Germany fly an electronic warfare/reconnaissance version of the Tornado.
[127] Shawn Snow, "The Corps is down to one final EA-6B Prowler squadron", *Marine Corps Times*, May 16, 2018.
[128] Carlo Kopp, "Operation Desert Storm: The Electronic Battle, Part 2", *Air Power Australia*, June/July/August 1993.
[129] Miniature Air Launched Decoy (ADM-MALD 160) used by the US Air Force.

Drones, both big and small, can be used for similar purposes. In fact, the most spectacular air combat victory since 1945 – the 1982 battle of the Beqaa Valley – was initiated by a drone that triggered the Syrians to turn on their missile radars.[130]

As almost all Command, Control, Communications, Computer, Intelligence, Surveillance and Reconnaissance (C4ISR) systems are nowadays computerized and networked, it should also be possible to disable or trick them with cyber weapons. It has been suggested that the successful Israeli air raid on a Syrian reactor in 2007 was facilitated by hacking and corrupting the Syrian air defence surveillance system.[131]

4.2.2.2 Hard-kill countermeasures

Finally, hard-kill countermeasures have the potential to aim for any of the links in the kill chain. Disabling a search radar, communications links or a missile dump can potentially be almost as effective as taking out an engagement radar or a missile launch unit.[132] Especially against missile systems with a range beyond the horizon, taking out the sensors (usually radars) that provide early warning, cueing and targeting data, or the communication links, can be highly effective. If these sensors or links are disabled, and there is no back-up, the missile-firing unit will be limited to the targets it can detect itself, and will not be able to make use of its great nominal range.

However, as it can be difficult to assess whether such targets have really been neutralized, and as there may be alternative sensors or communications channels, preference is often given to striking the "archer", that is the launch and control units, or the "arrows", that is the missiles, bombs, grenades, and so on, while in the air.

It is of course infinitely more complicated and costly to hit a small missile, bomb or grenade travelling at very high speed than it is to hit a stationary target or an aircraft or ship moving at moderate speed. Thus, this option is usually reserved for either threats that are otherwise hard to reach, such as mobile ballistic missiles or long-range cruise missiles, or a last-ditch defence against incoming missiles.

The upper tier is represented by missile defence systems such as Patriot PAC-2/3, the US Navy's Aegis system when equipped with SM-3 missiles or the Israeli Arrow system. The lower tier is represented by Israel's Iron Dome system, which

[130] Israel destroyed 17 out of 19 SAM batteries and shot down more than 80 Syrian fighters, for no losses of their own. Gunnar Åselius, *Krigen under kalla kriget* (Stockholm: Medströms, 2007).
[131] Oliver Holmes, "Israel confirms it carried out 2007 airstrike on Syrian nuclear reactor", *Guardian*, 20 March 2018.
[132] Greenert, Welsh, "Breaking the …".

has had a very good success rate against the numerous artillery rockets fired from Gaza or Lebanon, or naval Close-In Weapons Systems (CIWS), which are standard issue on most modern ships and use high-speed guns to put up a barrage of steel in front of an incoming missile.[133]

However, the more common approach for hard-kill countermeasures is to strike the unit that launches and controls the weapons. This can either be done in a deliberate and pre-planned fashion (deliberate targeting), or in response to a suddenly appearing threat or a target of opportunity (time-sensitive or dynamic targeting). Pre-planned countermeasures are usually part of an effort to suppress, degrade or destroy the enemy's A2/AD capabilities, either as an objective in itself or in order to provide protection for other forces.

Importantly, while of obvious special interest to air forces, operations against A2/AD assets (including SEAD missions) are not exclusively an air force task. If there is friendly terrain reasonably close to the target, ground units such as special forces or long-range artillery can also contribute effectively, as might naval units (especially missile-armed submarines) if the target is a ship or on the shore.[134] Importantly, the geography of the Baltic Sea region favours the use of ground forces against A2/AD assets, as all of the Kaliningrad exclave is within range of rocket artillery or special forces based in Poland or Lithuania. While supposedly a Russian bastion and a thorn in NATO's side, when viewed through this kind of lens, Kaliningrad and the high-value forces placed there look very vulnerable.[135] Similarly, units based in the vicinity of St Petersburg might be vulnerable to similar strikes from Estonia or naval units in the Gulf of Finland.

Pre-planned missions against A2/AD assets can be based on extensive intelligence and utilize a method known as target systems analysis in order to determine the target system's vulnerabilities and the aim-points that give optimal effect. For example, an S-400 battery only has a single Grave Stone engagement radar. This means that a successful strike on that one unit will render the whole battery, with its four missile launchers and 16–64 ready missiles, useless. If the location of that radar is known, missiles or GPS-guided glide bombs can be launched from a safe distance in order to disable it. It can safely be assumed that

[133] Keck Zachary, "Iron Dome: Here Is How Israel Protects Itself From Hamas In Gaza", *National Interest*, 22 July 2018.

[134] Timothy Bonds et al., *What Role Can Land-Based, Multi-Domain Anti-Access/Area Denial Forces Play in Deterring or Defeating Aggression?*, RR-1820-A (Santa Monica, CA.: RAND, 2017).

[135] Most of the US approaches to dealing with A2/AD were developed with China in mind. While China controls the entire coastline from Vietnam to North Korea, this is not the case in the Baltic Sea region, where Russia is hemmed in and has alien territory close to its basing areas, making these much more vulnerable. Robin Häggblom, "Kaliningrad and the Suwałki Gap – a look from the other side", *Corporal Frisk*, 11August, 2016; Frühling and Lasconjarias, "NATO, A2/AD…".

the USA, not least the USAFE (US Air Force in Europe), using various means to keep tabs on the whereabouts of these heavy SAM units and on the concrete-reinforced firing positions that have been prepared for them in the region.[136]

Moreover, in a pre-planned operation it is possible to orchestrate a multitude of assets – surveillance, jammers, decoys, long-range missiles, artillery, special forces, stealth assets, and so on – to achieve good effects with acceptable levels of risk.[137] If it is a known high-value target in defended airspace, scarce stealth strike assets (B-2 bombers, F-35s) can be detailed to simply take it out with satellite-guided bombs. As F-35s increasingly come on line in the coming years in US and allied air forces, stealth assets will cease to be an exclusive resource.

Western and Israeli strikes in Syria are recent examples of successful pre-planned strikes, as were initial parts of Desert Storm in 1991.[138] In Desert Storm, when satellite-guided weapons were not available in great quantities, the main weapons for SEAD were anti-radiation (i.e. radar-homing) missiles, such as HARM and ALARM, which were used in great quantities to destroy or silence Iraqi search and engagement radars. However, one should keep mind that there are also examples of less immediately successful SEAD-efforts from recent decades, particularly from the Kosovo war in 1999. There, the Serb air defence units practiced a kind of guerrilla tactics, shutting down and hiding their radars and missile-launchers so they could not be targeted. That way, they avoided detection and destruction, but at the price of only functioning intermittently or as a fleet-in-being.[139]

While anti-radiation/radar-homing missiles have been partly eclipsed by satellite-guided missiles and glide bombs, they still play a crucial role in the self-defence of aircraft or air units that penetrate into enemy airspace. SEAD-equipped aircraft can be detailed as support for a group of strike aircraft when operating in areas where the presence of enemy SAMs is suspected. Either the aircraft or the missiles themselves are equipped with sensors that warn the crew if air defence radars become active. The missile's sensor then locates the source of the signals and locks on to it, even if the radar's crew shuts down the radar.

If an aircraft is caught in the beams of a tracking or missile engagement radar, time is of the essence and it becomes a duel between the crew on the ground and

[136] First and foremost by "national technical means", but the US also has special forces personnel stationed in all three Baltic states. Schmitt "US Lending Support…"

[137] Such orchestration is expressed in an Air Tasking Order (ATO), which is a complex document that takes considerable time to prepare and execute.

[138] Successful, that is, in terms of hitting the designated targets without losses. Whether the desired effects were achieved is another matter.

[139] Ivo Daalder and Michael O'Hanlon, *Winning Ugly: NATO's War to Save Kosovo* (Washington, DC: Brookings, 2001).

the pilot or the crew in the air. If the plane launches a anti-radiation missile the missile becomes autonomous after launch, so that the pilot is free to take evasive action or launch decoys. Most medium or long-range SAMs require guidance and/or illumination of the target by a ground-based radar throughout the engagement sequence. Destroying or shutting down the radar while the SAM is in flight will hence cause the missile to miss its target.

4.3 Taking stock of countermeasures

Without delving into number crunching, or into a level of detail incompatible with unclassified publishing, it seems that NATO – in reality mainly the USA – has a fairly wide set of measures available to counter the threat from Russian A2/AD systems in the Baltic Sea region. Moreover, this menu is likely to widen and improve in the coming years as equipment and training for SEAD, including its associated electronic dark arts, have been receiving much more attention of late.[140]

The combination of countermeasures that might be applied, and in what proportion, would probably depend on a number of factors, such as:

- the nature of the conflict (e.g. crisis or war);
- the time available for countermeasures (time-urgent or deliberate);
- what was at stake (e.g. NATO access, the county of Narva, or the whole of Estonia);
- the amount and type of force already used by Russia;
- whether the response was from NATO or from a coalition of the willing within the alliance;
- whether NATO members or partners close by participate in or support the action;
- the amount and type of forces available;
- the level of force authorized and any restrictions applied;
- whether Russian forces in Kaliningrad were used offensively, or just defensively, or as a fleet in being.

4.3.1 Anti-air systems

Probably the least difficult threat to tackle is the much talked about threat from long-range SAMs, such as the S-400 and S-300, especially in the Kaliningrad exclave. While impressive in many respects, their effective range is restricted by

[140] Pietrucha, "The Need for SEAD Part I…"; Pietrucha, "The Need for SEAD Part II..."; Thomas Withington, "The Need for SEAD", *Armada International*, 24 August, 2017.

the curvature of the Earth and by their dependence on ground-based radars. These limitations make them mainly a long-range threat to large aircraft flying at high altitudes, such as tankers, transports and AWACS, while the effective range against tactical aircraft or missiles flying at lower altitude is considerably shorter.

With their present deployment in Kaliningrad, this means that the threat to large aircraft over the Baltics could largely be avoided by rerouting those aircraft somewhat, in combination with escort jamming. Similarly, the ingress/egress route of tactical aircraft and cruise missiles could be adjusted to avoid the much smaller area close to the SAM site where these missiles would be a threat.

However, such measures would not suffice when it comes to large aircraft flying into airports in Lithuania, south-western Latvia or north-east Poland. Fighter aircraft operating in the same airspace would have to fly at lower altitudes to stay safe from the S-300/400, which would increase fuel consumption and might increase some other risks. In addition, even if the protective bubble of each S-300/400 battery only has a radius of 35 km, these bubbles could have the cumulative effect of creating a zone where Russian aircraft were relatively safe and where Western aircraft and missiles would need the aid of countermeasures to reach their targets with acceptable risk.

This problem could either be addressed by soft-kill countermeasures, such as jamming or decoys, or be met head on by first neutralizing the SAM batteries. Here, the characteristics and vulnerabilities of the S-300 and S-400 systems come into play. While the Russians are very good at operational deception (maskirovka) and the use of mock-ups and inflatable decoys, the components of S-300/400 units are large and therefore hard to hide when they are ready for use. In particular, for as long as the 40N6 missile is not operational, the long-range engagement capabilities of S-300 and S-400 batteries are dependent on a single engagement radar to illuminate targets during much of the trajectory. While transmitting, that radar can be easily located – and if that radar is knocked out the battery becomes next to useless.

The short- (9M96) and medium-range (9M96DM) missiles for the S-400-system, however, have active seekers and are thus not dependent on illumination from the ground during the whole flight. But they cannot still be labelled – except at comparatively short ranges – as true fire-and-forget-missiles as they require updates of target-data by data link from the ground station while in flight. If and when the 40N6 missile becomes operational with S-400 batteries, it remains to be assessed how good it is at operating in an active mode. If well-functioning, it might be possible for it to operate in “fire and forget” within perhaps 30-50 km distance from the battery. However, for more distant airborne targets even these missiles will probably depend on updates of the target’s position, course and speed provided from a radar on the ground and conveyed by data link.

Another vulnerability of S-300 and S-400 systems is their capacity to handle multiple targets simultaneously. An S-300 battalion's target engagement radar is reported to be able to handle 12 targets simultaneously and the battalion has 24 missiles available without reloading.[141] Standard Russian practice is to fire two missiles at each target. This means that an attack of more than 12 incoming missiles or glide bombs is likely to overwhelm the S-300 battalion – what in military jargon is called a saturation attack.[142]

Similarly, an S-400 battery can have 16 long-range missiles ready to fire, or 64 medium-range missiles or a mix of the two. A battalion of S-400 consists of two batteries and thus has twice those numbers. Russian sources claim the S-400 system can handle up to 36 targets simultaneously, but the number of missiles and the doctrine of firing two missiles means that a battalion can handle a maximum of 16 targets at the same time with long-range missiles, or 64 targets if only medium-range missiles have been loaded.[143] However, that two batteries in the same battalion should have loaded up with only medium-range missiles seems unlikely, as that would mean yielding the capability to engage at long range. The large long-range missiles of the S-300 and S-400 systems are heavy and bulky (weighing close to two tons), which means that reloading after a salvo has been fired takes time.

