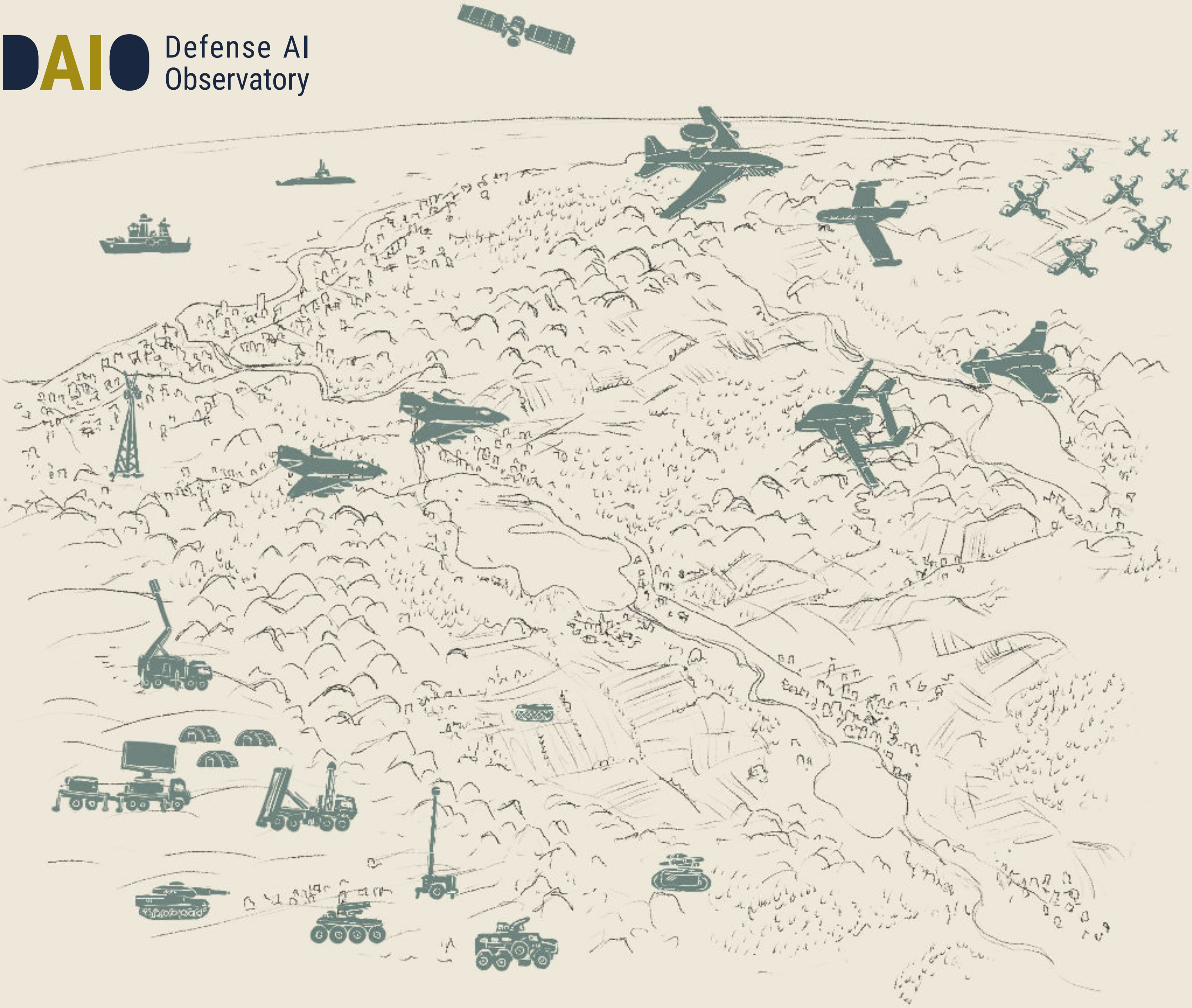

Beware the Hype

What Military Conflicts in Ukraine, Syria, Libya, and Nagorno-Karabakh (Don't) Tell Us About the Future of War

Heiko Borchert, Torben Schütz, Joseph Verbovszky

DAIO Study 21|01

Ein Projekt im Rahmen von dtec.bw
Zentrum für Digitalisierungs- und Technologieforschung der Bundeswehr

About the Defense AI Observatory

The Defense AI Observatory (DAIO) at the Helmut Schmidt University in Hamburg monitors and analyzes the use of artificial intelligence by armed forces. DAIO comprises three interrelated work streams:

- Culture, concept development, and organizational transformation in the context of military innovation
- Current and future conflict pictures, conflict dynamics, and operational experience, especially related to the use of emerging technologies
- Defense industrial dynamics with a particular focus on the impact of emerging technologies on the nature and character of techno-industrial ecosystems

DAIO is an integral element of GhostPlay, a capability and technology development project for concept-driven and AI-enhanced defense decision-making in support of fast-paced defense operations. GhostPlay is funded by the Center for Digital and Technology Research of the German Bundeswehr (dtec.bw).

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Content

1 Summary

Examining current conflicts in order to elicit what may inform future force development is an important task for analysts and force planners. However, it carries an inherent risk of overhyping single elements. We contend that this risk is clearly at play in the coverage of the most recent conflicts in Ukraine, Syria, Libya, as well as between Armenia and Azerbaijan over Nagorno-Karabakh. Our comparative assessment of the commonalities and differences of these four conflicts prompts us to express strong words of caution. While these conflicts offer insights into certain aspects of future warfighting, they are not game changing. With a particular focus on the interplay between Unmanned Aerial Vehicles (UAV), air defense, and electronic warfare we find that the lines of continuity in deploying these assets are much more distinct than the elements of adaptation and change. Thus, we offer five key findings in two groups.

First, we argue that a disproportional focus on UAVs led to a distorted perception of the actual warfighting reality. While we acknowledge specific refinements in the way warring parties have actually deployed UAVs, tried and tested tactics have prevailed. By contrast, the use of electronic warfare assets as seen in all four conflicts and the particular vulnerabilities of air defense systems should receive much more attention.

Second, the value of every single military asset very much depends on its overall degree of integration into the C4/5ISTAR[1] value chain that constitutes the military backbone. Those actors that have successfully managed this complex military ecosystem prevailed across all four conflicts whereas patchy plug-and-play approaches without proper integration performed badly. Conceptual and organizational changes that might pertain to the operation of the C4/5ISTAR value chain thus need more attention as they go hand in hand with overall aspect of military decision-making.

1 Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance, Target Acquisition, and Reconnaissance.

Third, in line with the ecosystem argument, humans still play a decisive role in every aspect of warfighting. If and to what extent the human role changes in the future very much depends on the readiness of planners, operators, and engineers to break new ground. This however depends on a complex interplay of different factors, which tend to favor the status quo over radical change.

In addition to these status quo-related findings two additional aspects are worth mentioning as they offer windows into future developments that can cause change because they provide new incentives to adapt behavioral patters and offer novel ways for force development. First, the military world is increasingly dominated by warstreaming, i.e., the ability of warring parties to provide live feeds from the battlefield. Warstreaming affects perceptions and has led to an overemphasis on the role of UAVs at the expense of other aspects like C4/5ISTAR integration or electronic warfare that are hard to see. We speculate that in the long run the aesthetics of warstreaming could incentivize changes in operational behavior in order to satisfy the hunger for pictures not yet seen before.

Finally, a distinct feature not yet properly addressed is War as a Service (WaaS), a new politico-strategic "business model" that enables and facilitates (temporary) military power transfer on a government-to-government basis. WaaS should be interpreted as the provision of a "white label" turn-key solution including not only technology assets but also planning and operational assistance as well as embedded force elements and training. We consider WaaS as an important alternative route to force development that could offer options to leapfrog over adversarial peers depending on the readiness of the recipient to insource military power from a strategic ally as well as the ally's conceptual, organizational, and technological maturity and willingness to take risks on behalf of the recipient.

2 Introduction

Being ready for the next war is challenging because military concept developers and force planners only have past experience and current knowledge about perceived future challenges to prepare for the future. Real wars thus offer a plethora of observations that can provide glimpses of how the future of warfighting might look like. In times of perceived technological change that might underpin military success, observers pay particular attention to how armed forces have been using the latest technology not least because this is "the easiest to observe in most cases."[2]

Against this background, this paper sheds light on the most recent military conflicts in Ukraine, Syria, Libya, and Nagorno-Karabakh. Three factors motivated our case selection: First, these conflicts are relevant from an analytical perspective because they no longer fall into the paradigm of counterinsurgency operations or international interventions against local warfighting parties that have come to dominate the international landscape since the end of the Cold War. Rather, all four conflicts show elements of different types of conflicts such as the preference for operations that are hard to attribute to any of the parties involved in the conflict (Ukraine), geographically limited peer-to-peer conflicts (Turkey vs. Russia in Syria and in Libya), and regional interstate war with outside support (Armenia vs Azerbaijan). Thus, the shades of gray resulting from these types of conflicts in combination with the underlying power struggle for (regional) dominance is in line with a growing body of literature trying to capture the essence of future conflict pictures.

Second, many analyses covering the four conflicts portray them as game changing. We are much more cautious and believe that this is a great exaggeration. We do not discard the importance of these conflicts as illustrations of elements of future warfighting. But most of the elements currently considered as game changing are neither novel nor disruptive. And some observations we believe are important – such as warstreaming and temporary military power transfer via War as a Services (WaaS), which have both evolved throughout the four conflicts – have not yet made it to the fore because current perceptions are greatly distorted. Readjusting perceptions with regard to these four conflicts is paramount as distorted views are likely to lead to the identification of the "wrong" lessons, which in turn constitutes a grave danger for future concept, capability, and technology developments.

Overall, our analysis of the four conflicts puts major emphasis on the interplay between Unmanned Aerial Vehicles (UAV), electronic warfare (EW), and air defense. First of all, this emphasis results from the focus of GhostPlay (Box 1), the four-year capability and technology development project that provides the framework for the activities of the Defense AI Observatory and shapes is priorities. Second, the hype surrounding the extensive use of UAV and their partial successes against air

2 Horowitz/Pindyck, "What Is a Military Innovation and Why It Matters," p. 51.

defense systems, for example, largely ignores the use of well-known existing tactics, the integral role of supporting EW assets and what is likely human intelligence when it comes to the right timing of the attack. What is thus missing is a comprehensive view on the mechanics of complex defense ecosystems,[3] whose performance very much depends on the overall degree of integration of every single element.

Finally, these conflicts look the way they do because of the parties involved. This might seem tautological, but it is very important to remind readers that some conflict characteristics are very specific and thus hard to recreate. Russia's use of threat text messages to members of the families of Ukrainian soldiers, for example, has benefited from the fact that Vodafone Ukraine is a subsidiary of Mobile TeleSystems of Russia, which has facilitated network access (chapter 4.1). In a similar way Turkey's intelligence preparation of the battlespace in northern Syria benefited from close geographical proximity to the homeland (chapter 4.2).

Box 1: Project GhostPlay – Main Features

GhostPlay creates a high-performance, synthetic simulation environment (= Ghost) in order to develop decision-making procedures taking into account different parameters (= Play) by means of artificial intelligence (AI) and in interaction with opponents that have different performance profiles. The focus is on the tactical level and on operations of highest tempo (e.g., duels). GhostPlay focuses on the suppression of enemy air defense (SEAD) and the use of air defense against intervening SEAD units. GhostPlay's defense decision algorithms will be transferred to training simulators to demonstrate how to augment the sensor-to-effector network with AI-enhanced decision support commensurate with varying mission requirements and environmental conditions.

Traditional AI focuses on the extraction of patterns from mass data. GhostPlay's methodological approach goes significantly beyond this approach. The goal is to develop an approach in which context-aware, complex, and optimal multi-stage decision-making procedures are developed for attacking units and defending air defense units. Therefore, GhostPlay uses

- Deep reinforcement learning in combination with operations research and game theory
- Transfer learning to provide an AI solution based on real-world conditions developed in a simulation environment
- Meta learning in the sense of "lifelong learning" to continuously evolve decision procedures in a non-stationary environment that may change over time.

3 We define defense ecosystems as the interplay between actors (e.g., armed forces, battlefield engineers, defense contractors, proxy forces) and equipment (e.g., land/air/sea platforms, missiles, unmanned systems), which is embedded in and shaped by institutions, relations, concepts and cultural norms (e.g., doctrine), to deliver military performance in fulfillment of specific missions (e.g., strike, surveillance, air defense). This definition is inspired by the definition of innovation ecosystems put forward by Granstrand/Holgersson, "Innovation ecosystems," p. 3.

Based on our analysis this paper argues that, while offering important insights, all four conflicts are well anchored in current warfighting paradigms, hardly show unique ways of operating and employing assets and are thus not game changing.[4] Rather the impression of "disruption" on the battlefield stems from an overemphasis of singular aspects that downplays the fact that armed forces need comprehensive proficiency in many different dimensions in order to provide added value with the use, for example, of UAV. UAV alone do not make the difference; they need to be integrated in a complex defense ecosystem to do so. This observation is reinforced by the fact that Russia's open support for Syria and the conflict between Armenia and Azerbaijan in Nagorno-Karabakh have seen War as a Service (WaaS) as a new type of government-to-government military assistance. As we will argue below, it is not surprising that Turkey plays a key role in this context, as Ankara is the one actor across all conflicts analyzed that is most proficient in using UAV matched with a high level of conceptual readiness and technological maturity. Warstreaming, i.e., live feeds from the battlefield, further strengthens this impression. While violent non-state actors initially used warstreaming in Syria, Turkey and Azerbaijan have perfected its use also thanks to specific technical features of Turkish UAVs. In line with the emphasis on mastering a complex ecosystem and WaaS, we also contend that all four conflicts reemphasize the pivotal role of the human element. None of the four conflicts analyzed provides a glimpse into a future battlefield in which humans might share command authority with machines and/or algorithms. Rather humans continue to play a pivotal role in operating all warfighting assets in all four conflicts.

We present our findings in four steps. First, we briefly summarize the literature on military innovation. This body of literature is important because it provides the conceptual building blocks to assess if and to what degree developments observed in practice might be considered innovative. In reviewing the literature, we focus in particular on conceptual/doctrinal, organizational, and technological change as key elements of defense innovation and take into account the interplay between these three vectors of change and humans. Second, we provide a quick scan of the four conflicts thereby focusing on the political and geostrategic context, the parties involved, the operational conditions, the main assets in use, and the current state of play. This discussion provides the basis for our assessment of the degree of novelty of the four conflicts which is followed by the paper's conclusion that will shed light on some of the aspects that we consider important for future concepts and technology development.

4 For example, the use of UAV in the first wave of air operations to blind adversarial air defense assets is not unique. Rather it follows tried and tested Suppression of Enemy Air Defense (SEAD) concepts with the only difference that tasks hitherto executed with manned fighter jets are now delegate to UAV, which are controlled by pilots in command and control centers.

3 Military Innovation: Building Blocks

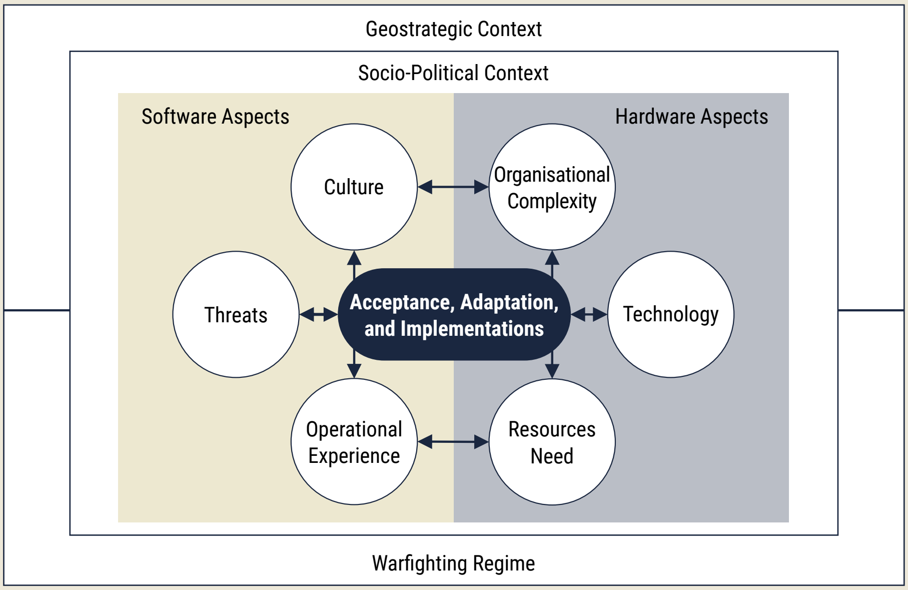
Military innovation is an important, but challenging concept because of the lack of consensus to define the term.[5] This paper is not the appropriate place to discuss in detail how a significant body of literature goes about solving this definitory challenge. Rather we are interested in briefly describing those building blocks identified in the literature as important elements that can advance our understanding if and to what extent developments in the military domain could be considered "innovative." In doing so, we follow Andrew Ross' very generic definition of military innovation as "change in how militaries prepare for, fight and win wars."[6] However, in order to provide military added value, the respective change needs to offer unique elements that can translate into military advantage. These unique elements can refer to conceptual/cultural, organizational or technological novelties.[7] These three elements, in turn, need to be seen in context with the operational requirements. The various forces underpinning this interplay can be grouped into software and hardware aspects of innovation.[8] These two elements from the inside dimension of the framework which is embedded in an outside dimension (Figure 1).

Overall, it is important to note that military innovation is a process, not a static outcome. A process diffuses and might be amplified by supporters or nullified by opponents. The literature on military innovation offers different explanations for how and why innovation diffuses. For example, imitation can prompt the armed forces of one country to mimic the tactics of a peer. The tactics and the battlefield performance of one country can be adapted to meet the requirements of another country. Or countries can explore truly novel concepts, tactics and structures to employ military force.[9] In this regard we argue that the sole replacement of manned assets (fighter jets) with unmanned assets (UAV) without changing the underlying concept of operations may constitute imitation, but it very much depends on the battlefield outcome if this approach equates innovation or not. As a consequence, for these assets to constitute a military revolution "a complex mix of tactical, organizational, doctrinal, and technological innovations" would need to come together to "implement a new conceptual approach to warfare."[10]

With regard to diffusion, War as a Services (WaaS) is a notable phenomenon. As we will explain in chapter 5.5, WaaS entails the combination of concepts, structures, technical assets and manpower in a turn-key solution to provide government-to-government military support. This opens up a potentially new avenue for

5 Horowitz/Pindyck, "What is military innovation and why it matters."
6 Ross, "On Military Innovation," p. 1.
7 We acknowledge that uniqueness is challenging to grasp, as it can refer to simple imitation, the adjustment of concepts or methods or the development of truly novel structures, concepts or tactics to employ military force. Against this background we argue that the replacement of manned assets with unmanned assets without changing the underlying concept of operation may constitute imitation but does not equate innovation. For more on this, see also: Raska, *Military Innovation in Small States,* pp. 168-169; Hoffman, *Mars Adapting,* pp. 5-8.
8 See also: Goldman/Eliason, "Introduction: Theoretical and Comparative Perspectives on Innovation and Diffusion," pp. 7-8.
9 For more on this, see: Raska, *Military Innovation in Small States,* pp. 168-169.
10 Murray/Knox, "Thinking about revolutions in warfare," p. 12.

Figure 1: Elements of Military Innovation



Source: Adapted from Borchert/Kraemer/Mahon, Waiting for Disruption?!, p. 18.

force development. If, however, WaaS will change the status quo by introducing new ways of warfighting, very much depends on the readiness and the capacities of WaaS suppliers and recipients to do so.

3.1 Environment

The outside dimension of our military innovation framework consists of the geostrategic environment, the warfighting regime and the immediate socio-political context:

- The geostrategic environment mirrors the global and regional power balance that influences the way in which decision-makers perceive international power dynamics.[11]

11 Kuo, "Military Innovation and Technological Determinism," p. 2; Isaacson/Layne/Arquilla, *Predicting Military Innovation,* pp. 4, 12-13.

- The prevailing warfighting regime responds to the geostrategic environment and is shaped by national levels of ambition and the readiness to fight wars. The warfighting regime also reflects past operational experience and builds on cultural and doctrinal guidelines.[12]
- The socio-political context acts as a two-pronged filter, by selecting how decision-makers perceive the geostrategic context and by determining what use of military power is politically palatable.[13] The socio-political context is also an important factor influencing civil-military relations, which in turn is interpreted as a major driver or stumbling block for military innovation. In addition, the socio-political context can shape strategic preferences. As Katarzyna Zysk argues with regard to Russia, "national interest is likely to remain a higher priority than privacy and human rights," which suggests that "ethical and moral considerations related to military applications of AI and autonomous weapon systems will likely not emerge as a major factor constraining further development."[14]

3.2 Hardware Aspects

The interplay between technology, resources need, and organizational complexity characterizes the hardware dimension of our innovation model. It is easy to overemphasize the role of technology as a driver for innovation, as Horowitz/Pindyck discuss in their extensive assessment of the military innovation literature.[15] What matters most in the context of our study is the interplay between conceptual, organizational, and technological aspects. This leads to the innovation vs. acceptance paradox. For new technology to be accepted by armed forces, it might help to use existing concepts of operations and familiar ways of fielding new equipment. As argued above with regard to a nation's risk appetite, being on familiar ground might be a safe bet, but acceptance can eat innovation as armed forces will continue to use new equipment in the same traditional way. This suggests that true change, that will be hard for peers to emulate and copy, might stem from conceptual and organizational transformation rather than from the availability of new technology.[16]

Technological complexity adds another layer of complexities. As Andrea Gilli and Mauro Gilli argue the increase in complexity of military technology has changed "the system of production that has made the imitation and replication of the

12 Barno/Bensahel, Adaptation Under Fire, pp. 9-29; See with a particular focus on the role of emerging technologies like unmanned systems and artificial intelligence: Raska, "The sixth RMA wave."
13 Borchert/Kraemer/Mahon, "Waiting for Disruption," p. 19.
14 Zisk, "Defence innovation and the 4th industrial revolution in Russia," p. 24.
15 Horowitz/Pyndick, "What is a Military Innovation and Why it Matters," pp. 11-13.
16 Adamsky, *The Culture of Military Innovation,* p. 21; Horowitz, *The Diffusion of Military Power,* p. 34.

performance of state-of-the-art weapon systems harder."[17] Commercial or military technology off-the-shelf (C/MOTS) won't do the trick. C/MOTS might play a key role in developing certain types of UAV like the Bayraktar TB2 drone by Turkish manufacturer Baykar. At around $2.5 million per piece[18] this platform also seems to be relatively cheap which might prompt armed forces to lose them. But as we will argue in chapters 5.1 and 5.2, armed forces still need to properly integrate these assets into the C4/5ISTAR value chain in order to achieve superior effects – and this where the true costs originate.

