

Center for Strategic and International Studies

TRANSCRIPT

Event

“The Russia-Ukraine Drone War: Innovation on the Frontlines and Beyond”

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Gregory C. Allen: Good morning. I'm Gregory Allen, the director of the Wadhvani AI Center at the – here at the Center for Strategic and International Studies.

Today we've got a really exciting event on "The Russia-Ukraine Drone War" and all the kinds of technological innovation going on in that drone war, including but not limited to AI and autonomy. And we're extremely fortunate that two of the foremost scholars studying this conflict are here with us today to give exceptional presentations on just what exactly is going on and how it's evolved over time.

So here's how today's event's going to go. Pretty soon we're going to start with a presentation by my CSIS Wadhvani Center colleague Kateryna Bondar, who's going to talk about the Ukrainian side, and how they've incorporated drones into their armed forces, and what technologies and strategies they've done to be so effective. Then we're going to go over to Samuel Bendett, who is a non-resident scholar here at CSIS and also a senior advisor to the CNA organization, and he's going to study and talk about his work on the Russian side of the equation.

Russia and Ukraine and this war has been an unimaginable transformation in so many different aspects of conflict and technology. And that's why I'm mostly excited to be, just like you in the audience, learning and listening from this presentation. So, without further ado, let's go over to my colleague Kateryna Bondar.

Kateryna Bondar: Hi. Good morning, Greg.

Mr. Allen: Good morning.

Ms. Bondar: Thanks for having me.

So let's start with Ukraine. Ukraine operates its unmanned systems across all three domains – in air, sea, and land – and we will start with air.

So, first, we have to remember that Ukrainian war has started in 2014, and at that time the most common drone which was deployed on the frontline was Chinese DJI Mavic drone. It was quite expensive; it was \$2,000. And mostly it was acquired by Ukrainian soldiers, so they couldn't afford to buy a lot, but it already has proved to be really efficient for ISR missions.

So Ukrainian manufacturers saw a potential in this ISR mission and they started producing their own systems. So these were the first systems developed by Ukrainian manufacturers for ISR missions before 2022, before full-scale invasion. And by the way, they are still operational, way improved, and work much better.

So, with the full-scale invasion, the most common drone has become an FPV drone. FPV drone is a first-person-view drone. And basically, what it is? It's a set which consists of a pretty simple quadcopter, a remote control station, and goggles so, basically, an operator can see what the drone sees when it's flying. And these drones are much cheaper already, so their average cost is about 200 (dollars) to a thousand dollars. Their range is not that big, so they can fly five to 15 kilometers on average. And their payload is also not that big because these are pretty small drones.

I said "pretty small," but now what we can see on the frontline is that these drones are getting bigger and bigger. We started with a seven-inch drone in 2022, and these drones became much bigger and increased to 13-inch drones used in 2024 and 2025.

So why these drones are, basically, getting bigger? Because they need to carry additional equipment. And what is happening is that an FPV drone has become a universal platform. So, as we can see here, we take an FPV drone as a base, and dependent on which equipment we attach to this drone it can become a bomber. It can become an ISR drone if there is a camera. If this is a relaying system, it becomes a relaying drone.

So drones can also be AI-enabled, and let's get back to this integration. So how AI is integrated into an FPV drone? Basically, by attaching also a module which sometimes consists of a camera and a chip, and we will see this a bit later. And in such a way, these drones can be enabled with two main functions. And these two main functions is autonomous navigation – and last-mile solution as part of this function – and automatic target recognition. So, basically, this is usage of computer vision systems which help the operators to recognize objects and lock on the target so the drone can reach the target more efficiently and strike and hit the target.

So these are the most, probably, common ways of how AI is integrated with a drone. It can be a module like this, which consists of a chip, so, basically, these kind of chips are hidden in here and then attached to, basically, any platform, any hardware. It can be an FPV drone and it can be a fixed-wing drone. And sometimes they are integrated with a camera already, so there is a chip and a camera, and mostly these systems are used for so-called targeting.

Mr. Allen:

So early in the war there were already drones. The drones already had cameras on them. And then if you want to include AI capabilities, you need a beefy computer chip that's capable of actually reading that video. So the pilot maybe is still flying the drone, but now there's also this chip that is interpreting the video live.

Ms. Bondar: : Exactly. So the analysis is happening on the drone, in the drone, and the operator already sees pre-analyzed information. So it transmits the analyzed information to the operator.

But AI is really hard. Let's be honest. It requires a lot of resources. It requires a lot of development. And basically, AI plays the main function of overcoming jamming and spoofing. And as I said, it's hard, so Ukrainian developers came up with a much simpler solution. It's, basically, attaching a drone to a cable, and this is how fiber-optic drones have appeared. So their range – and Ukrainian manufacturers claim that their range can go up to 40 or 50 kilometers, but their payload is much lower because they have this additional equipment as you can see, which carries this cable, and it's pretty heavy.

Mr. Allen: So this thing is literally going to go 40 to 50 kilometers and it's carrying this cable the whole way. There's no radio communications because they're concerned about interception or jamming or – wow.

Ms. Bondar: Exactly. Exactly. And the quality of this connection is actually way better than the radio connection or any wireless connection, let's say. So it gives, actually, more opportunities.

