Additive Manufacturing

Fix them where they fight

by Maj Catherine DeLeal

Gen Berger has declared logistics the pacing function for achieving his planning guidance, reorienting the Marine Corps to maintaining our prowess as an unquestionably lethal amphibious expeditionary fighting force. As we look to reimagine future logistics and sustainment, we have come to understand the antiquated methods we have relied upon for decades will no longer sustain our lethality and have become an operational liability. Our lines of supply and sustainment are increasingly vulnerable during both low-intensity competition and potential large-scale conflict with a near-peer adversary. While not the only answer, additive manufacturing (AM) has emerged as a viable contributor to logistics and sustainment modernization efforts. Essentially, at its simplest level, AM provides a vital opportunity to modernize how we sustain the force by bringing the point of repair closer to the point of breakage, and it has the potential to dramatically expand what can be repaired at that point for continued fighting.

Briefly, standard manufacturing is subtractive manufacturing, and most of the parts and systems we operate are constructed from components that have been manufactured in a subtractive way. Generally, subtractive manufacturing starts with a larger sheet or piece of metal, and in a variety of processes which encompass a wide swath of techniques, it is reduced to a smaller piece requiring further finishing—like smoothing out rough edges or seams. This is time consuming, waste producing, and can also be more costly for a variety of reasons. Additionally, while the Marine Corps does have an expeditionary traditional fabrication capability, a Shop Equipment Mobile Machine Shop, it has a large footprint. Consisting of two 20' ISO containers and requiring significant heavy equipment support, it typically does not even go on a MEU because of its space requirements and emplacement needs. With AM or 3D printing, pieces or parts are constructed layer by layer through a computer-controlled process in much smaller footprints. This can speed up the parts creation process, eliminate waste, save money, and expand the type of materials parts can be made from. As the field grows, so too do the materials we can use. Currently, industry can 3D print in a wide variety of polymers, metals, and even concrete.

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Most relevant to the Commandant's Expeditionary Advanced Base Operations concept, AM has the ability to move the point of repair of certain parts closer to the point of damage, procure certain parts faster or cheaper, obtain only the necessary components of larger subassemblies, and ultimately sustain our legacy systems plagued by diminishing manufacturing sources and material shortages (DMSMS). When and where the supply chain lags as a result of DMSMS or transportation requirements to overcome geographical challenges, AM can fill gaps. That is where Marines benefit. In garrison, units will see items with fewer days deadlined when a part can be printed in nineteen hours rather than shipped in nineteen days. Units will see part transportation and storage cost reductions when lower-demand items can be printed as necessary rather than stocked, just-in-case. During operations, units maintain momentum when certain broken or damaged equipment can be repaired at a combat outpost, repair and replenishment point, or a forward arming and refueling point in a matter of hours, compared to having to coordinate evacuation to a combat service support area or depot before then having to await repair or replacement.

The effort to ensure AM meets the Marine Corps' expeditionary needs as briefly outlined above is grounded in two efforts currently underway. The first effort embraces technology in logistics, which is crucial to how AM processes have the ability to deliver a digital Class IX block—a Digital Manufacturing Data Vault (DMDV). The DMDV is a central repository containing the technical data packages (TDP) required by the 3D printers to create parts. This

has the real potential to drastically reduce a physical Class IX footprint and sizably contributes to solving how we sustain our forces as they are engaged in the distributed operations envisioned in the Expeditionary Air Base Operations concept. A skilled Marine with a 3D printer can access the technical data packages in the DMDV to create thousands of parts required to maintain our equipment inventory and then fabricate those parts closer to the point of need as described above.

The second effort underway is intertwined with the DMDV, and it is the development of the deployable AM equipment to accomplish fabrication. This is how the TDP files become the necessary parts. In December, we started fielding the first of seventeen Program of Record XFABs (expeditionary fabrication)—a 20' ISO container that works into our existing maintenance battalion expeditionary machining and welding capabilities. The following fiscal year, we are scheduled to field our pelican-case portable tactical fabrication (TACFAB) units to non-maintenance battalions across the fleet. The intent is to put AM in the hands of every battalion and provide them a deployable, expeditionary repair capability to fix what breaks as close to the point of breakage as possible.