3.3 Software Aspects

Software aspects refer to the interplay of threats and threat perceptions, doctrine and culture as well as operational experience. Dima Adamsky posits that "the relationship between technology and military innovation is (…) socially constructed."[19] Societal values, which are shaped by the socio-political context, very much determine which wars nations are willing to fight, how they will fight, and what technologies they are ready to use. When it comes to the use of UAV, for example, risk appetite is an important factor influencing the offensive or defensive use. Attitudes vis-à-vis change in the geostrategic environment in general and technological progress in particular are influenced by military culture, that is "identities, norms and values that have been internalized by a military organization and frame the way the organization views the world, and its role and function in it."[20] Military culture is not universal across services. Rather service-specific subculture matters a lot and may play a key role in the service's readiness to embrace and drive (technology-enabled) change.[21]

In this regard the dynamic between culture, conceptual as well as organizational change is important. Different factors shape this dynamic. For example, access to military and political sources of power willing to drive change or inter- and intra-service competition are important.[22] In addition, promotional aspects and prestige might matter as well. "I was happy when drones came in," a US Air Force helicopter pilot quoted by P.W. Singer argued, because it meant that "we were no longer at the bottom of the totem pole."[23] Rewarding specific skills that might be related to the use of new technologies could thus provide important incentives for

17 Gilli/GIlli, "Why China Has Not Caught Up," p. 142.
18 Urcosta, "The Revolution in Drone Warfare," p. 59. Some sources set the platform price without control stations even lower at $0.5m. See: "Kington, "Libya is turning into a battle lab for air warfare."
19 Adamsky, *The Culture of Military Innovation,* p. 10.
20 Theo Farrell's definition, quoted by Raska, *Military Innovation in Small States,* p. 4.
21 Mansoor/Murray, "Introduction", pp. 11-14.
22 Raska, *Military Innovation in Small States;* Adamsky, *The Culture of Military Innovation;* Horowitz/Pindyck, "What is a Military Innovation and Why it Matters," p. 15-17.
23 Singer, *Wired for War,* p. 253.

members of the armed forces to change attitudes. In this context it is noteworthy that Azerbaijan's President Ilham Aliyev awarded the "Karabakh Order" to Selcuk Bayraktar, the Chief Technology Officer of Baykar, the Turkish company providing UAVs to Azerbaijan. The award will most likely enhance the impression that this type of equipment is decisive in military operations and might add prestige also to the pilots operating it.[24]

Military culture also interacts with operational experience and threat perceptions. Geostrategic dynamics can affect military innovation if nations perceive these dynamics as a threat to their core values. If and to what extent armed forces change in response to these dynamics depends on additional aspects such as organizational age and operational experience. Organizational age tends to have a cautioning influence as older organizations have a tendency to resist change.[25] Operational experience can reinforce existing cultural patterns and thus reinforce resistance. Proximity to familiar tactics techniques, and procedures might increase acceptance of novel ideas and technologies, because it builds on common ground.[26] This explains why most UAVs – or unmanned systems deployed onshore and at sea – are used in traditional ways and simply replace specific tasks hitherto executed with manned assets.

Software aspects also very much shape the risk appetite and the readiness to outpace peers. Advantages early adopters/movers could gain are "inversely proportional to the diffusion rate of the innovation."[27] Thus waiting can be wiser than leapfrogging as long as questions with regard to the benefits of military innovation prevail. Similarly, the literature also suggests that even status quo challengers are likely to be risk averse. They prefer emulating peers, if "pursuing their own innovation proves costly relative to imitation, little information exists about the effectiveness of alternative innovations, and the perceived risks of failing to imitate another state outweigh the perceived benefits of pursuing a novel but risky new technology."[28] This, in turn, makes the proliferation of operational concepts and technologies a most interesting phenomenon to study as the rise of alternative role models that goes hand in hand with the fact that different actors might come up with different ways of using modern equipment creates a divergent set of benchmarks that observing actors can use for emulation. But as we will discuss later, the four conflicts under review in this paper illustrate that a deviation from current operational concepts to use UAVs is not yet in the cards.

24 "Baykar CTO Bayraktar receives 'Karabakh Order' from Alyev."
25 Horowitz, *The Diffusion of Military Power,* p. 38.
26 Murray, *Military Adaptation in War,* p. 3.
27 Horowitz, *The Diffusion of Military Power,* p. 50.
28 Liou/Musgrave/Daniel, "The Imitation Game: Why Don't Rising Powers Innovate Their Militaries More?," p. 159.

4 Current Conflicts: Quick Scan

The conflicts in Ukraine, Syria, Libya and between Armenia and Azerbaijan over Nagorno-Karabakh illustrate different ways of using UAV, EW and air defense assets. Overall, these conflicts are reminiscent of a "military interregnum" as they sit at the intersection of traditional modes of warfighting and the use of assets driven by emerging technologies. All warring parties have been experimenting with these new assets, some of them more others less successful. While it might sound tautological, it is very important to understand that the fighting that was observed in these conflicts looked the way it did because of the parties involved and the very diverging levels of maturity in integrating these new assets. The scope of outside assistance, that most parties in these conflicts have received, played an important, in some cases a pivotal role to tilt the balance.

The conflict between Ukraine and pro-Russian separatists is an amalgamation of tried and tested tactics with new assets. UAVs have been used to provide beyond-line-of sight sensing for armor, infantry, and in particular Russian artillery thus extending their reach into adversarial territory while at the same time limiting losses. UAVs also played a key role in advancing battlespace awareness, also because their use has hardly been contested. The ultimate feature of this conflict, however, is the extensive use of EW assets in particular by Russian forces. The use of EW has spun a broad range of tasks including sabotage, jamming, spoofing and threat campaigns. UAVs were used to support EW operations as well. The role of air defense was more subdued in comparison to the other conflicts analyzed.

Russia and Turkey have used the fighting in Syria as a testbed to deploy new equipment. The conflict has been characterized by the heavy use of UAVs and UCAVs in addition to EW assets. Local non-state actors also made use of UAVs not only for intelligence, surveillance, and reconnaissance, but also for what has become a famous "swarm attack" against the Russian Khmeimim air base. Syrian air defense has been severely tested and did not perform well. Some of Russia's air defense assets performed below expectations (Pantsir S-1) whereas others have reportedly not actively engaged targets (S-300 and S-400). Russian use of EW in support of air defense, however, has reportedly been instrumental in bringing down adversarial UAV and US missiles.

Like in Syria, UAVs and air defense assets have been extensively used by the warring factions in Libya. Both sides seemingly acknowledge the important role of UCAVs as strike assets since they attacked each other's drone infrastructure. Overall, the record of air defense assets is mixed as they were at times successful against various air assets and times not. This uneven performance hints at another feature of the conflict, the Turkish use of EW in favor of its ally, the Government of National Accord (GNA), as well as combatant adaptation to the battlefield. In combination with traditional assets for land and aerial warfare either side conducted successful offensive operations going back and forth across Northern Libya.

The conflict between Armenia and Azerbaijan over Nagorno-Karabakh is characterized by a distinct asymmetry of operational proficiency to the benefit of Azerbaijan – most likely thanks to strategic Turkish support and embedded force elements –, a dire state of military preparedness on Armenia's side as well as the 24x7 live streaming of drone-based operations. Permanent media coverage of the conflict had a decisive impact on public perception, notably the role of Turkish Bayraktar TB2 UAVs and IAI's Harop loitering munition. Drones played a key role on both sides with Azerbaijan getting the upper hand. The dismal state of Armenia's air defense is one of the major reasons for Azerbaijan's drone-based air power. In addition, Azerbaijani operators creatively used these assets to deceive adversarial air defense assets. EW assets were less prevalent in this conflict – only speculated to have been used sparingly by Armenia at the very beginning and possibly by Russia at the very end to defend internationally recognized Armenian territory.

4.1 Ukraine: The Old, the New, the Ugly

The current conflict is a direct result of the Maidan revolution, Russia's annexation of the Crimean Peninsula, and the ensuing revolt of pro-Russian forces in the Donetsk and Luhansk Oblasts in eastern Ukraine. The conflict demonstrates many features of a "frozen conflict," but due to continuous ceasefire violations it has a greater potential to flare up again. The unstable ceasefire is currently regulated by the Minsk II agreement, signed on 15 February 2015. The Minsk Agreement – designed as a roadmap to end the conflict – is a major political and diplomatic win for Russia and the separatists, whose demands make up many of the terms within the agreement.[29]

The conflict primarily takes place between Ukraine and pro-Russian separatist Republics of Luhansk (LPR) and Donetsk (DPR). Russia is actively involved on the side of the separatists and has invaded Ukrainian territory on numerous occasions, most significantly during the separatist counteroffensive in August 2014.[30] However, Russia prefers to "White-label" its involvement in the Ukraine through separatist and "volunteer" forces. The Minsk II agreement demonstrates the usefulness of "white labelling" even if Russian involvement is no longer plausibly deniable. Although supportive of Minsk II, Russia claims not to be a party to the conflict and thereby not responsible for implementation.[31] This serves the purpose of both providing – at least localized – international legal legitimacy to the Russian proxies LPR and DPR and placing blame for lack of progress of implementation with Ukraine.

29 Kofman et al., *Lessons Learned from Russia's Operations in Crimea and Eastern Ukraine*, p. 48.
30 Ibid., p. 45.
31 Kramer/Gordon, "U.S. Faults Russia as Combat Spikes in East Ukraine."

The majority of the fighting takes place in the Donbass region of Ukraine. It is primarily characterized by flat, grassy plains, small to medium sized urban centers, as well as the coastal and peninsular region, bordering on Crimea. The situation of Crimea and its connection to mainland Ukraine remains a key factor, as does control over the Sea of Azov. The vast majority of Crimea's water supply comes from mainland Ukraine. Failure by initial offensives of pro-Russian forces in 2014 and 2015 to capture the mainland water supply to Crimea means that Crimea remains dependent on Ukrainian political will to supply water to the peninsula despite Russian occupation. At present, the Ukrainian position remains not to supply Crimea with water, something which plays into Russian calculations to pursue a military conquest of the water supply.

Separatist and Russian success against Ukrainian forces can be attributed to a set of capabilities which, when used in combination, could effectively degrade and destroy Ukrainian resistance to separatist offensives. The first capability includes the widespread use of UAVs, primarily in the role of indirect fire support. The second is air defense, which grounded the Ukrainian air force. Finally, but perhaps most importantly, Russia's extensive use of EW, especially offensively, allowed Russian-backed forces to carry out operations at the margins of what would be considered "war."[32]

Russian use of UAVs in Ukraine show that drones do not bring about a military revolution but allow for new combinations of existing elements to produce devastating effects: "(T)he sensor platforms that are often used at multiple altitudes over the same target with complimentary imaging; a command-and-control system that nets their input and delivers a strike order; and an on-call ground-based strike capability that can execute an attack on short order."[33]

Artillery strikes were followed by attacks with armor and infantry – in line with the Soviet reconnaissance/strike model.[34] Here the use of drones does not include any large-scale adaptations of doctrine to their use. However, using them in the reconnaissance role allows Russia to achieve a similar level of effectiveness and precision that would come from close-air-support or precision-munitions, at a potentially much lower cost. Significant use of Russian UVAs for indirect support was noted at the decisive Russian/Separatist victory of Debaltseve, including GRANAT-4, Forpost and Orlon-10.[35] Likewise, this possibly provides Russia an alternative to deploying manned air assets, whose sophistication would make them more

32 Part of Russia's success can also be attributed to the lethality of the munitions used. Russia has been willing to conduct area fires using Multiple Launch Rocket Systems and has increased effectiveness by relying on Dual-Purpose Improved Conventional Munitions, sensor-fused weapons, scatterable mines, top-attack munitions, and thermobaric warheads, many of which the United States does not field. Angevine et. al., *Learning Lessons from the Ukraine Conflict,* p. 9.
33 Ibid., p. 8.
34 Ibid, pp. 8-9.
35 "#MinskMonitor: Russian Drones Directed Separatist Artillery Against Ukraine."

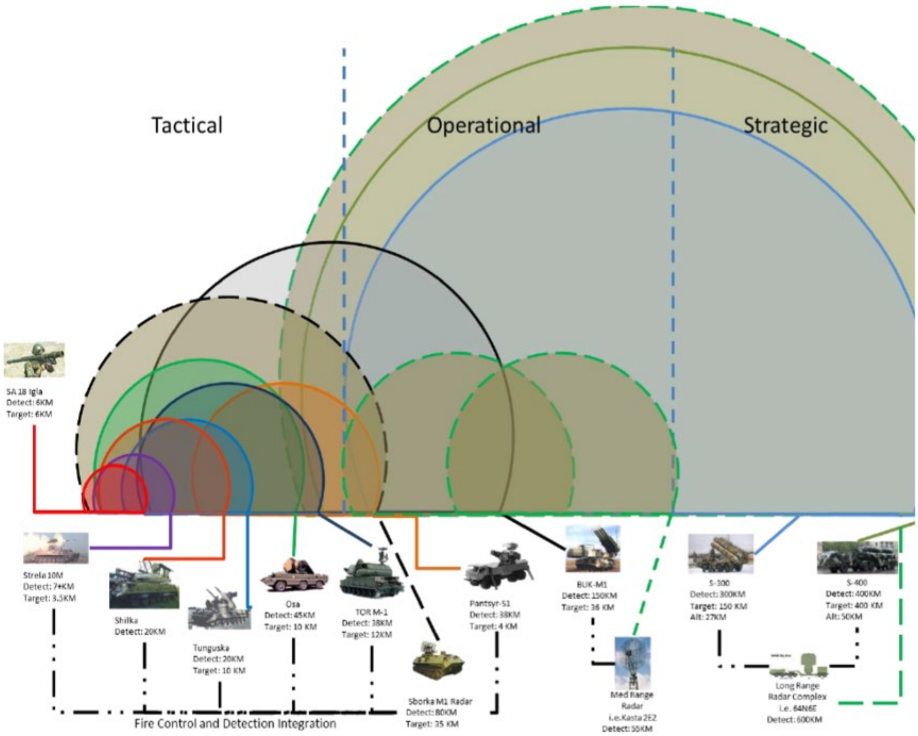
difficult to present as weapons of rebels and therefore may trigger a more robust western response.

One of the unique features of the War in Donbass is that neither side uses traditional air assets such as manned aircraft, whether fixed wing or helicopters. In order to maintain some semblance of plausible deniability, Russia has avoided deploying helicopters or fixed wing aircraft for close air support.[36] However, Ukraine initially attempted to provide close air support to its ground forces. This failed for two reasons: Endogenous, the Ukrainian air force had poorly trained pilots and outdated equipment.[37] On the other hand, Russia provided the separatists with the entire "backbone" of integrated air defense, from S-400 to MANPADS directly deployed in separatist and Russian units operating in the Ukraine (Figure 2).[38]

Although not as visible as Russian artillery strikes and air defense systems, Russia's EW capabilities are decisive and potentially its most effective weapon. Samuel Bendett went so far as to describe it as "eyewatering."[39] EW covers a broad swathe of activities, from sabotage, to jamming, spoofing and information campaigns. Russian sabotage of Ukrainian equipment purchased before the war started by means of kill switches installed in the devices.[40] Additionally, Russia has extensively employed jamming against Ukraine. In the early stages of the conflict, Russia successfully jammed Ukrainian legacy radios.[41] Sabotage and jamming forced Ukrainian armed forces to switch to commercial radios and cellular networks which the Russians then relentlessly attacked.[42] Russia could also use Ukrainian dependence on cellular networks to geolocate and target mobile communication with artillery fire, in particular using Orlon-10 UAVs.[43] Ukraine now uses frequency-hopping radios from Harris and Aselsan. While the situation may have improved, Ukrainian officials can provide no further information on whether these changes have been effective against Russian jamming.[44] In addition to jamming and hacking Ukrainian communications systems, Russia and the Russian-backed separatists have used jamming against Ukrainian UAVs and surveillance UAVs deployed by the Organization for Security and Cooperation in Europe (OSCE).[45] Between 2015 and 2017, Ukraine lost 100 UAVs to Russia jamming and spoofing the Global Navigation Satellite System (GNSS).[46] Likewise, the 72 Raven drones provided in 2016 as security assistance from the United States, were immediately

36 Angevine et. al., *Learning Lessons from the Ukraine Conflict,* p. 11.
37 Ibid.
38 Ibid.
39 McCrory, "Russian Electronic Warfare, Cyber and Information Operations in Ukraine," p. 2.
40 Mocanu, "Lessons after the electronic war in Ukraine," p. 1.
41 McCrory, "Russian Electronic Warfare, Cyber and Information Operations in Ukraine," p. 3.
42 Trevitschik, "Ukrainian Officer details Russian Electronic Warfare Tactics Including Radio 'Virus'."
43 McCrory, " Russian Electronic Warfare, Cyber and Information Operations in Ukraine," p. 3.
44 Trevitschik, "Ukrainian Officer Details Russian Electronic Warfare Tactics Including Radio 'Virus'."
45 Hudson, "International Monitor Quietly Drops Drone Surveillance of Ukraine War." According to Hudson, OSCE UAVs were also attacked by missiles.
46 McCrory, "Russian Electronic Warfare, Cyber and Information Operations in Ukraine," p. 3.

Figure 2: Russian ADA Protection Concept



Source: Angevine et. al., Learning Lessons from the Ukraine Conflict, p. 16.

jammed by separatist forces.[47] Russia has, however, largely avoided jamming or spoofing the Ka-band satellite, which both Russia and Ukraine share.[48]

Ukraine itself has drawn the lesson that it must invest heavily in drone technology, both indigenous and exogenous to counter Russian superiority. As Ukraine realized the devastating potential of drone technology – particularly for indirect fire support – several initiatives spawned in the country, including crowd-funding campaigns.[49] The Ukraine seeks drones for reconnaissance as well as for combat roles – specifically as loitering munitions.[50] In addition to indigenous develop-

47 Stewart, "Exclusive: U.S.-supplied drones disappoint Ukraine at the front lines."
48 Trevitschik, "Ukrainian Officer Details Russian Electronic Warfare Tactics Including Radio 'Virus'."
49 Müller, „Krieg führen per Crowdfunding."
50 Ibid.

ments, Ukraine has also procured drones from abroad, most notably the Bayraktar TB2 from Turkey.[51]

At the time of writing, the conflict remains unresolved as a stalemate. However, indications of a potential escalation by Russia are evident. Based on this overview, the Russian-backed separatists would hold a significant advantage over Ukrainian forces. The Ukraine appears to have placed its bet on the technological solution – investment in drone technology. Russian-backed separatists meanwhile benefit from integration into a complex ecosystem of capabilities, most prominently UAV for ISR and indirect fire support, integrated air defense and EW.

4.2 Syria: The Ideal Testbed

The Syrian civil war started with civilian uprisings against the central government in March 2011. Over the course of the conflict, various parties were and are involved in it, from the Syrian government and its supporters (Russia, Iran, Hezbollah) to quasi-independent proto-states like Rojava and the Syrian Arab Republic (and its armed forces, the Syrian Democratic Forces) to foreign-backed entities like the Syrian Interim Government (backed by Turkey).[52] Additionally, non-state actors like Hayat Tahrir al-Sham (HTS)[53] and the Islamic State (IS)[54] emerged at times as actors controlling significant parts of the country, which led to US-led multinational intervention in form of Operation Inherent Resolve.[55] Lastly, Israel repeatedly attacked targets in Syria with air strikes since 2013.[56]

Over its ten-year duration, various military campaigns and changes in military conduct by the participating parties themselves have occurred.[57] In alignment with the focus of this study on unmanned systems, air defense and EW, this quick scan focusses on the Russian military operations as well as Turkey's interventions, especially Operation Spring Shield in 2020. Russian military operations in Syria are now in their sixth year, while the first large Turkish intervention took place in 2017. During these campaigns, a variety of actors in Syria experimented with new equipment and doctrines, using Syria as a testbed which in turn spurred military insights relevant to advance their organizations.

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51 Malyasov, "Ukraine confirms procurement of Turkish unmanned combat aerial vehicles."
52 "Why has the Syrian war lasted 10 years?."
53 Tsurkov, "Hayat Tahrir Al-Sham (Syria)."
54 Steinberg, *Das Ende des IS?*, p. 10 f.
55 https://www.inherentresolve.mil/ (last accessed 4 May 2021).
56 O'Connor, "Access denial. Syria's air-defence network", p. 22ff.
57 See for example for the Syrian Armed Forces Berelovich, "The Syrian Civil War – Evolution of the Syrian Army's Way of War" or for the Russian military Clark, *The Russian military's lessons learned in Syria*.

The operation conditions across Syria vary considerably – from the mountainous western part to the flat deserts of the eastern part of the country. Moreover, population is unevenly distributed with most urban centers lying to the west and 55% of the population living in urban centers.[58] Population and urban centers in the east are largely concentrated around the Euphrates. Consequently, infrastructure is denser in the west and in the vicinity of population centers as compared to scarce infrastructure in the eastern part of Syria. At least for the latter, this lack of alternative lines of control (LoCs) led to predicable routes of advances. Since the original civil unrest often took place in large cities, sub-urban and urban fighting was a constant feature of the Syrian civil war. Overall, limited vegetation, mostly trees in agricultural plantations, also limits opportunities for cover in most parts of the country. While most of the fighting between the Regime and its militias (including those provided by Iran and Hezbollah) and the opposition was ground-based, both Turkey and Russia made significant use of air power. This does not preclude their use of ground troops, which both did, but signifies a different approach in their operations. Air power should be well suited to engage targets in the described environment if provided with sufficient intelligence, surveillance and reconnaissance (ISR) capabilities and given a favorable weather situation, e.g., absence of fog on hilltops.[59]

Berelovich differentiates between three distinct phases of the Syrian civil war,[60] which roughly delineate both foreign interventions and the course of the war. Between 2011 and 2013, the war was largely an intra-Syrian affair, in which the regime forces concentrated on holding or capturing major urban centers and important LoCs. Nevertheless, towards the end of this first phase, opposition forces controlled entire regions and parts of the four most important cities: Damascus, Homs, Hama and Aleppo. In its second phase ranging from 2013 to 2018, the Syrian civil war became an international affair. The entry of the USA to fight the Islamic State in 2014 went beyond the previous shipment of non-lethal supplies and weapons to moderate opposition factions. Similarly, Russia's entry in 2015 to support the regime marked a significant escalation. Additionally, 2013 marks the first use of Hezbollah troops in the war. While the regime was on the backfoot between 2013 and 2015, the increasing influence and support by Russia and Iran reversed this trend between 2015 and 2018. Since 2018, the regime is largely consolidating the regained territory in this third phase. The last major offensive by the regime from late 2019 to summer 2020 aimed at regaining the north-western Idlib province. Idlib was the center of Turkish activity in the war, together with some parts of northern Syria. Through its offensive here, the regime encountered Turkish forces, setting the scene for the escalation of the Turkish Operation Spring

58 https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=SY (last accessed 4 May 2021).
59 Kasapoglu/Ülgen, "Operation Olive Branch: A Political-Military Assessment," p. 9.
60 The following paragraph is based on Berelovich, "The Syrian Civil War – Evolution of the Syrian Army's Way of War," p. 2 f.

