

Failures of the Russian Aerospace Forces in Ukraine

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Russian thinking on Russian aerospace forces' capabilities prior to the invasion of Ukraine reveals the force faced interconnected and unresolved challenges, including a mistaken strategic priority on defensive over offensive operations, a failure to develop sufficient capacity and capability for large-scale operations, and comparatively undeveloped operational concepts. As European NATO partners modernize their forces in the coming years, these critical shortfalls provide lessons related to acquiring specific technologies and platforms, engaging relevant operational concepts, and committing to extensive, ongoing training.

Since the start of Russia's invasion of Ukraine in February 2022, one of the enduring questions of the conflict has been why Russian airpower has failed to establish air superiority against a seemingly less capable adversary. Failing to establish air superiority—or even air supremacy—over Ukraine, Russia's leadership has limited its Russian aerospace forces (VKS) to conducting long-range cruise missile and drone strikes from within the bastion of its national borders, or worse, to dangerous low-altitude strikes in the heart of man-portable air defense and air defense artillery engagement zones.

Starting a war without controlling the electromagnetic spectrum is tantamount to defeat.

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Why has Russia not taken advantage of its numerical and technological air advantage over Ukraine? This article examines Russian sources to argue intellectual biases among Russian defense planners have resulted in technical shortcomings, an absence of operational concepts especially in the critical area of suppression of enemy air defenses (SEAD) and destruction of enemy air defenses (DEAD), and a force that is too poorly trained for the combat environment found in Ukraine. Many Russian-language airpower experts under-

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1. Anatoly Tsyganok, "Применение сил и средств РЭБ в войнах и конфликтах XXI века" [The use of forces and means of electronic warfare in wars and conflicts of the XXI century], *Nezavisimaya Gazeta*, last modified September 20, 2019, <https://nvo.ng.ru/>.

stood these gaps, which at least in the trans-Atlantic community, were papered over by massive military investment and credulous analysis of that investment.

Russia's struggles in the air also offer lessons for NATO's procurement efforts. As European alliance members invest in critical tactical air capabilities, they must consider the observed gaps in Russian airpower capability. One of the most serious is the lack of a tactical-level, dedicated electronic attack aircraft capable of both intelligence, surveillance, and reconnaissance (ISR), and SEAD/DEAD. Current European procurement efforts, even of the F-35 Lighting II, do not completely fill this gap.

In addition, European air forces must be wary of believing that technological innovation equals improved battlefield outcomes. As procurement efforts progress, developing practical operational concepts and practices will be imperative as the number of strike aircraft increases. Failure to do so will place European air forces in the same conundrum Russia currently finds itself. Finally, European NATO partners must commit to sufficient training and aircraft maintenance to enable Alliance air supremacy in a potential conflict with Russia.

Perspectives on Russian Airpower

A number of authors have examined the problem of the so-called "disappearance" of the Russian air force in the Ukraine conflict.² Studies that reflect longer-term analyses of the Russian war in Ukraine began emerging in late 2022, less than a year into the conflict. Thus far, the two most thorough examinations of the air war in Ukraine indicate Russia's failures in large part stem from the inability of the VKS to consistently suppress or destroy Ukrainian ground-based air defense systems at the outset of the conflict.³

These analyses describe Russia's success in the opening week of the war when Ukrainian surface-to-air-missile (SAM) systems could be well-mapped and few defensive measures were taken to enhance their survivability. But once this initial flurry subsided, the VKS began to stumble. Inadequate Russian SEAD/DEAD and Ukraine's ability to sustain its ground-based air defense denied air superiority to Russia and resulted in a deadlocked air conflict. Both sides became limited to tentative jabs, small-scale tactical innovation (Ukraine), and reliance on long-range precision strikes (Russia) against fixed targets.

Yet these otherwise thorough works offer little in the way of Russian-language evidence to support their case. Further, these perspectives reveal critical flaws in Russian capabilities. As this article will demonstrate, many reliable Russian-language airpower

2. Justin Bronk, "The Mysterious Case of the Missing Russian Air Force," Royal United Services Institute (RUSI), February 28, 2022, <https://rusi.org/>; Phil Stewart and Idrees Ali, "What Happened to Russia's Air Force? U.S. Officials, Experts Stumped," Reuters, March 2, 2022, <https://www.reuters.com/>; and Dougal Robertson, "Getting It Wrong: The Missing Russian Air Campaign over the Ukraine," *Australian Defence Business Review*, September 2, 2022, <https://adbr.com.au/>.

3. Justin Bronk, Nick Reynolds, and Jack Watling, *The Russian Air War and Ukrainian Requirements for Air Defence* (London: RUSI, 2022), 1, <https://rusi.org/>; and Justin Bronk, *Russian Combat Air Strengths and Limitations: Lessons from Ukraine* (Arlington, VA: Center for Naval Analyses [CNA], 2023), <https://www.cna.org/>.

sources observed before the war that for all of Russia's technological improvements in airborne ISR and electronic attack, it had yet to translate those improvements into effective operational practice.

Piecing together prewar Russian thought on VKS operations reveals a set of interwoven challenges that Russia had not yet solved by the outbreak of the war. This includes a strategic priority on defensive over offensive operations, failure to develop sufficient capacity and capability for operations at this scale, and comparatively immature operational concepts. These lessons have critical implications as NATO partners undergo major force modernization over the next several years.

