

PEO GCS's Digitized Towed Howitzer Supports the GWOT

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The Joint Program Manager Lightweight 155mm (JPM LW155) howitzer, in partnership with industry and the U.S. Army Armament Research, Development, and Engineering Center (ARDEC), has delivered a digital fire control system (DFCS) for the M777A2 155mm howitzer to support the towed artillery mission across the Army and U.S. Marine Corps (USMC). The M777A2 is a Joint program between the Army and the USMC that upgrades the basic M777 (conventional glass and iron sights) to the M777A2. The M777A2 incorporates the advanced DFCS — a first for U.S. towed artillery — and is currently being used by the Army, USMC, and Canadian forces in *Operations Enduring and Iraqi Freedom (OEF/OIF)*. Army and USMC procurements total nearly 800 howitzers. The USMC is the lead service for the program, but JPM LW155 was established at ARDEC to leverage the artillery domain expertise that resides there. As a Joint program office, JPM LW155 reports directly to the U.S. Army Program Executive Office Ground Combat Systems (PEO GCS) and the USMC PEO Land Systems, and takes a Joint Army and Marine perspective in managing system development, acquisition, testing, integration, product improvement, fielding, and sustainment of the system. This article discusses the key role digitization plays every day in the global war on terrorism (GWOT), the acquisition process for developing DFCS, and future JPM LW155 efforts in digitization.

During a calibration exercise in Camp Taji, Iraq, in January 2008, Soldiers from Battery B, 2nd Battalion (Bn), 11th Field Artillery Regiment (FAR), cleared a target area and fired their M777A2 LW howitzer several miles downrange as quickly and accurately as possible. (U.S. Army photo by SPC Aaron L. Rosencrans, 2nd Stryker Brigade Combat Team.)

Why Digitize?

DFCS provides each M777A2 howitzer with onboard navigation, digital communication with the Fire Direction Center (FDC), and automatic weapon-pointing capability. As compared with conventional surveying and sighting of artillery, DFCS provides each DFCS-equipped gun with much greater autonomy through significantly reduced time for gun emplacement and increased speed and efficiency in mission execution.

The system uses information from an inertial navigation system, together with the Global Positioning System (GPS) and vehicle motion sensor, to accurately locate the weapon and orient it in space for precision aiming (<1 mil) and firing. The system embeds a radio for digital transmission of data between the FDC and the howitzer, and has graphical and text screens for displaying mission data to the crew. The system also has redundancy to continue digital operations in the absence of a GPS signal. These improvements increase crew survivability through greater speed into and out of action. DFCS also provides the ability to program and fire the M982 Excalibur Precision-Guided Munition, which delivers leap-ahead precision strike capability in support of maneuver units.

The Scope of the Digitization Effort

JPM LW155, with its prime contractor, BAE Systems, manages the production and fielding of M777A2 howitzers. As a major subcontractor to BAE Systems, General Dynamics Armament Technical Products produces and integrates the DFCS while General Dynamics Canada (GDC) supplies the computer and displays. GDC also developed the initial version of M777A1 software referred to as Towed



Here, a 3rd Bn, 321st FAR, LW155 M777A2 howitzer is being airlifted by a USMC V-22 Osprey during air assault operations. (U.S. Army photo courtesy of PM LW155 howitzer.)

Artillery Digitization (TAD) Block 1. ARDEC provided matrix-engineering support to the JPM LW155 during the design and development of the Block 1 software effort and performed formal qualification testing of that software.

Taking an evolutionary approach to building objective capability, JPM LW155 tasked ARDEC to upgrade the Block 1 software to incorporate upgrades emerging from complementary systems, and to expand the howitzer's capabilities. This software, also referred to as TAD Block 1A software, was provided to BAE Systems as a government

furnished item for installation onto the M777A2 howitzers being delivered.

To develop this Block 1A software, ARDEC's software development team

had to work closely with the teams developing the Enhanced Portable Inductive Artillery Fuze Setter (EPIAFS), the Advanced Field Artillery Tactical Data System (AFATDS), and GDC to acquire production representative hardware to support Block

1A software development activities. ARDEC's fuze division worked closely with PM Excalibur and Raytheon to

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develop the means to inductively set a precision-guided round. The software had to support a new digital interface with the EPIAFS and incorporate a new variable message format interface as well as a new fire mission thread of control to interface with the FDC. In parallel with the M777A2 activities, PM Battle Command needed to insert this capability into AFATDS.

