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MASTER OF MILITARY STUDIES

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The Strategic Imperative for the US Army  
to Develop a Comprehensive Counter-UAS Strategy

SUBMITTED IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE DEGREE  
OF MASTER OF MILITARY STUDIES

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US ARMY

AY 2017-18

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### *Executive Summary*

The 2018 National Defense Strategy reminds military leaders that America has no preordained right to victory on future battlefields. Observable lessons from recent conflicts suggest that military leaders, at least in some services, are failing to suitably prioritize a critical threat to future operations – unmanned aerial systems (UAS). Recent conflicts involving state and non-state actors, and the acquisition priorities of US rivals provide evidence that future battlefields will contain the widespread use of UAS. The re-emergence of long-term geopolitical competition with rivals employing a variety of drones, rapid diffusion of drone technologies throughout every operational region, and adversary warfighting concepts that integrate drones into effective offensive operations result in a strategic imperative for the US Army to develop and implement a counter-UAS strategy. This strategy must provide a framework for improving the acquisition process to better leverage emerging technologies and develop a comprehensive soldier training program that integrates these technologies to regain the initiative through improved warfighting.

## INTRODUCTION

The 2018 National Security Strategy asserts a new era of geopolitical competition between the United States (US) and regional powers like Russia and China. The strategy also reaffirms the threat posed by transnational terrorist and criminal groups.<sup>1</sup> These challenges occur within a complex security environment characterized by rapid technological change, rival military activities in every operational domain, and the negative effects of sustained combat operations on US military readiness. Accordingly, the 2018 National Defense Strategy reminds military leaders that America has no preordained right to victory on future battlefields. To ensure success, leaders must “make difficult choices and prioritize what is most important to field a lethal, resilient, and rapidly adapting Joint Force.”<sup>2</sup> However, observable lessons from recent conflicts suggest that military leaders, at least in some services, are failing to suitably prioritize a critical threat to future operations – unmanned aerial systems (UAS).

Recent conflicts involving state and non-state actors, and the acquisition priorities of US rivals provide evidence that future battlefields will contain the widespread use of UAS (i.e., drones in colloquial vernacular). For example, Russia and Russian-backed separatists effectively used at least fourteen different types of drones during their ongoing conflict with Ukraine.<sup>3</sup> In Syria, an Army Special Operations Command representative recently claimed that US forces do not retain operational control of the airspace under 3,500 feet in which the Islamic State in Iraq and Syria (ISIS) conducts lethal and non-lethal drone operations.<sup>4</sup> Looking towards the future, the International Institute for Strategic Studies notes that China is allocating more than \$10 billion on land and sea based advanced drone technology as part of its recent \$150 billion defense buildup.<sup>5</sup> For the first time in over six decades, US ground forces are under aerial attack

and may not be properly protected by American air supremacy as the result of an inability to counter adversaries using drones to disrupt operations and attack military facilities.<sup>6</sup>

The US Army remains vulnerable to the long-term operational risks resulting from the proliferation and use of drones by state and non-state adversaries. The Army must be prepared to “compete, deter, and win against any adversary,”<sup>7</sup> so it must not allow its forces to confront a known risk without effective countermeasures. The re-emergence of long-term geopolitical competition with rivals employing a variety of drones, rapid diffusion of drone technologies throughout every operational region, and adversary warfighting concepts that integrate drones into effective offensive operations result in a strategic imperative for the US Army to develop and implement a counter-UAS strategy. This strategy must provide a framework for improving the acquisition process to better leverage emerging technologies and develop a comprehensive training program that integrates these technologies to regain the initiative through improved warfighting. The remainder of this paper explains the nature of the UAS threat, describes the scope of the threat across a range of state and non-state actors, and then explains the type of counter-UAS strategy necessary to protect the US Army from the new technological threat of battlefield drones.

## **NATURE OF THE UAS THREAT**

Variation between UAS types creates different threats to US military forces. The US Department of Defense (DoD) classifies drones according to a system’s size, speed, and operational range. Based on these characteristics, the DoD categorizes drones in one of five groups: Group 1 – micro tactical, Group 2 – small tactical, Group 3 – tactical, Group 4 – persistent, and Group 5 – Penetrating (figure 1).

