Atlantic Council
SCOWCROFT CENTER
FOR STRATEGY AND SECURITY

ISSUE BRIEF

The Melians' Revenge:

How Small, Frontline, European States Can Employ Emerging Technology to Defend Against Russia

JUNE 2019 T. X. HAMMES

Perhaps the most famous quote from Thucydides is "the strong do what they can, the weak suffer what they must."[1] For thousands of years, it has been accepted that the weak must comply or face the fate of the Melians. Today, the technology of the Fourth Industrial Revolution may be revising that truth. It is creating a wide range of small, smart, cheap weapons that can provide small states combat power previously reserved to major powers.[2]

This is good news for European nations that face much the same problem as the Melians—a large, more powerful neighbor that believes it must project strength in order to maintain its place in the world. The question is how, given current realities, these nations can take advantage of the revolution to deter Russian aggression. This paper argues that the convergence of new technologies means NATO nations can adopt an affordable new operational concept to deter Russian conventional forces. For a relatively modest investment, frontline states could present Russia with a complex defense of inexpensive autonomous drones, missiles, and ubiquitous improvised explosive devices (IEDs). When supported by other NATO nations' forward-deployed units, cruise missiles, and long-range autonomous drones, this defense can present the Russian bear with an indigestible porcupine.

The paper consists of three parts. First, it will discuss the limits of current defenses for Europe's eastern flank. Second, it will explain how emerging technologies tied to new operational concepts can deter Russian aggression. Finally, it will offer a brief conclusion.

The Scowcroft Center for Strategy and Security's Transatlantic Security Initiative brings together top policymakers, government and military officials, business leaders, and experts from Europe and North America to share insights, strengthen cooperation, and develop common approaches to key transatlantic security challenges.

The Limits of Current Defenses for Europe's Eastern Flank

The fundamental problem for NATO is simple. If Russia strikes with minimal warning, it could occupy the Baltics and portions of Poland before NATO could reinforce them. It can then "escalate to de-escalate," by threatening to use nuclear weapons to defend the newly seized territory.[3] Thus, the key issue for the frontline states is deterrence. As always, deterrence can be achieved through denial, punishment, or a combination of the two. Simply put, if an aggressor cannot succeed, or knows the cost will exceed the gain, a rational aggressor will be deterred.

Eastern European states understand the problem and are taking steps to strengthen their defenses to deter Russia. For several years, NATO has also been conducting exercises, and deploying small battle groups to the Baltics and Poland, to reinforce that deterrence. However, all the nations involved still understand that NATO cannot deploy sufficient forces in time to keep the Russians from seizing the Baltic States. The proximity of Russian forces and the Baltics' lack of geographic depth means these states can be overrun if NATO defenses remain based on current plans.

In short, Russia's rejuvenated armed forces appear to be an existential threat to NATO frontline states and—if NATO fails to defend them—to NATO itself. Compounding the problem, geography dictates that any response to Russian military incursions into the Baltic States must be made in hours or days.

In their December 2018 paper, *Permanent Deterrence: Enhancements to the US Military Presence in North Central Europe*, General Philip Breedlove and Ambassador Alexander Vershbow provided force-posture recommendations to deter Russian actions.[4] The paper provided solid recommendations for the United States, but almost no recommendations for other NATO nations. And, while the recommendations are all possible, they will require increased US investment in Europe at a time when the administration is actively reducing the role of the United States globally. At the same time, European nations are not willing to invest heavily in the conventional forces necessary to defeat a Russian incursion using traditional concepts. Thus, while the recommendations are solid militarily, they may not be politically feasible.

A primary internal challenge for each NATO nation is sustaining its political commitment to NATO's Article 5 provision. An integral part of this challenge—and, actually, a more troubling concern—is the problem of maintaining the political will to fight in defense of their own nations.

Polling data show majorities in most NATO countries are unwilling to fight for either NATO or their own countries. A 2015 Carnegie Europe poll asked 11,116 people in eight NATO countries if their nations should defend an ally if that ally was attacked. Only a median of 48 percent believed they should. The British were the most positive, with 49 percent in favor. Even the Poles had only 48 percent in favor—despite 70 percent seeing Russia as a direct military threat—and only 38 percent of the Germans polled thought Germany should fight to defend an ally.[5] In the same year, WIN/Gallup conducted a global poll that phrased the question differently, and asked if those surveyed would be willing to fight for their own countries. The results were much worse. Only 25 percent of Europeans said yes. Of particular concern, the three largest and most powerful countries had very low numbers, with the UK at 27 percent, France at 29 percent, and Germany at a dismal 13 percent.[6]

As the will of NATO nations to fight is coming into question, the means have also diminished greatly. In 2017, Germany—previously one of the most powerful members of NATO—was reduced to only ninety-five operational Leopard 2 tanks and twenty-nine combat-ready aircraft, and was even forced to borrow civilian helicopters to conduct training.[7] At the end of 2017, it had no operational submarines or transport aircraft, and was short twenty-one thousand officers.[8] The United Kingdom also suffers from personnel and equipment issues; it can only deploy a single brigade.[9] Even if NATO nations muster the will to support an ally, they may lack the means to do so.

