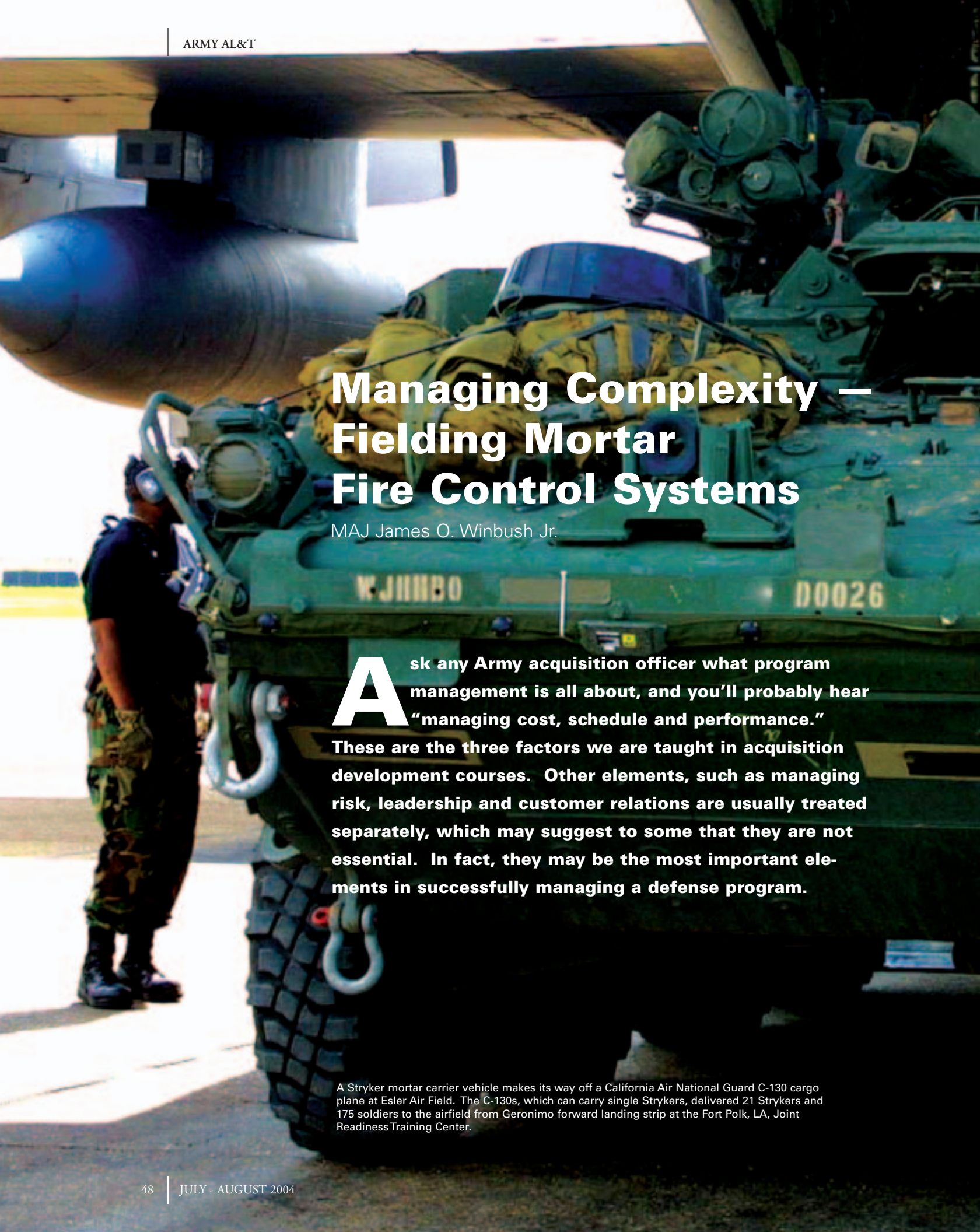

Managing Complexity — Fielding Mortar Fire Control Systems

MAJ James O. Winbush Jr.

Ask any Army acquisition officer what program management is all about, and you'll probably hear "managing cost, schedule and performance." These are the three factors we are taught in acquisition development courses. Other elements, such as managing risk, leadership and customer relations are usually treated separately, which may suggest to some that they are not essential. In fact, they may be the most important elements in successfully managing a defense program.

A Stryker mortar carrier vehicle makes its way off a California Air National Guard C-130 cargo plane at Esler Air Field. The C-130s, which can carry single Strykers, delivered 21 Strykers and 175 soldiers to the airfield from Geronimo forward landing strip at the Fort Polk, LA, Joint Readiness Training Center.

Lightweight Hand-Held Mortar Ballistic Computer

With this in mind, the Product Manager for Mortar Systems (PM Mortars) at Picatinny Arsenal, NJ, adopted an incremental development strategy to get the Mortar Fire Control System (MFCS) out of development and into the hands of Soldiers on point around the globe. This approach allowed engineers and managers to break the complex system into manageable increments and facilitated the delivery of digital fire control for mounted 120mm weapons.