Shield – which took off after a regime airstrike killed at least 33 Turkish soldiers.[61] As major operations have come to an end in the second half of 2020 and only sporadic attacks occur, the regime directly controls roughly two-thirds of the country, the SDF roughly a quarter and Turkish-backed opposition parties the remaining ten percent. Major failures of foreign-supported parties in the civil war were usually accompanied by stronger support by the backer, e.g., Russia and the regime from 2015 onwards and the Turkish-backed rebel factions in 2019/2020.

Both Russia and Turkey used their military activities in Syria as a testbed for military innovations in equipment and doctrine. Both used a wide range of military capabilities to achieve their goals, from artillery to UAVs and manned combat and ISR aircraft to EW assets. Despite a focus on support functions, most importantly fire support delivered by ground assets or aerial assets, both militaries suffered notable casualties – around 120 Russians and between 260-310 Turkish soldiers over the course of their engagements in Syria.[62] Nevertheless, combining their various military assets with local proxies as ground forces (mostly light infantry), both executed successful operations conquering and holding ground.

UAVs were and are a constant feature of the Syria skies and are used by various actors for missions like ISR, strike, suicide/IED delivery and propaganda.[63] Gettinger identifies 38 distinct UAVs being used in Syria and Iraq,[64] of which is it highly likely that nearly all of these are also operated in Syria alone. Russia[65] primarily uses smaller tactical UAV (like the Orlan-10) in Syria for missions like "aerial reconnaissance, providing target designation, controlling airstrikes, and adjusting artillery fire."[66] However, Russian forces also recognized the limits of this distributed sensor-to-shooter loop without UCAVs against small, maneuvering targets.[67]

Turkey used its UAVs for ISR, artillery spotting and strike missions,[68] including against high-value single targets.[69] Turkish UAV operations in Syria also benefitted from geographical proximity as this enabled extensive intelligence preparation of the battlefield in view of identifying adversarial air defense posture and the adversary's electromagnetic footprint in Syria.[70] Moreover, Turkey extensively used video material collected by its drones for propaganda purposes. While Turkey's use of

61 Crino/Dreby, "Turkey's Drone War in Syria – A Red Team View."
62 For extensive collection of information based on open sources, see https://en.wikipedia.org/wiki/Russian_Armed_Forces_casualties_in_Syria and https://en.wikipedia.org/wiki/Turkish_Armed_Forces_casualties_in_Syria (last accessed 4 May 2021).
63 Laconjarias/Maged, "Fear the Drones: Remotely Piloted Systems and Non-State Actors in Syrian and Iraq," p. 13 f.
64 Gettinger, *Drones Operating in Syria and Iraq*, p. 1.
65 Russia has reportedly also used unmanned ground vehicles (UGV) for demining operations often "synchronized with the use of jammers to suppress radio signals in the remote activation of improvised explosive devices." See: Allik., *The Rise of Russia's Military Robots*, p. 12.
66 Bendett, "Russian Unmanned Vehicle Developments: Syria and Beyond", p. 41.
67 Adamsky, "Russian lessons from the Syrian operation and the culture of military innovation."
68 Nicholson, "'Revolutionary' warfare or good marketing: Turkey's Syria drone strikes."
69 Urcosta, "The Revolution in the Drone Warfare: Lessons from the Idlib De-Escalation Zone," p. 54.
70 Mikhenko, "Unmanned Aerial Vehicles vs Air Defenses," pp. 48-49.

ANKA-S and Bayraktar TB2 UAVs during Operation Spring Shield was promoted as revolutionary, it was not without cost, as Turkey lost about 10-15% of its total UAV strike force in just three weeks – the two weeks before Spring Shield and during the Operation – albeit including losses in Libya at the same time.[71] If this attrition rate is sustainable in the long-run very much depends on the production rate. Currently, Baykar is reported to produce around 90 Bayraktar TB2 UAV per year.[72]

While the USA retained known operational patterns of ISR and strike missions for their UCAVs in Syria, non-state actors conducted the now famous "swarm-attack" on the Russian Khmeimim Air Base on 5 January 2018, composed of 13 drones with small explosives.[73] One successful non-state early adopter of UAVs for ISR and strike missions seems to be Hezbollah, especially through its close cooperation with the Iranian Republication Guard Corps (IRGC).[74]

Air defense assets were primarily deployed by the Syrian regime and its allies, Russia in particular.[75] Yet despite a comparatively dense – albeit largely outdated and patchy – air defense network with a mixture of Russian effectors and Chinese radars,[76] the Syrian regime was not able to prevent recurring aerial attacks by Western forces, Israel or Turkey. This includes the destruction of several Pantsir-1 systems by Turkish UAVs during Operation Spring Shield, which added to the skepticism regarding this systems performance that emerged with the parallel destruction of several Pantsir-1s in Libya.[77] However, as in the case of Libya, EW, a patchwork deployment of the Pantsirs and inexperienced crews, combined with Turkey's surprise attack, are more likely to have been the decisive factors. Nevertheless, Russia regards counter-UAV capabilities vital for the future of warfare.[78] Russian advanced air defense assets (S-300 and S-400) deployed primarily to defend its bases in the country have not actively engaged targets – the reasons being unclear.[79]

Turkey, Russia and Israel all used EW to achieve non-kinetic effects in Syria, mostly for SEAD purposes, thus enabling the application of air power, be it with manned of unmanned systems. This is especially true for Turkey's deployment of its KORAL

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71 Crino/Dreby, "Turkey's Drone War in Syria – A Red Team View."
72 Bilgic, "Turkish Drone Maker Baykar Makina Gets Government Support."
73 Rempfer, "Did US drones swarm a Russian base? Probably not, but that capability isn't far off;" "Russia foils massive attack on its Syrian bases by electronically 'controlling' 6 drones, downing seven;" Smith, *Russian Electronic Warfare*, p. 4.
74 Laconjarias/Maged, "Fear the Drones: Remotely Piloted Systems and Non-State Actors in Syrian and Iraq," p. 10.
75 For this analysis, we disregard the defensive deployment of NATO air defense assets in Turkey as part of Operation Active Fence. Moreover, Turkey often provided air defense against fixed-wing assets via the deployment of F-16 with AMRAAM-120 missiles and AEW&C aircraft patrolling over the Turkish-Syrian border. See Kasapoglu, "Turkey's Drone Blitz Over Idlib."
76 O'Connor, "Access denial," p. 22 f.
77 Nicholson, "'Revolutionary' warfare or good marketing: Turkey's Syria drone strikes."
78 Clark, *The Russian military's lessons learned in Syria*, p. 39.
79 Ibid., p. 25.

systems during Operation Spring Shield[80] and for Israel across its hundreds of strikes against targets inside Syria over the course of the civil war.[81] Russia employed short-range EW, for example, to engage parts of the swarm-attack on Khmeimim Air Base, allegedly bringing down six of the 13 UAVs.[82] On a meta-level, the Syrian experience led the Russian armed forces to double down on their concept of "Superiority of Management"[83] which includes a heavy emphasis on EW.[84]

4.3 Libya: Tipping the Balance

Libya's second civil war embroiled several factions in a struggle for military supremacy in the country from 2014 to 2020.[85] The two main actors were the internationally recognized Government of National Accord (GNA, based in Tripoli) and the Libyan House of Representatives (HoR, based in Tobruk). The latter is better known by its military organization, the Libyan National Army (LNA) under the command of Khalifa Haftar. The main campaign we analyze in this context is the LNA's offensive to capture Tripoli and the subsequent counter-offensive by the GNA, roughly covering the timespan from April 2019 to June 2020.[86]

It is the fighting during this campaign, that caught the eyes of many observers as possibly presenting "the future of warfare"[87] and included extensive support of both sides by foreign actors. Due to this support, the battlefield included a variety of participants, from semi-state forces like the LNA with support by militias, private security and military companies (Wagner) and state forces (UAE) on one side and semi-state forces like the GNA with support from militias (Syrian militias transported to Libya by Turkey) and state forces (Turkey) on the other side.[88] With the exception of foreign state forces, these actors are attributed with limited military skills, moral and discipline.[89]

The operation conditions in northern Libya, where the campaign was concentrated, is rather conductive for mobile and air-heavy operations with its open

80 Urcosta, "The Revolution in the Drone Warfare: Lessons from the Idlib De-Escalation Zone," p. 53; Frantzman, "Russian air defense systems outmatched by Turkish drones in Syria and Libya."
81 Melman, "Why Syria Isn't Firing Its S-300 Missiles at Israeli Jets."
82 McDermott, "Russia's Electronic Warfare Capabilities as a Threat to GPS."
83 For a definition see Clark, *The Russian Military's Lessons Learned in Syrian*, p.14. "The Russian military defines command and control as an internal process conducted by commanders on one's own subordinates in combat operations. Management is contrarily a recurring, cyclical process carried out on both friendly and opposing forces. Russian analysts state that management consists of three simultaneous and repeating components: commanders making a decision, reconnaissance assets gaining information about the operational environment, and executive elements carrying out decisions."
84 Clark, *The Russian Military's Lessons Learned in Syrian,* p. 38.
85 Eriksson/Bohman, "The Second Libyan Civil War," p. 11; Cumming-Bruce/Walsh, "Libya Cease-Fire Raises Hopes for Full Peace Deal."
86 Wintour, "UN-backed Libyan forces oust renegade general from Tripoli."
87 Vest/Clark, "Is the Conflict in Libya a Preview of the Future of Warfare?"
88 Bermudez, "Moscow's Next Front;" Fasanotti, "The Biden administration inherits a rapidly deteriorating Libya."
89 Pack/Pusztai, *Turning the Tide*, p. 13.

flat desert geography and generally scarce population. There are two important exceptions to this: the hilly terrain around Garian (south of Tripoli) and sub-urban and urban fighting in and around the main population centers (like Banni Walid, Garian and Tripoli). Libya is heavily urbanized with an estimated 80% of its total population living in urban centers.[90] Scarce vegetation also limits the use of natural cover. Limited infrastructure and thus few valuable LoC's predetermine the axes of advances and supply lines on the operational level. Taken together, these factors form what Pack and Pusztai call "the uniquely Libyan way of warfare"[91], in which "control of key pieces of transport infrastructure – highways, airports, strategic crossroads – is essential"[92] but difficult to achieve if forces are undisciplined and face an enemy with air superiority and strike capabilities. Due to the length of the campaign, it stretched across the whole year and thus changing weather conditions. While the authors could not find any hints at the influence of weather during the campaign, NATO aircraft experienced weather conditions that hampered parts of their operations in 2011.[93]

The early days of the Western Libya Campaign of the LNA in April 2019 (Operation Flood of Dignity[94]) saw substantial territorial gains by the LNA, in particular south of Tripoli, the main target of its offensive. However, fighting in the sub-urban and urban terrain slowed progress and allowed the GNA to mobilize. Superior air power for the LNA at the time played a crucial role in this success.[95] Between April and June 2019, GNA forces successfully counterattacked and regained control of the southern entrances to Tripoli, including Garian. Further GNA offensives starting roughly in March 2020 expelled the LNA from areas held by the LNA at the start of the offensive to the west of the capital.[96] Moreover, by June 2020 GNA forces expelled the last LNA forces from the east/south-east of the Tripoli area.[97] Overall LNA gains after the end of major operations are mostly to the east of the theater, foremost the capture of Sirte. Previous gains like a central LoC leading up to Garian and Banni Walid were lost again, with additional losses as compared to the start of the campaign to the west. Later offensives (like a GNA offensive to recapture Sirte[98]) did not result in significant changes, leaving the parties in a stalemate and the fronts stabilized until the ceasefire in August 2020. Significant military successes of either side were always accompanied by a larger involvement (or the threat thereof) by foreign supporters of the opposite side. Turkey's support to the GNA increased significantly when the LNA advanced on Tripoli, as did to

90 https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=LY (last accessed 4 May 2021).
91 Pack/Pusztai, *Turning the Tide*, p. 13.
92 Ibid.
93 Kidwell, "The U.S. Experience: Operational," p. 141; Mayne, "The Canadian Experience: Operation Mobile," p. 256.
94 Eltagouri, "Haftar's Final Play: Operation Flood of Dignity and the Fight for Tripoli."
95 Pack/Pusztai, *Turning the Tide*, p. 1.
96 Binnie, "Mediterranean moves," p. 21 f.
97 Wintour, "UN-backed Libyan forces oust renegade general from Tripoli."
98 "Libyan army dispatches military vehicles to Sirte."

Russian and Egyptian support when the GNA successfully counterattacked and threatened to retake Sirte.[99]

The campaign saw extensive use of unmanned systems and air defense assets on both sides as well as the use of EW by the GNA-allied Turkish forces. Moreover, the whole range of traditional land and air warfare assets were also deployed by both sides: from main battle tanks to armored vehicles to artillery to attack helicopters to combat and AEW&C aircraft as well as Turkish frigates.[100] It was only through the interplay of these assets, that either side could exert a military advantage and conduct successful offensive operations.

Since 2019, small UAVs were used by both sides for battlefield reconnaissance and artillery fire observation.[101] With the introduction of larger UAVs[102] – Turkish ANKA-S and Bayraktar TB2 on the side of the GNA – and Emirati-operated Chinese-built WingLoong I/II on the side of the LNA, these assets took over further missions, especially strike and DEAD,[103] including air interdiction missions.[104] At least 29 large UAVs were lost in 2019 and 2020, 11 Wing Loong I/II and 17-18 Bayraktar (incl. TB2).[105] Already by the end of 2019, over 1,000 air strikes had been performed by UAVs,[106] a number that certainly increased with the accelerated operational tempo of Turkish UAVs in 2020. Importantly, both actors seemingly acknowledged the important role of UAVs as strike assets as they attacked each other's drone infrastructure. This led to battlefield adaptations like distributed operations by the GNA/Turkish UAV forces.[107]

Air defense assets of both parties show a mixed record in their effectiveness against air assets: Early in the conflict both parties were able to shoot down enemy air assets, especially UAVs and attack helicopter. However, air defense assets also fell victim to air attacks: either due to attacks before they reached operational readiness[108] or because of the significant use of EW, limiting their detection capabilities.[109] The most important role of air defense systems came during the GNA's counteroffensive against the LNA, especially with the deployment of an integrated and layered air defense zone by Turkey, including HAWK missile systems, HISAR short-range SAMs and KORKUT anti-aircraft guns.[110] This capability provided sufficient protection for land and air operations that drove the LNA forces from Tripoli.

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99 Binnie, "Mediterranean moves," p. 23 ff.
100 Gurcan, "Battle for air supremacy heats up in Libya despite COVID-19 outbreak."
101 Pack/Pusztai, "Turning the Tide – How Turkey Won the War for Tripoli," p. 12.
102 Gady, "Useful, but not decisive: UAVs in Libya's civil war."
103 Destruction of Enemy Air Defense
104 Pack/Pusztai, "Turning the Tide – How Turkey Won the War for Tripoli," p. 12.
105 https://dronewars.net/drone-crash-database/ (last accessed 4 May 2021).
106 Lacher, "Drones, Deniability, and Disinformation: Warfare in Libya and the New International Disorder."
107 Gady, "Useful, but not decisive: UAVs in Libya's civil war."
108 Pack/Pusztai, *Turning the Tide*, p. 6.
109 Fishman/Hiney, "What Turned the Battle for Tripoli."
110 Ibid.

Yet at least the HAWKs also proved to be vulnerable, as the 4 July 2020 attack on Al-Wativa airbase after their deployment there demonstrates.[111]

At the same time, LNA air defenses, especially the Pantsir-1 medium-range air defense system, earned a bad reputation for allegedly failing to engage Turkish UAVs during the conflict. However, this performance was most likely the result of extensive use of EW assets by the GNA, especially the Turkish KORAL EW system. Allegedly, it can either jam the radar of the Pantsir-1 or is able to locate it due to electronic emissions, making it vulnerable for air strikes in the first and artillery strikes in the second case.[112] Moreover, Turkey seems to use at least five to six drones for attacks, which might overwhelm Pantsir-1 tracking systems[113] and crews, especially if they are not well trained or experienced.[114] Lastly, some Pantsir-1 seem to not have been in operational mode while being attacked, e.g. standing in hangars or being transported in flatbed transports.[115] With time, Pantsir-1 operators apparently successfully adapted their operating procedures and began to only use their passive electro-optical sensors.[116] The widespread impression of their failure also has to do with the selective publication and dissemination of videos and pictures from selected engagements between UAVs and air defense assets. At least in the popular debate, a skewed perception based on these few videos prevails.

4.4 Armenia vs Azerbaijan: The Polished War

The conflict between Armenia and Azerbaijan began in its modern form around the time of the collapse of the Soviet Union. Nagorno-Karabakh had been part of autonomous region of Azerbaijan since 1921 but requested transfer to Armenia in 1988.[117] Until the end of the Soviet Union, the conflict remained unresolved. After its dissolution, the conflict between Azerbaijan and Armenia over Nagorno-Karabakh turned violent. The results of the hostilities led to a situation in which Armenia controlled about 20% of Azerbaijani territory by the time a ceasefire was signed in 1994.[118]

The end of hostilities did not lead to lasting peace. Over the 30-year span between the First Nagorno-Karabakh War and the Conflict in 2020, Azerbaijan and

111 Kington, "Libya is turning into a battle lab for air warfare."
112 Pack/Pusztai, *Turning the Tide*, p. 12.
113 Frantzman, "How did Turkish UAVs outmaneuver Russia's Pantsir air defense in Libya: Lessons and ramifications."
114 Mikhnenko, "Unmanned Aerial Vehicles vs Air Defenses," p. 49.
115 Frantzman, "How did Turkish UAVs outmaneuver Russia's Pantsir air defense in Libya: Lessons and ramifications."
116 Pack/Pusztai, *Turning the Tide*, p. 12.
117 Ripley/Cranny-Evans, "Unmanned Edge," p. 19.
118 Ibid.

Armenia took decidedly different approaches to the conflict, demonstrating how important political will is to set the stage for victory. Azerbaijan pursued a decades-long military modernization program with the single-minded focus of regaining the Karabakh region.[119] Stronell refers to this as the "national will to fight" – a determination to achieve a military objective by making use of all aspects of national power, and to pursue that objective even at significant political, economic and military expense.[120] Azerbaijan – buoyed as well by an oil boom – invested heavily in creating a modern military, diversifying its arms suppliers and procuring advanced weapons systems and equipment including UAVs, precision-guided weapons, long-range rockets, mine-protected vehicles, surveillance systems and armored vehicles.[121] During the same period, Armenia was characterized by a false sense of superiority and lethargy.[122] According to Stronell, victory in the first Nagorno-Karabakh War led to complacency.[123] At the same time, Armenia – with considerably fewer resources – failed to modernize its military. In 2019, Armenia purchased SU-30SM fighters to modernize its air force but could only afford four and during the recent conflict, had not yet received weapon package upgrades.[124] Likewise, instead of upgrading its 9K 33 OSA systems, it purchased an additional 35 from Jordan, which had been originally supplied by the Soviet Union in the 1980s and had never been upgraded.[125] These had no ability to counter UAVs effectively.[126] As Kofman points out, it cannot be overlooked how severely Armenia failed to adapt, despite having faced both Azeri UAVs and loitering munition already in 2016.[127]

Both the alliances of Armenia and Azerbaijan played the decisive role in the outcome of the conflict. Armenia has traditionally fostered good relations with Russia, however these have deteriorated recently. While perhaps not the main reason, an important factor in Russia's complacence in the face of Armenia's potential defeat, was Putin's displeasure with Armenian Prime Minister Nikol Pashinyan, whose 2018 revolution swept away the previous Moscow-friendly government.[128] Furthermore, an Armenian defeat was conducive to Russia's geopolitical interests in the region, particularly Russian peace plans for Nagorno-Karabakh which called for the cession of Armenian held territory – Armenia had up until the conflict remained recalcitrant.[129] In response to a request for help by Armenia, the Russian

119 Stronell, "Learning Lessons from the Nagorno-Karabakh War the Russian Way," p. 4.
120 Ibid.
121 Ripley/Cranny-Evans, "Unmanned Edge," p. 19.
122 Kofman, "A Look at the military lessons of the Nagorno-Karabakh Conflict," p. 5.
123 Stronell, "Learning Lessons from the Nagorno-Karabakh War the Russian Way," p. 4.
124 Ripley/Cranny-Evans, "Unmanned Edge," p. 20.
125 Ibid.
126 Stronell, "Learning Lessons from the Nagorno-Karabakh War the Russian Way," p. 4.
127 Kofman, "A Look at the military lessons of the Nagorno-Karabakh Conflict", p. 5.
128 Popescu, "A captive ally: Why Russia isn't rushing to Armenia's aid." If the Russian aim was to weaken Panshinyan, it was successful as Pashinyan has agreed to resign in April 2021 and call for snap elections as a result of Armenia's defeat in the recent conflict. See: "Armenian prime minister to step down in April."
129 Gressel, "Lessons from Nagorno-Karabakh, Reasons for Europe to worry."

Ministry of Foreign Affairs released a statement clearly stating that it would only intervene on behalf of Armenia, should Armenian territory itself be attacked.[130] Tellingly, the four Su-30 interceptors that Armenia recently bought from Russia, remained grounded during the entire conflict allegedly due to Russian pressure.[131] This leads Gustav Gressel from ECFR to speculate that Russia "served air superiority to Azerbaijan and Turkey on a silver platter."[132] However, Rob Lee contends, that "Armenian pilots only had limited time on these Su-30SM and they have no history with these kind of fighters" suggesting that their operational value would have been limited anyway.[133]

If lack of Russian support was responsible for Armenian defeat, Turkish support was equally responsible for Azerbaijan's success. Shortly after fighting broke out in July 2020, Turkey announced its "unconditional support" to Azerbaijan.[134] This unconditional support amounted to the entire backbone of Azerbaijan's warfighting capability as we discuss in more detail in chapter 5.5. Turkey allegedly also supplied up to 1,300 Syrian and 150 Libyan fighters who took part in the conflict.[135] Additionally, Turkey also airlifted weapons, supplies and personnel throughout the conflict,[136] and made a symbolic but nonetheless important deterrent gesture by stationing six F-16s at the Gabal airbase in Azerbaijan.[137]

The mountainous terrain which characterizes the Nagorno-Karabakh region lends itself to defensive positions and small detachments of troops.[138] Kofman and other analysts initially believed terrain to play a major role, and to benefit Armenia.[139] Armenia also had the "Ohanyan Line," a series of defensive fortifications from the First Nagorno-Karabakh War in the 1990s.[140] However, the mountainous terrain and defensive fortifications provided little protection against UAV surveillance and loitering munitions and Azeri forces were able to attrite Armenia's forces with airpower.[141]

The Nagorno-Karabakh conflict is rapidly earning the title of the "First Drone War."[142] Although both sides made use of UAVs, it is Azerbaijan's effective use of them – and in particular the IAI Harop loitering munition and the Turkish Bayraktar

130 Foy/Seddon, "Armenia calls for Russian help as fight with Azerbaijan intensifies."
131 Gressel, "Lessons from Nagorno-Karabakh, Reasons for Europe to worry;" Arbeiter, "Das Labor des Krieges," p. 11.
132 Gressel, "Lessons from Nagorno-Karabakh, Reasons for Europe to worry."
133 https://twitter.com/RALee85/status/1331494284172922880 (last accessed 4 May 2021).
134 Keddie, "What's Turkey's role in the Nagorno-Karabakh Conflict?"
135 Ibid.
136 Ibid.
137 Trevithick, "Turkey's forward deployed F-16s have moved to a new base."
138 Ripley/Cranny-Evans, "Unmanned Edge."
139 Kofman, "A look at the military lessons of the Nagorno-Karabakh Conflict," p. 4.
140 Stronell, "Learning Lessons from the Nagorno-Karabakh War the Russian Way," p. 3.
141 Kofman, "A Look at the military lessons of the Nagorno-Karabakh Conflict," p. 4.
142 Gady, „Krieg um Berg-Karabakh 2020," p. 1.