The technical baseline focused on providing essential capability to fire Excalibur projectiles using soon-to-be-fielded digitized M777A1 howitzers. No additional electrical or mechanical interfaces were required since the EPIAFS was already anticipated and planned for when finalizing the Block 1 system architecture. Key milestones that were incorporated into the program's

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Integrated Master Schedule included support of a March 2006 Excalibur Limited User Test and a Materiel Release date in June 2006. To support these key events, the delivery of production representative hardware items and the availability of AFATDS, EPIAFS, and the Excalibur projectile (some of which were still under development) all had to be intensively managed by their respective organizations and the software Integrated Product Team had to stay on track. These dependencies represented the majority of items registered in the project's risk database.

The Digitization Process

ARDEC employed processes conforming to the Software Engineering Institute's Capability Maturity Model

Integration (CMMI)-based processes to develop the software. The project was planned using an incremental approach that focused on providing core capabilities needed for Excalibur in the first software drop, with the remaining functionality to be provided in a second drop. Several hundred tasks entered in Microsoft® Project were logically grouped into 63 different cost accounts for earned value measurement. The project used Telelogic's DOORS for requirements management. Monthly measures of volatility, number of change requests, and timeliness of processing these requests were collected. Likewise, defect data resulting from user design reviews, code reviews, and testing was collected and analyzed. The results of internal process audits drove actions to assure process compliance. Quantitative project management and predictive measures included a control chart of the monthly cost/performance index for cost containment and a Rayleigh curve of the number of defects found per week during testing to predict the remaining weeks until the software was of sufficient maturity for release. The measures collection provided JPM LW155 and ARDEC management with the necessary insight to make informed decisions throughout the development cycle.

ARDEC performed extensive user design reviews covering all aspects of display screens. To the maximum extent practical, the team defined all entry and exit conditions causing intra- as well as inter-screen transitions. User and JPM LW155 representatives were able to review and approve screen designs prior to implementing them in code. User design reviews were conducted after developers had an opportunity to analyze the requirements and were given the mission to begin representing



Breakdown of Towed Artillery Digitization



PVT Corey Rodriguez pulls the lanyard on the M777A2 during the first firing of the Army's GPS-guided Excalibur round on Feb. 25, 2008, at Camp Blessing, Afghanistan. (U.S. Army photo by SGT Henry Selzer, 173rd BCT Public Affairs.)

the screens in code. These reviews provided the necessary forum for both developers and testers to suggest changes and provide value-added comments on feasibility. The team operated under a “no surprises” philosophy to ensure that both the user community and JPM LW155 were in lockstep with all refinements to the human computer interface, irrespective of the magnitude of change. User design reviews served as an effective means to illuminate potential problems early in the development cycle. They also improved design synthesis by providing developers a vehicle for vetting potential improvements without

having to adopt the “build it and they will come (to accept it)” attitude.

As a result of the above process, only the first unit equipped with a M777A1 digitized howitzer in January 2007 needed to be retrained. All subsequent fieldings of M777A2 howitzers were accomplished with Block 1A software. The M777A2 with TAD Block 1A software was approved for full materiel release in July 2007. In 2006, ARDEC's Armament Software Engineering Center, in large part because of their efforts in developing and fielding the M777A2 software, was the first DOD organization to attain a CMMI maturity level 5 rating

in the disciplines of Systems Engineering, Software Engineering, and Supplier. In 2007, ARDEC was also a recipient of the Malcolm Baldrige National Quality Award.

Future Digitization Efforts

ARDEC currently supports and maintains the M777A2 software. The next release will include support for new munitions, including the Precision Guidance Kit fuze that improves the accuracy of existing projectiles using GPS guidance. Subsequent releases of the software will include additional capabilities of TAD Block 2. These capabilities include muzzle velocity management, ammunition selection, and onboard ballistic computations with registration corrections.

Digitization is also going to be brought to the M119A2. In January 2008, JPM LW155 was directed by the Army to proceed with the digitization of the M119A2, employing an evolutionary acquisition strategy that maximizes commonality of hardware and software across the brigade combat team (BCT). Soon the crews of all towed howitzers will reap the benefits that are afforded by digitization.

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