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Directive Interface for Autonomous Ground Vehicles

Part 1: Operator Tasks

Robert Chesney
DRDC Suffield

Technical Memorandum
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Abstract

Autonomous unmanned ground vehicles (UGVs) in military roles require a level of oversight and supervision, no matter the level of autonomy assumed. A "Directive Interface" is required to establish the goals for the autonomous system, monitor progress toward those goals, and to receive and interpret the information generated by the system. Components of the operator interface will relate to the supervision and monitoring of the unmanned vehicle, but in a military context, a significant element of the operator role is to merge the operations of the autonomous system into the command and control hierarchy that a military force applies to all units. This paper presents the high level requirements for a directive interface for autonomous UGVs in a military context; focussing on UGVs applied to surveillance roles.

Résumé

Les véhicules terrestres autonomes sans pilote de l'armée jouent un rôle qui requiert un certain niveau de surveillance et de supervision quelque soit le niveau d'autonomie théorique. Une « interface directive » est requise pour établir les objectifs du système autonome, surveiller son progrès vers ces objectifs et pour recevoir et interpréter l'information générée par le système. Les composantes de l'interface permettent à l'opérateur de superviser et de surveiller le véhicule sans pilote mais comme il s'agit d'un contexte militaire, un élément important du rôle de l'opérateur est de fusionner les opérations du système autonome en une hiérarchie de commandements et de contrôles qu'une force militaire appliquerait à toutes les unités. Cet article présente les besoins de haut niveau en matière d'interface directive pour les véhicules terrestres sans pilote autonomes dans un contexte militaire et s'oriente particulièrement vers le rôle de surveillance appliqué à ces véhicules.

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Executive summary

Increasing autonomy in unmanned ground vehicles (UGVs) does not remove the requirement for an operator control station. However, it transitions it from a remote driving / tele-operation station to one oriented to direction and supervision of the autonomous system and an interface between that system and the military command, control and communication system. This will be much more of a “directive interface”, although it must be recognized that, for the foreseeable future, the operator may be involved in interpreting data from the UGV payload, and have a reversionary role to directly operate the vehicle. This paper seeks to outline, at a high level, what the functions of such a directive interface will need to be, to support command and control of future UGVs.

For the purpose of this work, the assumption is made that the role of a battlefield UGV will be primarily reconnaissance, although other roles such as radio relay or fire platform are included in consideration to a minor extent.

The primary roles of the operator directing a highly autonomous UGV in operations start with order receipt, interpretation and mission planning - conceptually very similar to the commander’s preparation for a manned unit. Once the UGV, or group of UGVs, are launched on the mission, the functions required are monitoring progress against mission expectations and interpreting system reports or payload data. The operator will be validating target reports and entering the information into the command and control system. Mission re-planning, to change the goals of the UGV system in response to targets identified, or changing command requirements will need to be fully supported. As noted, the directive interface will still need to support reversionary modes for direct vehicle control in the event of system failure or some unusual combination of obstacles that the system fails to interpret successfully.

In summary, the operator functions for unmanned vehicles are not separable from the command and control functions that the operator needs to fulfill as the “commander” of his sub-unit on the battlefield. Tight integration with command and control concepts and systems will be required to make unmanned vehicles a success in operational roles.

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Sommaire

Les besoins en matière de station de contrôle d'un opérateur existent toujours malgré l'augmentation du niveau d'autonomie des véhicules terrestres sans pilote. Ces besoins ont cependant évolué à partir d'une station pour conduite à distance /téléguidée pour s'orienter vers une station qui dirige et supervise le système autonome et agit comme interface entre ce système et le système du commandement militaire, du contrôle et de la communication. Il s'agit donc beaucoup plus d'une « interface directive » bien qu'on reconnaisse que dans un avenir assez rapproché, l'opérateur participera peut-être à l'interprétation des données à partir de la charge utile du véhicule et aura peut-être le rôle réversif d'opérer directement le véhicule. Cet article cherche à souligner à un haut niveau la nature des fonctions d'une telle interface directive visant à soutenir le commandement et le contrôle des véhicules terrestres sans pilote.

