CSIS BRIEFS

Drone Saturation

Russia's Shahed Campaign

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MAY 2025

THE ISSUE

- Russia's drone campaign utilizes inexpensive Shahed drones to saturate Ukrainian air defenses and erode civilian morale through persistent nightly attacks. Originally Iranian made, these drones are now mass produced in Russia using Western electronics and essential Chinese components.
- Ukraine urgently requires layered, cost-effective air defenses, including high-energy laser systems, to counter drone saturation. Targeted long-range strikes on drone production and launch sites and disrupting China's supply of critical electronics to Russia are essential steps.
- Russia's relentless use of low-cost drones signals a broader shift toward attrition warfare based on overwhelming air defense systems with sheer numbers. Western governments must innovate in economical defenses and tackle Chinese technology flows fueling Russian drone production.

Russia is using a **punishment strategy** to force Kyiv into negotiations designed to end the war and hamper Ukrainian sovereignty for the next generation. This approach increasingly relies on a single weapon: the Shahed drone. Originally imported from Iran but now mass produced in Russia using a mix of smuggled Western electronics and important Chinese parts, these low-cost attack drones cause millions of Ukrainians to wake up to the sound of air raid sirens every night. This terror campaign has lasted longer than the infamous **Blitz** aerial bombing of London during World War II and shows no signs of letting up.

The intensive use of these low-cost drones highlights the need to help Ukraine discover additional low-cost countermeasures that limit the ability of Russia's punishment campaign. Specifically, European states and U.S. firms should work together to test new approaches to air defense that build on Ukrainian wartime innovations (e.g., acoustic sensors, an integrated air defense network, and improvised surface-to-air missiles) and emerging approaches that use electronic warfare and even high-energy lasers. Second, the U.S. military should catalogue these efforts and use them to accelerate its own thinking about layered air defense in future conflicts, which will almost certainly see a mix of cruise missiles and ballistic missiles attacking alongside waves of one-way attack drones. In these fights, point airfield defense and mobile counter-unmanned aircraft systems will not be enough to counter drone saturation designed to break air defense systems and open attack lanes for more exquisite weapons.

This brief proceeds by analyzing Shahed attack trends during the Ukraine war. Understanding these trends highlights three policy options for both helping defend Ukraine

and reducing the ability of Russia's punishment strategy with low-cost drone attacks:

- Testing and fielding new high-energy lasers to add an additional layer to Ukraine's air defense network.
- Increasing long-range strikes against Shaheed production, supply, and launch points.
- Countering the flow of Chinese electronic components to Russian weapons.

DRONE SATURATION: COST-EFFECTIVE ATTRITION WARFARE

Russia's dependence on Shaheds is based on attrition logic: Each drone costs approximately $20,000-$50,000, whereas even a single modern surface-to-air missile (SAM) battery or interceptor missile can cost several hundred thousand dollars. Russia has tolerated high loss rates—often losing more than **75 percent** of its drones—in an effort to gradually overwhelm Ukrainian air defenses. Conversely, Ukraine's ability to scale up interceptors, radar networks, and point-defense systems has helped maintain a favorable cost-exchange ratio, although this has depleted expensive Western-supplied interceptors. Consequently, Ukraine has increasingly relied on electronic warfare tactics, prioritizing reducing drone accuracy rather than direct interception owing to the sheer number of Shaheds launched each night.

Starting in September 2024, Russia significantly ramped up its use of Shahed drones, increasing from approximately 200 launches per week to more than 1,000 per week by March 2025 as part of a sustained pressure campaign.

The net result is drone saturation. It doesn't matter if an individual Shahed hits its target. What matters is the compound effect the terror weapon has on civilians and the stress it places on air defenses. By saturating the skies with low-cost weapons, Moscow wages an attritional campaign targeting both the will of the Ukrainian people and the readiness of its air defense network.

Starting in September 2024, Russia significantly ramped up its use of Shahed drones, increasing from approximately 200 launches per week to more than 1,000 per week by March 2025 as part of a sustained pressure campaign. Initially designed in Iran, Shahed drones are now manufactured by Russia **using engines from various sources**, including China. The Russian company Alabuga **has contracted** with Iran for Shahed drone deliveries. Recent reports indicate that Russia significantly increased its manufacturing capability, particularly **at the IEMZ Kupol facility**, and has developed an advanced version of the Shahed drone: the Shahed-238 Loitering Munition. These versions likely include a mix of software-defined radios and other guidance systems that make them more difficult to jam. Russia has also started to explore methods for increasing the "punishment" value of each Shahed strike, including adding **tungsten balls** and lacing components with **toxic agents** to maximize civilian harm.