Background

MFCS is the Army's first fully digitized fire control system for mortars and a critical combat enabler for enhancing mortar responsiveness, accuracy and lethality. Leveraging components of other Army programs and nondevelopmental items (NDIs), the program showed promise of being fielded as early as 1999. However, translating the operational requirements into specifications that the contractor could decompose into functional software and suitable hardware proved more difficult than anticipated. The PM ended the system development and demonstration contract in July 2000 and turned the software development and hardware integration over to experts at the U.S. Army Armaments Research, Development and Engineering Center (ARDEC), also at Picatinny Arsenal.

Almost immediately, the PM/ARDEC team correctly assessed that the software was too complex for near-term delivery with full functionality. They also incorrectly assumed that the hardware components selected by the contractor would meet operational requirements, permitting software integration into a functioning system. They failed to properly assess the individual components' integration readiness level. As a result — though the software was completed in time to support the initial operational test (IOT) in September 2001 — a failure of the fire control computer, specifically, the Commander's Interface (CI), led the PM to request a 1-year delay for IOT.

The PM opted for an old leadership tool — the after action review (AAR) — to determine why the program failed to reach acceptable maturity. Although painful, the structured AAR was beneficial in setting the stage for future success. The MFCS had functioning software. Unfortunately, the CI did not perform to requirements. The fire control computer, however, was just a symptom of an underlying problem: the development team had focused on qualifying each MFCS component and had lost the program's "total system focus."

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Avoiding Pitfalls

The new development team was determined to avoid the pitfalls that had thus far plagued the program, so they focused on the following best practices:

- Identify and solve the root cause of problems; get out of the action-reaction mode.
- Apply appropriate methodologies for problem resolution that include impacts on all stakeholders.
- Keep users involved in all matters regarding program status and get them involved in all key decisions.
- Focus on risk management for issues relating to schedule and performance.
- Ensure understanding of how each component interacts with every other component — vertically and horizontally — within the system.
- Ensure that quality is considered in a comprehensive manner that includes a viable plan for system reliability growth.

Engineering Challenges

Systems integration was the first engineering challenge. The second was finding a replacement CI in time to execute IOT within 12 months. The integration problem proved to be multifaceted. While the strategy of using NDI components saved time and money, this approach demanded that program integrators stay informed of any circuitry or firmware changes and assess integration risk for the production hardware. This forced the team to establish effective relationships with item managers and other PMs.

The lead time to procure a replacement CI could have been detrimental to the program. Fortunately, one of the leading U.S. ruggedized computer manufacturers, Miltope Corp., purchased the CI contractor. The PM immediately engaged Miltope's president and established an effective working relationship. The PM extended his trust and the opportunity to perform without prejudice to Miltope's leadership. They responded with improved internal process controls and successfully modified the CI to survive the high-shock environment of the 120mm mortar, improved its thermal problem and simplified the internal layout. Miltope also rapidly delivered prototypes to the development team for subsystem testing and systems integration.

Managing Risk

Although we had confidence that Miltope would deliver a quality product, we wanted to mitigate the risk with a plan to qualify an alternative CI. Our development partner, ARDEC, took on this task and executed a parallel plan to qualify alternative computers that could serve as CI. This alternative program provided a backup CI that allowed us to accelerate different phases of our system's developmental testing and maximize system-level testing in a representative IOT environment at Yuma Proving Ground, AZ. Because we also performed extensive engineering testing using the alternate CIs, we were able to reduce the normal 12 weeks of formal software qualification testing to just 6 weeks once Miltope delivered the low-rate production computers.

In general, identifying and quantifying risk in development programs is a difficult and time-consuming task. However, the program gains that we believed could be realized through proper risk analysis and application to the MFCS program demanded that we incorporate formal risk management into our overall management philosophy. The PM ultimately decided to use a commercially available risk analysis software program to perform a quantitative analysis of cost and schedule risks. The analysis produced a tool that outlined the probability of occurrence and the overall program impact for each key program risk element. From this, we were able to set thresholds for applying additional resources to maintain the program's critical milestones.

The Leadership Variable

No matter how good the plan, leadership often spells the difference between success or failure. Part of effective leadership also means knowing when to lead and when to support. The PM was in charge of the overarching integrated product team (OIPT), which included members from all Army test agencies. The test personnel were invaluable in assisting the PM/ARDEC team to avoid several pitfalls mentioned earlier. Many PM offices view the test community as the enemy, which creates an "us-versus-them" environment. Our feeling mirrors that of LTG Joseph L. Yakovac Jr., Military Deputy (MILDEP) to the Assistant Secretary of the Army for Acquisition, Logistics and Technology (ASAALT), who said in an interview for the January-February 2004 issue of *Army AL&T* Magazine, "The testers are all of us. If you blame something on the testers, I contend you haven't worked with them."

> Fortunately, we forged a strong relationship with the test community and openly shared all the information about our system — both the positives and negatives — which promoted mutual trust.

Fortunately, we forged a strong relationship with the test community and openly shared all the information about our system — both the positives and negatives — which promoted mutual trust. At times, the PM functioned in a support role, assisting the test agencies to properly test or evaluate MFCS.

