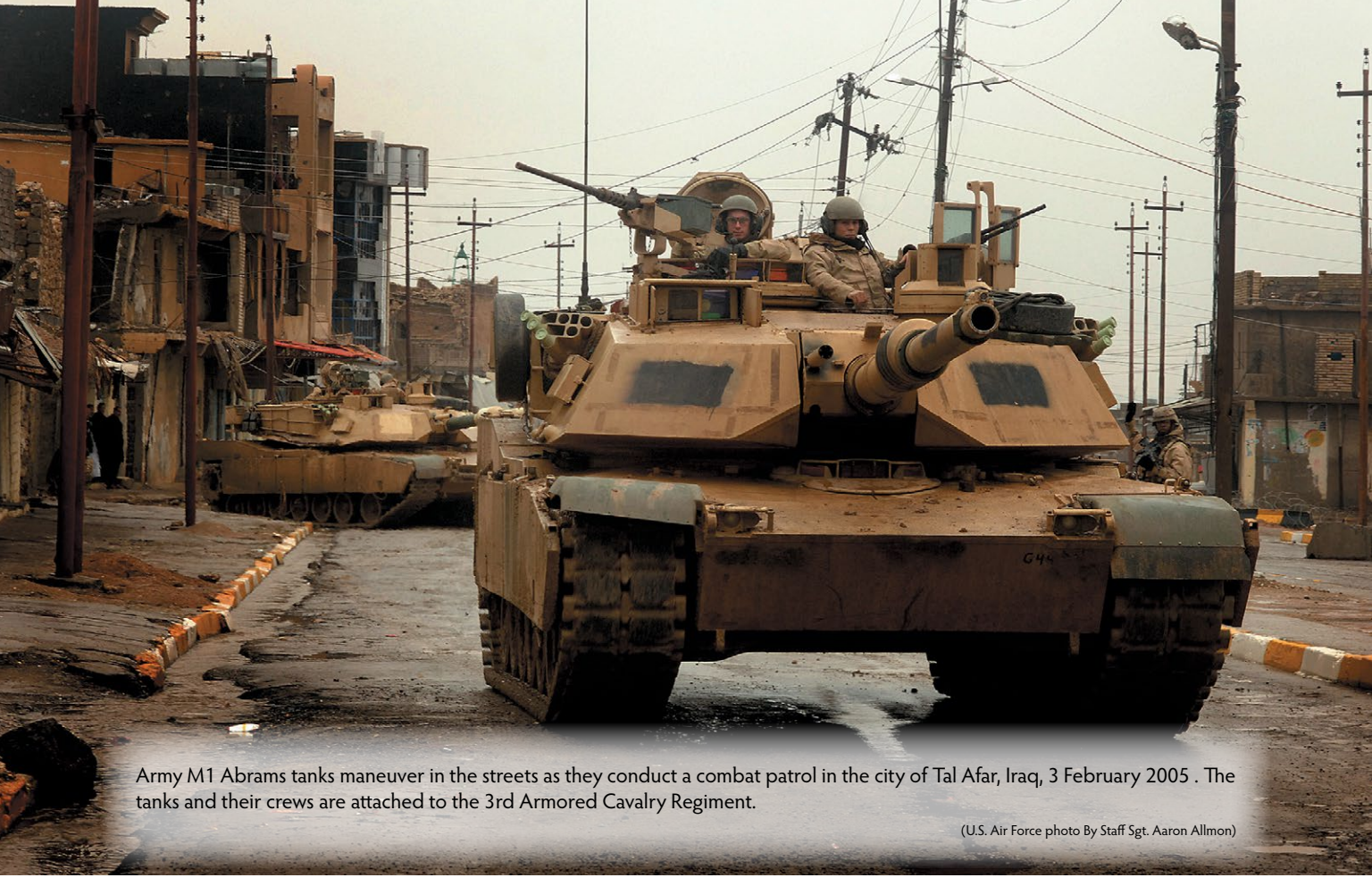

Army M1 Abrams tanks maneuver in the streets as they conduct a combat patrol in the city of Tal Afar, Iraq, 3 February 2005 . The tanks and their crews are attached to the 3rd Armored Cavalry Regiment.