These characteristics would seem to allow an adversary to devise a straight-forward saturation attack consisting of escort jamming, dozens of air-launched precision-guided stand-off weapons, and air-launched decoys. The incoming attack will force the battery to light up its engagement radar and reveal its location. Then, once the readied surface-to-air missiles have been expended on incoming decoys and missiles, taking out the engagement radar should not be too difficult.[144]

Alternatively, an S-300 or S-400 unit could be taken out by long-range rocket artillery or by guided glide bombs delivered by stealth aircraft. [145] This, however,

[141] "Profile: Russia's S-300 missile system", *BBC News*, 4 September 2013. However, Kopp says a battery can have up to 8 launch vehicles with four missiles each. Kopp, *Almaz S-300P/PT/PS/PMU/PMU1/PMU2…;*

[142] For a similar argument, see Sebastien Roblin "S-400: The Air Force's Ultimate Nightmare or Over-Hyped?" *National Interest*, 17 July, 2018.

[143] Frühling and Lasconjarias, "NATO, A2/AD…".

[144] When doing the maths on such an engagement, the fact that batteries deployed in proximity of each other could provide protection, and that Pantsir units are likely to be detailed for close-in defence would have to be factored in.

[145] The Small Diameter Bomb (SDB or GBU-39) has flip-out wings and a stand-off range of about 100 km if dropped at high altitude. It is very well suited to take out targets such as air defence

requires reasonably reliable data on the battery's location, something drones or special forces could contribute to, particularly in the small and accessible Kaliningrad exclave.[146]

Finally, account needs to be taken of the fact that the track record of Russian-made air defence systems against Western or Israeli airpower in Syria is less than impressive (see Appendix 1). The loss of an Israeli F-16 to Syrian SAMs in February 2018 was a reminder that the IAF has operated without losses in Syrian airspace for more than three decades.[147] The USA and its allies have successfully conducted two major raids on Syrian compounds associated with chemical warfare, in 2017 and 2018, without any effective response from Syrian or Russian air defences. Furthermore, as part of Operation Inherent Resolve against the Islamic State (IS) in Syria and Iraq, coalition air forces have conducted a good-size air campaign in Syrian airspace for four consecutive years.[148]

That said, prudence would seem to call for avoiding sending high-value aircraft within the effective range of these batteries before they have been neutralized one way or another. Similarly, it would be prudent to factor in a higher success rate for Russian short- and medium range air defence systems (not only the 9M96/9M96DM-missile and the Pantsir system, but also the SAM-systems attached to maneuver units, such as the SA-15 and SA-17) in a Baltic conflict than has been the case in Syria. Finally, having several different types of air defence systems integrated in the same area – e.g. the Kaliningrad exclave – is likely to create synergistic effects and to make the air defence more resilient to suppression.

All in all, this might call for a greater length of time and a greater number of sorties and weapons to be expended before the targets can be confirmed as neutralized and the air defence system sufficiently downgraded. Moreover, short- and medium range SAM-systems of the ground forces would have a limiting effect on NATO use of tactical aircraft and helicopters for other missions in their vicinity as long as these SAMs remain an active threat. As such, whereas Russian A2/AD bubbles may prove far from impenetrable, they could still contribute to a delay in reinforcement – a vital effect in the Baltic Sea theatre of operations, where Russia would be likely to seek to end any conflict quickly.

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radars and missile launchers, and has been used in Libya and Syria. Robin Häggblom, "The Unlucky Coot", *Corporal Frisk*, 22 September 2018.

[146] Robin Häggblom, "Kaliningrad and the Suwałki Gap – a look from the other side", *Corporal Frisk*, 11 August. 2016.

[147] Isabel Kershner, Anne Barnard and Eric Schmitt, "Israel Strikes Iran in Syria and Loses a Jet", *New York Times*, 10 February, 2018.

[148] See appendix 1 for specifics and references.

4.3.2 Anti-ship systems

Dealing with long-range anti-ship missiles could be a slightly more demanding, but also more limited, challenge. The modern and supersonic Bastion system is intended for use against large high-value surface targets, such as aircraft carriers, and might be used in the Baltic against larger surface combatants, large landing ships or transports. With a reported 300-km or 350-km nominal range and a supersonic approach, when based in Kaliningrad this system would seem to present a threat to NATO sea-lines of communications (SLOCs) to the Baltic states and also to Poland.[149] The older and shorter-range range Bal coast defence system uses a missile analogous to the Western Exocet or Otomat systems of the 1980s, and is thus mainly considered a threat to frigate-size vessels closer to the shore.[150]

What effect Western soft-kill (decoys, jamming) or hard-kill (anti-aircraft missiles, CIWS) ship-borne countermeasures might have against a swarm of incoming Oniks or Kh-35 can hardly be estimated without access to classified sources. However, it seems likely that the countermeasures would have better effect against the older Exocet-analogue Kh-35 than against the newer and supersonic Oniks missile. That said, the high trajectory of the Oniks missile in mid-phase, in combination with its large size, might make it a good target for modern upper-tier long-range air defence missiles such as the US-made SM-2 or the SM-6. But once the Oniks has acquired its target and descended to sea level, and has come within range of more common naval air defence missiles such as the ESSM, it might be a very difficult target for defensive systems.[151]

The missiles used in the Bastion and Bal systems have built-in active radar seekers for the final approach and are not dependent on a separate radar to illuminate the target. Although they would undoubtedly benefit from updates on the target's position when firing at long ranges, they are potentially "fire-and-forget" missiles. This makes the missile batteries easier to hide and harder to target and engage, although they are reported to have to be deployed in the vicinity of the coastline.

A weakness of these coast defence systems is that the practical range of the target-acquisition radars is limited by the radar horizon. When deployed at near sea level the range of the radar against surface targets is 40-60 km. For engaging targets further out, these batteries are dependent on the provision of target data from

[149] "Bastion-P: Costal defense missile system", *Military Today*-website.
[150] "Bal: Coastal defense missile system", *Military Today*-website.
[151] Standard Missile 2 (SM-2) and Standard Missile 6 (SM-6) are the US Navy's most potent and long-range weapons against aircraft and cruise missiles, but also very costly. The SM-2 is semi-active, while the SM-6 has an active radar seeker. Evolved Sea Sparrow Missile (ESSM) is a ship-borne medium-range semi-active air defence missile widely used in Western navies.

another source. If the missiles are to be able to utilize anything close to their nominal range, that source of target data must be airborne or forward-based, and the data must be of reasonable quality. In most cases the missile battery would also need updates of the targets position while the missile is in flight.

This dependence on external sensors makes it possible to limit the effective range of the battery by disabling – using soft- or hard-kill means – the external sensor or the data links connecting the sensor and the battery. Unless a hard-kill of the sensor or the link is achieved, however, it might be difficult to ascertain whether it has truly been disabled, and thus whether it is safe to send ships within range of the missiles.

Furthermore, the possibility must be considered that the battery might fire based on lower-grade target data provided by submarines, aircraft, drones, satellites, listening stations or rapporteurs on civilian ships.

Here, the circumstances of the conflict matter greatly. If it is an article 4 situation (a serious threat to an ally, but not yet an armed attack), or soon after hostilities have commenced, the seascape is likely to be filled with civilian ships. While this might make it possible to use an automatic position reporting systems to determine the identity of targets, the presence of numerous civilian ships ups the ante and it becomes risky to shoot from the hip. If, on the other hand, the sea is devoid of ships other than the adversary's, it is less risky to fire at an unknown echo or on somewhat dated data.

All in all, and factoring in that a single ship can carry a lot of crucial resources, making a loss potentially catastrophic (cf the loss of *SS Atlantic Conveyor* in the Falklands war), prudence calls for hedging bets on being able to disable remote sensors or finding and neutralizing all anti-ship missile batteries. Such efforts need to be combined with a robust capability to protect ships or convoys by electronic jamming, decoys and a multi-layered anti-missile defence.

Thus, the effect of the land-based anti-ship missile threat may be that reinforcement and resupply by sea – necessary for bringing forward heavy units – to the Baltic states may be delayed or have to be re-routed, and that the existence of a lingering residual threat will increase the risk of such transports.

4.3.3 Land-attack systems

Land targets are both much more numerous and less obvious than aircraft or ships, which makes it well-nigh impossible to protect all possible targets with countermeasures against missiles. It is therefore necessary to get a better measure of the size and nature of the threat before considering countermeasures.

The Iskander-M, Iskander-K and Kalibr missiles deployed in Kaliningrad represent a significant threat to both fixed and moveable high-value targets in the southern Baltic Sea region. By striking such targets as airbases, long-range missile bases, troop concentrations, command centres, communication nodes or critical transport infrastructure, Russia could potentially significantly delay or weaken a NATO response to aggression.

Even if these missiles are not fired, they can put Western high-value targets at risk, a capability that can be useful both for coercion and for deterrence in a crisis or war. Moreover, the capability to swiftly and with great certainty strike high-value targets in an opponent's rear areas forces a rational opponent to take compensatory measures (such as hardening, redundancy or dispersal) or to devote resources for the protection of sensitive targets (e.g. anti-missile defence).

Much has been made in the media about the Iskander missile brigade in Kaliningrad, and its deployment has already had an effect on Sweden's defence policies, as is discussed in chapter 5. However, in strict military terms, the impact of a unit that can fire 24 missiles with 500–700-kg warheads, and as many in a second salvo 30–60 minutes later, is limited as long as the warheads are not nuclear. Moreover, as the US Aegis Ashore installation in Poland is likely to be a priority target (for destruction or just for holding at risk), and as Kaliningrad cannot count on receiving more missiles during a war, at least one battalion's worth of missiles (8 + 8) has to be set aside for that task. This leaves only 16 + 16 Iskander-M missiles for all the other targets in the southern Baltic region.[152]

Furthermore, there will almost certainly be a need to hold short-range ballistic missiles in reserve for nuclear use, especially in Kaliningrad which is both vulnerable and within range of several very high-value NATO targets. If 25 per cent of the remaining 16 + 16 Iskander-M missiles are on nuclear withhold, that leaves only 12 + 12 missiles for the rest of the entire target set in the south.

The missile brigade at Luga has as many missiles as the brigade in Kaliningrad, but has a less target-rich environment and less need for nuclear withhold. In addition, it can easily be resupplied with additional missiles. It can therefore be expected to focus more of its firepower on high-value targets in the Baltic states, in southern Finland, and – if the range so permits – possibly also in the Stockholm area.

With regard to countermeasures against the threat from Iskander-M, trying to locate and disable the launchers using hard-kill means is probably a non-starter. Finding and striking such easy-to-hide assets in enemy territory is notoriously

[152] However, simply having extra missiles in storage in the exclave might be an option.

difficult, as the futile hunt for Iraqi Scud missiles in the first Gulf War demonstrated.[153]

The limited number of Iskander-M missiles available for strikes against "normal" targets, especially in the south of the Baltic region, in combination with the large number of potential targets, also makes the costly option of ballistic missile defence against Iskander-M seem less self-evident.[154] However, the prospect of the break-down of the Intermediate-range Nuclear Forces (INF) treaty which bans ballistic missiles with a range between 500 and 5500 km, may change this calculus.[155]

Regardless of the utility and cost-effectiveness of ballistic missile defence, however, passive countermeasures such as dispersal of assets, camouflage and redundancy would seem to be a necessary and low-cost way of reducing the problem and mitigating the consequences.

When it comes to dealing with the threat from cruise missiles, the problem is qualitatively different. While the number of land-attack cruise missiles deployed to the region is still rather modest – probably 48 + 48 Iskander-Ks and 16 Kalibr on corvettes – this is largely irrelevant because of the very long range of the new generation of Russian cruise missiles.

To paraphrase Tom Lehrer, what matters is not where the missiles go up, but where they come down. The threat to the Baltic Sea region from cruise missiles is not a function of the number and types of missiles deployed there, but of the number and type of Russian cruise missiles that can hit targets in the region. Even if there were no cruise missiles whatsoever in the region, numerous targets could still be hit by missiles fired from ships in the Black Sea or the Caspian Sea. Similarly, Kh-101 air-launched land-attack cruise missiles – which are reported to have a range of more than 2500 km – if launched from bombers flying over Moscow could hit targets anywhere in Europe.[156]

The fact that Russia has now acquired the type of long-range precision strike cruise missiles that the USA has had for 30 years, and is taking advantage of the intentional gaps in the INF treaty put there by the USA, is immensely important politically and militarily. It means that a huge set of civilian and military fixed

[153] Eric Schmitt, "Pentagon Claims on Scuds Disputed", *New York Times*, 24 June 1992.
[154] Cf. Robin Häggblom, "The Iskander Threat", *Corporal Frisk*, 21 February, 2019.
[155] David Herszenhorn, "Mike Pompeo says US will quit nuclear treaty in 60 days: In ultimatum to Putin, US secretary of state demands compliance with INF accord", *Politico*, 4 December 2018.
[156] "Kh-101/Kh-102", *CSIS Missile Threat Project;* "Russia hits Islamic State in Syria with advanced cruise missiles," *Reuters*, 5 July, 2017.

targets in Europe and the USA – long considered to be safe – can now be held at risk or destroyed, conventionally and with high-precision.

This is a qualitatively new threat that warrants consideration of wide-ranging countermeasures both passive, such as dispersal, camouflage and hardening, and active, such as a much upgraded air defence of especially valuable targets. Due to its lack of geographic limitations to a specific region, however, it does not merit further discussion in the context of Russian A2/AD capabilities in the Baltic Sea region.