Pour atteindre l'objectif de ces travaux, on fait l'hypothèse que le rôle d'un véhicule terrestre sans pilote dans un champ de bataille sera de faire d'abord la reconnaissance des lieux bien que l'on tienne compte d'autres rôles auxquels on consacre peu de temps tels que celui de plate-forme de relais hertzien ou d'incendie.

Le rôle primordial de l'opérateur qui dirige un véhicule hautement autonome durant les opérations consiste d'abord à recevoir l'ordre puis à interpréter et planifier la mission - ce rôle serait conceptuellement très semblable à celui du commandant préparant une unité pilotée. Une fois que le véhicule ou le groupe de véhicules est mis en circulation pour remplir la mission, les fonctions requises sont de surveiller le progrès par rapport aux attentes de la mission et d'interpréter les rapports des systèmes ou bien des données de la charge utile. L'opérateur doit valider les comptes-rendus d'objectifs et entrer les données d'information dans le système de commandement et de contrôle. Il faut que la re-planification de la mission consistant à changer les objectifs du système des véhicules en réponse aux objectifs identifiés ou que le changement des besoins en commandement soit entièrement géré. Tel que noté plus haut, l'interface directive aura toujours besoin de soutenir les modes réversifs pour réactiver le direct contrôle du véhicule au cas d'une panne de système ou d'une quelconque combinaison anormale d'obstacles que le système ne pourrait réussir à interpréter.

En résumé, les fonctions de l'opérateur des véhicules sans pilote ne peuvent être séparées de celles de commandement et de contrôle que l'opérateur doit remplir comme « commandant » de sa sous-unité sur le champ de bataille. Il faudra implémenter une intégration serrée des concepts et des systèmes du commandement et du contrôle pour que les véhicules sans pilote soient une réussite au niveau de leurs rôles opérationnels.

Robert Chesney. 2004. Directive Interface for Autonomous Ground Vehicles. DRDC Suffield TM 2004-300. R & D pour la défense Canada – Suffield.

Table of contents

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1. Background

Unmanned ground vehicles(UGVs) have numerous current and potential military roles. To date, most applications have relied upon tele-operation control of the remote vehicle, with the operator guiding the vehicle continuously based on a real time video display from a “driving” camera on the vehicle. Newer approaches are now proposed that sense the environment near the vehicle, manoeuvre the vehicle, and control many onboard functions of the vehicle without operator intervention. In some instances, multiple vehicles may be used to accomplish a task, potentially as a collaborative unit where vehicles are not individually tasked.

In this class of UGV system, the operator role changes to one of establishing operational goals and monitoring the progress of the vehicles (or the vehicle group) in achieving those goals, rather than directly controlling the functions of an individual vehicle. This transitions the traditional tele-operational command interface to one that is some of a “directive interface”. As a result of this change, it is desirable to revisit the requirements of the operator control interface and establish all of the tasks the operator needs to complete in order to plan UGV operations and to monitor the results. The directive interface for a UGV system will be implemented as a computer application, so many aspects of the requirements analysis and methods can be borrowed from general human computer interaction principles. The structure used within this analysis is modelled on that documented by Engel [1]. Once the task requirements have been identified, the tasks can be analyzed to partition the tasks into those that are candidates for automation and those that are best left in human control.

At a later point, tasks that the human is assigned then need to be analyzed to establish the workflow and group the tools required for segments of the operation. The mechanics of each task will then be elaborated to provide a basis for the design of the human machine interface.

It must be noted that the operator is not solely a UGV driver. The control of the UGV system isn’t his job, it is merely a tool he uses to do his job. He is tasked by his commander to complete an objective, to report on the progress of that task, and to report on the completion of the task. The operator workstation has to consider and support all aspects of the operator role, including the integration of the operator’s command and control responsibilities.