(U.S. Air Force photo By Staff Sgt. Aaron Allmon)

The M1 Abrams
Today and Tomorrow

Dr. Alec Wahlman and
Col. Brian M. Drinkwine, U.S. Army, Retired

The main battle tank of the U.S. Army is under pressure due to critical scrutiny from numerous fronts questioning its relevance to the modern security environment. The M1 Abrams played a key role briefly in Operation Iraqi Freedom and rarely in Operation Enduring Freedom. Moreover, due to an apparent perception within NATO that heavy U.S. armor was no longer needed, the Army redeployed the last of the Abrams based in Europe to the United States in 2013.[1] Elsewhere, the relevance of heavy armor is being challenged. Anti-armor weapon technology has advanced considerably, to the point that even nonstate actors such as Hezbollah have seen some success against advanced main battle tanks (i.e., Israeli Merkavas in 2006).[2] Finally, the downward trajectories of both the overall U.S. military budget and the Army force structure threaten the Abrams force. The cumulative effect of these pressures will make tank force structure and tank modernization efforts prime candidates for budget reductions.

This article is not an argument against all such reductions, but it does propose that contemplated

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reductions should be weighed carefully against realistic requirements and associated risks, and that options for maintaining a capable armor force be thoroughly explored based on the viability of extending and revitalizing the remaining Abrams.[3]

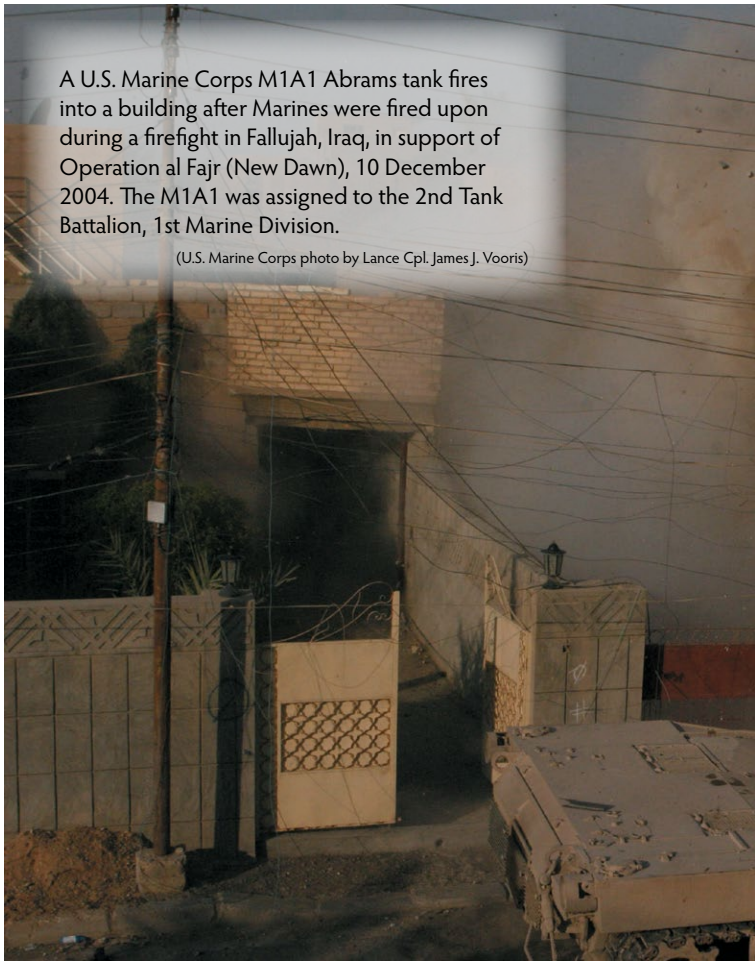
Over the decades since the Abrams was first fielded, several technologies have been advancing that should be examined as potential enhancements to extend the useful life of the Abrams. Specifically, technologies for engines and small precision munitions have advanced greatly since the fielding of the first M1 in 1980. Given today's strategic and fiscal environments, most would consider development of a new-generation main battle tank beyond reach, with any such initiative destined to suffer the same fate as the ambitious Future Combat System (FCS), which was cancelled in 2009 because it was deemed too expensive. That is why pursuing the more modest option of upgrading existing Abrams with new engine and precision munitions technologies deserves close scrutiny. These technologies could offer enhancements to the Abrams that would extend its useful lifespan well into the future to meet a variety of foreseeable challenges within manageable fiscal resources. Moreover, these technologies may offer tactical synergies when combined with each other and the existing capabilities resident on the Abrams to meet unforeseen requirements. Simulation and experimentation could play a key role in modeling and exploring the tactical implications of such improvements.

