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LCDR Matthew Galamison

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Writing & Teaching Excellence Center
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14. ABSTRACT

Since the start of Russia's invasion of Ukraine in February 2022, one of the enduring questions of the conflict concerns Russia's misuse of air power. Choosing to forego offensive air operations to establish air superiority – or even air supremacy – over Ukraine, the Russian leadership has limited its Russian Aerospace Force (VKS) to conducting long-range cruise missile and drone strikes from within the bastion of its national borders or worse, dangerous low-altitude strikes in the heart of Man Portable Air Defense (MANPAD) and Air Defense Artillery (ADA) engagement zones. Why has Russia not taken advantage of its numerical and technological air advantage over Ukraine to seize the skies? While analysis of Russia's failure to achieve air superiority has tended to focus on the technical-tactical features of the conflict, few have offered a Russian perspective on the VKS' challenges. Piecing together pre-war 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 undergoes major force modernization over the next several years.

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The Failures of the Russian Aerospace Force in Ukraine

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The Failures of the Russian Aerospace Force in Ukraine

Since the start of Russia's invasion of Ukraine in February 2022, one of the enduring questions of the conflict concerns Russia's misuse of air power. Choosing to forego offensive air operations to establish air superiority – or even air supremacy – over Ukraine, the Russian leadership has limited its Russian Aerospace Force (VKS) to conducting long-range cruise missile and drone strikes from within the bastion of its national borders or worse, dangerous low-altitude strikes in the heart of Man Portable Air Defense (MANPAD) and Air Defense Artillery (ADA) engagement zones. Why has Russia not taken advantage of its numerical and technological air advantage over Ukraine to seize the skies? Many authors have examined the problem of the so-called 'disappearance' of the Russian Air Force in the Ukraine conflict. But none of those writers have offered Russian-language evidence to support their case. What the Russians say about their challenges matters. Indeed, before the war, many reliable Russian-language air power sources observed that for all of Russia's technological improvements, they had yet to translate those improvements into effective operational practice.

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 air power capability. One of the most serious is the lack of a tactical-level, dedicated electronic attack aircraft capable of both ISR and electronic suppression of enemy air defenses (SEAD). 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 increase. Failure to do so will place European air forces in the same conundrum Russia currently finds itself.

Literature Review

Studies that reflect longer-term analysis of the Ukraine War began emerging in late 2022, less than a year into the conflict. Thus far, the most thorough examination of the air war in Ukraine, published by the Royal United Services Institute, indicates that Russia's failures in part stem from the fact that the VKS was unable to reliably suppress or destroy Ukrainian ground-based air defense (GBAD) systems at the outset of the conflict.¹ Bronk, Reynolds, and Watling describe Russian success in the opening week of the war, a reasonably unsurprising achievement given the inherent first-mover advantages in a battle of the first salvo, when Ukrainian 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. Its advantages in the air domain were limited by its inability to suppress Ukrainian GBAD. What should have been a significant Russian advantage became, at best, 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.

While analysis of Russia's failure to achieve air superiority has tended to focus on the technical-tactical features of the conflict, few have offered a Russian perspective on the VKS' challenges. Piecing together pre-war 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

¹ Justin Bronk, Nick Reynolds, and Jack Watling, *The Russian Air War and Ukrainian Requirements for Air Defence* (London, UK: RUSI, 2022), 1, <https://rusi.org/explore-our-research/publications/special-resources/russian-air-war-and-ukrainian-requirements-air-defence>.

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 undergoes major force modernization over the next several years.

The Defensive Bias

An analysis of Russian military doctrine reveals that 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.² "Russia has no intention to assault anyone," ran one Russian analysis of the Aerospace Defense Forces in 2019.³ Politically expedient or not, this sentiment has influenced the strategic direction of the Aerospace Forces. As a result, Russia's military spending priorities have placed less emphasis on operational concepts like Suppression and Destruction of Enemy Air Defenses (SEAD/DEAD), a critical requirement for gaining air superiority over a contested area of operations, and, thus, an essential element of any air campaign.