The Defensive Bias

An analysis of Russian military doctrine reveals the VKS is primarily anchored to Russia's enduring military priority of defending "Mother Russia" from a so-called "aerospace blitzkrieg" by NATO, to the detriment of sustained, strategic offensive air operations.⁴ "Russia has no intention to assault anyone," ran one Russian analysis of the Aerospace Defence Forces—the predecessor of the VKS—in 2019.⁵ Politically expedient or not, this sentiment has influenced the VKS' strategic emphasis and prioritization of tasks. As a result, Russia's military spending priorities did not accentuate operational concepts such as suppression and destruction of enemy air defenses, a critical requirement for gaining air superiority over a contested area of operations, and thus an essential element of any air campaign.

Most Russian operational planning in the post-Soviet period has focused on defense against NATO aerospace attacks, especially in the "initial period of war . . . the most critical and decisive period of conflict when countries launch strategic operations with already deployed forces."⁶ In Russian assessments, the initial period of war for a NATO attack on Russia would consist of what Russia terms a massed missile-aviation strike, now more commonly referred to as an integrated massed air strike.⁷ The concept of this massed-aerospace assault has driven much of Russian thinking on air operations. As Russian thinkers have emphasized the need for aerospace defense at the operational level of war, they have commonly landed on these integrated massed air strikes as a primary threat to national security.

This, in turn, has pushed the state's military-technical development, procurement, and training into integrated air defense rather than more offensively oriented air dominance operations. While Russia demonstrated an increase in offensive air operations in recent conflicts such as Georgia in 2008, Crimea in 2014, and Syria in 2015, "the fundamental

4. Thomas Withington, "Defending Mother Russia's Skies," RUSI, July 13, 2022, <https://rusi.org/>.

5. S. N. Borisko and S. A. Goremykin, "Analyzing the State of Russia's Aerospace Forces, Development Projects," *Military Thought* 28, no. 1 (2019).

6. Michael Kofman et al., *Russian Military Strategy: Core Tenets and Operational Concepts* (Arlington, VA: CNA, 2021), 3.

7. Kofman et al., 21.

orientation and posturing of the Russian military over the years still remains centered on defending its heartland and vital industries and cities, using layered and integrated air defense.”⁸ Even if Russian military theory posits a mixture of offensive and defensive air actions, as prominent Russian airpower theorists have noted, “it can be assumed that in the general concept of aerospace defense, the main semantic load still falls on the concept of ‘defense.’”⁹

Because of this cognitive prioritization on integrated air and missile defense, Russian airpower strategists have spent less intellectual capital on preparation for complex, offensive air superiority and air dominance campaigns. Retired US Air Force Lieutenant General David Deptula has noted “Russia has never fully appreciated the use of airpower beyond support to ground forces,” and “as a result, Russia, in all its wars, has never conceived of or run a strategic air campaign.”¹⁰

Russian military strategy has generally prioritized the defense of critical infrastructure and close air support of ground troops rather than power projection in defended airspace. Because of this, the development of operational concepts and doctrine for air dominance operations, including SEAD/DEAD, has suffered. The cognitive defensive bias has led, intentionally or not, to the deprioritization of the planning, practice, and execution of offensive operations to gain air superiority in contested airspace.

Inadequate Procurement

While Russia has conducted a thorough reform of its military since the Georgian War of 2008, it is unclear at this point if the rubles have been spent wisely for a twenty-first-century conflict. One Russian defense analysis points out that while established Russian hardware designs experienced successful growth, only marginal progress was made in producing completely new weapons and platforms such as fifth-generation aircraft.¹¹ Since 2010, the VKS has received approximately 350 modern strike-fighter aircraft, most of which are upgraded designs of older platforms, including Su-30SM multirole fighters, Su-35S air-superiority fighters, and Su-34 bombers.¹² But this investment in upgraded

8. Diptendu Choudhury, “Russia’s Military Understanding of Air Power: Structural and Doctrinal Aspects,” Vivekananda International Foundation, May 23, 2022, <https://www.vifindia.org/>.

9. Valentin Dybov and Yuri Podgornykh, “Всесторонне проработанной теории ВКО пока нет” [There is no comprehensively elaborated theory of WSC yet], VKO, last modified December 2015, <http://www.vko.ru/>.

10. Phillips Payson O’Brien and Edward Stringer, “The Overlooked Reason Russia’s Invasion Is Flourishing,” *Atlantic*, May 9, 2022, <https://www.theatlantic.com/>.

11. Richard Connolly and Cecilie Sendstad, “Russian Rearmament: An Assessment of Defense-Industrial Performance,” *Problems of Post-Communism* 65, no. 3 (October 19, 2016), <https://doi.org/>; and Julian Cooper, *Russia’s State Armament Programme to 2020: A Quantitative Assessment of Implementation 2011–2015* (Stockholm: FOI [Swedish Defence Research Agency], 2016), 48, <https://www.foi.se/>.

12. Justin Bronk, “Is the Russian Air Force Actually Incapable of Complex Air Operations?,” RUSI, March 4, 2022, <https://rusi.org/>.

strike platforms has masked the underinvestment and underdevelopment of less flashy but critically essential systems necessary to overcome Ukrainian ground-based air defenses as part of a successful air campaign.

