

# An Advance to Joint Robotics

How MCWL's history in ground robotics illuminated the path to success  
by SSgt Matthew Foglesong, PhD.

The Science and Technology (S&T) Division of the Marine Corps Warfighting Laboratory (MCWL) identifies, develops, and delivers innovative capabilities for warfighter assessment and experimentation in support of the Marine Corps future force design and development activities. Additionally, the S&T Division assesses emerging commercial technologies with potential military utility. One focus area of development and assessment for the S&T Division since its inception has been on the use of robotic and autonomous systems to help enhance the capabilities and survivability of our warfighters. Unmanned aircraft systems always received a lot of the attention, but the S&T Division also has an extensive history developing unmanned ground vehicles (UGVs) and their ability to share a common controller to reduce redundancy, extraneous gear, and extra weight on the infantryman. Moving into the future, UGVs will increasingly proliferate the battlefield, especially in the highly dispersed and mobile operations that current force design efforts seek to address. One thing has become clear throughout S&T Division's development and assessment of UGVs. The key to efficiently developing and fielding the most effective UGVs for the Marine Corps greatly depends on close collaboration and integration with the other Services and defense agencies. The Marine Corps does not have the budget to develop its own unique UGVs. Just as important, Marine Corps' UGVs must be fully interoperable with the full spectrum of joint manned and unmanned systems and their corresponding command and control (C2) networks.

**>SSgt Foglesong is a 0321/Reconnaissance Marine, currently serving as the Robotics and Autonomous Systems Branch Head at the Marine Corps Warfighting Laboratory.**

Early robotics and autonomous system efforts at MCWL experienced relative levels of success but revealed a need for better inter-Service interoperability. The early-2000s saw the development of the Dragon Runner, a twenty-pound, tracked, man-packable robot, developed with Carnegie Mellon University's National Robotics Engineering Center and a small company in Pittsburgh, PA, by the name of Automatika, Inc. (Since acquired and known as Qinetiq North America). Designed to operate in areas too dangerous for or inaccessible to hu-

man operators, the Dragon Runner saw significant use by both Marine Corps and Army EOD units. The United Kingdom Ministry of Defense also ordered 100 units to augment their IED disposal efforts. Dragon Runner demonstrated the potential for how UGVs can greatly reduce the risk to warfighters on the modern battlefield, but it was simply a self-contained, rugged, remotely-operated vehicle with some sensors and manipulators. It was difficult, if not impossible, to do things like readily share sensor feeds with other units or pass control of the Dragon Runner from one team to another. This was due in part to the early maturity of the system but more so because interoperability had not been designed into the system at its inception. In a Global war on Terrorism scenario, Dragon Runner could have been much more effective



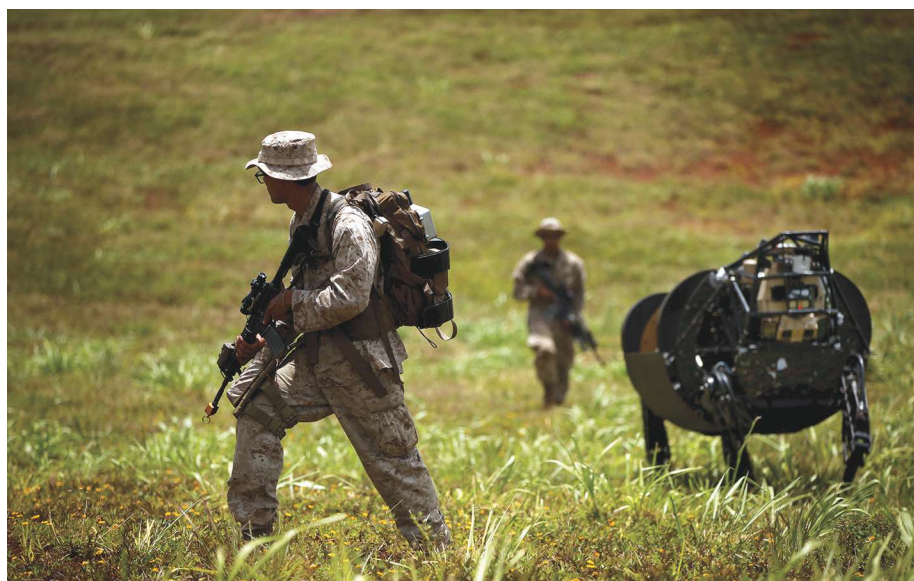
**Dragon Runner, first developed in the early 2000s, demonstrated how UGVs could reduce risk to EOD teams. (Photo: Courtesy MCWL.)**