In addition to understanding leadership's role in the project, the PM felt that it was equally important to ensure that key leaders on the HQDA staff were constantly updated on the program's progress. By demonstrating that there was a realistic plan in place to achieve program success, the PM successfully built strong support for the program with all stakeholders. Bad news was never hidden and, as a result, the PM overcame detractors who might have otherwise terminated the program upon the announcement that IOT was being delayed.

> Once fielded, MFCS will enhance 3ID's combat capability and provide them with organic battalion fires capable of responding to calls for fire in less than 1 minute following mission receipt.

The other critical leadership decision was empowering IPT members to execute in their respective areas of responsibility. A complex program managed by the IPT process requires that each IPT member have the power to make day-to-day decisions within the overall program plan's boundaries. We encouraged our IPT members to be proactive and take responsibility to solve individual problems and issues.

Delivering MFCS

The MFCS successfully completed the preliminary qualifications test in August 2002. In September 2002, MFCS entered a rigorous 6-week IOT with soldiers from the 1-9th Cavalry Regiment, 3rd Brigade, 1st Cavalry Division. The soldiers demonstrated that MFCS, using digital communications, significantly improved mortar fire responsiveness and effectiveness during battalion combined team operations.

In January 2003, following a successful IOT in November 2002, the ASAALT MILDEP and the 1st Cavalry Division asked PM Mortars to accelerate MFCS fielding to support possible combat operations in Iraq. This required us to

deliver one divisional set instead of the scheduled brigade set.

Following the 1st Cavalry Division fielding, we were tasked to deliver MFCS Version 2 (V2) software 3 months ahead of schedule to support the Stryker Mortar Carrier Version B IOT in February 2004. Applying the lessons learned from the baseline MFCS program, we compressed our development and testing schedule to support the Army's newest mounted 120mm mortar weapon system. MFCS V2 was the critical element supporting the evaluation of the effectiveness and responsiveness of 120mm mounted mortars at the company level without a dedicated fire direction center vehicle.

Today, PM Mortars is once again engaged in supporting urgent warfighter needs. Since November 2003, we have been working with the 3rd Infantry Division (3ID) and the HQDA staff to accelerate MFCS fielding to support the Army Chief of Staff's modularity initiative to build additional brigades throughout the Army. We began fielding a divisional set to 3ID in May 2004. Once fielded, MFCS will enhance 3ID's combat capability and provide them with organic battalion fires capable of responding to calls for fire in less than 1 minute following mission receipt.

MAJ JAMES O. WINBUSH JR. is the Assistant PM for Mortar Systems, responsible for fielding the MFCS to Stryker and heavy forces. He has a B.S. and an M.S. in engineering from Old Dominion University.

Did You Know?

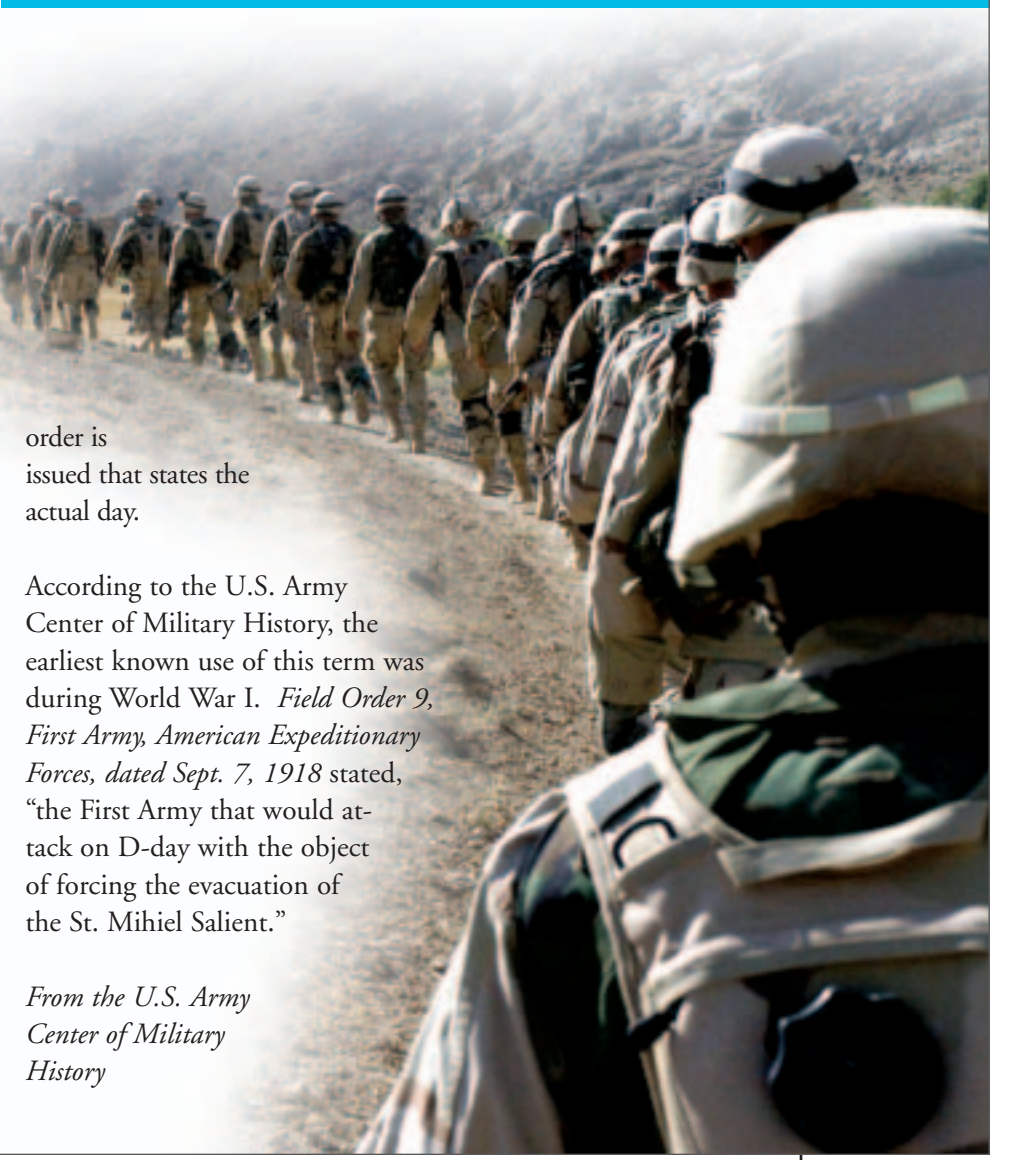
Most people think of D-day as June 6, 1944, the day of the invasion of Normandy. But, did you know the term D-day is used for the day on which any combat attack or operation is to be initiated? The "D" designates the day of an operation when the date hasn't yet been determined, or where secrecy is essential. The letter is derived from the word for which it stands — "D" is for the day of the invasion. There is only one D-day for all units participating in a given operation.