Much of the Russian operational planning in the post-Soviet period has focused on defense against NATO aerospace attacks, especially in the "Initial Period of War." 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 (MRAU), now more commonly referred to as an integrated massed air strike (IMVU).⁴ The concept of this massed-aerospace assault has driven

² Michael Kofman, "It's Time to Talk About A2/AD: Rethinking the Russian Military Challenge," War on the Rocks, last modified September 5, 2019, accessed January 21, 2023, <https://warontherocks.com/2019/09/its-time-to-talk-about-a2-ad-rethinking-the-russian-military-challenge/>.

³ S.N. Borisko, S.A. Goremykin, "Analyzing the State of Russia's Aerospace Forces, Development Projects," Military Thought No. 1, Vol. 28 (2019).

⁴ Michael Kofman et al., Russian Military Strategy: Core Tenets and Operational Concepts (Arlington, VA: Center for Naval Analyses, 2021), 21.

much 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 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."⁵ Even if Russian military theory posits a mixture of offensive and defensive air actions, as prominent Russian air power 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.'"⁶

Because of this cognitive prioritization on integrated air and missile defense (IAMD), Russian air power strategists have spent less intellectual capital on preparation for complex, offensive air superiority and dominance campaigns. Retired Lieutenant General David A. Deptula has noted that "Russia has never fully appreciated the use of airpower beyond support to ground forces" and that "as a result, Russia, in all its wars, has never conceived of or run a strategic air campaign."⁷ Russian military strategy has generally prioritized the defense of critical

⁵ Diptendu Choudhury, "Russia's Military Understanding of Air Power: Structural and Doctrinal Aspects," Vivekananda International Foundation, last modified May 23, 2022, accessed October 23, 2022, <https://www.vifindia.org/article/2022/may/23/russia-s-military-understanding-of-air-power>.

⁶ 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, accessed October 23, 2022, <http://www.vko.ru/oboronka/vsestoronne-prorabotannoy-teorii-vko-poka-net>.

⁷ Phillips Payson O'Brien and Edward Stringer, "The Overlooked Reason Russia's Invasion Is Floundering," *The Atlantic*, last modified May 9, 2022, accessed October 23, 2022, <https://www.theatlantic.com/ideas/archive/2022/05/russian-military-air-force-failure-ukraine/629803/>.

infrastructure and close air support of ground troops. Because of this, the development of operational concepts and doctrine for air dominance operations, including suppression of enemy air defenses, has suffered. Moreover, the cognitive defensive bias has led, intentionally or not, to the de-prioritization of the planning, practicing, and execution of offensive operations to gain air superiority in contested airspace.

The Right Tools for the Job

While Russia has conducted a thorough reform of its military since its poor performance in the Russo-Georgian War of 2008, it is unclear at this point if the rubles have been spent wisely for a 21st-century conflict. Richard Connolly and Cecilie Sendstad point out that while established Russian hardware designs experienced successful growth, only marginal progress was made in producing new, sophisticated high-tech weapons and platforms.⁸ Since 2010, the VKS has received approximately 350 modern strike-fighter aircraft, most of which are upgraded designs of older platforms, including Su-30SM multi-role fighters, Su-35S air-superiority fighters, and Su-34 bombers.⁹ But this investment in upgraded strike platforms has masked the underinvestment and underdevelopment of less flashy but critically essential systems necessary to overcome Ukrainian GBAD as part of a successful air campaign.

Russia's own military experts may not believe that Russia has put its money or focus on the right technology. Air power observers have noted that the defense industry has failed to develop capability and capacity, especially in intelligence, surveillance, and reconnaissance

⁸ 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/10.1080/10758216.2016.1236668>.

⁹ Justin Bronk, "Is the Russian Air Force Actually Incapable of Complex Air Operations?," Royal United Services Institute, last modified March 4, 2022, accessed October 23, 2022, <https://rusi.org/explore-our-research/publications/rusi-defence-systems/russian-air-force-actually-incapable-complex-air-operations>.

(ISR) and electronic attack, for the purpose of SEAD and DEAD. For example, a 2021 *Military Thought* article 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.”¹⁰ This is an indication amongst military leaders that a defense-focused “semantic load” has resulted in capability gaps in critical offensively oriented areas such as SEAD and DEAD.