4.3.4 Asymmetric and indirect options

So far, almost all the countermeasures assessed in this chapter have been direct and symmetric in that they address the problem of Russia's A2/AD capabilities in the region head-on. However, there is also a need to consider three indirect or asymmetric options for handling the problems that Russian A2/AD assets in the Kaliningrad exclave pose for the reinforcement, resupply and defence of the Baltic states.

4.3.4.1 A more robust forward presence

One way to reduce the impact of Russia's capabilities to interfere with NATO's lines of communications would be to reduce NATO's dependence on early reinforcement in a crisis or war by stationing, in peacetime, substantially more combat forces, equipment and supplies in the three Baltic states and in north-western Poland.[157] A 2016 RAND study concluded that the presence of a mechanized brigade in each of the three Baltic states, in addition to local forces and those that could be swiftly deployed there, might make a Russian attack seem a risky proposition.[158] Adding a bit of extra rocket artillery and medium-range air-defence, which the national Baltic forces currently sorely lack, would also be worthwhile.[159]

While such a proposal makes eminent sense from a military point of view, would make the Baltic states safer and would also eliminate or greatly reduce the strategic instability emanating from the current Russian advantage in the region, it runs into three substantial obstacles in the short run.[160]

The first obstacle is the current dearth of high-readiness mechanized units for this task within NATO. A 2017 RAND study concluded that the major European

[157] Colby and Solomon, "Facing Russia: Conventional Defence…"
[158] Shlapak and Johnson, *Reinforcing Deterrence*…
[159] Dalsjö, "Baltikum".
[160] On the strategic instability created by the current military vulnerability of the Baltic states, see Dalsjö, *Brännpunkt Baltikum*.

NATO member states would be hard-pressed to field a heavy brigade each within a month, and a recent FOI study of Western military capabilities yielded similar results.[161] In addition, following the defence cuts of US Secretary of Defense Donald Rumsfeld and President Barack Obama, the US Army only has some 16 heavy brigade combat teams in its entire active force, with few to spare.[162]

The second obstacle is the current lack of suitable infrastructure (especially barracks, garages, workshops, storage and training areas) for lodging three heavy NATO brigades in the Baltic states. Finding room for the eFP battalion combat groups has already strained Baltic resources, with the result that some Baltic soldiers had to sleep in tents.

The third obstacle to creating a more robust forward presence, which could provide deterrence and defence on NATO's eastern "flank",[163] is political in nature. There is a widespread belief within the Western strategic community that a permanent presence of substantial combat forces on the territory of the "not so new" NATO member states would violate promises made to Russia in the NATO-Russia Founding Act (NRFA) of 1997.[164]

However widely held and deeply felt this view is, there is nothing to support it either in the text of the agreement, or in its negotiating history. While a commitment not to station nuclear weapons on the territory of the new members was indeed made, the commitment not to "station additional permanent stationing of substantial combat forces" (also made in the NRFA) has no linkage whatsoever – explicit or implied – to the new member states.[165] Thus, it might as well apply to the whole of Europe – and also have the force levels of 1997 as its baseline.[166]

Moreover, this later pledge was explicitly made contingent on "the current and foreseeable security environment". It would be difficult to argue that there has not been a radical change in those circumstances since 1997, or that this change is not due to the belligerence and aggressive acts of Russia. Thus, it could be argued that Russia has itself abrogated the NRFA by its actions and attitude.

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[161] Michael Shurkin, *The Abilities of the British, French, and German Armies to Generate and Sustain Armored Brigades in the Baltics*, RAND RR-1629-A (Santa Monica, CA: RAND, 2017); Pallin, ed., *Västlig militär förmåga*… .

[162] IISS, *The Military Balance 2018*.

[163] This is really a misnomer as "front" would be more correct, but "eastern front" has certain connotations…

[164] *Founding Act on Mutual Relations, Cooperation and Security between NATO and the Russian Federations, signed in Paris, France*, 27 May 1997.

[165] William Alburque, *'Substantial Combat Forces' in the Context of NATO-Russia Relations*, Research Paper Nr 131, June 2016 (Rome: NATO Defence College, 2016).

[166] Interview with a key participant in the negotiations, Tallinn, 13 May 2017.

These facts notwithstanding, it is a political fact of life that large parts of the political class in some major NATO member states (not just Germany) believe in the myth of the "no substantial forces" pledge, or are otherwise loath to take steps that would antagonize Russia or that could be labelled provocations. Thus, it appears to be difficult to move forward on this issue rapidly without jeopardizing an often fragile NATO consensus on policy vis-à-vis Russia.

Thus, although a highly sensible proposal for the medium term (and the short-term stationing of long-range artillery and ground-based air defence should certainly be considered), the stationing of heavy maneuver brigades in the Baltic states does not seem to be a viable short-term solution to the A2/AD problem.

4.3.4.2 Deterring the use of A2/AD assets in Kaliningrad

Western writers are almost unanimous in seeing the Kaliningrad exclave as a heavily armed and strongly fortified bastion in the midst of NATO's eastern member states; a Gibraltar of the North capable of projecting power far afield and into NATO's rear. However, seen from Moscow's perspective, the Oblast can appear a small and vulnerable island surrounded by NATO's territory and forces – isolated far forward of Russian lines with little chance of resupply in case of war. Moreover, the Kremlin is constantly concerned about the risk for loss of control over peripheral parts of its empire, especially this former German territory.[167]

First and foremost, it should be recognized that the lines of communications to the Baltic states are much less under threat from forces in Kaliningrad than those to West Berlin were throughout the Cold War. Although all communications to West Berlin had to pass through East German territory or airspace, the Russians only tried to cut these during the Berlin blockade of 1948–1949. This was never tried again during later crises, such as those in the early 1960s. Moreover, even during the Berlin blockade, Russia did not dare to fire on NATO aircraft keeping Berlin alive by air. More recently, during US and Israeli air strikes in Syria, Moscow has refrained from firing on strike aircraft or missiles, even when the targets have been close to Russian base areas and Russian lives have been lost.[168] Thus, one option in case of a crisis short of war could simply be to let air traffic and shipping flow to the Baltic states and to dare the Russians to start World War 3 by firing on them.

Second, it has been suggested that NATO could leverage the exclave's vulnerability and Moscow's fears of loss of control in order to deter Russia from using

[167] Westerlund, *Russia's Military Strategy*…; Frühling and Lasconjarias, "NATO, A2/AD…".
[168] Reuters, "Russia Says a Military Aircraft Vanishes Near Syria During Israeli, French Strikes", *New York Times*, 18 September, 2018; Starr and Browne, "Syrian regime accidentally…".

its long-range A2/AD assets to interfere with NATO's lines of communications to the Baltic states in a crisis or a limited war. By reinforcing maneuver forces adjacent to the exclave, adding long-range fire, and exercising this force, NATO could signal to Russia that it has the option of neutralizing Kaliningrad through offensive action.

Thus, it is argued, the exclave can effectively be held hostage to Russian restraint in the use of long-range assets there. This would create a strategic dilemma for Russia because offensive use of the A2/AD assets in Kaliningrad might also mean losing not just the assets, but Russian control of the exclave.[169] On the other hand, it might be difficult to reach agreement on such a course of action within NATO, as offensive action against Russian territory could be seen as too escalatory in itself, or because assets there play a critical role in the defence of mainland Russia.[170]

4.3.4.3 Taking the route through Sweden

There is also the option of avoiding passing through the danger zone created by Russia's A2/AD systems in Kaliningrad by rerouting air and ship traffic through Sweden, using Swedish airspace for vulnerable high-value aircraft such as tankers and AWACS, and possibly also temporarily basing tactical aircraft there.[171]

For transport aircraft from the USA or the UK, flying over Sweden is a natural choice; and for transports from northern Germany or the Netherlands it would only be a minor detour. Landing in Lithuania may be a problem given its proximity to the Kaliningrad exclave, so flights might have to terminate in Latvia.

For ships coming from the Danish Straits or from northern German ports, avoiding a 300-km danger-zone from the Kaliningrad coastline would mean hugging the Swedish coastline, passing west of Öland and west and north of Gotland, before reaching ports in Estonia – or possibly Latvia.[172] Alternatively, freight could be landed in Gothenburg, trucked across Sweden to the east coast and from there loaded on to ships for the final leg to the Baltic states.[173]

Either way, if a 300-km danger zone from Kaliningrad is to be avoided, this means that the major ports of Klaipeda, Liepaja and Ventspils, and possibly also

[169] Frühling and Lasconjarias, "NATO, A2/AD…".
[170] Zapfe, Haas, "Access…".
[171] Häggblom, "Kaliningrad…".
[172] The passage through the Irben Sound, which is the gateway to the bay of Riga, is narrow and difficult, and probably not hard to mine.
[173] This might mean that other goods transports would be temporarily crowded out.

Riga, cannot be used. This is a major drawback of this option, as it only leaves the Estonian big ports of Tallinn/Muuga and Paldiski which are instead both within 300 km of St Petersburg. If instead the danger zone could be reduced to 100 km, for example by neutralizing long-range or forward-placed sensors, things become more favourable for the rerouting option as it leaves all major Baltic ports except Klaipeda reasonably safe for traffic.[174] Of course, there still might be a threat to sea-traffic from aircraft, submarines or mines. While undeniably a risk, managing this would however involve other means than those analysed in this study.

Finally, there is the matter of using Swedish airspace for overflights by tactical aircraft and missiles, and of using airbases and facilities in Sweden, as suggested in two recent reports.[175] The use of airbases and facilities in support of a NATO air operation could range from allowing emergency landings or urgent refuelling, to the temporary forward-basing of several squadrons of fighter aircraft, as is suggested in RAND's Baltic war games.[176]

A glance at the map in combination with a basic understanding of air operations should suffice to see why it could be highly advantageous for NATO to have access to Swedish airspace and Swedish airbases in a crisis or a war in the Baltic Sea region.[177] Some of these advantages – shorter transit routes if operating from bases in the UK, Norway or Denmark, less need for tankers if able to refuel in Sweden and higher sortie rates if operating from bases in Sweden – would apply in part even if there were no A2/AD threat from Kaliningrad. In the presence of an anti-air threat stretching perhaps 250 km from Kaliningrad at an altitude of 10 000 meters, these advantages become more pronounced as basing in the north of Poland or Germany becomes less attractive.

[174] It has not been possible in the context of this study to estimate how much transport capacities would be reduced by taking these alternative routes, but this could be done fairly easily using OR/SA-tools.

[175] Frühling and Lasconjarias, "NATO, A2/AD…"; Shlapak and Johnson, *Reinforcing Deterrence*… .

[176] Shlapak and Johnson, *Reinforcing Deterrence*…

[177] "No island as important as Gotland, says US military chief", *Local*, 24 July 2017.

5 Implications for NATO: A problem but not an impregnable barrier

Having taken stock of Russian A2/AD capabilities and possible countermeasures, what implications do these have? For the transatlantic alliance, the results of this study are comparatively optimistic, suggesting that Russian A2/AD capabilities are less formidable than is frequently claimed, and that an extensive set of countermeasures is readily available. This would require materiel acquisition and the relearning of skills that were once at the core of NATO's mission, and might well justify a further troop presence in the Baltic states. In essence, however, Russia's A2/AD bubbles in the Baltic Sea region pose a significant threat but are entirely burstable – and the Baltic states hence eminently defensible.

While Russian A2/AD capabilities in the Baltic Sea region have grown significantly and require concerted countermeasures, they are far from the impregnable shield many would have us believe.

First, Russia's A2/AD capabilities and the threat they might pose to NATO's freedom of action have been exaggerated. While these capabilities are significant, both technical analyses and reviews from the Syrian theatre, suggest that they are considerably less impressive against moving targets than the marketing hype implies, and more vulnerable to countermeasures than is often appreciated.[178] Against fixed targets, the threat has increased significantly because Russia has fielded a new generation of long-range air- and sea-launched cruise missiles. This threat is not connected to a specific region, however, but applies to the whole of Europe. Even so, in the event of conflict in the Baltic Sea region, these assets could come into play, for instance by holding high-value targets in the Baltic states and neighbouring states hostage by threat of attack, or by attacking infrastructure nodes or military bases to delay NATO reinforcements.[179]

Second, a wider and potentially more effective set of countermeasures to Russian A2/AD capabilities is more conceivable than commonly appreciated. These countermeasures have the prospect of deterring, disrupting, degrading or destroying Russian capabilities to interfere with NATO operations or lines of communication. However, in order to credibly counter Russian A2/AD efforts, NATO will need to rebuild capabilities – such as SEAD – that were allowed to

[178] For first-draft analysis of what can be learned about Russian-manufactured SAM systems from the conflict in Syria, see appendix 1. While there may be several reasons why Russian assets in the Baltic Sea region might be expected to perform better than those in service in Syria, after-action reviews nonetheless illustrate several of the countermeasures that may be used to successfully cope with Russian-manufactured SAM systems.

[179] Försvarsberedningen, *Motståndskraft*, 64.

languish during the Afghanistan years. It also needs to create new ones, including capabilities that leverage the vulnerable geography of the areas where Russia could base A2/AD-systems. This would also to some extent require theatre-specific planning and preparations, potentially including the prepositioning of equipment, target acquisition and joint and/or multinational operations planning and exercises.[180]

Third, in the light of the first and second factors, Russia's A2/AD capabilities in the Baltic Sea region do not warrant giving up the aim of being able to reinforce, resupply or defend the Baltic states. However, NATO member states would have to set aside – or build – assets that could handle the A2/AD problem, and also to allow time for their application in NATO contingency plans, before movement forward of reinforcements or supplies could start in earnest.