So let's talk about a different class of drones, which is called Baba Yaga drones. These drones, as you can see, they are multi-rotor drones, and they actually come from agriculture. Ukraine is an agricultural country, and Ukrainians use these drones for spraying the fields, for monitoring the fields, but now actually you can attach bombs here and it becomes a really efficient bomber. It can go pretty far across the frontline and it can bomb positions and actually come back, which saves a lot of resources.

So now another version – and here we get in a bit of swarming concept – is a mothership drone. So this is the recent development of Ukrainian manufacturers. It's basically a fixed-wing drone which can carry up to six FPV drones. So it flies over the Russian position and then releases these drones, which can execute the mission whatever it is. And this drone is actually playing a role of a relaying drone, so it can transit the signal to its smaller FPV drones.

So –

Mr. Allen: So it is the communications relay station.

Ms. Bondar: Yes. Yes.

Mr. Allen: I see.

Ms. Bondar: Can work the same way.

So a separate class of Ukrainian development is long-range drones. These are just some examples, and basically these are the drones with which Ukrainians make deep strikes deep into Russian territory. It started with just filling with explosives usual commercial small planes and making them remotely controlled and sent to Russian territory, but now Ukrainians have developed their own drones, probably coming from Bayraktar models, more or less. But Lyutyy and Bober, these are the most popular models that are used to bomb Russians and to bomb Russian territory.

Mr. Allen: So if quadcopters have a range of five to 15 kilometers, those drones would have the range in 50, 100, 200 kilometers?

Ms. Bondar: So President Zelensky claimed just couple of weeks ago that these drones can fly up to 3,000 kilometers.

Mr. Allen: Wow.

Ms. Bondar: So, basically, covering all Russian territory where they have any strategic objects, because further is only Siberia and forest.

So, based on those achievements, Ukrainians have developed a new class of unmanned systems, at least this is what they call it. It's a missile drone. Basically, the opinions of experts differ here. Someone says that it's a cruise missile. Someone says it's a drone. But basically, most probably this is a drone with a turbojet engine. So we know – this is a very highly classified program, so we don't know many details. But these are two systems that are – that have been announced, and this is the pictures that we can get.

Mr. Allen: And they have a jet engine, not a propeller engine like some of these other ones.

Ms. Bondar: Yes. Yes.

Mr. Allen: Yeah.

Ms. Bondar: And the last but not least class of drones are drones interceptors. So, as we know, Russians bomb Ukraine with Shahed drones almost every day and there is a need to intercept those drones. And one of the ways to do this is with the help of drones interceptors. So there's also a couple of types of those drones: Fixed-wing drones; they might be quadcopters, depending on which altitude they're flying and where you want to intercept them. And the most recent development – sorry for this not-very-high-quality picture, but it's the only one that we have – it's a Sting system. So this is basically a quadcopter drone, but it can fly high, up to 3,000 kilometers. So – and, yeah, intercept Shaheds on this altitude.

So let's switch to the next domain, and it's sea. So, first of all, humans were trying to make unmanned systems, sea systems, for centuries, but there was one little issue, which was connection. And this issue was overcome by Ukrainians with the help of a small, little thing, and you will see the answer on this picture, and this is Starlink. So, basically, the answer to this problem of connection was found with the help of Starlink, and Ukrainians just started integrating first this kind of Starlinks, then mini-Starlinks, and now those drones can go as far as 3(00), 400 kilometers and strike Russian, specifically Black Sea Fleet, on big distances.

So these are the most, again, popular types of Ukrainian sea drones. Sea Baby is used by Security Service of Ukraine. Magura is the most famous and famed system, is used by defense intelligence. And this is a new type which was just presented but I haven't heard that it's been used yet.

So if we're talking about Magura drones family, it started with Magura 5, which is basically a boat having a camera and Starlink on this, and you can put, like, a hundred kilograms of payload and send into the Russian ship. And then it was improved with air missiles, and sometimes Ukrainians even put a ship gun there, and this system is called Magura 7. We can see that it's much bigger than the previous version, but they both are being used in Ukraine.

Mr. Allen: So with these first ones, I mean, to me just eyeballing it, I mean, that looks like a commercial consumer speedboat that has been retrofitted to be remotely operable via satellite connection, and that's basically the story, whereas this looks more like a true warship custom-built kind of a thing. Is that accurate?

Ms. Bondar: Yes. This is how it started, basically. It started with just filling ski jets with explosives or just a boat, so that's exactly the impression it has and that was the origin of this system.

And let's quickly talk about land systems, because they appeared much later. They started to be developed in 2023, mostly, because unmanned ground systems are much harder, are much more expensive, and they have way more challenges to be developed and to be actually delivered to the frontline to be deployed, to be serviced, et cetera, et cetera. And their average price is already much higher, so you have to consider where you use an unmanned system and where you're not, and should it be a ground system or air system.

So they play different roles and they have different functions, and we will start with the most common. And the most, I would say, useful and efficient is basically logistics. So it allows to save soldiers' lives and people's lives when evacuating wounded soldiers, so you can see a platform for evacuation here, and just delivering supplies to the trenches and to the

frontlines. So they can be on wheels. There are also a lot of experiments with crawlers. You just – these are just examples that are available on the market.

Another big part of functions, let's say, is mining and demining. So, basically, the same systems can be used for both. But again, as we can see, there is a lot of experiment going on. There is not – there is no common or perfect design yet. So these are systems for mining. We can see a lot of mines here. They can –

Mr. Allen: This is offensive mining, not demining, right?