Russia's own military experts may not believe Russia has put its money or focus on the right technology. Airpower observers have noted the defense industry has failed to develop capability and capacity, especially in ISR and electronic attack, for the purpose of SEAD and DEAD. For example, a 2021 article published in *Military Thought*—the English translation of the journal of the Soviet Union's and Russian Federation's Ministry of Defense—made a tacit admission that Russia is still lagging in the development of a wide variety of platforms, including “advanced fixed-wing and rotary, low-altitude and stratospheric, reconnaissance and reconnaissance-strike, fighter and jammer, and relay and radar surveillance and guidance UAV [unmanned aerial vehicle].”¹³ This indicates a defense-focused semantic load evident in the doctrine that has resulted in capability gaps in critical offensive air dominance capabilities such as SEAD and DEAD.

Like any kill chain, SEAD and DEAD rely highly on timely, accurate ISR. As of 2022, Russia's most prolific airborne ISR platforms are the Ilyushin Il-20 Coot and the Su-24MR. The Il-20, a Cold War-era turboprop built in the 1970s, is almost entirely unsuited to operations in a contested environment, while the Su-24MR is a modification of the 1980s fighter-bomber. Both aircraft can collect and classify electronic intelligence from ground-based radar systems, but they lack electronic suppression systems. Additionally, the Su-24MR can generate synthetic aperture radar imagery.¹⁴ Yet in the 2008 Georgia War, the Su-24MR was ineffective against Georgian air defense systems, which, like Ukraine's, were Soviet-produced.

Operations there also revealed Russian aircraft could not accurately locate enemy radars with available electronic intelligence technologies. Su-24MR crew training was also considered to be subpar.¹⁵ Currently, it is assessed that Russia has a global inventory of 10 operational Il-20s of various configurations, and 48 Su-24MRs are believed to be still operated by the VKS as of January 2023.¹⁶ It is not clear how many of each aircraft are allocated to Ukraine operations, but given global demand, whatever the number, it is almost certainly too few.

Notably, Russia has recently attempted to modernize its strategic ISR force with the Tu-214R. Russia currently operates only two of these modern ISR aircraft, with a third still in development. Russian sources claim the Tu-214R can detect radar systems out to

13. S. N. Kurilov, A. N. Kiryushin, and Yu. N. Moiseyev, “Current Problems of Air Forces Tactics and Ways to Solve Them,” *Military Thought* 30, no. 3 (September 30, 2021): 22.

14. Piotr Butowski, *Russia's Warplanes: Russian-made Military Aircraft and Helicopters Today* (Houston, TX: Harpia Publishing, 2015), 178, 192.

15. Tsyganok, “Применение сил.”

16. “An In-Depth Review of Russia's Current ISR Aircraft,” Key.Aero (website), May 18, 2022, <https://www.key.aero/>; and “Su-24 Inventory,” Janes, accessed January 21, 2023, <https://www.janes.com/>.

400 kilometers, but development issues have plagued the platform.¹⁷ Russian military bloggers have been especially critical of the delayed development of the Tu-214R, asserting if Russia had been able to field the Tu-214R on time and in sufficient numbers for the invasion of Ukraine, then the “resistance of the Armed Forces of Ukraine would have been suppressed long ago.”¹⁸

For all its publicly claimed capabilities, it seems the VKS has been disappointed in the performance of the Tu-214R and has canceled further production.¹⁹ This program cancellation leaves the Russian aerospace forces with a few dozen legacy aircraft and three poorly performing modern ISR aircraft. Russian unmanned aerial vehicles such as the Orlan-10 have filled in gaps but are operated by Russian ground forces and do not appear to provide rapid and reliable ISR mapping for SEAD/DEAD missions.²⁰

There is also little evidence to show the VKS has fully developed the proper capabilities for electronic attack in support of SEAD/DEAD. First, Russia has no dedicated tactical airborne electronic attack aircraft to nonkinetically suppress adversary SAM systems. The Il-22PP is equipped with a standoff electronic warfare suite, but the airframe is based on an Il-18D airliner.²¹ Unsurprisingly, an airframe based on an antiquated airliner makes for a poor tactical SEAD asset in a dynamic SAM environment, where standoff jamming is insufficient, and speed and maneuverability are required to maintain jamming alignment with supported strike aircraft. One Russian military analyst has noted that the use of the Il-22PP for electronic attack is “not the ideal solution.”²²

To compensate, the VKS currently fields the RTU 518-PSM electronic warfare suite on its Flanker family of aircraft.²³ This wing-mounted pod, also known as the Khibiny family of jamming pods, is reported to be highly capable of detecting and defeating adversary SAM radars, utilizing what appears to be digital radio frequency memory technology.²⁴

While the Su-34 can be configured with Khibiny pods to act in an escort jamming role, open-source reporting alludes to the fact that the Khibiny pods primarily operate in an

17. Boyoko Nikolov, “Russia is Testing a Tu-214R Reconnaissance Aircraft over Ukraine,” *Bulgarian-Military.com*, last modified September 24, 2022, <https://bulgarianmilitary.com/>; and “Russian Military Confident in Tu-214R Capabilities after ELINT Missions in Syria,” *Air Recognition*, last modified 2015, <https://airrecognition.com/>.

18. Andrey Mitrofanov, “Tu-214P в специальной военной операции на Украине: не прошло и года” [Tu-214R in a special military operation in Ukraine: Less than a year], *TopWar*, last modified September 27, 2022, <https://topwar.ru/>.

19. “Tu-214ON/Tu-214R,” *Janes*, last modified August 2, 2022, <https://www.janes.com/>.