Like any kill chain, SEAD and DEAD rely highly on timely and 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 is a Cold War-era turboprop built in the 1970s, while the Su-24MR is a modification of the 1980s fighter-bomber of the same designation. Russia inherited both platforms from the Soviet Air Force after its collapse in 1991. Both aircraft can collect and classify ELINT from ground-based radar systems and record EO/IR imagery. Additionally, the Su-24MR can generate SAR imagery from its side-looking Shtyk radar.¹¹ Currently, it is assessed that Russia has a global inventory of ten operational Il-20s of various configurations, and forty-eight Su-24MRs are believed to be still operated by the VKS as of January 2023.¹² The latter are expected to be removed from inventory.

It should be noted that Russia has attempted to modernize its strategic ISR force with the recently produced Tu-214R. Russia currently operates only two of these modern ISR aircraft,

¹⁰ 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, <https://dx-doi-org.usnwc.idm.oclc.org/10.21557/MTH.70170486>.

¹¹ Piotr Butowski, *Russia's Warplanes: Russian-made Military Aircraft and Helicopters Today* (Houston, TX: Harpia Publishing, 2015), 178, 192.

¹² “An In-Depth Review of Russia's Current ISR Aircraft,” *Key.Aero*, last modified May 18, 2022, accessed October 23, 2022, <https://www.key.aero/article/depth-review-russias-current-isr-aircraft>; “Su-24 Inventory,” *Janes*, accessed January 21, 2023, https://customer.janes.com/EntityProfile/Equipment/Equipment_5185/inventories.

with a third still in development. Russian sources claim the Tu-214R can detect radar systems out to 400 kilometers, but development issues have also plagued the platform.¹³ Russian military bloggers have been especially critical of the delayed development of the Tu-214R, asserting that 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.”¹⁴ For all its claimed capabilities, it seems as if the VKS has been so disappointed in the performance of the Tu-214R that it has canceled the production of the platform.¹⁵ Ultimately, this program cancellation will leave the VKS with three substandard, modern ISR aircraft with no new developments on the horizon.

Even when examining the electronic attack capabilities that Russia *has* developed, there is little evidence to show that they are fully effective in a SEAD or DEAD role. In the first place, unlike the United States, which operates the EA-18G Growler, Russia has no dedicated tactical airborne electronic attack aircraft to suppress adversary SAM systems non-kinetically. The Il-22PP has an electronic warfare suite, but the airframe is based on an Il-18D airliner.¹⁶ Unsurprisingly, an airframe based on an antiquated airliner makes for a poor tactical SEAD asset in a dynamic SAM environment like Eastern Ukraine, where standoff jamming at long ranges is

¹³ Boyoko Nikolov, "Russia is Testing a Tu-214R Reconnaissance Aircraft Over Ukraine," BulgarianMilitary.com, last modified September 24, 2022, accessed December 11, 2022, <https://bulgarianmilitary.com/2022/09/24/russia-is-testing-a-tu-214r-reconnaissance-aircraft-over-ukraine/>; "Russian Military Confident in Tu-214R Capabilities after ELINT Missions in Syria," Air Recognition, last modified 2015, accessed December 11, 2022, <https://airrecognition.com/index.php/archive-world-worldwide-news-air-force-aviation-aerospace-air-military-defence-industry/global-defense-security-news/global-news-2016/august/2821-russian-military-confident-in-tu-214r-capabilities-after-elint-missions-in-syria>.

¹⁴ Andrey Mitrofanov, "Ту-214Р 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, accessed December 11, 2022, <https://topwar.ru/202346-tu-214r-v-specialnoj-voennoj-operacii-na-ukraine-ne-proshlo-i-goda.html>.

¹⁵ "Tu-214ON/Tu-214R," Janes, last modified August 2, 2022, accessed January 21, 2023, <https://customer.janes.com/Janes/Display/JEMAA321-JC4IA>.

¹⁶ "An In-Depth," Key.Aero.

insufficient, and speed and maneuverability are required to maintain jamming alignment with supported fighter and strike aircraft to ensure survival.