The October 2018 Trident Juncture Exercise demonstrated NATO's ability to work together and deploy troops, but only after months of planning and preparation. While it provided reassurance that NATO forces can work together, it provided little reassurance that these forces can deploy quickly to Eastern Europe.

In addition to the severe internal challenges, European nations face major external challenges. Donald Trump's "America First" policy, public statements, and tweets

Russia offers an entire family of missiles and drones packaged in standard shipping containers. Until the missiles are raised, this container is unlikely to attract the attention of enemy intelligence analysts. The Club-K container missile complex at MAKS-2011. *Credit*: *Vitaly V. Kuzmin*

have been cause for uncertainty about what action the United States would take in the event of a Russian invasion. By 2018, only 9 percent of Germans thought the United States remained a reliable security partner.[10]

But, the major external challenge is the fact that most analysts believe Russia could seize selected Eastern European states before sufficient NATO forces could arrive to stop them. In response to Russian aggression, NATO has once again pledged the NATO Response Force (NRF) will be ready to deploy on short notice. However, it has made the same promise since the NRF was declared fully operational in 2006—and has never met its own deployment standards.[11] In an effort to provide some reinforcement rapidly, NATO created the Very High Readiness Joint Task Force (VJTF) inside the NRF. The VJTF's *lead* elements will *start* deploying forty-eight hours after they receive the order to do so.[12] Thus, only a small element of the NRF will reach the frontline states in time. A recent RAND report, "Reinforcing Deterrence on NATO's Eastern Flank," concluded that preventing the Baltic States from being quickly overrun would require "a force of about seven brigades, including three heavy armored brigades—adequately supported by airpower, land-based fires, and other enablers on the ground and ready to fight at the onset of hostilities." The report admitted that even this would not be sufficient for a sustained defense, or to restore members' territorial integrity.[13]

The Emerging Technology Solution for Europe's Eastern Flank

NATO, particularly its frontline states, must consider how to deal with the current security situation without significant increases in defense funding. One approach for NATO frontline states would be to continue down the same path, and hope for the best. This approach does not have a great historical record. Fortunately, the Fourth Industrial Revolution is providing a second option.[14] Its converging technologies will provide small and medium nations military capabilities previously reserved for major powers—and for a reasonable price. The question is how these nations can take advantage of the revolution of small, smart, and inexpensive weapons to deter the Russians from aggressive action against them. Deterrence can be achieved through denial, punishment, or a combination of the two. Obviously, in addition to having the capability to deny or punish, a nation must ensure the potential opponent knows it has that capability. Thus, an active information campaign is an integral part of deterrence.

This section will examine how small and medium states can exploit the converging technologies of the Fourth Industrial Revolution to deter a Russian conventional threat.

Assumptions

As with any planning discussion, it is essential to state assumptions before discussing options.

1. The conflict will commence from a standing start. Warning time will be very limited.

2. NATO forces will not be much larger than they are today.

3. NATO nations will continue to disagree about whether Russia or mass migration is a bigger threat to European security.

4. NATO will only have tripwire forces in the frontline states. These forces will be insufficient to defeat a Russian conventional invasion.

5. Reserve forces cannot be trained to regular standards, due to a lack of resources, particularly training time.

6. Frontline states are aware that some NATO nations will not respond.

Given these assumptions, it is nearly impossible for a conventional defense of a frontline state to work. Even worse, the Russians will come to the same conclusion. The deterrent value of these forces is based on the idea that NATO will fight to eject the Russians from seized territory. Unfortunately, as noted in the poll data above, there is uncertainty about whether the populations of many NATO nations will, in fact, fight. There is even greater uncertainty about whether some nations would fight to free a state that has been overrun.[15] Article 5 only requires that a member state take "such action as it deems necessary, including the use of armed force..."[16] In effect, NATO members are only required to think about what they might do.

The Key Emerging Technologies

Fortunately, five existing technologies can provide small states the destructive power to deter large ones: small warheads, three-dimensional (3D) manufacturing, drones, task-specific artificial intelligence, and inexpensive space capabilities.

Small Warheads

While new explosives are increasing the power of warheads, the most effective use of small warheads is to adopt the concept of "bringing the detonator, not the explosive." Rather than building a system to deliver a large warhead, this concept uses a small, smart drone to detonate the very large explosive potential of adversary equipment like a parked aircraft, the rocket pod of a multiple-launch rocket system (MLRS), a fuel truck, or the huge potential of many fixed facilities. In a recent series of attacks, Russian or Ukrainian separatists used drones to drop thermite grenades on Ukrainian ammunition dumps, and detonated thousands of tons of explosives.[17]

Explosively formed penetrators (EFPs) can also be used to increase the destructive power of very small warheads. An EFP one inch in diameter, with one ounce of explosive, can punch through half an inch of steel. This device is about the size of a thumb, and can be mounted on a wide variety of small drones to act as the detonator for materials provided by the enemy. It

The XQ-58A Valkyrie demonstrator, a long-range, high subsonic unmanned air vehicle completed its inaugural flight March 5, 2019 at Yuma Proving Grounds, Arizona. The XQ-58A is the version of the Kratos QX222 that the US Air Force Research Lab is testing. *Credit: Air Force photo by Senior Airman Joshua Hoskins*

is also powerful enough that, if fired into the hood of a motor vehicle, it will destroy the engine. If an organization has the skill to move beyond very basic EFPs, it can also build them with multiple penetrators and self-forging fins to increase their effectiveness.[18]

3D Manufacturing

Using 3D manufacturing, also known as additive manufacturing, developers have mastered the technology necessary to produce tens of thousands of small, smart, inexpensive drones in a day. In April 2016, Carbon started selling a commercial 3D printer that prints composite material one hundred times faster than previous printers. With massive new investment in 3D printing, additive-manufactured products have increased in both quality and complexity, even as the speed of production continues advancing at an incredible pace.

