U.S. Marines: Seeking a Few Good Co-Creators

Leveraging open-source product development, the Marines are using digital technology and 3D printing to enhance their supply chain

By Robert Grace

Frustrated by the unresponsiveness of traditional supply chains, members of the U.S. Marines Corps (USMC) from the Twentynine Palms military base in Southern California opted for a radical new approach. Wanting to find an innovative way to use emerging technologies to design and build a versatile new type of logistics vehicle, they threw down a challenge—to the world. And the world responded.

In the end, from roughly 90 entries, an ambitious young engineer from India named Arnab Chatterjee produced, on his second try, the winning design.

USMC worked with various partners, including Deloitte, Siemens, and Oakland, Calif.-based advanced manufacturing design firm Fathom, via a co-creation platform operated by Launch Forth (www.launchforth.io). The latter is a subsidiary of San Francisco-based LM Industries Group Inc., which describes itself as "the world's first digital OEM." LM's other subsidiary is Local Motors, an American motor vehicle manufacturing company that focuses on low-volume production of open-source motor vehicle designs using multiple microfactories.

"We are prime contractors to the U.S. Department of Defense, and Deloitte and Siemens … are subcontractors to us," noted Launch Forth Executive Vice President Rob Coleman, in an interview at LM Industries' Knoxville, Tenn., microfactory this past May.

MLV module platform, in the midst of transition from the administrative module (left) to construction module (right), at Camp Pendleton, Calif. Courtesy of Launch Forth

Launch Forth declares: "We connect businesses to our global solver community of designers and engineers and use agile manufacturing to develop, build, and deploy mobility solutions." Launched in 2010, that online community—which is free to join—features more than 200,000 members worldwide.

It has now executed more than 100 challenges, yielding more than 9,500 product designs, according to Coleman. Winners of these challenges stand to earn prize money (Chatterjee won $20,000) and considerable public recognition; in return, they agree to turn over all rights to the intellectual property of their winning entry.

Crowdsourcing Design Ideas

Launch Forth signed a contract with the Marines in late 2017, and began an online design challenge early the following year. For this concept challenge, dubbed the Modular Logistics Vehicle (or MLV) project, Launch Forth asked participants to design a new type of light vehicle with modular elements that will allow for the vehicle to meet various use-cases.

The objective of this concept challenge was to give Marines operating "behind the wire" (within the confines of a base) improved functionality and experience while conducting operations. This new vehicle was to incorporate modular adjustments "to improve the Marine experience and their corresponding operations." As new needs and use cases become discovered, they also wanted the ability to design new modules and customize them on-base. (They noted that none of these use cases are in combat, and asked participants to not include weapons on the design.)

The vehicle's maximum dimensions were specified as: 72 inches high by 141 inches long by 64 inches wide, with a maximum curb weight of 2,000 pounds, and a gross vehicle weight of up to 4,000 pounds. It also needed to have a minimum ground clearance of 10 inches.

The four initially proposed use cases included:

» Personnel movement (for six or more people and their gear);

» Mechanical repair (to allow for transport of one or two people, plus replacement parts and related tools);

» Administrative support (to serve as a "moving office" for Marines overseeing operations and completing quality assurance tasks); and

» Construction support (to allow for the preservation, packaging and packing of supplies used to build infrastructure such as fences or buildings).

Refining Initial Concepts

After an initial round of entries (and winners), the partners further developed the project and launched what they called the technical challenge in spring 2018. For the new effort, dubbed "MLV: Refined," they stated: "We are asking you to take inspiration from the winners of the previous MLV Design Challenge and either expand upon your earlier MLV concepts or design something entirely new. Designs will need to incorporate new and innovative technologies, show module designs for all four use cases, and be provided in CAD."

Launch Forth EVP Rob Coleman, at LM Industries' Knoxville, Tenn., microfactory. Photo by Robert Grace

The design brief also spelled out a series of five principles that "solvers" needed to address:

» Modular—Interoperability is all that matters

» Breakable/hackable—Design for the need but anticipate the unexpected.

» Understandable—Intuitive for users of all types to use, modify, and share functional builds

» Function over form—Fewer format features maximizing usability over aesthetics

» High capacity—Room to hold more people, more equipment, and more functions.

From the first round, the judges particularly liked concepts that consisted of a front cab with segmented modules that loaded in the back. Those segments made for easy module swapping and simple transport. They urged participants "to try to design the modules as self-contained units and refer to the use cases below to see exactly what needs to be transported."