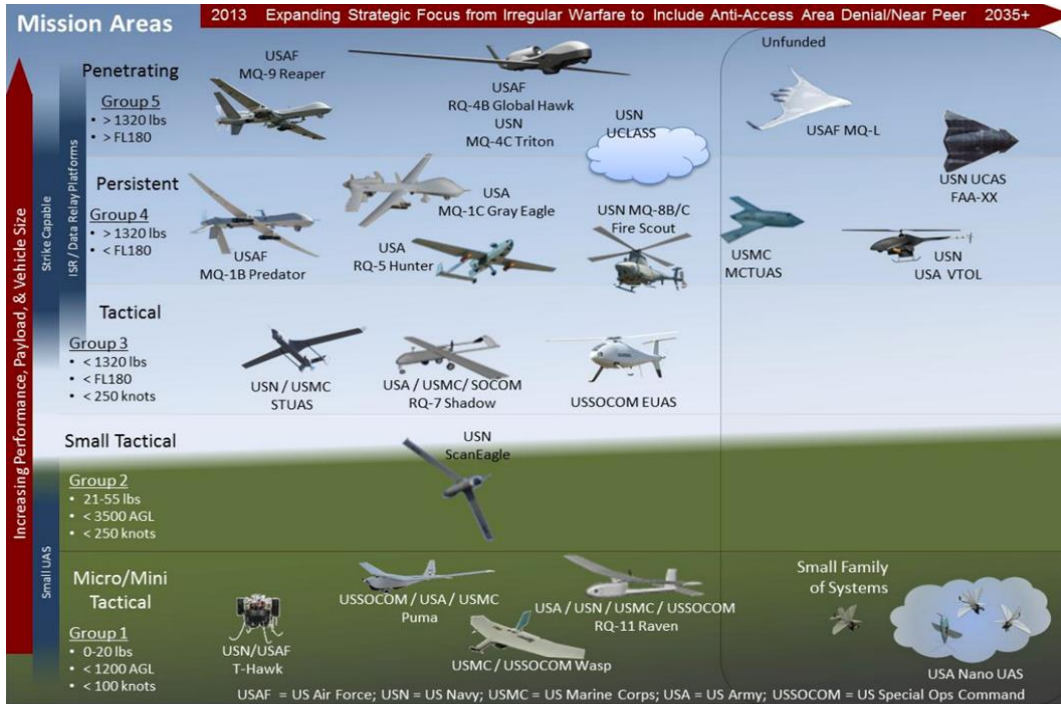


Figure 1. US Department of Defense UAS Group Chart.<sup>8</sup>

Tactical drones (i.e., groups 1-3) are smaller models that have slower speeds and shorter ranges, and remain harder to detect, identify, and defeat than larger tactical and persistent systems.<sup>9</sup> These characteristics make tactical drones well-suited for localized intelligence, reconnaissance, and surveillance (ISR) missions. The miniaturization of components has also improved tactical drones' lethal attack capabilities. Drones in groups 1-3 are commercially available which, when combined with their small size and low cost, has led to their widespread proliferation. As a result, tactical drones are those most likely to be used by non-state actors, though state actors also extensively use them.<sup>10</sup>

Operational drones (i.e., groups 4-5) are much larger, have longer range, and are more expensive than tactical drones. These drones have characteristics like manned aircraft and

present similar threats; however, they also require similar logistical and operational support. Because of these factors, operational drones are less prevalent and most often used by state actors.<sup>11</sup> The long loiter times of drones in groups 4-5 provide capabilities for persistent ISR of a target or target area. Many of these systems also have air-to-ground attack capabilities that deliver larger weapon payloads than armed tactical drones. Some states are also working to develop UAS air-to-air offensive capabilities. The similarities between operational drones and manned aircraft make the former are more vulnerable to interdiction by traditional air defense systems like the Patriot theater air defense system or the FIM-92 Man-Portable Air-Defense System (i.e., Stinger missile).<sup>12</sup>

The US Army now finds itself in a paradoxical situation given the technological advancement and proliferation of drones over the last decade, especially those in groups 1-3. Its future threat estimates focused on near-peer conflicts and called for focused development of theater-level missile defense systems such as the Terminal High Altitude Area Defense system (THAAD) or advancements to the MIM-104 Patriot.<sup>13</sup> These threat estimates were partially correct given the emerging strategic context; however, they neglected to account for the proliferation of commercially available tactical drones whose characteristics make them the most likely and pervasive UAS threat. A comprehensive counter-UAS strategy must address the different nature of threats presented by the various types of UAS. It must also provide solutions for confronting the full scope of UAS challenges by potential state and non-state adversaries.

