



THE CONNECTIVITY CHALLENGE

FIRST LESSONS FROM UKRAINE

TECH INSIGHTS

NETWORKED SOLDIERS CREATE MILITARY ADVANTAGES

Connected soldiers have shaped the early outcomes in Ukraine, allowing the outgunned Ukrainian military to stall and redirect the invading Russian forces. While the long-term outcome is uncertain, the Ukraine conflict offers important early lessons for soldier modernization programs worldwide.

The Ukrainian Advantage Is Networks at the Tactical Edge

In Ukraine, the “sensor-to-shooter” chain is short and information moves fast, because networked sensors are everywhere. Citizens with cellphone cameras and small drones operated by forward units can deliver target information directly to Ukrainian combat units in real time. This allows Ukrainian artillery batteries and Javelin-equipped infantry units to target Russian units without warning. The combination of a huge network of connected sensors with small units equipped with precision-guidance weapons has helped Ukraine blunt the

Russian offensive and impose heavy costs on Russian units that enter or move within the reach of the sensor network.

The innovative aspect of this approach is that intelligence moves directly from sensor to shooter, with neither sensor nor shooter needing to know who the other is. Information enters a distributed tactical network, and units able to exploit the information are equipped to do so. No up-and-down chain of command delays are needed – target information can be acted upon as it enters the network. Speed and integration – not mass or firepower – create tactical advantages for the Ukrainian side.

Networks Combine Military and Civilian Resources

Unique combinations of military and civilian resources are the foundation of the Ukrainian distributed tactical network. On the civilian side, Starlink – a civilian satellite internet constellation that provides high-speed, low-latency broadband internet using advanced satellites in low earth orbit – is now operating in Ukraine with over 10,000 dish antennas.¹ Starlink enables members of the Ukrainian military to carry

out sophisticated intelligence collection and fire support operations against Russian positions. Many of the Starlink kits donated to Ukraine include a 23-inch-wide receiver dish and a cable connected to a simple router that projects a Wi-Fi internet signal. Starlink helps because it is hard to jam and allows target information to be widely available¹.

Artillery batteries and infantry units receive target information directly over Starlink on networked computer tablets². The local units can then use traditional fires-planning methods to carry out strikes by direct or indirect fire. This method eliminates drawn-out daily target-planning processes and allows the Ukrainian military to maintain continuous pressure on Russian forces. In turn, continuous pressure means that Russian units are less able to mass firepower or develop coordinated large-scale attacks.

Flat and Fast

In the first months of the conflict, Ukrainian units have been effective because they receive target information over flat, fast networks using cellular, wireless voice and text information. Target intelligence generated from drones allows Ukrainian anti-tank and artillery units to engage targets as rapidly as they appear. The Ukrainian military uses more than 6,000 drones, mostly manufactured in China. Most of the unmanned aerial vehicles are commercially available multirotor craft typically used in the media, agriculture and engineering sectors. They can operate for up to 30 minutes and as far as 7 kilometers (4.3 miles) into enemy territory³.

Small teams of soldiers control the drones from off-road vehicles near the front line, relaying location and topographic data to artillery batteries via military channels on the Telegram messaging application. The basic technique is similar to techniques applied by the Taliban to identify and target NATO forces in Afghanistan, although the Ukrainian forces have far greater firepower and more sophisticated drone technology.

Inexpensive, widely available technology – cell phones and camera-equipped drones – linked directly to small units with precision-guided weapons has provided a significant tactical advantage in the early stages of the war in Ukraine. Other countries with limited defense resources are already adjusting their plans and budgets to capture the advantages of this approach.

THE WORLD IS WATCHING

The war in Ukraine is being watched particularly closely on Taiwan. One of the most important lessons for the island is about the kinds of weapons it seeks to buy, according to senior defense officials. Previously, Taiwan focused on flashy platforms such as F-16 fighter jets or M1A1 Abrams tanks, instead of the kinds of asymmetric capabilities that could inflict greater damage on an invading force. Taiwan's military is now re-focusing on drones, anti-tank missiles and network capabilities on the Ukrainian model⁴.

