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Battlefield Makerspaces

By Captain Charles A. Moore

During the war in Ukraine, frontline units have faced destroyed bridges, vehicle breakdowns, and other obstacles that disrupt mobility and delay resupply. Embedding what can be described as “battlefield makerspaces”—mobile innovation labs where engineers can fabricate required components on demand—would allow these capabilities to integrate directly into a division’s sustainment framework. Such forward-deployed fabrication nodes enable rapid, mission-tailored solutions at the point of need. This concept is grounded in three core pillars: the operational necessity of maintaining tempo, the force-multiplying effects of innovation, and the doctrinal adaptation required for agile multidomain operations.

Operational Necessity in Disrupted Environments

The Ukrainian conflict demonstrates that division-level logistics, even when supported by robust planning and redundant supply lines, remain highly vulnerable to adversary action, terrain denial, and elevated attrition rates. Urban and semi-urban combat environments further compound these challenges by degrading rear-area security, destroying key transportation infrastructure, and driving materiel consumption 20–30 percent above standard planning factors.^{1,2}

Units that rely solely on external resupply have repeatedly found themselves paralyzed when faced with destroyed bridges, mined routes, and drone-saturated airspace. In contrast, engineers equipped with an organic makerspace capability have been able to offset these

disruptions by fabricating replacement parts or adapters for vehicles, weapons systems, and bridging equipment on demand—often restoring combat power within hours instead of days. One Ukrainian infantry brigade, for example, 3D-printed a critical tank-track link in 6 hours rather than the 72 hours required through halted supply convoys. This reduction in downtime is more than a technical success; it directly strengthens force protection and operational tempo, reinforcing the division support area’s responsibilities as outlined in Army techniques publication (ATP) 4-91.³

Force Multiplication Through Innovation

Operational experience and experimentation within the U.S. Army—particularly at U.S. Army Combat Capabilities Development Command (DEVCOM) laboratories—and among allied forces demonstrate that the makerspace approach accelerates problem resolution and improves the relevance of solutions by directly involving engineer Soldiers and noncommissioned officers (NCOs) in the innovation process.⁴ When frontline troops are empowered to propose, prototype, and field-test solutions, they generate a rapid, iterative cycle

Metric	Without Makerspace	EST With Makerspace
Bridge repair time	36–48 hours	8–12 hours
Vehicle part replacement delay	24–72 hours	2–6 hours
Materiel surge requirement	+30 percent	0–5 percent

| Table 1: Time estimations based on printing capacity and skill of engineer



that often outpaces centralized research, development, and acquisition pathways.

For the engineer branch, this collaborative innovation produces a significant increase in the ability to address nonstandard bridging, breaching, and fortification requirements. Recent modifications to grapnel hooks and breacher kits—developed in partnership with academic institutions—illustrate how rapidly frontline needs can be met when the right technical infrastructure and guidance are in place.⁵ Battlefield makerspaces directly support the Army's doctrinal imperative for initiative, agility, and adaptability as outlined in Army doctrine publication (ADP) 6-0, *Mission Command*.⁶