TB2 – which received the vast majority of attention.[143] However, the use of loitering munition is not new – and also not new to the conflict in Nagorno-Karabakh, as it was already seen in 2016.[144] Bayraktar is likewise hardly the invincible system that its reputation coming out of the Nagorno-Karabakh conflict may suggest and that owes a lot the practice of warstreaming (chapter 5.4). Turkey has previously lost Bayraktar TB2 systems in the Libyan conflict for example.[145] However, Azerbaijan's relentless, effective and sometimes creative use of UAVs – particularly in use against Armenian air defense systems demonstrate some noteworthy developments.

One such development involves the so-called "bait drone." Azeri forces took a An-2 crop duster and fitted it with a remote-control. They then proceeded to use the An-2 to locate Armenian air defense positions and identify equipment its forces could target.[146] Azeri forces also used UAVs in combination with artillery to great effect against Armenian T-72s and S-300 air defense systems.[147] The key takeaway is Azerbaijan's effective use of UAVs in combination with other systems and their effectiveness in SEAD missions. Azerbaijan placed high priority on disabling Armenian air defense systems. In the early phase of the conflict, Azeri forces used their UAVs to attack Osa and 2K12 systems and paid particular attention to the S-300 system in southern Armenia which covered the entire Nagorno-Karabakh region.[148] Knocking out Armenian air defenses and radar stations made Armenian forces blind an unable to act in a coordinated manner.[149] From that point onward, Azeri ground forces including T-90, T-72 tanks and BMP-3 AFVs could would follow up with a ground assault, effectively gaining territory.[150]

The dismal state of Armenian air defense is one of the principal reasons why Azeri UAVs were so effective. Armenian air defense was primarily made up of Soviet legacy systems such as the 2K11 Krug, 9K33Osa, 2K12 Kub, and 9K35 Strela-10 which were not built for. The Bayraktar TB2s flew too high for these systems.[151] The destroyed S-300s were likewise not designed for counter UAV missions.[152] UAVs are small and slow moving which would be a challenge for exported Russian air defense systems, which unlike their indigenous counterparts, lack plot fusion.[153] Armenian MANPADS were also ineffective against UAVs since they cannot acquire targets that are too small for the operator to see.[154] EW capabilities would

143 Ibid., p. 2.
144 Kofman, "A Look at the military lessons of the Nagorno-Karabakh Conflict," p. 5.
145 Ibid., p. 2.
146 Fogel/Mathewson, "The next Frontier in drone warfare," p. 2.
147 Shaikh/Rumbaugh, "The Air and Missile War in Nagorno-Karabakh," p. 8.
148 Ripley/Cranny-Evans, "Unmanned Edge," p. 22.
149 Ibid.
150 Ibid.
151 Shaikh/Rumbaugh, "The Air and Missile War in Nagorno-Karabakh," p. 7.
152 Ibid.
153 Gressel, "Lessons from Nagorno-Karabakh, Reasons for Europe to worry."
154 Ibid.

have been effective as counter UAV measures but Armenia only briefly effectively jammed UAV signals using Russian Polye-21s for four days at the beginning of the conflict.[155] Likewise, it is speculated that Russia may have used Krasukha EW systems to stop Azeri reconnaissance into Armenia proper in the final days of the conflict.[156]

With a significant transfer of Nagorno-Karabakh's territory from Armenia to Azerbaijan, the outcome of the conflict was a clear win for Azerbaijan. However other winners included Turkey and – somewhat surprisingly – Russia. Russia may in fact turn out to be the biggest geopolitical winner of the conflict as Russia is the only signatory of the peace deal and only Russian peacekeepers will patrol the corridor between Armenia and Azerbaijan.[157]

155 Shaikh/Rumbaugh, "The Air and Missile War in Nagorno-Karabakh," p. 7.
156 Gressel, "Lessons from Nagorno-Karabakh, Reasons for Europe to worry."
157 Gubaev, "Viewpoint: Russia and Turkey - unlikely victors of Karabakh conflict."

5 Current Conflicts: Why Major Change Has Not Yet Arrived

Are the four conflicts illustrating the future of warfare? No – or at least not to the extent that mainstream coverage of the conflicts would make us believe. As we look at the four conflicts with our focus on the interplay of UAV, EW, and air defense,[158] we will argue below that the lines of continuity are much more distinct than the elements of change.

First, current modes of operating the three major assets under discussion cement the status quo. Overall, tried and tested tactics prevail, while we also acknowledge that the four conflicts show further refinement with regard to the use of UAVs and their interplay with EW. Whereas the focus on UAVs dominates most analyses, we argue that the use of EW assets as seen through all four conflicts should receive more attention. Second, current modes of operation dominate because for single assets to yield warfighting benefits, they need to be fully integrated into the C4/5ISTAR value chain. When it comes to organizing this value chain, we see no major breakthroughs. We argue, however, that the need for proper integration and thus the need to take into account the complexities of modern defense ecosystems is overlooked in current assessments of the four conflicts. Third, and closely related to the ecosystem argument, humans still play a decisive role in every aspect of warfighting – from procurement decisions to tactical operations. Anthropocentricism may break down in the future, however. As more and more countries operate unmanned systems, different role models might emerge. If planners, operators, and engineers started to come up with new operational concepts, change may follow. But readiness to break new ground depends on many different factors, as we have argued in chapter 3, and none of them seems present in the four conflicts.

This gets us to the two notable elements of change. The first is about using new technical assets for influence activities. Warstreaming as the ability of warfighting parties to provide live feeds from the battlefield has been a major feature in Syria and in Nagorno-Karabakh. But again, the advantages of warstreaming very much depend on the overall characteristics of the respective conflict and can be nullified if all warring factions operate on par with each other. Given the strong lines of continuity, it is no surprise that the only true novelty that we have identified comes at the politico-strategic level: War as a Service (WaaS) as provided by Russia to

158 We have not looked in detail at the use of cyber operations, as they seem to play only a subordinate role in the respective conflicts. Ukraine is the exception, but here specific characteristics of the conflict need to be taken into account. Russia has allegedly used cyber operations against critical infrastructure such as transportation systems and power grids or to disseminate threat text messages. With the exception of Russia seemingly exploiting hardware vulnerabilities of the radio systems in use by Ukraine, there are hardly any public reports about direct cyber operations against military assets. Russia's cyber activities, in particular the infiltration of commercial telecommunication infrastructure, seems to have benefited from the fact that Vodafone Ukraine is a subsidiary of Mobile TeleSystems of Russia, which begs how the lack of privileged access would affect this type of operations in other conflicts. Overall, cyber operations seem to have been of limited use also because of the low level of digitalization of Ukrainian forces and low levels of effort given limited recourses and targets. For more on the use of cyber operations in Ukraine, see in particular: Urcosta, "The Revolution on Drone Warfare," p. 60; McCrory, "Russian Electronic Warfare, Cyber and Information Operations in Ukraine," pp. 4-5; Brantly/Cal/Winkelstein, *Defending the Borderland,* p. 26; Kostyuk/Zhukov, "Invisible digital front: can cyber attacks shape battlefield events?," pp. 24-29; Trevithick, "Ukrainian officer details Russian electronic warfare tactics including radio 'virus'."

Syria and Turkey to Azerbaijan and Libya – with a turn-key solution including not only technology assets but also planning and operations assistance as well as embedded force elements and training – constitutes a novel element of temporarily transferring military power on a government-to-government basis. Ironically, WaaS might further subdue the forces of innovation as the supplier defines all doctrinal, organizational, and technological aspects pertaining to the use of traditional and new assets like UAVs.

5.1 Evolutionary Use of Technical Assets Dominates

UAVs, EW, and air defense assets need to be regarded as a complex ecosystem whose optimal function depends on proper integration (chapter 5.2). Today, however, the public reception of the four conflicts under review is focusing on single elements rather than the complex ecosystem. This leads to hyperbole assessments of the role and benefits of these single elements that downplays the central role of "backbone" (e.g., C4/5ISTAR) in optimally using them.

UAVs are the single most overhyped asset across all for conflicts

As Table 1 illustrates with reference to our discussion in chapter 4, UAVs have been used in different missions. Most importantly, UAVs have provided operators with a limited reconnaissance-strike complex in particular by using them in tandem with artillery fire. Baykar's Bayraktar TB2 UAVs have grabbed media attention as one of the most decisive assets deployed in three of the four conflicts. But as we contend in more detail below, the role of these UAVs is shaped to a far greater extent by the way they have been embedded in Turkey's WaaS offering than by the pure technical specifications of the platforms. Without downplaying the progress of the Turkish defense industry in developing these systems, Bayraktar TB2 remain relatively simply assets, and the use of commercial components has created problems once sanctions related to the very deployment of these assets in Nagorno-Karabakh led to export bans of specific components (chapter 5.4).[159]

Most importantly, while UAVs played an important role across the four conflicts, the tactics used for their employment mirror the status quo.[160] In this regard, two observations offering windows into the future deserve mentioning. First, in the Nagorno-Karabakh conflict, Azerbaijan has operated An-2 airplanes, hitherto used

159 "The expert explains why Russia is 25 years behind in the field of attack drones."
160 One could even argue that some warfighting parties wanted to keep up maximum plausible deniability, which in turn affected the choice of unmanned platforms deployed. See for example: Allik, *The Rise of Russia's Military Robots*, p. 10.

Table 1: Ideal-Type Missions Executed with Unmanned Systems across the Four Conflicts Analyzed

Mission	UKR	SYR	LIB	ARM-AZE
ISTAR				
Situational awareness (e.g., aerial imagery, 3D mapping)	By UKR	By RUS	By GNA By LNA	By AZE
Find, fix, track adversarial targets		By TUR By RUS	By GNA By LNA	By AZE
Guiding precision-guided weapons	By RUS	By RUS By TUR		By AZE
Effects				
Air interdiction		By TUR	By GNA By LNA	
Attack lines of supply	By RUS	By TUR	By GNA	By AZE
Attack adversarial targets	By RUS	By TUR	By GNA By LNA	By AZE
Destruction of Enemy Air Defense (DEAD)		By TUR	By GNA	
Electronic warfare (including Suppression of Enemy Air Defense, Jamming)	By RUS	By RUS		By AZE
Relay function (e.g., signal transmission)				By AZE
Deception (e.g., provoking activation of air defense radar)				By AZE

for agricultural purposes, as a kind of flying honeypot to attract fire from Armenian air defense and launch counterstrikes at them (chapter 4.4). In addition, Azerbaijan also successfully destroyed a Tor-M2KM anti-aircraft missile system "located among residential buildings."[161] Both operations suggest a level of sophistication

161 "Azerbaijan destroys Armenia's Tor-M2KM anti-aircraft missile system in direction of Khojavend district."

that might only have been achieved because of Turkey's embedded force elements (chapter 5.5). In addition, it remains to be seen if this tactic would withstand a more powerful adversarial air defense able to detect the strike and surveillance assets that had been accompanying the An-2. Although tactics are but one metric to evaluate the potentially game changing character of new assets, the comparative assessment in this report suggests that the true added value of these assets has not yet been fully exploited. As we will argue in chapter 5.4, Warstreaming and the hunger for battlefield pictures not yet seen before could create new incentive to use UAV in riskier maneuvers that could be potentially disruptive.

Second, in Libya Turkey reportedly flew several drones in coordination to attack Pantsir-1 air defense systems (chapter 4.3). A similar pattern has occurred over Nagorno-Karabakh.[162] This raises questions with regard to the tactics used for UAV synchronization. It could be that at least one UAV had been remotely piloted while the remaining UAVs have been electronically synchronized to follow the leader. This procedure would very much depend on the absence of electromagnetic operations in the air space as the communication of the UAVs could be denied or degraded.[163] In addition, sophisticated adversarial air defense assets could also test such a group of UAVs by emitting false air defense signals in order to verify if and to what extent the flight pattern of the group would change thereby detecting and possibly neutralizing the leader.

While this example might suggest the advent of unmanned swarms, the jury is out on this idea as well. None of the four conflicts has seen mass use of unmanned assets, with the exception of loitering munitions. Rather, as Libya has shown, the small number of UAV both sides had at their disposal limited their capacity to generate sorties and targeted forces were "increasingly aware of the number of munitions being carried by the UAV."[164] Finally, the one event that could constitute a swarm attack, the deployment of 13 UAVs against Russia's air defense posture at Khmeimim Air Base in Syria, was only partly successful due to Russia's allegedly successful use of electronic countermeasures against the swarm (chapter 4.2). At the same time this event also triggered Russia to reconsider counter UAV solutions by creating a "separate counter-UAV command post and working group at Khmeimim in late 2017, coordinating air-defense and EW systems into a single defense complex."[165]

162 Background interview with air defense expert on 18 February 2021.
163 Assuming they don't carry electronic self-protection payloads.
164 Gady, "Useful, but not decisive."
165 Clark, *The Russian Military's Lessons Learned in Syria*, p. 30.

Electronic warfare provides invisible (asymmetric) benefits

Contrary to the prevalent discussion of UAVs, the use of EW in all four conflicts receives much less attention. Overall, EW has been used in support of offensive operations to jam and attack adversarial defense assets, support air defense, listen in on and disrupt adversarial communication. While Turkey has made recourse to EW means, the main actor to watch out is Russia.

Turkey has reportedly used the land based KORAL and REDET systems produced by Aselsan in Libya and Syria to jam and deceive adversarial radars, attack them, and track cell phones to identify adversarial radar operator positions.[166] The close coordination of Bayraktar TB2 UAV sorties with the use of KORAL to identify adversarial AD radars in Syria[167] suggests an advanced understanding of the multiplying force of EW, while at the same time illustrating the need for UAV protection by other assets. The KORAL system also seems to have been effective against Pantsir-1 systems in Libya.[168] In addition, foreign assets played crucial roles as well. According to Intelligence Online, the Turkish Spring 2020 offensive in Tripolitania "was carried out by fixed Raytheon radar in Tripoli and Misrata and Thales radar on Turkish ships along the coast."[169]

While Turkey has been portrayed as the drone power champion across the four conflicts, Russia pushed the envelope for EW in particular in Ukraine. As discussed in chapter 4.1, Russia has been using different EW systems for a broad mission set including tasks like targeting of Ukrainian UAV, disruption of communications, targeting command and control systems, disrupting electronically fused munitions, direction finding of radio transmitters, jamming/spoofing of GPS signals and spreading false information thereby partially using UAV. Interestingly, Russia is also reported to have experimented with new EW algorithms and developed new tactics to support operations with the large scale use of EW.[170] This is important as technological developments went hand in hand with organizational reform with the result that "EW assets are highly distributed, present in all service branches of the armed forces and in all geographical locations."[171]

Russia's use of EW in Syria, by contrast, is more difficult to assess as there is little public discussion in Russian sources. Western observers, by contrast, at times considered Syria as the "most aggressive (EW) environment on the planet from our

166 Urcosta, "The Revolution in Drone Warfare," pp. 52-53; "How Turkey won the electronic warfare battle against Syria in Idlib."
167 Mikhnenko, "Unmanned Aerial Vehicles vs Air Defenses," p. 49; Frantzman, "Russian air defense systems outmatched by Turkish drones in Syria and Libya."
168 Gurcan, "Battle for air supremacy heats up in Libya despite Covid-19 outbreak."
169 "A2/AD strategy delivers Turkish success," p. 4.
170 McDermott, *Russia's Electronic Warfare Capabilities to 2025*, p. 25.
171 Kjellen, *Russian Electronic Warfare*, p. 61.

adversaries."[172] Contrary to the extensive use in Ukraine, Russia has tested EW in Syria on a more limited scale[173] with defensive uses to augment force protection as a key mission.[174] Although independent evidence is hard to establish, the most high-profile use could have involved the Russian Krasukha-4 EW system in defense against US Tomahawk cruise missiles against the Al-Shayrat base. According to Moscow, 36 out of 59 missiles have missed the target.[175] Occasionally, Russia has also used EW to jam airborne radars, low earth orbit satellites, and rebel communication systems.[176]

Overall, we draw three conclusions about the use of EW in the conflicts analyzed:

- First, EW assets have been primarily used by one conflict party thus giving the user considerable operational advantages. In particular in Ukraine, Russian EW deployment faced an adversary that was technologically inferior.[177] As McDermott has suggested, "this raises questions with regard to the consequences for NATO." [178] Syria, by contrast, might be more reminiscent of the heavy cluttered, congested, and contested electromagnetic spectrum that many observers believe to be constitutive of future warfare. In addition, Kjellen suggests that Russia's consideration of EW goes significantly beyond the military battlefield and also includes "attacking an adversary's defense industry" as a dedicated EW task.[179] This puts the emphasis on the home front and raises serious questions for national defense.
- Second, Russian experts conclude that EW should become an integral element of future air defense solutions. In their view, EW is to become a primary means for countering UAV.[180] In view of future UAV swarm attacks "Russian companies involved in EW development (…) concluded that air defenses require miniature hit-to-kill missiles."[181] Both aspects are to change the future operating environment for the use of UAV, which starts being reflected in new developments like self-protection modules for UAV.[182]
- Finally, the use of EW against assets that depend on positioning, navigation, and timing signals from space prompts different development avenues in

172 Clark, *The Russian military's lessons learned in Syria,* p. 23; Pomerleau, "Why Syria may be the most aggressive electronic warfare environment on Earth."
173 McDermott, *Russia's Electronic Warfare Capabilities to 2025,* p. 21.
174 Ibid, p. 23.
175 McDermott, "Russia's electronic warfare capabilities as a threat to GPS." For a different view, see: Johnson, "Tomahawk strike in Syria stokes debate about Russian air defences," p. 4.
176 McDermott, *Russia's Electronic Warfare Capabilities to 2025*, pp. 22-23; Loukianova, "Moscow's emerging electronic warfare capabilities," p. 8-9.
177 Experts disagree if international sanctions against Russia have had a significant impact on Russia's EW industry. Trevithick, "Ukrainian Officer Details Russian Electronic Warfare Tactics Including Radio 'Virus'" suggests Russia might face problems in the future, whereas Kjellen, *Russian Electronic Warfare,* p. 74-75, disagrees.
178 McDermott, *Russia's Electronic Warfare Capabilities to 2025,* p. 28.
179 Kjellen, *Russian Electronic Warfare,* p. 23.
180 Clark, *The Russian military's lessons learned from Syria,* pp. 30-31.
181 McDermott, "Russia's electronic warfare capabilities as a threat to GPS."
182 Trimble, "Reaper at 20," p. 34.

Turkey and Russia. Russia is reportedly working on integrating its own UAV into the Russian GLONASS system, whereas Turkey seems to be developing sensor fusion systems that could possibly limit GPS dependence all together.[183] Both trajectories should receive more attention in the West as they suggest a closer amalgamation of air and space-based asset which is of particular importance given the international space collaboration activities of both nations.

Air Defense Vulnerabilities Come to the Fore

All four conflicts lean towards the offensive, whereas defense assets have come under pressure. This is most obvious in the field of air defense. In particular the conflicts in Syria, Libya and Nagorno-Karabakh have come to be portrayed as a success of Turkish UAV in combination with EW against Russian air defense assets.[184] This impression emerges out of the specific force postures in these conflicts, but some of the vulnerabilities that have come to the fore are also relevant for air defense assets of Western origin, as – for example – UAV and missile attacks by Houthis on Saudi Arabian targets between 2019 and 2021 make amply clear.[185] In this context the following observations are of particular importance:

- First of all, individual air defense elements do not yet make up an integrated system, as we will argue in more detail in the following chapter. This is particularly true for C-UAV, for which none of the conflict parties was properly prepared. As a consequence, the conflict party operating UAVs mostly enjoyed – more or less – unrestricted air superiority. Armenia, for example, kept three of the four Russian S-300 air defense systems at home rather than in Nagorno-Karabakh.[186] Russian Pantsir S-1 that have been targeted in Syria and Libya have originally been built to protect S-300 and S-400 air defense systems as part of larger integrated solutions. Thus, they have been used in missions deviating from the original purpose and without the long-range radars essential for their optimal performance.[187] Similarly, S-400 systems used in Syria had been stationed too far away from Shayrat air base, for example, to be effective against strikes.[188] However, existing air defense assets also proved

183 Urcosta, "The Revolution in Drone Warfare", p. 60.
184 Ukraine does not fit into this logic as Ukrainian air force assets performed badly against Russian air defense assets in Donbas (chapter 4.1).
185 Hinz, "Meet the Quds 1."
186 Ripley/Cranny-Evans, "Unmanned edge," p. 23.
187 "Russian Pantsir Air Defense System: Sitting Duck or Top Dog?;" "Some 23 Russian Pantsir Air Defense Systems Destroyed in Syria, Libya: Reports." The lack of synchronization of Pantsir S-1 systems with long-range radars differentiates their performance in Libya from Syria where the two were deployed in tandem.
188 "After US strikes Syrian air base, Russians ask: 'Where were our vaunted air defense systems'." Other reports suggest that Russia has never used S-300 and S-400 air defense systems in combat. See: Clark, The *Russian Military's Lessons Learned in Syria*, p. 25.

effective against the UAV threat. Syria, for example, has downed around 20 Turkish UAV with the Russian-built Buk-M2E air defense missile systems.[189]

- Second, most of the air defense systems in use in the three conflicts are export versions. Thus, it is unclear to what extent these systems might have been missing important components needed for proper functioning. This could explain why the radar systems used for Russian S-300 and Pantsir S-1[190] systems operated in Syria have reportedly been unable to detect and hit Israeli cruise missiles.[191]
- Third, Soviet legacy systems in operation in Syria had been encountered before in Iraq, former Yugoslavia, and Libya (2011). This might have provided opportunities to adjust attack systems by taking into account the performance characteristics of these systems, for example the limited ability to track only one system at a time.[192] Turkey in particular is said to have been familiar with the weaknesses of Russian air defense systems.[193] And the interest in better understanding how these systems operate also explains the quarrel between Turkey and the US with regard to extracting a Pantsir S-1 unit from Libya.[194]
- Fourth, irrespective of stripping down export versions, limitations remain. For example, experts have speculated that Pantsir S-1 radars might have particular difficulties detecting slow and low flying targets in particular when operating on their own.[195] It is believed that Pantsir S-1 systems can track three targets at the same time, but, as Seth Frantzman argues, "they need to come in from the same direction. If attacks occur from serval directions, the system needs to turn the radar by 180 degrees. In addition, the illumination radar has an azimuth of 30-45 degrees. Finally, launchers need to see the target throughout the engagement phase at a range of up to 24km." These limits might have played a role when Pantsir S-1 systems have been struck in the back seemingly unable to see the incoming threat.[196]
- Finally, human intelligence is another aspect that needs to be take into account. In Libya, Pantsir S-1 were "in a convoy or in shelters and not operating."[197] In Syria, rebel attacks on Khmeimim air base occurred "when, for a short period, the entire system of radio-electronic jamming was off."[198]

189 "Syria: How many Turkish UAVs shot down the Buk-M2E system."
190 The Pantsir S-1 systems supplied to LNA by the Emirates were export versions. See Al-Atrush, "Lybia: How the US and Turkey agreed to share a captured Russian defence systems."
191 "Syria says Russian missile defence system 'ineffective'."
192 O'Conner, "Access denial", pp. 23-24.
193 Mikhnenko, "Unmanned Aerial Vehicles vs. Air Defenses," p. 49.
194 Al-Atrush, "Libya: How the US and turkey agreed to share a captured Russian defence system."
195 Reim, "US Army to exploit crucial weakness in Russian, Chinese air defences."
196 Frantzman, "How did Turkish UAVs outmaneuver Russia's Pantsir air defense in Libya."
197 Ibid.
198 Urcosta, "The Revolution in Drone Warfare," p. 51.

