DefenseNews

THE ONGOING EVOLUTION OF GROUND VEHICLES

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By: Matt McLaughlin

The M2 Bradley fighting vehicle went into service for U.S. military forces in 1981, and it has been a valuable part of U.S. operations in the decades since. The Bradley served successfully as a troop carrier and combat vehicle during the Persian Gulf War in the early 1990s, as well as the Iraq War, beginning in 2003.

More recently, the vehicle has been used in Ukraine's conflict with Russia. The U.S. shipped 50 M2 Bradley vehicles to Ukraine as part of an aid package, and they have been successful in combat against Russian tanks, as well as being used to transport endangered non-combatants to safety.

The Bradley Fighting Vehicle was conceived in the post-Vietnam era, at a time when analog systems and mechanical engineering defined the battlefield. Built before the rise of microelectronics and networked warfare, the platform's architecture reflected the technological limits of its day. While decades of upgrades have extended its service life, its original design now constrains further adaptation. The Army's pursuit of a next-generation vehicle reflects the need for a system built from the ground up for digital integration, sensor fusion, and autonomous capabilities.

Much of the talk about modern warfare revolves around new technology, such as unmanned aerial vehicles (UAVs) or hypersonic missiles. But armored forces still play a vital role, as they are needed to take and hold territory, especially in fast-developing conflicts where terrain advantages or maintaining supply lines are critical to ensuring success. While the venerable Bradley has played this role in conflicts for decades — including currently doing so in Ukraine — the modern battlefield demands more capability from fighting vehicles, such as controlling UAVs, counter-drone capabilities, silent overwatch and more.

Soldiers from 2nd Battalion, 5th Cavalry Regiment participate in a virtual experiment at the Detroit Arsenal in Warren, Michigan. The soldiers were providing input on possible crew configurations for the next-generation combat vehicle.

DAN HEATON/ U.S. ARMY

"There's an urgent need to refocus the Army's combat vehicle modernization strategy to prepare for existing and emerging threats as current vehicles face challenges of age and obsolescence," said Chris Haag, Vice President of Business Development and Strategy at American Rheinmetall. "Peer threats have developed increasingly capable systems, including advanced kinetic energy ammunition, anti-tank guided missiles, loitering munitions, unmanned aerial systems and even cyber, electronic and electromagnetic weapons. The ongoing conflict in Ukraine has highlighted some critical gaps in current Army vehicle capabilities, so the Army, in order to maintain its overmatch against current and future threats, has focused on modernization."

The next-generation combat vehicle, now XM30, is just one of several vehicle modernization initiatives going on within DoD. The changing nature of combat demands an evolution in military vehicles, but many of the overall objectives of modernization remain steady from previous generations: the modernized vehicles must be mobile, they must protect U.S. troops, and they must be lethal.

However, the Army also has many new requirements for its modernized vehicles, which are intended to provide a decisive overmatch for U.S. forces. Beyond the traditional capabilities, these must have robust cybersecurity, as well as communication and networking capabilities that deliver

decision dominance to U.S. and allied troops.

Critical to this dominance is the ability for combat vehicles to provide electrical power and greater mobility. To do so teams have been working on engines with roughly twice the power of current combat vehicles coupled with hybrid electric drive transmissions. The horsepower combined with these transmissions provide significantly faster dash speeds and produces 200+kW of electrical power compared to the current 20kW. This provides power to command and control and protection systems while also offering the ability to silent maneuver to a position of tactical advantage.

The Army also aims for its modernized vehicles to be able to operate when crewed or uncrewed, depending on the demands of a given situation. This further improves crew safety and enables new potential use cases for the vehicles.

Coalition Forces assigned to the 278th Armored Cavalry Regiment, Task Force REAPER, scan their sector from the ground and with M2 Bradley Fighting Vehicles as part of a security perimeter during a patrol in an undisclosed location.

MASTER SGT. RAY BOYINGTON/ U.S. ARMY

As the Army and its industry partners work toward their vehicle modernization goals, perhaps their biggest challenge is balancing the different demands. For example, adding heavy armor and advanced systems can improve the protection and lethality of the vehicle, but they also increase weight, which can affect fuel efficiency and mobility. Digital engineering methods are proving to be critical in helping these modernization projects achieve their objectives.

Involving Soldiers in Modernization Efforts

In addition to digital engineering, the Army is using soldier-centric design to improve the outcomes of its vehicle modernization initiatives. By bringing soldiers into the design phase and incorporating their direct feedback, modernization efforts can take advantage of their experience and real-world expertise.