Ms. Bondar: Yeah. Yes, this is mining. So the mines can be put in such a way, in this way. There should be, like – they can be, like, really small, little things. So for different, different purposes, there are different systems.

And, of course, they can be kamikazes as well. And mostly, it is used like you just put a landmine on it and you send it into the trench, and this is where the trench is not a – (laughs) – shelter anymore and it just blows up, so. But these systems are not \$10,000; these are a bit more – a bit cheaper, around \$2,000, so it still makes sense to use them rather than using infantry to do these offensive missions.

And the last mission is offensive mission and offensive function. But – (laughs) – strikingly – and this looks really cool, right, a system which can go autonomously and which can shoot – but practically, this is the least-useful function and least-used function on the battlefield today just for one simple reason, because the technology is not perfect and it's really hard to shoot precisely using this UGV. So it's hard to balance it. It's hard to fix it. If it's moving, it's really hard to shoot precisely.

So there are sometimes additional systems. These sometimes can be even AI-enabled to recognize objects, to lock on the target. But still, the system, the terrain itself, it's really hard to manage to make it –

Mr. Allen: So the one that is probably closest to the typical American's mental model –

Ms. Bondar: Yes.

Mr. Allen: – of a warfighting robot is actually the one that's the least mature and arguably the least useful, at least for right now, yeah.

Ms. Bondar: Exactly, exactly.

So that was the short overview of Ukrainian unmanned systems and their deployment on the frontline, and that's it from my side.

Mr. Allen: Great. So, well, thank you, Kateryna, for that amazing overview of the universe of unmanned systems that we have operating in the Ukrainian armed forces.

Now we're going to turn to Samuel Bendett, who's going to give us an overview of the Russian side of the equation. And I should say that I've known Sam for almost a decade now, and he has been one of the leading researchers on Russian unmanned systems for over a decade, long before it was a popular topic of study here in Washington, D.C. And so we're so privileged that he's part of the greater CSIS community and so privileged that he's here today to give us this incredible overview. So, Samuel, over to you.

Samuel Bendett: Thank you, Great. And thank you to CSIS for hosting us and for hosting this discussion.

I'm going to talk about some of the key Russian developments and some of the key trends we're witnessing in this war. I think it's important to preface this discussion by noting some of the main developments that took place before 2022, before Russia's mass-scale invasion of Ukraine. And I think a lot of the developments here are similar to the ones that were witnessed world over, and that is the research, development, testing, and evaluation cycle for robotic, autonomous, and unmanned systems was rather lengthy. There was really no pressure on the military or any military to really speed anything up. There was an emphasis on some of the more expensive and more exquisite platforms that was – that cost a lot of money, those that actually looked very cool. Russians concentrated on some of the combat UAVs, some of the long-range ISR platforms. They concentrated on some of the larger and more expensive unmanned ground vehicles that were full of sensors, cameras, and all kinds of equipment.

At the same time, Russian military was monitoring some of the key developments that were taking place world over, including in Syria where they were involved after – I believe after 2015 or 2017. And Russian military actually tested some of their technologies there, but also on a very limited scale. Russians were monitoring the war in Nagorno-Karabakh that took place in 2020 that utilized loitering munitions, ISR drones, and placed a great emphasis on air defense systems. And Russians were monitoring the use of some of the long-range runway attack drones by Houthis against targets in Saudi Arabia on the Arabian Peninsula, as well as in the UAE.

But the development of most of those systems was basically concentrated in a few defense industry majors, so there were just a few companies that were working on a lot of equipment. But most of the attention and most of the resources was concentrated with them.

Russians, of course, were developing different types of UAV ISR platforms, so drones for intelligence, surveillance, and reconnaissance. But again, this was a rather slow development. And in fact, the year 2022 was supposed to be the year when Russians were going to test a lot of those equipment in various military exercises. And then, of course, when Russia invaded Ukraine, a lot of these plans – a lot of these technologies – actually turned out to be not necessarily unsuitable for the type of war that resulted in Ukraine, but it was very clear that a very different approach was necessary.

And so, just like in Ukraine, Russians are utilizing and developing similar types of technologies. In fact, Ukraine is a mirror image – Ukraine war is a mirror image of military development, and so Russians and Ukrainians are trying to copy some of their successful designs and develop countermeasures to them. The key to the war in Ukraine right now when it comes to autonomous, robotic, and unmanned systems is a very quick research, development, testing, and evaluation cycle. It has shrunk from years to now weeks, and at most several months.

Another interesting defining feature of Russian military development of these systems is the fact that the development has now sort of migrated and morphed away from some of the defense industry majors to a very rapidly growing volunteer and startup community. So for the first time in its history, Russia actually has a semblance of a private military industry where civil society has stepped up to deliver some of the products and materials that were absent in the Russian military, starting in mid-2022 when it became clear that this war would be stationary, attritional, and possibly long term. Russians are, in fact, working on a lot of systems that were shown in Kate's presentation, and I'll get to that in just a few seconds.

Another defining feature of this war are sheer numbers. And in the beginning of this invasion, Russia probably went in with its pre-2022 fleet of approximately 2,000 UAVs. That's the number that was quoted in all official publications. Well, now we're dealing with millions of UAVs on a regular basis. So last year Ukraine utilized about 1.5 million UAVs in total; Russia probably utilized up to 4 million UAVs. And there are so many developments which are taking place –

Mr. Allen: I mean, those are like – those are like artillery shell numbers.

