THE FUTURE FOR UNMANNED GROUND VEHICLES

For decades, unmanned air vehicles have been developed and used operationally but, despite the obvious roles for them, unmanned ground vehicles (with the exception of bomb disposal) are only now in demand. Unlike the US, European nations are still not funding research and development for the rapid progress that is required for support of front-line forces. In this section, authors from Germany, Sweden, UK and US describe the role of UGVs in bomb disposal, protection and reconnaissance (particularly in urban areas), not only in defence, but also in police and fire-fighting operations. Technology is only one of the issues, because there are important questions over safety, cost-effectiveness, weight, power and command and control.

Challenges to Acceptance and Proliferation of Tactical UGVs

by **Myron E. Mills**

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The street was way too quiet, thought the sergeant. The locals were clearing out; almost imperceptibly at first, but now more obviously. Mike-15 rolled along quietly behind the squad, scanning for trouble and dutifully copying their path and movement patterns, the hum from its electric motors and the crunching of debris under its six high flotation tyres barely audible a few feet from the machine. A child darted across the street in front of Mike-15, and the unmanned ground vehicle (UGV) automatically slowed allowing the child to pass safely and then resumed its former speed. Suddenly, a decrepit old sedan screeched to a halt at the head of the street. Automatic weapon fire erupted from the car and bullets screamed around the patrol. As the squad scrambled for cover, Mike-15 followed its mission plan and sprinted ahead, avoiding the running, diving soldiers and inserting itself between the squad and the incoming fire. Guided by its gunfire location and identification system, Mike-15's turret spun toward the threat as bullets occasionally smacked and whined against its armour. A simple message of 'TARGET LOCK' appeared on the sergeant's universal controller device display overlaid on an image of the sedan, the tangos inside, and an identification of the weapon being fired at the squad. The sedan was moving now, still firing on the squad as it started to retreat from the UGV. Mike-15's sensors maintained lock on the moving target as the gun turret tracked the threat. The sergeant squeezed a trigger switch on his controller, and Mike-15's Mini-gun burped off a short volley. Gunfire from the old sedan ceased as it careered into a wall and crashed to a halt. Silence returned as a plume of greasy black smoke began to rise from the wreckage. A smattering of Oo-Ra's issued from the squad as it began to regroup to continue its mission.

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Science fiction or certain near future? Those engaged in unmanned systems development would like to believe it is the latter. However, before UGVs with the characteristics described above are proliferated, or even introduced for tactical use, many significant engineering and operational challenges must be met. This article highlights some of the thornier issues associated with UGVs.

Achieving Autonomy

It's a fair assessment that achieving autonomy, or semi-autonomy, on the ground is significantly more difficult than in the air. The ground environment is marked by continuous change and dynamics. This morning's carefully planned and passable mission route may, only a few hours later, contain blast craters, burning vehicle hulks, blown-out bridges and detours or barricades. Improvised explosive devices (IEDs) and ambushes are ever-present threats that can turn a viable mission into complete chaos in fractions of a second. Before UGVs will be widely embraced, they will have to be shown not to burden the soldier more than they improve his lot. To avoid taking a soldier away from his job or out of the fight and endangering him by causing him to go head down on a controller, manual control or intervention (commonly referred to as tele-operation) must be the exception, not the rule, for tactical UGVs.

The capabilities of following roads and paths, relatively simple obstacle avoidance, Global Positioning System (GPS) waypoint following, and leader-follower behaviour have been demonstrated. However, those capabilities represent an insufficient level of autonomy for most missions. The UGV must be able to avoid not only easily definable fixed objects, but automobiles, trains, people and even livestock. Additionally, for many missions the UGV must be able to discern hostiles from friendly forces from non-combatants.

The SMSS shows all its potential carrying a squad's worth of equipment cross-country in a tele-operated mode [Lockheed-Martin]

An unmanned SMSS breezes along a country path in supervised autonomy mode [Lockheed-Martin]

The UGV must be able to distinguish between surfaces such as firm dirt/pavement, mud/sand/snow, and water if it is to avoid getting stuck in realistic tactical environments. In many cases, the UGV will need to be able to ford or swim water obstacles in order to follow dismounted troops and some mechanised units. Rocks, stumps, urban debris, sudden drops and holes must be recognised and assessed to govern the need for avoidance reactions and speed of traverse. Recognising common obstacles like jersey barriers, barrels, bollards and walls is a given, but what about forms of fencing such as post and cable, chain link, barbed wire and concertina wire that may be more transparent to sensors and more confusing to algorithms? What if the UGV is in follow-me mode with a dismounted soldier and the patrol suddenly comes under attack? What must the UGV do when the soldier (or soldiers) it was following suddenly disappears into a building, dives for cover, or falls to the ground immobilized by wounds?