"Army Senior Leaders (decision makers) expect R&D to include multiple early touch points w/ soldiers – this is a game changer and also a deal breaker if they aren't involved" said Haag.

Feedback from soldiers is critical to the design of next-generation combat vehicles. Their experiences in using new systems can also help Army developers design new capabilities to adapt to requirements on the battlefield.

"The direct involvement of soldiers in next-generation combat vehicle development isn't just beneficial, it's fundamental," said Haag. "Their firsthand experience from the field provides invaluable insights that translate directly into a more effective, survivable, and ultimately mission-capable vehicle. It's about ensuring that combat vehicles are truly built for the soldier, by the soldier."

The Role of Digital Engineering in Vehicle Modernization

Digital engineering tools and approaches enable developers to modernize the design, development and production of new vehicles and capabilities. The Army has made digital engineering an essential part of several vehicle modernization programs, including the establishment of common contracting language and standards for digital engineering methods.

"Digital engineering is a huge opportunity to reduce costs and reduce risks for Army systems," said David Gorsich, chief scientist at the Army's Ground Vehicle Systems Center, in a May 2025 interview. "And I think it's a journey. It's not like we're done with it today. We will continue to improve our processes to be more efficient. But I think we've made great progress so far."

Among the digital engineering

practices the Army is using in vehicle modernization are:

• **Model-based systems engineering:** MBSE is a digital engineering practice that uses models, computer design, digital analytics and software development for requirements, designs and behaviors instead of traditional document-based methods. It allows systems engineers to simulate and evaluate different design alternatives without having to build physical prototypes, speeding the early detection of issues and facilitating the exploration of innovative solutions.

"MBSE provides a common visual language that supports better collaboration and communication across multiple disciplinary teams," Haag said. "And the approach provides better traceability and transparency by capturing relationships between the system components requirements in design decisions."

• **Digital twins:** Modernization efforts use digital twinning to create virtual models of real-world objects or systems that integrate specifications, architecture and real time data. By replacing outdated paper based models for complex systems, digital twins provide a single digital representation where critical information can be accessed for simulation, testing and manufacturing.

By using digital twins, Army developers can process live battle data, assess damage, simulate optimal maneuvers and uncover weaknesses in real time, allowing them to aggregate and identify vulnerabilities and rapidly improve designs.

• **DevSecOps:** The rapid development of software is essential to vehicle modernization. DevSecOps practices unify the efforts of development, security and operations teams to improve the speed, quality, accuracy and security of the software used in vehicles and systems. The approach integrates security throughout the development process and incorporates automation to accelerate the delivery of software.

By having multiple teams working together in the development pipeline with DevSecOps, modernization efforts are able to make continuous improvements and integrate new capabilities throughout the software lifecycle.

Ultimately digital engineering approaches accelerate development by enabling the visualization and simulation of designs instead of having static documents. This allows engineers to work faster and smarter, and facilitates rapid modernization at reduced cost by ensuring that designs are validated before manufacturing. It also offers more opportunities for industry competition and innovation throughout a vehicle's lifecycle.

Modular Open Systems Approach (MOSA)

Chris Haag emphasizes that MOSA is about more than compliance—it's about agility. The XM30 program is the Army's lead effort to prove that modular, open architectures can deliver a combat vehicle that evolves alongside the threat. With MOSA, new technologies, from advanced sensors to counter-UAS systems, can be added as they mature, ensuring soldiers always fight with the most capable vehicle on the battlefield. Haag calls this a turning point: a system designed not for a single moment, but to continuously outpace adversaries.

Modernizing Vehicles to Last

Durability is an essential characteristic of military vehicles. They face far more challenging conditions than commercial vehicles, including rough terrain, temperature extremes and combat. Even when they're not in motion, military vehicles spend far more time idling than other vehicles, putting even more strain on systems and parts. And their reliability is critical: If a combat vehicle won't operate, it could mean the difference between life or death for U.S. troops.

The longevity of the M2 Bradley has been remarkable. During its more than four decades of service, the Army has sought to replace it with a new platform multiple times, but those efforts have been unsuccessful. Instead, the Army has continuously updated the M2, for example, adding armor and communications equipment to address needs that arose as the vehicles saw use in conflicts around the world.