Mr. Bendett: Exactly.

Mr. Allen: Wow.

Mr. Bendett: Exactly. And in many ways, drones are actually replacing artillery shells where artillery shells are absent or in very short supply. And now, after several years of this conflict, after all of this technological development, and

after all of the – all of the systems that were used in the war, Russians are saying that they and the Ukrainians are actually ahead of the entire world when it comes to the application of many tactical technologies such as UAVs and counter-UAV systems.

So Russians are using very similar systems to the ones that we've seen in Kate's presentation, and Russians are also using long-range, mid-range, and of course short-range and close-range UAVs. One of the biggest Russian successes in this war has been its import from Iran, the Shahed drone, that Russia received in 2022 and has since modified to give it greater capabilities. In fact, there are so many Shaheds manufactured in Russia under the Russian name of Geran that Russians can launch attacks with several hundred of these drones at once alongside with missiles. Russia is on track to manufacture many thousands of these long-range Shahed-type drones for its war, and is, again, modifying them to include a jet engine and more advanced features. These drones have a range anywhere from several hundred kilometers to over 1,500 kilometers, so these drones can also cover the entirety of Ukraine. And in fact, whenever a drone attack happens over Ukraine Shaheds are always the culprit.

Mr. Allen: And this is – you said has a range of up to 1,500 kilometers. What's the price point for one of these things when you think about, like, what it costs Russia to manufacture and launch one of these?

Mr. Bendett: So it probably varies depending on the version of the Shahed, but it's been quoted anywhere from 20,000 (dollars) to 50,000 (dollars) or \$70,000.

Mr. Allen: Which is just shocking, right? Because if you think about going back 20, 25 years, if you wanted a missile that was going to be decently accurate and have a range of 1,500 kilometers, we're talking hundreds of thousands or millions of dollars a shot.

Mr. Bendett: Right, right.

Mr. Allen: And this has now brought it down to tens of thousands of dollars per shot for that range and that precision, which is –

Mr. Bendett: Exactly.

Mr. Allen: – just sort of the war that we're in right now.

Mr. Bendett: Exactly.

And just like Ukraine, Russia's concentrating on mass. So they're manufacturing very large numbers of different types of drones which are expendable, which are attritable, which are easily replaceable – again, in

contrast to Russia's thinking before 2022 when a lot of the UAVs, for example, were designed for long-term multi-range mission requirements and were probably a lot more expensive.

Russia's also utilizing a lot of intelligence, surveillance, and reconnaissance UAVs such as the Zala that's pictured here alongside the Orlan, the Eleron, the Supercam, and the Albatros family. Russia's using lots of mid-range loitering munitions like the Lancet as well as the KYB, which have a range anywhere from, let's say, 15 to 20 and up to 70 kilometers. So these drones can now strike Ukrainian targets well beyond the line of contact, and they can disrupt logistics and communications.

And in fact, Kate actually highlighted the importance of interceptor drones. Those UAVs were developed to go after Russian ISR UAVs, which were becoming extremely important to the Russian military and very successful at monitoring the entirety of Ukrainian battlespace.

And just like the Ukrainian UAV developers, Russians are also utilizing a very large number of FPV drones. Commercial quadcopters like DJIs, which are still irreplaceable because Russians were unable to really come up with their own version of a DJI drone to replace the dependence on these imports.

Mr. Allen: It's interesting you say this because DJI, obviously, the largest commercial and industrial drone manufacturer in the world.

Mr. Bendett: Right.

Mr. Allen: It's a Chinese company. China has said they've cut off both Ukraine and Russia from these drones.

Mr. Bendett: No, not really.

Mr. Allen: But you're saying it's still incredibly widely used.

Mr. Bendett: Yes, and they can be purchased at any number of physical or online marketplaces. Russian soldiers are always fundraising for DJI Mavic drones for ISR and combat missions. And again, Russia and Ukraine are trying to come up with their own alternatives to a DJI, and there are models and there are certain types already in service but not quite the ones that can actually replace the DJI.

Mr. Allen: And even when they come up with an alternative, they're probably using the same spare parts ecosystem that feeds DJI, right?

Mr. Bendett: That's possible.

Mr. Allen: Yeah. Yeah.

Mr. Bendett: And of course, another issue is the price point. DJI has become very cheap. Developing an alternative to a DJI means you have to come up with your own domestic components, which sometimes means more expensive manufacturing, and the cost of a DJI replacement can actually rise significantly.

Mr. Allen: Yeah.

Mr. Bendett: And Russians are also using a number of fixed-wing UAVs, one-way attack drones. Russians are utilizing radio-controlled as well as fiber-optic-controlled UAVs in this war. In fact, Russians were the first movers when it came to utilizing fiber-optic UAVs at scale. They used them against Ukrainian forces in the Kursk region after Ukrainians invaded Russia in 2024. And these drones have become extremely successful in disrupting Ukrainian logistics and supply lines, and were in a large part responsible for pushing Ukrainians largely out of Russia's Kursk region.

On unmanned ground vehicles, again, the developments are very similar to those in Ukraine. The emphasis is on cheaper tactical, attritable systems, those that could be easily built and easily replaced. It's interesting that most of the UGVs used right now in this war are very small types for very simple tasks like the ones that Kate has described for logistics, for supply, for mining/demining, one-way kamikaze roles. Fewer UGVs are used for actual combat. And a lot of them are actually coming from this volunteer startup community, this private military enterprise known in Russia by the moniker of People's VPK. "VPK" stands for military-industrial complex. So the People's VPK supplies parts and components and sometimes ready-made UGVs to the front, so much so that the Russian defense minister remarked a few weeks ago that the most successful UGVs he has seen are the ones built by soldiers themselves at the front.