When used in combination with figures and plus or minus signs, the term indicates the length of time preceding or following a specific action. Thus, D-3 means 3 days before D-day; D+3 means 3 days after D-day.

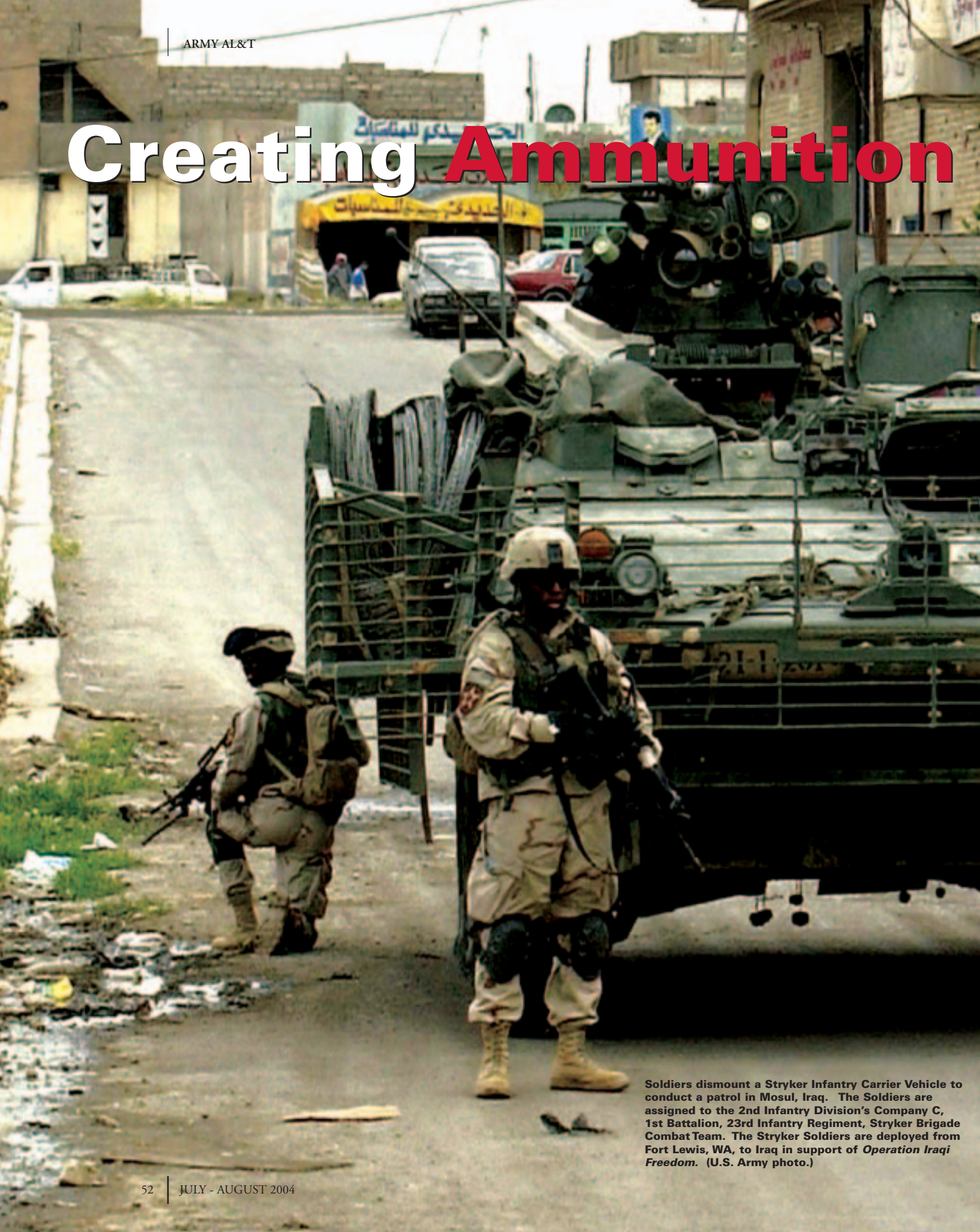
Plans for large-scale operations are made up in detail long before specific dates are set. Thus, orders are issued for the various steps to be carried out on the D-day minus or plus a certain number of days. At the appropriate time, a subsequent order is issued that states the actual day.