20. Bronk, *Russian Combat*, 17.

21. “In-Depth Review.”

22. Nikolai Litovkin, “Russia Receives First Il-22PP Porubschik Electronic Countermeasures Planes,” *Russia Beyond*, November 9, 2016, <https://www.rbth.com/>.

23. Joseph Trevithick, “Ukraine Just Captured One of Russia’s Most Capable Aerial Electronic Warfare Pods,” *Drive*, September 12, 2022, <https://www.thedrive.com/>.

24. Roman Skomorokhov, “Комплекс РЭБ «Хибины» чудо-оружие армии России?» [Complex EW “Khibiny” miracle weapon of the Russian army?], *TopWar*, last modified October 31, 2017, <https://en.topwar.ru/>.

autonomous mode, with pod software detecting, classifying, and transmitting a jamming signal back to the threat radar.²⁵ In effect, they provide only self-protection jamming for aircraft, not electronic suppression of threat radars required for SEAD/DEAD. There are indications the VKS may have developed escort-jamming abilities to suppress enemy radars, but this capability is not confirmed, nor is there any indication that it has mastered the concept.²⁶

Ukrainian air defenses have shot down at least one Su-35 and one Su-30SM equipped with Khibiny pods since the start of the conflict.²⁷ This is not altogether unsurprising, given the deficiencies of digital radio frequency memory jamming against modern SAM systems. The frequency agility of modern radar-guided SAMs can make it difficult for such a jammer to consistently replicate a return signal sufficient to mask the jamming aircraft continually.²⁸ The vital lesson regarding how the VKS utilizes these pods is that they are likely most beneficial when defending against a surface-to-air engagement and should not be relied on as a substitute for dedicated escort SEAD.

Finally, Moscow must also contend with the fact it requires adequate high-end forces in case of a conflict with NATO, and losses in Ukraine have put great pressure on the force. As one Russian observer has noted, “The more modern a vehicle we send to hunt for Ukrainian air defense systems, the less likely it will be shot down, but the more painful the loss will be.”²⁹

Given this, Russia’s use of high-performance aircraft to conduct electronic attack for force-packaged groups of aircraft is perhaps technically possible but of limited capability and capacity and still immature in practice. As one 2016 analysis argues, “Substantiation of the necessity to mount electronic warfare equipment on the operational tactical aircraft, is . . . a prospective trend in military scientific research, requiring an immediate practical solution.”³⁰ While Russia’s experience in Syria’s uncontested skies did provide relevant experience, considering the current performance of VKS tactical aircraft in SEAD/DEAD missions, it appears Russia has made little progress in the years since.

The lack of a high-performance, dedicated electronic attack platform leaves Russia with few options to nonkinetically suppress an adversary’s integrated air defense system. With limited nonkinetic options, the only choice that remains is to try and eliminate threat SAM systems kinetically. With limited precision-guided standoff munitions to engage

25. Butowski, *Russia’s Warplanes*, 85–86.

26. Roger McDermott, “Russia’s Advances in Electronic Warfare Capability,” *Eurasia Daily Monitor* 16, no. 135 (October 2, 2019), <https://jamestown.org/>.

27. Trevithick, “Ukraine.”

28. Reuben F. Johnson, “Russian EW Weaknesses Endure While Other Nations Innovate,” AIN Online, June 16, 2019, <https://www.ainonline.com/>.

29. Andrey Mitrofanov, “Неудобные вопросы: господство в воздухе над Украиной и его последствия” [Awkward questions: Air supremacy over Ukraine and its consequences], TopWar, last modified June 24, 2022, <https://topwar.ru/>.

30. V. I. Vladimirov and V. I. Stuchinsky, “Rationale for Combat Use of Aircraft EW Equipment at Operational Depth to Gain Information Superiority,” *Military Thought* 25, no. 2 (June 30, 2016): 29.

and destroy adversary SAM systems, the VKS has few options to target an enemy's integrated air defense system.³¹ One of the primary methods observed throughout the Ukraine conflict thus far has been the use of antiradiation missiles.

Designed to acquire and guide on the radar signature emitted by SAM radar systems, antiradiation missiles can be an effective tool if employed correctly. Russian Su-35S and Su-30SM aircraft have been observed flying combat sorties against Ukraine with load-outs of Kh-31 antiradiation missiles.³² Yet based on videos appearing on social media, the employment altitude, flight profile, and ranges observed are unlikely to maximize the desired effects.³³

Russian fighters have also been observed firing salvos of antiradiation missiles and then escaping the weapons engagement zone. Savvy radar operators can defend against this by blinking their radar system off and back on. With no radar emissions in the air, the missile loses its primary method of guidance and goes "dumb." While radars may temporarily be suppressed, the effect can often be measured in seconds. Surface-to-air missile operators will simply turn the radar back on once the antiradiation missile threat has passed and continue prosecuting aircraft. This tactic underscores the need for layered ISR, strike, and jamming capabilities. In addition, Russian pilots require well-developed operational concepts that are rigorously practiced with the right platforms. None of these requirements are present at scale in the VKS.

Poorly Developed Operational Concepts

Even successful modernization efforts in Russia over the last decade presented the military with a newer and equally challenging conundrum that remained unsolved on the eve of war in Ukraine. Russian aerospace forces made the cognitive and technological leap into sophisticated electronic attack capabilities, but translating those twenty-first-century developments into operational practice has revealed itself to be another challenge altogether. Russia went into the Ukraine conflict with immature operational concepts for both ISR and electronic attack.