To compensate, the VKS currently fields the RTU 518-PSM electronic warfare suite on its Flanker family of aircraft.¹⁷ 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 (DRFM) technology.¹⁸ 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 autonomous mode, with pod software detecting, classifying, and transmitting a jamming signal back to the threat radar.¹⁹

With little to no operator input, these pods, in effect, act like a self-protect jamming system, not one designed to protect large sweeps of fighter and strike aircraft. Such a system would allow the operator to manually slew and modify the radar jamming beams to priority SAM threats, thereby maximizing survivability for aircraft under the jamming platform’s protection. For a system touted as a “miracle weapon of the Russian army,” 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.²⁰ This is not altogether unsurprising, given the deficiencies of DRFM jamming against modern SAM systems. The frequency agility of modern radar-guided SAMs

¹⁷ Joseph Trevithick, "Ukraine Just Captured One Of Russia's Most Capable Aerial Electronic Warfare Pods," The Drive, last modified September 12, 2022, accessed October 23, 2022, <https://www.thedrive.com/the-war-zone/ukraine-just-captured-one-of-russias-most-capable-aerial-electronic-warfare-pods>.

¹⁸ Roman Skomorokhov, "Комплекс РЭБ «Хибины» чудо-оружие армии России?" [Complex EW "Khibiny" Miracle Weapon of the Russian Army?], Top War, last modified October 31, 2017, accessed October 23, 2022, <https://en.topwar.ru/128491-kompleks-reb-hibiny.html>.

¹⁹ Piotr Butowski, *Russia's Warplanes: Russian-made Military Aircraft and Helicopters Today* (Houston, TX: Harpia Publishing, 2015), 85-86.

²⁰ Trevithick, "Ukraine Just," The Drive.

can make it difficult for a DRFM jammer to consistently replicate a return signal sufficient to mask the jamming aircraft continually.²¹ The vital lesson regarding how the VKS utilizes these pods is that they are likely most beneficial in defensive situations when combined with defensive maneuvers and countermeasures and should not be relied on as a substitute for dedicated SEAD.

Attaching Khibiny pods to strike platforms carries other challenges. 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.”²² Further, each modern, high-end platform that Russia dedicates to a questionable electronic attack role is one less that can be used in air-to-air or ground support roles.

Given this, Russian use of high-performance aircraft to conduct electronic attack for force-packaged groups of aircraft is technically possible but still relatively immature in practice. A 2016 *Military Thought* article argued that “substantiation of the necessity to mount EW equipment on the operational tactical aircraft, is ... a prospective trend in military scientific research, requiring an immediate practical solution.”²³ Considering the current performance of VKS tactical aircraft in SEAD/DEAD missions, it appears that Russia has made little progress in the years since.

²¹ Reuben F. Johnson, “Russian EW Weaknesses Endure While Other Nations Innovate,” AIN Online, last modified June 16, 2019, accessed December 11, 2022, <https://www.ainonline.com/aviation-news/defense/2019-06-16/russian-ew-weaknesses-endure-while-other-nations-innovate>.

²² 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, accessed December 11, 2022, <https://topwar.ru/198065-neudobnye-voprosy-gospodstvo-v-vozduhe-nad-ukrainoj-i-ego-posledstvija.html>.

²³ 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, <https://dx-doi-org.usnwc.idm.oclc.org/10.21557/MTH.47073783>.

The lack of a high-performance, dedicated electronic attack platform leaves Russia with few options to non-kinetically suppress an adversary's integrated air defense system (IADS). With limited non-kinetic options, the only choice that remains is to try and eliminate threat SAM systems kinetically. With limited precision-guided munitions to effectively target, engage, and destroy adversary SAM systems, the VKS has few options to target an enemy's IADS.²⁴ One of the methods observed throughout the Ukrainian conflict thus far has been through the use of anti-radiation missiles (ARM).

Designed to acquire and guide on the radar signature emitted by SAM radar systems, ARM can be an effective tool *if* employed correctly. Unfortunately, Russia seems overly confident in the capabilities of its anti-radiation missiles, with Russian military bloggers misguidedly touting ARM as the definitive option for destroying enemy air defense systems.²⁵ Russian Su-35S and Su-30SM aircraft have been observed flying combat sorties against Ukraine with load-outs of Kh-31P anti-radiation missiles.²⁶ However, based on videos appearing on social media, the employment altitude, flight profile, and ranges observed are unlikely to maximize the desired effects.²⁷

²⁴ Justin Bronk, "The Mysterious Case of the Missing Russian Air Force," Royal United Services Institute, last modified February 28, 2022, accessed October 23, 2022, <https://rusi.org/explore-our-research/publications/commentary/mysterious-case-missing-russian-air-force>.

