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**THE FIRE SUPPORT DILEMMA**

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**EVOLUTION OF SELF-PROPELLED HOWITZERS**

Cannon-based artillery has long been the primary means for ground combat maneuver forces, including armor, infantry, cavalry, airborne, and air assault, because of its ability to deliver accurate fires at relatively long ranges. The self-propelled howitzer (SPH) had its origin in World War I, when a few experimental mounts were tested with medium-caliber cannons rigged on tractor chassis. By the end of World War II, SPHs were becoming common in the armored and mechanized forces of Western (i.e., the British, French, U.S., and German) armies.

In spite of the technical advance the SPH represented, the tactics and procedures employed in the early self-propelled units were virtually identical to those used for the traditional towed-cannon batteries. For example, guns were placed roughly on line, normally in sight of each other, and the actions of the guns were closely controlled by the battery headquarters. The main advantage that the SPH batteries had over their towed counterparts was cross-country mobility. SPHs were also seen as providing at least some level of armor protection for crew and ammunition. Although technology was able to improve self-propelled artillery in different ways through the years, the fundamental operation of these battery formations paralleled that of the towed cannons from World War II until the early 1990s.<sup>1</sup>

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<sup>1</sup>Until the 1990s, the fire control and position/navigation technologies had not matured to a point that would enable individual guns to operate independently.

## **USE OF SELF-PROPELLED HOWITZERS IN DESERT STORM<sup>2</sup>**

During Desert Storm, the U.S. Army was equipped with 25 battalions of 155mm SPHs, generally consisting of M109 A2 and A3s. These howitzers were used for providing preparatory fires, direct support to maneuver, and, to some extent, counterfire. Although the ground offensive portion of Desert Storm was relatively short (roughly four days), the 155mm SPHs fired approximately 43,500 total rounds. About half of the rounds fired contained the dual-purpose improved conventional munition (DPICM) bomblets, about a third of the rounds fired were standard high-explosive (HE) rounds, and the remaining percentage of rounds (about 15 percent) were HE rocket-assisted projectiles (RAP) for extended range.

Across all howitzers, the average SPH fired only about 70 rounds during the ground attack operation; however, the six most active battalions (division artillery of the 1st Infantry Division, involved in the breach, and the 1st Armored Division) averaged around 130 rounds per howitzer. These SPHs provided extensive support to their maneuver elements, typically requiring between one and two full reloads from their resupply vehicles. Altogether in Desert Storm, the firing distribution among the different SPH units for fire support tended to be fairly uneven.

Prior to Desert Storm, several key shortcomings of the M109 series howitzer were noted. These included

- Firepower (rate of fire and range)
- Cross-country mobility
- Manpower requirements (e.g., lack of autoloader)
- Survivability from enemy counterfire.

Most of these key shortcomings were also apparent in Desert Storm. For example, with respect to the firepower shortcoming, the Iraqis had Russian and South African cannons with significantly greater ranges than the M109. Fortunately for coalition forces, they did not

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<sup>2</sup>Data on performance of U.S. SPHs in Desert Storm were collected from documents and interviews with artillery officers who fought in Desert Storm.

have the intelligence system needed to effectively acquire targets or an adequate command-and-control network for directing fires. Also, the U.S. M109s had frustratingly low firing rates, particularly for firing preparations. However, this shortcoming did not turn out to be of much consequence because the ground commanders were able to call on additional tubes (cannon and rocket) beyond the normal division allocation.

One of the most prevalent observations was that the cross-country mobility of the M109s was inferior to that of the Bradley fighting vehicles and Abrams tanks. U.S. forces either had to move at the slower pace of the M109s or leave their cannons behind to catch up later.

With regard to manpower requirements, one U.S. artillery officer noted that when the M109 crews were engaged in fire missions, they were focused on the handling and preparation of ammunition. With their attention so engaged, they were not able to attend to local security of the battery.