So, just like with the UAVs, there's an emphasis on commercial components. You can quickly cobble together a UGV from commercial parts like hoverboards or anything that you can get your hands on. Most of them are radio-controlled. A lot of them are now switching to fiber-optic control to overcome the electronic warfare and other jamming. And in fact, some of these smaller UGVs are also starting to come out of Russia's defense-industrial enterprises as well. So the big and the expensive are still there, but the emphasis is on the small, the cheap, the attritable in very large numbers.

Mr. Allen: And one more thing on the ground vehicles. I just want to emphasize everything you're showing is using tank treads or wheels.

Mr. Bendett: Correct.

Mr. Allen: So while there's a lot of sensational media about a future of walking-leg robots or humanoid robots, nobody on the battlefield is using that today, right?

Mr. Bendett: I think Ukrainians are experimenting with some of these robot dogs.

Mr. Allen: Oh, really?

Mr. Bendett: Russians also want to follow suit. But you go for the practical.

Mr. Allen: Right.

Mr. Bendett: And you go for something you can use right now, you can build it very quickly. Again, and if you lose it in combat, it should be easily replaced.

Mr. Allen: Right.

Mr. Bendett: On the unmanned surface vehicle developments, Russians are actually admitting that Ukraine has the advantage. Ukraine was the first mover in building out systems enabled by Starlink to go after Russian Black Sea Fleet. In fact, it has done horrendous damage to the Russian Black Sea Fleet. And Russians went to the drawing board, and they didn't necessarily get rid of their pre-2022 developments in USVs but they looked at what Ukraine has, and they copied in some form some of their designs. And so the USVs that the Russians are advertising today, which are ready to go into production, kind of look like the ones that you've seen earlier in the presentation.

They are simple boats. Some of them are actually also enabled by Starlink. Some of them are enabled by Russia's version of Starlink, although they're not necessarily going into details. They want to use USVs for monitoring the Black Sea area around their fleets, around their ports, around their bases. They want to use USVs to go after Ukrainian unmanned surface vessels. So they want to place weapons on them, bombs. Some of them are now carriers for FPV drones and other types of UAVs to go after Ukrainian targets at sea and on shore. So there's about half a dozen types in development and close to actual mass scale production on the Russian side.

We have to discuss the impact of electronic warfare and counter-UAS technologies because, as I've indicated, each development in this war gives an impetus and a necessary push for counter development. And so every significant advantage has a counter advantage. And electronic warfare has been very successful in going after adversarial drones with simple jamming and other types of interferences. But electronic warfare doesn't work successfully by itself. It has to work in a system. And so Russians are writing and practicing this whole kind of layered defense approach where signals

intelligence tries to identify what kind of drones are in the area, followed by jamming and electronic warfare, of those drones that have been identified as adversarial, followed by physical protection and some kind of kinetic countermeasures against these drones. And they involve shotguns, rifles, physical protection, nets, physical barriers, and everything in between.

Communication is key in this war. And lack of communication results in drone fratricide. And this is an issue for both Russian and the Ukrainian militaries. Units that don't cooperate and don't necessarily inform each other usually end up shooting each other's UAVs. And so the statistics on drone losses actually are rather high, but they're also high because of lack of communication and this specific drone fratricide.

There's a lot of emphasis on tactical electronic warfare. Russians are calling it trench-level warfare. It barely existed before 2022 because, prior to that, Russians were building very large, vehicle-based electronic warfare systems. But in this war they emit a lot of signals. They're easy targets for FPVs and all kinds of Ukrainian attacks. And so the emphasis now is on what soldiers can carry. So in this image there's a soldier with a portable electronic warfare system in his backpack, and the gun to shoot the incoming FPV drones. So there's a lot of training on – in the development of different types of portable, vehicle-based, or stationary smaller-sized electronic warfare and counter-UAV systems.

And this goes for radio-controlled UAVs as well as fiber optic-controlled drones. So, again, the communication and training is key, and is lacking on the Russian side on many sections of the front. The technology that's developed for this specific countering of UAVs is, likewise, coming from both the defense sector as well as the people's VPK, from the volunteers and startups. So quality is uneven and the application is rather uneven. So Russians are pushing for training and standardization of these technologies development as well as implementation at the front.

Mr. Allen: So, historically, Russia has had a reputation as being extremely innovative in electronic warfare. This was true even in the Syria conflict, where Russia was supporting Syria, that they had a good reputation for being innovative in electronic warfare. Do you feel like they've lived up to that reputation and still are doing noteworthy things today? Or are they sort of at parity with Ukraine?

Mr. Bendett: Well, Ukrainians do admit that Russian electronic warfare is causing a lot of issues for Ukrainian drones. Russians, at the same time, admit that they need more, they need better systems, they need uniformity in how these systems are developed and applied at the front. This mishmash of different types of tactical EW systems can result in successful defenses against Ukrainian drones, but it can also kind of lead to a lot of issues with technology

integration and technology training.