According to the U.S. Army Center of Military History, the earliest known use of this term was during World War I. *Field Order 9, First Army, American Expeditionary Forces, dated Sept. 7, 1918* stated, "the First Army that would attack on D-day with the object of forcing the evacuation of the St. Mihiel Salient."

From the U.S. Army Center of Military History



Creating Ammunition



Soldiers dismount a Stryker Infantry Carrier Vehicle to conduct a patrol in Mosul, Iraq. The Soldiers are assigned to the 2nd Infantry Division's Company C, 1st Battalion, 23rd Infantry Regiment, Stryker Brigade Combat Team. The Stryker Soldiers are deployed from Fort Lewis, WA, to Iraq in support of *Operation Iraqi Freedom*. (U.S. Army photo.)

Enterprise Excellence

BG Paul S. Izzo, Kevin Fahey, Robert Crawford and Normand L. Frigon

The U.S. Army transformation philosophy calls for using the best industry practices to restructure the Army to make it more flexible and responsive to warfighter needs. The Army Program Executive Office for Ammunition (PEO Ammo) has accepted this challenge as part of its responsibility for integrating conventional ammunition life-cycle management. In addition to overseeing acquisition strategies, research and development, program management, budgeting, logistics and sustainment of ammunition families, PEO Ammo serves as the Single Manager for Conventional Ammunition (SMCA). As such, it is charged with integrating other DOD services' acquisition and logistics requirements into the Army's to create a single voice in SMCA operations and Army ammunition management. To accomplish this, PEO Ammo has taken the lead in establishing the Ammunition Enterprise.

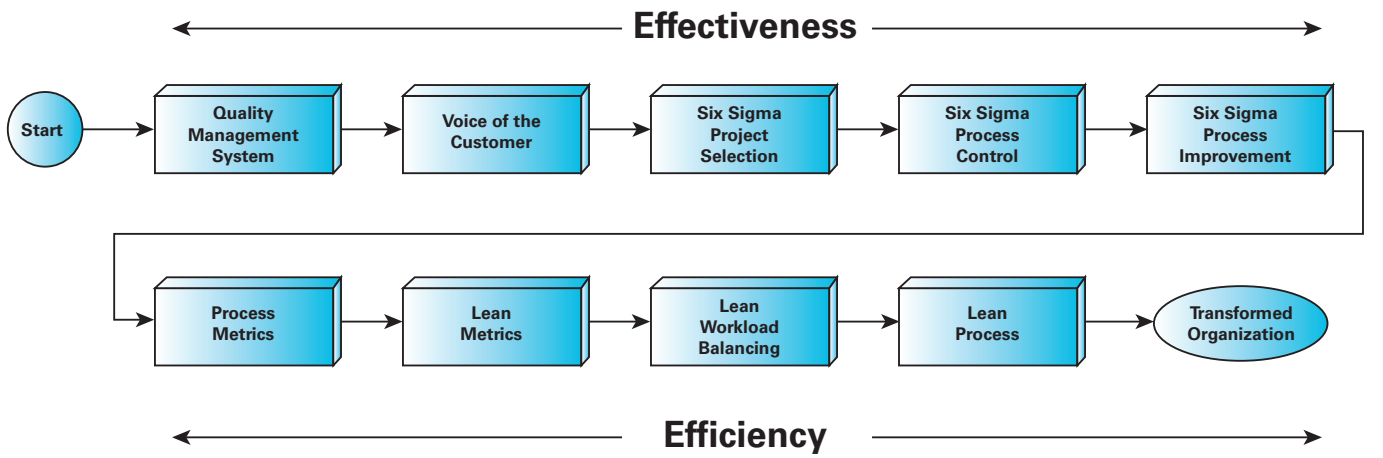


Figure 1. E2 Philosophy

Ammunition Enterprise

The Ammunition Enterprise was established by PEO Ammo; the U.S. Army Research, Development and Engineering Command's (RDECOM's) Armament Research, Development and Engineering Center (ARDEC); and the Joint Munitions Command (JMC) to create an integrated organization that sees the "big picture" and hears the "customer's voice." The underlying strategy brings together the people, infrastructure and processes required for total ammunition life-cycle management to support warfighters. It is focused on developing an effective and efficient enterprise for fielding munitions, optimizing key business processes and implementing Lean Manufacturing/Six Sigma process initiatives into all enterprise elements including design, development, manufacturing, administration, stockpile management and strategic planning. Establishing the Ammunition Enterprise has led directly to the selection of the Enterprise Excellence (E2) model as the philosophical approach to achieve transformation.