5.2 Effective Defense Ecosystems Continue to Dominate

True military revolutions are the product of changes and reconfigurations in both software and hardware dimensions as defined in chapter 3.[199] Our analysis shows that specific defense ecosystems, which have coordinated different military capabilities based on rather traditional doctrinal principles of force employment, were decisive.

Hardware Aspects

Operations by major war participants in the four conflicts were characterized by the creation of an effective "battle network"[200] based on their equipment. How this battle network then was employed was different according to national doctrines and military traditions. Yet the hardware aspects of military innovation are not limited to armed forces and the application of force, but also the defense industrial environment enabling rapid adaptability, especially when it comes to lessons learned from conflicts:

Battle Networks

Those actors who were not able or willing to develop, deploy or use battle networks lost out. Generally, increased complexity in these networks won against simpler networks, if sufficiently integrated. Even though some battle networks integrated assets on a scale not seen before, foremost UAVs, the network itself was the most important asset. Limited hardware innovation for singular components as well as the use of existing or only slightly altered doctrines does not constitute a revolution. The observed battle networks improved over time yet did not change to a new "competitive regime,"[201] which might be the case due to either insufficient durations of the campaigns or insufficient resources and capabilities by one side to adapt at the speed of the other battle network.[202] So even though some hardware was replaced, e.g., manned strike aircraft by unmanned systems, the underlying capabilities remained true to tested concepts. Moreover, both Russia and Turkey built on traditional doctrinal concepts in their integration of new technologies and equipment into their forces – as is expected from the military innovation theory.

199 The software aspect covers conceptual and organization changes while the hardware aspect covers technological changes. For the three changes and their relation to innovation, see: Cheung/Mahnken/Ross, "Frameworks for Analyzing Chinese Defense and Military Innovation", p. 37

200 As defined by Stillion/Clark, *What it Takes to Win,* p. 1: "Fundamentally, a battle network is a combination of target acquisition sensors, target localization sensors, command and control (C2) elements, weapons, weapon platforms, and the electronic communications linking them together."

201 Stillion/Clark, *What it Takes to Win*, p. 3.

202 Ibid., p.3.

Ubiquitous sensors on the battlefield and their integration with strike assets have ambiguous effects on the attractiveness of the offensive. While most examples discussed in this study seem to validate that offensive operations are more effective, deterrence is also strengthened by highly integrated battle networks – an observation we call "deterrence by sensing."[203] This is illustrated, for example, by Russia's use of active electronic sensing capabilities to monitor Ukrainian forces in the region. The combination of active and passive sensing capabilities provides Russian forces with a comprehensive situational awareness picture over Ukraine,[204] and the lethal capabilities of the S-400 air defense system are a significant deterrent to Ukrainian air operations.

The required organizational complexity for successful battle networks makes it more likely that mature and large armed forces emerge as users of them. Hence, it is not surprising that Russia and Turkey were successful when they had the necessary political will to deploy a complex battle network. Interestingly, Russian observers seem to come to the same conclusion for the sub-aspect of air defense, demanding more complex approaches to C-UAV defense.[205] This increase in complexity between air defense and UAVs, which describes one element of the battle network competition, is in line with what is expected and will likely spur further UAV developments.[206] Consequently, dealing with complexity (e.g., through effective integration) becomes ever more important.

Defense Industry

At least for Turkey and Russia, with their extensive domestic defense industries, participation of the national armed forces in the respective conflicts has yielded insights into room for improvement on various products. While improvements in some products have become visible over the years, observers are also cautious to ascribe too much influence on the testing of weapon systems in limited conflicts. Examples for the first category include Turkish updates on armored vehicles including cage-armor against RPGs and ballistic protection for some technicals.[207] Moreover, experiences with the vulnerability of armored vehicles, including M-60 main battles tanks, during Operation Euphrates Shield[208] also invigorated Turkish efforts to introduce active protection systems.[209] By contrast, Clark voices a rather skeptical view regarding the innovative value of the battlefield deployment of Russian assets in Syria.[210] While Adamsky mentions the deployment of engineers and scientists from across the Russian defense industrial ecosystem, including

203 McCrory, "Russian Electronic Warfare, Cyber and Information Operations in Ukraine," p. 3.
204 Ibid., p. 3.
205 Sukhankin, "The Second Karabakh War: Lessons and Implications for Russia (Part One)."
206 Stillion/Clark, *What it Takes to Win,* p. 94.
207 Kasapoglu/Ülgen, Operation Olive Branch: A Political-Military Assessment, p. 10f.
208 Yesiltas/Seren/Özcelik, "Operation Euphrates Shield – Implementation and Lessons Learned," p. 45.
209 Kasapoglu/Ülgen, Operation Olive Branch: A Political-Military Assessment, p.10.
210 Clark, "The Russian military's lessons learned in Syria," p. 30 f.

development bureaus,[211] examples for concrete improvements derived from the operations in Syria are absent. Deploying your own engineers to adapt your own equipment – even when offered as assistance to allies – makes a difference and offers insights that will not be available to operators that rely on equipment from third parties without battlefield engineering support.

For all actors except Russia, access to the global supply chain for defense equipment, spare parts or subsystems was critical to guarantee constant supply. Azerbaijan likely took deliveries of additional munitions during the six-week war with Armenia.[212] Turkey's use of Bayraktar TB2 UAVs ran the risk of temporary insecurity of supply due to export embargos on specific components (chapter 5.4.). This shows that the dependence on foreign supplies might turn an operational risk into a politico-industrial challenge and could further spur the political will to establish a fully-fledged indigenous defense industry.[213]

Lastly, there is an export and marketing angle to these conflicts and the components of battle networks. Single systems like the Pantsir-1 might lose credibility with customers, while others might gain such as the Bayraktar TB2 UAVs.[214] However, potential importers will have to look closely at the decisive influence of the respective battle networks and the configuration of the respective systems provided to export markets (chapter 5.1). For suppliers, economies of scale will serve as an important argument to highlight capabilities and the role specific systems played in a conflict, which is likely one factor in Turkey's aggressive promotion of its products.

Software Aspects

While it is difficult to "reverse engineer" a clear picture of the doctrines[215] used by all actors in the four conflicts, highlighting the most important operational approaches suggests, that only limited doctrinal adjustments seem to have taken place. Moreover, most adjustments were evolutionary, building on long-standing traditions in the respective armed forces. Our focus here is on Russia, Turkey, and Azerbaijan more than on the other actors as these three are largely seen as pacemakers in the respective conflicts. The two most important operational factors across all four conflicts were the establishment of air superiority (regardless of whether through air defense or fighters) and the close integration of strike assets

211 Adamsky, "Russian lessons from the Syrian operation and the culture of military innovation".
212 Lavallée, "Experts believe Israel unlikely to drop lucrative arms sales to Azerbaijan."
213 Fahim, "Turkey's military campaign beyond its borders is powered by homemade armed drones;" Düz, *The Ascension of Turkey as a Drone Power;* Kurc, "Between defence autarky and dependency."
214 Bakeer, "The fight for Syria's skies."
215 As defined by Posen, *The Sources of Military Doctrine,* p. 7, "(…) military doctrine sets priorities among various military forces and prescribes how those forces should be structured and employed to achieve the ends in view."

(ground and air) with sensors (ground and air) – highlighting the important role of the latter as described for example by Watling.[216]

Russia

Russia has effectively begun to realize its old dream regarding the future of conventional warfare: the implementation of the reconnaissance-strike (strategic/operational level) and reconnaissance-fire (tactical level) complex (RFC/RSC).[217] Originally, this wording was used in the Soviet Union to describe what the West calls Network-Centric Warfare (NCW).[218] After the war against Georgia in 2008, the Russian military began a sweeping reform aiming to correct significant shortcomings, especially in ISR and joint operations.[219] Coming of age during the Ukraine crisis,[220] Russia successfully demonstrated the value of RFC/RSC during the war in Syria, where Russia claims to have had 60-70 UAVs airborne daily in order to gather intelligence and deliver EW effects.[221] Moreover, Russia seems to have successfully integrated these assets with strike assets in an overarching C4ISTAR structure, accelerating combat management tempo between 20 and 30%.[222]

Yet a distinctive difference as compared to Western conceptions of NCW is the widespread use of unguided munitions, both by the air force and ground forces, especially artillery. Adamsky estimates that only 5% of used munitions in Syria were smart.[223] The Russian military leadership considers the integration of real time ISR assets (e.g. Orlan-10 UAVs, special forces) with unguided munitions as sufficient to create effects similar to smart munitions.[224] This, of course, requires a constant real time data and information stream, which was unproblematic in Ukraine and Syria given the unsophisticated EW by the respective adversaries, and the significant Russian EW capabilities, especially in Ukraine (chapter 4.1). Utilizing UAVs for ISR and EW purposes also influenced the way Russia integrates them into its artillery units and larger formations containing artillery units. As of now, military units at brigade levels and higher have organic UAV-based ISR/EW capabilities.[225] Despite the success with unguided munitions, it is likely that Russia will also pursue the further development and integration of precision-guided munitions.[226]
This approach mirrors what the Soviet/Russian traditional doctrines imagined as the RFC/RSC. Hence, it very much describes gradual path-dependent innovation more than revolutionary change. Even the use of UAVs for ISR purposes was long

216 Watling, "The Key to Armenia's Tank Losses: The Sensors, Not the Shooters".
217 Adamsky, "Russian lessons from the Syrian operation and the culture of military innovation."
218 Adamsky, *The Culture of Military Innovation*, pp. 26-37.
219 Kofman, "Russian Performance in the Russo-Georgian War Revisited."
220 Grau/Bartles, *The Russian Reconnaissance Fire Complex Comes of Age.*
221 Clark, *The Russian Military's Lessons Learned in Syria*, p. 31.
222 Adamsky, "Russian lessons from the Syrian operation and the culture of military innovation."
223 Ibid.
224 Ibid.
225 Grau/Bartles, *The Russian Reconnaissance Fire Complex Comes of Age*, pp. 11/13.
226 Clark, *The Russian Military's Lessons Learned in Syria*, p. 26 f.

in the making – from the 1970s and 1980s onwards.[227] While the current innovation is more relevant to its ground forces – unsurprising given the traditional focus on that branch as well as the "Ukrainian genesis" of the UAV integration – it will be interesting to see how the Russian air force implements its Syrian experiences about PGMs and real time ISR. One factor that could help with aggressive implementation of new ideas is that the Russian armed forces drew the conclusion from Syria (and potentially from Ukraine) that junior officers get more freedom of action, thus developing/strengthening creativity and initiative for an accelerating battlefield.[228] Path dependency is also visible in Russian efforts to boost counter-UAV capabilities, primarily with EW (including the integration of EW units in air defense units[229]), thus building on their traditional strengths in these two areas instead of opting, for example, for UAVs with air-to-air capabilities.

Regarding the organization of forces, Russia aims to increase the level of jointness of force command (inclusive multi-echelon unity of command) as one consequence of the deployment in Syria.[230] While this is nothing new either,[231] the need to pursue this reform is more urgent than ever if the Russian armed forces want to reap the benefits of close real time integration of various assets beyond organically integrating them into units. One building block of this integration is a unified mobile C2 system for tactical and operational levels.[232] On an operational level, the battalion tactical group (BTG) was an innovation widely used in Eastern Ukraine between 2013 and 2015.[233] Although its roots go back to the Russian efforts of implementing a brigade system,[234] BTG's received their baptism of fire in Ukraine. Given the limited deployment of Russian ground forces for offensive purposes they played no role in Syria, though. Another important organizational change in the wake of the adaption to brigades was the wide distribution of EW companies in all major land force divisions and especially brigades. This is both true for the army and the airborne forces and provides them with organic EW capabilities.[235] Lastly, it is notable that the Russian operations as observed in Ukraine and Syria seem to require a "foothold" in the area and/or geographical closeness (as in Ukraine), despite mounting an impressive logistics campaign to support the deployed troops in Syria. Force entry operations are, at least with the current configurations observed, only possible in neighboring countries/the near abroad.

227 Bartles/Grau, "Integration of Unmanned Aerial Systems Within Russian Artillery", p. 31.
228 Clark, "The Russian military's lessons learned in Syria", p. 19 f. This observation is particularly interesting as the personality of individual commanders plays a key role in Russian military decision-making. See: McDermott, *The Revolution in Russian Military Decision-Making.*
229 Clark, *The Russian Military's Lessons Learned in Syria,* p. 31.
230 Ibid., p. 18.
231 Ibid., p. 19.
232 Adamsky, *Moscow's Syrian Campaign,* p. 19.
233 Fiore, "Defeating the Russian Battalion Tactical Group", p. 9.
234 Bartles/Grau, *The Russian Way of War,* p. 37.
235 Kjellen, *Russian Electronic Warfare,* p. 34.

Turkey

Turkey's approach to applying military power across the conflicts in Syria, Libya and, to a certain degree and via transfer to Azerbaijan, is closer to a Western/NATO approach.[236] In a sequence remarkably familiar to Western campaigns of the last 30 years, gaining, retaining, and utilizing air superiority was at the center of Turkish operations. Both the extensive use of EW (KORAL) for SEAD as well as the continuous DEAD operations with UCAVs underline this. Moreover, the use of aircraft – manned and unmanned – to gather intelligence, deploy precision-guided munitions against enemy assets and perform air interdiction missions is common to this approach. Beyond the "narrow" SEAD/DEAD focus, the deployment of advanced manned fighter aircraft in interception range (F-16 in Turkey/Azerbaijan), HAWK SAM forces (Libya) and AEW&C aircraft (Libya, Syria) served as a deterrence against potential adversarial attacks on Turkey's UCAVs operating above enemy airspace - as two Syrian Su-24 painfully experienced.[237]

Even though Turkey also successfully integrated the real time ISR data gathered by its UAVs (foremost Bayraktar TB2 and ANKA-S) with tube and rocket artillery assets (Syria, likely Libya) and loitering munitions (Nagorno-Karabakh), its focus seems to lie on a closed sensor-to-shooter loop in one system. Ongoing development of more advanced UAV systems in Turkey underline this conclusion.[238] This concentration of sensor and shooter is a more Western approach as compared to the distributed system Russia so far prefers. Nevertheless, ground-based artillery also played a vital role, particularly in the early stages, of Operations Euphrates Shield (2016-17) and Olive Branch (2018), engaging more targets than airborne assets.[239] This also became clear in Syria, where the "traditional" integration of artillery with ground-based weapon-locating radar led to effective counter-battery fire against LNA artillery forces until these adopted "shoot-and-scoot" tactics.[240] The better and faster integration of ground-based indirect fire assets with airborne ISTAR is hailed as an important step.[241]

Notably, both Euphrates Shield and Olive Branch featured manned aircraft (F-16 and F-4), with Olive Branch also using attack helicopters (T-129) and UAV (Bayraktar TB2), although only for ISR and target designation.[242] This is a major difference as compared to Operation Spring Shield (2020), which employed only UAVs for cross-border missions. Likely, this change in emphasis is caused by the growing capabilities of especially the Bayraktar TB2 as well as the larger risk for manned systems in the last operation as it was conducted against the Syrian regime and

236 See also: Ringler, "Turkey's New Joint Operational Concepts Foreshadow the Future of Armed Conflict."
237 Kasapoglu, "Turkey's Drone Blitz Over Idlib."
238 "Turkish Akinci Combat Drone's 2nd Prototype Completes Maiden Flight."
239 Kasapoglu/Ülgen, "Operation Olive Branch: A Political-Military Assessment," p. 5.
240 Pack/Pusztai, "Turning the Tide – How Turkey Won the War for Tripoli," p. 11.
241 Kasapoglu, "Military scorecard of Operation Olive Branch."
242 Kasapoglu/Ülgen, Operation Olive Branch: A Political-Military Assessment, p. 7.

its allies with air defense assets as compared to the earlier operations against the YPG and IS, which only had MANPADS for air defense. All three operations, though seen to be examples for a concept called "Rapid Dominance," which, if so, used in the Turkish armed forces, has its roots in US-American thoughts about shock and awe.[243] This would underscore an evolutionary innovation in Turkish air doctrine inspired by its Western allies.[244]

So far, we have not found any information on major organization reform in the Turkish armed forces. Land forces used in the operations, e.g., a Battalion Task Force in Euphrates Shield,[245] are a well-known formation that Turkey deployed as long as 20 years ago as part of their engagement in KFOR.[246] The jointness of all four major Turkish operations in Syria is highlighted as another major achievement, though without more detail.[247] Lastly, and like Russia, Turkish forces so far require either a foothold or geographical proximity to deploy and prepare their forces. Turkey used rather extensive preparations to enhance the military value of its UAVs by establishing several signal relay stations along their border with Syria[248] and in Libya.[249]

Azerbaijan

The Azeri campaign in the Nagorno-Karabakh war of 2020 offers an interesting mix in doctrines. While the country still displayed rather uncoordinated frontal ground assaults in the early days of the war,[250] a simultaneous effort was made to gain air superiority.[251] Initial ground operations according to older doctrines against heavily defended Armenian position resulted in expectable losses with only very limited territorial gains.[252] However, trough the successful SEAD/DEAD campaign, air superiority was achieved, which in turn enabled Azerbaijan to start attrite Armenian forces, especially heavy equipment, thus making ground offensives significantly easier.[253] Notably, this second phase saw a close integration of airborne ISTAR assets and ground artillery,[254] similar to Turkish and Russian experiences. The air campaign required significant integration of ISR, EW and strike missions with a variety of assets, which in turn requires highly professional armed forces and a robust C4/ISTAR infrastructure and turned out remarkably similar to

243 The term "rapid dominance" repeatedly appears in Kasapoglu/Ülgens, Operation Olive Branch: A Political-Military Assessment, with particular reference to similar US concepts related to shock and awe on p. 6.
244 This seems to be vindicated by the fact that Azerbaijan's mode of operation – most likely with the significant support of Turkey – bears striking resemblance with Turkey's Operation Spring Shield in February/March 2020, thus suggesting the inter-theater transfer of experience. See: Kasapoglu, Haard Fighting in the Caucasus, pp. 12-16.
245 Yesiltas/Seren/Özcelik, "Operation Euphrates Shield – Implementation and Lessons Learned," p. 23.
246 "The Turkish Battalion – Brothers in arms."
247 Yesiltas/Seren/Özcelik, "Operation Euphrates Shield – Implementation and Lessons Learned," p. 19.
248 "Eastern Promise: The Baykar Bayraktar TB2 in Profile."
249 Crino/Dreby, "Turkey's Drone War in Syria – A Red Team View."
250 Kofman/Nersisyan, "The Second-Nagorno-Karabakh War, Two Weeks In."
251 Ripley/Cranny-Evans, "Unmanned edge. The Nagorno-Karabakh conflict," p. 22.
252 Kofman, "A Look at the Military Lessons of the Nagorno-Karabakh Conflict."
253 Ibid.
254 Shaihk/Rumbaugh, "The Air and Missile War in Nagorno-Karabakh: Lessons for the Future of Strike and Defense."

recent Turkish campaigns.[255] Interestingly, the survivability of Azeri UAVs in the most recent conflict contrasts with the loss of 13 platforms in the short flare-up conflict in July 2020,[256] which either hints at a deliberate deception campaign or the significant influence of the other factors (such as EW, Turkish F-16 stationed in Azerbaijan as implicit deterrent) in conducting this campaign.

So far, it is unknown what lessons the Azeri armed forces will take from this conflict, but given their success, it is likely that they will continue along the trajectory taken in the past years – that is integration of ground and airborne assets with an emphasis on UAV and artillery. Nevertheless, Azeri casualties are similarly high as Armenian ones, which underline the cost even a "clear cut victory" can entail if it includes substantial ground operations.[257]

Additional Notable Observations

Innovation and adaptation took place in all conflicts and might offer interesting insights into potential elements of future doctrines. Most of them symbolize reactions to the high density of sensors and intensive integration of ISR and strike assets described above. Defensive measures like the intensification of concealment and cover and the deployment of decoys to deceit[258] adversarial ISR assets is an evident reaction – even though it might only have limited positive effects for e.g., armor as trails left by their tracks can be easily followed.[259] Changing tactical behavior is another field, ranging from the switch to using optical guidance by Pantsir-1 operators in Libya[260] to "shoot-and-scoot" tactics by LNA artillery forces[261] to geographically distributed operations by GNA-allied drone forces avoided airfields[262] and Armenian splitting of platoons into groups as primary infantry formations.[263] Lastly, context-specific organizational innovation like the privately-organized support for Ukrainian troops by citizens can be interpreted not only as a reaction to a dysfunctional military procurement system, but also as an opportunity to adapt to rapidly changing requirements by soldiers on the frontlines and unbureaucratic responses.

255 Kasapoglu, "Turkey Transfers Drone Warfare Capacity to Its Ally Azerbaijan."
256 Ripley/Cranny-Evans, "Unmanned edge," p. 20.
257 "Nagorno-Karabakh conflict killed 5,000 soldiers."
258 "Future Warfighting in the 2030s: An Interview with Franz-Stefan Gady."
259 Watling, "The Key to Armenia's Tank Losses: The Sensors, Not the Shooters."
260 Pack/Pusztai, *Turning the Tide,* p. 12 f.
261 Ibid., p. 11.
262 Gady, "Useful, but not decisive: UAVs in Libya's civil war."
263 Gady, „Krieg um Berg-Karabach 2020: Implikationen für Streitkräftestruktur und Fähigkeiten der Bundeswehr," p. 4.

5.3 Humans Remain Pivotal

The future relationship between humans and machines and algorithms is one of the most hotly debated issues in security studies and strategic affairs.[264] The four conflicts analyzed in this paper hardly offer significant insights for this debate as they cement the central role of humans across all key dimensions of military innovation discussed in chapter 3.