²⁵ Evgeny Fedorov, "Подавление украинской ПВО: противорадиолокационный арсенал российской авиации" [Suppression of Ukrainian Air Defense: Anti-Radar Arsenal of Russian Aviation], Top War, last modified April 29, 2022, accessed October 23, 2022, <https://topwar.ru/195541-podavlenie-ukrainskoj-pvo-protivoradiolokacionnyj-arsenal-rossijskoj-aviacii.html>.

²⁶ Justin Bronk, "Getting Serious About SEAD: European Air Forces Must Learn from the Failure of the Russian Air Force over Ukraine," Royal United Services Institute, last modified April 6, 2022, accessed October 23, 2022, <https://rusi.org/explore-our-research/publications/rusi-defence-systems/getting-serious-about-sead-european-air-forces-must-learn-failure-russian-air-force-over-ukraine>.

²⁷ Justin Bronk (@Justin_Bronk), "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 AM, https://twitter.com/Justin_Bronk/status/1500736766487281666?s=20&t=aduTqUeFox_32mscTbwPSA.

Ideally, ARM is employed as a complementary weapon to non-kinetic effects like radar jamming. Based on the observed “belt-fed” employment of ARM by Russian aircrew, savvy radar operators can defend against anti-radiation missile attacks by simply “blinking” their radar system off and back on. With no radar emissions in the air, the missile will have nothing to guide on and essentially go “dumb.” While this defensive “blinking” tactic can provide a temporary SEAD sanctuary for aircraft, generally, the scope of time for this sanctuary can be measured in seconds or minutes (at best). SAM operators will simply turn the radar back on once the ARM threat has passed and continue prosecuting aircraft. This method of defeating ARM elucidates the need for layered kinetic and non-kinetic SEAD and raises the complexity levels of operations against modern air defense systems. To combat this complexity, 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 modern Russian Air Force.

Poorly Developed Operational Concepts

Even successful military modernization efforts in Russia over the last decade presented its 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 21st-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 is crucial in modern combined arms campaigns, especially in SAM-dense environments. But NATO officials have indicated that 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 air power 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."²⁸ Indeed, Bronk, Reynolds, and Watling observed that it takes the Russian military at least 48 hours to process actionable intelligence and assign it to a strike platform.²⁹ This is wholly inadequate in a dynamic surface-to-air missile environment.

Russian air power theorists were, in fact, aware of this problem prior to the war. The fleeting nature of air and ground targets requires exceptionally rapid and efficient intelligence, surveillance, and reconnaissance. In this regard, operations in Syria provided valuable experience. But browsing the Russian journal *Aerospace Forces: Theory and Practice*, the leading journal of air power in Russia, reveals that in the years leading up to the Ukraine conflict, Russian air power practitioners were still wrestling with the challenge of providing accurate, timely, and complete reconnaissance for strike platforms.³⁰ Interestingly, the creation of fused intelligence over multiple combat platforms was considered especially challenging; space-based ISR even more so.³¹

²⁸ Tim Martin, "Russia's air campaign hampered by poor ISR based strikes and target processing: NATO official," *Breaking Defense*, last modified November 4, 2022, accessed December 11, 2022, <https://breakingdefense.com/2022/11/russias-air-campaign-hampered-by-poor-isr-based-strikes-and-target-processing-nato-official/>.

²⁹ Bronk, Reynolds, and Watling, *The Russian*, 28.

³⁰ For example, see V.A. Vasiliev, P.A. Fedyunin, M.P. Belyaev, V.A. Manin, "Otsenka Urovnya Razvedyvat'nogo Obsespecheniya 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.

³¹ N.T. Shevtsov, A.N. Moor, "Sposob Dorazvedki Ob'ektov Protivnika Pri Vedenii Boyevykh Deystviy Smeshannaoy Aviatsionnoy Divizii," ("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; V.A. Vasiliev, P.A. Fedyunin, M.P. Belyaev, V.A. Manin, "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.