Therefore, this article focuses on the Abrams' tactical utility as justification for pursuing such upgrades. Technological maturity or engineering feasibility are not investigated in depth other than to identify technological trends that appear to match up with desirable enhancements to the Abrams. While technology and engineering questions are certainly critical to the fielding of new equipment, a better understanding of tactical utility must precede such discussions. No sense in perfecting the useless.

Enduring Need for the Main Battle Tank

There are two key questions: "Do we still need a main battle tank?" If so, "Will the Abrams serve the purpose in the future?"

Before considering these, it is useful to observe that transitions between classes of weapons usually are gradual rather than abrupt, and with good reason. Even as it becomes apparent that some new technology has a brighter future than an existing one, it often takes some time before the tipping point of obsolescence is reached for older technologies. Very often the overlap of time enables the older technology to serve well beyond that point in some revised role. For example, battleships served as key fire support platforms for U.S. amphibious operations in World War II and later conflicts long after they had ceased to be the preeminent naval warfare system. In another example, the Air Force's B-52 Stratofortress, which was first introduced into service in 1952 as a strategic bomber capable of attacking deep targets in the Soviet Union with nuclear payloads, continues to serve well as a stand-off weapons platform and as a loitering close-air-support platform in low-threat environments, decades after losing its ability to penetrate sophisticated integrated air defenses. Planned upgrades to its systems now take its anticipated lifespan out to



A U.S. Marine Corps M1A1 Abrams tank fires into a building after Marines were fired upon during a firefight in Fallujah, Iraq, in support of Operation al Fajr (New Dawn), 10 December 2004. The M1A1 was assigned to the 2nd Tank Battalion, 1st Marine Division.

(U.S. Marine Corps photo by Lance Cpl. James J. Vooris)

approximately 2040, almost 90 years since it was first introduced.

Similarly, while some would argue that the tank today does not play as dominant a role in countering enemy armor as it used to, it would be a gross exaggeration to assert that it will no longer play a useful role on the future battlefield. Since its first fielding in 1980, the role of the Abrams has expanded well beyond readiness to defeat Soviet armor in the open terrain of Germany's Fulda Gap, the mission originally envisioned by many.

One example of the Abrams' expanded role is in counterinsurgency operations. The emergence of the improvised explosive device in the last decade and the class of new vehicles it spawned serve as a reminder of why highly survivable ground vehicles are important in such environments. A U.S. Marine Corps Abrams-equipped armor company that deployed to Afghanistan in 2011 completed its tour having suffered only one wounded in action, despite experiencing 19 improvised explosive device strikes.[4] This is not to argue that tanks are the solution to all or even most of the challenges while conducting counterinsurgency, but that, as noted in the new *Army Capstone Concept*, the Abram's combination of high mobility and protected firepower can at times prove of paramount importance in such environments.[5]

Urban warfare is another example of the Abrams' expanded role. The contrast between Mogadishu in 1993 and Baghdad in 2003 highlighted the game-changing role tanks can play in an urban environment. Lack of even a modest U.S. armor presence in Somalia hobbled mission efforts, requiring United Nations armor (Pakistani forces) be called upon to mount a rescue effort of surrounded Army Rangers and other special operations forces in October 1993.[6] In stark contrast, the rapid seizure of Baghdad and quick defeat of organized Iraqi forces at the outset of Operation Iraqi Freedom in 2003 were largely the result of Iraqi inability to effectively counter highly mobile heavy armor in an urban environment.