For example, rapid, coordinated ISR for emergent target mapping and battle damage assessment is crucial in modern combined arms campaigns, especially in SAM-dense environments. Given the technical capabilities described above, VKS forces should have the ability to rapidly turn emergent SAM radar detections into strike operations on the

31. Bronk, "Mysterious Case."

32. Justin Bronk, "Getting Serious about SEAD: European Air Forces Must Learn from the Failure of the Russian Air Force over Ukraine," RUSI, April 6, 2022, <https://rusi.org/>.

33. Justin Bronk (@Justin_Br0nk), "Interesting footage showing use of Su-35S air superiority fighter purportedly over #Ukraine with a mixed air-to-air and Suppression of Enemy Air Defences (SEAD) missile load (Kh-31). Also carries Khibiny self defence pods. Still only looks like a singleton sortie, however," Twitter, March 7, 2022, 2:35 a.m., <https://twitter.com/>.

fly. But NATO officials have indicated Russia's ISR and targeting processes have not been up to the task in this conflict.

British Air Marshal Johnny Stringer, deputy commander of NATO's Allied Air Command, noted that "the transformation in US and NATO airpower over the last five decades has no equivalent in the VKS [Russia's air force], nor do the Russians have anything like the ISR-led strike capabilities of NATO Air Forces, nor the targeting processes to exploit them."³⁴ Indeed, analysts have observed it takes the Russian military at least 48 hours to process actionable intelligence and assign it to a strike platform.³⁵ This is wholly inadequate in a dynamic surface-to-air missile environment.

Russian airpower theorists were, in fact, aware of this problem well before the Russian war in Ukraine. In the 2008 Georgia War, the Russian air force conducted small raids using two to four aircraft. It did not use escort reconnaissance aircraft to detect pop-up SAM threats, nor did it employ electronic warfare to suppress detected Georgian air defense systems. In addition, it did not allocate special aircraft to destroy any detected air defense systems, and it could not conduct post-strike battle damage assessment.³⁶

In this regard, operations in Syria may have provided some experience, but a review of the journal *Aerospace Forces: Theory and Practice*, the leading journal of airpower in Russia, reveals the VKS had not yet solved the problems exposed by the Georgia War.³⁷ Interestingly, the creation of fused intelligence over multiple combat platforms, so vital to effective emergent target mapping and battle damage assessment, was considered especially challenging; space-based ISR for tactical strikes was considered even more difficult.³⁸

The failure to solve these problems poses a conundrum for Russian pilots in Ukraine. Russian military analysts themselves noted this in 2021:

It has become more difficult to avoid destruction from the fire of mobile and covert low-altitude air defense systems. Climbing to medium altitudes calls for more effective neutralization techniques—jamming countermeasures against

34. Tim Martin, "Russia's Air Campaign Hampered by Poor ISR Based Strikes and Target Processing: NATO Official," *Breaking Defense*, November 4, 2022, <https://breakingdefense.com/>.

35. Bronk, Reynolds, and Watling, *Russian Air War*, 28.

36. Tsyganok, "Применение сил."

37. For example, see V. A. Vasiliev et al., "Otsenka urovnya razvedyvat'l'nogo obespecheniya udarnykh dystviy aviatsii" [Assessment of the level of support for air strike operations], *Vozdushno-Kosmicheskiye Sily: Teoriya i Praktika*, no. 15 (September 2020): 52–62.

38. N. T. Shevtsov and A. N. Moor, "Sposob dorazvedki ob'ektov protivnika pri vedenii boyevykh deystviy smeshannaoy aviatsionnoy diviziony" [Enemy objects reconnaissance method during the conduct of combat operations by a mixed aviation division], *Vozdushno-Kosmicheskiye Sily: Teoriya i Praktika*, no. 19 (September 2021): 57–73; and V. A. Vasiliev et al., "Analiz vozmozhnostey kosmicheskoy razvedki po informatsionnomu obespechniyu upravleniya aviatsiyey pri vypolnenii ognevykh zadach" [Analysis of space intelligence capabilities for information support of aviation management in the performance of fire missions], *Vozdushno-Kosmicheskiye Sily: Teoriya i Praktika*, no. 17 (March 2021): 47–56.

detection and targeting assets of medium-range air defense systems. However, as altitude increases, aircraft bombing accuracy diminishes to an unacceptable level.³⁹

Further complicating the issue is that for all the Russian failures to effectively execute SEAD and DEAD in the Ukraine conflict, a host of additional contributing factors have left the VKS unable to conduct sustained, complex air operations to gain control over the skies above Ukraine.

Insufficient Training and Maintenance

Equally essential to understanding Russian airpower deficiencies is an analysis of Russian air force training, aerospace doctrine, and aviation maintenance programs.

Training and Doctrine

For any pilot, training, proficiency, and experience are at the forefront of a list of factors that contribute to success or failure in combat. VKS pilots log fewer than 100 flight hours annually for currency and proficiency.⁴⁰ This is approximately half of what US and UK aircrew receive for annual flight time. Indeed, Royal Air Force and US Air Force leadership have expressed concern about their aircrew's ability to maintain combat readiness with 180 flight hours per year.⁴¹ Russia's low training rate is evident in the Russian war in Ukraine. Poor performance as a result of pilot training problems identified in the 2008 Georgia War has apparently continued. If the VKS focus on integrated air and missile defense occupies the majority of the 100 annual training hours, supporting missions like SEAD and DEAD are likely left on the cutting room floor. Further compounding the issues of aircrew ability is the rigidity of Russian tactical doctrine concerning the employment of VKS aircraft.