> The underlying strategy brings together the people, infrastructure and processes required for total ammunition life-cycle management to support warfighters.

E2 Philosophy

E2 focuses on "value to the customer." To our customers — combatant commanders and their Soldiers — this means delivering safe, reliable ammunition at the right time, to the right place, at an acceptable cost. Integrating this strategy ensures that the cultural and organizational changes essential for transformation are realized. PEO Ammo employs a holistic approach to manage and improve organization operations. Critical systems and processes are central to all leadership, management and technology decisions and tools such as the Quality Management System, Voice of the Customer and Lean Manufacturing/Six Sigma processes are used to accomplish tasks and achieve a balance between effectiveness and efficiency as depicted in Figure 1.

Transformation

These new Ammunition Enterprise and E2 business models make fact-based decisions that will improve the quality, cost, schedule and risk of munitions life-cycle systems and processes while bringing about continuous measurable improvement (CMI) of all Ammunition Enterprise business processes. Already, there have been positive changes at all enterprise levels and in all business processes as E2 brings a disciplined acquisition management approach to managing ammunition as a system-of-systems, not a series of individual programs. The

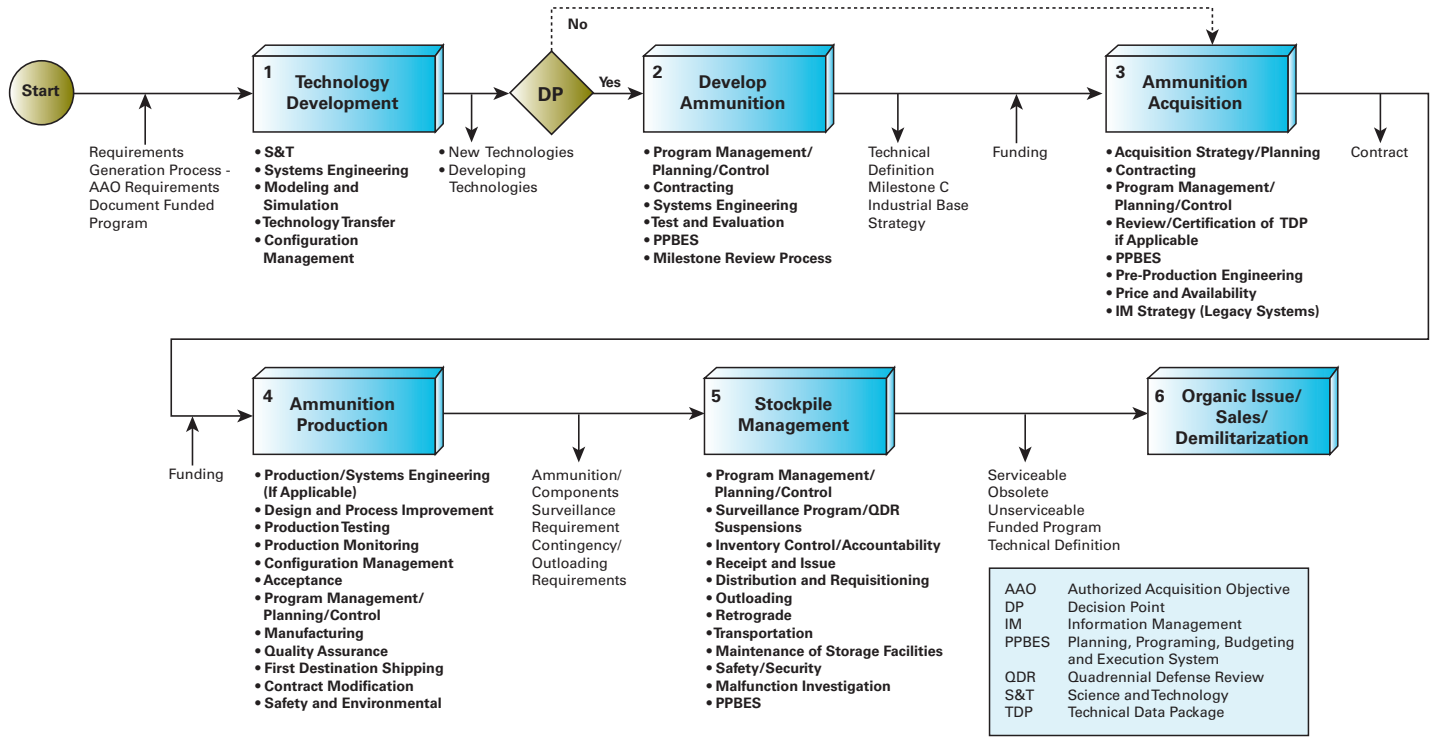


Figure 2. The Ammunition Enterprise Process Map

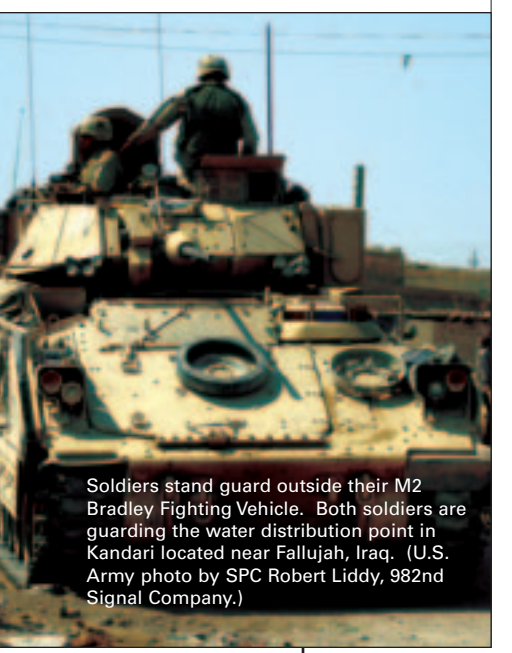
first step to the transformation to E2 was Lean/Six Sigma Executive Black Belt Workshops led by VSE Corp. The workshops concentrated on applying lean techniques to increase organizational speed, while combining the tools and culture of Six Sigma to improve efficiencies and focus on customer issues.

It is said that leadership starts at the top and, in this instance, BG Paul S. Izzo, PEO Ammo, not only participated in the Executive Black Belt Workshop, he chairs the Ammunition Enterprise Executive Board, which was instituted to ensure that the new business models are institutionalized throughout the organization. Deputy PEO Ammo Kevin Fahey; JMC Deputy for Operations Robert Crawford; and senior executives from PEO Ammo's program management offices, JMC and RDECOM's ARDEC also took part in the cross-functional, multidisciplinary workshops that explored causes of customer critical-to-quality issues as well as issues that created the longest lead-time delays in the acquisition process. This led to numerous Black Belt Improvement Projects and the application of Lean/Six Sigma practices in three Ammunition Enterprise process teams: Procurement of Ammunition, Supplier Assessment and Engineering Support.