Additionally, one of this article's authors had first-hand experience in combat operations with the Abrams in Fallujah, Iraq. From the fall of 2003 through the spring of 2004, the Abrams proved its worth in supporting raids and cordon-and-search operations in and around the city in operations conducted by Task Force One Panther. The Abrams was adept at securing key terrain, providing overwatch with its sensors, and intimidating the insurgents with its imposing physical presence.[7] The Abrams would also later play a decisive role in Operation Phantom Fury, the assault into Fallujah in November 2004. A Presidential Unit Citation issued for operations in Fallujah described "the overwhelming combat power, speed, and shock effect of the incredibly lethal mechanized infantry and armor units … ."[8]

The decisive value of armor in an urban environment is also supported by research conducted by the other author of this article, who closely analyzed four major urban battles fought by U.S. ground forces (World War II to Vietnam) for a doctoral dissertation in military history. In all four cases, tanks proved crucial for the success of U.S. forces in urban environments, including at Hue City (1968), when poor weather over an entire month greatly reduced the air support available.[9]

A Merkava IIID Baz tank fires a round during a training day held in the Golan Heights for the 188th Armored Brigade, Israel Defense Forces, 20 March 2008. The goal of the day was to test the level of the brigade's combat fitness.

(Photo by Israeli Defense Forces film unit)

Armor versus Air Power

However, irrespective of its effectiveness in such collateral roles, countering enemy armor formations remains the key role of the Abrams for several reasons. Though air power has made great gains in its lethality versus armor, as shown in both Gulf Wars, it has clear limits. Consequently, any future overreliance on airpower alone to counter enemy armor will create a perilous single point of failure in U.S. military capabilities. Although there certainly will be cases when airpower is the best option for dealing with enemy armor, there are too many variables to rely on airpower as the only option available. For example, what if some future opponent were able to challenge U.S. control of the air for just a few critical days at the beginning of a conflict?

Such occurred when the Israelis paid a heavy cost for their dependency on air power in the early stages of the 1973 Yom Kippur War, when the effectiveness of Egypt's air defenses came as a surprise and temporarily neutralized Israeli air superiority.[10] Elsewhere, the forests and weather of Kosovo, along with strict rules of engagement, made allied targeting of Serbian armor from the air ineffective. NATO estimated that in three weeks of airstrikes, only about a dozen tanks had been destroyed.[11]

While many of the air-delivered precision weapons available today are billed as all-weather, adverse weather still causes problems with their employment, which requires greater understanding and anticipation of collateral damage risks associated with targeting. Additionally, attacking armor dispersed in an urban environment often involves highly restrictive rules of engagement and other targeting challenges to preclude unnecessary civilian casualties and damage to infrastructure.

Add to the equation the impact of advanced man-portable air defenses, such as the SA-24 that confronted NATO aircraft in Libya in 2011, and we then have a situation where manned aircraft are forced to fly higher while lower-flying armed drones are more vulnerable—all of which degrades the ability to target and deliver payloads accurately against not only armor but other targets. Consequently, an air-only threat to an enemy will not always be a viable option.

In contrast, the availability of heavy armor capable of counter-armor operations provides to friendly planners much greater flexibility and a wide span of options for tailoring operations—simultaneously confronting adversaries with the problem of trying to react speedily and effectively to whatever course of action we might choose.

Historical Examples

The high-speed nature of mechanized combat operations leaves little time for defenders to adapt to the unexpected.[12] In 1940, the French were well behind the Germans in recognizing or preparing for the potential of mechanized forces. One consequence was that it

took the Wehrmacht's armored formations only a few weeks to overrun France's key terrain, a span of time far shorter than the French army needed to adapt to the new mobile threat. Additionally, several Arab-Israeli wars have presented each side with but days to learn, limiting adaptation to its most shallow forms.