As demonstrated in the Zapad 2021 exercise, VKS aircrew are primarily trained to act in support of ground forces when not conducting long-range strike missions.⁴² Unlike in Western doctrine, however, VKS pilots are heavily constrained in the execution of these types of strike operations. Russian airborne strike doctrine emphasizes the use of ground controllers to direct aircraft and "enslaves combat pilots to preplanned target sets."⁴³ This rigidity can often result in wasted ordnance on a mobile target that moves from where it was originally located. It does not provide flexibility for aircrews to engage emergent targets.

39. Kurilov, Kiryushin, and Moiseyev, "Current Problems," 24.

40. Piotr Butowski and Thomas Newdick, "Russian Aggressor Squadron Gets Its First Su-35S Fighter Jets," Drive, October 4, 2022, <https://www.thedrive.com/>.

41. Bronk, "Mysterious Case."

42. Michael Kofman, "Zapad 2021: What We Learned from Russia's Massive Military Drills," *Moscow Times*, September 23, 2021, <https://www.themoscowtimes.com/>.

43. David Axe, "The Russian Air Force Is Back in the Fight in Ukraine. But It's Not Making Much of a Difference," *Forbes*, September 16, 2022, <https://www.forbes.com/>.

In contrast, Western aircrew frequently train in dynamic targeting and have more tactical flexibility. For most of the war, Russian tactical airstrikes have been carried out using traditional ground-control intercept tactics with unguided bombs and rockets against predesignated targets. Against SAM systems, VKS forces have also resorted to crude salvo tactics with antiradiation missiles against predesignated SAM radars.⁴⁴

Aircraft Maintenance

Training and doctrine are not the only VKS deficiencies. Based on recent history, basic aircraft maintenance also appears to be a challenge. Recent catastrophic mishaps have highlighted a potential shortfall in Russia's ability to maintain combat aircraft. In April 2023, a MiG-31 jet burst into flames in flight and crashed near Murmansk. In September 2022, a Su-25 crashed shortly after takeoff, followed by an October 2022 incident where a Su-34 bomber experienced an apparent engine failure and crashed into an apartment building.⁴⁵ One Russian aviation maintenance professional has noted serious shortcomings, including

delays in signing contracts with co-contractors; constant increases in cost beyond the scope of state service contracts and delayed processing of repair and components supply requests due to an excessive number of intermediaries involved in the organization of maintenance service; incomplete fulfillment of the entire volume of service requests; low revolving stock of spare parts; inadequate organization of aircraft repair shops for prompt repairs and troubleshooting; a poor claims mechanism for dealing with breaches of contract; lack of the necessary operational and repair documentation; and underqualified engineering and technical personnel or their shortage, including in field service teams.⁴⁶

The cumulative impact of all these maintenance failures leaves little doubt the Russian aviation maintenance program is fundamentally broken. Maintaining a peacetime air force is in and of itself a significant challenge. Yet, since February 2022, Russia's aviation maintenance personnel have had to add an exponential increase in aircraft flight hours, parts wear, and battle damage to an already expansive workload.

The NATO Lens

Thus, Russia's air war in Ukraine offers crucial lessons for European NATO partners as they increase defense spending and embark on systematic upgrades across their joint forces, especially the air forces. The growing sentiment among European nations that the

44. Bronk, Reynolds, and Watling, *Russian Air War*, 1.

45. Thomas Newdick, "Su-25 Attack Jet Crash May Point to Wider Russian Airpower Issues (Updated)," Drive, September 12, 2022, <https://www.thedrive.com/>; and Emma Helfrich, "Russian Su-34 Fullback Jet Slams into Apartment Building in a Ball of Fire (Updated)," Drive, October 17, 2022, <https://www.thedrive.com/>.

46. Z. G. Omarov, "Problems of Aviation Equipment Operation at the Present Stage," *Military Thought* 31, no. 3 (September 30, 2022): 125.

EU and NATO are too reliant on the United States for defense is reflected in statements such as that of French president Emmanuel Macron, who has championed the concept of “strategic autonomy,” the idea that European countries must invest in their own defense to diminish their reliance on NATO and, in turn, the United States.⁴⁷

Russia’s invasion of Ukraine has only exacerbated Europe’s need to come to terms with NATO’s overreliance on the United States for defense. But for all the bloviating about European strategic autonomy, are European NATO Allies taking action to decrease military dependence on the United States? Will NATO be prepared to execute effective, large-scale air campaign operations against Russia without the United States’ full support?

Air dominance operations—and their necessary SEAD/DEAD component—are a critical case in point. Euro-Atlantic strategists have long pointed out the challenges presented by Russian integrated air and missile defense bastions in the Baltic states region, the Black Sea region, and elsewhere.⁴⁸ Suppressing and destroying these bastions will be the essential centerpiece of any military campaign against Russian aggression. But as the Ukraine case shows, a failure to enact focused procurement efforts for specific technologies and platforms, develop operational concepts, and provide extensive, ongoing training, can lead to strategic failure.

