SCANDINAVIAN JOURNAL OF
MILITARY STUDIES

Hammes, T. X. (2019). Defending Europe: How Converging Technology Strengthens Small Powers. *Scandinavian Journal of Military Studies*, 2(1), pp. 20–29. DOI: https://doi.org/10.31374/sjms.24

**PRACTICE-ORIENTED ARTICLE**

# Defending Europe: How Converging Technology Strengthens Small Powers

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NATO's frontline states cannot prevent a Russian invasion using current operational concepts and equipment. Further, there is increasing uncertainty about America's commitment to defending these states as well as the willingness of European peoples to fight. Fortunately, by applying new operational concepts that combine different training for reservists with emerging small, smart, and inexpensive weapons systems, frontline states can create a porcupine defense to defer and, if necessary, defeat a Russian invasion. Other NATO nations can reinforce the frontline states by purchasing relatively inexpensive, long-range cruise missiles that can provide immediate support to the frontline forces. However, to implement this concept, nations will have to rethink how they train, equip, and employ their military forces.

**Keywords:** Baltics; NATO; Emerging technology; IEDs; swarms; cruise missiles; artificial intelligence

The convergence of fourth industrial revolution technologies[1] – autonomous drones, 3D printing, potent explosives, cheap space, and others – make possible a new generation of smart and cheap weapons. They have the potential to be game changers for small NATO nations, but only if governments change their current policies to take advantage of these breakthroughs. Russian aggressiveness backed by its rejuvenated armed forces appears to present an existential threat to frontline NATO members which they cannot stop using current concepts, organizations, and equipment. Compounding the problem, NATO nations, particularly the frontline states, face major internal and external national security issues which make any defense using the current approach questionable.

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 that 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% believed they should. The British were most positive with 49% in favor, the Poles had only 48% in favor – despite 70% seeing Russia as a direct military threat – and only 38% of the Germans polled thought Germany should fight to defend an ally (Simmons, Stokes & Poushter 2015). In the same year, WIN/Gallup Poll conducted a global poll that phrased the question differently and asked if those surveyed would be willing to fight for their own country. The results were much worse. Only 25% of Europeans said yes. Of particular concern, the three largest and most powerful countries had very low numbers with the UK at 27%, France at 29%, and Germany at a dismal 13% (Gallup International 2015).

Even as the will of NATO nations to fight is coming into question, the means have diminished greatly. Today, it is questionable whether individual European nations possess military forces capable of supporting an ally – particularly on short notice. In 2017, Germany, previously one of the most powerful members of

[1] See Klaus Schwab's book *The Fourth Industrial Revolution* for an in-depth discussion. Schwab, K. (2017). *The fourth industrial revolution*. New York, NY: Crown Business. https://www.weforum.org/about/the-fourth-industrial-revolution-by-klaus-schwab.

NATO, was reduced to only 95 operational Leopard 2 tanks and 29 combat ready aircraft, and was even forced to borrow civilian helicopters to conduct training (Woody 2018). At the end of 2017, it had no operational submarines or transport aircraft and was short 21,000 officers ("Germany's lack" 2018). The United Kingdom also suffered from serious personnel and equipment issues. It could only deploy a single brigade in 2017 (Brown & Williams 2017). Clearly, 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 deploy troops – after months of planning and preparation. Even with the extended planning, the deployment of forces to NATO started in August. Admittedly set to a peacetime pace, Trident Juncture provided reassurance that NATO forces can work together, but little reassurance that these forces can deploy quickly to Eastern Europe.

In addition to the severe internal challenges, European nations face major external challenges. Trump's 'America First' policy and his public statements and tweets have been cause for uncertainty about what action America will take in the event of a Russian invasion. By 2018, only 9% of Germans thought America remained a reliable security partner ("Picking up the pieces" 2018).

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 that 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 (Ringsmose & Rynning 2017). 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 48 hours after they receive the order to do so (NATO 2015). 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 to prevent 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" (Shlapak & Johnson 2016: 1–2). But even this would not be sufficient for a sustained defense or to restore members' territorial integrity.