By way of comparison, the early German successes in Europe in the late 1930s with mechanized forces shocked the Soviet Union into rapidly reforming their armored forces starting in mid-1940, just one year before the Wehrmacht attacked. Although the Soviet Union had developed a large armor force prior to World War II, Stalin's purges gutted the Red Army of its human capital for mechanized warfare just before the Nazi invasion. As a result, when the Germans crossed the Soviet border in June 1941, not one of the Red Army's 61 tank division commanders had more than 12 months in command, and the state of the organization, training, and logistical support for the Soviet mechanized forces was abysmal. The issue was not so much materiel, as the Soviets enjoyed a 3:1 advantage in tanks and assault guns (11,000 vs. 3,600), but rather deficiencies in the broader suite of factors that makes any particular weapon system effective (such as doctrine, organization, training, and personnel).[13]

Fortunately for the Soviets, the Red Army was able to trade vast amounts of territory for time, though it suffered massive losses. It had enough time to reconstitute an armored force and adjust tactics. The sheer vastness of Russia allowed the Red Army the several years it needed—a cost probably only the Soviet Union could afford to pay.

Unfortunately, neither the French nor the Israelis had the luxury of trading space for time in order to adapt to the new mobile threat, as did the Soviet Union. Moreover, in the current security environment, it is unlikely the United States will have the luxury of time to respond to a crisis that would be mitigated in large part by sending armored units. Despite remarkable technological advances in weapons systems, physically holding ground still matters. Several past U.S. ground counteroffensives would have looked very different if there had been no launching pads available—as there were in the Pusan Perimeter (1950) during the Korean War, in Saudi Arabia (1991) during Operation Desert Storm, and in Kuwait (2003) at the outset of Operation Iraqi Freedom. Support to allies and partners would also suffer in the conduct of security force assistance, as a much smaller U.S. Army tank community would have proportionally less capability.

Were the United States military to sharply reduce (e.g., by 50 percent or more) its heavy mechanized capabilities, building that force back up (not necessarily to today's level) would likely be a mid-term proposition requiring at least several years. Although the United States currently faces little threat of being overrun by mechanized forces, its global network of allies and partners includes many nations that do. If not pre-positioned or already deployed, many potential scenarios might be decided by employment of even a modest armored force (e.g., one tank company) over a fairly short period via air to some key terrain such as an airfield or port. Efforts by an enemy to overrun such a force would prove very difficult, as Iraqi forces in Baghdad discovered in 2003.[14]

Army Chief of Staff Gen. Raymond Odierno has implied a continued role for heavy forces in the future. In a November 2012 address, he stated, "I want an Army that is capable of many missions at many speeds, many sizes, under many different conditions, and the capability to operate in any environment."[15]

Suite of Improvements

Let us stipulate that U.S. ground combat forces in the future must continue to be composed of a mix of forces as seen today, spanning from light to heavy mechanized. What capabilities might the main battle tanks provide in the heavy mechanized component of that mix, whatever its relative size in the overall force?

Tactical solutions worth serious consideration cannot be conceived in a resource vacuum, and any future developments for heavy armor in the U.S. military need to anticipate austere budgets ahead. The conclusion of the nation-building wars in Asia, and the difficult decisions that will be forced on Congress and the White House from the current massive federal deficits, will almost certainly foster an era of less for the Department of Defense. Therefore, major new weapons development initiatives will be minimal. All-new, cutting-edge systems entail much technological risk, require long timelines to develop and field, and often include substantial increases in unit cost. The coming era is unlikely to tolerate such cost and risk for ground force systems.

However, it is possible for a few key enhancements to today's M1 Abrams to substantially increase that platform's effectiveness with manageable technological risk and cost to prolong its serviceable lifespan. The key is to merge the existing strengths of the Abrams with some promising technologies. The Abrams is mobile, survivable, and lethal to line-of-sight targets within four or five kilometers. That said, its engine design is based on older technologies, meaning that it requires frequent refueling, and its main weapon cannot engage targets outside five kilometers or its line of sight.