## **SCOPE OF THE UAS THREAT**

Drones were once an advanced technology used exclusively, though relatively infrequently, by the world's leading militaries. This changed during the past decade. For

example, between 1995 and 2011 the United States' MQ-1 Predator drone program logged 1,000,000 flight hours. After 2011, this amount doubled in less than three years as the value of these systems became apparent during wars in Iraq and Afghanistan, and as part of America's global counter-terrorism initiatives.<sup>14</sup> During this same period, the evolution of electronics and software technologies and the changing character of warfare converged to influence the rapid and widespread proliferation of civilian and military drones. Today there are more than 600 types of armed and unarmed drones used in over eighty countries (figure 2).<sup>15</sup>

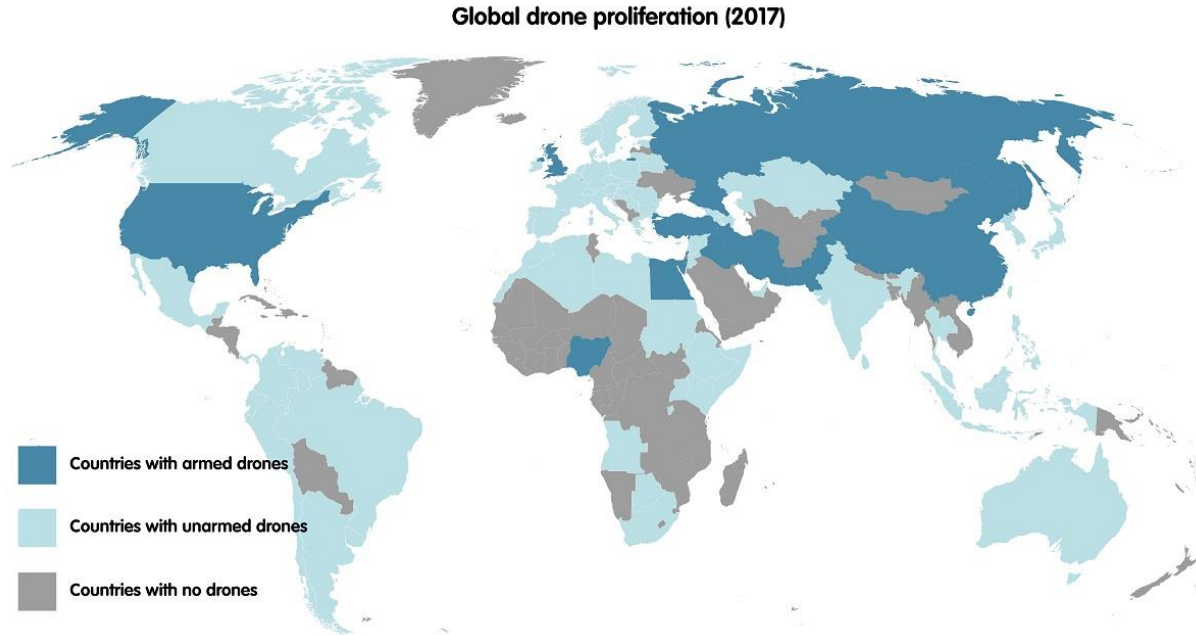


Figure 2. Global drone proliferation as of 2017.<sup>16</sup>

The level of tactical and operational risk to US ground forces has increased dramatically as over a dozen countries, including Russia, China, Iran, and North Korea, are known to possess armed drone capabilities.<sup>17</sup> The list of hostile non-state actors with drone capabilities is also rapidly growing and now includes terrorist organizations such as ISIS, Hezbollah, and Hamas,

insurgent groups such as Houthi rebels in Yemen and the Revolutionary Armed Forces of Colombia, and transregional criminal organizations such as the *Cártel de Jalisco Nueva Generación*.<sup>18</sup> It is also likely only a matter of time before groups in Africa such as Boko Haram or Al Shabab incorporate drones in their military operations given their ties with Hezbollah.<sup>19</sup>

**State-Based Threats.** The armed drone capabilities of states like Russia, China, and Iran traditionally fall into groups 4 or 5; however, these states have demonstrated innovation in the operational employment of tactical drones that qualitatively sets them apart from the United States. Russia and its proxies' use of tactical drones highlights the complex nature of the threat that a state actor might bring to bear in modern conflict. Iran's drone innovations and willingness to share UAS technologies with US rivals highlight how states might complicate US responses to regional crises. China's aggressive development of all types of drones reveals how a near-peer competitor might seek to exploit current US military vulnerabilities. Together, these behaviors and capabilities highlight the challenge for the United States in this highly contested environment.<sup>20</sup> The challenge for the Army within this newly contested environment will be the defeat of group 1-3 drones, which evidence suggest will become more effective and prevalent over time, while still managing to address and deter group 4-5 drones.