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GPS outages, either due to environmental factors or to deliberate jamming, must be mitigated. Masking due to urban or real canyons or heavy tree canopy may cause temporary loss of GPS. Using some combination of electronic compass, inertial measurement unit (IMU), distance indicators and onboard sensors combined with a priori map and feature knowledge might be used by the UGV in some cases to navigate, especially in an urban environment. However, how will the UGV deal with lost GPS reception in a heavily forested area or in a featureless expanse of desert, tundra or snow field?

Protection, Weight and Power

Once the armed services have significantly invested in numbers of sophisticated UGVs and they are placed in harm's way, the UGVs (and the missions and soldiers that will depend on them, not to mention the investment they represent) must be protected to some level against the threats they will face. As the saying goes, a ton of lightweight armour still weighs a ton. Using the best of today's lightweight ceramic-composite armour systems to protect against even modest threats, such as armour piercing, light machine-gun fire represents a significant weight and cost burden for even a medium-size UGV. The additional weight of armour can start a design/requirements spiral of cost, payload capacity, transportability, survivability, power, range and mobility from which there may be no ready escape. In some uses, particularly dismounted patrols, reconnaissance missions or special operations, the UGV will need to operate quietly for extended periods of time. The rumble of a diesel engine will not be welcome with troops needing to proceed into or through a hostile sector quietly on foot.

Command and Control

Command and control of UGVs is rife with issues. Currently, there are no concepts of operation (CONOPS), no tactics, techniques and procedures (TTP), and no infrastructure to blend UGVs with the conventional forces. The hierarchy of control at different command levels must be established as will the number of controllers (both human and device) capable of controlling each UGV.

'Friendly fire incidents must be prevented as must inadvertent use against non-combatants'

If the primary soldier responsible for the UGV is incapacitated or his controller device is destroyed, what happens? If the battalion commander urgently needs to retrieve UGVs for a priority mission, and those assets are at that moment on patrol with a squad in hostile territory, who has priority? If a squad UGV's mission plan for autonomous operation is suddenly rendered useless by the squad coming under attack, what happens to the UGV, how will it be utilised to best effect, and who becomes responsible for it? Is a hand-off of control made to someone outside the fight – perhaps a nearby squad not engaged or a controller at the nearest forward operating base (FOB)? How will the person receiving

A digital concept of the Squad Mission Support System (SMSS) future development [Lockheed-Martin]

the hand-off know quickly where the UGV is located, what sort of terrain and obstacles it faces, and what he is supposed to do with it? What happens if the UGV or one of its controllers falls into enemy hands? Does the UGV need to know? How will it be remotely disabled from enemy use and then later recovered by friendly forces?

Safety

Safety issues abound for UGVs. Besides the obvious general safety concerns of not indiscriminately running over people, how will we deal with the need for an emergency stop capability? How will we prevent the enemy from exploiting an emergency stop while still making it available to the soldiers who must deploy with the UGV?

UGVs will need self-protection systems to prevent malicious or accidental damage by unauthorised people, particularly in hostile urban crowds. Will the methods used be lethal, non-lethal or both? What are the limitations on such protection systems imposed by ethics, law, treaty or convention?

Once UGVs are used as weapons platforms, the safety issues are compounded. Friendly fire incidents must be prevented as must inadvertent use against non-combatants. Even use of automated weapon systems against hostile forces is likely to be contentious with military leadership, due to the media immediacy factor attached to any accidents or mishaps and to general fear in the public of 'robot killers' on the battlefields.

Value for Money

Last, but not least, is system cost versus utility. Ultimately, even after all the technical and operational challenges mentioned above have been resolved, the large-scale proliferation of UGVs will be judged, like other military materiel, on cost effectiveness. If the services can buy four or five up-armoured High Mobility Multi-purpose Wheeled Vehicles (HMMWVs) for the same price as one UGV, there will be very real questions concerning whether or not most missions will really benefit from the use of unmanned systems. To pass muster in this regard, systems will need to be just barely capable enough to perform their missions. They will need to be highly maintainable; they will be expected to be at least as reliable as a typical military truck or patrol vehicle; and the services will resist requirements for additional specially trained technicians beyond their current force structure. They will need to improve the soldiers' fighting efficiency and survivability and, most importantly, they will need to enable the armed forces to do more with fewer soldiers. ■