Rising to the Challenge

Arnab Chatterjee, a freelance mechanical engineer in Bangalore, India, who earned his degree in August 2016, did not win or place in the first challenge, but he was not deterred. He says he declined an offer to pursue his Ph.D. in mechanical engineering at Clemson University in South Carolina and instead opted to strike out on his own. He saw an article about Local Motors 3D printing functional cars and was fascinated. When he learned of the MLV design challenge, he decided to enter.

He says the biggest obstacle he faced was that he had never before participated in a design challenge, so he had to do a lot of research. His initial design, called the Hybrid Adaptive Transport (or HAT), did not impress the challenge's judges. That only motivated him more.

He explained his thought process in a YouTube video

Thermwood LSAM 3D printer in LM Industries' Knoxville, Tenn., microfactory. Courtesy of Launch Forth

interview from late last year: http://bit.ly/Arnab_MLV_Refined. When reviewing the other entries and going through the judges' feedback, he says: "I realized that actually there were a lot of faults in my design, so I had to overcome that. And that feedback actually helped me to come up with the HAT 2.0, which was, to me, much, much better than the first version."

In the summary of his second, 69-page submission, he wrote: "When going through the different winning designs, I started to note down the strong points of each in my diary. Once that was done, it was a process of combining these strong points and then improving upon it. I spent a week just doing my research.

"Eventually I realized that the best way to achieve all the targets and improve upon them will be to develop a platform on which any type of module can be placed or built. Hence I divided the entire vehicle into two parts—the module and the platform."

About Hybrid Adaptive Transport 2.0

The resulting effort led to him to develop HAT 2.0 (http://bit.ly/HAT2_files), which features a hybrid drivetrain system and is completely modular, making it adaptable to a wide variety of circumstances and user needs.

"The HAT 2.0 platform is built to be as light as possible while still remaining a robust platform," Chatterjee explains in his project brief. "The main frames at the top and bottom are proposed to be 3D printed with possibly carbon-filled nylon. ... The top and bottom 3D-printed frames are joined with structures made of aluminum sockets and carbon fiber tubes joined together with aerospace-grade adhesives."

The hybrid drive train consists of 12 Tesla-sized modules of 5.3 kWh each at the back, yielding a 63.6 kWh lithium-ion battery pack, weighing a total of 660 pounds. It also is designed to have a JP-8 or diesel-run generator at the front, making it a truly hybrid vehicle. Fitted with an advanced differential steering system, the HAT 2.0 concept offers different driving modes—from manual to wireless to semi-autonomous to fully autonomous (which is feasible, given that a military base is a highly controlled environment).

"Practicality is the first priority for me," Chatterjee says. "I have to make my name for it. I can't just be a particle in the universe who once existed for just a fraction of the time for which the universe existed. So that inspires me to wake up every day and do better than the previous day."

The prize money, Chatterjee notes, helped him to move from Calcutta to Bangalore in southern India, where better technology resources exist. He continues to develop new concepts he hopes will get the attention of Launch Forth going forward.

Compressing Development Lead Time

Launch Forth, meanwhile, points out that the entire MLV project was completed in less than a year. It held the initial innovation session at Twentynine Palms, and this is what inspired the co-creation challenge that was run on its platform and opened up to the community. Fathom then, using both additive and traditional manufacturing processes, took just 10 weeks to build a proof-of-concept vehicle. That prototype then was demonstrated to the Marines at Camp Pendleton near San Diego.

Never intended to be a fully functional prototype, that vehicle instead focused on modularity as a key design feature and on the benefits of additive manufacturing. The MLV remains a concept, and no such vehicles are yet in everyday use.

Fathom's team used Siemens' Product Lifecycle Management (PLM) software, creating a cloud-based digital thread where Fathom's designers could access the 3D computer-aided design (CAD) files to further refine them. USMC describes the digital thread as "a single, seamless strand of data that stretches from initial design concept to the finished product."

Fathom engineers translated designs from the digital reference into production plans and machine-specific instructions for direct-to-digital manufacturing. The engineers analyzed and optimized the winning design before any part was produced—thereby saving time and pre-empting waste. This was vital, given that the MLV prototype comprised more than 1,800 components.

Base of the HAT 2.0's water module, as printed from carbon fiber-filled ABS on the Thermwood LSAM (left). HAT 2.0's final water tank, which can hold 3,615 liters of fluid. Courtesy of Launch Forth

Weaving a Digital Thread

Going forward, all production data captured in the digital thread is available to inform future builds. For every manufactured MLV component, USMC notes, a part-specific digital twin was created and stored in the digital thread. The digital twin is a parallel, cloud-based embodiment of all data captured throughout a product's lifecycle, ranging from initial design to field use.