More than 8,000 kilometers (4,970 miles) away, the tiny European nation of Moldova is drawing similar conclusions. "The war in Ukraine is changing the whole concept of assuring the security of our citizens," says Viorel Cibotaru, the country's former defense minister. "To respond to military aggression, Moldova would need modern weaponry like Javelins, anti-aircraft systems, and weapons for light infantry." ⁵

Soldier modernization programs are underway in nearly every land force. These programs range from basic upgrades of personal weapons and protective equipment to integration of artificial intelligence and augmented reality, and they will shape the capabilities of land forces for decades. What can the early experience in Ukraine teach us about the requirements and limitations of soldier modernization programs?

EARLY LESSONS FROM UKRAINE: NETWORKING, ADAPTABILITY AND SIMPLICITY

The Ukraine conflict may not be resolved soon, and the outcome remains uncertain. At the same time, some lessons are emerging from this tragic conflict that may be useful guides for investments in soldier modernization programs.

Flat, Fast Networks Link Sensor to Shooter

Ukraine's effectiveness in the early stages of the conflict did not emerge from superior firepower, or from advanced AI processing of target information. Rather, Ukraine's forces were effective because they were able to exploit data from ubiquitous sensors – in this case, cellphone cameras, citizen observers and inexpensive drones. By moving this data across a commercial messaging application (Telegram) directly to infantry and artillery units, Ukraine was able to

create tactical advantages. Satellite internet services like Starlink helped ensure that this self-generating network of sensors and shooters remained operational and kept the network secure against physical or cyber attacks.

What does this mean for soldier modernization programs? Rather than focusing on highly-advanced soldier applications such as artificial intelligence or language processing (the model used by the US Integrated Visual Augmentation System (IVAS) and similar systems), the Ukraine experience demonstrates that shooters need basic connectivity to target information using commercial technologies. Networks that can connect commercial cell networks to military radio and deliver voice, data and video are ideal for the environment developing in Ukraine.

This technology is already available, although not in wide use. Mobile ad-hoc networking (MANET) solutions allow sensors and shooters to share GPS, high-definition video, text messages and voice communications. Linking commercial cell and military radio networks can be accomplished using this technology. With this solution in place, infantry and artillery units can exploit citizen-generated targeting data.

Open Architectures Allow Adaptation to Emerging Technologies

Ukraine's military has operated with new technology from many sources, including drones from Turkey and China, anti-tank systems from the UK and US, vehicles and communication systems from NATO countries, and its own military systems. Connecting these technologies and allowing rapid transfer of basic targeting information requires open systems and API's.

Soldier modernization programs that focus on developing a closed ecosystem of sensor and communications technologies are ill-suited to this environment. Modernized soldier systems take advantage of the lessons from Ukraine when these systems are open to integration of new technologies that transmit and receive digital information.

The open-systems approach benefits from common physical connections between devices, such as those provided by the Nett Warrior or NATO STANAG 4695 standards, or even USB and HDMI standards used for commercial technology. The key requirement is for modernized soldier systems to be open to digital data transmitted from the widest possible range of commercial and military systems.

SIMPLICITY ENABLES RAPID ADOPTION

Complicated systems with extensive feature sets have not been widely adopted in Ukraine. Instead, soldier systems are basic and sturdy: cell phones, simple drones, basic artillery fire direction systems and soldier-portable antitank systems. Ukrainian forces had to expand rapidly, with volunteer service members and little time to train. In this environment, soldiers need technology that requires little or no training. Applications like Telegram, communications over cell phone, and basic video captured through drones have produced significant tactical advantages.

Soldier modernization programs can exploit this lesson by delivering connectivity between individual soldiers and civilian sources of information. In Ukraine, soldier systems are used to answer four basic questions: Where am I? Where is my unit? Where is the enemy? What is my mission? Technology that contributes to answering these questions, and is easy to use, gains rapid adoption and generates tactical advantages.

At higher levels of command, where space and time exists to allow analysis of tactical data, more complex technologies like artificial intelligence and data visualization can be usefully applied. But the early lessons of Ukraine show clearly that simple, rugged networks that can deliver voice, data and video in real time are helpful to soldiers.

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