Addressing Human Factors Issues for Future Manned Ground Vehicles (MGVs)

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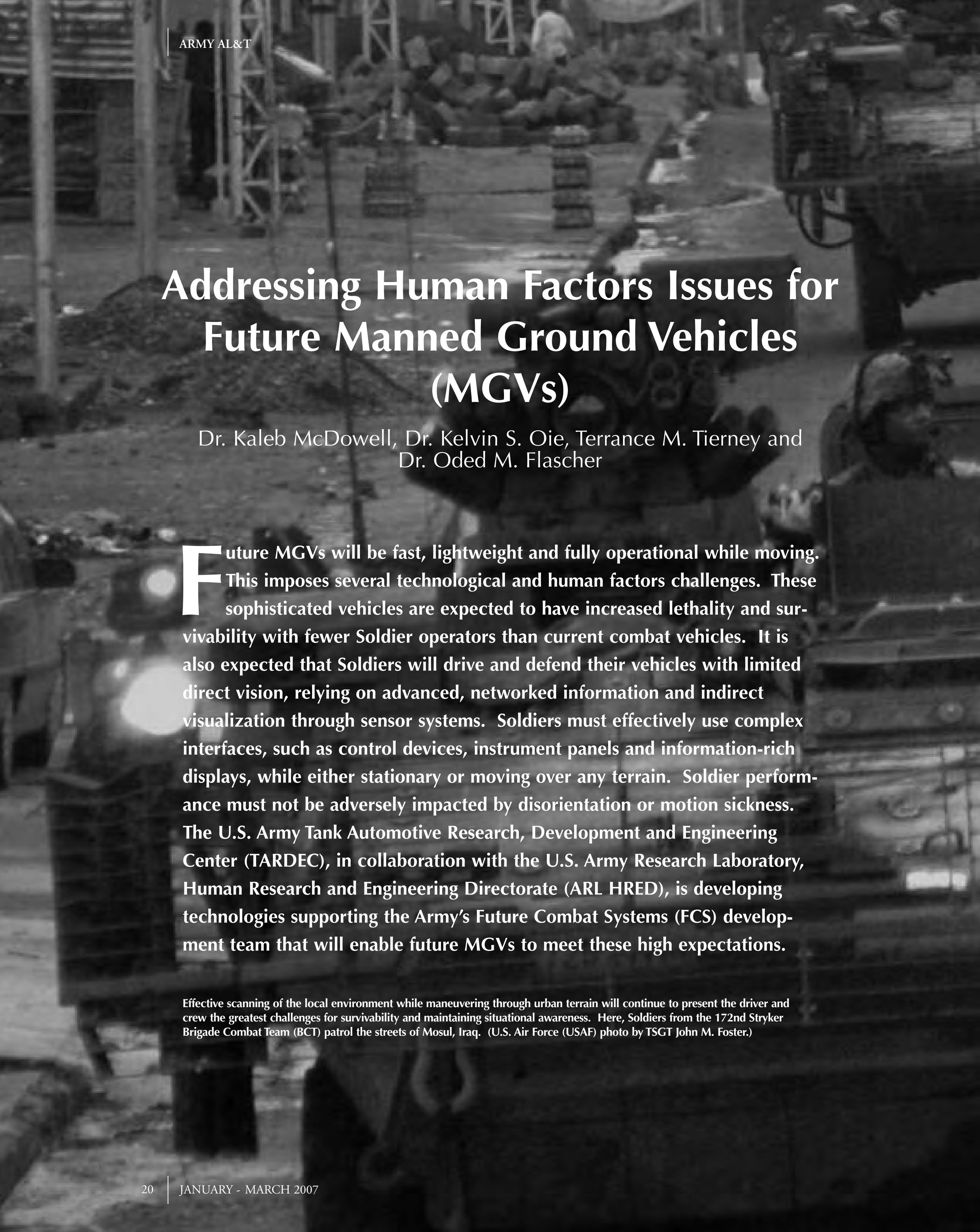
Future MGVs will be fast, lightweight and fully operational while moving. This imposes several technological and human factors challenges. These sophisticated vehicles are expected to have increased lethality and survivability with fewer Soldier operators than current combat vehicles. It is also expected that Soldiers will drive and defend their vehicles with limited direct vision, relying on advanced, networked information and indirect visualization through sensor systems. Soldiers must effectively use complex interfaces, such as control devices, instrument panels and information-rich displays, while either stationary or moving over any terrain. Soldier performance must not be adversely impacted by disorientation or motion sickness. The U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC), in collaboration with the U.S. Army Research Laboratory, Human Research and Engineering Directorate (ARL HRED), is developing technologies supporting the Army's Future Combat Systems (FCS) development team that will enable future MGVs to meet these high expectations.