Mr. Allen: Yeah. And that soldier who you have depicted in this image, you know, he's got an electronic warfare system on his backpack. So he's trying to jam drones. He's trying to make drones be ineffective. But then there's another category of drones where, literally, that jamming signal is the homing signal for them to target in on. And that's why he's got that shotgun, to defend himself from the counter-EW drones. That's not a fun job to have in the Russian military. (Laughs.)

Mr. Bendett: And there's a lot of issues with this picture, obviously. There's health issues associated with the emissions and the impact of close-range EW on one's body and on the organs. But he is trying to do what he thinks is important. And there's more and more such training taking place within the Russian military. Again, tactical-level training against incoming FPV drones, especially fiber optic UAVs that can only be shut down with a shotgun or stopped by physical countermeasures, not necessarily by EW.

Mr. Allen: Wow. Incredible.

Mr. Bendett: Just like Ukraine and Russian military is working on development of artificial intelligence and integration of certain forms of AI in their drones, and, just like you've heard recently, Russians are also using AI for terminal guidance, for target lock, for image recognition in a simpler format. These are not autonomous UAVs. These are not UAVs that can fly on their own. They still need an operator to direct the UAV and to approve the target. But there's more and more evidence of Russian drones having those sort of target lock terminal guidance technologies that can fly at target on their own once the operator approves it, and therefore they're also impervious to electronic warfare because there's no more communication with the operator.

Mr. Allen: So, just to understand, this terminal guidance part of the story, that's not – that is not human turns on drone, drone goes off and executes a three-hour mission by itself, doesn't even know what it's looking for but once it finds it, the drone approves its own, you know, ability to kill it. That is not what we're talking about. What we're talking about is a human has been remotely flying this drone and then finally they see something – let's just say a soldier on a motorcycle – and they know that they want to blow up that soldier on the motorcycle. And so they can say: That is the target and you fly to it. But you're not flying to fixed coordinates, you're flying to this AI lock on of it. So instead of a heat-seeking missile, which locks onto the heat of a jet engine, this is, like, an optical, visual light lock on which is based on machine learning algorithms reading the camera on the drone to maintain that terminal lock. Have I said it correctly?

Mr. Bendett: That's correct. And therefore Russians, like Ukrainians, are also engaged

battlefield data collection and analysis. They're trying to develop data sets for training. They've hinted at that development. They certainly talked a lot about this before the war, how AI is supposed to aid in decision making and data collection. We're starting to witness how some of that is actually taking place on the battlefield. There's training for nascent swarming tactics which is taking place in the Russian military. It's unclear exactly how successful Russians are. The word "swarm" is used interchangeably just to denote a group of UAVs, but almost always there's at least one operator behind each drone in that specific group.

Mr. Allen: Oh, wow. So when they say "swarm," they don't necessarily mean what the U.S. military means when it usually says "swarm."

Mr. Bendett: No. It's not an autonomous swarm where each member acts independently of the operator. It's an actually human-directed group of UAVs. And sometimes one pilot can possibly direct several UAVs, but almost always there's at least one operator behind each UAV we see on the battlefield. And so Russians are pledging to utilize AI more and more in their systems, in aerial systems, ground systems, in in maritime systems. But we're kind of getting this hyperbolic statements from the government and the military. The actual data is probably classified at this point.

Mr. Allen: Yeah, this is – this is a challenge that you've raised in your previous research, including some of the research that we collaborated on back when I was in DOD. The terminology game is tough here. It's tough because, number one, there's an incentive to deceive. You know, Russia doesn't want the world to know – have perfectly accurate understanding of what all their capabilities are. But then there's also a chance of misunderstanding because the terminology is different. The way Russia uses the word "swarm" is not necessarily the way we use the word "swarm." The way Russia uses the word "AI" is not necessarily the word we use "AI."

So I remember, you know, when you and I were having a conversation on this topic seven, eight years ago I was like, oh my gosh, look at all these Google translated Russia documents I found that talk about their use of AI. And you were the one who had to educate me, well, when they say AI they don't necessarily mean machine learning, which in the United States military AI at this point is almost a synonym for machine learning. But for them, it can be a more rules-based, traditional automation-type system, and they'll still happily call that AI. So that's why we're all lucky to have folks like you who can sort of explain all this incredible nuance.

Mr. Bendett: And there's so much data coming out of Russia right now, it's also important to kind of caveat that. A lot of this information is in the public domain and is therefore part of this larger information environment and information competition. So we have to scrutinize statements from the government,

statements from media – like images like this one – and try to understand exactly what that means, or doesn't mean, for us.

And then finally, Russian military, again, is drawing very significant, very important lessons from this war. It's certainly looking at the Ukrainian developments. It's looking at the Western developments, how the West is trying to understand what is happening in Ukraine. So Russia is launching its own unmanned systems forces, following Ukraine's announcement and launch of that last year. And this unmanned systems force is supposed to be stood up in or around September-October of this year.

There's a lot of push for the defense industry to cooperate with this volunteer startup community, which also manufactured a lot of successful designs for this war including UAV and counter-UAV technologies. There's a lot of emphasis from the government and the military to refine and redefine military training that incorporates lessons from the war, and especially lessons from Ukraine and other conflicts when it comes to the use and application of different types of robotic and autonomous systems. And Russians are calling for the greater integration of different types of robotic systems from multiple domains in a single sort of unified information battlefield space. Whether that's going to happen soon is an open question.

Mr. Allen: Amazing. Well, Samuel, thank you so much for that incredible presentation.