This lack of capabilities and immature concepts has had a compounding effect, placing Russian pilots on the horns of a dilemma. As Russian writers themselves note, “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 detection and targeting assets of medium-range air defense systems. However, as altitude increases, aircraft bombing accuracy diminishes to an unacceptable level.”³² 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.

Contributing Factors

Equally essential to understanding Russian deficiencies is an analysis of the manning and training of the Russian Air Force. 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.³³ This is approximately half of what US and UK aircrew receive for annual flight time. For comparison, RAF and US Air Force leadership have expressed concern about aircrew’s ability to maintain combat readiness with 180 flight hours per year.³⁴ If the VKS focus on IAMD occupies the majority of the 100 annual hours of Russian aircrew training, supporting missions like SEAD and DEAD are likely left on the

³² Kurilov, Kiryushin, and Moiseyev, "Current Problems," 24.

³³ Piotr Butowski and Thomas Newdick, "Russian Aggressor Squadron Gets Its First Su-35S Fighter Jets," The Drive, last modified October 4, 2022, accessed October 23, 2022, <https://www.thedrive.com/the-war-zone/russian-aggressor-squadron-gets-its-first-su-35s-fighter-jets>.

³⁴ Bronk, "The Mysterious," Royal United Services Institute.

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.³⁵ Unlike 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.”³⁶ In contrast, Western air force aircrew frequently train in dynamic targeting, whereas Russian aircrew/aircraft are treated like “flying artillery...they simply deliver explosives to certain coordinates, regardless of what might actually be at those coordinates at the time of the strike.”³⁷ This rigidity can often result in wasted ordnance on a mobile target that has since moved from where it was last located and allows for no flexibility on the part of the aircrew delivering ordnance on target. Thus, for most of the war, Russian tactical airstrikes have been carried out using tried and true ground control intercept tactics against pre-designated targets with unguided bombs and rockets. Against SAM systems, VKS forces have also resorted to the aforementioned crude ARM tactics, employing anti-radiation missiles against pre-designated SAM radars.³⁸

It is worth mentioning that a large percentage of Russian pilots have received at least some combat experience in the last ten years. It is assessed that approximately 90 percent of

³⁵ Michael Kofman, "Zapad 2021: What We Learned From Russia's Massive Military Drills," The Moscow Times, last modified September 23, 2021, accessed October 23, 2022, <https://www.themoscowtimes.com/2021/09/23/zapad-2021-what-we-learned-from-russias-massive-military-drills-a75127>.

³⁶ David Axe, "The Russian Air Force Is Back In The Fight In Ukraine. But It's Not Making Much Of A Difference.," Forbes, last modified September 16, 2022, accessed October 23, 2022, <https://www.forbes.com/sites/davidaxe/2022/09/16/the-russian-air-force-is-back-in-the-fight-in-ukraine-but-its-not-making-much-of-a-difference/?sh=4b28fa7f1235>.

³⁷ Axe, "The Russian," Forbes.

³⁸ Bronk, Reynolds, and Watling, The Russian, 1.

invasion of Ukraine has only exacerbated the European nations' need to come to terms with NATO's over-reliance on the United States for defense. But for all the bloviating about European "strategic autonomy," are NATO countries taking the correct steps to decrease their 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, Black Sea, and elsewhere. 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. Have European nations avoided these pitfalls?

Due to its highly publicized announcement of an increase in defense spending shortly after the Russian invasion of Ukraine, Germany serves as an excellent case study highlighting the military modernization efforts by NATO countries. On February 26th, 2022, German chancellor Olaf Scholz announced that Germany would dedicate €100 billion to modernize the German military and meet the NATO goal of 2 percent of GDP spending dedicated to defense.⁴⁷ A portion of this modernization 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,

<https://www.aa.com.tr/en/europe/french-president-says-europe-should-limit-dependence-on-us-for-security/2769816#>.

⁴⁷ Matthew Karnitschnig et al., "Inside Olaf Scholz's historic shift on defense, Ukraine and Russia," Politico, last modified March 5, 2022, accessed January 21, 2023, <https://www.politico.eu/article/olaf-scholz-historic-shift-defense-ukraine-russia-war/>.