Increased Range

Bearing in mind the low losses suffered by Abrams from enemy action during Operations Desert Storm and Iraqi Freedom, it could be argued that the M1's range limitations hindered optimal full tactical employment far more than did enemy action. In Desert Storm (1991), tremendous efforts were required to keep fuel-hungry U.S. mechanized forces supplied, which shaped the timing of the ground war. Similar fuel-related constraints hampered operations during Operation Iraqi Freedom in 2003. For example, in one case, a brigade came within an hour of running out of fuel.[16] Additionally, U.S. forces had to be diverted from the drive on Baghdad to isolate and clear urban areas used by Iraqi irregulars as bases from which to interdict U.S. supply convoys.[17] In Baghdad, several ammunition and fuel trucks were lost while running a gauntlet of enemy fire to reach isolated armored units holding key intersections—units that were in dire need of resupply. Therefore, it is time to re-evaluate options to increase the Abrams' range.[18]

Over the three plus decades the M1 has been in service, the Army has upgraded or replaced almost everything on it but the original Textron Lycoming AGT 1500 turbine engine (based on late-1960s technology). The Army did award a development contract in 2000 for a new turbine engine to be used in both the Abrams and the then-planned Crusader artillery vehicle, but this effort ended shortly after the Crusader was cancelled.[19] The M1A2 System Enhancement Program upgrade added an auxiliary power unit, which saves fuel by reducing the need to run the engine at idle

Soldiers from 1st Battalion, 4th Cavalry Regiment, 1st Infantry Division, fuel their M1A1 Abrams main battle tank at a traffic control point outside the city of Samarra, Salah Ad Din Province, Iraq, during Operation Baton Rouge, 3 October 2004.

(U.S. Air Force photo by Staff Sgt. Shane Cuomo)

while stationary. In 2007, the Army did begin the Total Integrated Engine Revitalization (TIGER) program for the AGT1500, but with the objective of improving reliability and durability, not fuel economy.[20]

Engine technology has come far since the Abrams was introduced. The M1 turbine's 1,500 horsepower originally stood out from other tank engines for its power, but now many other main battle tanks match that output with more efficient diesel engines. For example, the Leopard II carries 37 percent less fuel and yet has a range five percent greater than the M1.[21]

Of course, a decision to replace the M1's engine would involve a diverse set of factors not explored here in detail. However, the tactical limitations that arise from the M1's current range, combined with the maturity of diesel engine technology and the age of the current M1 engine, make the conversion to a new engine (diesel or otherwise) worth serious consideration.[22]

Industry successfully conducted trials with a diesel engine in the M1 in 1997 in case any export customer wished to pair a diesel engine with the M1, which suggests the compatibility issues are manageable.[23] A key engineering question would be the volume differences between a diesel and the current turbine engine. If the diesel is larger, it might force a reduction in internal fuel capacity, at least partially cancelling out any range increase.

Also, any fuel consumption reductions for the Abrams need to be put in the proper organizational context. Tanks rarely operate alone, but rather as part of combined arms battalions within an armored brigade combat team. Each combined arms battalion contains 58 Abrams and more than twice as many other vehicles, thus diluting the overall fuel savings if only the Abrams becomes more efficient.[24]

Nevertheless, reducing the fuel needs of the M1 could have ripple effects through logistics units. Less survivable logistics units may reduce their need to traverse unsecured territory and thus reduce the associated risks.[25] A reduced fuel demand for the Abrams also could allow a reorganization of logistics units, freeing up manpower for other units. Finally, less fuel demand could mean that fewer logistics personnel are needed in the critical early phases of a deployment (known as a better *tooth-to-tail ratio*).

Other questions of concern include tactical issues related to changes involving increased noise or smoke output and loss of acceleration with the use of the diesel engine versus the turbine. The turbine provides excellent acceleration, and any reduction in that should be explored for its tactical implications.

Non-Line-of-Sight Engagement Capability

The Abrams is unique in presenting both chemical energy (high-explosive antitank rounds) and kinetic energy (sabot rounds) threats to enemy tanks, complicating the enemy's defensive efforts.[26] However, though the 120 mm gun on the M1 is highly accurate and lethal, it is limited to engaging line-of-sight targets out to a range of approximately five km.