At the politico-strategic level decision-makers have remained key to formulate and express political will, intentions and military goals to be achieved in conflict. Government-to-government military support by way of War as a Services, as will be discussed in the next chapter, is impossible without decision-makers' dedicated willingness to embed foreign force elements (Azerbaijan) and to take the risk of operational presence on the ground (Turkey).

Inadequate decisions at the politico-strategic level played a key role in Armenia's defeat. Past procurement decisions favoring heavily outdated missiles and air defense systems rather than more modern equipment seem to have played a role as did the fact that three out of the four more modern Russian-made S-300 air defense systems were stationed in Armenia, not in Nagorno-Karabakh.[265] In addition, Armenia has reportedly also been under pressure by Moscow not to use Russian fighter jets against Azerbaijan.[266] Furthermore, the country's political and military leadership also seems to have completely misinterpreted the fitness of its armed forces and the readiness of the commanders to follow orders.[267] In contrast, "Russian articles on the conflict credit Azerbaijan with an astute, decade-long military modernization program executed with a laser focus on regaining Karabakh."[268]

Adequate or inadequate preparedness also played a decisive role at operational and tactical levels. Here again the Armenian experience is striking. Reports indicate that about 25% of the forces called up to the front lines did not show up and more than two-thirds of the officer corps has been deemed unfit for mission in

264 It could be argued that the concept of manned-unmanned teaming cannot be applied to the four conflicts as it has so far been mostly discussed among armed forces of great powers. In response we point out that the concept is already starting to diffuse beyond great powers by influencing conceptual thinking as well as research and development in other countries. The Control and Avionics Laboratory at the Istanbul Technical University, for example, is reportedly working on "manned-unmanned system teaming C2 software." See: Türk, *An Investigation for Maturity Level and Roadmap of Unmanned Aerial Vehicle Technologies in Turkey,* p. 50.

265 Ripley/Cranny-Evans, "Unmanned edge," p. 20; Kofman, "A look at the military lessons of the Nagorno-Karabakh conflict;" Stronell, "Learning the lessons of Nagorno-Karabakh the Russian way."

266 Ripley/Cranny-Evans, „Unmanned edge," p. 23; Arbeiter, „Das Labor des Krieges", p. 11.

267 "Samvel Babayan spoke about the reasons for the defeat in the second Artsakh war;" Kofman, "A look at the military lessons of the Nagrono-Karabakh conflict."

268 Stronell, "Learning the lessons of Nagorno-Karabakh the Russian way."

retrospect.[269] Preparedness to fight goes hand in hand with important aspects like warfighting stamina, morale and the coping capacity of armed forces to deal with the psychological effects of attacks with unmanned systems and loitering munition systems. Reports covering these aspects again with regard to Armenia clearly show that the type of warfare conducted by Azerbaijan added a new dimension to "psychological warfare," that Armenian soldiers were totally unprepared for.[270] The use of Israeli Harop loitering munition systems is a case in point. These systems make a screaming noise in nosedives[271] but as they are difficult to spot soldiers throw themselves to the ground. Warstreaming reinforces this effect by evoking the impression of almost relentless effectiveness and seemingly unmatched superiority of the party operating the respective platform.

In stark contrast to the Armenian example stands the role of Turkish trainers, operators, advisers, and commanders. Russian reports covering the conflict in Nagorno-Karabakh suggest heavy Turkish troop presence following the Turkish-Azerbaijani exercises in July-August 2020 including 50 instructors, 90 military advisers and around 20 drone operators. These force elements seem to have been instrumental in planning and executing the operation against Armenia and in providing much needed intelligence support.[272] Prior to the conflict Turkey seems to have dispatched UAV trainers to Azerbaijan, and Azerbaijani drone operators have reportedly received training in Turkey.[273] Reports covering Turkey's involvement in Libya present a similar picture with Turkish military personnel working in the GNA operations room as well as training Libyans at the Turkish Defense School in order to improve their proficiency in handling Turkish counter-drone equipment.[274]

When reflecting upon embedded outside force elements, we should also not forget the heavy use of proxy forces from Chadian mercenaries in Libya to Syrian mercenaries in Nagorno-Karabakh to the Wagner private military company in Ukraine, Libya and Syria. Even though these groups have, except for Wagner, only operated as light infantry with light and unsophisticated equipment, they are an important part of the type of warfare observed in these four conflicts. Proxies provide additional manpower for both frontline and rear tasks, enhance plausible deniability for external actors and decrease the political cost of potential casualties for both domestic and foreign actors. Moreover, both Russia and Turkey seem to aim for a more structured approach to their proxies, with Russia focusing on pre-

269 "Samvel Babayan spoke about the reasons for the defeat in the second Artsakh war;" Kofman, "A look at the military lessons of the Nagrono-Karabakh conflict."
270 "Samvel Babayan spoke about the reasons for the defeat in the second Artsakh;" Daubenberger/Guckelsberger, "Auf der Spur der Drohnen."
271 See for example: https://twitter.com/kylejglen/status/1311725913172856833?lang=de (last accessed 4 May 2021).
272 "Forcing conflict;" "The expert explains why Russia is 25 years behind in the field of attack drones."
273 Kington, "The drone defense dilemma;" Frolov/Tynyankina, "War of a new era."
274 Binnie, "LNA claims it has been attacked by Turkish-made UAVs," p. 17; Binnie, "Turkish UAV seen in Libya," p. 20; Binnie, "Turkey hints at new Libyan air defenses," p. 17.

planned coalitions instead of ad-hoc coalitions like in Syria[275] and the widespread use of private contractors familiar with Russian military thinking and Turkey "institutionalizing" the use of their most formidable Syrian formations, such as the "Sultan Murad" in Syria, Libya[276] and, supposedly, in Nagorno-Karabakh.[277]

Finally, there is also an important human element at the military-industrial intersection, which is a key interface for concept and technology development. On the one hand "Russians have emphasized digital interoperability among different command and control systems," but humans remain an "essential element of UAV integration into the Reconnaissance Fire System," in particular as "UAVs do not communicate directly with the fire control elements of the batteries."[278] Given the fact that Russia is a latecomer in UAV operations, it will be very interesting to observe if this approach might change once Russia's conceptual and technological maturity advances. On the other hand, embedded engineers played a role in some of the conflicts in order to improve the performance of deployed equipment. Turkey "sent in engineers who improved the software of the drones on the fly, while there was no similar learning curve with the Chinese UAVs operated by the UAE to assist Hifter," as Jalel Harchaoui, Senior Fellow at the Global Initiative against Transnational Organized Crime, pointed out.[279] With a similar goal the Russian Ministry of Defense deployed "engineers and scientists from the design bureaus, scientific institute, and industry to accompany their products and to calibrate them technologically and conceptually based on the hands-on combat experience."[280]

275 Clark, "The Russian military's lessons learned in Syria," p. 21.
276 "Libya: Are Turkey's Syrian mercenaries a new threat?"
277 McKernan, "Syrian rebel fighters prepare to deploy to Azerbaijan in sign of Turkey's ambition."
278 Grau/Bartels, *The Russian Reconnaissance Fire Complex Comes of Age*, p. 11.
279 Kington, "The drone defense dilemma."
280 Adamsky, "Russian lessons from the Syrian operation and the culture of military innovation," p. 8.

5.4 Warstreaming Benefits May Be Very Short-Lived

The ubiquity of all kinds of sensors[281] is a commonality of all four conflicts analyzed. Sensor ubiquity contributes to better situational awareness and situational understanding. It also gives rise to warstreaming as the ability of warfighting parties to provide live feeds from the battlefield in order to shape mindsets and public opinion.

Rebel forces, the Islamic State (IS) and occasionally also the Syrian army have started using warstreaming in Syria.[282] Videos of destroyed Syrian armor were used to illustrate the warfighting power of these violent non-state actors. In addition, IS militants also used videos for propaganda and to step up recruitment.[283]

Warstreaming has been further refined in Nagorno-Karabakh.[284] Unlike in Syria, warstreaming in Nagorno-Karabakh was primarily used by official forces and the Ministries of Defense of Armenia and Azerbaijan which might have attracted further attention. In addition, technical assets have become more professional. Turkish UAVs by Baykar, for example, seem to have been built with warstreaming missions in mind, as the Baykar Live Video Streaming System provides high fidelity 3D simulation with augmented reality and direct video streams.[285] Ironically, however, some of the key sensors relevant for warstreaming such as the Wescam CMX15D gimbal turret have been of non-Turkish origin and fell victim to sanctions once it had become clear that their use did violate export restriction regulations of the exporting country, in this case Canada.[286]

Warstreaming might give one warfighting party the upper hand with regard to influencing public opinion, but it is a dual-edged sword. As we will argue in the next chapter, high fidelity video streams might reveal patterns of operator proficiency not seen in past combat, which might serve as an indicator that (outside) force elements are at play. This observation, in turn, might run counter to the interest in plausible deniability by a third party that provides military support – proverbially speaking – under the radar. In addition, warstreaming is a particular challenge to observers and experts analyzing a conflict. Whereas the second Nagorno-Karabakh war has become synonymous with the use of UAVs, the pictures delivered from the conflict in Ukraine have reinforced the impression of an attrition-heavy

281 Watling, "The key to Armenia's tank losses," p. 1; Ripley/Cranny-Evans, "Unmanned edge," p. 24.
282 Different types of drones like Phantom, Inspire, and F550 Flame Wheel all seem to have been equipped with video cameras. See: Gettinger, *Drones Operating in Syria and Iraq*, p. 4.
283 See for example: Speckhard/Ellenberg, "Deterrence for Online Radicalization and Recruitment in the 21st Century."
284 See also: Ripley/Cranny-Evans, "Unmanned edge," p. 21.
285 Baykar, *Bayraktar TB2 Catalogue*, p. 56-57.
286 "Canada suspends drone technology sales to Turkey after claims of use by Azeri forces." Aselsan has reportedly provided an alternative to the Wescam gimble. See: "Ankara finds solution to Wescam embargo."

conflict characterized mainly by movements and counter-movements on the ground. But in this case, UAV-based warstreaming was primarily absent, which potentially downplays the role of UAVs in this conflict. Warstreaming will thus require analysts to pay more attention to properly analyze all aspects of the conflict rather than believing in what they see.

In doing so, analysts should pay particular attention to the future evolution of warstreaming as different development trajectories might occur. On the one hand Miron Lakomy has argued that "video games have become a valid and increasingly significant means of jihadist digital propaganda."[287] Likewise nations interested in showing off their UAV proficiency could start to influence the aesthetic of video games by having their UAVs integrated.[288] As a result, game players would be permanently exposed to certain types of platforms which in turn could shape their perceptions.[289] It is worth speculating if this could – depending on the diffusion rate and the emulation of the respective video games – also have an impact on the public acceptance of UAVs – and in particular UCAVs – in the long run. On the other hand, the audience consuming warstreaming might be saturated quite quickly. If images play a major role in portraying a UAV-operating nation as innovative or fearless, the "hunger" for new, yet unseen video material could trigger an incentive to experiment with new and different styles of flying a UAV (e.g., via a First Person View as established in the UAV racing and freestyle flight scene)[290] or equipping them with payloads to deliver novel effects. This could stimulate a growing risk appetite which would then be reflected in new video material. While we contend that this thought is speculative right now, it is possible that this incentive mechanism could lead to new ways of operating UAVs, which might be of particular interest to non-state actors.[291]

287 Lakomy, "Let's Play a Video Game," p. 383.

288 This idea builds on the work of Dauber et. al., "Call of Duty: Jihad," p. 17, who note that "(Islamic State) has turned to video games, regularly mimicking and even directly copying the aesthetic and design of First Person Shooter games, most often Call of Duty, in their videos and other groups have followed suit."

289 Certain flight patterns, for example, might be considered as cool, and if the flight pattern is related to a particular type of UAV, this could contribute to cement and propagate a certain image, which in turn could further the acceptance of this specific platform in different communities.

290 For an example outside of a dedicated racing track and more applicable for warfare, see: https://www.youtube.com/watch?v=bBb_kSO3vTo (last accessed 4 May 2021).

291 See also Archambault/Veilleux-Lepage, "Drone imagery in Islamic State propaganda," p. 956, who argue that the use of UAVs by non-state actors "entails a symbolic contestation of state sovereignty, distinct from the immediate security dangers posed by the drones and the munitions they drop."

5.5 War as a Service Provides a Novel Way of Government-to-Government Military Support

Given the above analysis it is not surprising that the one novelty that stands out from the four conflicts occurs at the politico-strategic, rather than the operational or tactical level: it is the way in which the complex ecosystem of modern warfighting assets is being made available by outside actors to governments involved in the conflict.[292] We call this approach War as a Service (WaaS), which describes a specific form of temporary military power transfer as witnessed with Russia's support of Syria and Turkey's support of Azerbaijan and the GNA in Libya. WaaS combines all elements needed for military innovation as discussed in chapter 3 thus making it a potentially powerful driver for novel ways to deliver military power.

WaaS includes turn-key force packages consisting of assets/technology, organizational force elements as well as operators and commanders. Syria, for example, benefited from Russian deliveries of traditional air and land assets as well as embedded experts. As Eyal Berelovich argues "the introduction of Russian commanders and units into the war in September 2015 brought a significant change to the capabilities" of Assad's forces as "Russian domination of the planning and command of operations significantly improved tactical and administrative conduct."[293] Turkey's WaaS offering is equally comprehensive and consists of:

- Operational planning by Turkish commanders
- Turkish UAVs optimized for use with Turkish effectors such as missiles and electronic warfare payloads
- Operation of Turkish UAVs out two operations centers in Turkey[294]
- Close synchronization of UAV operations with force elements of the recipient as seen in Azerbaijan with the interplay between UAV and artillery[295]
- Third party pilots[296] and air defense operators trained by Turkey prior to the conflict
- Turkish troop elements and commanders/advisers present on the ground to assist allies
- Turkish engineers present on the ground and ready to improve the operational performance of Turkish assets

292 Pack/Pusztai, *Turning the Tide,* p. 16, draw a similar conclusion by observing: "Over the last months the KORAL EWS, TB2s, Anka-S, and mini-UAVs have left their imprint on Libya's future and shown new aspects of how airpower will likely be used in non-state and extraterritorial warfare in the mid-2020s."
293 Berelovich, "The Syrian Civil War," p. 5.
294 The centers are in Ankara and Hatay Province. See: Urcosta, "The Revolution in Drone Warfare," p. 57
295 ibid. UAV-artillery interplay has also been characteristic of Russia UAV use in Ukraine. See: Angevine et. al., Learning Lessons from the Ukraine Conflict, p. 9.
296 See for example the Bayraktar TB2 training of Azerbaijani soldiers in a video released by the Ministry of Defense of Azerbaijan in May 2021: https://twitter.com/Caucasuswar/status/1389560916061077510 (last accessed 4 May 2021). It is not clear, however, when and where the video was recorded.

WaaS should be seen as a politico-military business model that offers warfighting advantages with limited risk for suppliers and recipients and plausible deniability. Deniability, however, might wane the more the involvement of the supplier becomes evident. WaaS can be considered a specific type of surrogate warfare.[297] Most importantly, it is a government-to-government model, which sets this approach apart from traditional outsourcing of warfighting proficiency to either private military/security companies[298] or violent non-state actors. In some way, WaaS "renationalizes" a government's monopoly of power, albeit by insourcing the respective monopoly with recourse to the service offered by another government.

WaaS as seen in Syria and Azerbaijan depends on a high degree of mutually reinforcing motives and ambitions on both sides. The recipient (Syria/Azerbaijan) is ready to give the supplier (Russia/Turkey) a free hand by accepting the turn-key solution. The supplier is willing to offer the full package and to take the risk of getting involved with its own force packages on the ground. At the same time the supplier keeps the force package ecosystem under full control by using its own assets. In parallel the supplier feels at ease with "white labeling" its contribution, which means that the force package is ostensibly owned by the recipient but controlled by the supplier. This creates the benefit of limited plausible deniability.[299]

Deniability, however, might be counterbalanced by extensive warstreaming as discussed above. While warstreaming supports influence operations and thus shapes public perceptions in favor of the recipient, it can easily be overdone. Some of the operations captured on video by live-firing drones in Azerbaijan clearly indicate a high level of proficiency of the drone pilots (e.g., very short latency between fixing a target and releasing the missiles),[300] which might stand in stark contrast to previous battle performance by the recipient. This, in turn, could suggest that embedded force elements are at work. Given the experience with WaaS in Azerbaijan, observers will most likely be more alert to watch out for these and other patterns in the future. Thus, the first mover advantage of WaaS augmented by warstreaming might be limited.

That said, the success of WaaS very much depends on the conflict characteristics and thus also its dynamic. If there is only one WaaS supplier in the conflict because the opponent lacks access to similar support, the recipient and its supplier gain a free hand. In this case the conflict dynamic will be shaped by the ambitions of the recipient and its supplier. The conflict in Nagorno-Karabkah showed that the

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297 Surrogate warfare can be defined as a "patron's externalization of the strategic, operational, or tactical burden of warfare, partially or wholly, to a delegate or substitute." Following this definition, Azerbaijan would be the patron and Turkey the delegate. See: Krieg/Rickli, *Surrogate Warfare,* p. 4.

298 In fact, as Turkey's example in Azerbaijan shows, the Turkish government also made recourse to insurgents from Syria and Libya to beef up the warfighting capacity of its partner in Baku. See: Arbeiter, "Das Labor des Krieges," p. 11; "Forcing conflict."

299 If and to what extent deniability is needed depends on the level of ambition of the warring parties.

300 Background interview with air defense expert, 18 February 2021.

escalation was under control as Azerbaijani and Turkish ambitions were seemingly congruent. Whether WaaS is successful under other conditions remains to be seen. In a WaaS-on-WaaS conflict, things would most likely be back to square one as this would likely mirror the traditional peer-to-peer conflict dynamic. The risk appetite of the WaaS suppliers is likely to drive the outcome of such a conflict.

The support of Field Marshal Haftar by the UAE in Libya might offer a glimpse into the reasons, why WaaS did not produce the same outcome in this conflict. First, open-source information suggests that Emirati pilots did not operate UAE-made UAVs but rather flew Chinese-built Wing Loong UAV acquired by Field Marshal Haftar in 2016.[301] Several of these platforms were downed over Libya which either suggests that the air domain has been more contested or that Emirati pilots might be less experienced than their Turkish counterparts when operating UAV in a less than benign environment.[302] In addition, the kind of integrated engineering support that Turkey could provide because UAVs are locally built, seems to have been missing from the Emirati support for Field Marshal Haftar. Second, UAE forces on the ground were less present[303] than either Russian or Turkish force elements in Syria and Nagorno-Karabakh, respectively. Third, and this might have been a cardinal mistake by Field Marshal Haftar, he overplayed the idea of diversification. He relied not only on different WaaS suppliers, but also mixed state suppliers with non-state suppliers (e.g., Wagner Group) while seemingly missing a home-grown capability to properly integrate their contributions into seamless force packages. To make things even worse, Egypt and the UAE started to distance themselves from each other throughout the conflict leaving him with a patchwork of loosely coordinated elements to execute force rather than integrated force elements.[304] Although these aspects only provide weak evidence, they nonetheless suggest that the degree of control over assets deployed in combination with the risk preference of the WaaS supplier seem decisive in lending credibility to this politico-military business model.

Finally, we should also take into account that WaaS by Turkey in Azerbaijan has been limited to offensive air operations and against an opponent that was clearly inferior. This use case provides no evidence if WaaS would work for signaling and deterrence, although we speculate that the use of remotely piloted assets could play a key role in deterrence by detection.[305] In addition, we also lack experience with regard to the potential relevance of WaaS for post-conflict stabilization.[306]

301 Urcosta, "The Revolution of Drone Warfare," p. 56.
302 While we contend that this assertion is speculative, open-source information suggests that the UAV portfolio of Turkey is more homogenous than that of the UAE. Provided the UAE does not rely on contracted pilots, UAV pilots fly Seeker (Denel), Camcopter (Schiebel), Wing Loong (AVIC), and RQ-1 Predator (General Atomics) platforms. Turkey, by contrast, only flies Heron 1 UAV in addition to locally manufactured UAV. See: Gettinger, *The Drone Databook,* pp. 201, 207.
303 Some observers suggest that the UAE might also have been wary of the media effects of casualties. See: Kington, "Libya is turning into a battle lab for air warfare."
304 "Haftar's defeats by Ankara undermine his foreign support," p. 4.
305 Mahnken/Sharp/Kim, *Deterrence by Detection.*
306 For more on this, see: "Krieg/Rickli, "Author's response: a rejoinder," p. 14.

6 Conclusion

This paper has provided a comparative assessment of the role of UAV, EW, and air defense in the conflicts in Ukraine, Syria, Libya, and Nagorno-Karabakh. As argued in the introductory chapter on military innovation, technology alone is insufficient to change the way armed forces operate. Rather technology needs to be embedded in the broader cultural, conceptual, and organizational context. That's why, our conclusion focuses on three interrelated aspects: the need for proper force integration of new assets, the challenge of countering unmanned assets, and the risk of WaaS proliferation.

Thinking About Integration. If and to what extent armed forces can leapfrog over peers by using new assets such as unmanned systems very much depends on the way these assets will be integrated. Integration, in turn, can occur via stand-alone units that provide a plug-and-play option to augment existing force elements with additional capabilities. Alternatively, new assets can be embedded organically into existing force elements. Russia's key lesson from the four conflicts under review seems to be that UAVs and EW are to become integral and thus organic elements of the future force structure.

Deeply integrating UAV and EW into the force structure is likely to go hand in hand with changes in the command and control procedures and structure in order to provide for seamless interaction.[307] Deep integration is likely to prompt questions with regard to defining the "ownership" of new assets and delineating the areas of responsibilities among the services involved. These issues are about to become even more important when considering the fact that organizational integration and data-related integration can be separated from each other.

One of the major challenges stemming from the ubiquitous use of sensors across all domains is data management. Currently, there is a preference for cloud-based solutions at all levels, but the benefits of

307 From a Russian perspective the "biggest obstacle in Syria was the ability to rapidly close sensor-to-shooter loops and hit small, maneuvering targets in longer ranges." See: Adamsky, "Russian lessons from the Syrian Operation and the Culture of Military Innovation," p. 5. For more on the reform of Russia's command-and-control approach, see also: McDermott, The Revolution in Russian Military Decision-Making.

clouds might be deceiving given assumptions about the prevalence of heavy adversarial "electromagnetic fire" in future conflicts. In addition, edge-based technologies might enable stronger horizontal interaction in the future that could collide with vertical organizations currently dominating. Organizational adaptation and agility should thus receive much more attention as indicators of possible force transformations underway than the current focus on the latest technology.

Countering Unmanned Systems Requires Additional Perspectives. Success in countering the increasingly prevalent use of unmanned systems across different domains will very much depend on the integration question just discussed. This will be particularly relevant for counter-swarm solutions that might require different layers of detection at various ranges as well as a multitude of effectors to engage incoming unmanned systems. Right now, the focus is on developing all kinds of new counter unmanned solutions using kinetic and electromagnetic effects. Although there are obvious capability gaps also with Western armed forces, our discussion emphasizing the need to properly think about, conceptualize, and implement complex ecosystems suggests that additional perspectives are needed.