SPH survivability did not become an issue because shoot-and-scoot operations were rarely exercised in Desert Storm. The inaccuracy of Iraqi fires and the effectiveness of the Multiple Launch Rocket System (MLRS) for counterfire reduced the need for quick movement from established fire positions.

### **PALADIN DOES NOT RESOLVE SHORTFALLS**

The U.S. Army's Paladin (M109 A6) was one of the first vehicles to integrate position and azimuth determining devices with systems that permitted on-board computation of firing data by individual howitzers. Paladin, conceived in the late 1980s and first fielded in 1993, is the latest and envisioned to be the last version of the M109 series. Operationally, it dramatically improves on the position, navigation, and fire control capabilities of its M109 predecessors. More specifically, it can receive fire missions via radio, quickly occupy a firing position, compute and automatically lay on firing data (since it has an on-board computer that provides data to automated azimuth and elevation drives), and quickly displace upon completion of the fire mission. Because Paladins can operate in small groups under a pla-

toon headquarters, there is no need for a traditional battery formation.<sup>3</sup>

Although the Paladin version of the M109 is seen as a dramatic improvement over earlier versions, ironically, it improves many aspects of the SPH that were not critical in Desert Storm. Since Iraqi counterfire was not effective for the reasons identified above, the need for rapid positioning, firing, and scooting (a key area of improvement for Paladin) was not considered to be essential.<sup>4</sup> The other key shortcomings of the M109 A2s and A3s experienced during Desert Storm—e.g., firepower, mobility, and manpower requirements—are not significantly enhanced by the Paladin version of the M109. Improvements in these areas are largely considered technical challenges because of chassis restrictions; the Paladin modifications are seen as taking the M109 chassis to the limit. And while some future modifications are possible, it is likely that further improvements will result in concessions that may have to be made elsewhere.

### **CRUSADER IS A SYSTEM DESIGNED TO MEET NEAR-TERM FUTURE NEEDS**

Crusader at the most fundamental level is a two-part cannon artillery system consisting of a self-propelled howitzer (SPH) and a versatile ammunition and fuel resupply vehicle (RSV). Figure 1 shows the proposed configuration of the system. Together these two vehicles represent a system that is unmatched by any other self-propelled cannon-based artillery system. The volume of fire deliverable by Crusader is expected to be markedly higher than any other cannon-artillery system in existence today or planned for the near future.

The primary reason for this unmatched capability is the combination of new technologies. In addition to an autoloader, a modular artillery charge system (MACS), and a multi-option fuze artillery (MOFA) in the SPH that allows for rapid initial, *surge* rates of fire, this

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<sup>3</sup>Smaller groupings of howitzers, required by increasing threats from counterfire systems, are becoming the norm in the artillery arms of the better armies around the world. While “traditional” gun batteries will be around for years to come in many armies, artillery will increasingly be small groups of weapons that present far less lucrative targets than the concentrated battery positions of the past.

<sup>4</sup>The M109s generally did not operate in shoot-and-scoot mode in Desert Storm.



**Figure 1—The Crusader Artillery System**

system is envisioned to use active liquid cooling in the gun barrel, which will allow higher *sustained* rates of fire. Streamlined resupply methods in the RSV will allow simultaneous refueling and reloading operations that fully replenish the SPH in 12 minutes.<sup>5</sup> Although Crusader's solid-propellant gun cannot reach as far as the originally envisioned liquid-propellant gun,<sup>6</sup> it can still reach as far as most other SPHs currently in existence or in development. Also notable, Crusader uses new technologies that reduce its susceptibility to counterfire.