Given the current political climate and military readiness, NATO and particularly its frontline states must consider how to deal with the 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. However, planning for the best case scenario does not have a great historical record. Fortunately, the fourth industrial revolution is providing a second option. Its convergence of technologies will provide small and medium-sized nations with military capabilities that have previously been 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 (Hammes 2016). Deterrence can be achieved through denial, punishment, or a combination of the two. Simply put, if an aggressor knows he cannot succeed or knows the punishment inflicted will exceed any gain, a rational aggressor will be deterred. Obviously, in addition to having the capability to deny or punish, a nation must ensure that the potential opponent knows it has that capability. Thus, an active information campaign is an integral part of deterrence.

Because of these internal and external challenges, including Russia, European NATO nations are faced with a pressing need for creative and effective solutions to their defense planning. This article will examine how small and medium-sized states can exploit the converging technologies of the fourth industrial revolution to deter the Russian conventional threat. Dealing with the threat of a conventional attack in an affordable way will allow frontline states to focus resources on the non-military actions necessary to defeat potential gray zone attacks from Russia. Including this introduction, the article is structured in four main sections: an exploration of the alternative agenda made possible by the fourth industrial revolution; a discussion of the strategic implications, including for the associated concept of deterrence (a porcupine); and finally a conclusion with takeaways for NATO defense planners.

## The Fourth Industrial Revolution and Warfare

### *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 will only have tripwire forces in the frontline states. These forces will be insufficient to defeat a Russian conventional invasion.
4. Reserve forces cannot be trained to regular standards due to a lack of resources, particularly training time.
5. Frontline states are aware that some NATO nations will not respond.

Given these assumptions, it is nearly impossible that a conventional defense of a frontline state will work. Even worse, the Russians will come to the same conclusion. The deterrent value these forces do have 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. And if they decide to fight, it is unlikely that they can arrive in time to prevent Russia from overrunning a frontline state. There is even greater uncertainty about whether some nations would fight to free a state that has been overrun (Pew Research Center 2017). Article 5 only requires that a member state take "such action as it deems necessary, including the use of armed force" (North Atlantic Treaty 1949/2018, art. 5). In effect, NATO members are only required to think about what they might do.

## *The alternative*

Fortunately, five existing technologies have the potential to revolutionize the ability of small states to deter large ones: small warheads, 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 an adversary equipment like the fuel tanks of an aircraft, the rocket pod of a Multiple Launch Rocket System, a fuel truck, or the huge potential of many fixed facilities. In 2017, Russian or Ukrainian separatist drone attacks on a Ukrainian ammunition dump achieved truly dramatic results (Mizokami 2017).

A second approach for increasing the destructive power of a small warhead is the use of an explosively formed penetrator (EFP). An EFP approximately 2.5 cm in diameter with as little as 30 grams of high explosives can penetrate up to 12 cm of steel (ISSEE n.d.). Such a device is small enough to be mounted on a wide variety of small drones and can serve as the detonator. It is also powerful enough that if fired into the hood of a motor vehicle it will destroy the engine. While EFPs have been used widely in Iraq, the insurgents were limited to ground-placed improvised explosive devices (IEDs). Drones can provide a new way to deliver these lethal charges to selected targets. It is also possible to create warheads with multiple penetrators (Fong, Ng, Thompson, & Tang 2004) and self-forging fins (Liu, Gu, Lu, Xu, & Wu 2014) to increase stand-off ranges and lethality.

## *3D manufacturing*

3D manufacturing, also known as additive manufacturing, is the vehicle that will allow the production of tens of thousands of small, smart, but inexpensive drones. As 3D pioneers mastered various materials and techniques, they began to focus on speed of printing. Of particular importance in small drone production is rapid printing of composite material. In April 2016, Carbon introduced a commercial 3D printer that is a hundred times faster than previous printers. With massive new investments 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, researchers at the University of Virginia successfully 3D printed a drone in one day. By snapping in place an electric motor, two batteries, and an Android cell phone, they made an autonomous drone with a range of approximately 50 kilometers. It took about 31 hours to print and assemble the drone at a total cost (excluding the printer) of about $800 (Golson 2014). While it could be controlled by a ground station, the GPS in the phone allowed the drone to fly a specified route autonomously. Such a system would be vulnerable to GPS jamming, but a number of new approaches are being developed that will allow drones to navigate in GPS-denied environments (Bauer, Nollet, & Biaz 2014).

