Fostering Innovation

Utilizing additive manufacturing to support the MAGTF

by Sabrina Patel

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The Marine Corps Systems Command (MCSC) Additive Manufacturing (AM) Team has made large strides in the field of AM, from acquiring the capability to deploying it. The overarching mission of the AM Team at MCSC is to support program office and warfighter success through the implementation of sound engineering principles. As such, the focus of the AM Team's mission is to assist Marines across the MAGTF in learning about and utilizing the technologies, hardware, and software related to their locally deployed AM systems as well as providing on-site technical and engineering support.

USMC Impact

The MCSC AM Team is structured to take fleet requests for gear improvements, create the necessary three-dimensional (3D) printable files, and either print them locally at the MCSC Advanced Prototyping Facility or send the files to the unit for printing. In addition to 3D modeling, the AM Team has gained experience with and identified the applications of different printing methods, printers, and materials offered. Computerized design optimization analyses have also been performed, as applicable, to reduce the overall size and weight of an item as well as the material and cost required to print the part. Alongside these engineering efforts, the AM Team has developed a process to evaluate candidate parts for AM based on size, material, function, design complexity, applied forces, risk, and criticality. Aside from prototyping, AM has been found to bridge the gap between long lead or expensive items and operational readiness.

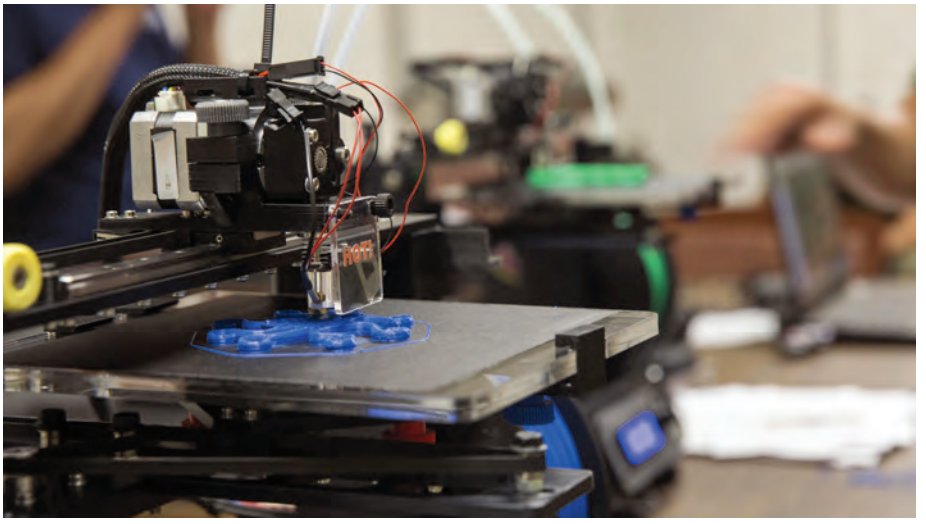
Since an AM capability was established at MCSC two years ago, it has experienced a sharp increase in both the number and intensity of AM-related projects. Currently, they fund and manage a variety of projects, such as 3D-printed concrete buildings and walls, metal 3D printing, polymer printing, and hybrid printing. There are approximately 70 units across the Marine Corps to which the AM Team has deployed an organic 3D printer. Marine Depot Maintenance Commands at both Albany, NY, and Barstow, CA, for example, have recently received large, metal 3D printers (EOS 400). The pace of AM in the Marine Corps continues to increase as Marines realize the benefits of low rate, small batch production.

As stated by the Commandant of the Marine Corps to Congressional Defense Committees, AM will be implemented to "flatten the supply chain" and ensure that the Corps

> continue[s] to stay at the cutting edge of military innovation. Marines are at the forefront of this effort, optimizing the potential of AM in garrison and overseas in austere environments. Our Marines are the world's military leaders in … using AM to produce time and mission critical components.

He also points out that the Marine Corps is

> fostering innovation through the establishment of 'makerspaces' in the operating forces and supporting establishment. Once fully integrated, this capability will enable our Marines to create custom solutions to tactical problems, enhancing flexibility and speed, while fundamentally altering the supply chain and wartime logistics.



Additive manufacturing means that Marines can produce parts quickly, with exact specificaitons, at almost any location. *(Photo by Cpl Justin Updegraff.)*

Local Efforts

Providing support to the end user has been an integral part of the AM Team's effort in developing the 3D printing capability across the Marine Corps. For example, explosive ordnance disposal technicians at MCAS Beaufort, SC, sought to replicate the drone bomblets that were employed by ISIS in Syria. The replicated bomblets serve as training aids to help Marines practice for possible encounters in the future. Using images found in news articles, the AM Team was able to develop near-to-scale 3D assemblies of the two requested bomblet configurations in a single day. The next day, the bomblet replicas were printed and assembled for shipping.