Procurement

Due to its increase in defense spending shortly after the Russian invasion of Ukraine, Germany serves as an excellent case study highlighting NATO member military modernization efforts. In February 2022, German chancellor Olaf Scholz announced Germany would dedicate €100 billion to modernize the German military and meet the NATO goal of 2 percent of gross domestic product spending dedicated to defense.⁴⁹ A portion of this investment was set aside for the purchase of new strike-fighter aircraft for the German air force.

Seeking to replace its aging fleet of Panavia Tornados, Germany initially favored the purchase of a combination of 30 F/A-18 Super Hornets and 15 EA-18G Growlers.⁵⁰ The Growler would have served as a fitting replacement for the electronic combat and reconnaissance (ECR) variant of the Tornado, continuing to fill the critical SEAD and DEAD role for the German air force.

47. Handan Kazanci, “Europe Needs to Gain More Autonomy on Technology and Defense Capabilities, Including from the US,” Says French President,” AA [Anadolu Agency], last updated December 22, 2022, <https://www.aa.com.tr/>.

48. Robert Dalsjö, Christofer Berglund, and Michael Jonsson, *Bursting the Bubble: Russian A2/AD in the Baltic Sea Region: Capabilities, Countermeasures, and Implications* (Stockholm: FOI, March 2019), <https://www.foi.se/>.

49. Matthew Karnitschnig et al., “Inside Olaf Scholz’s Historic Shift on Defense, Ukraine and Russia,” *Politico*, March 5, 2022, <https://www.politico.eu/>.

50. Grant Turnbull, “NATO Investment Brings Electronic Warfare Back into Fashion,” *Global Defence Technology*, <https://defence.nridigital.com/>.

In December 2022, however, Germany announced it would instead spend \$8.4 billion on 35 Lockheed Martin F-35 Lightning II fighters.⁵¹ This abrupt change highlights what has become a recurring pattern by European countries looking to modernize their air forces. Since 2018, Belgium, Poland, Switzerland, Finland, the Czech Republic, and Germany have pledged to purchase the F-35A Lightning.⁵²

To its credit, Lockheed Martin has done an excellent job marketing the F-35 globally. It is currently the only exportable fifth-generation fighter in the world and, by the company's proclamation, capable of executing "any and all mission[s]" required of a modern-day military aircraft, including SEAD/DEAD and electronic warfare.⁵³ At first glance, the F-35 is especially appetizing for a NATO nation looking to modernize its air force with a fifth-generation, multirole fighter.

Any procurement decision for modernization includes a critical analysis of cost versus capability. Currently, one of the biggest driving factors behind European F-35 procurement is that the total cost of ownership for the platform is dramatically lower than its closest competitors. An assessment of Denmark's 2016 decision to purchase 28 F-35s reveals there is more to procurement decisions than the per-unit cost of the aircraft.

For example, Denmark compared the aircraft's service life across the three-competing contracts. While the F/A-18 Super Hornet and Eurofighter Typhoon are advertised as having a service life of 6,000 flight hours, the F-35 has an advertised service life of 8,000 hours.⁵⁴ This service life gap between the F-35 and the F/A-18 helped sway Denmark's decision to purchase the F-35 instead of the F/A-18. Because of the longer service life, Denmark purchased 10 fewer aircraft than it would have if it had chosen the F/A-18 or the Eurofighter. This translates into a more modern, more reliable, more capable aircraft for less than the price of a fleet of older, fourth-generation fighters.

But even if the current economic landscape makes the F-35 the most cost-effective modern fighter jet to procure, NATO countries must remain aware of the vulnerabilities of a Swiss-Army-knife fallacy: the idea of a one-stop-shop platform that can dominate all mission sets. Just because the F-35 can execute SEAD does not mean that it should be a primary asset for the suppression of adversary SAM systems.

Of Germany's 35 new F-35 aircraft, how many will be dedicated to executing airborne electronic attack against the Russian integrated air defense systems in a conflict, and are European countries willing to utilize fifth-generation fighters to conduct SEAD in support of fourth-generation aircraft? For every F-35 allotted to SEAD, one less aircraft

51. Sebastian Sprenger, "Germany Clinches \$8 Billion Purchase of 35 F-35 Aircraft from the US," *Defense News*, December 14, 2022, <https://www.defensenews.com/>.

52. Vivienne Machi, "How the F-35 Swept Europe, and the Competition It Could Soon Face," *Defense News*, September 4, 2022, <https://www.defensenews.com/>.

53. "Air-to-Everything," Lockheed Martin, accessed January 21, 2023, <https://www.lockheedmartin.com/>.

54. Sydney J. Freedberg Jr., "F-35 Wins Denmark Competition: Trounces Super Hornet, Eurofighter," *Breaking Defense*, May 12, 2016, <https://breakingdefense.com/>.

executes an air-to-surface strike on a critical target or consummates air-to-air intercepts against Russian fighters and long-range bombers in contested airspace.

