



Creative Maintenance Solutions in a Fiscally Constrained Environment

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Maintenance in a fiscally constrained environment is increasingly challenging. To combat this, 3rd Infantry Division (ID), 1st Battalion, 64th Armored Regiment, 1st Armored Brigade Combat Team (ABCT) has developed cost-effective, unique solutions to correcting what would be dead-lining faults with long lead times to repair. While deployed to the United States European Command (EUCOM) theater from January to October 2025, 1-64 AR served as the North Atlantic Treaty Organization (NATO) Battlegroup Poland and was task-organized with a company of light British reconnaissance, Romanian air defense artillery (ADA), and Croatian light infantry. During this time, the battalion utilized relationships, three dimensional (3D) printing, and precautionary measures to save money and keep vehicles in the fight.

1-64 AR's innovations cell originally acquired three Prusa MK4S 3D printers to facilitate production of first-person view (FPV) drone frames utilizing a variety of different filaments. After experimenting with the production of drone frames, unit icons (for crisis response option [CRO] planning purposes), and other smaller projects, the battalion maintenance control section (MCS) and battalion innovations cell combined to look at options for repairing dead-lining faults using the available printers. Three M2A4 Bradleys within the battalion had faults originating from missing auxiliary back-up sight thumbscrews and missing Joint Battle Command Platform (JBC-P) bushings. These two parts are vitally important to the Bradley and its operation. The auxiliary sight thumbscrew enables the gunner to adjust the sight picture and improves their ability to engage targets under degraded conditions. The JBC-P bushings prevent the computer system from taking damage in the turret while

moving cross-country. Working together, the battalion innovations cell and MCS designed and printed replacement parts within 6 hours of original identification by rapid prototyping in the motorpool where the vehicles are stored. This enabled parts that would have potentially taken weeks to order, ship, and receive to be corrected nearly "on the spot" and with extremely minimal expense.

By utilizing the maintenance shop office "expandable van" that offers on-board power generation, the innovations cell was able to bring the broken part to a computer, take measurements, and print a prototype in 15 minutes. These prototypes were then tested on the actual vehicle and adjustments were made on the spot using 3D modeling software. Finalized versions of the repair parts were then exported to USB drives for transportation to the other two 3D printers, where the final designs were produced in the required quantity (16x parts)

with a production time of 6 hours.

For this example, a standard bushing for an M2 Bradley JBC-P commander's screen is costly and each screen requires 6x bushings to be mounted properly. Additionally, bushings on order typically take around 30 days to be delivered (dependent on location of vehicle). However, a set of 6 bushings can be printed in under 6 hours and done at a fraction of the cost. This provides the battalion with a rapid, low-cost replacement part to keep the vehicle fully mission capable (FMC) until the new parts come in. In this example, the cost to produce was far less than the actual part cost and effectively served as a stopgap to keep the vehicle FMC.

To further the capabilities of 3D printing efforts, the battalion innovations cell frequently queried operators during preventative maintenance checks and services (PMCS). The subject of

their discussion was parts missing on their vehicles or current identified faults. Following discussion, the members of the innovations cell, alongside operators, conducted parts research to determine what parts could be 3D printed to restore capabilities to a vehicle, and sometimes even remove a dead-lining fault. During one of these engagements, the innovations cell determined that the battery retaining device on the D7 Dozer, commonly long-lead and expensive, is able to be 3D printed. With this in mind, the innovations cell began development of the part, which can be used to restore a critical mobility and counter-mobility asset to the battlegroup. This is just one of the many examples of how 3D printed Class IX repair parts can be used to build readiness and retain combat power.

