Grassroots Wartime Innovation: Civilian-Led technological adaptation and Informal Defense Innovation in Ukraine

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Introduction

Ukraine's experience in the full-scale war against Russia has been marked by rapid adaptation, fast learning, and improvised solutions, particularly during the initial phase of the invasion in 2022.

Innovation has helped Ukraine to withstand and keep up with a militarily superior enemy (cf. Dee et al. 2025). At the same time, the war has demonstrated how crises often trigger spontaneous forms of civilian self-organisation to fill the gap left by state actors and institutions that are lacking behind (cf. Channel-Justice 2023, p. 189). In Ukraine, civilians like teachers, entrepreneurs, and retirees, who, in their professional lives, are far distant from elected officials and political and administrative officials proved to be very efficient and extremely helpful at the onset of the war.

These forms of grassroots mobilisation and cross-sector collaboration can be understood through the lens of recent research on Open Social Innovation (OSI). OSI is defined as collaborative and multi-actor approaches that bring together citizens, civil society organizations, public authorities and private actors to address complex societal challenges (cf. Pacheco et al. 2025). From this perspective, innovation does not arise solely from formal institutions or technological development, but also from bottom-up initiatives and decentralized forms of problem-solving emerging within communities themselves.

Studies on wartime innovation in Ukraine has highlighted rapid battlefield adaptation, digital transformation, and the emergence of defense innovation ecosystems (cf. Bondar 2025). One promising framework conceptualizes these dynamics through mission-oriented innovation systems (MIS), uniting diverse sectors such as state institutions, industry, and civil society to innovate jointly and unite around one common mission (cf. Bower 2024). In the case of Ukraine this mission would be existential survival.

This paper introduces in the following the CAMO project and its empirical foundation, situates the analysis within existing innovation frameworks, develops the concept of grassroots wartime innovation, and examines its manifestation in Ukraine through interview-based evidence before discussing its wider implications.

1. The CAMO project

The Civil Augmentation of Military Operations (CAMO) project in Ukraine is led by the University of Applied Sciences Kehl, the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" and the Strasbourg-based Association de Prospective Rhénane. This research focuses on civilian support structures in military contexts, resilience under hybrid threats and the transfer of lessons learned from the war in Ukraine to European security and crisis management frameworks.

The data collected as a result of this project, which involves 30 indepth interviews carried out in Ukraine between July 2025 and February 2026, demonstrate a more

decentralized and improvised dynamic of wartime innovation, which we call *grassroots wartime innovation*. Rather than emerging primarily through institutional coordination, many forms of technological adaptation were developed through informal civilian initiative, horizontal networks, and direct collaboration with frontline actors under conditions of institutional insufficiency.

2. Wartime Innovation beyond Institutional Ecosystems

Existing frameworks such as Mission-oriented Innovation Systems (MIS) and Open Social Innovation (OSI) provide valuable lenses to understand collaborative and multi-actor innovation. MIS approaches describe innovation as emerging through coordinated interaction between state institutions, industry, research actors, and governance structures and define the societal mission as "a complex problem that motivate large groups of heterogeneous actors to work toward achievable solutions through innovation and problem-solving actions" (Bower 2024, p. 2). Similarly, OSI emphasizes the role of citizens, civil-society and private actors in addressing societal challenges through decentralized, grassroots initiatives (cf. Pacheco et al. 2025). Studies on Ukraine's wartime adaptation have also highlighted the rapid digital transformation and the emergence of defense innovation ecosystems particularly through the close cooperation between the military, civilians, private technology companies, and volunteer networks (cf. Bondar 2025).

However, these frameworks only partially capture the decentralized, improvised and civilian-led dynamics observed in Ukraine especially during the early phase of the full-scale invasion. While MIS and OSI emphasize collaboration and multi-actor involvement, they often assume a degree of institutional coordination or pre-existing structures that were largely absent in the initial months of the war. As Channell-Justice (2023) notes, spontaneous self-organization often fills the gap where state actors and institutions lag behind. In Ukraine, this gap was particularly pronounced: civilians, teachers, entrepreneurs, retirees, became central actors in technological adaptation not through formal ecosystems, but through informal networks, rapid experimentation and direct collaboration with frontline actors.

Thus, the interview material analyzed here points toward a different dynamic. Rather than institutionalized coordination, innovation frequently emerged through horizontal collaboration and personal networks, as civilians mobilized resources and expertise outside traditional frameworks. This challenges the assumption that innovation in defense requires state coordination or market mechanisms. Instead, grassroots wartime innovation, decentralized, improvised, and driven by existential urgency, emerged as a distinct and critical phenomenon.

3. Grassroots Wartime Innovation in Ukraine- Institutional Insufficiency and Civilian Initiative

What emerged under the extreme conditions of the full-scale invasion was the rapid mobilization of untrained and unauthorized civilians acting as innovation

drivers developing and incorporating urgently needed products for military use. As crises erupt, spontaneous self-organization frequently emerges as civilians attempt to compensate for institutional gaps. Interviewees repeatedly described situations in which state procurement systems and institutional capacities were unable to respond rapidly enough to battlefield realities. This created space for civilian initiative and improvised technological adaptation. Importantly, the state did not initially intervene and impose restrictions on these forms of collaboration. In peacetime, direct cooperation between military units and private individuals would simply not have been feasible, but wartime urgency temporarily relaxed institutional boundaries and enabled forms of civilian–military collaboration outside ordinary bureaucratic frameworks (cf. Dee et al. 2025).