Fourth, compared to a scenario without Russian A2/AD in the Baltic Sea region, the need to deal with A2/AD first will mean a delay of some length before reinforcements can start to flow.[181] The higher the level of degradation of threat required, the longer this will take.

Fifth, NATO members and partners that for 30 years have had the luxury of operating aircraft and ships only in peacetime conditions or a permissive environment will have to adjust to operating in the warlike conditions of a contested environment, to protect vulnerable assets, and to accept a certain level of risk of losses.

Sixth, in the light of the fourth and fifth factors, it seems warranted for NATO to consider reducing its dependence on early and rapid reinforcement for the defence of exposed member states in favour of having a more robust forward presence in place.[182]

[180] It would be odd if elements of this were not already included in the some of the increasingly numerous and complex exercises in the region in recent years, such as ACE, Aurora, Baltic Coasts, Trident Juncture and Saber Strike. For instance, in October 2016, the US military's Joint Staff war-gamed four different scenarios in Latvia in which Russia used drones, cyberwarfare and media manipulation. Schmitt, "US Lending Support…".

[181] Bringéus, *Säkerhet i ny tid*…, 46-47.

[182] Karl Mueller, David Shlapak, Michael Jonsson and David Ochmanek "In defence of a wargame. Bolstering deterrence on Nato's Eastern Flank". *War on the Rocks*, 14 June 2016.

6 Implications for Sweden: A defence- and security-policy challenge

For Sweden, drawn into ever closer collaboration with NATO by the prospect of an armed conflict in the Baltic Sea region, the study reinforces the strategic conundrum that the country has faced since the Russian annexation of Crimea.[183]

The perceived heightened risk of a war in the Baltic Sea region and particularly of a Gotland grab has already forced a paradigmatic shift in the country's security and defence policy.[184] While no longer officially neutral since joining the EU, Sweden has still maintained its military non-alignment. But now a consensus has formed among its political class and the defence establishment that the country would be likely to be drawn into any conflict in the Baltic states.[185] Hence, Sweden now collaborates closely militarily with Finland, the USA and other NATO member states. To the extent that military exercises should be interpreted as outward signalling, the country is preparing to defend itself "together with others".[186]

With insufficient military capability to repel large-scale Russian aggression on its own, Sweden has thus gradually deepened military collaboration with the USA, Finland and other neighbouring states, while reiterating its military non-alignment.[187] To uphold its part of the implicit bargain with the USA, however, the Swedish Armed Forces need to be capable of deterring and if need be repelling any attempt to use Swedish territory to deploy hostile A2/AD systems.

Beyond this, there is a broad spectrum of possible actions Sweden could take that would greatly facilitate defence of the Baltic states in the event of a conflict.[188]

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[183] See for instance Bringéus, *Säkerhet i ny tid…,* 42-48; Försvarsberedningen, *Motståndskraft*, 61-64, 71.

[184] Bringéus *Säkerhet i ny tid*…, 76; Dalsjö, "Sweden and its…".

[185] Bringéus, *Säkerhet i ny tid*…, 46-47; Försvarsberedningen, *Motståndskraft*, 61, 63, 73-74.

[186] In spite of Sweden being militarily non-aligned, senior decision makers have taken to repeatedly stating that the country is pursuing its defense policy "together with others". Commenting on the 2017 Aurora exercise, Swedish Chief of Defence Mikael Bydén for instance commented that "[w]e have security-politics solution [eg. policy] in Sweden where we are building security together with others in the broader context". Joel Wendle "ÖB Mikael Bydén om Aurora: Vi lär oss mycket" *Sveriges Radio*, 13 September 2017.

[187] Cf. Robert Dalsjö, "Sweden and its deterrence deficit: Quick to react, yet slow to act", in Nora Vanaga and Toms Rostoks, eds., *Deterring Russia in Europe: Defence Strategies for Neighbouring States* (Abingdon: Routledge, 2018). According to Bringéus, it is difficult to draw any other conclusion than that "Sweden – like the other European countries – is dependent on support from other states and organizations in order to uphold its sovereignty in a crisis". Bringéus, *Säkerhet i ny tid*…, 54.

[188] Bringéus, *Säkerhet i ny tid*…, 47.

None of these would be uncontroversial with the Swedish public, however, and each would significantly strain political cohesion within the country.

With this in mind, Russian A2/AD capabilities are likely to push Sweden to continue on the trajectory on which it has already embarked, with ever-closer collaboration with its Nordic neighbours and the USA, and steadily growing military capability and budgets. Importantly, further improvements to Russian A2/AD capabilities would probably only serve to reinforce this dynamic, not deter it.[189]

6.1 In peacetime

Following the annexation of Crimea, there was a rude awakening in Sweden regarding critical gaps in the Swedish Armed Forces' capability to defend the national territory. These weaknesses per se had been known for some time. In 2012, the Chief of Defence let slip that the armed forces could only defend a small part of the country for a week and in 2013 Russian strike aircraft conducted a mock attack on targets in Sweden.[190] At the time, one close observer noted that due to underfunding, "[f]undamentally, Sweden no longer has a military capable of defending itself or securing the Baltic Sea around it".[191]

When coupled with a demonstrably assertive and aggressive Russia, these vulnerabilities quickly became intolerable to the Swedish public and policy makers.[192] In 2014, a submarine hunt further highlighted severe gaps in Swedish anti-submarine warfare capabilities and Russian fighter aircraft acted increasingly aggressively over the Baltic Sea. At the same time, the improved Russian A2/AD capabilities also raised the prospect of a Gotland grab that – with the island de facto demilitarized at the time – could have allowed Russia to establish a keep-out zone in the central Baltic Sea.[193] This made it possible to envisage a scenario in which Russia might think it could win a limited war in the Baltic states, and thereby rupture NATO cohesion, through an incursion into Sweden.[194]

[189] Dalsjö, "Sweden and its…".
[190] Mikael Holmström, "Försvar med tidsgräns", *Svenska Dagbladet*, 30 December 2012.
[191] Charly Salonius-Pasternak, *Will Sweden become a net consumer of security – or will Svea wake up to assume its traditional role as a stabilizing power in the Baltic Sea?* Finnish Institute of International Affairs, FIIA Comment 19, 29 November, 2013.
[192] On the impact of these events on public and political support for a stronger defence posture, see Dalsjö, "Sweden and its…".
[193] Emma Fagerberg "Hotet mot Gotland" *Horisont Magasin*, 30 May, 2016; Krister Bringéus, *Säkerhet i ny tid. Betänkande av Utredningen om Sveriges säkerhets- och försvarspolitiska samarbeten* SOU 2016:57 (Stockholm: Wolters Kluwer, 2016), 46–47.
[194] Bringéus *Säkerhet i ny tid*… 42–48;

Since 2014, these dynamics have forced a tectonic shift in Sweden's security and defence politics, making them reminiscent of the pragmatic solution during the Cold War, when formal neutrality was coupled with close but highly classified cooperation with the USA.[195] First, the assessment that control of Gotland (and the Danish island Bornholm) would be vital to ensuring control of the southern Baltic Sea became broadly accepted in defence policy circles, and gradually among the broader public as well.[196] This implied that Sweden would be likely to be drawn into a conflict in the Baltic states in its early stages.[197] At the same time, the annexation of Crimea and the increasingly tense situation in the Baltic Sea region led to the perception that the risk of an armed attack on Sweden – which was earlier deemed close to unthinkable – "cannot be excluded", in the words of an official defence White Paper.[198]

To decrease the temptation to simply put troops on demilitarized Gotland, in 2016 a company of light infantry was hurriedly deployed to the island. The deployment occurred a year ahead of schedule and was quickly transformed into a permanent presence of a mini-battlegroup, consisting of a standing mechanized infantry company and a part-time tank company.[199] In the 2017 large-scale, multinational joint Swedish exercise, Aurora, one component of the scenario involved Swedish and Finnish troops jointly defending Gotland.

Swedish security politics have also become increasingly intertwined with those of its neighbours and NATO. Sweden and Finland have gradually deepened military collaboration, representing a paradigmatic shift away from both countries' traditional neutrality.[200] Collaboration between the Swedish and Finnish Armed Forces has also gradually deepened, with particularly close ties between the respective air forces and navies, but gradually deepening ties between the armies too. With Gotland viewed as an "unsinkable aircraft carrier" and key to defending the Baltic states, there has also been a growing mutual interest in increasing military collaboration between Sweden and the USA, manifest both through doctrinal security politics and military exercises.[201] In 2015, the Swedish

[195] For a full history of Sweden's collaboration with the US during the Cold War, see for instance Robert Dalsjö, *Life-Line Lost: The Rise and Fall of 'Neutral' Sweden's Secret Reserve Option of Wartime Help from the West* (Stockholm: Santérus Academic Press, 2006).

[196] Försvarsberedningen, *Motståndskraft,* 74; Fredrik Sjöhult "Varningen till Sverige – när Baltikum rustar för krig". *Expressen*, 16 July, 2018.

[197] Försvarsberedningen, *Motståndskraft*, 62-63; Fagerberg "Hotet mot Gotland".

[198] Försvarsberedningen, *Motståndskraft*, 61.

[199] Niklas Granholm, "Did a Top Secret Threat Assessment Prompt Sweden to Deploy Troops to the Baltic Island of Gotland?", *RUSI Commentary*, 28 September, 2016; Associated Press, "Sweden to Re-establish Military Unit on Baltic Sea Island, *Defense News,* 13 December, 2017.

[200] Bringéus, *Säkerhet i ny tid*…, 14-15

[201] Bringéus, *Säkerhet i ny tid*…, 14-15, 84-85; Rahul Krishna, "Inching Closer: The Impact of Sweden's Growing Relationship with NATO, *Atlantic Council*, 22 August, 2016.

and Finnish Defence Forces signed an agreement on deepened defence cooperation.[202] In 2016, Sweden signed an agreement on Host Nation Support;[203] and in 2017 the then US Secretary of Defense Jim Mattis reportedly stated during a visit by the Swedish Minister of Defense, Peter Hultqvist, that: "if Sweden is in need, we will be there".[204] In May 2018, Sweden, Finland and the USA signed a trilateral Statement of Intent, pledging, among other things, to improve practical interoperability and situational awareness in the Baltic Sea region, and improve abilities to conduct combined multinational operations.[205] Taken together, the approach of remaining nominally militarily non-aligned while deepening a set of bilateral military relationships became known as the "Hultqvist doctrine".

With defence spending still hovering around 1 per cent of GDP, in 2018 Sweden announced that it would be buying US Patriot air defence systems.[206] Perhaps equally important, national defence and the armed forces have become a political priority again. Whereas the center-right then-Prime Minister Fredrik Reinfeldt called the armed forces a narrow "special interest" in 2013, in the 2018 election the two largest political parties, the Social Democratic Party and the Moderate Party (liberal-conservative), both promised substantial increases in the national defence budget.[207] Thus, the defence establishment is expecting defence budgets to increase significantly over time. As a result, it could be argued that the growing tensions in the Baltic Sea region and the perceived threat of Russian A2/AD capabilities have forced Sweden to make adjustments – particularly plugging gaps in national defence capabilities and beginning to increase the defence budget – that should have been made a long time ago.

6.2 In a crisis or a war

In the event of a crisis or war in the Baltic Sea region, maritime transport is likely to be disturbed and possibly even halted entirely. This is of particular concern to Finland, which is heavily dependent on maritime transports arriving over the

[202] Finnish Defence Forces & Swedish Defence Forces, "Final reports on deepened defence cooperation between Finland and Sweden", *Regeringskansliet*, 17 February, 2015.
[203] Reid Standish "Fearing Russian Bear, Sweden Inches Toward NATO", *Foreign Policy*, 26 May 2015; Atlantic Council, "Sweden Ratifies NATO Cooperation Agreement, May 25, 2016.
[204] Mikael Holmström "I maktens slutna rum får Sverige amerikanskt stöd" *Dagens Nyheter*, 26 May 2017. This reinforced statements by then-vice president Joe Biden, who stated in August 2016 that "No-one should misunderstand, neither Mr Putin nor someone else, this is inviolable territory! Period". Negra Efendic "Biden: Sverige är okränkbart territorium – punkt", *Svenska Dagbladet*, 25 August, 2015.
[205] Government Offices of Sweden, "Minister of Defense Peter Hultqvist signs trilateral statement of intent", 8 May 2018.
[206] Johannes Hellstrom and Mike Stone, "Sweden seeks to buy $1 billion U.S. Patriot air defense missile system", Reuters, 7 November. 2017.
[207] TT, "Försvarsdebatt irriterar Reinfeldt", *Svenska Dagbladet*, 29 January, 2013.

Baltic Sea, but the country has maintained extensive inventories of food, fuel, medicine and other necessities to be used in the event of a national crisis.[208] Sweden's most important harbour is Gothenburg, facing the North Sea, and the country is thus less acutely dependent on maritime transport over the Baltic Sea. On the other hand, Sweden let its "total defence" concept languish at the end of the Cold War and has only recently begun in earnest to re-establish it. Whereas the need to create inventories of vital supplies – including food – is broadly recognized, this process is mostly in the planning stages.[209] Furthermore, Gothenburg harbour is vital to supplying not only Sweden, but also Norway and Finland, and could therefore be a tempting target for sabotage.