Other programs allow a cell phone camera to identify people and objects even under low light conditions (Grigonis 2017). Combining small warheads, GPS-independent navigation, and cell phone target identification can create autonomous, inexpensive drones that can range for dozens of miles, then hunt and engage specific targets. Think of them as IEDs that hunt you.

Best of all, they can be produced by the tens of thousands. UPS has already created a factory with 100 printers that accept orders, price them, print them, and ship them in the same day from the adjacent UPS shipping facility. UPS has plans to expand the plant to 1,000 printers to support major production runs (Kavilanz 2015). A small factory with only 100 Carbon 3D printers could make 10,000 drone bodies a day. A Carbon 3D manufacturing plant expanded to 1,000 printers could print 100,000 drones a day. The limitation is no longer the printing, but the assembly and shipment of the finished products. Both processes can be automated with robots. In the near future, drones could be produced at a rate exceeding many types of ammunition – and often for less per round. With massive numbers available, it is no longer necessary to ensure that a drone has reliability in the high 90$^{th}$ percentile. Reliability, and hence cost, can be much lower.

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. This threat will not be limited to short-range drones. Long-range air (Aerovel 2014) and undersea autonomous drones (Thompson 2013) are being produced today, and manufacturers are competing hard to reduce the price. Thus, naval and air forces will also be at risk from inexpensive, smart, long-range weapons. In particular, fixed facilities like airbases with be vulnerable.

It is one thing to have access to thousands of drones. It is quite another to have the logistics and manpower available to effectively employ them. One method that demonstrates that it can be done is the Chinese system that mounts 18 Harpy unmanned combat air vehicles (UCAV) on a single five-ton truck. The Chinese can transport, erect, and fire these fairly large drones (nine-foot wingspan) with a two-person crew. A similar-size truck could be configured to carry hundreds of the U.S. Switchblade or Israeli Hero-size drones. Thus, a single battery of 10 trucks could launch thousands of autonomous, active hunters over the battlefield. The key is autonomy, since it would be nearly impossible to provide sufficient pilots for each battery. A swarm of tens of thousands of autonomous, but non-coordinating drones is clearly possible today.

Russian, Chinese, and American companies are already selling drones and missiles loaded into standard shipping containers, which creates two major advantages. First, any truck or ship that can carry a container becomes a potential weapons platform. Second, it is almost impossible to preempt weapons in this configuration; there are simply too many shipping containers to be targeted in a preemption campaign. They can also be hidden in garages, barns, tunnels, underpasses, etc.

Commercial firms are also dramatically increasing the range of drones. The Aerovel Flexrotor has a range of 2,400 kilometers, the Defiant Lab DX-3 over 1,400 kilometers (Aerovel n.d.; Defiant Lab 2017), and the Volans-I can carry 9 kilograms over 800 kilometers at sustained speeds over 230 kilometers per hour (Kolodny & Weaver 2018). While not technically stealthy, the small size of these systems means that they have the radar signature of a small bird (Rogoway 2016). And, like most new technologies, these systems can be greatly improved for relatively little money.

On the military side, progress has been even more dramatic combining range with payload. Israel's currently operational Harop has a range of 1,000 kilometers with a payload of 25 kilograms (Airforce Technology n.d.). The Kratos QX-222 Valkyrie autonomous drone can deliver 220 kilograms of ordnance (a pair of Small Diameter Bombs) a distance of 2,400 kilometers at speeds up to 0.85 mach. Costing only $2 million each, it can also be sent on a one-way mission out to 4,800 kilometers. The QX-222 also makes use of a stealth configuration (but not coatings) to reduce its radar signature significantly. 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.

### *Task-specific artificial intelligence*

There is a great deal of disagreement over when or even if general artificial intelligence (AI) will emerge. While an interesting discussion, it is irrelevant for the purposes of this article. Much more important is the current state of limited or task-specific 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. Hence, in its niche area, task-specific AI creates a distinct advantage for the nation that fields it first.

