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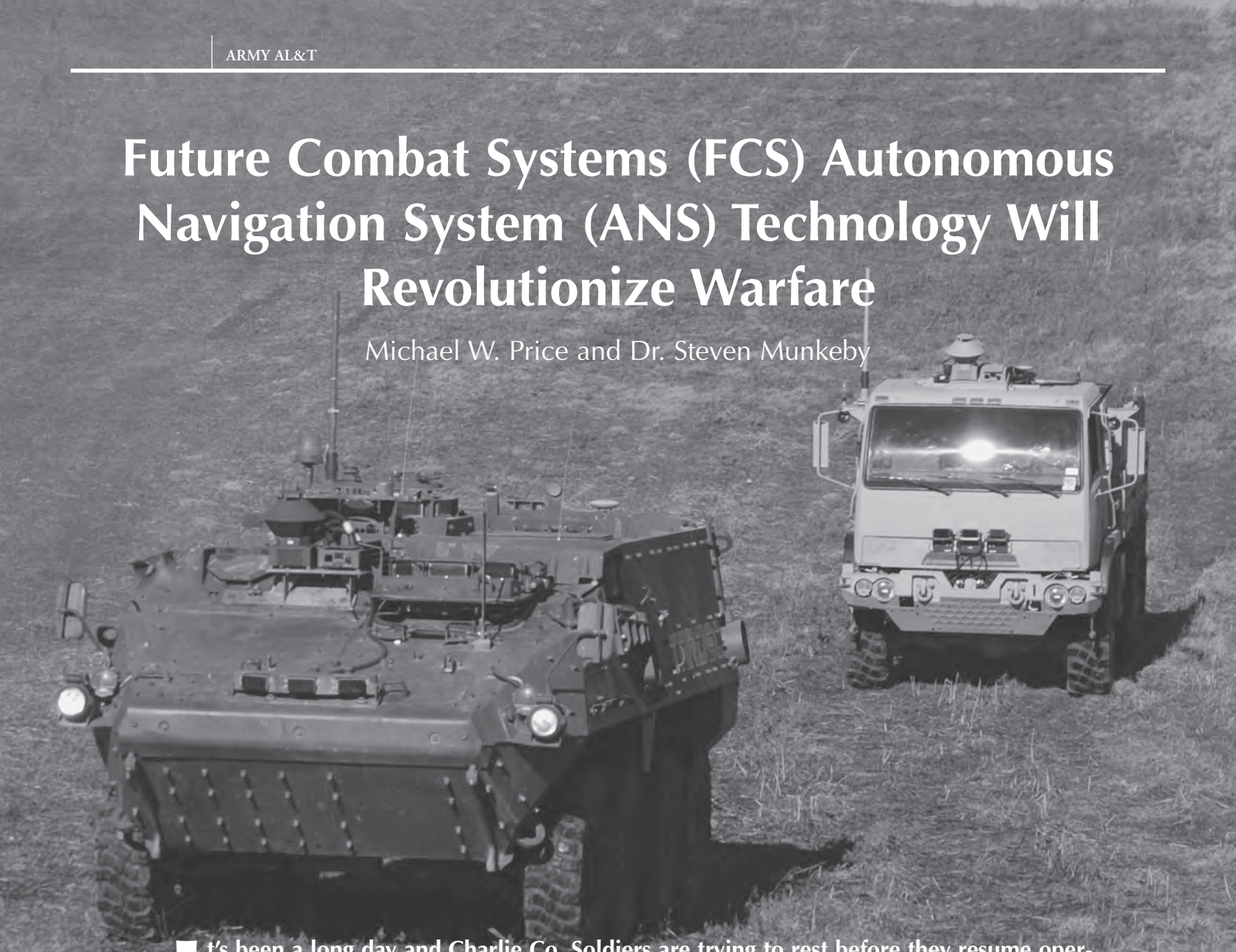
Future Combat Systems (FCS) Autonomous Navigation System (ANS) Technology Will Revolutionize Warfare