Effective scanning of the local environment while maneuvering through urban terrain will continue to present the driver and crew the greatest challenges for survivability and maintaining situational awareness. Here, Soldiers from the 172nd Stryker Brigade Combat Team (BCT) patrol the streets of Mosul, Iraq. (U.S. Air Force (USAF) photo by TSGT John M. Foster.)

History

Since the early 1990s, TARDEC has teamed with ARL HRED to develop crew stations for future warfighters. The Crewman's Associate Advanced Technology Demonstration (ATD) provided baseline advanced Soldier-machine interface concepts and explored the feasibility of reduced manning in performing ground combat vehicle functions within a simulation environment. Appropriate Crewman's Associate designs were subsequently leveraged by the Vetronics Technology Testbed (VTT), which integrated two crew stations into a Bradley A0 hull. VTT demonstrated drive-by-wire capability, indirect vision driving, embedded simulation and multifunctional displays, and examined the viability of reduced crew size to perform a scout mission.

This work evolved into the Crew Integration and Automation Testbed (CAT)-ATD, focusing on reducing crew workload and improving crew performance through automation technologies. CAT-ATD integrates the latest generation of crew stations into a surrogate, FCS-like (Stryker) chassis, using the Autonomous Navigation System (ANS) for enhanced mobility. These state-of-the-art crew stations have been used several times to demonstrate developing capabilities for tasks including indirect vision driving, navigation, command and control, communications, target acquisition, and control of ground and air unmanned assets in field environments. CAT-ATD is augmented by the Technology for Human-Robot Interactions (HRI) in Soldier-Robot Teaming Army Technology Objective (ATO), which focuses on effective Soldier teaming with robotic assets, while also minimizing workload requirements. In all, TARDEC and ARL HRED have worked for more than 15 years on developing experimental, field-testable crew stations for the future.

Capabilities for Solving Human Factors Issues

Critical to MGV development is the ability to address Soldier performance issues during the research and development cycle. TARDEC and ARL HRED have amassed and continue to develop capabilities and resources toward these ends through:

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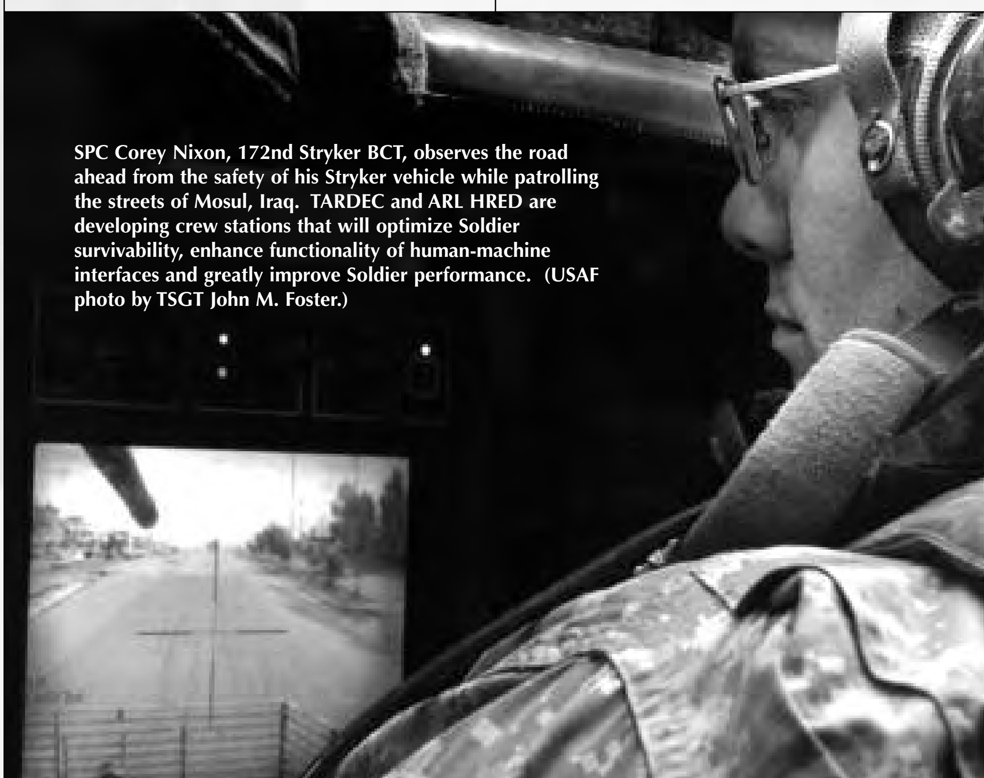
- Ruggedized platforms (CAT-ATD) to evaluate design alternatives for crew station functionality in field environments.
- Motion-base platforms in TARDEC's Ground Vehicle and Simulation Laboratory to test system and Soldier performance in realistic but controllable motion environments.
- High-fidelity, flexible, in-house computer simulation capabilities and reconfigurable testbeds located on-site with vehicle developers enabling rapid prototype development.
- Established collaborations with academic, government and industry research institutions to ensure the best concepts impact the development process.

These resources, coupled with in-house expertise, allow TARDEC and ARL HRED to perform necessary Soldier performance evaluations so that critical information is available at optimal times within the developmental cycle.

FCS MGV Soldier Performance Issues

Ensuring that system performance requirements are met begins with analyzing and breaking down human factors requirements to identify fundamental issues. Four interrelated, core issues that must be addressed to enable effective FCS MGV designs have been



SPC Corey Nixon, 172nd Stryker BCT, observes the road ahead from the safety of his Stryker vehicle while patrolling the streets of Mosul, Iraq. TARDEC and ARL HRED are developing crew stations that will optimize Soldier survivability, enhance functionality of human-machine interfaces and greatly improve Soldier performance. (USAF photo by TSGT John M. Foster.)

The CAT-ATD vehicle recently completed a field experiment where Soldiers performed indirect vision driving, robotic convoy control, route planning, local area security and simulated weapons firing tasks. (Photo courtesy of Lockheed Martin.)

identified by TARDEC, ARL HRED and FCS Lead Systems Integrator (LSI) representatives as follows:

- *Manning*. FCS MGVs are being developed to be smaller and more mobile than currently fielded systems under the paradigm of information dominance: "See first, understand first, act first and finish decisively." One consequence of smaller vehicles is downsizing the crew. Reduced vehicle manning potentially allows the future Army flexibility in managing manpower and reducing its logistical footprint in the field. MGVs are planned to be operated by two common crew members: the driver and the commander. The Mounted Combat System will have three crew members — commander, driver and gunner — and in most variants, additional mission crew members will operate mission-specific equipment. Reducing crew size increases each crew member's responsibilities and challenges developers to ensure that designs enable Soldiers to execute missions without being overwhelmed.
- *Area Security*. FCS design concepts will result in limited direct vision around the vehicle. The crew will use indirect vision systems that provide a high-fidelity representation of the area around their vehicle. These systems must compensate for the lack of direct vision and augment FCS network information, which is required to automatically identify and inform warfighters about most threats. However, indirect vision systems that allow quick and effective scanning of the local environment are under development. This poses a significant risk to Soldier survivability in the near term and, ultimately, to mission success in certain environments, such as urban terrain where local threats may not always show up in the FCS network information system. Expected performance decrements associated with future design concepts have a secondary manning consequence. Two common crew members will already have difficulty with mission management and mobility tasks (see *Indirect Vision Driving*, below), which will be further compounded by maintaining area security.