To create the AI necessary for truly autonomous attack drones, designers must address two issues: navigation and target identification. Task-specific AI has clearly reached the point where it can provide the navigation and target acquisition necessary for swarms of drones to work. The Harpy is designed to use GPS guidance to arrive in a target area and then shift to visual, infra-red, and electronic search modes to identify and attack a target. To defeat jamming, a wide range of institutions are seeking non-GPS-reliant autonomous navigation systems. Just as the Tomahawk combined inertial guidance with visual to achieve exceptional accuracy, new systems are doing the same for a fraction of the cost.

Targeting is a separate problem. It will require the autonomous system to be able to identify a specified target and then maneuver through obstacles to strike it. While this is a very challenging issue, commercial firms are already deploying autonomous air taxis and ground vehicles based on a range of ever more effective, precise, and inexpensive sensors which have obvious applications in improving the hunting capability of autonomous drones. In January of 2019, commercial firms were offering nine different models of drones that could autonomously follow and film an athlete to include dirt bikers riding trails (Young 2019).

Larger drones like the QX-222 Valkyrie sidestep this requirement because they can deliver existing smart weapons such as Small Diameter Bombs and air-to-air missiles. After release, these weapons provide their own navigation and targeting. As the primary function of a strike aircraft becomes getting 'smart' ordnance to the right airspeed and altitude, relatively inexpensive drones will execute that mission and change the cost curve for precision, long-range strike.

A key issue is whether or not to have the drones coordinate their actions within the swarm or simply count on the sheer numbers for effect. Both have potential downsides. Coordination requires communication between drones which is both more expensive and provides a path for an enemy to either jam or seize control of the drones. Sealed drones operating independently will be harder to disrupt, but will inevitably suffer from fratricide when employed in large numbers. Both approaches will probably be developed with coordination limited to more expensive drones, while cheaper drones are treated as rounds of ammunition that do not require coordination. Think artillery Time on Target missions.

A second 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 the vulnerability to enemy cyber or microwave defenses. If one treats a drone as we do other smart munitions, it will not require a recall capability.

### *Cheap space capabilities*

Given the very long range of new drones, a third major technical problem is locating the targets. Until recently, only major powers had access to the space sensors necessary to search very large areas. However, over the last two decades, the development of cube satellites and the infrastructure to launch them cheaply in large numbers has made space imagery commercially available (NASA 2015). Planet, a private company, uses its cube sat network to take sub-meter resolution imagery of the entire planet *daily*, and it sells these images online (Hurst 2017). Planet can provide images based on visual or infrared cameras as well as synthetic aperture radar. The days of hiding military movement on the surface are clearly drawing to a close.

### *Counter-drone*

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 are 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 coatings on the drones (Hambling 2016). Microwave and cyber can be degraded by sealing the autonomous system from outside signals and protecting the electronics with a Faraday cage. 3D printing has reached the point where printers can create a Faraday mesh around the electronics during the manufacturing process. Aircraft and drones can also be equipped with counter-lasers and programmed to roll so that the laser cannot remain on the same spot (Wang 2017).

### *Plus some older technology – cruise and ballistic missiles*

While not new, cruise and ballistic missiles must be part of the conversation concerning the transition from manned to unmanned aerial platforms. They already significantly outrange manned tactical aviation. Thus, unless an air force has massive tanker support, the enemy's missiles can range its fighter airfields. With a range of 2,500 kilometers, the Russian Kaliber land attack cruise missile obviously presents a serious challenge to NATO fixed wing tactical aviation (Missile Defense Project 2016). Russia has announced its plans to field an extended range version (4,500 kilometers) by the late 2020s (Panda 2019). These mobile, easy to conceal, container-based missiles can force NATO tactical aircraft to base much farther from the frontlines and therefore deeply reduce the number of sorties available and create a requirement for many more aerial tankers.

Compounding the problem for manned aviation, advanced manufacturing will cut the cost of cruise missiles. While improved missiles present a major problem for big powers, they provide real opportunities for smaller states.

The combination of inexpensive drones and much more capable cruise missiles offers small and medium-sized states affordable anti-access/area-denial (A2/AD) and precision, long-range strike capabilities. One of the great advantages of cruise missiles is the fact that they can be fired from a variety of land and sea launchers to include standard shipping containers.