So now we're going to move to the discussion part of the event. So we're back with Kateryna and Samuel. And let me just go right into it. How big a deal have drones been in this war? I mean, there's so many different things going on. It's the largest land war in Europe since the end of World War II. But with this event title, you're calling it a "drone war." So just how much of the story of this war is unmanned technologies? And, Samuel, why don't we start with you?

Mr. Bendett: Well, you can't read a single article about the war in Ukraine without coming up on drones, or without somebody describing the impact of UAVs. I think in this particular conflict, and the attritional, stationary nature that we are witnessing right now, where breakthroughs are very difficult, where massing forces is practically impossible or extremely difficult, drones have been absolutely paramount. They fill the battlespace. They provide reconnaissance. They provide intelligence. They provide overwatch over the entire battlefield. So anything that moves, anyone that moves, can potentially be tracked and ultimately attacked. But not just by one UAV, by multiple UAVs.

So both sides are flooding the battlespace, that area zero to 10 or 15 kilometers from the line of contact, and about zero to 2 or 3,000 feet in the air, this kill box, with hundreds of thousands of UAVs each month. So they've become absolutely paramount. But that also means that significant progress

is also difficult, because each side possesses the same capabilities to identify and go after the adversarial targets.

Mr. Allen: Mmm hmm. And, Kateryna, let me ask a slightly modified version of that question. Which is, how important have drones been in the story of Ukraine's defense? I've encountered the argument before that some would say if they hadn't been so effective at leveraging commercial drone technology and figuring out what the effective ways to incorporate that into military strategy were, Ukraine would have lost this war already. So is it fair to say that this factor has been decisive, at least in Ukraine's ability to maintain its defense, difficult as it was even with this?

Ms. Bondar: Sure. It's 100 percent accurate to say this. And we can see this especially by the numbers, because in 2023 Ukraine produced around 800,000 drones. In 2024, there were 2 million drones. And 2025, Ukraine is going to produce up to 5 million drones, and procure all that. Of course, it says that drones –

Mr. Allen: Let me just interrupt you for one second to say that anybody who knows anything about who knows anything about, like, American missile procurement, you know, we talked about, like, hundreds, or in a fabulous year thousands, of missiles. And you're talking about millions of drones. And not all of those are performing a missile-type function, but these are just jaw-dropping numbers from somebody who's been looking at defense technology for a while.

Ms. Bondar: Definitely. And it shows how important the drones are. And for example, if you ask the captured soldiers, they claim that they haven't seen the soldiers of the – of another side at all on the front line. So they saw the soldiers for the first time only when they were captured.

Mr. Allen: And they surrendered to a drone, probably, yeah.

Ms. Bondar: Yes, yes. Most probably. So it's a drone war because they fight with drones, drones against drones. Yeah.

Mr. Allen: So I want to now dwell in the institutional reforms that enabled this. Because, you know, the United States, for my entire life, we just sort of assumed that we had the best military technology in everything. Now that hasn't actually been true in every single domain of military technology, but to a first approximation, yeah, the Americans had the best stuff. And here we are, in the midst of the Ukraine-Russia War, where both Russia and Ukraine compliment themselves but also compliment the adversary and say, no, we, these two people who are trying to kill each other, actually have the most sophisticated stuff going on in the world. Samuel, do you think that's fair? I mean, do you think that both of these countries really have advanced past what the rest of NATO, what the rest of the United States is doing in drone

technology?

Mr. Bendett: They're certainly well ahead of many NATO countries, many countries around the world with utilization of different types of drones at different ranges and different missions. Obviously, United States maintains prominence with heavy, long-range UAVs like Global Hawk, like the Predator. Those are still undisputable champions. But those are very few. They're usually slow-flying UAVs that could be potentially susceptible.

Mr. Allen: Yeah. I mean, a Global Hawk, the most expensive one of those, can cost \$220 million, right? So those are – those are drones that you really don't want to lose. And Iran did shoot one down one time, whereas the type of stuff that Ukraine is pumping out is so much cheaper that you can really afford massive losses.

Mr. Bendett: And both sides are now gearing up to manufacture interceptors of each other's long-range UAVs, so that can potentially spell danger for some of the more expensive long-range drone programs around the world. Of course, a lot of countries are looking at the lessons of Ukraine combat. A lot of countries are monitoring the drone developments. They're directly involved sometimes in how these drones are developed – countries like Turkey, China, Iran. But, again, it's important to note that United States UAV prominence came about in the early 2000s when the United States really didn't have a lot of adversaries, or any adversary that could impact how those UAVs are used. In the global war on terror, the adversaries that United States face could not shoot down or impact these UAVs with missiles or electronic warfare technologies. And so in Ukraine you have a very active battlespace teaming with all kinds of countermeasures at all ranges and at all frequencies.

Mr. Allen: You're totally right. I mean, the American design paradigm for drones grew up in a world where adversary anti-air capabilities were almost nonexistent. And now we've seen in the Houthi, you know, campaign, the United States is experiencing a pretty high rate of losses amongst its Predator and Reaper drones, because suddenly you are facing an adversary with anti-air capabilities.

So I want to shift from the technology itself to the organization. So, you know, Ukraine and Russia are clearly out front in this new paradigm of military technology. What did they do to get to this position where they were able to do that? And, Kateryna, I know this is an area of active research for you, so what would you say, organizationally, bureaucratically, what is the secret sauce behind Ukraine's success?