Drones

The dramatic increase in 3D printing speeds has major implications for militaries. In 2014, David Keesler and two graduate students at the University of Virginia designed and flew a 3D-printed drone. The drone design was simple enough that the body of the plane could be printed and assembled in thirty-one hours. Guided by an Android cell phone and powered by a simple electric motor, it had a range of approximately fifty kilometers, but cost (excluding the printer) only $800.[19]

Google has produced a program that allows a cell phone not connected to the Internet to use its "camera to identify people and objects even under low light conditions."[20] Numerous companies and universities are developing navigation for small drones that is not dependent on the Global Positioning System (GPS).[21] Putting these three technologies—small warheads, cell-phone target identification, and GPS-independent navigation—on a single platform creates an autonomous, inexpensive drone that can travel dozens of miles to hunt, and then kill, designated targets. Think of these drones as IEDs that hunt people.

Best of all, they can be produced by the tens of thousands. UPS is planning to expand its 3D-printing plant in Tennessee from one hundred to one thousand printers.[22] It also has major facilities in Chicago and Singapore, as well as dozens of onsite printers at UPS locations across the United States—and it is only one of many companies building 3D-printing facilities.[23] "Only 100 Carbon 3D printers could make 10,000 drone bodies a day; 1,000 printers could print 100,000 drones a day."[24] Supported by robotic assembly lines, 3D-printed drones could be produced at rates exceeding many types of artillery ammunition—and often for less per round. With massive numbers available, reliability, and hence cost, can be much lower.

The Polish Army is already fielding large numbers of relatively cheap drones. In December 2016, the Polish Ministry of Defense announced the Polish Army would buy one thousand Polish-manufactured, cheap combat drones every year.[25] It is buying two different models—both weigh about eleven pounds, require a two-man crew, and cost about $7,000.[26] The first, Warmate, is a fixed-wing drone with the warhead in the nose, and a range of twenty kilometers. The other, Dragonfly, is a vertical-takeoff-and-landing UAV, only about three feet long, and with a range of about ten kilometers. Both systems have high-explosive, high-explosive anti-tank (HEAT), and fuel-air explosive (also known as thermobaric) warheads. The high-explosive anti-tank round can penetrate six to nine inches of armor.[27] This is sufficient to penetrate all but frontal tank armor, and the fuel-air explosive warhead provides a new capability for suicide drones. The next step is to shift from remote pilots to autonomous drones, so the Russians cannot jam the control signals.

The implications for ground forces are obvious—thousands, or even tens of thousands, of drones actively hunting vehicles, ammunition dumps, fuel trucks, and other soft targets. They will need to be prepackaged in containers like the Chinese Harpy unmanned combat air vehicles (UCAV), which load a container of eighteen on a five-ton truck. Manned by two personnel, a similar-size truck could carry hundreds of smaller drones like the US Switchblade. A single battery of ten trucks could launch thousands of autonomous, active hunters over the battlefield. With focused effort, this is achievable today.

Commercial firms are also dramatically increasing the range of drones. The Aerovel Flexrotor has a range of 1,500 miles, the Defiant Lab DX-3 more than nine hundred miles, and the Volans-I can carry twenty pounds out to five hundred miles, at sustained speeds of more than one hundred and fifty miles per hour.[28] The small size of these drones, and the material used to build them, gives them the radar signature of a small bird, and almost no thermal signature.[29] The increased ranges means even naval forces and air bases hundreds of miles from the conflict zone will be vulnerable.

Military drones are even more impressive. Israel's currently operational Harop has a range of six hundred miles, with a payload of fifty-five pounds.[30] The Kratos QX-222 Valkyrie autonomous drone can deliver a pair of small-diameter bombs, or two air-to-air missiles, out to 1,500 miles at speeds up to .85 mach. Costing only $2 million each, this drone can also be sent on one-way missions out to three thousand miles. The QX-222 is also stealth configured.

Each of these systems is vertical launch. All, except the Harop, can recover vertically. Thus, they are not tied to an easily identified and targeted airfield. Compare these ranges to the F-35A's operational range of six hundred and eighty miles. And, the F-35 is further handicapped by its requirement for a well-developed airfield.[31]

Russian, Chinese, and American companies are already selling drones and missiles loaded into standard shipping containers. This means commercial trucks and ships can become weapons simply by loading a shipping container. The sheer number of these containers and commercial vehicles in most countries means they cannot all be targeted in a preemption campaign. They can also be easily hidden in garages, barns, tunnels, underpasses, etc.