6.2.1 If alone

As outlined above, Russian A2/AD capabilities can be used to exert pressure and limit the freedom of maneuver of the Swedish Navy and the Swedish Air Force. If Sweden decides to act alone in the event of a crisis or conflict in the Baltic Sea region, a basic requirement would be that the Armed Forces are able to deter, or if need be repel or deal with, incursions into its territory. This is particularly the case regarding the forward-basing of SAM systems either on Gotland or on the Swedish mainland.

6.2.2 If together with others

If Sweden on the other hand decides to act "together with others", as the official phrase puts it, there is a spectrum of possible actions to which the Swedish authorities could acquiesce or that they could actively participate in. Each has a set of implications. None would be uncontroversial with the Swedish public and the more extensive the collaboration, the greater the likelihood that Sweden would itself become a target.[210]

- At a basic level, Sweden could agree to share air data and intelligence, and allow overflights, including emergency landings.
- This could be complemented by allowing foreign aircraft to land and refuel, and the forward basing of combat search and rescue (CSAR) assets and other support resources.
- A further step would involve allowing temporary basing of NATO strike aircraft at Swedish bases.
- Sweden could also offer defensive participation, involving fighter aircraft defending Swedish airspace from incursions.
- Lastly, if already drawn into a war Sweden could potentially participate in offensive operations, primarily using fighter aircraft.

[208] Försvarsdepartementet *Motståndskraft*, 172.
[209] Försvarsdepartementet *Motståndskraft*, 170–172.
[210] This list elaborates modestly on observations made in, for instance, Bringéus "Säkerhet i ny tid…", 46–48; For a similar argument, see also Försvarsberedningen, *Motståndskraft*, 73–74.

7 Prospects and conclusions

7.1 Prospects for the future

In a ten-year period following the 2008 attack on Georgia, the Russian armed forces have undergone a marked transformation, primarily becoming mobile, more ready and more combat-capable, but also receiving and learning to use more advanced weapons and systems.[211] During operations in Ukraine and Syria, Russia has largely relied on trusted tools such massed artillery and dumb bombs, but it has also proudly demonstrated some new high-tech capabilities such as long-range precision strike, drones and electronic warfare.

These capabilities came as a nasty surprise to Western military establishments long used to regarding Russia as a somewhat prickly partner and to writing the Russian military off as hopelessly outdated. The shock caused a jump in the curve of Western assessments of Russian military capabilities, in many cases causing them to overshoot. In this, the deluge of boisterous messages about Russia's capabilities and new systems also played a role. That these messages were partly strategic communications intended to boost Russia's claims to have made a comeback as a high-tech world power was seldom factored in in the West.

Elements of braggadocio notwithstanding, the Russian defence industry is still very competent in some sub-sectors, and Russia has made important strides in the production and use of some military technologies in recent years.[212] Examples of this are high-speed weapons designed to defeat missile defences, such as the Zircon anti-ship missile and the Kinzhal air-to-ground missile (which is an air-launched variant of the Iskander-M missile).[213] If these are deployed in numbers – and if they work as advertised – they will increase Russia's capability to penetrate defences to strike at high-value targets.[214]

[211] This development is covered in detail by FOI's Russia-team in the report Russian Military Capability, which is published every three years. The next issue is due out at the end of 2019.

[212] Cf. Persson, ed., *Russian Military Capability*… ; Kjellén, *Russian Electronic Warfare*… ; Dalsjö, *Brännpunkt Baltikum*; Julian Cooper, *Russia's state armament programme to 2020: a quantitative assessment of implementation 2011-2015* FOI-R--4239--SE (Stockholm: FOI, 2016).

[213] Mark Episkopos, "Russia Has Tested Its Tsirkon Hypersonic Missile 'Over Ten Test Launches'", *National Interest*, 23 December 2018; David Axe, "Is Kinzhal, Russia's New Hypersonic Missile, a Game Changer?", *Daily Beast,* 15 March, 2018.

[214] Michael Peck, "Britain Admits that Russian Missiles Can Blow Its New Aircraft Carriers Out of the Water", *National Interest*, 30 April, 2017.

Furthermore, it should be recognized that old technology and brute force can work perfectly well, especially if applied against an adversary which lacks the means to counter them. Russia may have won ugly in Georgia 2008 or in Aleppo, but it won. “Old tanks can kill too”, as our FOI-colleague Johan Norberg puts it.

However, it should be kept in mind that Russia is a country with a GDP comparable to Italy’s or Spain’s and beset with cronyism and corruption, where high-level attempts to modernize the economy and to develop a manufacturing base have failed, and where the economy is essentially based on the extraction of oil and gas. There are thus limits to the technical miracles that can be performed by its engineers and its industry.

Several of the advancements in technology and tactics that Russia has demonstrated for the first time in Ukraine and Syria – precision-guided air-dropped bombs, the use of drones for target-spotting, and long-range precision-guided cruise missiles – essentially reflect a level of sophistication that the US already possessed in the first Gulf War. So, copying these capabilities 30 years later, – at a time when you can buy a drone with satellite navigation and a camera at the local hobbyist store for a few hundred dollars – is not such great feat. Nor is it in itself a sign of technical sophistication, particularly as some of these technologies have been bought from Israel or been pilfered by spies.

Furthermore, while Russia’s defence industries have received ample funding in the past decade, they have also been hit by supply disruptions and embargoes on Western technology since the annexation of Crimea and the war in Donbas. These cut-offs are said to have hit the defence electronics sector of the industry particularly hard, as the dependence on imported parts has been greatest here, due to Russia’s failure to participate in the silicone revolution.

So, while a lot of more advanced capabilities – such as Cooperative Engagement – are technically possible to achieve within 10 to 15 years, and while it is easier to copy an already working concept, any giant strides or dramatic turns in Russian A2/AD-capabilities in the coming years do not seem likely. Nonetheless, there are some low hanging fruit to be picked and also the prospect of importing key technologies or capabilities from Israel or from China.

The lowest hanging fruit is probably a Cooperative Engagement Capability for coastal (or ship-based) anti-ship missiles, which would extend the effective range of such batteries considerably. Acquiring Medium-Altitude Long-Endurance (MALE) drones with a basic sensor kit should not be too difficult, given that the technology for this has now become a commodity. Even a very basic configuration would in effect create an unmanned version of the old-fashioned naval spotter plane, which could be very useful in extending daylight surveillance and engagement ranges beyond the horizon. This would not only extend the effective

range of the missiles, but also increase situational awareness, simplify targeting, and improve battle damage assessment. The addition of a surveillance radar and a signals intelligence kit would be slightly more demanding, but would add a capability for operations in the dark or in cloudy conditions.

Given the fact that already Soviet naval doctrine called for this kind of capacity (albeit using manned aircraft), given the low threshold for acquiring such a capability, and given the high pay-off in operational terms, it would be odd if Russia did not field this capability within 5-10 years.

Achieving a similar Cooperative Engagement Capability against aircraft or missiles beyond the radar horizon would be an altogether different matter, however. The Diagram below indicates the number – but not the magnitude – of the complex tasks involved in the US Navy's development of the first-ever such capability. Nor does the diagram's time-line cover all the necessary preparatory work.

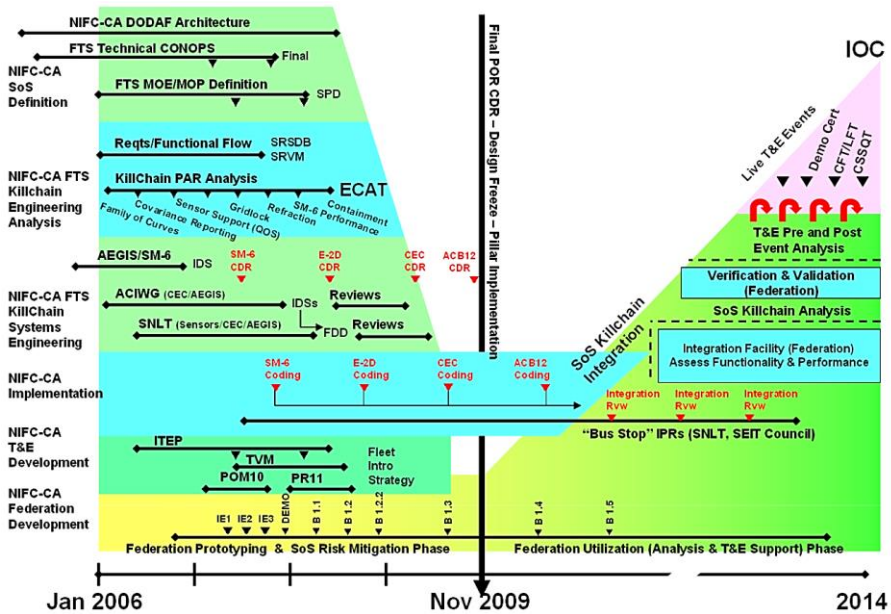

Figure 4: NIFC-CA capability Acquisition and Engineering.[215] .

Before work can start in earnest on furnishing the Russian armed forces with such a capability it will probably be necessary to replace Russia's AWACS-equivalent

[215] McConnell, Jeffrey, *Naval Integrated Fire Control – Counter Air: Capability- Based System of Systems Engineering* (N.p.: Naval Surface Warfare Center, Dahlgren Division, 2013), 7.

(A50 Mainstay) with a much more modern successor, having a digital and active electronically scanned array (AESA) radar. Such an aircraft, dubbed the A-100, exists in prototype and first flew in 2017. But given the extended timelines for development, testing and production in the Russian defence industry in general, and in particular the problems on the electronic side, a fielded capability with these aircraft should not be expected anytime soon. When the time and trouble of developing, testing and producing a working CEC-solution for airborne targets are added, it seems unlikely that this will happen within 10-15 years.

In the West – barring a calamitous collapse of the Transatlantic link – the shift of the defence sector's focus to deter and defend against Russia and China is likely to continue. This means a revival of interest in almost all aspects of high-end warfare against a near peer competitor, including hardware and capabilities relevant to counter-A2/AD, such as SEAD, electronic warfare, precision strike, ISR and long-range fire.

Several allies and partners are also in the process of acquiring land-attack cruise missiles, such as JASSM and JASSM-ER, and/or replacing third or fourth generation tactical aircraft, such as the F-16, with stealthy and highly advanced fifth generation F-35s. Their stealth features make them hard for Russian air defences to detect, while their built-in sensor suite makes it easier to find targets and to avoid threats. With the fielding of the long-range missiles and F-35s on a broad front, and after a period of transition, these assets will cease to be an exclusive resource and NATO's ability to conduct precision strikes against deep targets with strong air defences will increase significantly. Pressure will also increase on allies such as the UK, Germany and Italy to replace aging SEAD-assets with newer gear.

As a result, in the coming 5-15 years there will be new hardware and new or revamped counter-A2/AD capabilities coming on line. First to be fielded – apart from the F-35s - among the new equipment will probably be the results of fast-track projects decided on by the US after Crimea, which can be expected within 5 years:

- updated versions of existing but nearly outmoded gear (e.g. the new version of the radar-homing missile HARM, called AARGM);
- adapting existing systems to fulfil other roles (e.g. the anti-ship missile LRASM);[216]
- mating parts from two existing systems to create a new capability (e.g. the long-range anti-air missile SM-6).

[216] Turning the ramjet-powered anti-aircraft missile Meteor into a long-range high-speed anti-radiation missile seems like an attractive idea that would fill a void.

Most probably there will also be:

- significantly raised capabilities for offensive electronic warfare;
- the adoption or adaptation of systems and practices successfully employed by Israel in Syria (e.g. loitering anti-radiation missiles, such as Delilah, or "kamikaze" drones, such as Harop);
- production of stand-off air-to-ground weapons previously shelved (e.g. JSOW B);
- an across-the-board increase, although not sufficient, in the inventories of precision-guided munitions in the European air forces.

In the longer term, 10-15 years, entirely new systems and capabilities will probably also be fielded, but these lie beyond the remit of this study.

Zooming out from the particulars above, our assessment is that Western capabilities to do counter-A2/AD are likely to increase significantly in the coming 10-15 years, in both an immediate and the medium-term perspective.

However, there are at least three turn of events which could significantly alter or even radically change the picture of the A2/AD-dynamics of the Baltic region presented in this study.

The first is almost a certainty: that the INF-treaty will expire in August 2019, and that Russia and the US thus become free to build and deploy medium-range land-based missiles. The potential political and military implications of the INF-treaty's demise is a major issue that merits a study of its own, and is not further analyzed here, beyond a few points. On the Western side the military impact of this will be almost negligible in the short term, as the US has no medium-range ballistic missiles in production or in development, and the deployment of land-based cruise missiles to Europe would be likely to trigger a political uproar that risked tearing NATO apart.

The military effects of scrapping the ban on Euromissiles are much more significant and immediate in Russia, which could probably rapidly extend the range of the Iskander-K cruise missiles, do likewise with the SSC-8 land-based cruise missile, and start deploying these on the landmass of European Russia. In a slightly longer perspective, Russia could also extend the range of the Iskander-M somewhat and start development and production of truly new Euromissiles. Both of these developments would significantly increase the missile threat to fixed or movable land targets, and thus change the overall correlation of forces in Europe.