First, force protection and training should receive much more attention. Video streams from Armenian soldiers fleeing their vehicles and compounds had a devastating effect on morale. But how would soldiers from EU and NATO countries respond to simultaneous attacks with adversarial UAVs? Adequate behavior requires training. This could be an option for a joint European approach, for example by establishing a multi-domain training program using state-of-the-art simulation technology. This program should also reflect the fact that weaponized unmanned systems carrying explosives are one thing, but the use of CBRN threat agents would significantly up the ante for force protection.[308]

Second, future conflicts could give rise to more frequent encounters among unmanned systems. Given the use of UAV to provide be-

308 Reisner, "The Indisputable Power of Drones."

yond-line-of-sight sensing for artillery it is feasible to assume that a constellation of UAVs with loitering munition could be used to find and engage UAV launch and recovery locations. This prompts the need for concepts of operations that replace static locations with a more dynamic "shoot and scoot" approach.[309] In addition, targeting critical military infrastructure based in the homeland is part of some adversaries' military rulebook.[310] This should prompt more serious thinking with regard to the need to properly protect UAV command and control stations located far away from the battlefield.

Will WaaS Proliferate? So far force transformation against the background of new operational requirements or technological innovation has been challenging and time-consuming. WaaS might provide a short cut to leapfrogging by insourcing turn-key force packages from an allied nation willing to lend military power to partners.

Given the conceptual, organizational, and technological challenges that come with new force elements based on emerging technologies, WaaS must be considered a reasonable alternative force development path. As we have argued in chapter 5.5, the diffusion rate of WaaS will essentially depend on political ambition, risk appetite, and the broader geostrategic context of a conflict. For WaaS to be successful, the insourcing process cannot occur overnight but will require preparation. Much of the current discussion on proliferation is focusing on technology. This focus might become obsolete if WaaS provides the full package and the supplier has already mastered the relevant technology building blocks.[311] WaaS in turn requires more focus on tactics, techniques, and procures needed to fully absorb WaaS force elements in the recipient country's force structure. Training and military exercises should therefore receive more attention, in particular in view of identifying new behavioral patterns that might suggest the "hidden hand" of an outside actor willing to offer WaaS.

309 Angevine et. al., *Learning Lessons from the Ukraine Conflict,* p. 15.
310 Adamsky, *Moscow's Aerospace Theory of Victory,* p. 6.
311 Here the increasing use of commercial-off-the shelf could accelerate the process as the respective building blocks do not require the highest levels of defense industrial maturity.

Along similar lines observers should start to think if and to what extent WaaS could change the character of bilateral relations. The insourcing of military power by a WaaS user also comes with the supplier's readiness to support its client. In this regard, WaaS could vaccinate bilateral relations from outside interference. This effect could be particularly strong, if both partners' strategic interests align as this might prompt them to take more risks to fend off outside interference. In addition, the defense industrial maturity of the WaaS supplier will be essential as this is likely to reduce the risk of defense export bans that hamper security of supply and undermine WaaS. Furthermore, the defense industrial sophistication of the WaaS supplier also plays a key role in shaping the portfolio on offer. It is one thing, for example, to offer the capability that comes with a relatively limited reconnaissance-strike capability like a Turkish Bayraktar TB2 UAV. But the possibility to offer clients a fully integrated air defense ecosystem as Russia could potentially do is an order of magnitude different and reinforces the message conveyed in chapter 3 that the geostrategic context is essential to understand what drives military innovation by way of WaaS.

Ultimately, WaaS could also become a most interesting object of further research as many questions remain to be analyzed in more detail: Is WaaS a push or rather a pull market? Should we interpret the readiness of outside powers to back local insurgents and rebel groups and establish them as legitimate, quasi-state like actors as early warning signals for future WaaS clientele in the making? Which nations show a propensity to take recourse to WaaS and how will these nations' military establishment respond to the outside force elements that should be integrated? What is the impact of WaaS on civil-military relations in the recipient nation? Are joint offers of new weapon systems and accompanying training packages – as currently witnessed with regard to Turkey's support for Ukraine and Qatar – early warning indicators for new WaaS clients in the making? How sustainable is WaaS if both sides in a conflict have access to WaaS suppliers of equal strength? And is it more difficult or easier to regulate a state offering WaaS than a private actor supplying military power?

Literature

“#MinskMonitor: Russian Drones Directed Separatist Artillery Against Ukraine,” DFRLab, 30 July 2018, https://medium.com/dfrlab/minskmonitor-russian-drones-directed-separatist-artillery-ukraine-e8e4cc52b425 (last accessed 4 May 2021).

“A2/AD strategy delivers Turkish success,” Intelligence Online, 10 June 2020, p. 4.

“After US strikes Syrian air base, Russians ask: ‘Where were our vaunted air defense systems?’,” Radio Free Europe/Radio Liberty, 7 April 2017, https://www.rferl.org/a/weher-was-the-s-300-s-400-missile-defense-systems/28417014.html (last accessed 4 May 2021).

“Ankara finds solution to Wescam embargo,” Intelligence Online, 21 October 2020, p. 6.

“Armenian prime minister to step down in April,” Deutsche Welle, 28 March 2021, https://www.dw.com/en/armenian-prime-minister-to-step-down-in-april/a-57032226 (last accessed 4 May 2021).

“Azerbaijan destroys Armenia’s Tor-M2KM anti-aircraft missile system in direction of Khojavend district,” Trends, 9 November 2020, https://menafn.com/1101097871/Azerbaijan-destroys-Armenias-Tor-M2KM-anti-aircraft-missile-system-in-direction-of-Khojavend-district-VIDEO (last accessed 4 May 2021).

“Baykar CTO Bayraktar receives ‘ Karabakh Order’ from Aliyev,” Daily Sabah, 1 April 2021, https://www.dailysabah.com/business/defense/baykar-cto-bayraktar-receives-karabakh-order-from-aliyev (last accessed 4 May 2021).

“Canada suspends drone technology sales to Turkey after claims of use by Azeri forces,” Reuters, 5 October 2020, https://www.reuters.com/article/armenia-azerbaijan-canada/canada-suspends-drone-technology-sales-to-turkey-after-claims-of-use-by-azeri-forces-idUSL1N2GW19N?edition-redirect=uk (last accessed 4 May 2021).

“Eastern Promise: The Baykar Bayraktar TB2 in Profile,” Overt Defense, 8 January 2021, https://www.overtdefense.com/2021/01/08/eastern-promise-the-baykar-bayraktar-tb2-in-profile/ (last accessed 4 May 2021).

“Forcing conflict. Sources of Kommersant told how Turkey was preparing the ground for aggravation in Nagorno-Karabakh,” Kommersant, 16 October 2020, https://www.kommersant.ru/doc/4537733 (last accessed 4 May 2021).

“Future Warfighting in the 2030s: An Interview with Franz-Stefan Gady,” Strife Blog, 9 September 2020, https://www.strifeblog.org/2020/09/09/future-warfighting-in-the-2030s-an-interview-with-franz-stefan-gady/ (last accessed 4 May 2021).

“Haftar’s defeats by Ankara undermine his foreign support,” Intelligence Online, 10 June 2020, p. 4.

“How Turkey Won the Electronic Warfare Battle Against Syria in Idlib,” Defense World, 2 April 2020, https://www.defenseworld.net/news/26643/How_Turkey_Won_the_Electronic_Warfare_Battle_Against_Syria_in_Idlib (last accessed 4 May 2021).

“Libya: Are Turkey’s Syrian mercenaries a new threat?,” Deutsche Welle, 11 February 2020, https://www.dw.com/en/libya-are-turkeys-syrian-mercenaries-a-new-threat/a-52329943 (last accessed 4 May 2021).

“Libyan army dispatches military vehicles to Sirte,” Anadolu Agency, 19 July 2020, https://www.aa.com.tr/en/africa/libyan-army-dispatches-military-vehicles-to-sirte/1915145 (last accessed 4 May 2021).

“Nagorno-Karabakh conflict killed 5,000 soldiers,” BBC, 3 December 2020, https://www.bbc.com/news/world-europe-55174211 (last accessed 4 May 2021).

“Russia foils massive attack on its Syrian bases by electronically ‘controlling’ 6 drones, downing seven,” DEBKAfile, 8 January 2018, https://www.debka.com/russia-foils-massive-attack-syrian-bases-electronically-controlling-6-drones-downing-7-seven/ (last accessed 4 May 2021).

“Russian Pantsir Air Defense System: Sitting Duck or Top Dog?”, Defense World, 19 June 2020, https://www.defenseworld.net/feature/42/Russian_Pantsir_Air_Defense_System__Sitting_duck_or_Top_Dog_#.Xux1D2gzbIW (last accessed 4 May 2021).

"Samvel Babayan spoke about the reasons for the defeat in the second Artsakh war," Armenia Today, 13 December 2020, https://armeniatoday.news/artsakh/211628/ (last accessed 4 May 2021).

"Some 23 Russian Pantsir Air Defense Systems Destroyed in Syria, Libya: Reports", Defense World, 9 June 2020, https://www.defenseworld.net/news/27161/Some_23_Russian_Pantsir_Air_Defense_Systems_Destroyed_in_Syria__Libya__Reports (last accessed 4 May 2021).

"Syria says Russian missile defence system 'ineffective'," Middle East Monitor, 1 May 2020, https://www.middleeastmonitor.com/20200501-syria-says-russian-missile-defence-system-ineffective/ (last accessed 4 May 2021).

"Syria: How many Turkish UAVs shot down the Buk-M2E system," Reporter, 9 March 2020, https://en.topcor.ru/13515-stalo-izvestno-skolko-tureckih-bpla-sbili-sistemy-buk-m2je-v-sirii.html (last accessed 4 May 2021).

"The expert explains why Russia is 25 years behind in the field of attack drones," MK.RU, 5 December 2020, https://www.mk.ru/politics/2020/12/05/ekspert-obyasnil-pochemu-rossiya-otstala-v-oblasti-udarnykh-dronov-na-25-let.html (last accessed 4 May 2021).

"The Turkish Battalion – Brothers in arms," Kosovo Force (KFOR), 13 March 2007, https://www.nato.int/Kfor/chronicle/2002/chronicle_03/09.htm (last accessed 4 May 2021).

"Turkish Akinci Combat Drone's 2nd Prototype Completes Maiden Flight," DefenseWorld.net, 17 August 2020, https://www.defenseworld.net/news/27651/Turkish_Akinci_Combat_Drone___s_2nd_Prototype_Completes_Maiden_Flight#.YHR4WT9CTRY (last accessed 4 May 2021).

"Why has the Syrian war lasted 10 years?," BBC, 12 March 2021, https://www.bbc.com/news/world-middle-east-35806229.

Adamsky, Dima, "Russian lessons from the Syrian operation and the culture of military innovation," Security Insights 47 (February 2020), https://www.marshallcenter.org/en/publications/security-insights/russian-lessons-syrian-operation-and-culture-military-innovation (last accessed 4 May 2021).

Adamsky, Dima, Moscow's Aerospace Theory of Victory: Western Assumptions and Russian Reality (Arlington: CNA, 2021), https://www.cna.org/CNA_files/PDF/IOP-2021-U-029278-Final.pdf (last accessed 4 May 2021).

Adamsky, Dima, Moscow's Syria Campaign (Paris: Institut Français des Relations Internationales, 2018), https://www.ifri.org/sites/default/files/atoms/files/rnv_109_adamsky_moscow_syria_campaign_2018.pdf (last accessed 4 May 2021).

Adamsky, Dima, The Culture of Military Innovation. The Impact of Cultural Factors on the Revolution in Military Affairs in Russia, the US, and Israel (Stanford: Stanford University Press, 2010).

Ahronheim, Anna, "Is an Israeli air defense system shooting down Israeli drones in Libya?", The Jerusalem Post, 12 April 2020, https://www.jpost.com/middle-east/is-an-israeli-air-defense-system-shooting-down-israeli-drones-in-libya-624413 (last accessed 4 May 2021).

Al-Atrush, Samer, "Libya: How the US and Turkey agreed to share a captured Russian defence system," The Africa Report, 25 February 2021, https://www.theafricareport.com/68186/libya-how-the-us-and-turkey-agreed-to-share-a-captured-russian-defence-system/ (last accessed 4 May 2021).

Allik, Sten et. al., The Rise of Russia's Military Robots. Theory, Practice and Implications (Tallinn, ICDS, 2021), https://icds.ee/en/the-rise-of-russias-military-robots-theory-practice-and-implications/ (last accessed 4 May 2021).

Angevine, Robert G. et. al., Learning Lessons from the Ukraine Conflict (Alexandria: Institute for Defense Analysis, 2019), https://nsiteam.com/social/wp-content/uploads/2019/07/NS-D-10367-Learning-Lessons-from-Ukraine-Conflict-Final.pdf (last accessed 4 May 2021).

Arbeiter, Armin, „Das Labor des Krieges", Kurier, 13 December 2020, p. 11.

Archambault, Emil and Yannick Veilleux-Lepage, "Drone imagery in Islamic State propaganda: flying like a state," International Affairs, 96:4 (July 2020), pp. 955-973.

Bakeer, Ali, "The fight for Syria's skies: Turkey challenges Russia with new drone doctrine," Middle East Institute, 26 March 2020, https://www.mei.edu/publications/fight-syrias-skies-turkey-challenges-russia-new-drone-doctrine (last accessed 4 May 2021).

Barno, David and Nora Bensahel, Adaptation Under Fire. How Militaries Change in Wartime (Oxford: Oxford University Press, 2020).

Bartles, Charles and Lester Grau, "Integration of Unmanned Aerial Systems Within Russian Artillery," FIRES (July-August 2016), pp, 31-37, https://www.researchgate.net/publication/330009563_Integration_of_Unmanned_Aerial_Systems_Within_Russian_Artillery (last accessed 4 May 2021).

Baykar, Bayraktar TB2 Catalogue (Istanbul: Baykar, 2018), https://baykarsavunma.com/upload/ingilizce(Baykar_catalog_eng.pdf (last accessed 4 May 2021).

Bendett, Samuel, "Russian Unmanned Vehicle Developments: Syria and Beyond," in Mankoff, Jeffrey (ed.) Improvisation and Adaptability in the Russian Military (Washington, DC: CSIS, 2020), https://csis-website-prod.s3.amazonaws.com/s3fs-public/publication/200430_Mankoff_Russian%20Military_web_v3_UPDATED%20FINAL.pdf?w8E_tmNl65QbUPtiv6FomIF5U7yGzqBl (last accessed 4 May 2021).

Berelovich, Eyal, "The Syrian Civil War: Evolution of The Syrian Army's Way of War," Military Strategy Magazine (February 2021), https://www.militarystrategymagazine.com/exclusives/the-syrian-civil-war-evolution-of-the-syrian-armys-way-of-war/ (last accessed 4 May 2021).

Bermudez, Joseph S., "Moscow's Next Front: Russia's Expanding Military Footprint in Libya," CSIS Analysis, 17 June 2020, https://www.csis.org/analysis/moscows-next-front-russias-expanding-military-footprint-libya (last accessed 4 May 2021).

Bilgic, Taylan, "Turkish Drone Maker Baykar Makina Gets Government Support," Bloomberg, 5 September 2019, https://www.bloomberg.com/news/articles/2019-09-05/turkish-drone-maker-gets-government-support-to-boost-output (last accessed 4 May 2021).

Binnie, Jeremy, "LNA claims it has been attacked by Turkish-made UAVs," Jane's Defence Weekly, 22 May 2019, p. 17.

Binnie, Jeremy, "Turkey hints at new Libyan air defences," Jane's Defence Weekly, 10 February 2021, p. 17

Binnie, Jeremy, "Turkish UAV seen in Libya," Jane's Defence Weekly, 4 September 2019, p. 20

Binnie, Jeremy, "Mediterranean moves," Jane's Defence Weekly, 26 August 2020, p.20.

Borchert, Heiko, Tim Kraemer, and Daniel Mahon, "Waiting for Disruption?! Undersea Autonomy and the Challenging Nature of Naval Innovation," RSIS Working Paper (Singapore: S. Rajaratnam School of International Relations, 2017), https://dr.ntu.edu.sg/handle/10356/83745 (last accessed 4 May 2021).

Brantly, Aaron, F., Nerea M. Cal, and Devlin P. Winkelstein, Defending the Borderland. Ukrainian Military Experiences with Information Operations, Cyber, and Electronic Warfare (West Point/New York: US Army Cyber Institute at West Point, 2017), https://apps.dtic.mil/sti/pdfs/AD1046052.pdf (last accessed 4 May 2021).

Cheung, Tai Ming Thomas G. Mahnken, and Andre L. Ross, "Frameworks for Analyzing Chinese Defense and Military Innovation", in Tai Ming Cheung (ed.), Forging China's Military Might. A New Framework for Assessing Innovation (Baltimore: Johns Hopkins University Press, 2014),

Clark, Mason, The Russian Military's Lessons Learned in Syria (Washington, DC: Institute for the Study of War, 2021), http://www.understandingwar.org/report/russian-military%E2%80%99s-lessons-learned-syria (last accessed 4 May 2021).

Crino, Scott and Dreby, Andy, "Turkey's Drone War in Syria – A Red Team View," Small Wars Journal, 4 May 2020, https://smallwarsjournal.com/jrnl/art/turkeys-drone-war-syria-red-team-view (last accessed 4 May 2021).

Cumming-Bruce, Nick and Walsh, Declan, "Libya Cease-Fire Raises Hopes for Full Peace Deal," New York Times, 23 October 2020, https://www.nytimes.com/2020/10/23/world/middleeast/libya-ceasefire.html (last accessed 4 May 2021).

Daubenberger, Manuel und Florian Guckelsberger, „Auf der Spur der Drohnen", Zenith, 23 February 2021, https://magazin.zenith.me/de/gesellschaft/deutsche-bauteile-tuerkischen-drohnen-und-der-krieg-um-bergkarabach (last accessed 4 May 2021).

Dauber, Cori E. et. al., "Call of Duty: Jihad – How the Video Game Motif Has Migrated Downstream from Islamic State Propaganda Videos," Perspectives on Terrorism, 13:3 (June 2019), pp. 17-31.

Düz, Sibel, The Ascension of Turkey as a Drone Power. History, Strategy, and Geopolitical Implications (Istanbul: SETA, 2020), https://www.setav.org/en/analysis-the-ascension-of-turkey-as-a-drone-power-history-strategy-and-geopolitical-implications/ (last accessed 4 May 2021).

Eltagouri, Yousuf, "Haftar's Final Play: Operation Flood of Dignity and the Fight for Tripoli," Foreign Policy

Research Institute, 12 April 2019, https://www.fpri.org/article/2019/04/haftars-final-play-operation-flood-of-dignity-and-the-fight-for-tripoli/ (last accessed 4 May 2021).

Eriksson, Mikael and Elias Bohman, The Second Libyan Civil War – Security Developments during 2016-2017 (Stockholm: FOI, 2018), https://www.foi.se/rest-api/report/FOI-R--4571--SE (last accessed 4 May 2021).

Fahim, Kareem, "Turkey's military campaign beyond its borders is powered by homemade armed drones," The Washington Post, 29 November 2020, https://www.washingtonpost.com/world/middle_east/turkey-drones-libya-nagorno-karabakh/2020/11/29/d8c98b96-29de-11eb-9c21-3cc501d0981f_story.html (last accessed 4 May 2021).

Fasanotti, Federica Saini, "The Biden administration inherits a rapidly deteriorating Libya," Order from Chaos, 19 January 2021, https://www.brookings.edu/blog/order-from-chaos/2021/01/19/the-biden-administration-inherits-a-rapidly-deteriorating-libya/ (last accessed 4 May 2021).

Fiore, Nicolas J., "Defeating the Russian Battalion Tactical Group," ARMOR – The Professional Bulletin of the Armor Branch, CXXVIII:2 (Spring 2017), pp. 9-17, https://www.benning.army.mil/Armor/eARMOR/content/issues/2017/Spring/2Fiore17.pdf (last accessed 4 May 2021).

Fishman, Ben and Conor Hiney, "What Turned the Battle for Tripoli?," The Washington Institute for Near East Policy, 6 May 2020, https://www.washingtoninstitute.org/policy-analysis/what-turned-battle-tripoli (last accessed 4 May 2021).

Fogel, Benjamin and Andro Mathewson, "The next frontier in drone warfare? A Soviet-era crop duster", The Bulletin of the Atomic Scientists, 10 February 2021, https://thebulletin.org/2021/02/the-next-frontier-in-drone-warfare-a-soviet-era-crop-duster/.

Foy, Henry and Max Seddon, "Armenia calls for Russian help as fight with Azerbaijan intensifies," Financial Times, 1 November 2020, https://www.ft.com/content/9ca3163a-d267-4ac2-bfc3-77f86995dc75 (last accessed 4 May 2021).

Frantzman, Seth, "How did Turkish UAVs outmaneuver Russia's Pantsir air defense in Libya: Lessons and ramifications," Middle East Center for Reporting and Analysis, 28 May 2020, https://www.mideastcenter.org/post/how-did-turkish-uavs-outmaneuver-russia-s-pantsir-air-defense-in-libya-lessons-and-ramifications (last accessed 4 May 2021).

Frantzman, Seth, "Russian air defense systems outmatched by Turkish drones in Syria and Libya," Long War Journal, 20 June 2020, https://www.longwarjournal.org/archives/2020/06/russian-air-defense-systems-outmatched-by-turkish-drones-in-syria-and-libya.php (last accessed 4 May 2021).

Frolov, Andrey and Anastasia Tynyankina, "War of a New Era", Global Affairs (March-April 2021), https://globalaffairs.ru/articles/vojna-novoj-epohi/ (last accessed 4 May 2021).

Gady, Franz-Stefan, „Krieg um Berg-Karabach 2020: Implikationen für Streitkräftestruktur und Fähigkeiten der Bundeswehr", BAKS Arbeitspapier Sicherheitspolitik 3/2021, https://www.baks.bund.de/sites/baks010/files/arbeitspapier_sicherheitspolitik_2021_3.pdf (last accessed 4 May 2021).

Gady, Franz-Stefan, "Useful, but not decisive: UAVs in Libya's civil war," IISS Analysis, 22 November 2019, https://www.iiss.org/blogs/analysis/2019/11/mide-uavs-in-libyas-civil-war (last accessed 4 May 2021).

Gettinger, Dan, Drones Operating in Syrian and Iraq (Annandale-on-Hudson: Center for the Study of the Drone, Bard College, 2016), https://dronecenter.bard.edu/drones-operating-in-syria-and-iraq/ (last accessed 4 May 2021).

Gettinger, Dan, The Drone Databook (Annandale-on-Hudson: Center for the Study of the Drone, 2019), https://dronecenter.bard.edu/projects/drone-proliferation/drone-databook-update-march-2020/ (last accessed 4 May 2021).

Gilli, Andrea and Mauro Gilli, "Why China Has Not Caught Up Yet: Military-Technological Superiority and the Limits of Imitation, Reverse Engineering, and Cyber Espionage," International Security, 43:3 (Winter 2018/19), pp. 141-189.