### *Plus one very basic technology: IEDs*

In addition to the new technologies, small countries can take advantage of an old technology that has caused major tactical and operational problems for Western forces in Iraq and Afghanistan: IEDs. With some creativity, they can be adapted to be 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. The state could buy sufficient fertilizer to create tens of thousands of IEDs and distribute it to reserve and home guard units. Those units will be trained to create and store the IEDs. As long as the high explosive detonators are not stored with the IEDs they are safe. The high explosives and 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 on the market and replaced with new stocks.

In Iraq, insurgents built thousands of IEDs, some as Explosively Formed Projectiles (EFPs) to increase their destructive power. They proved capable of destroying M-1 tanks. And it is possible to think much larger. For instance, a 20-foot shipping container can hold over 50,000 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 major elements of approaching Russian columns.

## Implications for the Concept of Deterrence

Frontline states can take advantage of the small, smart, and inexpensive revolution to develop a new concept of deterrence. The operational concept is that of the porcupine. A bear can certainly eat a porcupine, but it does not. Rather than trying to match Russian conventional forces or convince the 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.

Reserves and forward-deployed host nation forces will conduct the defense which continues in depth throughout the nation. Remaining host nation regular forces and forward-deployed NATO forces will conduct counterattacks to defeat Russian breakthroughs. To achieve this, the nations will have to change their basic concept of defense and take the following steps.

### *Engineering preparation of the battlefield*

South Korea has developed an extensive engineering obstacle system that heavily fortifies the limited avenues of invasion into its territory. Frontline states could conduct a detailed study to identify key chokepoints and reinforce those points with obstacles to channel an invasion force, before contracting the construction to local firms. This is an area where local terrain knowledge of reserve forces 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 to train 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 and home guard training*

Rather than attempting to train reserve forces to meet Russian armored forces in a head-on fight, they should train their reserves 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 chokepoints to ensure that 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.

If properly trained, organized, and equipped, reserve forces will be able to establish the kill zones before Russian forces can move into their territories. This goes a long way to solving the problem of defeating a sudden Russian attack.

### *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, the nations should conduct a simultaneous launch of inexpensive, autonomous drones that move to a specified range and engage targets. The fact that the Russians will not be able to detect any electronic signals post-launch will demonstrate that 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 50,000-pound shipping container IED.

Demonstrating credible, ready defense capability could also reduce the political pressure from the United States to increase defense spending. Measureable, fielded, demonstrated capability is superior to the crude standard of 2% of the GDP.

### *What happens if Russia develops these systems too?*

If Russia also produces very large numbers of autonomous drones along with its current missile and rocket inventory, 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, then it will be seen and attacked. By the nature of their mission, units on the defense create fewer signatures than units on the offensive. Since NATO's mission is defensive, this situation gives it a strategic advantage.

### *NATO states not in the frontline*

Even if NATO states meet the Wales pledge to spend 2% of the GDP on defense, they simply cannot afford to continue to pursue ever more exquisite and expensive systems. In particular, they cannot afford to continue to purchase frontline fighter bombers. Norm Augustine's Law concerning the exponential increase in the cost of modern aircraft continues to be in effect ("Defense spending" 2010). Thus, manned aircraft will remain on the wrong side of the cost curve since Russian missiles, which outrange modern fighter bombers, cost a fraction as much.

Fortunately, the fourth industrial revolution can provide those NATO states willing to support the frontline states with relatively inexpensive options. For instance, rather than buying a $ 100M-5$^{th}$ generation fighter, a nation could buy 50 of the vertical launch-and-recovery QX-222 drones. Vertical takeoff and landing drones do not require the massive investment in air and missile defense to defend fixed airbases. Nor do they require the operational, training, personnel, airbase, and maintenance costs necessary to operate a fighter. Hence, a nation could actually buy a multiple of 50 QX-222s for every fighter it forgoes. Rather than 27 F-35s, Denmark could have purchased 700 long-range drones and still had half its procurement money to extend its F-16 fleet. When combined with the existing F-16 fleet, the drones will provide a much greater challenge to Russia.