This report details the assumptions that are made with respect to the capabilities of the UGV systems that may be controlled (in initial implementations - at least); what the roles of the UGVs might be; and, scoping how the system might be employed. The operator tasks supporting this concept of operations are then discussed. Later reports will extend this work to further definition of the tasks and, looking at the timeline of operations to establish the operator workflow, and decompose the tasks into discrete operator functions. The function analysis will then form the basis of a design study for a UGV operator control station.

2. System Assumptions

The control interactions required by a UGV will, to some extent, depend upon what the unmanned system looks like and how it is being used. The supervision requirements for a multi-robot swarm may be very different from those of a single larger robot. As well, the control requirements for an unmanned target acquisition platform may differ from those of a logistics support UGV. While it may be hoped that a common interface can be developed to address a broad spectrum of roles and system organizations, certain assumptions about likely organizations and roles will assist in developing the structure of the interface. The assumptions noted below do not reflect the potential overall scope of UGV applications, but are limited to some roles that have been proposed for early adoption.

The underlying assumption taken with respect to UGV control is that there will only be one operator for a vehicle, or for a group of vehicles. While in some instances, it may be possible to assign more than one operator to supervise a vehicle group, it is highly desirable to reduce the number of personnel required. To that end, it must be possible one operator to achieve all control actions, even if there are times when more operators would be more effective.

Another key assumption that is made is that the nominal role of the UGV(s) under control will be reconnaissance. It is assumed that the vehicles will be equipped with a target acquisition imaging payload that will be capable of identifying and locating threat targets and threat target formations. The payload will have a level of automatic target detection incorporated that will reduce (but not necessarily remove) the requirement for continuous operator interpretation of the surveillance image. At the very least, the payload is expected to incorporate a level of cueing to identify suspect artifacts in the imager scene. Other surveillance payloads, such as radar are possible, but that type of payload would likely be exploited to cue an electro-optical imager rather than as a replacement payload.

A secondary role for the UGV may be as a fire platform. A UGV may carry missiles equipped with autonomous or semi-autonomous target tracking warheads that can be remotely fired at targets under observation by a manned platform or another unmanned vehicle. Other UGV roles may include radio relay or ECM / ESM (electronic counter / support measures). Specifically a UGV may commonly be used for radio relay either to extend the range of the UGV system operation or to support the communications of the supported force.

Another assumption is that the UGV equipped unit will have a limited number of vehicles assigned to the supervision and control of any single operator. As familiarity with UGV systems grows, and the autonomy of the individual vehicles is proven, this may be relaxed, however, for the moment it is assumed that no more than four vehicles would be available to one operator. In all likelihood the number will two or three for any initial deployment.

UGV(s) under command are expected to be highly autonomous for movement in low density urban or rural environments, but may require operator intervention at times when faced with unusual obstacles, or challenging combinations of obstacles. It is assumed that vehicles will be capable of reporting their position in an absolute coordinate frame (MGRS - military grid reference system). It is not expected that initial vehicles will be capable of autonomous operation in an urban environment with emplaced obstacles. Indoor operation requirements will not be formally considered.

The area of operations for the UGV is not expected to be extensive. UGVs are unlikely to be routinely deployed in excess of five kilometres from the control vehicle. They may have a technical capability to be operated at a greater distance (up to 10 Km), however, that would likely only be exploited in rare instances. Where multiple UGVs are deployed under the control of a single operator they would be expected to operate within a few kilometres of each other. The longest separation between multiple vehicles is unlikely to exceed five kilometres. The range of the surveillance imagers on the vehicles is likely to be on the order of 4,000 metres, although targets may be detected at greater distances (up to 10 Km). If equipped with radar systems, the UGVs may be able to detect possible targets at greater distances, however, they will be unable to identify them.

The UGV control station is expected to be vehicle based. For the moment it is assumed that the UGV operator will be a dedicated role within the vehicle, although in the longer term it may be desirable to integrate UGV control into the operator workstation functionality of future vehicles. This will impose significant dynamics on the operator as well as severely limiting the space available for an operator workstation. Control of UGVs by dismounted personnel will not be considered at this time, although it is expected that some of the same interaction mechanisms may be usable in that context.