*Russia.* The Russian military has demonstrated a tactical advantage in drone employment against their central European neighbors and members of the North Atlantic Treaty Organization (NATO).<sup>21</sup> This advantage does not stem from technological superiority or advanced drone capabilities, but from organizational learning. The Russian military's ability to learn from experience and integrate lessons into operational doctrine appears to outpace the United States who has fought only non-state actors in its recent history. Russia began to revise its drone employment doctrine following the Russo-Georgian War in 2008, during which the Georgian

military extensively used Israeli-made drones to conduct ISR.<sup>22</sup> Following the war, the Russian military clearly recognized the value of drones. Russia rapidly implemented a development and acquisition program that entailed purchasing Israeli-made drones while concurrently investing in domestic sourcing programs.<sup>23</sup>

The Russian military's expanded drone program paid dividends during their incursion into Crimea and Eastern Ukraine in 2014, where Russia's rivals confronted a large quantity and variety of drones.<sup>24</sup> The conflict in Eastern Ukraine is widely believed to be the first one in which every belligerent used drones to produce decisive battlefield results.<sup>25</sup> Russia relies on its proxies to employ tactical drones assessed to have a modular configuration that provides ISR targeting information to supporting Russian artillery units. This system provides near real-time intelligence that significantly improves target location accuracy, counter-fire response times, and fire mission lethality.<sup>26</sup> In one instance, during July 2014, Russia used this technique to destroy four Ukrainian Army brigades preparing to conduct a cross-border attack against Russian-backed separatists lines of supply.<sup>27</sup> Ukraine suffered severe losses over the course of several minutes, which set back their war effort by months (figure 3).<sup>28</sup>



Figure 3. Ukrainian Mechanized Brigade following July 2014 Zelenopillya Attack.<sup>29</sup>

*Iran.* Whereas Russia demonstrates innovation in drone employment techniques, Iran displays an inclination towards technical innovation and a willingness to share drone technologies with others. Iran started its drone program decades ago during its conflict with Iraq and is now one of the most developed in the Middle East.<sup>30</sup> Though Iran's exact technical capacity is unknown, it has excelled in other advanced technology fields like nanotechnology, stem-cell research, and nuclear development, all despite an array of foreign economic sanctions.<sup>31</sup> More troubling, Iran has demonstrated its willingness to share advanced drone technology with others throughout the Middle East. It reportedly flew drones like the Shahed-129 over Iraq and Syria, exported drone technology to Hezbollah and Hamas, and may have provided an assortment of drones to Houthis in Yemen.<sup>32</sup>

Iran appears willing to use its drones, or support others willing to do so, to confront US forces in the Middle East. For instance, in mid-2017, Iran made headlines when its military flew a domestically-sourced drone within 100 feet of a manned US fighter aircraft over the Persian Gulf.<sup>33</sup> Following this event, US forces engaged and destroyed two Iranian-made drones in Syria that conducted an attack against US ground forces.<sup>34</sup> These incidents highlight that Iran is continuing to expand its drone programs and is willing to employ drones as an asymmetric counter to US military superiority.<sup>35</sup> Iranian drones have been reported in locations from Pakistan to Syria and throughout the Persian Gulf region. They have become the centerpiece of Iranian technology exhibits used to showcase their advanced security capabilities despite rigorous international sanctions.<sup>36</sup>

*China.* The extent of China's UAS development in support of its military remains unclear to Western military analysts and senior leaders; however, there is evidence that China's efforts are a real cause for concern. General Joseph Dunford, the Chairman of the Joint Chiefs of Staff,

recently noted this when he stated, “frankly we’re closely tracking their rapid military modernization.”<sup>37</sup> He went on to note that “while Chinese military investment, capability development, and intentions are opaque, it is clear they’re investing in a manner that balance requirements.”<sup>38</sup> Some experts believe that the Chinese military’s drone efforts focus on swarming technology, increased payload, farther operational range, and the incorporation of artificial intelligence.<sup>39</sup> China’s military modernization efforts within the sphere of drone manufacturing and technological research give the appearance that they are no longer trying to simply offset American military drone technology, and instead are committed to overtaking it in the Asia-Pacific region.