AM is not just fabricating repairs onsite or reverse-engineering HMMWV door handles and antenna clips. While those are useful and helpful, they are truly the tip of the iceberg on what AM can provide a deployed battalion and the Marine Corps at large. Twenty years of combat operations has taught us that Marines—the individual rifleman, maintainer, operator, and communicator—possess a creativity born out of necessity that is truly remarkable. We have always prided ourselves on leaving it better than we found it and consistently doing more with less. As AM techniques began to infiltrate the personal interests of Marines, we began to see it amplify the sophistication of the improvements they introduced to their chains of command. Marines are inherently problem solvers out of sheer necessity and force of will. With AM, we enable them to do better than duct tape, 550 cord, and bubblegum, because we all know they will use whatever they can find around them. We were incredibly fortunate that our senior leadership nurtured our grassroots AM efforts by offering Marines innovation challenges and incorporating the best of their ideas across the fleet. This ultimately empowers them to improve their fighting hole by not just seeing problems but creating viable solutions informed by their experiences. We want our junior Marines to lead, and we recognize that officers and SNCOs are not the sole source of bright ideas. Our operators keenly appreciate how we value their input on the jobs they do every day, and as such, they remain out front in our research

and development. Marines are coming up with ideas that solve our immediate supply chain challenges but also move beyond repair parts and reverse engineering. The recent defense budgets will ensure that Marines maintain a growth mindset oriented toward the kind of innovations, which keep us agile and lethal in the face of an evolving enemy because we cannot count on money to solve the problem.

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One such example is a Steering Wheel Removal Device (SWRD). Certain common maintenance operations, both preventive and restorative, on MTVRs and LVSRs require removing the steering wheel with a slide hammer. The problem maintainers discovered was the slide hammer frequently broke the steering wheel, even when used correctly, resulting in deadlining an otherwise operational vehicle. Frustrated with deadlining vehicles and lost maintenance days while awaiting a new steering wheel, Marine maintainers designed, printed, and tested a polymer SWRD device—though it proved too fragile. However, upgrading to a 17-4 stainless steel printed device, these Marines led an effort that now provides the entire fleet with a solution. In the time that they were refining their SWRD, they calculated that I MEF spent over $6,000 and 25 days awaiting parts to repair steering wheels broken by the slide hammer in the last year. This is just one example of how frontline Marines lead us to meaningful improvements to their processes. That saves us money as well as time, and keeps us lethal and agile, while empowering Marines to lead us to solutions improves retention and talent management. This is the vein in which AM adds value to the individual battalion and to the Corps as a whole.

The DOD has expressed a growing interest in AM, and that, frankly, is opportune for Marine Corps logisticians. This ensures that AM within the DOD is not a fleeting technology or series of bright ideas that come to nothing substantial. It is imperative that we learn what is possible and then adopt what is sensible for EABO. We are looking across not just the DOD but also across our national industrial and technology base because where warfighters are in smaller formations spread throughout remote locations, dragging the iron mountain to them to keep them lethal simply will not work. The national industrial manufacturing base and the defense industry are creating systems that incorporate AM techniques at part and system inception. They are delivering end items with AM printed components. They are progressing AM techniques like cold-spray, which aims to improve depot-level maintenance across a variety of platforms that require coating or bonding of complex shapes, and realizes savings in materials, energy, and waste. Delving into more complex AM concepts, we are working with sister Services, industry, and universities to print vehicle hulls and attritable ship-to-shore connectors to deploy and sustain our forces. We are testing printing in concrete for gap closings and concealment structures.

As we learn how to use or incorporate AM to make improvements, we share that knowledge with fellow Marines through our MakerSpace courses and the DMDV TDP repository and with our sister Services through file sharing or through the Defense Logistics Agency's Joint Additive Manufacturing Model Exchange and Joint Additive Manufacturing Acceptability project. This is the behind the scenes AM effort that Headquarters Marine Corps and the Additive Manufacturing Operations Cell at MARCORSYSCOM orchestrate to ensure that FMFs benefit from what AM can offer to shape the battlefield. Sharing education, techniques, and TDPs ensures that AM is poised to meaningfully contribute to EABO logistics and sustainment.

Finally, Gen Berger has showed increased commitment to educating and retaining our forces. AM contributes to that effort as well. We are working with the national education base and looking to partner with a state-endorsed community and technical college system to incorporate parts of their curriculum, best practices, and, importantly, their certification into our MOS-granting schoolhouse. We are engaging this simultaneously with an effort to unite welders and machinists, and teach them 3D printing to create Fabricators. The envisioned Fabricator gives a maintenance battalion, for example, a triple threat Marine—one Marine with three vital repair skills. Additionally, ensuring our Marines learn the skills required to be nationally recognized, certificate-awarded fabrication experts will ensure we have a solid foundation to maintain our legacy systems.

AM is at the intersection of modernizing Marine Corps logistics and overall modernizations efforts across the DOD, national industrial, and education bases as we introspectively examine how we stay ahead of increasingly capable adversaries. We fight to win by harnessing these nascent AM technologies and applying them to age-old warfighting needs and legacy systems, as outlined in *MCO 4700.4* and *DODI 5000.93*. We embrace efforts like AM that demonstrate they will improve effectiveness and lethality.

As logisticians, engage your Marines to identify their maintenance and operations challenges as well as empower them to work with you on the solutions. Each MEF has a MakerSpace and AM capabilities with the tools and fabricators necessary to shape maintenance, repair, and sustainment. The task at hand is to pull AM into your concepts of support as we all pivot to distributed and dispersed expeditionary airbase operations.

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