> These new Ammunition Enterprise and E2 business models make fact-based decisions that will improve the quality, cost, schedule and risk of munitions life-cycle systems and processes while bringing about continuous measurable improvement of all Ammunition Enterprise business processes.

Accomplishments

After establishing Ammunition Enterprise and implementing E2, PEO Ammo has seen clear improvements in business processes and cultural changes within the ammunition community. One crucial outcome of E2 is the end-to-end Ammunition Enterprise Process Map illustrated by Figure 2. This map was developed jointly to



Soldiers stand guard outside their M2 Bradley Fighting Vehicle. Both soldiers are guarding the water distribution point in Kandari located near Fallujah, Iraq. (U.S. Army photo by SPC Robert Liddy, 982nd Signal Company.)

help communicate the big picture, clarify roles and responsibilities, prioritize improvement initiatives and understand the requirements, functions and processes throughout the munition systems life cycle. The Enterprise Process Map demonstrates the effort's comprehensive nature, provides an in-depth understanding of the munitions life cycle and outlines enterprise responsibilities and critical business processes.

Identifying requirements, functions, key processes and people is the centerpiece of transforming dispersant ammunition functions into an enterprise. A critical element is PEO/JMC/ARDEC integration to ensure Joint service requirements are being addressed. Figure 3 outlines lead and support responsibilities between JMC and PEO Ammo for the Ammunition Enterprise mission functions and is consistent with *DoDI 5160.68, Single Manager for Conventional Ammunition (SMCA): Responsibilities of the SMCA and the Military Services.*

MISSION	LEAD	SUPPORT
ACQUISITION		
RDT&E	PEO AMMO	JMC
Acquisition Strategy	PEO AMMO	JMC
Hardware Production	PEO AMMO	JMC
Components for Renovation (Maintenance Support)	PEO AMMO	JMC
APE (Maintenance Support)	PEO AMMO	JMC
PAA Program/Budget/ Receive Funding	PEO AMMO	JMC
Industrial Base	Co-Lead	
LOGISTICS/SUSTAINMENT		
Receipt/Issue	JMC	PEO AMMO
Storage/Distribution Management	JMC	PEO AMMO
Inventory/Accountability	JMC	PEO AMMO
Safety/Security	JMC	PEO AMMO
Quality Assurance (ASRP/Surveillance)	JMC	PEO AMMO
Maintenance	PEO AMMO	JMC
Demilitarization/Disposal	PEO AMMO	JMC
Transportation	JMC	PEO AMMO
OMA Program/Budget/ Receive Funding	JMC	PEO AMMO

RDT&E Research, Development, Technology and Engineering
APE Ammunition-Peculiar Equipment
PAA Procurement of Army Ammunition
ASRP Ammunition Stockpile Reliability Program
OMA Operation and Maintenance Army

Figure 3. Key to Enterprise Integration and Synchronization

PEO Ammo is the lead with JMC in the supporting role for all acquisition mission functions. For the industrial base mission function, PEO Ammo and JMC are co-leads. JMC is the lead for all logistics/sustainment mission functions except demilitarization and disposal, which is led by PEO Ammo's Product Manager for Demilitarization.