Introduction of a new medium-range, non-line-of-sight (NLOS) munition for that gun would greatly expand the engagement area, allowing more dispersed Abrams units to exert influence over more terrain. Such rounds would undoubtedly cost more than those now fired from the M1, but their costs may compare favorably with the cost of employing a precision munition from an aircraft when launch platform operating costs are included. Moreover, a medium-range engagement capability would yield survivability benefits by allowing the Abrams to engage from beyond the range of most ground-based anti-armor threats. Over the last decade, the development of a number of smaller and less expensive precision munitions, many for use on drones, may reduce the development risk for a precision round for the M1.

With the advances in air defenses already seen today, particularly man-portable air defense systems, engaging ground targets with precision munitions in some areas without the need to approach those areas with valuable aircraft or employ expensive long-range precision-guided munitions might prove beneficial. The Army does possess this capability currently in its tube and rocket artillery forces (e.g., the Excalibur 155 mm round and guided multiple-launch rocket system round), but to expand it to the highly survivable and mobile M1 would give future commanders more options in high-threat environments.

With an NLOS capability, a force of M1s in some cases might be able to dash forward and degrade air defenses, blending the effects of the 2003 Baghdad thunder runs with the role played by F-117s in

1991.[27] In the 1973 Yom Kippur War, the Israelis suffered heavy losses to surprisingly effective Egyptian air defenses until Israeli ground units were able to close with and destroy those air defenses.[28]

The U.S. Army was exploring just such a round in the XM1111 Mid-Range Munition, in association with the FCS program, awarding a development contract in 2008. With a planned maximum range of at least 12 km, the fire-and-forget XM1111 would have allowed an M1 to engage targets over an area almost six times larger than possible with today's five km engagement range. However, the Army terminated the XM1111 program in May 2009 as part of the dismantling of the larger FCS program.[29]

Any similar future munition would entail various logistics, training, and intelligence challenges. The round would need to fit in the M1's existing internal ammunition racks, and the crew training and workload ramifications would require study. A tank crew targeting, firing, and tracking an NLOS round likely would be distracted from the direct-fire fight, so the tactical tradeoffs should be investigated. With such a guided precision-engagement capability, the Abrams would have a greater need for acquiring and processing precision targeting data, which in turn might require a change in sensor capabilities in the armored brigade combat team (currently equipped with four Shadow drones).[30]

Role for Modeling, Simulation, and Experimentation

The synergy and relative value of these different enhancements should be explored initially with war gaming, modeling and simulation, and at some later stage, field experiments. Thorough exploration of the many varying conditions, threats, and combinations of enhancements will require a virtual environment capable of a rapid cycle time with modest hardware and personnel requirements. The involvement of experienced operators as human player-participants will be essential to exploring the potential of the new capabilities.

A pre-scripted set of enhancements should be part of the process; but as the participants become better acquainted with the models used and the simulated new capabilities, participants should be turned loose to explore the solution space. Ideally, participants would be presented with a budget they could use to select from a menu of enhancements (i.e., greater range or NLOS engagement capability). Those enhancements would be priced to reflect initial estimates of what it would cost to field those enhancements.

Over time, participants would become well acquainted with the capabilities and scenarios and would develop opinions on the relative value and utility of the capabilities; giving them a capabilities

Soldiers from 3rd Battalion, 7th Cavalry Squadron perform maintenance on an M1A1 Abrams tank at the unit maintenance collection point in central Iraq, 28 March 2003.

(Photo by Sgt. Igor Paustovski, Joint Combat Camera Center)

menu would allow them to explore their own *what ifs*. However, it should not be assumed that these enhancements are worthwhile. Players should be given the option instead to select additional unupgraded vehicles, essentially opting for more vehicles over better vehicles.

To properly explore the benefits of the enhancements and how they trade off with existing Abrams capabilities, some specific details would need to be included in the models. For example, if a new diesel engine required more space, to what extent would that necessitate a reduction in fuel capacity? How would a diesel engine vary from the turbine in acceleration, noise, and smoke generation? How would an Abrams crew be supplied with additional data to aid NLOS targeting? Including such information, even if derived from estimates, would enable some key tactical questions to be at least partially answered.

Good enough should be the mantra, and the pursuit of fidelity should be balanced with constraining the number of *what ifs* that can be explored. Key to this will be defining topics that are *not* being explored (such as the effects of sleep deprivation). Keeping the modeling and simulation hardware, software, and bandwidth requirements modest might allow a greatly expanded and distributed pool of participants.