There are also indications that Russia is set to expand its mass production of low-cost, long-range attack drones and add new variants. There are reports that China is manufacturing **Garpiya-3 drones** for Russia, which have a 2,000 kilometer (1,200 mile) range with a 50 kilogram (110 pound) payload. Moscow has also started production of a jet-powered variant of the Shahed, the **Geran3**, which has a range of 2,500 kilometers (1,533 miles) and can travel at speeds up to 550–600 kilometers per hour, making it much harder to intercept. These systems will allow Russia to increase its number of attacks while at the same time making it harder for Ukraine to shoot down every attack drone. Absent additional support to Ukrainian air defenses and new approaches to cutting off the flow of components used to mass produce attack drones, the net result could tip the war in Moscow's favor.

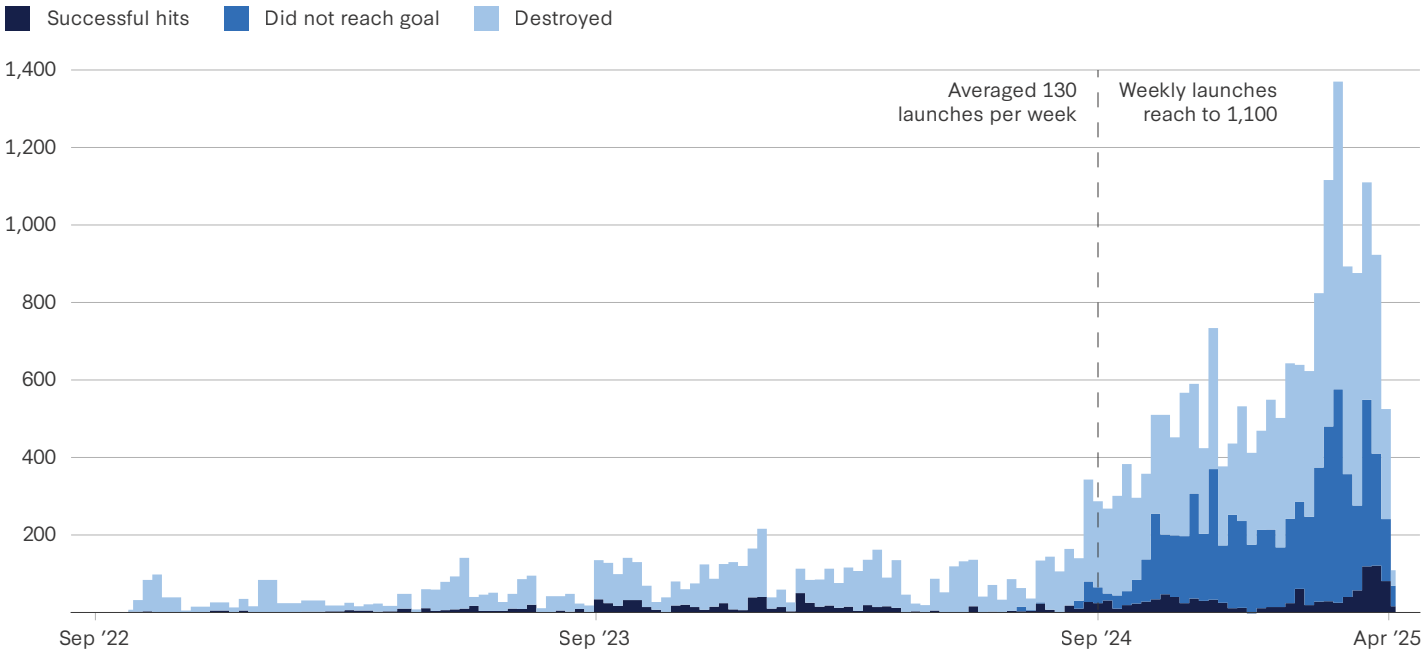
SHAHED LAUNCHES IN UKRAINE WAR

According to **data** released by the Ukrainian Air Force, Shahed drone launches have intensified significantly throughout the conflict.

The data reveals notable patterns:

- Starting in September 2024, Shahed drone launches escalated sharply. Before this period, the average

Figure 1: Weekly Russian Shahed Drone Launches Have Surged Since September 2024



Source: Ukrainian Air Force; CSIS Futures Lab.