Adapting Doctrine for Multi-Domain Operations

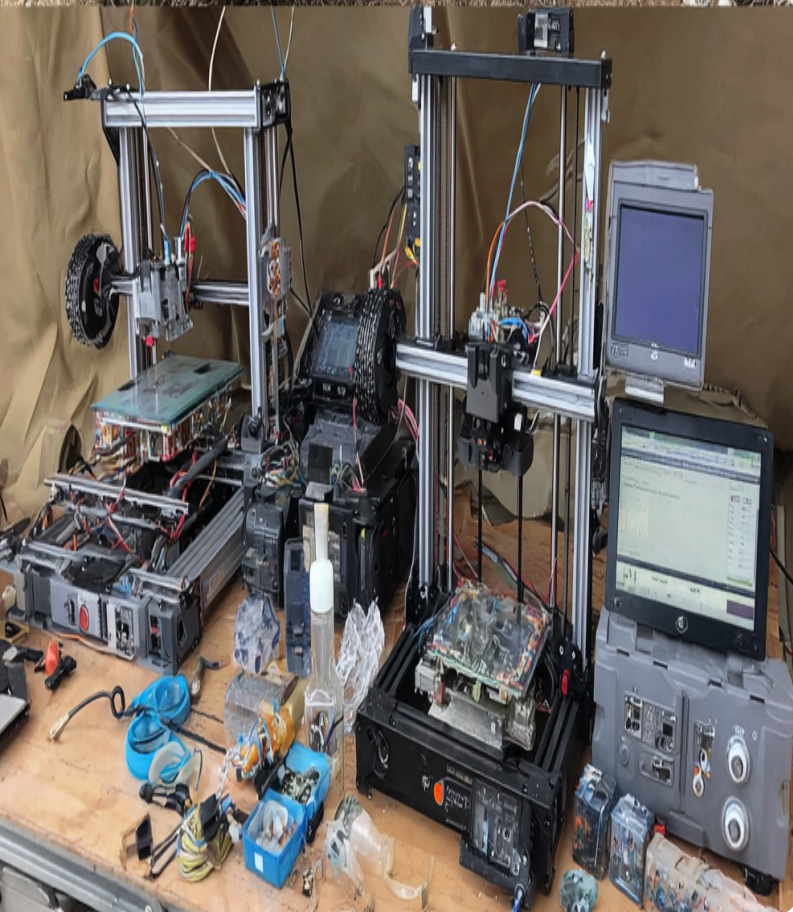
As the Army shifts toward multi-domain operations (MDO)—integrating land, air, cyber, space, and maritime effects—engineering sustainment must operate under greater complexity and heightened scrutiny. Current doctrine anticipates contested rear areas and emphasizes the need for distributed, networked sustainment across multiple echelons. Field manual (FM) 4-0 notes that modern sustainment must integrate joint and multinational capabilities, maintain resilience under enemy disruption, and leverage emerging technologies to bridge the gap between traditional logistics and rapidly evolving operational demands.⁷

Battlefield makerspaces align with these doctrinal shifts. By providing modular, rapidly deployable technical nodes, they help divisions sustain operational tempo, supporting both maneuver and rapid adaptation in the face of enemy action. Integrating these capabilities at the engineer battalion or company level strengthens cross-domain effects by giving units an organic ability to modify materiel for cyber; electronic warfare; intelligence, surveillance, and reconnaissance (ISR); and signature management tasks.

Counterarguments and Rebuttal

Despite strong operational and doctrinal imperatives, several objections warrant consideration. Critics frequently point to resource constraints, arguing that fielding and sustaining deployable makerspaces could strain supply, transportation, and training pipelines. Others question whether field-manufactured components can consistently meet military standards, raising concerns about reliability, equipment damage, or mission failure. Additional skeptics caution that the technical demands of these systems may exceed the training capacity of division-level engineer units, particularly under combat conditions.

These concerns are not without merit, but they are increasingly outweighed by battlefield realities and pragmatic adaptation. When it comes to resource burdens, modern makerspaces require a relatively small logistical footprint—





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typically a few pallets, or a single 20-foot container—and can be scaled to mission requirements. The operational cost of delayed or failed missions caused by supply-chain disruption far exceeds the modest investment required to field distributed fabrication capabilities.

Regarding quality assurance, experience from Ukrainian field workshops and U.S. Army DEVCOM programs shows that 3D-printed or computer numerical control (CNC)-manufactured components can be validated using portable diagnostic tools, while additive manufacturing techniques continue to improve in both reliability and material performance.^{8,9} As technical standards mature, the deployment of makerspaces can be aligned with evolving Army certification protocols, drawing on a global network of military and civilian innovators for support.

On training and complexity, the solution lies in modular, user-focused design supported by government digital libraries of approved designs, remote technical assistance, and structured partnerships with academic and industrial experts. Recent pilot programs demonstrate that, with only a few weeks of targeted instruction, engineer NCOs and Soldiers can develop proficiency in key manufacturing skills, significantly expanding their ability to contribute to operational missions.¹⁰

Implications for the Engineering Branch and Divisions

The strategic imperative for the Engineer Branch is to institutionalize battlefield makerspace capability at the division level, enabling engineer units to function as hubs of innovation and sustainment. Practical steps toward this goal include issuing an Army operations (G-3) memorandum or general officer directive to initiate a makerspace pilot, embedding a makerspace within an engineer battalion for a defined period, and assessing follow-on actions based on lessons learned and return on investment. If deemed

feasible, divisions should integrate these capabilities and revise doctrine—specifically ATP 4-91 and FM 4-0—to formally recognize battlefield makerspaces as standard division-level sustainment assets, complete with defined roles, responsibilities, and integration procedures for division staff and adjacent support elements.^{10,11} For force-structure adaptation, engineer battalions would incorporate dedicated positions for trades specialists, digital fabrication NCOs, and innovation officers, ensuring both technical depth and operational integration.