In a congressionally mandated report titled *US Department Of Defense, Military And Security Developments Involving The People’s Republic Of China, 2017*, analysts note that the number and types of China’s domestically developed UAVs continue to expand, with five new platforms displayed at the 2016 Zhuhai Airshow.<sup>40</sup> China also appears to be betting that swarms of low-tech drones linked with high-tech artificial intelligence will become the weapon of choice in future conflicts and capable of countering any military force, including the United States.<sup>41</sup> These efforts highlight the considerable amount of resources China is dedicating to UAS development, thereby suggesting the importance and relevance that China perceives for the potential of UAS technology in future conflict. China has also quickly risen to become a leading exporter of drone technology, including selling armed UAS to Pakistan, Nigeria, Iraq, Saudi Arabia, and the United Arab Emirates.<sup>42</sup>

In comparison, the United States which until recently operated under a restrictive set of drone export control policies, has lagged behind in exporting domestic UAS technology to

allies.<sup>43</sup> In the wake of these restrictions, China's various drone types are in high demand among Middle Eastern states, many of which carry rather questionable human rights records.<sup>44</sup>

**Non-State Threats.** Besides the activities of rival states, the recent employment of drones by non-state actors reveals how quickly and relatively easily these groups can disrupt advanced industrial militaries. Drones are attractive to these groups because of “the way they carry [destructive] power and the distance from which they allow an adversary to control its delivery.”<sup>45</sup> Small, commercially available drones give groups like ISIS the ability to field an air force capable of collecting ISR and providing limited close air support. The evolution of non-state actors' use of small drones began in 2004 when Hezbollah used drones to challenge the Israeli military.<sup>46</sup> Drone use by non-state groups continues to evolve and demonstrate the ability to conduct complex attacks. For instance, during the year-long fight to recapture Mosul, Iraqi Security forces faced persistent armed drone attacks that slowed their efforts to liberate ISIS-held neighborhoods.<sup>47</sup> Of particular concern is the increasingly complex and disruptive ways in which non-state actors use tactical drones in groups.

*Hezbollah.* As mentioned, Hezbollah has pioneered the development and use of drones by non-state groups for more than a decade.<sup>48</sup> Hezbollah has made significant progress in acquiring increasingly sophisticated drones, largely through its alliance with Iran and now displays the full range of UAS capabilities. Thanks to its patron Iran, Hezbollah arguably has the most comprehensive UAS capabilities of any non-state actor.<sup>49</sup> Hezbollah's first successful drone deployment took place in November 2004, when the group used an Iranian-made Mirsad-1 military surveillance drone in Israeli airspace. This marked the first time a non-state actor used aerial drones against a state. Since then, Hezbollah has continued to expand UAS capability as the most prolific non-state user of drones, continually establishing new precedents for non-state

actors.<sup>50</sup> In less than ten years, Hezbollah transitioned from having no drones to having its own drone airfield and a fleet of military and commercial drone systems. It uses these systems for surveillance, manufacturing propaganda, armed strike missions, and kamikaze-type attacks.<sup>51</sup>

Unlike Hezbollah, whose drones are typically modified versions of advanced Iranian systems, ISIS uses commercially available and homemade drones against military targets. ISIS has shown itself as being particularly innovative in applying homemade solutions to tactical problems. The first reports of ISIS's interest in drones emerged in 2013. Iraqi authorities arrested five men tied to the group who were planning to use remote-control helicopters to distribute sarin and mustard gas as part of an attack against unspecified targets in Iraq, North America, and Europe.<sup>52</sup> ISIS extensively used drones during the conflicts in Iraq and Syria. According to Peter W. Singer, a political scientist and strategist at the New America Foundation who specializes in 21<sup>st</sup> century warfare, ISIS flew over 300 drone missions in one month during the battle for Mosul, and about one-third of those were armed strike missions.<sup>53</sup> Following the recapture of Ramadi from ISIS, a field investigation team from the United Kingdom's Conflict Armament Research group discovered an ISIS drone workshop with an intact assembly line producing plywood fuselages and repurposed missile components (figure 4).<sup>54</sup>