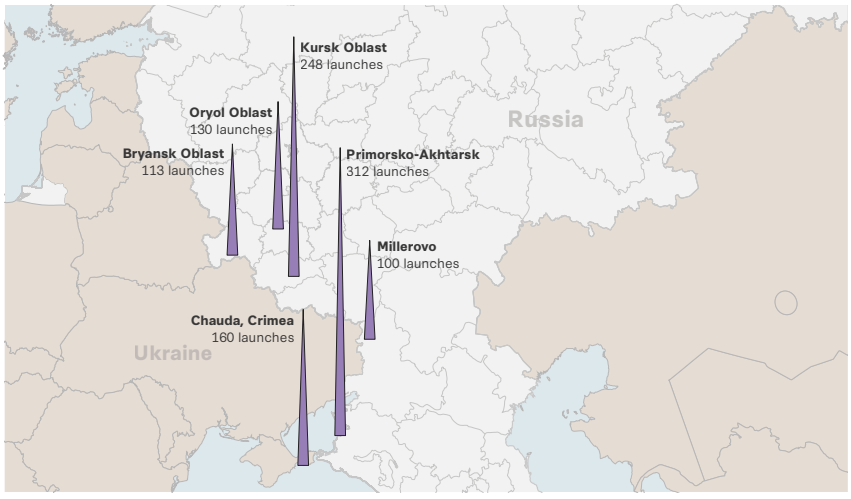
weekly launch rate was around 130. Within six months, the rate peaked at approximately 1,100 launches per week. This indicates that Russia effectively scaled both launch and production capacities within a short time frame.

- Despite Ukraine's continued success in intercepting or neutralizing these drones with electronic warfare methods, the relentless pressure of Shahed attacks constitutes a clear attrition strategy. The weekly number of successful drone hits reached approximately 110, nearly 10 times higher than the previous year's average. This indicates that increased launch intensity directly contributes to heightened damage.

Primorsko-Akhtarsk in Krasnodar Krai is the primary launch site (312 launches), underscoring the strategic importance of the southern front and the Black Sea corridor targeting infrastructure in the Odesa region. Crimea's Chauda airfield (160 launches) complements this southern axis, allowing drones to circumvent Ukraine's western air-defense systems. Additionally, oblasts bordering Ukraine—Kursk (248 launches), Bryansk (113), and Oryol (130)—serve as proximate launch points targeting the Donbas and Kharkiv regions, while Millerovo (100) and Yeysk (37) reinforce pressure on eastern targets. The extensive range of launch locations complicates Ukrainian air-defense targeting efforts, forcing allocation of scarce precision-strike and electronic warfare resources over a wide area.

Over the past seven months, there has not been a single uninterrupted three-day period without a Shahed drone launch. Salvos have occurred nearly every other day. Overall, 75 percent of Shahed launches have occurred on consecutive days (see Table 1).

Figure 2: Launch Locations of Shahed Drones



Source: Ukrainian Air Force; CSIS Futures Lab.

Table 1: Intervals Between Shahed Launches

Days Between Launches	Percentage
1	75%
2	14%
3	4%
4	2%
5	1.5%
6+	2.5%
Total	100%

Source: Ukrainian Air Force; CSIS Futures Lab.

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A STRATEGY OF CONSTANT PRESSURE

Russia's Shahed drone campaign illustrates the changing nature of aerial warfare in an era dominated by inexpensive, mass-produced unmanned systems. For most of the twenty-first century, the focus of aerial attack has been on precision. States use integrated global battle networks to find, fix, track, target, and assess strikes. Entire concepts of joint fires and targeting have evolved, largely driven by a mix of **U.S.**, Russian, and **Chinese** military theory that emphasize waves of precision strike. In **Russian writing**, these ideas have tended to include more of a focus on striking critical infrastructure that speaks to a counter value (e.g., civilian targets) and not just a counter force (e.g., military targets). This approach is consistent with what Robert Pape referred to as a punishment strategy in his seminal book ***Bombing to Win***. Seen in relation to competitive strategy, the logic is one of **cost imposition**, albeit focused more on civilian pressure points than critical military targets.

In addition, nightly waves of Shaheds produce a secondary effect of military value. Even if the low-cost attack drones are easy to intercept, they force the defender to spend limited defense resources to intercept them. That is, the attacks impose costs not just on Kyiv's leaders through popular pressure but also through attriting air defense assets. The net result is that Ukraine and its backers must find a way to change the cost calculus.

The key insight for defense analysts and strategists is that survival against large-scale drone saturation attacks requires a comprehensive, multi-layered defensive approach. This involves balancing the economic costs of attrition warfare with adaptable defense strategies. In other words, the theory of victory is lowering the cost of intercepting long-range, cost-effective attack drones like the Shahed.

To a large extent, Ukraine has developed ingenious solutions, many of which are linked to wartime innovation efforts run by its **Digital Ministry**, that lower the cost of intercept. First, Ukraine has fielded a network of tens of thousands of **acoustic sensors** to detect and track drones. Second, Ukraine has effectively built a common operating system called **DELTA** that allows it to track attacks and coordinate responses. By fusing data on attack drones with radar coverage and what frequencies systems are using, Kyiv can better allocate a mix of defense measures ranging from deploying **mobile anti-aircraft teams** to **electronic attack** and even aerial intercepts using **light attack propeller planes**. Other measures have included releasing small attack drones from high-altitude **balloons** and even custom, low-cost **interceptor drones**.