Michael W. Price and Dr. Steven Munkeby



It's been a long day and Charlie Co. Soldiers are trying to rest before they resume operations. Out of the distance, a convoy arrives with rations, water, ammo and needed medical supplies. The First Sergeant is pleased that the supplies arrived safely and that his Soldiers weren't needed to escort the convoy back. This convoy was the newest member of Charlie Co., an unmanned Multifunctional Utility/Logistics and Equipment (MULE) platform that autonomously travels back to the supply point and returns without a Soldier escort. The MULE conducted this mission autonomously avoiding obstacles and navigating rugged terrain using the latest autonomous navigation sensors and software developed for the Army's FCS. ANS performs the driving and navigation functions for all FCS unmanned ground vehicles (UGVs) and indirect driving for the manned ground vehicles.

The ANS functions of move-on-route and detect and avoid obstacles were enhanced with leader-follower capabilities, which allow one UGV to follow another vehicle's path in convoy-like operations. Here, during Phase I of the RCX, the ANS-equipped Stryker ICV is the leader and the LMTV is the follower. (U.S. Army photo courtesy of FCS(BCT).)

"The capabilities that the UGV and ANS provide to the warfighter will revolutionize the way we conduct combat operations," remarked LTC Steve Noe, FCS UGV Product Manager (PM). "They will reduce risk to the Soldiers in hazardous situations and reduce Soldier workload and manpower requirements, particularly with the MULE family of vehicles during combat and convoy operations."

Currently in the System Development and Demonstration phase, UGVs, with the ANS fully integrated into their configurations, will perform tasks designed to move the UGVs around the battlefield with minimal human oversight. Some of these tasks include move-on-route, obstacle detection and avoidance, and leader/follower. Each task provides day and night navigation tactical behaviors capability in all types of weather for survival on the battlefield. "ANS is the centerpiece of UGV technology, 'the eyes and brains' that emulates the human skills to interpret its surroundings and plot a course," said Dan Folk, FCS UGV Deputy PM.

RCX Phase I

The ANS demonstrated its robustness recently during Phase 1 of the Robotic Convoy Experiment (RCX) conducted at the White Sands Missile Range (WSMR), NM, in August 2007. Through a series of test operations emulating a real-time tactical environment while simulating combat amid rugged terrain, wind and sand, the ANS proved itself as an effective navigation system for manned and unmanned vehicles. The RCX included experimental maneuvers to evaluate the system's capability to avoid obstacles and to navigate rugged terrain using the latest autonomous navigation sensors and software developed for the Army's FCS.

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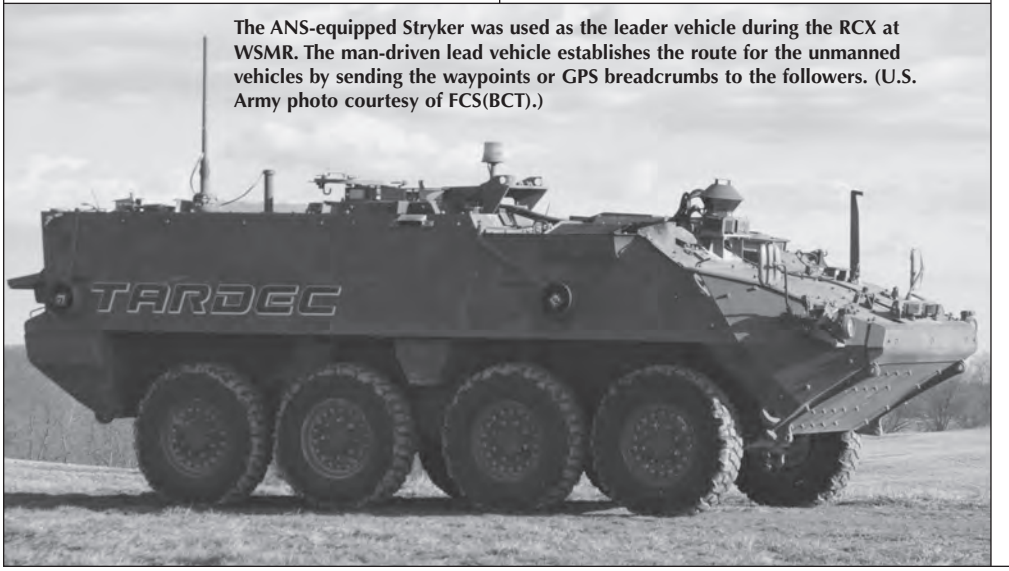
The RCX test vehicles were a Stryker Infantry Carrier Vehicle (ICV) and a Light Medium Tactical Vehicle (LMTV) equipped with ANS sensors, navigation and computing capabilities. The configuration allowed the test vehicles to be driven in teleoperation mode with a joystick. In addition to this capability, the ANS demonstrated remote capabilities beyond teleoperation where test vehicles navigated independent of direct Soldier control. Combining these two capabilities demonstrated the required FCS functionality for UGVs to move-on-route and detect and avoid obstacles using varying speeds and distances, numbers of waypoints, obstacle patterns and routes. ANS' cutting-edge autonomous navigation technologies are also confronting relevant environmental issues such as heat, dust, wind and rain.