if a Marine rifle company was able to use it to conduct a reconnaissance of their patrol route. Then, if the company found something that looked like an IED, the company could pass the video feed from the Dragon Runner to a supporting Army EOD who could take control of the UGV and conduct a detailed assessment from their base before sending a team to destroy or render the device safe. In other words, while UGVs still required a greater level of technical maturity, the greatest need was for much better Service integration.

With the lessons of Dragon Runner in mind, beginning in 2009, MCWL S&T Division initiated an eight-year off-road autonomy and perception algorithms development effort that resulted in the development of two technologies: the Ground Unmanned Support Surrogate (GUSS) and the Legged Squad Support System (LS3). GUSS added autonomy systems to legacy Internally Transported Vehicles and prototype Polaris MRZR All-Terrain Vehicles, which proved that fully autonomous UGV technology was mature enough to significantly reduce the physical and cognitive burdens of Marines while achieving a level of manned-unmanned teaming with the potential to revolutionize ground operations. GUSS demonstrated that a UGV no longer needed a dedicated Marine to control every move of the vehicle remotely. Instead, the Marine could give GUSS a destination and the robot would find its way autonomously, or GUSS could follow in trace of a Marine or convoy completely autonomously. Similarly, the LS3 was a purpose-built quadruped robotic mule made by Boston Dynamics programmed to autonomously follow an operator over rough terrain, carrying heavy loads like ammo, personal gear, water, and food. GUSS and LS3 were Marine-centric prototype and experimentation efforts, but MCWL S&T Division shared the results of the multiple assessments and experiments with Army counterparts who were conducting similar S&T efforts. The GUSS and LS3 projects significantly advanced the level of autonomy and man-unmanned teaming for UGVs and also made clear that, given the costs, these



**The Ground Unmanned Support System (GUSS) showed that a UGV did not need to be “remote controlled” by a dedicated Marine.** (Photo: Courtesy MCWL.)



**The Legged Squad Support System (LS3) was purpose-built to “follow” dismantled Marines.** (Photo: Courtesy MCWL.)

were not systems the Marine Corps had the resources to develop and field in any significant quantities on its own. The Army and the other Services and Service Agencies were conducting similar UGV S&T projects, and the Marine Corps needed to better influence and leverage those efforts.

The existence of multiple Service UGV efforts, sometimes complementary and sometimes duplicative, was one of the primary catalysts for the creation in 2016 of what became known as the Joint Ground Robotics

Integration Team (JGRIT). Primarily an Army and Marine Corps team, the JGRIT sought to address UGV limitations and interoperability issues. It was through the JGRIT that S&T Division’s next UGV project, the Forward Robotic RSTA Experimentation and TTP (FERRET) system and an unmanned systems Tactical Robotic Controller were initiated. Taking the lessons learned from past UGV projects and operating under the hypothesis that autonomous drive to object and mapping technology in denied environments



would require significant cognitive loads by their human operators, FERRET was an attempt to build autonomous tactics, techniques, and standard operating procedures for small, unmanned ground vehicles. The joint S&T program explored semi-autonomous behaviors for reconnaissance, surveillance, and target acquisition (RSTA) UGV assets, the integration of autonomous capabilities with robotics controllers, and the understanding of human-machine interaction on the battlefield.