Germany initially favored the purchase of a combination of thirty F/A-18 Super Hornets and fifteen EA-18G Growlers.⁴⁸ 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.

In mid-2022, German leadership reversed course on this decision to purchase Boeing's companion Super Hornet and Growler aircraft. On December 14th, 2022, Germany announced it would instead spend \$8.4 billion on 35 F-35 Lightning II fighters produced by Lockheed Martin.⁴⁹ 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 now Germany have all pledged to purchase the F-35.⁵⁰ To their credit, Lockheed Martin has done an excellent job marketing the F-35 globally, especially since it is currently the only exportable fifth-generation fighter in the world. Lockheed Martin's website outlines the capabilities of the F-35 as "Air-to-Everything," indicating that the F-35 is capable of executing "any and all mission[s]" required of a modern-day military aircraft, including SEAD/DEAD and electronic warfare.⁵¹ At first glance, the F-35 is especially appetizing for a NATO nation looking to modernize its air force with a fifth-generation, multi-role fighter.

⁴⁸ Grant Turnbull, "NATO Investment Brings Electronic Warfare Back Into Fashion," Global Defense Technology, https://defence.nridigital.com/global_defence_technology_jun20/nato-electronic-warfare-investment.

⁴⁹ Sebastian Sprenger, "Germany clinches \$8 billion purchase of 35 F-35 aircraft from the US," Defense News, last modified December 14, 2022, accessed January 21, 2023, <https://www.defensenews.com/global/europe/2022/12/14/germany-clinches-8-billion-purchase-of-35-f-35-aircraft-from-the-us/>.

⁵⁰ Vivienne Machi, "How the F-35 swept Europe, and the competition it could soon face," Defense News, last modified September 4, 2022, accessed January 21, 2023, <https://www.defensenews.com/global/europe/2022/09/04/how-the-f-35-swept-europe-and-the-competition-it-could-soon-face/>.

⁵¹ "Air-to-Everything," Lockheed Martin, accessed January 21, 2023, <https://www.lockheedmartin.com/en-us/products/f-35/f-35-capabilities.html>.

Weaved tightly into any procurement decision for modernization is a critical analysis of cost versus capability. Currently, one of the biggest driving factors behind European procurement of the F-35 is that the total cost of ownership for the F-35 has proven to be dramatically lower than its closest competitors. When examining Denmark's 2016 decision to purchase 28 F-35s, it becomes clear that 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.⁵² 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. Additionally, because of the longer service life of the F-35, Denmark decided to purchase ten fewer aircraft than it would have if it had chosen the F/A-18 or the Eurofighter. So, in the Danish leadership's eyes, they are getting a more modern, more reliable, more capable aircraft for less than the price of a fleet of older, 4th 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 doesn't mean that it *should* be considered 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 IADS in a conflict, and are European countries willing to utilize fifth-generation fighters to

⁵² Sydney J. Freedberg, Jr, "F-35 Wins Denmark Competition: Trounces Super Hornet, Eurofighter," Breaking Defense, last modified May 12, 2016, <https://breakingdefense.com/2016/05/f-35-wins-denmark-competition-trounces-super-hornet-eurofighter/>.

conduct SEAD in support of fourth-generation aircraft? For every F-35 allotted to SEAD, there is one less aircraft executing an air-to-surface strike on a critical target or consummating air-to-air intercepts against Russian fighters and long-range bombers in contested airspace.

Training must be factored into this equation as well. Much as we have seen the 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.⁵³ 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 multi-role 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 that 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. The benefit of having a dedicated SEAD/DEAD platform is that those aircrew become experts in their mission set instead of trying to be jacks of all trades.

Although Germany ultimately decided against investing in the EA-18G, the German leadership 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

⁵³ Michael Peck, "Bad News NATO: German Pilots Aren't Getting Enough Flight Time," *The National Interest*, last modified August 19, 2021, accessed February 15, 2023, <https://nationalinterest.org/blog/reboot/bad-news-nato-german-pilots-aren%E2%80%99t-getting-enough-flight-time-192022>.

to develop the Eurofighter ECR as a replacement for the Tornado ECR.⁵⁴ 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 is still in development.⁵⁵

Germany likely decided to invest in this electronic warfare variant of the Eurofighter because the German air force already operates the single-seat version of the Eurofighter. Rather than incorporate an entirely new platform into its air force inventory, the German air force will benefit from commonality *across* platforms, much like the United States Navy did through the development of the EA-18G Growler, an electronic warfare adaptation of the F/A-18F Super Hornet. While this decision may save Germany money in the long run, the fact that the Eurofighter ECR must go through a development and testing phase means that, for the time being, the German air force must rely on SEAD/DEAD support from the Tornado ECR.