To further complicate Russia's problem, states can purchase cruise missiles to provide both sea denial capabilities and responsive deep fires. 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 Sea or Black Sea. The much longer range (2,500 kilometers) of land attack cruise missiles can provide a way for NATO states to provide immediate fire support to nations under attack – as well as neutralize Russian airfields. And they can do so without deploying forward. Thus, the Russians cannot attempt to interdict their movement forward or suppress them with a preemptive attack. There are simply too many places where a nation can store and launch containerized missiles. Even if they could locate the tens of thousands of potential hiding places, no nation has enough ordnance to attack every standard shipping container that might contain a weapon.

If NATO chooses to deploy forces forward, units equipped with standoff weapons in standard shipping containers will not require special trains, trucks, reinforced bridges, etc. Any commercial route and vehicle combination that can handle a standard shipping container could deploy these forces. Thus, these systems can provide rapid thickening of frontline state defenses and, as part of an information campaign, demonstrate NATO resolve.

## Conclusion

The fundamental problem for European defense planners is that their populations will not fund the massive buildup of conventional weapons needed to deter Russia. Several issues expand this beyond the realm of political will. First, defense planners have to struggle with the rapid increase in the cost of modern, conventional weapons. Augustine's Law, that the cost of fighter aircraft increases exponentially, remains in effect with the F-35. Thus, even if a nation can buy the F-35, it is unlikely that it can afford the next generation of manned aircraft. More importantly, today's cruise missiles and drones outrange the F-35 and may be rendering it obsolete. Efforts to extend the range of the F-35 include the JASSM-ER extended range cruise missile which will have a range of 800 kilometers. The question obviously becomes: If cruise missiles are ranging out to 2,500 kilometers (with planned systems extending the range to 4,500 kilometers), why buy $100M aircraft to launch missiles that can only reach 800 kilometers?

The combination of the huge costs of modern weapons and the development of relatively inexpensive options that can defeat those exquisite weapons should provide ideal conditions to rethink current operational concepts and procurement programs. Even better, historically military innovation has succeeded when developed to solve specific tactical and operational problems against a specific enemy in a specific theater.

The frontline states face the specific problem of how to deter Russia from attempting to seize their territories in a quick conventional invasion. The more distant NATO states have to find a way to support the frontline states that is affordable and politically feasible. Fortunately, a combination of emerging technologies, older technologies, and new operational concepts can solve both problems.

For the frontline states, deterrence will only be credible if the Russians believe those states can either deny their forces or inflict more punishment than any gains are worth. Thus, they need to shift from current operational concepts based on fighting a symmetrical conventional force battle to using the cheaper asymmetrical approaches enabled by new technology. The key is for defense decision-makers to start the shift now. Start by reorganizing the training, equipping, and employment of reserve and home guard forces. The willingness of their citizens to come forward in defense of their nations is commendable. Their defense leaders should not force them into a direct confrontation with Russian forces that they are doomed to lose. Rather let these civilian soldiers exploit their advantages in local knowledge and creativity to present the Russians with an innovative and difficult-to-defeat challenge.

The supporting NATO states will have the major challenge of uprooting the conventional military organizations and making them accept that they should no longer purchase fighter aircraft, combat ships, or armored forces. These systems will remain in their forces as they build, field, train, and test the new concepts and systems. Then, like all previous weapons systems, they will be phased out in favor of superior new approaches. It is critical that each nation understands that concepts, new organizations, and training are every bit as important as the new technology. All must be developed in conjunction.

The bottom line for frontline states is that they cannot count on current forces or NATO reinforcements to stop a Russian conventional invasion. Thus, they can either rely on NATO forces to rally and eject Russian forces or 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 which 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 Russia with a genuine deterrent today.

## Competing Interests

The author has no competing interests to declare.

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**How to cite this article:** Hammes, T. X. (2019). Defending Europe: How Converging Technology Strengthens Small Powers. *Scandinavian Journal of Military Studies,* 2(1), pp. 20–29. DOI: https://doi.org/10.31374/sjms.24

**Submitted:** 15 December 2018 **Accepted:** 25 January 2019 **Published:** 25 March 2019



SCANDINAVIAN MILITARY STUDIES

*Scandinavian Journal of Military Studies* is a peer-reviewed open access journal published by Scandinavian Military Studies.

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