As the NATO Battlegroup Poland, 1-64 AR had the unique opportunity to have three allied nations attached through

NATO tactical control (TACON). One of the companies, a Romanian ADA company, "The Transylvanian Gepards" of the 3rd Air Defense Battalion, 81st Mechanized Infantry Brigade (ROU), has an integrated combat service support platoon. The platoon is well versed in custom fabricating and repairing parts rather than ordering new parts due to the age of some of the vehicles in their fleet and long part lead time, such as the FlaK-Panzer Gepard. Due to this, their mechanics commonly rebuilt mechanical parts and electrical wiring harnesses. When the 1-64 AR arrived in theater, it struggled to maintain its fleet of M88A2s. A common issue on each of the deadlined M88A2s was the brake pressure switch, which had an extremely long lead time of nearly 12 months. After working closely with the Transylvanian Gepards for a few months, 1-64 AR approached their maintenance team and asked if they could assist with the brake

Figure 1: D7 Dozer batteries with retainer missing
(Photo by 1LT John Douglas)



Figure 2. Top view of CAD Rendering of D7 Dozer battery retainer created by the Innovations Cell. (Photo by 1LT John Douglas)

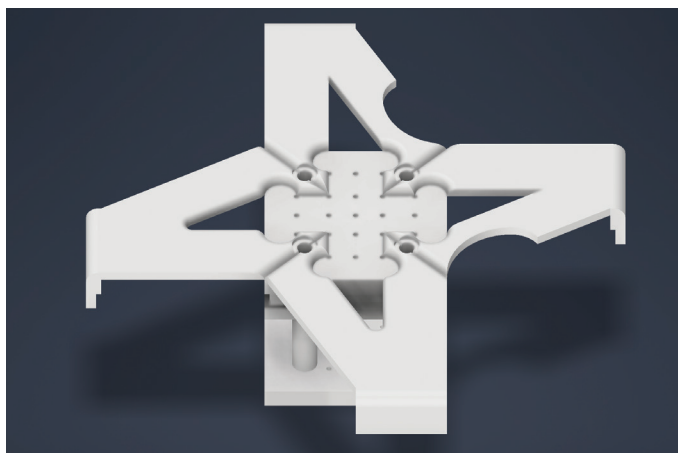


Figure 3. Side view of CAD rendering of battery retainer created by the Innovations Cell. (Photo by 1LT John Douglas)





Figure 4. U.S. Soldiers assigned to 1st Battalion, 67th Armored Regiment, 3rd Armored Brigade Combat Team, 1st Armored Division conduct live fire exercises in a M2 Bradley fighting vehicle during Rotation 23-06 at the National Training Center, Fort Irwin, Calif., April 7, 2023. (U.S. Army photo by PFC Ridhard Monyer)

pressure switch. Due to their many years of custom fabricating and repairing parts, the Transylvanian Gepard's maintenance team was able to repair every brake pressure switch in the battalion and do so at a fraction of the cost of a new one. The repaired parts were tested and found to be fully functional and the failure had occurred due to o-ring age.

Prevention of fault causation or worsening is the cornerstone to any effective maintenance program. The 1-64 Armor Battalion attempts to identify vehicle faults during PMCS and identify solutions to prevent faults from occurring in the first place through innovative solutions. The Battalion M2 Bradley Master Gunner identified a vulnerability in one of the controller area network (CAN) bus cables that runs on top of the JBC-P in the commander's station. This cable is

vulnerable because it sits on top of the JBC-P which swings open and closed to enable the Bradley commander and vehicle crew to access the coaxial machine gun. As the door swings open, the CAN bus cable can become torn or impinged on the sharp edges of the commander's periscopes. To correct this, the Master Gunner designed a bracket which can be installed overtop of the vulnerable cables and shield them from becoming damaged. Easy to print and install, the device has been shown to successfully prevent the costly cable from becoming damaged. The 1-64 Armor Battalion has outfitted all Bradleys in their fleet with this device and has also shared it across the Brigade and with the 3rd Infantry Division Marne Innovations Center for dissemination across the Army as a whole.

Further working with the Engineers of the Battlegroup, the Battalion

Innovations Cell once again focused their sights on the critical D7 Dozer fleet. During PMCS, the fusebox cover of one of the Dozers was found to be missing by an operator. The innovations cell was able to design and print a replacement cover (which can commonly become misplaced or lost) within the period of 48 hours. Without the cover, the fusebox is extremely vulnerable to the elements and can quickly become corroded and render the vehicle inoperable. The fusebox is also costly to replace and commonly long-lead. In an environment where every dollar counts for vital Class IX, an ounce of prevention is key to maintaining operational readiness (OR) rates. Using this as an example, the Battalion Innovations Cell plans on continuing to identify common faults and using 3D printed solutions to correct them where possible.