As always, whenever a new weapon is developed, so are countermeasures. Today, direct-fire, missile, laser, and microwave systems can destroy individual drones. Cyber systems can cause a drone to crash, or even take control of the system in flight. However, none of these systems is currently capable of dealing with an autonomous drone swarm. Direct fire is overwhelmed by numbers. Missiles are much too expensive. Laser systems can be hindered by atmospheric conditions, such as smoke, or intentionally degraded by the use of dialectic mirrors or ablative materials coating the drones.[32] Aircraft and drones can also be equipped with counter-lasers, and programmed to roll so that the laser cannot remain on the same spot.[33] Microwave and cyber countermeasures can be degraded by sealing the autonomous system from outside signals and protecting the electronics with a Faraday cage. Also, 3D printing has reached the point that printers can create a Faraday mess around the electronics during the manufacturing process. Planners should not count on any easy technological fix to the problem of drone swarms.

Task-Specific Artificial Intelligence

Experts disagree about whether mankind will ever achieve general artificial intelligence. Fortunately, that argument is irrelevant to the creation of swarming weapons; what is important are the rapidly increasing capabilities of limited, or task-specific, artificial intelligence (AI). While the literature normally refers to this type of AI as "limited," task-specific is more accurate. It is better than any human at the specific task it is designed to do. Thus, in its niche area, task-specific AI creates a distinct advantage for the nation that fields it first.

For swarms of autonomous attack drones to work, they must have the ability to navigate to a designated area, and then identify the correct targets. Task-specific AI can already do both. The Harpy uses GPS to navigate to the specified area, and then searches in the visual, infrared, and electronic spectrums to identify and attack a target. As noted earlier, institutions worldwide are already seeking non-GPS-based autonomous navigation systems. In the early 1990s, Tomahawk cruise missiles combined inertial and visual navigation to hit a specific building after traveling one thousand miles. New systems can do the same for a fraction of the cost.

Attacking an identified target is a separate problem, since the drone may need to avoid obstacles to hit the target. While this is a challenging task, commercial firms are already selling drones that identify and follow an individual athlete, even through complex cities and forest trails.[34] Larger drones, like the QX-222 Valkyrie, can deliver existing smart weapons that, after release, use onboard systems to guide to the target. Drones are reducing the cost of precision, long-range strikes by orders of magnitude.

A major issue is whether autonomous drones will be required to maintain a command-and-control link so the mission can be cancelled or diverted. Doing so would increase the technical complexity of the systems, as well as increase the vulnerability to enemy cyber or microwave defenses. If one treats a drone in the same manner as other smart munitions, they will not require a recall capability.[35] Most likely, a mix will be developed.

Cheap Space Capabilities

As range increases, finding the targets will become a challenge. For decades, expensive satellite systems have been the best method to look deep into enemy territory. However, the relatively recent development of cube satellites and their launch infrastructure has made space imagery commercially available.[36] Planet, a private company, images the entire planet *daily,* and sells those images to businesses.[37] Planet can provide images based on visual or infrared cameras, as well as synthetic-aperture radar. The days of hiding military activity are clearly drawing to a close. Planet, Earth-i, Urthecast, and Google Earth are all racing to provide near-real-time satellite imagery on demand, with resolution of less than one meter.[38]

Plus Some Older Technology

The effectiveness of these emerging technologies can be enhanced with the addition of two established technologies.

Cruise Missiles

While not new, cruise missiles should be a key element in the defense of Europe. They already more than double the range of manned tactical aviation. Thus, cruise missiles will force an enemy air force to employ numerous tankers to base its aircraft outside cruise-missile range, significantly reducing the number of sorties generated. Russian cruise missiles obviously present a serious challenge to NATO's fixed-wing tactical aviation.

Compounding the problem for manned aviation, advanced manufacturing will cut the cost of cruise missiles. This provides real opportunities for smaller states. New operational concepts that tie cheap drones and cruise missiles together can create effective anti-access/area-denial (A2/AD) and precision, long-range strike capabilities. Because cruise missiles can be fired from a variety of land and sea launchers, including standard shipping containers, they will be extremely difficult to preempt.

Improvised Explosive Devices

The second old technology, IEDs, has caused major tactical and operational problems for Western forces in Iraq and Afghanistan. With some creativity, IEDs can be adapted into ideal weapons against a Russian ground invasion. The base explosive can be ammonium nitrate—common fertilizer. This provides an inexpensive, easy, combat-tested way to obtain the explosive charge for a range of IEDs, from small anti-personnel devices to massive weapons that can stop an armored column. Each of the frontline states already uses ammonium nitrate in its agriculture, in amounts sufficient to allow reservists to create tens of thousands of IEDs. As long as the high-explosive detonators are not stored with the IEDs, they are safe. The detonators would be held by reserve officers, and distributed only in wartime. If the ammonium nitrate is unused during the year, it can be sold and replaced with new stocks.

In Iraq, insurgents built thousands of IEDs, some as EFPs to increase their destructive power. These weapons proved capable of destroying M-1 tanks. It is possible to think much bigger. For instance, a twenty-foot shipping container can hold more than fifty thousand pounds of ammonium nitrate. Given the ubiquitous nature of these containers, as well as the ease of moving and hiding them, these potentially huge IEDs could be used in choke points to wipe out the lead elements of approaching Russian columns.