Goldman, Emily O. and Leslie C. Eliason, "Introduction: Theoretical and Comparative Perspectives on Innovation and Diffusion," in Emily O. Goldman and Leslie C. Eliason (eds), The Diffusion of Military Technology and Ideas (Stanford: Stanford University Press, 2003), pp. 1-32.

Granstrand, Ove and Marcus Holgersson, "Innovation ecosystems: A conceptual review and a new definition," Technovation, 90-91 (February-March 2020), https://www.sciencedirect.com/science/article/pii/S0166497218303870.

Grau, Lester W. and Charles K. Bartles, The Russian Way of War – Force Structure, Tactics, and Modernization of the Russian Ground Forces (Fort Leavenworth: Foreign Military Studies Office, 2016), https://www.armyupress.army.mil/Portals/7/Hot%20Spots/Documents/Russia/2017-07-The-Russian-Way-of-War-Grau-Bartles.pdf (accessed 4 May 2021)

Grau, Lester, W. and Charles K. Bartles, The Russian Reconnaissance Fire Complex Comes of Age (Oxford: Oxford Changing Character of War Centre, 2018), http://www.ccw.ox.ac.uk/blog/2018/5/30/the-russian-reconnaissance-fire-complex-comes-of-age (last accessed 4 May 2021).

Gressel, Gustav, "Military lessons from Nagorno-Karabakh: Reason for Europe to worry," European Council on Foreign Relations, 24 November 2020, https://ecfr.eu/article/military-lessons-from-nagorno-karabakh-reason-for-europe-to-worry/ (last accessed 4 May 2021).

Gubaev, Alexander, "Viewpoint: Russia and Turkey - unlikely victors of Karabakh conflict," BBC, 12. November 2020, https://www.bbc.com/news/world-europe-54903869 (last accessed 4 May 2021).

Gurcan, Metin, "Battle for air supremacy heats up in Libya despite Covid-19 outbreak," Al-Monitor, 6 April 2020, https://www.al-monitor.com/pulse/originals/2020/04/turkey-libya-air-supremacy-heats-up-despite-amid-coronavirus.html (last accessed 4 May 2021).

Hinz, Fabian, "Meet the Quds 1," Arms Control Wonk, 15 September 2019, https://www.armscontrolwonk.com/archive/1208062/meet-the-quds-1/ (last accessed 4 May 2021).

Hoffman, Frank G., Mars Adapting. Military Change During War (Annapolis: Naval Institute Press, 2021).

Horowitz, Michael C. and Shira Pindyck, "What Is a Military Innovation and Why It Matters," draft manuscript, 13 October 2020, https://dx.doi.org/10.2139/ssrn.3504246 (last accessed 4 May 2021).

Horowitz, Michael C., The Diffusion of Military Power: Causes and Consequences for International Politics (Stanford: Stanford University Press, 2010).

Hudson, John, "International Monitor Quietly Drops Drone Surveillance of Ukraine War," Foreign Policy, 28 October 2016, https://foreignpolicy.com/2016/10/28/international-monitor-quietly-drops-drone-surveillance-of-ukraine-war/ (last accessed 4 May 2021).

Isaacson, Jeffrey A., Christopher Layne, and John Arquilla, Predicting Military Innovation (Santa Monica: RAND, 2007).

Johnson, Reuben F., "Tomahawk strike in Syria stokes debate about Russian air defences," Jane's Defence Weekly, 19 April 2017, p. 4

Kasapoglu, Can and Sinan Ülgen, Operation Olive Branch: A Political Military Assessment (Istanbul: Centre for Economics and Foreign Policy Studies, February 2018), https://edam.org.tr/wp-content/uploads/2018/01/Operation-Olive-Branch-01.pdf (last accessed 4 May 2021).

Kasapoglu, Can, "Military scorecard of Operation Olive Branch," Anadolu Agency, 26 March 2018, https://www.aa.com.tr/en/analysis-news/military-scorecard-of-operation-olive-branch/1099535 (last accessed 4 May 2021).

Kasapoglu, Can, "Turkey Transfers Drone Warfare Capacity to Its Ally Azerbaijan," Eurasia Daily Monitor, 15 October 2020, https://jamestown.org/program/turkey-transfers-drone-warfare-capacity-to-its-ally-azerbaijan/ (last accessed 4 May 2021).

Kasapoglu, Can, "Turkey's Drone Blitz Over Idlib," Terrorism Monitor, 17 April 2020, https://jamestown.org/program/turkeys-drone-blitz-over-idlib/ (last accessed 4 May 2021).

Kasapoglu, Can, Hard Fighting in the Caucasus: The Azerbaijani Armed Forces' Combat Performance and Military Strategy in the 2020 Nagorno-Karabakh War (Ankara: Republic of Turkey Ministry of Foreign Affairs Center for Strategic Research, 2021), http://sam.gov.tr/sam-papers-18.tr.mfa (accessed 4 May 2021).

Keddie, Patrick, "What's Turkey's role in the Nagorno-Karabakh conflict?," AlJazeera, 30 October 2020, https://www.aljazeera.com/features/2020/10/30/whats-turkeys-role-in-the-nagorno-karabakh-conflict (last accessed 4 May 2021).

Kidwell, Deborah C. "The US Experience: Operational," in Karl. P. Mueller (ed.), Precision and Purpose: Airpower and the Libyan Civil War (Santa Monica: RAND, 2015), pp. 107-151.

Kington, Tom, "Libya is turning into a battle lab for air warfare," Defense News, 6 August 2020, https://www.defensenews.com/smr/nato-air-power/2020/08/06/libya-is-turning-into-a-battle-lab-for-air-warfare/ (last accessed 4 May 2021).

Kington, Tom, "The drone defense dilemma: How unmanned aircraft are redrawing battle lines," Defense News, 15 February 2021, https://www.defensenews.com/global/europe/2021/02/15/the-drone-defense-dilemma-how-unmanned-aircraft-are-redrawing-battle-lines/ (last accessed 4 May 2021).

Kjellen, Jonas, Russian Electronic Warfare. The role of Electronic Warfare in the Russian Armed Forces (Stockholm: FOI, 2018), https://www.foi.se/rapportsammanfattning?reportNo=FOI-R--4625--SE (last accessed 4 May 2021).

Kofman, "Russian Performance in the Russo-Georgian War Revisited," War on the Rocks, 4 September 2018, https://warontherocks.com/2018/09/russian-performance-in-the-russo-georgian-war-revisited/ (last accessed 4 May 2021).

Kofman, Michael et. al., Lessons from Russia's Operations in Crimea and Eastern Ukraine (Santa Monica: RAND, 2017), https://www.rand.org/pubs/research_reports/RR1498.html (last accessed 4 May 2021)

Kofman, Michael, "A Look at the Military Lessons of the Nagorno-Karabakh conflict," Russia Matters, 14 December 2020, https://www.russiamatters.org/analysis/look-military-lessons-nagorno-karabakh-conflict (last accessed 4 May 2021).

Kofmann, Michael and Leonid Nersisyan, "The Second Nagorno-Karabakh War, Two Weeks In," War on The Rocks, 14 October 2020, https://warontherocks.com/2020/10/the-second-nagorno-karabakh-war-two-weeks-in/ (last accessed 4 May 2021).

Kostyuk, Nadiya and Yuri M. Zhukov, "Invisible digital front: can cyber attacks shape battlefield events?," manuscript, 12 July 2017, https://scholar.harvard.edu/zhukov/publications/invisible-digital-front-can-cyber-attacks-shape-battlefield-events (last accessed 4 May 2021).

Kramer, Andrew and Michael R. Gordon, "U.S. Faults Russia as Combat Spikes in East Ukraine," The New York Times, 13 February 2015, https://www.nytimes.com/2015/02/14/world/europe/ukraine-fighting-escalates-ahead-of-truce.html (last accessed 4 May 2021).

Krieg, Andreas and Jean-Marc Rickli, Surrogate Warfare. The Transformation of War in the Twenty-First Century (Washington, DC: Georgetown University Press, 2019).

Krieg, Andreas and Jean-Marc Rickli, "Author's response: a rejoinder," in Vladimir Rauta, "A Symposium: debating 'surrogate warfare' and the transformation of war," Defence Studies, 19:4 (October 2019), pp. 13-17,

Kuo, Kendrick, "Military Innovation and Technological Determinism: British and US Ways of Carrier Warfare, 1919-1945," Journal of Global Security Studies, 6:3 (September 2021), https://doi.org/10.1093/jogss/ogaa046. (last accessed 4 May 2021).

Kurc, Caglar, "Between defence autarky and dependency: the dynamics of Turkish defence industrialization," Defence Studies, 17:3 (July 2017), pp. 260-281, https://doi.org/10.1080/14702436.2017.1350107 (last accessed 4 May 2021).

Lacher, Wolfram, "Drones, Deniability, and Disinformation: Warfare in Libya and the New International Disorder," War on the Rocks, 3 March 2020, https://warontherocks.com/2020/03/drones-deniability-and-disinformation-warfare-in-libya-and-the-new-international-disorder/ (last accessed 4 May 2021).

Lakomy, Miron, "Let's Play a Video Game: Jihadi Propaganda in the World of Electronic Entertainment," Studies in Conflict and Terrorism, 42:4 (April 2019), pp. 383-406, https://www.tandfonline.com/doi/full/10.1080/1057610X.2017.1385903 (last accessed 4 May 2021).

Lasconjarias, Guillaume and Hassan Maged, Fear the Drones. Remotely Piloted Systems and Non-State Actors in Syria and Iraq (Paris: IRSEM, 2019), https://www.irsem.fr/institut/actualites/research-paper-no-77-4-september-2019.html (last accessed 4 May 2021).

Lavallée, Guillaume, "Experts believe Israel unlikely to drop lucrative arms sales to Azerbaijan," The Times of Israel, 5 October 2020, https://www.timesofisrael.com/experts-believe-israel-unlikely-to-drop-lucrative-arms-sales-to-azerbaijan/ (last accessed 4 May 2021).

Liou, Yu-Ming, Paul Musgrave, and J. Furman Daniel, "The Imitation Game: Why Don't Rising Powers Innovate Their Militaries More?," The Washington Quarterly, 38:3 (Fall 2015), pp. 157-174, https://doi.org/10.1080/0163660X.2015.1099030 (last accessed 4 May 2021).

Loukianova, Anya, "Moscow's emerging electronic warfare capabilities: a dangerous jammer on US/NATO-Russian relations?", unpublished manuscript, https://bit.ly/2ZgCBQ3 (last accessed 4 May 2021).

Mahnken, Thomas G., Travis Sharp, and Grace B. Kim, Deterrence by Detection: A Key role for Unmanned Aircraft Systems in Great Power Conflicts (Washington, DC: CSBA, 2020), https://csbaonline.org/research/

publications/deterrence-by-detection-a-key-role-for-unmanned-aircraft-systems-in-great-power-competition (last accessed 4 May 2021).

Malyasov, Cylan, "Ukraine confirms procurement of Turkish unmanned combat aerial vehicles," Defence Blog, 6 November 2018, https://defence-blog.com/news/ukraine-confirms-procurement-of-turkish-unmanned-combat-aerial-vehicles.html (last accessed 4 May 2021).

Mansoor, Peter R. and Williamson Murray, "Introduction," in Peter R. Mansoor and Williamson Murray (eds.) The Culture of Military Organizations (Cambridge: Cambridge University Press, 2020), pp. 1-14.

Mayne, Richard O., "The Canadian Experience: Operation Mobile," in Mueller, Karl P., Precision and Purpose – Airpower in the Libyan Civil War (Santa Monica: RAND, 2015), pp. 239-266, https://www.rand.org/content/dam/rand/pubs/research_reports/RR600/RR676/RAND_RR676.pdf (last accessed 4 May 2021).

McCrory, Duncan, "Russian electronic warfare, cyber and information operations in Ukraine", The RUSI Journal, 24 February 2021, https://www.rusi.org/publication/rusi-journal/russian-electronic-warfare-cyber-and-information-operations-ukraine (last accessed 4 May 2021).

McDermott, Roger, "Russia's Electronic Warfare Capabilities as a Threat to GPS," Eurasia Daily Monitor, 10 March 2020, https://jamestown.org/program/russias-electronic-warfare-capabilities-as-a-threat-to-gps/ (last accessed 4 May 2021).

McDermott, Roger, Russia's Electronic Warfare Capabilities to 2025. Challenging NATO in the Electromagnetic Spectrum (Tallinn: International Centre for Defence and Security, 2017), https://icds.ee/en/russias-electronic-warfare-capabilities-to-2025-challenging-nato-in-the-electromagnetic-spectrum/ (last accessed 4 May 2021).

McDermott, Roger, The Revolution in Russian Military Decision-Making (Washington, DC: Jamestown Foundation, 2021), https://jamestown.org/program/the-revolution-in-russian-military-decision-making/ (last accessed 4 May 2021).

McKernan, "Syrian rebel fighters prepare to deploy to Azerbaijan in sign of Turkey's ambition," The Guardian, 28 September 2020, https://www.theguardian.com/world/2020/sep/28/syrian-rebel-fighters-prepare-to-deploy-to-azerbaijan-in-sign-of-turkeys-ambition (last accessed 4 May 2021).

Melman, Yossi, "Why Syria Isn't Firing Its S-300 Missiles at Israeli Jets," Haaretz, 15 May 2020, https://www.haaretz.com/middle-east-news/syria/.premium-syria-s-300-missiles-israel-jets-iran-soleimani-hezbollah-1.8841093 (last accessed 4 May 2021).

Mikhnenko, Anton, "Unmanned Aerial Vehicles vs Air Defenses", Ukrainian Defense Review (April-September 2020), pp. 48-49.

Mocanu, Mircea, "Lessons after the electronic war in Ukraine," Defence and Security Monitor, 10 December 2019, https://en.monitorulapararii.ro/lessons-after-the-electronic-war-in-ukraine-1-25476 (last accessed 4 May 2021).

Müller, Björn, „Krieg führen per Crowdfunding," Frankfurter Allgemeine Zeitung, 11 March 2017, https://www.faz.net/aktuell/politik/ausland/wie-die-ukraine-sich-zum-drohnen-produzenten-macht-14911794.html (last accessed 4 May 2021).

Murray, Williamson, Military Adaptation in War. With Fear of Change (Cambridge: Cambridge University Press, 2011).

Murry, Williamson and MacGregor Knox, "Thinking about revolutions in warfare," in MacGregor Knows and Williamson Murray (eds.), The dynamics of military revolution 1300-2050 (Cambridge: Cambridge University Press, 2001), pp. 1-14.

Nicholson, Dylan, "'Revolutionary' warfare or good marketing: Turkey's Syria drone strikes," DefenceConnect, 9 March 2020, https://www.defenceconnect.com.au/strike-air-combat/5709-revolutionary-warfare-or-good-marketing-turkey-s-syria-drone-strikes (last accessed 4 May 2021).

O'Connor, Sean, "Access denial. Syria's air-defence network", Jane's Defence Weekly, 9 April 2014, pp. 22-28.

Pack, Jason and Wolfgang Pusztai, Turning the Tide – How Turkey Won the War for Tripoli (Washington, DC: Middle East Institute, 2020), https://www.mei.edu/sites/default/files/2020-11/Turning%20the%20Tide%20-%20How%20Turkey%20Won%20the%20War%20for%20Tripoli.pdf (last accessed 4 May 2021).

Pomerleau, Mark, "Why Syria may be the most aggressive electronic warfare environment on Earth," C4ISRnet, 24 April 2018, https://www.c4isrnet.com/electronic-warfare/2018/04/24/socom-chief-syria-most-aggressive-ew-environment-on-earth/ (last accessed 4 May 2021).

Popescu, Nico, “A captive ally: Why Russia isn’t rushing to Armenia’s aid,” European Council on Foreign Relations, 8 October 2020, https://ecfr.eu/article/a_captive_ally_why_russia_isnt_rushing_to_armenias_aid/ (last accessed 4 May 2021).

Posen, Barry R, The Sources of Military Doctrine (Ithaca: Cornell University Press, 1984).

Raska, Michael, “The sixth RMA wave: Disruption in Military Affairs?”, Journal of Strategic Studies, published online 25 November 2020, https://doi.org/10.1080/01402390.2020.1848818 (last accessed 4 May 2021).

Raska, Michael, Military Innovation in Small States. Creating a Reverse Asymmetry (London/New York: Routledge, 2016).

Reim, Garrett, “US Army to exploit crucial weaknesses in Russian, Chinese air defences,” Flight Global, 25 September 2020, https://www.flightglobal.com/helicopters/us-army-to-exploit-crucial-weakness-in-russian-chinese-air-defences/140311.article (last accessed 4 May 2021).

Reisner, Markus, “The Indisputable Power of Drones: What Current Conflicts Will Tell Us About the Future,” The Defence Horizon Journal, 4 March 2021, https://www.thedefencehorizon.org/post/the-indisputable-power-of-drones-what-current-conflicts-will-tell-us-about-the-future (last accessed 4 May 2021).

Rempfer, Kyle, “Did US drones swarm a Russian base? Probably not, but that capability isn’t far off,” Military Times, 29 October 2018, https://www.militarytimes.com/news/2018/10/29/did-us-drones-swarm-a-russian-base-probably-not-but-that-capability-isnt-far-off/ (last accessed 4 May 2021).

Ringler, Noah, “Turkey’s New Joint Operational Concepts Foreshadow the Future of Armed Conflict,” Georgetown Security Studies Review, 16 March 2021, https://georgetownsecuritystudiesreview.org/2021/03/16/turkeys-new-joint-operational-concepts-foreshadow-the-future-of-armed-conflict/ (last accessed 4 May 2021).

Ripley, Tim and Sam Cranny-Evans, “Unmanned edge. The Nagorno-Karabakh conflict”, Jane’s Defence Weekly, 20 January 2021, pp. 18-23

Ross, Andrew L., “On Military Innovation: Toward an Analytical Framework.” CITC Policy Brief No. 1 (San Diego: California Institute on Conflict and Cooperation, 2010), http://escholarship.org/uc/item/3d0795p8 (last accessed 4 May 2021).

Shaikh, Shaan and Wes Rumbaugh, “The Air and Missile War in Nagorno-Karabakh: Lessons for the Future of Strike and Defense,” CSIS Analysis, 8 December 2020, https://www.csis.org/analysis/air-and-missile-war-nagorno-karabakh-lessons-future-strike-and-defense (last accessed 4 May 2021).

Singer, P.W., Wired for War. The Robotics Revolution and Conflict in the 21st Century (New York: The Penguin Press, 2009).

Smith, Patrick, Russian Electronic Warfare. A Growing Threat to US Battlefield Supremacy (Washington, DC: American Security Project, 2020), https://www.americansecurityproject.org/perspective-russian-electronic-warfare/ (last accessed 4 May 2021).

Speckhard, Anne and Molly Ellenberg, “Deterrence for Online Radicalization and Recruitment in the 21st Century,” manuscript, 2 March 2021, https://www.icsve.org/deterrence-for-online-radicalization-recruitment-in-the-21st-century/ (last accessed 4 May 2021).

Steinberg, Guido, Das Ende des IS (Berlin: SWP, 2018), https://www.swp-berlin.org/fileadmin/contents/products/studien/2018S20_sbg.pdf (last accessed 4 May 2021).

Stewart, Phil, “Exclusive: U.S.-supplied drones disappoint Ukraine at the front lines,” Reuters, 16 December 2016, http://mobile.reuters.com/article/idUSKBN14A26D (last accessed 4 May 2021).

Stillion, John and Bryan Clark, What it Takes to Win. Succeeding in 21st Century Battle Network Competitions (Washington, DC: CSBA, 2015), https://csbaonline.org/research/publications/what-it-takes-to-win-succeeding-in-21st-century-battle-network-competitions (last accessed 4 May 2021).

Stronell, Alexander, “Learning the lessons of Nagorno-Karabakh the Russian way,” IISS Analysis, 10 March 2021, https://www.iiss.org/blogs/analysis/2021/03/lessons-of-nagorno-karabakh (last accessed 4 May 2021).

Sukhankin, Sergey, “The Second Karabakh War: Lessons and Implications for Russia (Part One),” Eurasia Daily Monitor, 5 January 2021, https://jamestown.org/program/the-second-karabakh-war-lessons-and-implications-for-russia-part-one/ (last accessed 4 May 2021).

Trevithick, Joseph, “Ukrainian Officer Details Russian Electronic Warfare Tactics Including Radio ‘Virus’,” The War Zone, 20 November 2019, https://www.thedrive.com/the-war-zone/30741/ukrainian-officer-details-russian-electronic-warfare-tactics-including-radio-virus (last accessed 4 May 2021).

Trevithick, Joseph, "Turkey's Forward deployed F-16s have moved to a new base," The Drive, 26 October, 2020, https://www.thedrive.com/the-war-zone/37278/turkeys-forward-deployed-f-16s-in-azerbaijan-have-moved-to-a-different-airport (last accessed 4 May 2021).

Trimble, Steve, "Reaper at 20," Aviation Week and Space Technology, 8-21 February 2021, pp. 32-34.

Tsurkov, Elizabeth, "Hayat Tahrir Al-Sham (Syria)," European Council on Foreign Relations, https://ecfr.eu/special/mena-armed-groups/hayat-tahrir-al-sham-syria/ (last accessed 4 May 2021).

Türk, Afsar, An Investigation for Maturity Level and Roadmap of Unmanned Aerial Vehicle in Turkey (Ankara: Middle East Technical University, 2020), https://cutt.ly/zbmmNfy.

Urcosta, Ridvan Bari, "The Revolution in Drone Warfare. The Lessons from the Idlib De-Escalation Zone", The Journal of European, Middle Eastern, and African Affairs, 2:3 (Fall 2020), pp. 50-65.

Vest, Nathan and Colin P. Clarke, "Is the Conflict in Libya a Preview of the Future of Warfare?," Defense One, 2 June 2020, https://www.defenseone.com/ideas/2020/06/conflict-libya-preview-future-warfare/165807/ (last accessed 4 May 2021).

Watling, Jack, "The key to Armenia's tank losses: the sensors, not the shooters," RUSI, 6 October 2020, https://rusi.org/publication/rusi-defence-systems/key-armenia-tank-losses-sensors-not-shooters (last accessed 4 May 2021).

Wintour, Patrick, "UN-backed Libyan forces oust renegade general from Tripoli," The Guardian, 5 June 2020, https://www.theguardian.com/world/2020/jun/04/un-backed-libyan-forces-oust-renegade-general-from-tripoli (last accessed 4 May 2021).

Yesiltas, Murat, Merve Seren, and Necdet Özcelik, Operation Euphrates Shield – Implementation and Lessons Learned (Istanbul: Foundation for Political, Economic and Social Research/SETA, 2017), https://setav.org/en/assets/uploads/2017/11/R97_Euphrates.pdf (last accessed 4 May 2021).

Zisk, Katarzyna, "Defence innovation and the 4th industrial revolution in Russia," Journal of Strategic Studies, published online 8 December 2020, https://doi.org/10.1080/01402390.2020.1856090 (last accessed 4 May 2021).

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