During move-on-route, the ANS drives the vehicle by issuing speed and steering commands that maneuver the vehicle along a preplanned route. An ANS movement route is identified by designated waypoints, or Global Positioning System (GPS) breadcrumbs, coordinates that determine the route of travel. During the RCX-conducted tests, vehicle routes were conducted with and without obstacles.

Since the UGV maneuvers without a human making its decisions, an important function of unmanned vehicles is the autonomous decision-making ability to detect and avoid obstacles. During the RCX testing, obstacles were positioned on the vehicle's proposed route to vary the route and challenge the ANS' abilities. The ANS was presented with three different sets of obstacle patterns requiring it to appropriately decide whether to steer left or right.

Though robotic vehicles will never take the place of a Soldier, these vehicles will help reduce risk to Soldiers and possibly save lives at the same time. According to Folk, "ANS technology will revolutionize warfare on a scale comparable to the ironclads of the Civil War and the [German] Messerschmitt, the first jet fighter in World War II."

The ANS exceeded initial test objectives with teleoperational speeds, even in



The ANS-equipped Stryker was used as the leader vehicle during the RCX at WSMR. The man-driven lead vehicle establishes the route for the unmanned vehicles by sending the waypoints or GPS breadcrumbs to the followers. (U.S. Army photo courtesy of FCS(BCT).)

move-on-route with obstacle detection. Patti Rose, U.S. Army government co-lead for ANS, added, "We were pleased with the initial results. Not only were we able to move the vehicle along the specified routes at high speeds, we were able to detect and avoid obstacles while moving at those greater speeds."