This closer, more formal UGV coordination through the JGRIT and with the Army, along with the lessons learned from MCWL S&T Division's past UGV development work, resulted in what can potentially be one of the most successful bottom up UGV innovation efforts for both the Army and Marine Corps. The MCWL S&T Division's Expeditionary Modular Autonomous Vehicle (EMAV) was created using a multitude of lessons learned from past and ongoing UGV efforts across the DOD to create the Marine Corps' first fully autonomous and adaptive UGV. Using the autonomy hardware and software developed for the GUSS project, EMAV includes a modular payload integration architecture that provides the ability to rapidly change payloads for a variety of missions across multiple warfighting functions. EMAV is capable of remote controlled or fully autonomous operations and provides combat forces with a highly mobile, MV-22 transportable, multiple payload UGV for use at the tactical level in a multitude of missions while retaining the ability to off-board stored electrical power. In March 2018, the Army Futures Command Ground Vehicle Support Center hosted a Robotics Rodeo in College Station, TX. There the EMAV outperformed all other UGVs in its size/weight category and demonstrated a level of modularity far beyond the other participating UGVs. After an additional series of successful demonstrations, developmental tests, and assessments, MCWL, with support from Pratt & Miller Engineering, entered the EMAV as a contender for the Army Robotic Combat Vehicle-Light (RCV-L) Program. The collaborative

efforts from developing this highly mobile, modular, and expeditionary platform led the Army to down select EMAV as the RCV-L vehicle of choice for further experimentation and tactics, techniques, and procedures as well as standard operating procedure development. While the Army pushes ahead with capabilities documentation and development aspects of the RCV-L program, the Marine Corps is leading the way in multi-mission payload development, warfighting integration, and man-unmanned teaming experimentation. The long-term success of

the RCV-L program, however, will rely on highly collaborative cross-service coordination and free sharing of data across the Services and developmental partners. In order to drive cost down, reduce developmental risk, find new avenues of approach, and ensure a common lexicon, the Marine Corps and the Army owe it to the warfighters of tomorrow to pave this road together.

The future of UGVs is joint. The future is purple. The JGRIT, a cross-DOD consortium of robotics and autonomous systems subject matter experts and uniformed stakeholders,



**The Forward Robotic RSTA Experimentation and TTP was an effort to develop standard operating procedures for autonomous UGVs. (Courtesy Photo Defense Media Activity.)**



**Joint Marine and Army coordination on UGVs produced the Expeditionary Modular Autonomous Vehicle—the first fully autonomous and adaptive UGV. (Photo: Courtesy MCWL.)**

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**Updated versions of Dragon Runner are still employed by joint and allied forces. (Photo by Spc Ryan Lucas.)**

provided significant credibility to UGV programs and projects throughout the DOD. Prior to the JGRIT, projects were joint only by personality and through individual collaborative efforts. That is to say, for many years, personal connections alone determined programmatic success in the robotics world. Unfortunately, the last JGRIT meeting occurred the fall of 2017. Although the JGRIT effort was brief, the relationships solidified by this formal integration team formed the bedrock for the ground robotics programs seeing success today. Joint collaboration at the action officer level has continued, and the Army's selection of the EMAV as their RCV-L development platform is a result of this continued collaboration. However, a more formal, higher-level, and enduring construct like the JGRIT is essential for the future of UGVs across all the Services. Advancing joint programs is more complicated but worth the effort, especially for the Marine Corps. In a fiscally constrained environment, joint coordination and development can lead to lower system costs through economies of scale and facilitate cross-Service systems integration. The Services need to reinvigorate the JGRIT and reap the benefits of programs that are inherently interoperable and aligned with national strategies.

Key documents and experimentation campaigns, such as the Office of Naval Research's Intelligent Autonomy Strategy, the Marine Corps' Expeditionary Advanced Base Operations concept, the Army's Project Convergence experimentation campaign, all directly call out the necessity of interoperability during joint operations. True success in the future combat environment, however, will rely on much more than discreet thinking and good intentions. A cross-functional team of technologists, acquisitions professionals, systems engineers, and systems integrators is integral for developing a joint system-of-systems that give combat commander's faith in the UGV technologies through interoperability, high-fidelity information, and system reliability.

The current ad hoc working relationships between the DOD's UGV subject matter experts must be solidified through engaged Service leadership with a common vision and guidance. It is only through this level of joint collaboration that UGVs can truly achieve the significant warfighting capabilities they have the potential to bring to the battlespace of the future.