Although Germany ultimately decided against investing in the EA-18G, Berlin has acknowledged the importance of a dedicated tactical SEAD platform in a modern-day air force. In March 2022, German leadership announced a continued partnership with Airbus to develop the Eurofighter ECR as a replacement for the Tornado ECR.⁵⁵ This two-seat version of the Eurofighter would fill the role of a dedicated tactical SEAD/DEAD platform capable of escort and stand-off jamming. Germany expects delivery of these Eurofighters between 2025 and 2030, but as of January 2023, the aircraft was still in development.⁵⁶

Operational Concepts

As seen with the VKS, however, just because hardware modernization is ongoing does not mean NATO's operational concepts have been suitable for success in the past. In NATO's 2016 *Allied Joint Doctrine for Air and Space Operations*, for example, a resources allocation table shows only a 10 percent allocation to SEAD in each of the first six days of a conflict.⁵⁷

Realistically, at the outset of a conflict with Russia, a thorough integrated air defense system rollback will be necessary, requiring robust SEAD/DEAD prioritization. As Russia's experience in Ukraine highlights, failing to prioritize SEAD/DEAD operations in the initial period of war can lead to devastating consequences and a failure to achieve air dominance over the battlefield. Fortunately, however, NATO has identified that SEAD has been underprioritized and is taking steps to correct it.

In April 2017, NATO released a SEAD vision paper acknowledging deficiencies and outlining a plan to modernize its operational concepts: "By 2030 we want to be able to have a tiered force able to deliver multiple full effects across the full spectrum of an enemy's air defense system."⁵⁸ The first goal of this SEAD modernization process consisted of a capability audit that was to be completed by the summer of 2019, followed by a capabilities gap analysis to be completed by the following year. The audit began in June 2023 and is expected to take 18 months to complete.⁵⁹ The capabilities gap analysis is now forecast

55. Gaston Dubois, "Confirmed! F-35 and Eurofighter ECR to Replace Lufwaffe's Tornado," *Aviationline*, March 14, 2022, <https://www.aviacionline.com/>.

56. Ricardo Meier, "Germany to Order 15 Electronic Warfare Eurofighters in Addition to F-35s," *Air Data News*, March 16, 2022, <https://www.airdatanews.com/>.

57. North Atlantic Treaty Organization, *Allied Joint Doctrine for Air and Space Operations* (London, UK: NATO Standardization Office, 2016), 4-19, <https://assets.publishing.service.gov.uk/>.

58. Tim Fish, "NATO Ponders SEAD Modernization as Russia Fields New Threats," *Journal of Electronic Defense* 41, no. 5 (May 2018): 26.

59. Richard Scott, "NIAG Study Group Explores Future SEAD Capability Options," *Janes*, June 30, 2023, <https://www.janes.com/>.

to be concluded by 2025.⁶⁰ With this modernization plan now three years behind, it is unclear if NATO will be able to meet its 2030 goal of being able to deliver “full spectrum effects” against an enemy’s integrated air defense systems.

Training

Training must be factored into this equation as well. Just as Russian pilots suffer in combat proficiency from a lack of flight hours, the same effect may occur for NATO F-35 aircrew, who are expected to be proficient in the myriad mission sets the F-35 is capable of flying. In 2020, only 512 of the Luftwaffe’s 875 pilots were able to meet the NATO target of 180 flight hours.⁶¹ While this flight-hour deficiency was explained by Luftwaffe leadership as a result of maintenance issues with aging aircraft, it highlights a common problem for pilots of multirole aircraft. When facing flight-hour uncertainty, every flight hour a pilot spends on SEAD/DEAD training is an hour not spent practicing air-to-air intercepts.

While one would assume the loss of flight hours due to maintenance would subside once German pilots have their new, more reliable F-35s, the fact remains that training must be split across all mission sets, ultimately resulting in a deficiency in one or more of these areas. A dedicated SEAD/DEAD platform means those aircrew become experts in their mission set instead of trying to be jacks-of-all-trades.

Other Challenges

Additional challenges unique to a regional alliance such as NATO are compounding the delay of NATO’s SEAD study. First, trust between nations is a sensitive and dynamic issue and may be inconsistent from country to country. Second, nations are constantly walking a tightrope of budgetary balance between national defense financial allocation and cooperative contribution. Third, duplication of effort becomes a concern where it can be difficult to determine how much of one capability should exist across all of NATO before it becomes cost prohibitive. Finally, there is the concern of “cross-contamination” of capabilities, where it becomes a liability for a country like Turkey to own and operate sensitive technology from both Russia and the United States.⁶²

Conclusion

The Russian aerospace forces failure in Ukraine demonstrates that the success of modern-day air dominance operations comes down to more than just the hardware at

60. Richard Scott, “Rebalancing AEA/SEAD Capability in NATO,” *Journal of Electromagnetic Dominance (JED)*, April 2022, <https://www.jedonline.com/>.

61. Michael Peck, “Bad News NATO: German Pilots Aren’t Getting Enough Flight Time,” *National Interest*, August 19, 2021, <https://nationalinterest.org/>.

62. Stephen “Muddy” Watters, “Strengthening NATO AEA,” *JED* 43, no. 1 (January 2020): 12.

one's disposal. While Russia's defensive-biased doctrine may have led to the undervaluing of offensive air operations, the effectiveness of modern ground-based air defense systems ensures it is more difficult than ever to build a sanctuary for aircraft to operate as safely and effectively as possible in combat. Any nation seeking to conduct successful air dominance operations in the twenty-first century, let alone achieve air superiority, must have the technology available to do so, aircrew with relevant training and experience, and sound operational doctrine.

Additionally, there must be an expanded emphasis on SEAD and DEAD operations across the joint and coalition forces. In Ukraine, Russia has proven that its air force is incapable of success in this arena. Thus far, NATO has shown it understands this requirement; although it currently lacks requisite airpower capabilities, it is taking steps to fill the seams and gaps. These questions remain: Will NATO effectively learn from Russia's failures, and will it be ready in time for the next major conflict? →✳

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