The second is a possibility that can no longer be dismissed: that the US pulls out of Europe and of NATO, leaving the Europeans to fend for themselves militarily and politically. This would of course be a turn of events with enormous and wide-ranging ramifications, only one of which would be the withdrawal of the many

high-end military capabilities that are crucial for dealing with and deterring Russia.

The third is more of a Black Swan, that is an unlikely but high impact event: a Russian break-through in the development, production and deployment of high-end, high-tech ground-based air defences. This could for example be if the 40N6 active long-range missile turns out to be as good and well-functioning as its Western quasi-equivalent the SM-6 missile within five years. Or if Russia were able to start fielding a workable Cooperative Engagement Capability against aircraft and missiles within ten years. Though unlikely, this could happen – perhaps as a result of espionage, like with Klaus Fuchs and the A-bomb – and would have major consequences for the balance between Russian A2/AD and Western counter-A2/AD.

Finally, it should be stated that electronic warfare and cyber warfare, or innovations in tactics and procedures, must be considered hidden wild cards. Changes here could potentially have very major effects on both sides, on the individual duel between systems as well as on the overall correlation of forces. If NATO could blind or paralyze Russian air defences or offensive systems by using electronic wizardry, and do this more or less across the board, it would of course have enormous consequences. Similarly, if Russia could successfully unmask stealth or disable Western electronic systems such as satellite navigation, data links and sensors, in and around Russian-controlled airspace, much of the Western supremacy in the air and in long-range precision-strike could be cancelled out.

7.2 Conclusions

Since the beginning of the war in Ukraine, much analytical energy has been devoted to mapping out the military balance of power in northern Europe, primarily centered on the Baltic Sea region.[217] It certainly is a fact that Russia maintains superiority in conventional forces in the region, and thus would have advantages in time and space during the first weeks of a regional conflict. But the main implication of this study is that the prospects for reinforcing the Baltic states in the event of a crisis or war are far less bleak than early analysis indicated. Similarly, a "Gotland grab" would not necessarily shut down access to the central Baltic Sea, as stand-alone systems would be more vulnerable to countermeasures than the multi-layered and thoroughly prepared defences in for instance Kaliningrad.

[217] Shlapak and Johnson, *Reinforcing Deterrence…*.; Pallin, ed., *Västlig militär förmåga…*

It is however our firm conclusion that Russian A2/AD capabilities, while undeniably substantial, to date do *not* create any large, impenetrable bubbles, and maximalist claims regarding their range and precision tend to shrink on closer inspection. While admittedly an imperfect test or comparison, analyzis of air operations over Syria likewise suggest that even late-model Russian-manufactured air defence systems can be vulnerable to a range of counter-measures, as illustrated by Israel. Beyond individual weapons systems, the study has identified a wide range of possible counter-measures – direct and indirect, passive and active – that can be employed.[218] Recognizing this, and further exploiting such vulnerabilities, makes any would-be Russian military adventure in the Baltic states more risky, and thereby less tempting. Hence, Western possession of such counter-A2/AD capabilities should not be considered destabilizing or aggressive, but as an important contribution to regional stability.

The overarching conclusion that Russia's A2/AD-capabilities are a problem that can be handled is, however, contingent on two basic conditions. First, that Western countries – primarily but not exclusively the U.S. – continuously relearn and further develop the capabilities needed for swift and successful counter-A2/AD operations, including SEAD. This involves the entire cycle from procurement of critical equipment, through training and planning, via the development of tactics, techniques and procedures, to joint and multi-national exercises. Signalling intent and capability to prevent attempts to create a Russian A2/AD-barrier will be a vital component in broader, multi-domain deterrence in the Baltic Sea theatre henceforth. Furthermore, as these capabilities are predominantly American, unequivocal US resolve to uphold its Article 5 commitments remains a cornerstone of Western deterrence. The US will remain critical to guaranteeing a "Europe – whole, free and at peace" [219] for the foreseeable future.

However, it also seems necessary for European powers to substantially improve their own counter-A2/AD and SEAD capabilities – which beyond acquiring the stealthy F-35s as many NATO allies are now doing – would require also vital add-on capabilities such as precision-guided munitions including radar-homing missiles.

The second condition is that Russia is not able to develop – more quickly than anticipated – some of the capabilities mentioned above. If the 40N6 missile is now – after several false starts – finally entering production lines, that would bring the maximum technical range of the S-400 system to its much-cited 400-km radius.[220] It remains to be seen how the missile performs and how much time

[218] C.f. chapters 4.1-4.2, for further elaboration of these options.
[219] Bush, *"*A Europe Whole and Free".
[220] Gady, "New Long-Range Missile…".

elapses before it enters service. But target acquisition and accurate guidance over extended distances still requires an external radar, for all but high-altitude targets. A more critical development would be if the Russian Armed Forces acquire Cooperative Engagement Capability against aircraft and missiles in a shorter time than the almost two decades it reportedly took the U.S. Navy. But that is a big if, given the technical problems that the Russian defence industry has experienced of late. That said, the Russian Armed Forces have made remarkable gains in their A2/AD capabilities since military reforms began in 2008 and have fielded several of their most capable systems in the Baltic Sea region over the last few years. Taken together, this means that Russia's capabilities have improved significantly. Hence, while there is still room to further develop Western capabilities, there is absolutely no time for complacency.

This study has combined in-house technical expertise at FOI with a broad-brush politico-military analysis of the implications of Russian A2/AD capabilities for the correlation of forces in the Baltic Sea region. Given the breadth and complexity of the topics covered, several components of the study could certainly benefit from more in-depth analysis and detailed empirical data. These include but are not limited to lessons from the Israeli air campaign against Iranian targets in Syria; a gap analysis of NATO assets for conducting a counter-A2/AD campaign in northern Europe; tabletop exercises to war-game scenarios involving use of A2/AD to support the rapid creation of a *fait accompli*; and target system analysis of Russian A2/AD-systems. For obvious reasons, such studies would typically be classified. But this study has hopefully shown that open-source data, politico-military expertise, and deep technical know-how can be usefully combined to produce a more realistic assessment of capabilities – in the process also rebutting unrealistic reports of capabilities and debunking myths that are based on propaganda and marketing statements.

Finally, an important caveat should be added – while this is our best estimate of the matter at hand, it is not any forecast of how things would play out in a conflict or a war. A desk-based analysis conducted in peacetime can never capture all the factors and dynamics of a shooting war. This is especially true when not analysing individual weapon systems, but synthesizing how confrontations between complex, multi-component systems would pan out, the intended usage and relative strengths and weaknesses of which remain closely guarded secrets.

Appendix 1: Air operations in Syria

Syrian air defences consist of Soviet/Russian-made materiel and the crews are trained according to Russian doctrine. The backbone of the Syrian air defences are modernized versions of Soviet-era systems such as the S-200 and SA-17 Buk, although recently newer systems such as the SA-22 Pantsir S1 have been added. Russian sources claim that the Syrian air defence system has been completely rebuilt recently and that operators have had "excellent training" by Russian specialists.[221] Russia has also formally declared that it has joined its own air defence system with that of Syria.[222]

However, this supposed jointness did not prevent Syrian missile crews in September 2018 from totally missing four Israeli F-16 that dropped glide bombs on targets near Latakia, but instead shooting down a Russian Il-20 electronic surveillance aircraft keeping watch just off the Syrian coast.[223] There is also reason to doubt that the Il-20 detected incoming Israeli F-16s and/or relayed this data to the missile crews.

A planned sale of S-300 systems to Syria in 2013 did not go through, reportedly due to pressure from the USA and Israel.[224] One of the pressure points may have been that if the S-300 were to prove ineffective against Israeli aircraft, its attractiveness on the export market would be ruined.[225] But after the debacle of the shoot-down of the Il-20, the sale has gone through and the equipment has reportedly been delivered.[226] Russia has also deployed its own S-300V4 (the most modern version of the S-300) and S-400 systems, as well as its most modern Su-35 and Su-57 fighters to Syria, ostensibly for the protection of Russian bases on the coastal strip, but these systems so far remain under Russian control.[227]

[221] Beaumont and Roth, "Russia claims…"; Judah Ari Gross, "'Operation House of Cards', the IAF mission to cripple Iran's presence in Syria", *Times of Israel*, 10 May, 2018.
[222] McDermott, "Russian Air Defense…".
[223] Starr and Browne, "Syrian regime…".
[224] Ron Friedman, "Russia canceled S-300 deal with Assad, report says", *Times of Israel*, 26 May, 2013.
[225] Judah Ari Gross, "Liberman: Israel would destroy Syrian S-300 if it attacked our jets", *Times of Israel*, 24 April, 2018; Andrew Osborn, "Russia, after Netanyahu visit, backs off Syria S-300 missile supplies", *Reuters*, May 11, 2018.
[226] Yohann Michel, "Moscow finally delivers on Syria's S-300 ambitions", *The Military Balance Blog*, 5 November, 2018.
[227] Mikhail Khodaryonok, "Three layers of Russian air defense at Hmeymin air base in Syria", *TASS*, 12 February, 2016; McDermott, "Russian Air Defense…"; Beaumont and Roth, "Russia claims…".

Israeli strikes have been aimed mainly at Hezbollah targets, but have included targets close to Russian base areas in Latakia, as well as an undercover Syrian nuclear reactor.[228] In the past five years Israel claims to have conducted close to 100 air raids in Syria, using fourth generation aircraft such as the F-16 and F-15.[229] In early 2019 the departing Israeli chief of staff even claimed to have hit "thousands" of targets since early 2017, dropping more than 2000 bombs in 2018 alone.[230]

In retaliatory raids following the loss of an F-16 in early 2018 – which the IAF claims was due to the crew flying too high and not taking countermeasures, thereby attracting more than 20 missiles – Syrian air defences and Iranian assets have also been struck. Israeli spokesmen claim that nearly half of Syria's air defences have been destroyed in these raids.[231] A video released by the IAF showing the destruction of a Syrian Pantsir air defence unit, filmed from the missile that destroyed it, went viral, prompting hurried Russian explanations for why it could happen.[232] In early 2019 yet another Pantsir unit was successfully engaged in another large strike, along with other elements of Syrian air defences, prompting speculation on the circumstances.[233]

The US launched two airstrikes in Syria in response to Assad's use of chemical weapons against civilians, with the purpose of degrading the capacity and deterring further use. The first strike, in April 2017, was in response to an attack on the town of Khan Sheikhoun, and involved the use of 59 Tomahawk cruise missiles launched from destroyers in the eastern Mediterranean. The target was the airbase from which the attack on Khan Sheikhoun emanated, and the aim

[228] Starr and Browne, "Syrian regime…"; David Makovsky, "The Silent Strike: How Israel bombed a Syrian nuclear installation and kept it secret", *New Yorker* 17 September, 2012; Amos Harel, Aluf Benn, "No longer a secret: How Israel destroyed Syria's nuclear reactor", *Haaretz*, March 23, 2018; Stephen Farrell, "Israel admits bombing suspected Syrian reactor in 2007, warns Iran" *Reuters,* 21 March, 2018.

[229] Amos Harel, "Israel struck Syrian and Hezbollah arms convoys nearly 100 times in five years, top general says", *Haaretz*, 17 August, 2018.

[230] Bret Stephens, "The Man Who Humbled Qassim Suleimani: An interview with Lt.Gen. Gadi Eisenkot, Israel's chief of staff", *New York Times*, 11 January, 2019.

[231] Gross, "Operation House…"; Harel, "Israel believes…".

[232] Daniel Brown, "Russian air defenses were caught on video getting beaten badly by Israeli forces in Syria - here are Russia's excuses", *Business Insider*, 14 May 2018; Robin Häggblom, "Pantsir taken out", *Corporal Frisk*, 15 May, 2018.

[233] Robin Häggblom, "Another Syrian Pantsir lost", *Corporal Frisk,* 21 January, 2019; Sebastien Roblin, "Israel Kamikaze Drones are Destroying Syria's Air Defences", *National Interest*, 26 January, 2019. Roblin thinks that Syrian air defences has been shaped up and strengthened since the raids of 2018 (e.g. supplied with the latest S2 version of Pantsir). This could have reduced the room for easy pickings for the IAF and caused them to expend more missiles and decoys.

points were reported as fighter jets, aircraft shelters, radars, and fuel and ammuni-tion storage.[234] Practically all the missiles appear to have hit the intended aim points and destroyed them, and there are no reliable reports of any missiles having been shot down. However, while the intended effect of degrading Syrian capabilities to use chemical weapons may have been partially achieved, the aim of deterring Assad from their further use clearly was not.[235]

A second and larger night time raid on three chemical warfare compounds near Damascus and Homs was launched a year later in response to yet another attack on civilians. This raid once again involved Tomahawk missiles launched from US ships, but also JAASM stealthy cruise missiles launched from US B-1B bombers (the first combat use of the JAASM) and Scalp/Storm Shadow cruise missiles launched by British fighter aircraft and from French ships and fighters. In all, 66 Tomahawks and a small number of Scalps were launched from ships in the Mediterranean, the Red Sea and the Persian Gulf, while the aircraft launched their cruise missiles from outside Syrian airspace. British Tornadoes took off from an airbase in Cyprus while the French Rafales used a base in France. According to the Pentagon, all the missiles reached their targets within minutes of each other and the targets were thoroughly destroyed.[236]

This time, the Russians were not notified in advance of the strike, but the Pentagon had planned the flight paths so as not to pass by Russian bases. More-over, two Prowlers were detailed for escort jamming and SEAD in case the Russians lit up their S-400 and S-300s.[237] Apparently, the US Central Command thought that, if required, two Prowlers would be sufficient for the task.