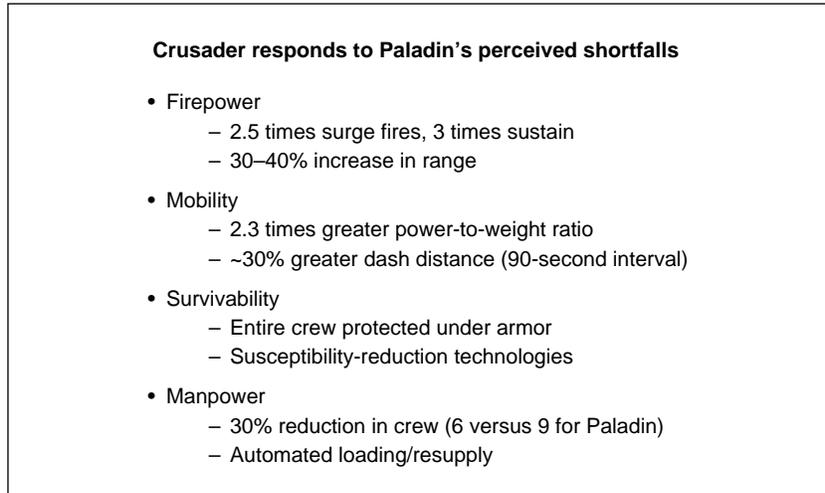
Altogether, Crusader employs a collection of new technologies that are envisioned to greatly improve on the capabilities available with Paladin (see Figure 2).

Crusader responds to the shortcomings noted for Paladin in many ways. Looking at the operational requirements document for Crusader, we note that it will significantly improve firepower and mobility (both in terms of offroad speed and dash capability), enhance survivability, and reduce manpower. Many of these improvements are synergistic and may result in further battlefield advantage, such as survivability enhancements resulting from smaller crews operat-

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<sup>5</sup>A single RSV can also resupply more than one vehicle.

<sup>6</sup>Initial testing revealed that the liquid-propellant gun also fell well short of the required ranges, also lacking consistency of fires.



**Figure 2—Crusader Offers Significant Improvements in Key Areas**

ing fully inside the vehicle, greater dash speeds, faster attrition of the enemy, and special susceptibility-reduction measures.

On the downside, introducing the combination of new technologies imposes a significant penalty in the form of weight. Each of the Crusader vehicles weighs roughly 55 tons fully loaded, resulting in a total system that weighs about 110 tons. These weights are well within the bounds of existing heavy combat vehicles (e.g., M1A1 weighs roughly 70 tons), but the Crusader SPH is nearly twice the weight of the system that it replaces, the Paladin. In addition to its weight, which can increase supportability requirements, the acquisition cost has also been raised as an issue. The unit cost of the combined SPH and RSV is estimated to be about \$14.7 million.<sup>7</sup>

<sup>7</sup>U.S. General Accounting Office, *Army Armored Systems: Meeting Crusader Requirements Will Be a Technical Challenge*, Washington, D.C., GAO/NSIAD-97-121, June 1997.

## **FOCUS OF THIS REPORT**

Thus the Army faces a dilemma: continue with Paladin, a good system that has known shortcomings and that cannot reasonably be improved, or continue to invest in Crusader, which carries the risk of being too unwieldy to mesh with the Army's vision of how it will fight in future wars.<sup>8</sup> To resolve this dilemma, the Army has to address the issues of weight and cost along with a number of other issues that have been raised about Crusader and the need for it. RAND's Arroyo Center was asked by the Office of the Deputy Chief of Staff Operations to research some of these issues. Specifically, we were asked the following:

- What does Crusader provide to Army XXI?
- What increase in the application of fires does Crusader provide over current capabilities?
- What technologies does Crusader carry to the Army After Next (AAN) weapon systems?

To answer these three questions, we conducted an extensive evaluation of technical information available on Crusader and applied, to a limited extent, our high-resolution simulation and modeling capabilities.

## **HOW THIS REPORT IS ORGANIZED**

The rest of this report attempts to answer these questions as well as address other issues associated with the Crusader system. Specifically, Chapter Two summarizes the results of a survey of such foreign trends and developments and suggests the implications these systems may have for U.S. artillery. Chapter Three quantifies the firepower that Crusader offers and explores a new mission for such firepower. Chapter Four explores where Crusader and its technologies fit into the future of the Army, including the AAN. Chapter Five summarizes our research findings and concludes with our recommendations.

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<sup>8</sup>Or reexamine the acquisition of a foreign system.