After creating the Ammunition Enterprise Process Map, the Executive Black Belt Working Group went through a structured evaluation using the Lean/Six Sigma tools to identify 78 enterprise processes and evaluate them per their need for improvement, risk and value added to create a prioritized plan for improvement initiatives.

The Enterprise Level Executive Steering Committee oversees the implementation of E2 to ensure that the

Paratroopers of the 82nd Airborne Division's Battery A, 2nd Battalion, 319th Field Artillery Regiment, fire their 105mm Howitzer during a training mission at Baghdad International Airport, Iraq. (Photo courtesy of the DOD.)

More bang for your buck: Lean Manufacturing/Six Sigma improvement initiatives are helping to reduce the cost of munitions production while also delivering safe, reliable ammunition at the right time and place.

CMI culture cascades throughout the Ammunition Enterprise. The committee creates an environment in which CMI can grow through:

- **Communication, cooperation and coordination.** Ensure workforce understands "why" CMI is key to enterprise's future.
- **Focus.** Approve and prioritize Lean/Six Sigma improvement initiatives based on enterprise process priorities and customer expectations.
- **Remove roadblocks.** Eliminate nonvalue-added requirements.
- **Progress review.** Help establish appropriate metrics and measure initiative progress and overall CMI growth.
- **Recognition.** Reward accomplishments and provide professional development opportunities such as Six Sigma Green Belt Certification.

> The Ammunition Enterprise Process Map demonstrates the effort's comprehensive nature, provides an in-depth understanding of the munitions life cycle and outlines enterprise responsibilities and critical business processes.

This structure is based on collaboration with JMC and ARDEC boards that will operate under an Ammunition Enterprise Executive Board to enable consistency and synergy among ARDEC, PEO Ammo and JMC CMI initiatives. Board members are senior leaders who are trained in the E2 model and understand the Lean/Six Sigma applications. The board is augmented with ad hoc members, when appropriate, based on process ownership.

As the Ammunition Enterprise deploys the E2 model, it is building on RDECOM ARDEC's experience in applying Lean/Six Sigma tools so they work for both administrative and manufacturing processes as follows:

- Reduction of procurement administrative lead time from 24 months to 11 months resulting in $12 million being cut from procurement costs.
- Identification of design deficiencies in the M734A1 Mortar Fuze production yield. Redesign reduced scrap from 5.0 percent to 0.1 percent for $50 thousand per month savings.
- Reduction of PEO Ammo's insensitive munitions waiver process from a 2-year cycle to only 7 months.
- Development of new large-scale manufacturing processes for PAX-2A explosives that reduced per pound cost from $65 to $30, saving the Army $349 million over the life cycle.
- Corrective actions were taken to release a mortar ammunition stockpile worth $200 million, following a 120mm Mortar Fin malfunction investigation. This action also reduced future procurement risks.

A Stryker Mortar Combat Vehicle test firing. (Photo courtesy of General Dynamics Land Systems.)

The initiatives described on Page 57 are just some of more than 60 improvement initiatives completed by the Ammunition Enterprise. "The culture change may be the most important outcome resulting from E2 implementation," Izzo remarked. "The Army and Joint Services Ammunition Management System has transformed itself into an enterprise. E2 implementation will continue at PEO Ammo and its impact on the Ammunition Enterprise will be significant," Izzo explained.

The Ammunition Enterprise and E2 will:

- Improve communication, cooperation and coordination.
- Promote a culture of fact-based decision making at every organizational level.
- Lead to better resource prioritization and application.
- Allow the PEO to get more and better ammunition into the field faster.
- Improve quality, cost and schedule significantly while reducing risk.
- Drive cultural change throughout the supply chain.

"Most important, it will mean that we can deliver munitions to the warfighter more efficiently and effectively than ever before. This is our primary objective," Izzo concluded.

BG PAUL S. IZZO is the PEO Ammo. He has a B.S. in business administration from St. Bonaventure University and an M.S. in management science from Central Michigan University. His military education includes the Command and General Staff College, Defense Systems Management College and the U.S. Army War College.

KEVIN FAHEY was the Deputy PEO Ammo when this article was written. He is now the Acting PEO for Ground Combat Systems. He has a B.S. in engineering from the University of Massachusetts and is Level III certified in program management and systems planning, research, development and engineering (SPRDE).

ROBERT CRAWFORD is JMC's Deputy for Operations. He has a B.S. in mechanical engineering from the University of Illinois and an M.B.A. from St. Ambrose University. He is Level III certified in SPRDE and program management and Level II certified in manufacturing, production and quality assurance.

NORMAND L. FRIGON is a Director of VSE Corp.'s Management Sciences Division. He has developed and implemented Six Sigma, Lean Enterprise and Supply Chain management programs at American Ordnance LLC, U.S. Army Tank-automotive Armaments Command, ARDEC, PEO Ammo, PEO Ground Combat and Support Systems and other Army suppliers. He has a B.A. in statistics and an M.B.A. in quantitative sciences from National University. He also graduated from the University of Michigan Executive Development Center's course in Strategic Quality Planning. Frigon is the former Associate Director, Reliability Engineering and Management Institute, University of Arizona.