4. Informal Networks and Horizontal Collaboration

A central feature of wartime innovation in Ukraine was the reliance on informal networks, personal trust, and horizontal coordination.

An interviewee described how she used her contacts abroad to procure necessary gear for the Ukrainian military, initially funding it herself and later involving friends, acquaintances, and businesses. She specifically mentioned supplying "scopes, weapon accessories, night vision devices, Mavics, the first drones" (INT 10) to military units while receiving direct specifications regarding frontline needs. She also described supplying "railings, and the first Starlinks" (INT 10) to specific individuals and units she personally knew had gone to fight.

The speed and adaptability of these networks were further highlighted by the immediate mobilization in the early days of the conflict "everyone had friends, acquaintances, and the sense of regional solidarity was strong. Patriotism of locals was a key factor. They shared intel, gave tips." (INT01). Even basic survival often depended on local support, as soldiers recalled: "We, the soldiers, also survived thanks to locals — they gave us wheat, buckwheat. They would bring us two eggs, and we'd make an omelet for the guys." (INT01).

These examples illustrate how wartime technological adaptation relied heavily on socially embedded civilian networks capable of rapidly mobilizing resources and responding directly to frontline demands. Rather than functioning through centralized coordination mechanisms, innovation emerged through flexible and trust-based collaboration.

5. Frontline Feedback and Improvised Experimentation

One important advantage of civilian-led innovation was its proximity to frontline users and its ability to generate tailor-made solutions.

For example, an interviewee described organizing the production of tactical vests and plate carriers at a friend's furniture factory. Lacking official templates, the group copied vest designs directly from military personnel. Collaborating with actors in the metal industry, her network also began producing body armor while experimenting to reduce the weight of armor plates from 15 kilograms to 7

kilograms (INT 10). This approach highlights how civilians adapted existing professional expertise for wartime needs: She leveraged prior experience certifying a business producing military helmets in order to understand the manufacturing process and coordinate production efforts.

Rather than relying on formal state certification systems, wartime urgency also enabled alternative forms of validation and frontline testing. As she explained, "[Regiment name omitted] did our field testing because the Ministry of Defense refused to certify us. So we took our own route—we didn't wait for the state" (INT 10). This spirit of self-reliance extended beyond armor production. The same interviewee actively participated in developing equipment needed on the front lines, including drones and other military technologies. According to her, parts of the business community had effectively started developing segments of the defense industry "on their own dime" (INT 10), without relying on the state.

This dynamic of self-organization and collective action was not isolated. In another city, a further interviewee explained: "We had an initiative called "[Name of the city omitted] Drone." My husband and I registered on our local website and, personally from our family and at our own expense—from our pensions—we bought Chinese parts and assembled 10 drones, which we handed over." (INT 03). Such grassroots efforts were often complemented by creative and practical support. The same interviewee recounted: "There was also a big apple harvest that year, so we dried apples for the soldiers—made apple chips. We ordered stickers saying "Vitamins for the defenders of Ukraine" and packed 850 bags of 100 grams each. From 1.1 kg of apples, we got 100 grams of dried chips. I sliced them all by hand. A neighbor helped too—she has two sons at war. My team members also helped. So we organized a drying operation and all worked together." (INT 03).

Other civilians also stepped in to fill institutional gaps, as another interviewee noted: "Some people have stayed, formed public organizations, we helped them make it happen. They're active — making camouflage nets for the military, offering various forms of help." (INT 07).

These examples illustrate how civilian-led innovation thrived on direct feedback from the front, improvisation and a willingness to act independently when formal systems were slow or unresponsive.

Conclusion

Many innovation theories assume that technological innovation emerges through state coordination, institutionalized governance structures, market actors, and significant material resources. The Ukrainian case demonstrates a different dynamic. Under conditions of existential crisis, decentralized civilian actors became central drivers of technological adaptation through improvisation, informal coordination, and direct frontline collaboration.

The findings in the interviews suggest that wartime innovation cannot be understood solely through institutionalized innovation systems. During the early

phase of the full-scale invasion, institutional insufficiency, urgency, and the temporary relaxation of peacetime constraints created permissive conditions for grassroots wartime innovation.

Yet beyond these immediate dynamics, the Ukrainian experience also reveals a broader, transformative trend: the democratization of military tools. Civilians, teachers, entrepreneurs, retirees, rapidly developed, adapted and deployed critical military technologies (drones, tactical gear, communication systems) with limited resources but deep proximity to frontline needs. This shift challenges traditional assumptions about who can innovate in defense and how. It also raises pressing questions: *How can such decentralized, grassroots wartime innovation be sustained without compromising safety, coordination or accountability?*

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