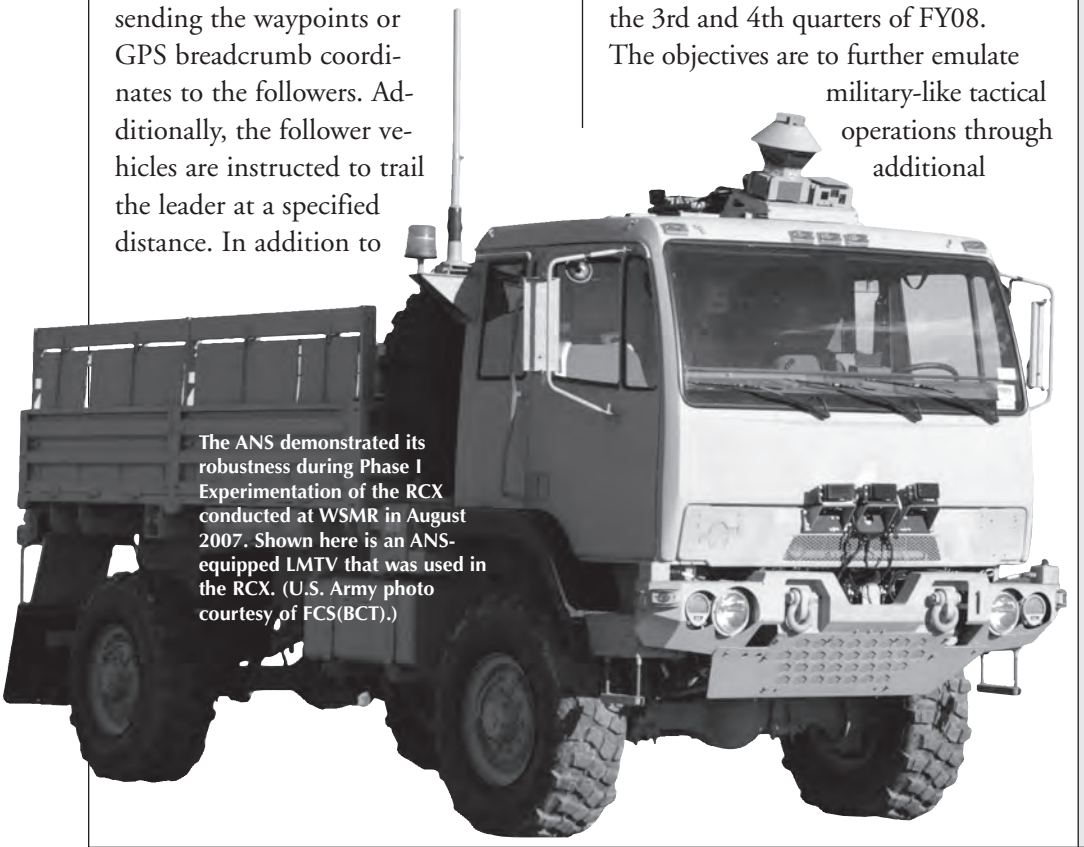
Leader-Follower Capabilities

Taking on this challenge of near-term convoy operations, the ANS functions of move-on-route and detect and avoid obstacles were enhanced with leader-follower capabilities, allowing one UGV to follow another vehicle's path in convoy-like operations. "Leader-follower," a term sometimes used interchangeably with "robotic convoy," evolved into the overall RCX goal while at WSMR. The leader-follower capability allows one man-driven vehicle to be followed by one or more unmanned vehicles in a convoy-like operation. The man-driven lead vehicle establishes the route for the unmanned follower vehicles by sending the waypoints or GPS breadcrumb coordinates to the followers. Additionally, the follower vehicles are instructed to trail the leader at a specified distance. In addition to the key accomplishments for speed and distance for teleoperational and move-on-route activities during RCX, the leader-follower "convoy operations" achieved high speeds with separation distances between the lead vehicle and follower even in heavy dust environments.

"The ANS program is developing a sophisticated autonomous route-following capability with obstacle detection and avoidance that will provide a future benefit to man-driven vehicles. The logistics implications are that ANS-equipped manned vehicles will alert drivers to hazards, allow drivers to rest or allow vehicle operation without drivers. We also see exciting opportunities for early spin out of some ANS features such as basic driver's aides and the leader-follower convoy capability demonstrated during our recent RCX," said Jay Kurtz, ANS Program Manager, General Dynamics Robotic Systems.

RCX Phase II

Phase II of the RCX is scheduled for the 3rd and 4th quarters of FY08. The objectives are to further emulate military-like tactical operations through additional experimentation with various routes, obstacle patterns and higher speeds. Further emphasis will be placed on ANS to demonstrate its ability to adapt and overcome unforeseen situations. FY08 experimentation will address the sustained speeds for longer periods of time and distances representative of current and future convoy operations covering various scenarios and situations. RCX successfully demonstrated more than 15 years of Pentagon-funded autonomous navigation work that is showing signs of reducing Soldier risk as envisioned in the FCS concept of operations. With preliminary test results as promising as they have been, Army officials believe unmanned vehicles might be applied to certain applications much earlier. An early potential application for these unmanned vehicles would include convoy operations in combat. As Noe summarized, "Helping Soldiers with their everyday high-risk tasks is a clear reason for developing the ANS capabilities as quickly as possible."



The ANS demonstrated its robustness during Phase I Experimentation of the RCX conducted at WSMR in August 2007. Shown here is an ANS-equipped LMTV that was used in the RCX. (U.S. Army photo courtesy of FCS(BCT).)

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