After the raid, Syria and Russia claimed that more sites had been attacked and that a varying number of missiles – ranging from 13 to 79 – had been shot down. However, the coalition denied any losses of missiles and said that the roughly 40 air defence missiles launched by Syria in response to the raid were launched after the missiles had already hit their targets. Furthermore, they said that the Syrian

[234] Michael Gordon, Helene Cooper and Michael Shear, "Dozens of US Missiles Hit Air Base in Syria", *New York Times*, 6 April, 2017; Nadia Khomani and Jamie Grierson, "US Military strikes on Syria: what we know so far", *Guardian*, 7 April, 2017.

[235] The strike was probably also intended as a demonstration of resolve and capability, and that the Trump White House did not share Obama's inhibitions about the use of force in Syria. The lacklustre results may in part be due to the fact that the Russians had been given advance warning of the raid and its intended targets.

[236] Helene Cooper, Thomas Gibbons-Neff and Ben Hubbard, "US, Britain and France Strike Syria Over Suspected Chemical Weapons Attack", *New York Times*, 13 April, 2018: Helene Cooper and Ben Hubbard, "Pentagon Says Syria Strikes Hit 'Heart' of Chemical Weapons Program", *New York Times*, 14 April, 2018; Beaumont and Roth, "Russia claims…"; MacAskill and Borger, "Allies dispute Russian…"; Davies, "Syria fired 40 missiles…".

[237] Snow, "The Corps is down…"

missiles had been launched "blindly" into the air, i.e. without guidance or having acquired a target.[238]

Besides these one-off raids in western Syria, US and coalition aircraft have also been operating in Syria since 2014, mainly in support of Kurdish forces and as part Operation Inherent Resolve fighting IS in the northern and eastern parts of the country. Although largely conducted away from the media limelight, these operations have been extensive and varied, involving a wide variety of aircraft ranging from helicopters and giant transports, such as the C-17, to A-10s and Harrier IIs for close air support, to high-end fighters such as F-18s and F-22s. The USA has also built and operated at least two airfields on Syrian territory.[239]

The size of this air operation can be glimpsed from the fact that up to August 2017, the coalition had carried out 11 235 airstrikes against targets in Syria. As a single strike can involve several aircraft, and as the definition of a "strike" excludes non-combat missions, this figure understates the magnitude of the operation. All in all, coalition forces are reported to have performed nearly 170 000 sorties in Syria and Iraq.[240] Although the operation is now rounding up the remnants of IS, in the first week of September 2018 coalition air forces still carried out 15 airstrikes in Syria.[241]

It might be argued that the air operations in Inherent Resolve should not be considered true operations in hostile airspace, or against Russian or Russian-made air defence systems, as the coalition is focused on defeating IS, which does not have advanced air defence systems, and as Assad is focused on defeating the insurgents in western Syria. Moreover, the geographic focus of the coalition is far from the coastal strip where the bulk of Russian assets are, and a de facto division of the airspace along the Euphrates river has been agreed. In addition, it seems clear that Moscow has generally tried to avoid direct armed clashes with the USA or Israel.[242]

While these factors have an impact on the conclusions that can be drawn, Operation Inherent Resolve is still an operation without the consent of the

[238] Davies, "Syria fired 40 missiles…".
[239] "Operation Inherent Resolve" *Aviationist* website entry; Liam, "A-10 Thunderbolts on Operation Inherent Resolve", *Warfare.Today*, 16 January, 2018; Shawn Snow, "The Corps is Down…"; Thomas Gibbons-Neff, "How a 4-Hour Battle Between Russian Mercenaries and U.S. Commandos Unfolded in Syria", *New York Times*, 24 May, 2018.
[240] US Department of Defense, "Operation Inherent Resolve. Targeted operations to Defeat ISIS".
[241] US Department of Defense, "Coalition Strikes Target ISIS Terrorists in Syria, Iraq", 10 September, 2018.
[242] Plopsky, *Russia's Air Defenses in…*

nominal government, and both Assad and Russia have made clear their displeasure at the coalition's presence and activities. Russia has also repeatedly warned that coalition aircraft in Syrian airspace west of the Euphrates might be considered hostile. It has also often sent aircraft east of the Euphrates. That Russian and coalition aircraft often operate in the same airspace is obvious from the daily sparring between aircraft, from the large number of incidents and from the fact that a mechanism for deconfliction exists.[243]

Moreover, as the end-game draws near, Syrian forces have become openly more hostile to the coalition's presence, as shown by two incidents that have received attention in the media. In June 2017, a Syrian Su-22 bombed US-backed forces and was shot down by a US F-18.[244] In February 2018, "pro-Syrian government forces" launched an all-out attack against a small outpost held by coalition forces, but were "annihilated" by US airpower, which included bombers and gunships. There are reports that as many as 200-300 of the attackers were killed, many of them Russians.[245] That US forces can use such a panoply of airpower to kill Russian and pro-government fighters on the territory of a Russian client state where Russia has bases and modern long-range air defence systems is at the very least noteworthy.

[243] Schmitt, "In Syria's Skies…"; David Cenciotti, "'We Always Managed To Get Behind US-led Coalition Fighter Jets Encountered Over Syria' Cocky Russian Pilot Says", *Aviationist*, 29 December 2017.

[244] James Drew, "U.S. Navy Super Hornet Shoots Down Su-22 in Syria", *Aerospace Daily & Defense Report*, 19 June, 2017; Notably, the Sidewinder X heat-seeking missile first fired by the F-18 was distracted by flares from the Su-22 and missed, which raises questions. The F-18 then fired an AMRAAM active radar missile, which hit. Kyle Mizokami, "How Did a 30-Year-Old Jet Dodge the Pentagon's Latest Missile? The AIM-9X Sidewinder failed to bring down an aging attack jet." *Popular Mechanics*, 26 June, 2017.

[245] About 500 men – many of whom were Russian mercenaries from the Wagner group – equipped with tanks, artillery and armoured personnel carriers, attacked an outpost near Deir al-Zour, held by t10 Americans and by Kurdish and Arab forces. When calls to the Russian command in Syria failed to stop the assault, the attacking force was "annihilated" by US airpower, drawing on Reaper drones, F-22s and F-15Es, B-52s, AC-130 gunships and attack helicopters. Thomas Gibbons-Neff; "How a 4-Hour Battle Between Russian Mercenaries and U.S. Commandos Unfolded in Syria", *New York Times*, 24 May, 2018.

Appendix 2: Some basics on hitting targets from a distance

Hitting a comparatively small target at distance, especially if the target is mobile or its location is unknown, involves a whole chain of steps that have to be taken, usually in sequence.[246]

This is often called the kill chain or the engagement chain, and is commonly taken to include the following steps, expressed in the acronym F2T2EA:

- Find the target, i.e. awareness of its presence
- Fix the target, i.e. determine its position
- Track the target, i.e. maintain sensor contact and determine the target's course and speed
- Target the target, i.e. decide on whether the target is to be engaged, and if so how, by whom and when[247]
- Engage the target, e.g. do calculations, illuminate the target and launch missile, drop bombs, or fire guns[248]
- Assess the effect of the engagement, i.e. determine whether the desired effect was achieved[249]

Before engaging the target, usually as a part of tracking or targeting, it is necessary to identify the target, so as not to engage your own, allied or neutral targets, and not to waste resources on decoys or low-value targets, even if hostile.

[246] Unless otherwise specifically indicated, this appendix is based on the authors' accumulated professional knowledge, on consultation with FOI's technical experts and on four written sources: Försvarsmakten, *Lärobok i telekrigföring för luftvärnet – Radar och radartaktik* (Försvarsmakten, 2004); Birger Gripstad, ed., *FOA Orienterar om robotvapen* (Stockholm: FOA, 1968); J F Rouse, *Guided Weapons*, 4th edition (London: Brassey's, 2000); Hans Törnblom, *Kompendium i robotteknik* (Stockholm: FHS, 2014). *FOA Orienterar om robotvapen* is 50 years old, but a classic and still surprisingly relevant. Our assessment of the laws of nature - or physics - changes only slowly, and most of the principles of guided weapons remain valid over time.

[247] This step usually involves several sub-steps.

[248] This step usually involves several sub-steps.

[249] Cf Mike Benitez, "It's about time: The pressing need to evolve the kill chain", *War on the Rocks*, 17 May 2017.

The risk to a target depends on its detectability, mobility, altitude and maneuverability:

(i) Targets that are hard to detect are also hard to hit, because you cannot hit what you cannot see. Hence the attraction of stealth technologies, but also of camouflage and concealment.
(ii) Fixed targets are easier to strike than moving targets since the position of the former is known at the outset of the launch whereas the latter has to be tracked throughout, and because fixed targets can be found and pinpointed long before the strike.
(iii) Airborne targets at high altitude are easier to detect than those at low altitude. The former are visible at a distance and in contrast to the sky, while targets at low altitude can hide in ground clutter and at long ranges disappear behind the horizon because of the curvature of the Earth.
(iv) Non-maneuverable targets face greater risks than maneuverable ones, since the former cannot evade incoming missiles.

All in all, this means that stealthy, mobile, maneuverable targets navigating at low altitude – such as modern fighter jets – incur the least dangers, or that the danger zone is much smaller for them.[250]

Of course, the threat posed by an A2/AD bubble also depends on the systems projecting it. This normally involves a complicated chain of steps often taken by different systems or levels of authority, the more so for long-range or highly potent systems or contingencies short of war. The more numerous and complicated the links in this chain are, the greater the risk that something could go wrong, or that the adversary could interfere in the process.

Detecting a target

First and foremost, the presence of a target has to be detected, its identity, approximate position, speed and direction of travel have to be determined, and the target has to be separated from other objects that might be around, including both civilian/lower priority targets and decoys.

For fixed targets these steps can largely be done in advance using intelligence assets, but for mobile targets this has to be done in real-time with the help of some kind of sensor or a combination of sensors. For targets on the ground this usually means airborne or space-based sensors, either radars or digital cameras.

[250] Berglund, Hagström and Lennartsson, "The Long-range…".

These sensors can be combined with intelligence assets (signals intelligence, human assets) for discrimination and identification.

For airborne or naval surface targets, target detection has to be conducted in real-time or close to real-time. For continuous surveillance, early-warning or search radars are the obvious choice, often combined with signals intelligence for target identification, but intermittently it is also possible to use optical sensors.

To reduce the risk of accidentally firing on own or friendly aircraft or ships, radars and missile systems are normally equipped with a system known as Identification Friend or Foe (IFF), which sends a coded radio signal to a detected target. If the target responds with the correct coded radio signal it is considered friendly, otherwise not.

Evidently, this procedure did not work in the September 2018 downing of a Russian Il-20 by a Syrian missile unit.

Second, a decision has to be taken on whether to engage the target, and if so, when and how. For shorter-range A2/AD-systems in the context of a general war, such decisions can be taken locally subject to rules of engagement or guidelines. For longer-range systems or for contexts short of general war, authorization from higher up would most probably be needed. This means that there have to be well-functioning lines of command and lines of communication between the different units and the headquarters concerned.[251] Evidently, these conditions were not at hand when a Russian SAM unit shot down a Malaysian airliner over eastern Ukraine in 2014.[252]

Third, if a decision to engage a target is taken, fixed targets can be engaged with the information already available, while for mobile targets, target data have to be refined and calculated with much greater precision in order to hit a small and moving target at great distances. These calculations have to include the distance and direction the target will travel during the engagement process, which includes the flight time of the missile used to engage the target. For air and sea targets, these measurements and calculations normally involve the use of a separate target engagement radar that measures position, direction of travel and speed with greater precision, and of a computerized fire-direction center to turn these data into a firing solution for engagement by missile systems.

[251] The time-honoured term command and control (C2), in which communication was implied (how else can you command or control?) has been expanded incrementally so that now it is Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR).

[252] Bellingcat Investigation Team, "MH17 – Russian GRU Commander 'Orion' Identified as Oleg Ivannikov", *Bellingcat*, 25 May, 2018.

While modern electronically scanned target engagement radars can track many targets simultaneously, older radars can only handle a handful of targets at the same time.[253] At a very simplified level, radars can be said to operate on the same principle as an echo-sounder (sonar) in a boat, only radars use pulses of radio beams instead of sound waves to detect objects and to measure distance. Pulses of radio beams are sent out into the air and if there is an object out there that reflects the beams, the radar will sense the weak echo when it returns. The time that passes between sending out the pulse and the echo returning gives the distance to the object, while the direction that the antenna points gives the bearing of the object.

However, much like the beam of a flashlight, the strength of even a narrow and focused radar beam dissipates with the distance travelled, making it harder to produce echoes at long distances.

Search radars traditionally use long wavelengths and a rotating antenna to sweep across the sky, while tracking/engagement radar uses shorter wavelengths and may use a smaller and "staring" antenna. Sophisticated radars, or experienced operators, can often deduce more information about the target than range, bearing and altitude, such as speed, direction of travel, type and aspect of the object, and so on.