"The MLV's components were then tested and validated," according to a USMC educational video. "The part's digital twin was compared against its digital reference to identify any variances between how the digital simulation of the physical part and the ideal digital model perform." This gave the Marines a deep review into part deviations before performance issues arise in the field. These test results were recorded in the part's digital twin and integrated back into the digital thread.

"The combination of data verification and product validation," the video notes, "ensures that the part will function as originally designed. At the end of the stage, the product's digital twin holds relevant data associated with its production process. Once assembled and validated, Fathom delivered the MLV prototype to the Marines."

As for specific materials and processes used to create the demonstration vehicle, Fathom printed the front bumper from ABS resin using Fused Deposition Modeling (FDM) on a Stratasys Fortus 900 machine.

Various curved edges were used to enhance the design aesthetic on parts such as the front fender's main construction, its cooling inlets, and its lower section. For that, they used ABS, nylon 12, and 3D Systems Inc.'s Accura Xtreme stereolithography (SLA) resin, employing both an FDM machine and HP Inc.'s single-layer Multi Jet Fusion (MJF) process on an HP Jet Fusion 3D 4200 machine.

Chatterjee's design delivered the desired modular vehicle design, and his submission addressed all four of the requested use cases. Fathom proceeded to 3D print and fabricate two modules and one platform as a proof-of-concept. Additionally, Chatterjee's submission included modules for other use cases that Launch Forth had not requested. So, when it came to demonstration day, the Marines got a bonus by 3D printing a water tank module, dubbed the "Charlie" build.

This "Charlie" model was the MLV demonstration vehicle on display in Local Motor's lobby when this reporter visited earlier this year. The firm had used the FDM process on a massive, new large-scale additive manufacturing (LSAM) machine from Thermwood Corp. to print the water module out of carbon-filled polycarbonate for the black tank, which measures 101 inches long by 63 inches wide by 71 inches high. It used Eastman Chemical Co.'s Amphora 3D printing material to print the tank's clear parts.

LM Industries is displaying the LMV in part to showcase the 3D printing capabilities at its Knoxville facility, including the Thermwood LSAM (www.thermwood.com/lsam_home.htm), which both can print and trim on the same machine. The model in Knoxville is capable of printing parts up to 40 feet by 10 feet by 6 feet in size, according to Coleman.

Touting CoLab Co-Creation

The Marine Corps, meanwhile, is excited about what it calls this new "CoLab process" of co-creation, which it says "disrupts a conventional approach to military design and manufacturing, compressing the development cycle from decades to months."

The digital thread facilitates the flow of information between various stages of the design and manufacturing processes. In doing so, it connects seemingly disparate data systems and technologies into a single coherent network. The CoLab digital thread process, USMC explains, consists of five key stages: 1) co-creation; 2) design and analyze; 3) build and monitor; 4) test and validate; and 5) deliver and manage.

"Each stage adds to a growing body of knowledge. This allows for continuous improvement of unique parts, as well as the entire portfolio of products." Chatterjee's Modular Logistics Vehicle is the first product in the CoLab portfolio.

Throughout its lifecycle, the Marines note, the MLV will be managed in the digital thread. This enables rapid repair and version iteration for product maintenance, customization, and evolution.

"With a CoLab digital thread, the Marines have a tool that supports a repeatable, scalable and flexible process. It helps them get mission critical capabilities deployed faster than ever before and it lets Marines adapt quickly to changing situations and needs."

The Right Kind of Disruption

Col. Howard Marotto, deputy director of the Next Generation Logistics Headquarters Marine Corps – Installation & Logistics, says USMC's CoLab "disrupts our conventional approach, the [Department of Defense's] conventional approach—and that's exactly what we need right now, with advancing, emerging technology and a rapidly advancing adversary."

Further, he notes, "These advances are driven by data and connectivity. We need a flexible, scalable technology to manage it all. That's why when we look toward the future of our supply chains, we think about the digital thread. With the digital thread, the CoLab is connected to systems and stakeholders to create innovative products."

The first such product, the MLV, was designed to adapt to mission needs at a moment's notice, and "will be a forerunner for numerous other systems."

"This is why," Marotto adds, "we think the CoLab, which gives us access to this digital supply network, is going to be absolutely critical to victory on the future battlefield."