Porcupine: The Operational Concept

Frontline states can take advantage of the small, smart, and inexpensive revolution to develop a new concept of deterrence—that of the porcupine. A bear can certainly eat a porcupine, but it does not. Rather than trying to match Russian conventional forces, or to convince NATO allies to forward deploy sufficient forces, these states can develop deterrence based on swarms of inexpensive, autonomous drones and fields of IEDs, all controlled primarily by reserve forces that live where they will fight.

Reserve forces will conduct a defense that can mobilize in hours and engage at the border. Remaining host-nation regular forces and forward deployed NATO forces will conduct counterattacks to defeat any Russian breakthroughs. However, to achieve this, the nations will need to change their basic concept of defense by taking the following steps.

Engineering Preparation of the Battlefield

Frontline states could conduct a detailed study to identify key chokepoints, and reinforce those points with obstacles to channel an invasion force. This is an area where reserve forces' knowledge of local terrain could be vital. They will know the impact of weather conditions and seasons on trafficability in their home areas.

Regular Training

Regular forces will continue training to meet Russian forces, but will add inexpensive drones and extensive minefields to their exercises. In addition, they will be responsible for training reservists in the manufacture, storage, handling, and employment of a full range of IEDs and drones in a box.

Reserve Training

Rather than attempting to train reserve forces to meet Russian armored forces in a head-on fight, reserves will

Marine Corps Lance Cpl. Nicholas D. Hettinga looks at a 3-D printed unmanned aircraft system at Camp Lejeune, N.C., Sept. 27, 2017. The drone was created through 3-D printing to be low cost, easily repaired and have simple maintenance. *Photo Credit: Marine Corps photo by Cpl. John A. Hamilton Jr.*

train to fight with standoff weapons that maximize the value of local knowledge of terrain. Upon mobilization, reserves will prepare the IED fields using the already forward-deployed ammonium-nitrate containers. In addition, they will prepare the containers of inexpensive, autonomous drones. Both IEDs and drone containers will be positioned to engage the engineered kill zones. Reservists will then take position to observe key choke points, to ensure IEDs and drones are employed when Russian forces enter the kill zones. The preferred method of triggering the devices will be hard-wired command detonation, with the reservists at least a kilometer away from the firing device. Camera signals and firing commands will be carried by wire, to protect them from signals exploitation or jamming. As the concept develops, the kill zones can be tied to regular forces' direct and indirect fires, as well as NATO air support.

Information Campaign

These steps need to be accompanied by a well-thought-out information campaign. Each nation should demonstrate its revised reserve training to include live-fire exercises using IEDs and autonomous drones. Once a year, nations should conduct a simultaneous launch of inexpensive, autonomous drones that move to a specified range and engage targets. The fact the Russians will not be able to detect any electronic signals post-launch will demonstrate whether the highly effective electromagnetic techniques they have used against Ukrainian drones will not be effective against these newer drones. During the coordinated exercise, at least one country should detonate a very large IED. If an appropriate firing range is available, it should include a fifty-thousand-pound shipping container IED.

The Role of Allies

The United States and NATO states not in the frontline can contribute to deterrence and defense of NATO's eastern flank.

NATO States Not in the Frontline

The Fourth Industrial Revolution can also provide those NATO states willing to support the frontline states with relatively inexpensive options. For instance, rather than buying a $100-million fifth-generation fighter, a nation could buy fifty of the vertical-launch-and-recovery QX-222 drones. These drones do not require the massive investment in air and missile defense needed to defend fixed air bases. Nor do they require the operational, training, personnel, airbase, and maintenance costs necessary to operate a fighter. Thus, a nation could actually buy a multiple of fifty QX222s-type drones for every fighter it forgoes. To further complicate Russia's problem, states can purchase cruise missiles to provide responsive deep-fire and sea-denial capabilities. A simple map study shows that the 250-nautical-mile range of modern anti-ship cruise missiles will allow them to engage any surface ship attempting to sail in the Baltic or Black Seas. The 1,500-mile range of land-attack cruise missiles would allow NATO states to provide immediate fire support to nations under attack—as well as to neutralize Russian airfields. Also, because cruise missiles can be built in standard shipping containers, they can be both mobile and virtually impossible to suppress.

Role of the United States

In the short term, the United States can make use of the recommendations in the Atlantic Council's *Permanent Deterrence* paper. In the longer term, the United States must assist its allies in shifting from a defense based on the few, exquisite weapons systems it currently procures to a family of small, smart, and numerous—but relatively inexpensive—systems. A key element in convincing allies to buy these weapons is for the United States to do so. While this seems like a radical departure from current US procurement plans, the United States has actually been moving in this direction for years. New weapons systems rarely jump right into the first ranks of a combat source; rather, they follow a pattern. First, a few visionaries see how a new technology could help the old. For instance, aircraft could scout over the horizon to find the enemy's battle fleet. Then, as the technology improves, it becomes a partner—as carriers and their aircraft did for battleships in the mid-1930s US Navy exercises. Finally, the new technology replaces the old, as when carriers replaced battleships as the fleet's capital ships.

The United States is well down this helper-partner-replacement path in a number of areas. Drones have already essentially replaced manned aircraft for long-term surveillance in low-threat areas. New drones are becoming partners in electronic warfare and communications relay. Kratos drones have already flown with US attack aircraft as "loyal wingmen" in experiments.[39] Cruise missiles have been full partners in strike since 1991, and have replaced manned aircraft in high-risk strikes. By focusing research, testing, gaming, and procurement in the most promising areas, the United States can lead the transitions. In the very short team, inexpensive, autonomous attack drones show real promise. On a longer timeline, the United States can continue augmenting, and start replacing, manned aircraft with autonomous drones and longer-range cruise missiles.