The reason for having separate search radars and tracking/engagement radars is that they are optimized for different tasks, giving them different technical and operational characteristics.[254] Search radars are optimized for long range and for round-the-clock surveillance of vast volumes of airspace or seascapes, like a rotating searchlight constantly sweeping the terrain. To achieve this, search radars sacrifice granularity and detail. Tracking and engagement radars lock on to a designated target and provide much more granularity and detail, much like a spotlight following a specific actor on the stage.

Search radars and tracking/engagement radars sometimes also belong to different parts of the armed forces, with search radars belonging to surveillance units while tracking/engagement radar belong to air defence or coast defence units. However, in an Integrated Air Defence System (IADS), these are supposed to be tightly connected. That this is not always the case in Russian-managed systems was

[253] Simply put, in an old-style radar the radar waves are produced by a vacuum tube (like the one in an old television or computer monitor) and transmitted by a (usually) rotating antenna. The rotation creates the scan. Modern radars often have antennae like flat-screens, and the radar beams are created by many solid-state transmission elements acting together. The interference between the many small beams created by these separate elements can be used to direct the resulting composite beam in different directions.

[254] Modern electronically scanned and phase-controlled radars, such as the SPY series used by the US Navy, sometimes combine search and tracking in one.

demonstrated by the downing of a Russian electronic surveillance plane by the Syrian air defence in September of 2018 (see Appendix 1).

As radars have become more sophisticated and capable, designers of combat aircraft and ships have responded with what is often called stealth technology, or signature reduction. It is not only the size of an object that determines how well it reflects radar beams, but also the shape of an object and the material it is made from. By avoiding certain shapes in structures and/or by coating structures in materials that badly reflect radar beams, it is possible to reduce the radar reflectivity of an object by several orders of magnitude.

This not only reduces the probability of detection, or the distance at which detection is possible, but also makes it easier to fool radars if the target is spotted by deploying electronic or physical decoys that mimic the radar returns of a target while the real target escapes. For the purpose of comparison, the radar reflectivity of an object is measured as the radar cross section (RCS), which is expressed in square meters. While a large 1950s bomber like the B-52 has an RCS of approximately 100 square meters, a 1980s bomber like the B-1 has an RCS of only 6 square meters and the B-2 stealth bomber has an RCS below 0.1 square meters. Similarly, traditional fighter aircraft may have an RCS of 2–6 square meters, while modern stealth fighters such as the F-22 and the F-35 are said to have an RCS equivalent to that of a metal marble or a golf ball.[255] RCS varies widely with the aspect angle the aircraft presents to the radar and these values represent the lowest values normally found in the front aspect.

However, while a low RCS bestows very important advantages it also comes at a cost, both in money for construction, building and upkeep, and in performance terms. For example, the requirement for smooth external surfaces means that stealth aircraft cannot carry weapons and extra fuel hanging under the body or wings, but have to carry these inside the body or under hatches, which greatly reduces the amount of payload that can be carried.[256]

Another factor not always appreciated by the layperson is that the range of radars is limited by the curvature of the Earth, severely limiting the effective range of ground-based radars, especially against targets close to the ground. Radar beams normally travel in a straight line, as do beams of light, while the Earth's surface is curved. Therefore, the effective range of radars is limited by the laws of physics to a radar horizon, in much the same way that a distant ship may appear to an observer on the shore to disappear under the horizon. The maximum distance

[255] Sebastien Roblin, "A 'Stealthy' F-15 'Silent Eagle'?: Smart Idea or a Waste of Money", *The National Interest*, 24 August, 2018; see also web-entries for "Radar Cross Section" on *Global Security* and on *Wikipedia*.
[256] Ibid.

detection that a ground-based radar can "see" under normal conditions is approximately the same as for an individual with powerful binoculars on a perfect day.[257] Of course, radars have the advantage of being able to "see" at night and in bad weather.

The distance to the radar horizon can be calculated by a simple formula if you know the height in meters of the radar antenna (h1) and the height in meters of the target (h2). The sum of the separate square root of h1 and h2, multiplied by a factor of about 4 (often 4.12) yields the approximate radar horizon (R) expressed in kilometers. Thus, if the height of the radar antenna is 16 meters and the height of the target is 25 meters, the maximum range can be approximated as 4 x (4+5) = 36 kilometers.[258]

However, if the target is way up in the sky while the radar is on the ground things become very different. If the target is at 10 000 meters while the radar antenna is at 16 meters, the radar horizon becomes approximately 400 kilometers, which is a very respectable distance. If the target is at 2500 meters the radar horizon becomes approximately 200 km, and so on. The same applies if the conditions are reversed; that is, if the radar is at 10 000 meters while the target is at 16 meters, the radar horizon becomes 400 km.

This explains the enormous advantage in having radars elevated, either on tall masts or on aircraft. If both the radar and the target is at an altitude of 10 000 meters the radar horizon theoretically becomes 800 kilometers.

In practice, at such extreme ranges it is often not the radar horizon that is the factor limiting the effective range, but the output of the radar station and its ability to detect and discriminate returning signals. Similarly, if an elevated radar is looking down at targets close to the ground, it may be unable to detect targets well within the radar horizon because of difficulties in distinguishing actual targets from ground clutter. Modern airborne radars do however have a function (Moving Target Indication, MTI) that uses the Doppler effect to discriminate moving targets from stationary ground clutter.[259]

From time to time, there are claims that someone is about to solve the problem of the Earth's curvature by fielding a new type of radar capable of "seeing"

[257] It should also be noted that under certain atmospheric conditions, known as "anomaly", which occur from time to time during the summer in the Baltic Sea region, radar beams can "bounce" on layers of air and thus reach targets below the normal radar horizon.
[258] Kristian Artman och Anders Westman, *Lärobok i Militärteknik, vol. 2: Sensorteknik* (Stockholm: FHS, 2007).
[259] Cf. Försvarsmakten, *Lärobok i telekrig…,* 87f.

beyond the horizon, dubbed Over The Horizon-radars (OTH).[260] If such a system could be made to work as advertised, it would potentially have profound effects on air and naval warfare at long distances. However, while such systems can indeed be made to work, the laws of physics and the available technology currently limit their usefulness in providing early warning of moving objects. Neither OTH-radar based on the principle of backscatter (OTH-B), nor OTH-radars based on the fact that radar beams in some cases can "hug the ground" over water, can deliver data of sufficient quality (specificity of coordinates and speed, frequency of updates) to provide the basis for using long-range weapons against moving targets.[261] While an OTH in Kaliningrad could conceivably report on there being, for example, a lot of targets in the air over known airbases in Denmark, any firing done on the basis of such data would be akin to longshots in the dark, or nuisance firing like the V1s and V2s on London in 1944–45.[262]

Hitting a target with a missile

The next step in the engagement sequence after target detection, identification, a decision to engage and tracking is the actual engagement of the target with missiles. Here, the speed of the missiles, their range and their guidance capabilities are key factors.

(I) The faster a missile flies, the shorter the time from launch to reaching the target becomes. This reduces the distance that the target can travel from the time that the missile is fired to when it hits, thus reducing the margin for error. Furthermore, less time from launch to hit also means less time for the target to detect an incoming missile and to take evasive action, deploy countermeasures or fire defensive missiles. High-speed missiles are also more difficult to hit with defensive missiles or defensive close-in weapons systems (CIWS).
(II) The longer a missile can fly, the more potential targets it can reach.
(III) Last but not least, guided missiles can be more or less intelligent and utilize different guidance systems.

[260] Sputnik News, "I See You: Russian-Made Sunflower Radar is Capable of Detecting F-35 Jets", *Sputnik*, 15 July 2016.
[261] Per Grahn et al., *Radar bortom horisonten – OTH. En kort översikt med fokus på ytvågs-OTH*, FOI-R--4039--SE (Stockholm: FOI, 2014); David Axe, "Don't Sweat Russia's Stealth-Fighter-Detecting New Radar: Sunflower can detect, but it can't target", *War is Boring*, 11 July, 2016.
[262] "Source: Russia may deploy 2 powerful radars in Baltic, Black Seas to counter NATO activity", *Baltic Times*, 5 July, 2016.

Fixed targets

Some missiles developed for fixed land targets – such as Tomahawk land attack cruise missiles or its Russian equivalents Kalibr and Kh-101, or the ballistic missiles ATACMS and Iskander-M – use the pre-set coordinates of targets and find their way to that point with the assistance of an internal (inertial and/or GPS) navigation/guidance system.

In the 1940s this internal navigation system was simple mechanical gyros, which meant that accuracy was measured in several kilometers and that the missiles could only be used for terrorizing very large targets, such as London. In the 1950s came more accurate inertial platform navigation systems, which reduced the error to about one kilometer. This is sufficient if the payload is a nuclear bomb but otherwise quite useless except for nuisance bombardment.[263]

In the 1980s, the USA fielded a new generation of missiles, e.g. the Tomahawk cruise missile, which used electronic maps to find their way, and optical or radar sensors to identify the pre-programmed target. This reduced the error to tens of meters or less, and made precision strike with conventional payloads possible over long distances, as demonstrated spectacularly in 1991 during the Gulf War.

In the 30 years that have passed since, this capability has gone from an expensive cutting-edge technology available only to the USA to being relatively cheap and widely available, as demonstrated by Russia's use of Kalibr Tomahawk-copies in Syria in 2015. The cheapness and wide availability of satellite navigation such as GPS has also made it possible to simply add intelligence to dumb weapons, thereby turning precision strike against fixed land targets into a cheap mass-market capability that can be bought in bulk, e.g. the US JDAM guided bomb. However, as GPS and its equivalents are vulnerable to jamming or disruption, depending solely on satellite guidance in a major war is risky.

Moving targets

Missiles intended for moving targets can be fully remote-controlled, have semi-active or active radar guidance, or have passive infrared (IR) terminal guidance.

Remotely controlled missiles rely on external guidance via a datalink from the launching unit to guide them to the target. The intelligence thus resides with the launch unit, which makes the missiles cheaper to manufacture but also means that

[263] Inertial navigation – very simply put – is based on acceleration meters that sense whether the missile is changing course or speed. These are connected to a calculator which runs dead reckoning and adjusts the course to hit the pre-set target. Inertial navigation can be made entirely independent of outside sources of information but produces an error that increases with time.

the launch unit has to keep monitoring the target and the missile during the time the missile is in flight in order to provide updates and corrections.

Semi-active radar-guided missiles have a passive radar receiver which picks up radar beams reflected from the target and homes in on them. This means that a separate fire-control or tracking radar, located on the ground, on a ship or on an aircraft, has to "illuminate" the target during the whole process. Originally, this was done manually and only for one target at a time, but modern fire-control radars can track targets automatically, and can track or illuminate several targets at the same time. During the tracking and illumination process the launch unit is easily detected and vulnerable to radar-homing missiles, which aircraft may carry for self-defence or for suppression of enemy air defences. If the launch unit is incapacitated or loses contact with the target while the missile is in flight, the missile will miss the target.

Active radar guided missiles have a near-complete guidance system built in, including a radar transmitter, and are not dependent on outside support once fired. This means that for moderate distances (up to 50 km) and targets travelling in a straight line, the missile is effectively "fire-and-forget". Fire-and-forget bestows great tactical advantages as the launch unit can turn to another target directly after launch, or hide in an inactive mode. If the distance to the target is great and/or if the target changes course or speed, the initial target data provided to the missile before launch will have to be updated and corrected during the missile's flight. This means that the target tracking radar has to continue to track the target and also that the launch unit has to provide updated target data to the missile by way of a data link.

IR-guided – or heat-seeking – missiles have a built-in seeker that locks on to and then homes in on a source of infrared radiation, such as the hot exhaust of a jet aircraft. IR-guided missiles are usually basic IR-seekers that just home in on the most intense source of heat, making them easy to spoof with flares dropped by aircraft. More advanced seekers (Imaging Infrared, IIR), however, look for structural features or pre-programmed images of likely targets. As IR radiation travels in straight lines but dissipates quickly if the air is moist, such as in cloud or fog, unassisted IR seekers, which lock on to the target before launch, are only used for short-range missiles, such as the well-known man-portable anti-aircraft missile Stinger. For distant targets, such as ships, target data have to be acquired by other means, whereupon the likely position of the target at impact is calculated and programmed into the missile before launch. The missile then flies towards the designated point, guided by internal guidance, before starting to look for the target.[264]

[264] George M. Siouris, *Missile Guidance and Control Systems*, Springer-Verlag, New York, 2004

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States with the ability to use a combination of sensors and long-range missiles to prevent adversaries from operating in an exclusion zone, or “bubble”, adjacent to their territory are said to possess anti-access/area denial (A2/AD) capabilities.

This study examines Russia’s A2/AD systems and their implications for the Baltic Sea region. Much has in recent years been made of Russia’s new capabilities and the impact they might have on the ability of NATO member states to reinforce or defend the vulnerable Baltic states in case of crisis or war. On closer inspection, however, Russia’s capabilities are not quite as daunting, especially if potential countermea-sures are factored in. In particular, surface-to-air missile systems currently create much smaller A2/AD bubbles than is often assumed and a number of countermeasures are possible. Experiences from Syria also raise questions about the actual capabilities of such systems in combat, relative to their nominal capa-bilities. Anti-ship and anti-land systems pose a greater threat but, here too, counter-measures are available.

The dynamics of this strategic vortex affect Sweden directly and indirectly. This is one of the reasons why Sweden’s security is increasingly interlocked with that of its neighbours and of the transatlantic alliance.

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