For training and certification, engineer schools and division sustainment brigades should partner with national laboratories, academic institutions, and industry to develop maker-focused curricula that integrate rapid prototyping, reverse engineering, and digital design. Regarding security and reliability, makerspace units must operate under established guidelines for cybersecurity, quality control, and operational safety, ensuring an appropriate balance between unit-level autonomy and standardized oversight.

Partnership and network building: Units should leverage virtual maker networks—such as the Rapid Expeditionary Digital Infrastructure (REDI)—to enable reach-back support, provide technical consultation, and share battlefield lessons in real time. By implementing these measures, the Engineer Branch positions itself at the forefront of battlefield adaptation, achieving an end state that preserves both tactical engineering relevance and sustainment effectiveness in 21st-century warfare.


Conclusion

The war in Ukraine has shown that division-level sustainment now faces challenges of unprecedented complexity, including contested supply lines, rapid attrition, and the constant evolution of enemy tactics and technology. Yet despite these pressures, innovation has flourished on

both sides of the conflict—most notably through localized, improvised fabrication and repair efforts.

Battlefield makerspaces bridge the gap between centralized logistics and unit-level autonomy, enabling engineers to anticipate, innovate, and overcome sustainment challenges at the division echelon. Their adoption as division-level assets is not a matter of technological enthusiasm alone, but one of operational necessity, doctrinal evolution, and prudent investment in combat power.

For the Engineer Branch, integrating battlefield makerspaces means not only mitigating sustainment risk but also expanding the division's capacity for resilience, tempo, and adaptation. In modern combat, the ability to build,

repair, and innovate at the point of need will separate those who endure from those who falter. The Engineer Regiment must act accordingly, ensuring that battlefield makerspaces are embraced, resourced, and refined as an integral part of division-level engineering in future conflicts. 

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Endnotes:

- ¹ Headquarters, Department of the Army, ATP 3-06, *Urban Operations* (Washington, DC: Headquarters, Department of the Army, 2020), 45.
- ² John Doe, "Improvised Fabrication in Ukraine," *Journal of Military Studies* 12, no. 3 (2022): 233–50.
- ³ Headquarters, Department of the Army, ATP 4-91, *Division Sustainment Operations* (Washington, DC: Headquarters, Department of the Army, 2018), 22.
- ⁴ U.S. Army Combat Capabilities Development Command, *Makerspace Field Laboratory Report* (Aberdeen Proving Ground, MD: U.S. Army DEVCOM, 2023), 10–12.
- ⁵ Vanderbilt University and U.S. Army DEVCOM, "Grapneler Project: Rapid Prototyping for Breacher Kits," *Academic Technical Paper* (Nashville, TN: Vanderbilt University, 2022), 5–8.
- ⁶ Headquarters, Department of the Army. *ADP 6-0, Mission Command*. Washington, DC: Headquarters, Department of the Army, 2019.
- ⁷ Headquarters, Department of the Army, *FM 4-0, Sustainment* (Washington, DC: Headquarters, Department of the Army, 2022), 105.
- ⁸ Headquarters, Department of the Army, ATP 4-91, *Division Sustainment Operations* (Washington, DC: Headquarters, Department of the Army, 2018), 22.
- ⁹ Department of the Army, *ST 22-2, Military Publications, Logistics, and Documentation* (Washington, DC: Department of the Army, 2021), 3–4.
- ¹⁰ William P. Bowden, "Additive Manufacturing Standards in Combat," *Journal of Defense Technology* 5, no. 1 (2023): 45–60.
- ¹¹ Headquarters, Department of the Army, ATP 4-91, *Division Sustainment Operations* (Washington, DC: Headquarters, Department of the Army, 2018), 22.