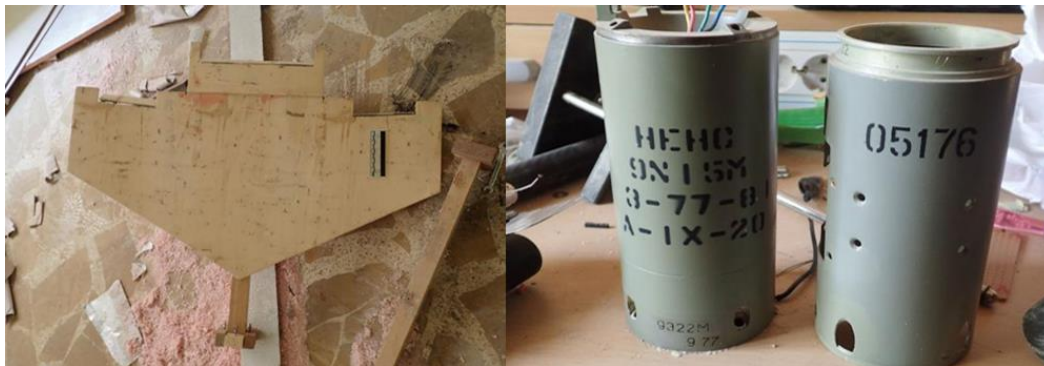


Figure 4. Homemade drone fuselage and repurposed warhead section of a Soviet 9M32M missile discovered at an ISIS workshop in 2017.<sup>55</sup>

Recent events in Syria also provide evidence of the continuing evolution and inherent threat of drones on modern battlefields. The Russian Ministry of Defense recently reported that in January 2018 its forces in Western Syria experienced an attack by a “swarm of home-made drones.”<sup>56</sup> According to the ministry, Russian forces at Khmeimim Air Base and Tartus Naval Facility faced a complex attack by thirteen drones armed with small diameter bombs that caused casualties and damaged facilities (figure 5).



Figure 5. Homemade drone used in “swarm” attack against Russian Forces in 2018.<sup>57</sup>

As reported, this attack does not meet the technical definition of swarming – a group of UAVs controlled by artificial intelligence which communicate with each other while in flight and are able to autonomously respond to changing conditions.<sup>58</sup> Regardless, this attack and the previous mention of Chinese intentions shows that adversaries are working towards that goal. Swarm type

attacks would be particularly threatening because existing kinetic defenses struggle to cope with the agility of small drones, and swarming would overwhelm most existing countermeasures.<sup>59</sup>

## **COUNTERING THE THREAT**

In *Military Misfortunes*, Eliot Cohen describes the dangers when a military fails to learn, anticipate, and adapt to changes in the character of warfare.<sup>60</sup> The discussion above notes that US adversaries are learning and adapting, but the US Army is failing to keep pace. Russia's operational employment of drones in Ukraine, Iran's proliferation of drone technologies, China's emphasis on developing full-spectrum drone capabilities, and the continuing evolution of drone use by non-state actors show that Army planners must anticipate extensive UAS employment in future conflicts. Changes in drone technologies and evolving adversary doctrines suggest that the Army must learn from recent conflicts, as the Russians did, and recognize that the changing character of warfare requires improved acquisition processes and training to effectively counter the UAS threat.

As previously noted, the Army decided to emphasize long-range air defense systems and further unbalanced its forces by eliminating short-range air defense systems given the threat assessment and wide spread military drawn down following the end of the Iraq War in 2013. According to senior leaders, the decision to reduce short-range systems was a calculated risk taken at a time when senior military leaders believed that the current and future capabilities of the US Air Force would defeat any aerial threat and maintain air superiority.<sup>61</sup> As the assumptions underlying this decision have been proven invalid in hindsight, the calculated risk resulted in the elimination of short-range air defense systems that has resulted in the current Army reliance upon aging anti-aircraft and missile intercept systems to counter drones of all

sizes.<sup>62</sup> Given the proliferation of tactical drones, the use of advanced air and missile defense systems is inappropriate due to cost and system availability.

The Israel Defense Force recently employed its US made Patriot missiles against a single small drone from Syria that violated Israeli airspace. The Israelis used multiple \$3 million PAC-2 Patriot missiles but failed to destroy the target.<sup>63</sup> This incident highlights the unsustainable cost and technical difficulty of employing limited theater-level air defense assets against tactical drones.<sup>64</sup> In 2017, the then Commanding General of the US Army's Training and Doctrine Command, General David Perkins, told an audience, "If I'm the enemy, I'm thinking, 'Hey, I'm just going to get on eBay and buy as many of these \$300 quadcopters as I can and expend all the Patriot missiles out there.'"<sup>65</sup> If the Patriot and Stinger missiles – which respectively cost \$3 million and \$38,000 each – remain the primary defense means for countering drones, it may be possible for an adversary to employ tactics like those used by ISIS against Russia in Syria to deplete a theater-level air defense capacity that costs tens of millions of dollars. This low-cost act would make an entire area of operations vulnerable to subsequent air attack.