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- *Indirect Vision Driving*. Indirect vision driving also has performance and workload consequences. Similar to the situation described above under *Area Security*, current indirect vision technologies will require enhancements to achieve direct-vision driving capability. The challenges become problematic in a reduced crew environment, and will force FCS drivers to maintain situational awareness (SA) over a broader area than current combat vehicle drivers. Today, driving is accomplished through teamwork, with all three or four crew members responsible for area security. Additionally, drivers must determine and maintain the vehicle's path. The smaller FCS crew size will force significant changes, with drivers likely assuming a large portion of the navigation function currently performed by the vehicle commander. This, in turn, will increase each driver's SA and workload demands. ANS utilization planned for FCS may at times significantly offset increased driver workload. However, ANS will, at best, need to be supervised and, at worst, necessitate manual driving because of changing tactical needs or ANS limitations.
- *Vehicle Motion Effects*. Maintaining high levels of Soldier performance when operations occur in moving vehicles is a recurring challenge. The "motion effects" challenge includes,

Depicted here is one of two CAT-ATD in-vehicle crew stations set for indirect vision driving operations and robotic convoy control. (Photo courtesy of Lockheed Martin.)

SGT Jeffrey Parish, 172nd Stryker BCT, monitors his Stryker vehicle's interior display monitors during a patrol in Mosul, Iraq. Lack of direct vision capability under combat conditions is a major concern for FCS MGV developers. Reducing crew risk and other human factors is the major focus of TARDEC and ARL HRED scientists and engineers. (USAF photo by TSGT Jeremy T. Lock.)

but is not limited to: understandable presentation of information, implementation of controls minimally influenced by vehicle motion, and reduction of Soldier disorientation and motion sickness. These factors reduce performance associated with security, driving and mission tasks, and will increase the associated workload, thereby influencing the manning issue.

Optimizing Soldier Performance Through Teamwork

The next step in addressing MGV human factors issues is identifying and developing potential solutions to enable effective engineering designs. Each FCS MGV issue outlined here could independently lead to MGV design failure, but it should be clear that these areas are also strongly interrelated. The greatest challenge will be designing a system that allows Soldiers to perform driving, scanning and mission tasks *simultaneously*. This highly complex problem is the focus of technology development and integration being undertaken by efforts such as CAT-ATD. These problems necessitate the distinctive, specialized capabilities and resources of TARDEC and ARL HRED as follows:

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- Fielded partial solutions to indirect vision driving including demonstrating the impact of unity vision and the effects of controller devices on drive-by-wire systems.
- Used the TARDEC motion-base platform to examine the impact of MGV motion on head-mounted and flat-panel displays used for driving.
- Collocated simulations and laboratories with developers, which allowed the interface for the CAT-ATD crew station to be redeveloped in two years.
- Established collaborations with the University of Central Florida, the National Institutes of Standards and Technologies, General Dynamics Land and Robotic Systems, BAE Systems and Lockheed Martin who have provided important insights into the implementation of robotic control.

Already, significant progress has been made toward solving the FCS MGV Soldier performance issues raised above. Considerable work, however, remains to be done to optimize Future Force designs for maximum Soldier effectiveness. The resources identified here provide TARDEC and ARL the Joint capability to assess and solve these and other human factors issues for the Future Force and beyond.

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