Over the past year, the AM Team has been working closely with the Methods of Entry School (MOES), the Precision Weapons Section, and, more recently, with the Marine Corps Shooting Teams. MOES is uniquely postured to fully exploit the benefits of AM technology because the majority of its expenditures are used for consumable items. The AM Team provides MOES with on-site support to ensure the seamless adoption of AM, such as setting up its AM production area, teaching Marines how to use the associated hardware and software, and creating customized 3D models. To date, MOES has been able to incorporate 3D-printed raptor clips, doorknobs, and deadbolts into its training. 3D-printed breaching strips, substituting the 330B rubber strips, are currently undergoing assessment to ensure their functionality; however, test results have indicated that they are not only functional but eliminate the safety hazard of the rubber strip as a potential projectile as well.

As stated by the Commandant of the Marine Corps,

> To ensure [Marines'] success in future conflicts, we continue to build upon our lethality as we adapt our training, driving changes in our programs … Innovation remains a critical aspect of our Corps as Marines continue learning through the testing and evaluation of new methodologies and technologies to gain advantage over our rivals.

MOES is leading innovation in the explosive ordnance disposal realm and capitalizing on the AM capability. As conceptualized by MOES leadership, the AM Team is engineering, designing, and developing an explosive door-breaching charge that has never before existed. This charge combines the application of a hinge slider charge with the functionality of a push charge and shape charge along with the safety and efficiency of a water-tamped charge.

Additive manufacturing and 3D printing allow Marines to make replacement hardware at their duty station or while deployed. *(Photo by LCpl Isabella Ortega.)*

While water-tamped charges are incredibly functional, they typically require the use of two IV bags, which are cumbersome loads when added to the gear Marines already carry. Because of this, this charge is very rarely used by the Marine forces. Additionally, the use of interior breaching charges is coming under review because of the adverse effects sustained by Marines as a result of exposure to exploded energy in a confined space. These types of situations are what drove MOES leadership to want to do better for the Marine forces, and their AM capability gives them the assurance that they can. There are many goals associated with the development of the breaching charge. These include minimizing the amount of explosive material required for a successful breach in order to make the most efficient use of that material and to drive down cost, minimizing the blast overpressure and fragmentation of the charge in order to decrease the safe standoff distance and reduce the risk of adverse effects to Marines, minimizing the time-on-target in order to ensure a rapid breaching operation and ensure the safety of the Marines, and minimizing the size and weight in order to reduce the burden on the Marines by making it easily transportable, assembled, and implemented.

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With these goals in mind, the AM Team is developing a design that is

universal in nature to maximize the potential applications of a single form factor while ensuring the function and safety of the charge is not degraded in comparison to the slider charge currently in use in training at MOES and in the field. "Universal" means the charge can be used on either a right-hand or left-hand hinge. The design also has the potential of being placed on a doorknob or deadbolt, defeating a door at a different target point. An exterior, outward-opening metal door is, theoretically, the most difficult to breach, so that is the minimum threshold the charges are being tested against for functionality. Another goal to achieve universality is that the charge should be able to be tamped with water, sand, or both. This allows its application to be configured based on the environment it's being employed in. MOES is capable of supporting on-site testing at its facilities, which will help minimize the time and cost to test these developing prototypes. If testing yields positive results, these charges may even be capable of replacing interior charges, ensuring the safety of the Marines.

Cost Savings

Within the overall 3D printing effort, the AM Team has deployed 3D printers and materials and has made technical data available to units worldwide. This effort has enabled Marine forces to rapidly adopt new technologies and sustainment capabilities, such as 3D-printed drones. Additionally, the AM capability has resulted in unprecedented cost savings for training units collocated at Marine Corps Base Quantico, VA, through the 3D printing of consumable items. The Precision Weapons Section is using AM to 3D print replacement rifle sling buckles for less than $0.25, rather than having to buy new slings at a cost of around $40. The Marine Corps Shooting Team is currently assessing 3D-printed throw levers, shotgun shell caddies, belt clips, and magwells with a projected cost savings of over 80 percent. The MOES is 3D printing doorknobs, deadbolts, and detonation cord connectors used in breacher training to realize a cost saving of around 95 percent of its annual consumable item budget.

These are just some of the ways AM is currently being applied to support innovation efforts throughout the Marine Corps; what the future holds is up to you!