Though the US Army has taken steps to improve its counter-drone capabilities, these actions have been insufficient. The Army recently began the process of expanding the availability of short-range air defense systems in the active force by having its Material Command overhaul legacy Avenger systems previously set to be destroyed.<sup>66</sup> Though a step in the right direction, reintroducing short-range air defense systems will take time during which maneuver forces remain vulnerable. The Army took steps to mitigate this by training and assigning Stinger teams to its maneuver forces, along with developing Stinger upgrades to improve their effectiveness against tactical drones.<sup>67</sup> However, this only offers a temporary solution that has proven ineffective in the past. When the Army made a similar attempt to

integrate Stinger teams in the 1990s, senior defense officials noted that the result “was not great, as we found that 80%, if not more, of all Stinger shots taken by maneuver Soldiers, were done in a revenge fashion, after the enemy had already destroyed most of the formation.”<sup>68</sup> As the drone threat continues to, so too must the solutions used to counter the threat.

The current drone threat is far too complex for a single solution to solve. A US Army counter-UAS strategy must provide a framework for a persistent and comprehensive approach that links soldier, material and software solutions. The Army must creatively employ all means along these three lines of effort to regain operational initiative. Along the soldier line of effort, the Army must retrain its soldiers to compete, fight and win in a drone saturated environment, while restructuring its formations to meet the added demands of counter-drone requirements. Along the material solutions line, the Army must reform its Industrial Age acquisition processes to promote rapid, creative, and independent technical solutions through public-private partnerships with corporate partners. Lastly, the Army must explore existing and emerging commercial technologies so it can rapidly field innovative software solutions compatible with existing systems. The newly-created US Army Futures Command, whose mission is intended to result in a more rapid acquisition process, should spearhead these lines of effort. Early success in this command along these lines will provide an opportunity for the US Army to leap ahead in drone technology and in ways to counter the drone threat.<sup>69</sup>

*Soldier.* The Army must place its primary emphasis on the soldier line of effort since this is arguably the most important in terms of near-term counter-UAS effectiveness. This will require redeveloping atrophied air defense warfighting skills necessary in a contested drone environment. Capability and training in air defense skills declined during decades operating under uncontested airspace and during counterinsurgency operations. The Army previously

trained soldiers in the field craft necessary to conduct active and passive air defense.<sup>70</sup> Active measures include tasks involving the detection and engagement of enemy aircraft, and passive defense measures include skills related to camouflage, concealment, position hardening, dispersion, and mobility to guard against air attack.<sup>71</sup> To its credit, the Army is starting to reintroduce training related to these skillsets.<sup>72</sup>

Reintroducing and strictly enforcing standards of the passive defense is a low-cost and rapid solution to immediately counter enemy drone threats. If Ukrainian forces at Zelenopillya had implemented passive air defense measures it is likely that the results of the Russian attack would have been much less. The Army should invest in home station training kits of commercial drone systems like they did following the emergence of the improvised explosive devices in Iraq and Afghanistan.<sup>73</sup> Once the Army realized the magnitude of the threat posed by these devices, the Army quickly integrated training methods designed to train deploying units how to counter and defeat the threat. They also tested preparedness during culminating training events at its three combat training centers. The same approach must be applied to counter-UAS training.

The Army will need to also improve its active air defense measures, which will require it to make changes in its maneuver formations. As mentioned above, the Army is already taking some steps in this direction by reintroducing the Stinger short-range air defense system into maneuver formations. More changes will likely be needed, however, as the limited quantity of these systems makes them subject to the same risks described for larger systems like the Patriot. Russia's recent innovations in Syria point to one avenue the Army might consider adopting. Russia created and deployed its first permanent tactical unit designed to combat unmanned aircraft and has developed others.<sup>74</sup> These units integrate air defense, aviation, and sniper elements working in tandem to combat drone threats. To date, the Russian military has created

approximately twenty of these special units across all services to actively counter the drone threat.<sup>75</sup> These forward deployed units are widely believed to be one reason Russian succeeded in defeating the “swarm” attack against its bases in Syria.<sup>76</sup>