Yet, for all the battlefield innovations, the rate of Shahed attacks keeps increasing. As a result, new methods to combat drone saturation are needed.

1. **Test and Field New Defeat Measures**

   Given the sheer volume of low-cost, long-range attack drones, Ukraine needs to develop new

approaches to protecting its skies. To complement its existing command and control system and network of mobile defense teams, Kyiv should work with partners in the United States and Europe to test and field high-energy lasers to counter drone saturation attacks.

There are large number of high-energy lasers on the market. RTX makes a 50-kilowatt laser mounted on U.S. Stryker combat vehicles (**DE M-SHORAD**) as well a smaller road mobile 10 kilowatt laser called the **H4**. This system would align well with the mobile air defense teams Ukraine already uses to hunt Shaheds. There are also **palletized options**, like **BlueHalo's LOCUST**, that can be quickly moved to adapt to Russian targeting.

There are also larger systems that could be integrated with urban power grids. Lockheed Martin manufactures the **HELIOS**, a 60-kilowatt laser that can be installed on ships.

Other countries also have candidate high-energy weapons that could support defending Ukrainian cities, including the **United Kingdom**, **Turkey** (through **Aselsan**), and Germany (through **Rheinmetall**), the latter of which has successfully tested a 50-kilowatt laser.

Ukraine presents a win-win opportunity. These firms need battlefield tests of their systems to further refine them. Every Russian low-cost, long-range attack drone shot down with a high-energy laser makes Ukrainian cities safer and sends a clear message to other coercive states.

2. **Increase Long-Range Strikes**

The best place to destroy a Shahed is on the ground. From factories where the drones are assembled to storage and launch facilities, there are multiple points Ukraine could hold at risk to decrease the number of Shahed attacks. Ukraine has demonstrated its ability to conduct long-range strikes against Russian **logistics networks** and **airbases**. These attacks could be complemented by cyber operations that reduce the rate of production, creating, in effect, virtual attrition. They can also involve covert action against the supply chain, a technique recently tried against Russian **first-person view (FPV) drone components**. In other words, Kyiv needs a campaign for targeting the entire system that produces, launches, and targets Shahed attacks daily that links kinetic and non-kinetic effects as well as conventional and unconventional methods.

3. **Counter the Flow of Components**

There is also a role for economic policy. The United States can work with European states to finally hold Chinese firms accountable for their support to Russia's war machine. Earlier in the war, Moscow used sanctions-evading networks of shell companies and third-country trading to import the electronics needed to build long-range precision strike systems. Now, that market has shifted to China. The **Main Intelligence Directorate of Ukraine's Ministry of Defense** has identified 200 component parts made in China that fuel Moscow's punishment campaign. These include critical Controlled Reception Pattern Antennas (CRP) in the Shahed as well as onboard computers used for multiple classes of drones and Kinzhal ballistic missiles. Furthermore, since late 2023, Russia has been using **Chinese technology** for engines in its long-range attack drones. While the United States and European states cannot stop the flow of technological components, they can take steps to make it more costly, including launching investigations, levying sanctions, and freezing assets.

CONCLUSION: WEAPONIZED COST IMPOSITION AND THE FUTURE OF AIR DEFENSE

Russia's Shahed campaign is more than a series of drone strikes—it's a warning shot about the future of war. In this new battlespace, coercive states don't need precision to win. They need volume, velocity, and the willingness to deploy cheap systems to break expensive defenses and the will of a populace to resist. The Shahed is not just a drone—it is a coercive instrument in a broader punishment strategy aimed at draining Ukrainian resolve and testing the limits of Western support. It's a slow grind, a war of wear and will, where the cost of each intercept slowly shifts the burden from offense to defense.

For defense planners and policymakers, the lesson is clear: Surviving drone saturation attacks in the age of autonomy and attrition requires more than exquisite systems and intermittent aid packages. It requires a full-spectrum approach—high-energy lasers for point defense, deeper

strikes against production nodes, and a concerted campaign to cut the technological lifelines that connect Chinese components to Russian launch rails. Ukraine's battlefield improvisation has bought time. What's needed now is a strategic shift—one that builds layered, resilient, and economically sustainable air defenses while targeting the industrial ecosystems that power drone warfare.

In the end, every Shahed in the sky is a signal. They signal a new phase of military competition—one defined not by singular decisive blows, but by the persistent erosion of capacity and will. The challenge for democracies is to adapt faster than their adversaries escalate. Because if war is ultimately a test of systems—political, economic, and military—then the side that learns faster, fields smarter, and fights cheaper will shape the future battlefield. ■

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This brief is made possible by general support to CSIS. No direct sponsorship contributed to this brief.