Picture credit: Elbit Systems

SIMULATING THE FUTURE

Ben Chiswick *outlines the Role of Simulation in Integrating Autonomous and Electrified Systems in Defence*

The defence sector is on the brink of a transformative journey as it integrates electrification and autonomous technologies. This integration holds immense potential to revolutionise warfare and defence, especially in unmanned ground vehicle platforms. Embracing an electric and autonomous future promises to enhance military operations, improve efficiency and reduce environmental impact, fuel costs and human risk. Moreover, purely electric propulsion systems offer advantages such as zero exhaust emissions and quieter operation, bolstering stealth capabilities.

To fully harness the benefits of autonomy and electrification, a complete reimagining of vehicle architecture is needed. This will enable the opportunity to integrate cutting-edge technology, and optimise power, range and performance through increased design freedom.

The integration of autonomy and electrification in defence vehicles heralds something of a paradigm shift, particularly in fully unmanned platforms where personnel are removed from harm's way. By leveraging autonomous technology, the risks associated with missions such as fuel convoys can be significantly reduced. This creates an opportune moment to optimise defence vehicles for electrification as well, as these two technologies seamlessly complement each other.

The US Army's Optionally Manned Fighting Vehicle (OMFV) programme is an excellent example of the future direction, showcasing the concept of manned/unmanned teaming. In this setup, crewed vehicles command missions while unmanned vehicles proceed ahead, deployed in more vulnerable areas.

Making the transition to unmanned vehicles means seats, windows, manual steering controls and crew support systems become obsolete, creating more valuable room

Ben Chiswick is director of engineering business development at Drive System Design

With the transition to unmanned vehicles, many traditionally essential components, such as seats, windows, manual steering controls and crew support systems become obsolete. This opens up ample space for engineering teams to reimagine the future of combat vehicles. Furthermore, electrification offers unique opportunities, enabling the introduction of more powerful surveillance systems and weapons that require higher voltages and larger batteries for silent watch operations.

Moreover, the reduced criticality of crew survivability allows for a significant reduction in the amount of necessary armour. This weight reduction creates additional room for integrating electrified subsystems and battery packs, fostering greater design flexibility. Additionally, the absence of extensive armour layers simplifies thermal management systems, eliminating cooling barriers traditionally associated with armoured vehicles.

By embracing autonomy and electrification in defence vehicles, a wealth of possibilities is unlocked, transforming the landscape of modern warfare and enabling innovative advancements in combat vehicle design and capabilities.

Given the myriad factors to consider, the engineering of defence platforms has rapidly evolved over the last five years, driven by new technologies, requirements, potential threats and ongoing government research and development. While fully autonomous or fully electric defence vehicles pose significant long-term challenges, the near term offers no shortage of obstacles to overcome. It is essential to engineer vehicles to be modular and upgradeable in readiness for the technology of tomorrow, considering the overlap between manned-manual, manned-autonomous and unmanned operational modes.

This technology overhaul may not be suitable for all defence vehicles, making it crucial to understand the applicable use cases for specific platforms and weigh the associated risks and benefits from the outset. Taking a whole system approach and reconstructing the propulsion system and vehicle architecture has the potential to deliver exponential gains.

To successfully transition to an integrated autonomous and electrified system in defence vehicles, a system-level approach is crucial. Here are key considerations within this approach:

Simulation-led method: Minimise risk and investment while ensuring safety and performance by using simulation to evaluate system integration. This approach provides insights into the system's response to different scenarios, operational conditions and real-world deployment opportunities. By simulating propulsion system capabilities and optimising subsystems in a controlled environment, the high costs of a hardware based validation process can be reduced.

Early thermal modelling and simulation: Understand and mitigate failure modes related to electrified systems by developing effective thermal management systems. Consider the harsh environmental conditions of military routes and challenges presented by armour requirements. Robust thermal modelling helps ensure durability, with defence applications often necessitating a 25 percent increase in temperature coverage.

Rapid prototyping: Leveraging digital twins and agile development methodologies is crucial for unmanned autonomous platforms. With relaxed constraints around armour and crew safety, the market demands faster realisation of these platforms. By avoiding a traditional build-fail-learn-repeat approach, agile development saves time, reduces investment and minimises resource waste. Digital twins enable early and efficient development, saving time and significant costs before physical testing.

Control development expertise: Control development plays a vital role in autonomous vehicles. The combination of autonomous logic and operation with a hybrid supervisory control system optimises energy usage for a given mission profile or conditions. This ensures successful path planning, obstacle detection and optimal power utilisation.

AN ELECTRIC AND AUTONOMOUS FUTURE PROMISES TO ENHANCE MILITARY OPERATIONS

By adopting a system-level approach, integrating autonomous and electrified technologies in defence vehicles becomes more efficient, reliable and capable of meeting the demands of modern warfare.

The unmanned and software-driven nature of autonomous platforms enables simpler upgradability, akin to how Apple continuously improves its iPhones through software updates. In contrast, traditional military vehicles require a more rigorous validation process when crew safety is at stake. Developing unmanned ground vehicles allows for agile development, early deployment and simpler upgrades and maintenance based on real-world data and feedback.

With the growing demand for higher voltages and power levels in various defence applications, it is crucial for power electronics, such as AC/DC converters, to perform reliably under extreme conditions. Flexible power electronics that can adapt to emerging battery and motor technologies are essential to deliver not only basic functionality, but also introduce additional features and upgradability.

By adopting a system-level approach and integrating autonomy and electrification from the vehicle's inception, it becomes possible to unlock increased innovation and accelerate deployment. Early recognition of the paradigm shift in mobility, lethality and survivability that is on offer allows for maximising innovation and development speed.

The integration of autonomous and electrified systems in defence vehicles holds vast potential for transforming warfare and enhancing military operations. By embracing simulation-led approaches, considering system-level design methods and leveraging the advantages of unmanned and software-driven platforms, the defence sector can harness the benefits of electric and autonomous technologies while meeting the demands of modern warfare. The future outlook is promising, as ongoing research and development continue to shape the landscape of electrified defence vehicles ●