*Material.* The blurred distinction between commercial and military drone production makes it necessary for the US Army to study and understand the future potential of these systems by working with commercial industry partners. Given the current reliance of non-state actors on the commercial development of this technology, collaborating with major manufacturers will provide the Army with insights on the direction of system change and potential threats. This early understanding will provide time for the Army to develop appropriate responses before adversaries employ the systems on the battlefield. As the Under Secretary of the Army recently announced regarding the creation of the US Army Futures Command, “We have to get more agile in how we work with both of those key constituencies or communities.”<sup>77</sup> He also noted that, “The entire Department of Defense really divested a lot of its systems engineering talent back in the 1990s and it’s been a challenge for the department for weapon systems development because of not having that organic capability inside the department.”<sup>78</sup>

The Army Futures Command is the ideal organization to implement the search and development of material solutions to counter drones. The Army must ensure that Futures Command is properly manned and given the necessary authorizations to become an institution that can reform an acquisition system that has become unable to keep pace with modern technological change. The US Special Operations Command’s relationship with SOFWERX provides a model for what larger-scale Army material collaboration might look like. SOFWERX is a public-private technology incubator that has recently been preparing to host a series of drone competitions to explore how these systems and equipment might benefit the US Special

Operations Command.<sup>79</sup> This public-private model would benefit the larger, conventional Army and provide a venue to discover how drones might benefit the service, but also to devise ways to counter them.

While global reach on commercial drone systems is still an emerging technology, the areas that will have significant impacts on a commercial to military crossover remain steadily focused on improvements in autonomous flight, increased battery performance, and location technologies. Currently, there remains few commercial drones that can fly without the aid of a user-directed path,<sup>80</sup> but this technology is quickly emerging along with the application of commercial artificial intelligence. Emerging advances in location technologies will also present a significant challenge to the military. The stated goal of companies working in this area is to build systems that can identify their location without the aid of GPS.<sup>81</sup> Combining all the above technological advancements into a single commercial platform – and there is little reason to suspect that will not happen – will provide a potential adversary a commercial version of the most advanced military drones in the world. The Army must work with industry partners so it has forewarning of when this may occur, and perhaps influence the timing.

*Software.* The final line of effort for developing a counter-UAS strategy is to link soldier and material solutions with systems software within the existing structure of US Army brigade combat team systems. The first step in developing these solutions will require developing software for existing systems that enable detecting and tracking drones. Current air tracking systems are already capable of tracking larger operational drones, so the focus must be on smaller tactical UAS. As mentioned earlier, tactical drones are smaller, so they have smaller radar cross-sections due to their small infrared and electromagnetic signatures. Therefore, the Army must invest in software for current and future sensors that can better detect tactical drones.

The uncertain budget environment makes the acquisition of new radar systems unlikely, and previous acquisition failures suggests that the Army should not invest limited funds in a specialized counter-drone radar. Instead, it must develop better software for existing radars like the AN/MPQ-64 Sentinel and AN/TPQ-53 radar systems. The AN/TPQ-53 radar was originally designed to track rocket, artillery, and mortar rounds, but the Army is testing to determine its ability to track drones.<sup>82</sup> One advantage that modern radars have is Active Electronically Scanned Array (AESA).<sup>83</sup> Radars with AESA have proven more versatile than older systems so developing software for these systems to track tactical drones provides a solution short of developing a new radar system.

## **CONCLUSION**

The current Chief of Staff of the Army, General Mark A. Milley, believes, “One of our most important duties as [military] professionals is to think clearly about the problem of future armed conflict.”<sup>84</sup> He also noted that fixed sites of any kind will be lethal magnets for destruction by enemies who will have a rich diet of targeting information.<sup>85</sup> This rich targeting information will likely be provided in large part by hostile drones, some of which may be capable of conducting attacks. Recent conflicts involving state and non-state actors, and the drone acquisition priorities of US rivals seems to confirm this reality. Despite these threats and the observable lessons from recent conflicts, the US Army remains vulnerable to the long-term operational risks resulting from the proliferation and use of drones by state and non-state adversaries. The re-emergence of long-term geopolitical competition with rivals employing a variety of drones, rapid diffusion of drone technologies throughout every operational region, and adversary warfighting concepts that integrate drones into effective offensive operations result in a strategic imperative for the US Army to develop and implement a counter-UAS strategy based

on soldier, material, and software solutions. This type of strategy will provide a framework for improving the Army's acquisition process to better leverage emerging technologies and develop a comprehensive soldier training program that integrates these technologies to regain the initiative through improved warfighting. The US Army has spent trillions of dollars in the last decade building and generating a force that can fight, dominate, and win in the land domain, yet states and groups with far less resources are rising to challenge the United States in the new arena of drone warfare. The Army must take necessary steps to mitigate this threat or risk losing the next war.

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