Key Advantages

Shifting to an in-place deterrence force, based on the employment of thousands of smart weapons and IEDs employed by reservists, has several major advantages compared to the current approach. It deals with the logistical weakness of current plans. It is affordable at current levels of US and European defense spending, and can be implemented relatively quickly.

The logistics element is particularly important, because the long timelines for moving reinforcements to Eastern Europe are a primary weakness of the current concept for defense of frontline states. Even if NATO solves the administrative, legal, and infrastructure problems that have delayed movement of exercise forces, each nation must still address infrastructure that cannot support moving heavy forces from their home stations to the frontlines. Simply put, the current road and rail networks through Poland and into the Baltics are not engineered to carry the weight of tanks and other heavy equipment. While it will take years, or even decades, to fix these deficiencies, the systems already move large numbers of standard shipping containers.

Forces equipped with standoff weapons in standard shipping containers will also be much easier to deploy to wartime positions in a crisis. With their extended ranges, these systems can provide nearly immediate thickening of frontline state defenses and, as part of an information campaign, demonstrate NATO resolve.

Affordability is also an essential element of any deterrent concept. As noted early in this paper, European publics are not in favor of increasing spending. While some of the individual nations are on the path to spending 2 percent of their gross domestic product (GDP) on defense, this is simply not a valid measure of capability. It measures gross input, with no attempt to determine if the output is sufficient. Rather than wasting the increased funding on buying more of the very same force structure that cannot prevent Russian invasions of Eastern Europe, the focus should shift to the affordable combination of reserves, cheap autonomous weapons, cruise missiles, and IEDs. Demonstrating credible, ready defense capability could also reduce the political pressure from the United States to increase defense spending. Measurable, fielded, demonstrated capability is superior to the crude standard of 2 percent of GDP.

Further, some NATO nations' lack of willingness to increase spending for defense is an honest disagreement over the nature of the threats facing NATO. Nations in the northeast of Europe see Russia as the primary threat. Nations on the southern fringe see mass migration out of the Middle East and Africa as a more immediate and dangerous threat. Each faction can make solid arguments for why NATO should invest in forces needed to address the threat it sees as most dangerous. Reducing the cost of defending against Russia will free up resources to deal with migration, and the experience acquired operating surveillance drones will help with the migration-control mission.

Another key advantage is that shifting to drones, cruise missiles, and IEDs should be faster than building up conventional military forces. The Baltic States have very small active forces, but have organized reserves across their nations. The training requirements to effectively build, deploy, and employ a variety of IEDs are significantly lower than those required to field conventional infantry units capable of fighting an armored force. Even more important, the reserves will be living across each country, on or near the ground where they will fight. If properly trained, organized, and equipped, reserve forces will be able to establish kill zones before Russian forces can move into their territories. This goes a long way toward solving the problem of defeating a sudden Russian attack.

What Happens if Russia Develops These Systems Too?

If Russia also produces large numbers of autonomous drones, along with its current missile and rocket inventories, it will obviously challenge NATO and the frontline states. But, it will also create a fundamentally defensive battle, since neither side will be able to maneuver forces freely. This reflects the fact that large numbers of inexpensive, smart weapons are likely to lead to defense dominating the tactical battlefield. If a vehicle or person creates a signature, it will be seen and attacked. By the nature of their mission, units on defense create fewer signatures than units on offense. Because NATO's mission is defensive, this situation provides it a strategic advantage.

Why the Focus on Europe?

The convergence of new technologies is democratizing precision weapons and, thus, leveling the playing field between major states, smaller powers, and even non-state actors. But, the porcupine concept is best suited for employment by the defense in conventional war. The proximity of the opponents in Northeast Europe maximizes the benefits of rapidly mobilizing reservist and home-guard units that can exploit their superior knowledge of terrain and trafficability. The combination of new and old technology can also be employed to deter China, but requires a somewhat different operational concept. However, that is a subject for another paper.

Conclusion

The convergence of Fourth Industrial Revolution technologies means NATO nations can build deterrence based on both denial and punishment. Inexpensive, smart, relatively short-range drone swarms—combined with large numbers of IEDs—can deny major Russian forces access to frontline states. Long-range drones and cruise missiles can provide other NATO nations with a relatively inexpensive way to provide immediate, effective support to their eastern allies.

The bottom line is that frontline states cannot count on current forces or NATO reinforcements to stop a Russian conventional invasion. They face a choice. They can continue to rely on NATO forces to rally and eject Russian forces, in the face of the Russian threat to escalate to nuclear weapons. Or, they can rethink how they defend their own territories. For a relatively modest investment, frontline states could present Russia with a complex defense of inexpensive autonomous drones, missiles, and ubiquitous IEDs, controlled by reserve forces that can be mobilized in hours, rather than days or weeks. When supported by frontline conventional forces, NATO's forward-deployed units, and the firepower of massed cruise missiles from other NATO states, NATO can present the Russian bear with an indigestible porcupine.