Conclusion

The Abrams has served well over the last three decades, but the argument for its continued role could use some bolstering. With the future focus of the U.S. military on the Pacific, there may be less need for the employment of large concentrations of armored vehicles, but this does not end the utility of armor. A smaller number of more capable Abrams would mitigate some of the associated strategic mobility and operational logistics challenges while still presenting adversaries with a highly lethal, mobile, and survivable threat. Moreover, recent events in the Ukraine have renewed interest in the Abrams. In September 2014, the Army announced that U.S. Army units employing Bradleys and Abrams would be participating in exercises in Eastern Europe for three months starting in October.[31]

Were the suite of enhancements described in this article applied to the Abrams successfully, its role might be expanded. Of particular interest could be how an enhanced Abrams might work with special operations forces, the role it could play in amphibious assaults, and its use to degrade air defenses.

The Abrams could be substantially more useful than it is today. Improvements may prove key in the arguments about its place in the future force. Modeling and simulation should be used to explore the implications of using upgraded Abrams tanks across a broad range of combat environments and threats. Although this article has focused on materiel, the implications of successfully enhancing the Abrams extend well beyond the benefits discussed and could include significant improvements to doctrine, organization, and training.

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Col. Brian M. Drinkwine, U.S. Army, Retired, was an Army combat arms officer and decorated combat veteran with over five combat tours and 26 years of service. His final tour of duty was an assignment at the Institute for Defense Analyses. He holds a B.A. from the U.S. Military Academy, an M.A. in political science from Auburn University of Montgomery, an M.S.S. from the U.S. Army War College, and an M.B.A. from the Darden School of Business, University of Virginia.

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12. Our colleague Dr. Kevin Woods deserves credit for reminding us of the relative learning time lines presented by conventional combat operations versus irregular warfare.

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22. 113th Congress, *National Defense Authorization Act for Fiscal Year 2014*: 534-535.

23. Dennis P. Finn, "The Abrams-Crusader Common Engine: Help is on the Way," *Armor*, CXI(2)(March-April 2002): 42; Christopher F. Foss, *Jane's Armour and Artillery 2002-2005*, (Surrey, UK: HIS Jane's, 2004), 158; Christopher F. Foss and Richard Strickland, eds., *Jane's Armour and Artillery Upgrades 2003-2004*, (Surrey, UK: HIS Jane's, 2003), 267-268.

24. *Maneuver Center of Excellence Supplemental Manual 3-90: Force Structure Reference Data, Brigade Combat Teams* (Fort Benning, GA: September 2011), 88-166.

25. Gordon and Trainor, *Cobra II*, 240. Example discussed regarding the the Army's 507th Maintenance Company, which suffered heavy losses passing through Nasiriyah, Iraq, in 2003.

26. *HEAT (High Explosive Antitank) warheads* have shaped-charged explosives that penetrate armor via the shape of the explosion formed by the warhead. Sabot rounds rely instead on the kinetic energy of a dense metal dart to penetrate armor.

27. Tom Clancy and Chuck Horner, *Every Man a Tiger*, (New York: G. P. Putnam's and Sons, 1999), 337, 346. In 1991, stealth F-117s *Nighthawk* aircraft were used to penetrate Iraqi air defenses and attack key air defense nodes from within, making Iraqi airspace safer for other nonstealth aircraft.

28. Martin Van Creveld, *The Sword and the Olive* (New York: Public Affairs, 1998), 217-*237.*

29. "XM1111 Mid Range Munition," http://www.deagel.com/Projectiles/XM1111-Mid-Range-Munition_a001136001.aspx; Leland S. Ness and Anthony G. Williams, *Jane's Ammunition Handbook: 2011-2012* (Surrey, UK: IHS Jane's, 2011), 449.

30. *Supplemental Manual 3-90:* 106.

31. "Army Sending Tanks to Eastern Europe as Tensions Escalate with Russia," *Inside the Pentagon*, 14 September 2014, Vol. 30, No. 36.