Ms. Bondar: Yeah. So Ukraine has quickly realized the potential of commercial technology and civil creativity, let's say. And I think the government took a very smart position in this situation by stop trying to lead this innovation race, into –

switch into being an enabler. So what I mean is that Ukrainian government has adapted to this situation and has changed its procedures and has changed its institutional architecture, let's say. So what I mean, first of all, is by changing procedural aspects of this, is that Ukraine has streamlined its acquisition process, especially in the part of procurement.

So they have simplified the procedures in the Ministry of Defense of adopting into service this commercial technology. So it has become really easy for commercial producers and civil engineers to present their innovation and to integrate it into the military arsenal. So when it is done, the procurement procedures were streamlined, which means you can buy a system in a week, for example. So basically, you test, evaluate, and then you select the product, and you sign an agreement. So – and it all happens in a week. I think it's unprecedented speed for most of Western military.

Mr. Allen: Oh, yeah. (Laughter.) I mean, in the Department of Defense it would take a week to find out who the right person to ask for a meeting to request for the budget to begin the process – I mean, it is years to do almost anything in the U.S. DOD. And so to go from a there's something bad happening to me on the battlefield, I need a solution, I'm on contracts to get that solution in a week, is just shocking.

Ms. Bondar: Yes. And when all those systems got, let's say, access to the military and started being fielded and deployed, Ukrainians faced another issue. That's what they call a zoo of technology. So these are different manufacturers with different systems. They talk to each other. They don't. They have to be integrated into situational awareness systems. So there was an issue of integration, and basically –

Mr. Allen: Interoperability.

Ms. Bondar: Interoperability among all these systems. So and that's partially why this unmanned system force was created. It's a separate branch of Ukrainian military, like a separate service basically, which was created, established in 2023, and fully deployed and launched in 2024. And their main function is not to create separate forces, but to collect this experience and to share knowledge across the front line and different units how different systems are used.

Their second function is to spread the knowledge about the innovation, about what's available on the market, because people sitting in the trenches don't have first access to innovations and they're not able to follow the market that fast. And basically, they consolidate all this knowledge, and develop guidelines and standards, and try to standardize this process to make it really separate and to integrate it into doctrine, basically. And to make it really a separate body of knowledge for everyone to be available.

Mr. Allen: So the final question that I want to end on is around AI and autonomy. So both of you discussed the use cases for AI. It's definitely the case that machine learning is delivering impactful capabilities for drones. But it's also the case that the sort of popular conception of AI-enabled autonomous killbots is just not where we are right now. But I'd like you both to sort of peer into your crystal ball and say, hypothetically, if this war was, God forbid, to continue for another five years, or even if it doesn't continue for another five years but nevertheless influences the next five years of research and development, where do you think, you know, Ukraine and Russia will be in terms of the utilization of AI-enabled and autonomous capabilities? Samuel, why don't we start with you?

Mr. Bendett: Well, there's a massive emphasis on AI research and development within the Russian military. This goes back to at least a decade and a half. Certainly was very active when you and I were cooperating on research into that specific topic. Russian Ministry of Defense and Russian government are constantly emphasizing the importance of AI for the development of Russian weapons and systems to develop greater autonomy. Not necessarily to create the killbots, but to enable and command existing systems with greater lethality – whether it's data analysis, decision making, or faster action.

There's a lot of experimentation taking place, and not just within the Russian defense industrial complex but also within the people's VPK, this groundswell of volunteer and start-up activity who have access to commercial technologies and can actually buy commercial microchips and enable their FPV drones and quadcopters with some degree of AI that we recently discussed. I think if this conflict were to continue, or if we're looking at how Russian military is going to be influenced by what happened in Ukraine, I think artificial intelligence and autonomy is going to be at the top of that agenda.

Mr. Allen: Kateryna, how about yourself?

Ms. Bondar: I completely agree with Sam about the role of AI in the war. Let's hope it won't continue that long. (Laughs.) But my opinion on Ukrainian side might be not that popular, as we can see in the media right now, because we have to understand where the Ukrainian innovation and technology comes from. So this AI, which we can see on the battlefield, on the front line right now, it comes from mostly open source, available technologies. And I would say that currently Ukrainian commercial sector, this start-up community, basically, has reached its, let's say, glass ceiling, because to make a leap in this technology and to make it really break through, you need way more resources. You need more investment into R&D. So you have to really work on deep tech. And it's going to be really impossible to keep using this surface technology which is available.

Mr. Allen: So you're saying, sort of, they have been exceptionally good at taking the commercial state of the art and maximizing the amount of military capability that you can add to that or squeeze out of that, but that they've sort of plateaued in terms of what's possible. So either commercial technology needs to make a quantum jump or they need to make a quantum jump in terms of the underlying capabilities. And that really is more resource intensive than they can realistically –

Ms. Bondar: Exactly. Exactly. So I think that Ukrainian AI future would develop – would depend on the amount of investment and how committed Ukrainian government would be on this – developing this specific technology.

Mr. Allen: Well, I just can't tell you both how grateful I am for sharing your insights, both here but also just all the papers that you've published and really helped shape Washington's understanding of these issues and the world's understanding of these issues. So thank you so much.

And thank you for watching at home this event. I hope you learned as much as I did. We'll be done here, but to continue looking at all the research that CSIS is putting out on AI, autonomous systems, the military implications of these, and the war in Ukraine, go to [CSIS.org](https://www.csis.org). Thanks for watching.

(END.)