* * *

Dr. T.X. Hammes is a distinguished research fellow with the Center for Strategic Research at the Institute for National Strategic Studies at National Defense University. Prior to his retirement from active duty, Dr. Hammes served for thirty years in the United States Marine Corps to include command of an intelligence battalion, an infantry battalion, and the Chemical Biological Incident Response Force. He participated in military operations in Somalia and Iraq and trained insurgents in various locations.

Endnotes

1 Robert B. Strassler, *The Landmark Thucydides: A Comprehensive Guide to the Peloponnesian War* (New York: Free Press, 1996), 416.

2 T. X. Hammes, "Technologies Converge and Power Diffuses: The Evolution of Small, Smart, and Cheap Weapons," CATO Institute, January 27, 2016.

3 Anya Loukianova Fink, "The Evolving Russian Concept of Strategic Deterrence: Risks and Responses," *Arms Control Today*, Arms Control Association, July/August 2017, https://www.armscontrol.org/act/2017-07/features/evolving-russian-concept-strategic-deterrence-risks-responses.

4 General Philip Breedlove and Ambassador Alexander Vershbow, *Permanent Deterrence: Enhancements to the US Military Presence in North Central Europe, Atlantic Council*, December 13, 2018, https://www.atlanticcouncil.org/publications/issue-briefs/permanent-deterrence-enhancements-to-the-us-military-presence-in-north-central-europe.

5 Kate Simmons, Bruce Stokes, and Jacob Poushter, "NATO Publics Blame Russia for Ukrainian Crisis, but Reluctant to Provide Military Aid," Pew Research Center, June 10, 2015, http://www.pewglobal.org/2015/06/10/nato-publics-blame-russia-for-ukrainian-crisis-but-reluctant-to-provide-military-aid/.

6 "WIN/Gallup International's Global Survey Shows Three in Five Willing to Fight for Their Country," Gallup International, 2015, http://gallup-international.bg/en/Publications/2015/220-WIN-Gallup-International%E2%80%99s-global-survey-shows-three-in-five-willing-to-fight-for-their-country.

7 Christopher Woody, "Germany's Military is Failing Behind, and the US is Putting it on Notice," *Business Insider*, February 3, 2018, https://www.businessinsider.com/german-military-falls-behind-the-us-puts-it-on-notice-2018-2.

8 "Germany's Lack of Military Readiness 'Dramatic,' Says Bundeswehr Commissioner," *Deutsche Welle*, February 20, 2018, https://www.dw.com/en/germanys-lack-of-military-readiness-dramatic-says-bundeswehr-commissioner/a-42663215.

9 Larisa Brown and David Williams, "Forces Cuts 'Mean the UK Cannot Deploy a Division Abroad in Future War,'" Daily Mail, May 30, 2017, http://www.dailymail.co.uk/news/article-4557046/Forces-cuts-mean-UK-war-abroad-says-US.html.

10 "Picking Up the Pieces," *Economist*, August 4–10, 2018, 49.

11 Jens Ringsmose and Sten Rynning, "The NATO Response Force: A Qualified Failure No More?" *Contemporary Security Policy* 38 (2017), https://www.tandfonline.com/doi/full/10.1080/13523260.2017.1350020?src=recsys.

12 "NATO's Readiness Action Plan Fact Sheet," NATO, last updated December 2015, https://www.nato.int/cps/en/natolive/103267.htm#tl.

13 David A. Shlapak and Michael Johnson, "Reinforcing Deterrence on NATO's Eastern Flank," RAND (2016), 1, https://www.rand.org/pubs/research_reports/RR1253.html.

14 "The Fourth Industrial Revolution, by Klaus Schwab," World Economic Forum, https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab.

15 "Germans Least Supportive of Defending Allies Against Russia," Pew Research Center, May 22, 2017, http://www.pewglobal.org/2017/05/23/natos-image-improves-on-both-sides-of-atlantic/pg_2017-05-23-nato-00-03/.

16 "The North Atlantic Treaty, Washington D.C.—4 April 1949," North Atlantic Treaty Organization, https://www.nato.int/cps/ie/natohq/official_texts_17120.htm.

17 Kyle Mizokami, "Another Ukrainian Ammo Dump Goes Up in Massive Explosion," *Popular Mechanics*, September 27, 2017,

https://www.popularmechanics.com/military/weapons/news/a28412/ukrainian-ammo-dump-explosion/.

18 Richard Fong, et.al., "Multiple Explosively Formed Penetrator (MEFP) Warhead Technology Development," 2004, www.dtic.mil/get-tr-doc/pdf?AD=ADA432897; Jian-qing Liu, et.al., "Formation of Explosively Formed Penetrator With Fins and its Flight Characteristics," *Defence Technology* 10, 2 (2014), 119–123, https://www.sciencedirect.com/science/article/pii/S2214914714000348.

19 Jordan Golson, "A Military-Grade Drone That Can Be Printed Anywhere," *Wired*, September 16, 2014, http://www.wired.com/2014/09/military-grade-drone-can-printed-anywhere.

20 Hillary Grigonis, "Google Designed an Object-Recognition Program that Won't Need the Internet," *Digital Trends*, June 15, 2017, https://www.digitaltrends.com/mobile/google-mobilenets-open-source/.