Due to the portability of the 3D printers, the Battalion Innovation Cell was able to prototype parts directly at the vehicle in need. By bringing the ability to manufacture to the mechanics, parts can be immediately identified, printed, and installed. However, there are several considerations when using 3D printed parts to remember: Parts must still be ordered against the ESR to replace the temporary 3D replacements. Any faults corrected by 3D parts can be moved from deadline to slash faults but cannot remove slash faults entirely (IAW Technical Bulletin [TB] 43-0249). Leaders who utilize 3D printed parts must use the "remarks" function on the ESR to indicate that parts must still be ordered and replace them once the original equipment manufacturer (OEM) parts arrive.

To further expand on this concept, the 1-64 Armor Battalion is currently expanding training on this capability to the formation. The Battalion Innovation's Cell will serve as the lead proponent of this effort and develop a block of instruction to share with members of each subordinate unit. The instruction includes a basic course on drafting engineering drawings which will give Soldiers the ability to communicate needed parts to the manufacturing hub (co-located at the field trains command post [FTCP]). A "part report" will be developed, standardized, and

distributed to be understood by operators as well. The report will include the location of vehicles needing parts, pictures of the broken part, number of required replacements, and dimensions of the broken part. This report will allow a manufacturing cell to print the required replacement and send them forward to the required operators on the daily battalion logistics package (LOGPAC). The Battalion Innovations Cell will also provide classes to all field maintenance teams (FMTs) and mechanics. This will allow them to understand the capability of 3D printers and encourage them to identify parts that can be replaced by 3D printed parts. Depending on the likelihood of a part to fail or become damaged / lost, this may even allow the innovations cell to produce a design for the part before it becomes an actual fault. The replacement design can then be kept on a local USB drive to be used when the part is required, almost like creating “running spares” on demand.

Sharing of Standard Triangle Language (STL) files is now commonplace amongst the Third Infantry Division at the Marne Innovations Center. The designs mentioned in this article and many more are currently being shared across the formation to not only enable the 1-64 Armor Battalion to save money and resources but to enable all adjacent units to do the same. To encourage ingenuity efforts in a formation, 1-64 Armor Battalion recommends establishing innovation’s cells at the Battalion level. Units should select personnel with engineering backgrounds, well-versed in CAD and other design software to develop prototypes for printing. 3D printers and the software to use them are multi-faceted in that they can be used for Class IX repair parts, small unmanned aerial system (sUAS), terrain model kit (TMK) parts, and weapons parts. Innovations cannot be treated as a secondary duty and therefore requires an officer in charge (OIC), at a minimum, to work in the cell full time. Innovations also does not stop at just 3D printing; The cell is currently working on a prototype, named “Project Dreadnuaght”, which will be a field expedient drone cage for the M1 Abrams to improve crew survivability. This is in partnership with the Brigade Allied Trades cell, who



Figure 5. Image of CAN bus cables without bracket installed. (Image by SFC Donald Fadel)



Figure 6. Image of CAN bus cables with 3D printed bracket installed. (Image by SFC Donald Fadel)

provides a robust welding capability to the Battalion Innovation’s Cell.

Creative solutions to ongoing problems are not rank dependent, it is the unit’s responsibility to arm Soldiers at the lowest level with the knowledge and guidance required to aggressively innovate across formations. Ingenuity wins wars and is a force multiplier. 3D printing, leveraging relationships, and

preventative measures are effective tools that units can arm themselves with to enable effective maintenance, regardless of current fiscal statuses. The maintenance of an ABCT is not cheap and is sometimes constrained by global supply lines; creativity and innovation will be critical to the next victory of the United States.

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Figure 7. A M88 Hercules Armored Recovery Vehicle belonging to 4th Battalion, 6th Infantry Regiment, 3rd Armored Brigade Combat Team, 1st Armored Division, leaves the Unit Maintenance Collection Point during exercise Balkan Sentinel to recover a vehicle at Korean Training Area, Bulgaria, June 3, 2025. (U.S. Army Photo by SPC Rayonne Bissant)