But as vehicle platforms age, maintaining them becomes an even greater challenge. Parts may become harder to find, and upgrades more challenging to integrate. The digital engineering practices and open-architecture approach that the Pentagon is taking with its vehicle modernization projects should allow systems to be completed and upgraded in the future at a faster pace.

The open standards approach also enables the military to avoid vendor lock-in. Rather than a vendor providing proprietary technology, the Army defines and owns the standard and maintains control as systems evolve over time. If a vendor encounters challenges or even goes out of business, others can move in to fill that role. In addition, competition among vendors can help keep costs down.

Digital design also improves maintenance capabilities by enabling the testing of new designs before manufacturing. This helps to speed new tools to troops who need them while avoiding issues as troops deploy

As the U.S. military focuses on ground vehicle modernization, new technologies such as robotic vehicles are being tested to evaluate their effectiveness in the field.

SPC. CHRISTIAN CARRILLO/U.S. ARMY

new capabilities in the field.

“As you get into the production phase of programs and tradeoff analysis, digital engineering practices allow assessments of design impacts for performance, cost and schedule,” Haag said. “These approaches allow you to have version control at every development stage so that you can validate a design before committing to any sort of physical prototyping.”

Vehicle Modernization in Action

The Army's next-generation combat vehicle represents an advanced, modern, and effective pathway to achieve critically needed combat vehicle modernization that delivers the game changing system needed to deter enemies and win on future battlefields. Legacy systems cannot suffice. As a replacement for the M2 Bradley, the new combat vehicle is the Army's first ground vehicle designed completely digitally, extensively applying digital engineering practices in all aspects of design and production. This begins with transitioning requirements documents into product lifecycle management tools

Digital engineering for the next-generation combat vehicle involves not only 3D model development but also ensuring modularity while tracing requirements and milestones throughout the various stages of the program’s progression. The program uses tools to manage developmental data, giving the Army unprecedented insight into design details and component interactions to validate performance.

These insights will help the program achieve the balance the Army is looking for between lethality and protection, implementing weapons such as a 50mm cannon and anti-tank guided missiles while also providing countermeasures against attacks by unmanned aircraft and electronic warfare.

Vendors are preparing prototypes of the vehicles for delivery in 2026, with initial production scheduled for 2028 and full production for 2030.

“The XM30 will replace the Bradley fighting vehicle, bringing new transformational capabilities to the fight; these will include improvements to lethality, soldier-vehicle survivability, and upgrade ability beyond the physical and economic limits of the Bradley,” said Douglas R. Bush, former assistant secretary of the Army for

Acquisition, Logistics and Technology.

Next Steps: The Future Evolution of Ground Vehicles

As development moves forward in the military's vehicle modernization projects, artificial intelligence (AI) will play an increasingly important role. AI and machine learning will be used to enhance targeting, enable countermeasures and allow unmanned operation when needed. Automation will supplement the efforts of human operators, reducing the number of crew members needed while helping to improve lethality, protection and efficiency.

Software acquisition must be another area of innovation as the Pentagon modernizes its vehicle platforms. DoD and the military services must be able to purchase software quickly when it is needed and replace it quickly when it is no longer useful.

The open-standards approach employed in vehicle modernization will enable the seamless integration of new AI tools, as well as other capabilities. As U.S. forces learn new lessons from conflicts, their modern vehicles will continue to evolve.

To achieve this vision, the Army will need to maintain its innovative approach to acquisition, design, development, testing and updating. Modernization initiatives should continue to employ digital engineering practices that can accelerate development while reducing costs. Continuing efforts to gain insights from soldiers in the field will also help the Army's modernized vehicles deal with developments in the battlespace that require new capabilities.

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For example, Army officials are looking to deploy systems that can protect vehicles from attacks by unmanned aerial vehicles and advanced antitank weapons used in the Ukraine conflict. These capabilities will continue to evolve and will require the integration enabled by open technical standards, increasing involving advanced communications and automation.

"As we look to the lessons from new conflicts, we'll see the evolution of formations where you have integrated tactical tasks between robots and manned platforms," Haag said. "We want to get to fully networked warfare capabilities where unmanned systems can reduce the risks of warfare for human troops." America's adversaries and peer competitors are modernizing at accelerated speeds and have caught up and in some cases, surpassed the U.S. in several critical warfighting capability areas. Land warfare is not going away nor will peace endure without credible deterrence – a deterrence achieved by maintaining land warfare superiority. **DN**

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