Much as we have seen with the VKS, however, just because hardware modernization is ongoing doesn't mean that NATO's operational concepts are suitable for success. When referencing NATO's 2016 "Allied Joint Doctrine for Air and Space Operations," SEAD appears to be an afterthought concerning air dominance. An example resources allocation table in the document shows only a 10% allocation to SEAD in each of the first six days of a conflict.⁵⁶ Realistically, at the outset of a conflict with Russia, a thorough IADS rollback will be necessary,

⁵⁴ Gaston Dubois, "Confirmed! F-35 and Eurofighter ECR to replace Luftwaffe's Tornado," Aviacionline, last modified March 14, 2022, accessed January 22, 2023, <https://www.aviacionline.com/2022/03/confirmed-f-35-and-eurofighter-ecr-to-replace-luftaffes-tornado/>.

⁵⁵ Ricardo Meier, "Germany to order 15 electronic warfare Eurofighters in addition to F-35s," Air Data News, last modified March 16, 2022, accessed January 22, 2023, <https://www.airdatanews.com/germany-to-order-15-electronic-warfare-eurofighters-in-addition-to-f-35s/>.

⁵⁶ North Atlantic Treaty Organization, Allied Joint Doctrine for Air and Space Operations (n.p.: NATO Standardization Office, 2016), 4-19, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/624137/doctrine_nato_air_space_ops_ajp_3_3.pdf.

requiring robust SEAD/DEAD prioritization. As we have learned from Russia, the failure 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. Luckily, NATO has identified that SEAD has been under-prioritized and is taking steps to correct it.

In April 2017, NATO released a SEAD vision paper to acknowledge its deficiencies and outline a plan to modernize its operational concepts. As stated in the vision paper, the goal is that “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.”⁵⁷ Initially, the first goal of this SEAD modernization process consisted of a capability audit which was to be completed by the summer of 2019, followed by a capabilities gap analysis to be completed by the following year. As of April 2022, this capability audit had still not been completed and is expected to finish in 2023. The capabilities gap analysis is now forecast to be concluded by 2025.⁵⁸ With this modernization plan now three years behind the planned timeline, 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 IADS.

Compounding the delay of NATO’s SEAD study are additional challenges unique to a regional alliance like NATO. In a 2020 opinion piece titled “Strengthening NATO AEA,” the president of the Association of Old Crows, Stephen “Muddy” Watters, highlighted four of these challenges.⁵⁹ The first concern is that trust between nations is a sensitive and dynamic issue and may be inconsistent from country to country. Second, nations are constantly walking a tightrope

⁵⁷ Tim Fish, “NATO Ponders SEAD Modernization as Russia Fields New Threats,” *Journal of Electronic Defense* 41, no. 5 (May 2018): 26.

⁵⁸ Richard Scott, “Rebalancing AEA/SEAD Capability in NATO,” *Journal of Electromagnetic Defense Online*, last modified April 2022, <https://www.jedonline.com/2022/04/11/rebalancing-aea-sead-capability-in-nato/>.

⁵⁹ Stephen “Muddy” Watters, “Strengthening NATO AEA,” *Journal of Electronic Defense* 43, no. 1 (January 2020): 12.

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.

Conclusion

Combining all the contributing factors to the Russian air force’s failure in Ukraine, the lesson learned is that the success of modern-day air dominance operations comes down to more than just the hardware at 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 that 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 21st century must have the technology available to do so, sound operational doctrine, and aircrew with the experience and training to operate tactically in a dynamic environment. 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 an understanding of that importance but that it currently lacks the capabilities required in the air power domain and is taking the steps to fill the seams and gaps. The question is: will NATO effectively learn from Russia’s failures, and will it be ready in time for the next major conflict?