21 Riley Bauer, Shannon Nollet, and Dr. Saad Biaz, "A Novel Approach to Non-GPS Navigation Using Infrasound: Technical Paper #CSEE14-03," September 11, 2014, www.eng.auburn.edu/files/acad_depts/csse/csse_technical_reports/csse14-03.pdf.

22 Parija Kavilanz, "Louisville Factory: 100 Printers, 3 Employees," *CNN Money*, May 4, 2015, http://money.cnn.com/2015/05/04/smallbusiness/cloudddm-3d-printing-factory-ups/.

23 Beau Jackson, "Fast Radius Scales up 3D Printing Production in Chicago," *3D Printing Industry*, August 29, 2018, https://3dprintingindustry.com/news/fast-radius-scales-up-3d-printing-production-in-chicago-138944/.

24 T. X. Hammes, "Uninhabited Aerial Systems: Disruption or Prescription?" (presentation to Royal Australian Air Force's 2018 Airpower Conference), http://airpower.airforce.gov.au/APDC/media/Events-Media/RAAF%20AP%20CONF%202018/08_Uninhabited-Aerial-Systems-Hammes.pdf.

25 "Misiewicz: 1000 Attack Drones for the Polish Army in 2017," *Defense24*, December 5, 2016, http://www.defence24.com/503694,misiewicz-1000-attack-drones-for-the-polish-army-in-2017.

26 "Polish Ministry of Defence: 16 Kruk Attack Helicopters and 200 UAV Systems—To Be Acquired before 2022," *Defense24*, December 2, 2016, http://www.defence24.com/502668,polish-ministry-of-defence-16-kruk-attack-helicopters-and-200-uav-systems-to-be-acquired-before-2022.

27 "Macierewicz: Thousands of UAV Systems for the Territorial Defence Component and for the Operational Units of the Polish Army," *Defence24*, November 14, 2016, http://www.defence24.com/488869,macierewicz-thousands-of-uav-systems-for-the-territorial-defence-component-and-for-the-operational-units-of-the-polish-army.

28 "Flexrotor Specification," http://aerovel.com/flexrotor/; "Defiant Labs Launches Next Gen Drone: DX-3," press release, Defiant Lab, February 10, 2017, https://news.usaonline.us/press-releases/Defiant-Labs-Launches-Next-Gen-Drone-DX-3-86383; Lora Kolodny and Darren Weaver, "These Drones Can Haul a 20-pound Load for 500 Miles and Land on a Moving Target," CNBC, May 26, 2018, https://www.cnbc.com/2018/05/26/volans-i-drones-can-haul-cargo-for-500-miles-and-land-on-a-moving-ship.html.

29 Tyler Rogoway, "Meet Israel's 'Suicide Squad' of Self-Sacrificing Drones," *Warzone*, August 8, 2016, http://www.thedrive.com/the-war-zone/4760/meet-israels-suicide-squad-of-self-sacrificing-drones.

30 "Harop Loitering Munitions UCAV System," *Air Force Technology*, www.airforce-technology.com/projects/haroploiteringmuniti/.

31 "F-35 Joint Strike Fighter (JSF) Lightning II Specifications," *Global Security*, https://www.globalsecurity.org/military/systems/aircraft/f-35-specs.htm.

32 David Hambling, "Drones Fight Back Against Laser Weapons," *Popular Science*, November 4, 2016, https://www.popsci.com/laser-guns-are-targeting-uavs-but-drones-are-fighting-back.

33 Brian Wang, "Combat Laser Versus Dielectric Mirrors, Ablative Materials Countermeasures," *nextBIGfuture*, November 20, 2017, https://www.nextbigfuture.com/2017/11/combat-lasers-versus-dielectric-mirrors-ablative-materials-countermeasures.html.

34 Lydia Chipman, "The Ten Best Auto Follow Drones," *Wiki.ezevid.com*, October 25, 2018, http://tinyurl.com/y44ebj2r.

35 T. X. Hammes, "Autonomous Weapons Are Coming, This is How We Get Them Right," *National Interest*, December 2, 2018, https://nationalinterest.org/blog/buzz/autonomous-weapons-are-coming-how-we-get-them-right-37532.

36 "What are Small Sats and Cube Sats?" NASA, February 26, 2015, https://www.nasa.gov/content/what-are-smallsats-and-cubesats.

37 Nathan Hurst, "How Daily Images of the Entire Earth Will Change the Way We Look At It," *Smithsonian*, March 13, 2017, http://www.smithsonianmag.com/innovation/how-daily-images-entire-earth-will-change-way-we-look-it-180962467/#J24AmE8xz2EVa3j8.99.

38 Jamie Carter, "Is a 'Live Google Earth' Coming?" *Techradar*, July 4, 2018, https://www.techradar.com/news/is-a-live-google-earth-coming.

39 Tyler Rogoway, "More Details Emerge On Kratos' Optionally Expendable Air Combat Drones," *Warzone*, February 7, 2017, http://www.thedrive.com/the-war-zone/7449/more-details-on-kratos-optionally-expendable-air-combat-drones-emerge.

Atlantic Council

Atlantic Council

1030 15th Street, NW, 12th Floor,
Washington, DC 20005

(202) 463-7226, www.AtlanticCouncil.org