While it is premature to make definitive assumptions at this time, operation of the UGV will likely include a “leapfrog” or bounding behaviour. This implies that the control vehicle will stay under cover or in concealment, until the UGV(s) advance forward, clearing an area. The control vehicle would then move forward to a new control point. This implies that in many instances the control vehicle may be stationary while the UGV is moving. However, this can not be guaranteed and, in any instance, the UGV will have to maintain surveillance while the control vehicle is moving.

The UGV equipped unit is expected to receive tasking orders and direction through a digital communication link. The operator control station is expected to be able to extract command and control information from a local data base (referred to as the operational data base – ODB) maintained by the link. The UGV reports are expected to be primarily entries to the local intelligence data base, with other command and control software being responsible for recognizing changes and propagating target reports. Parallel generation of formatted reports may be necessary in some instances to control latencies for time sensitive messages (fire direction, etc) or to provide information to allied forces.

The operator pool for UGVs is expected to be drawn from Canadian Forces (CF) personnel without significant aptitude selection. Likely ranks for designated UGV operators are Corporal through Sergeant. Ages are likely to range from early twenties to late thirties. Operators are more likely to be male. The operators will have a background in the combat arms, and will likely have training on computer based command and control systems in use in the CF. They may also have training on, or familiarity with, other types of surveillance systems. UGV control is not likely to be the exclusive role of a specialist. It is likely that control of the UGV will be handed off to other members of the crew within the control vehicle; at least in times of low activity. These operators will likely have more superficial training on the UGV system than primary operators.

It should be noted that UGVs will only be one component of an overall surveillance and reconnaissance structure that will include unmanned air vehicles, unattended ground sensors and manned units (both air and ground). While this paper discusses the requirements for the control of UGVs in isolation, it is likely that operational systems will end up with control of, or data from, multiple types of systems.

3. Operator Requirements

The functions that the operator will perform in the context of operating a UGV are outlined below. As noted above the functions identified are primarily developed in context of operating a small number of UGVs in a recce / fire support role. This should provide an adequate baseline functionality, but may not, in the end, be fully appropriate for all other contexts.

The functions identified include all of the interactions that the operator will have with the computer based workstation that he will use to monitor the robot. While this may be an important function within the control vehicle, it is likely that the operator will also have some other roles within the control vehicle when the UGVs are not deployed.

3.1 Tactical Information Context Development

The operator needs functions to receive orders and to query the command and control system for relevant tactical information. This information would include geographical descriptions of the objective, reporting lines, traces, the location of friendly forces, the suspected locations of enemy forces, etc. The general requirement will be to:

- read an orders message that may have an attachment that specifies an overlay for a tactical map, and
- to generate queries to an operational data base (ODB[1]) server that would extract specified elements of the data base (nominally geographically registered overlays) for a region of interest.

3.2 Tactical Map Display

The operator will need a "map board" to put the tactical information and vehicle locations, etc in context. This would likely start as a conventional tactical map display, with a geo-registered background image that may be based on a conventional paper map, an aerial image of the terrain, or a rasterized vector map. A tactical / object overlay would be provided in the manner of a conventional geographical information system (GIS). As in the manner of a GIS, some of the overlay objects could be "queried", bringing up additional information. Tactical data objects will have some additional information based on the type of object. As an example, enemy position reports may have times of observation, method of observation / data quality, direction and speed of motion, etc. Querying objects representing UGVs would provide a means of accessing data about that vehicle, or establishing a link to command that vehicle – in effect selecting the vehicle that the operator wishes to monitor more closely.

[1] The Canadian Forces use a data base implementing a data model developed by the Mutilateral Interoprerability Program – www.mip-site.org

Consideration should be given to adapting the “map board display” to a more generalized requirement where a global geo-referenced localization / description of the environment is not available. This may occur in dense urban or indoor environments. In this instance the map board would need to reflect multiple “views”/maps of the world generated by what each particular remote unit can currently measure about its environment, or has measured in the course of the mission. These views will not necessarily have a consistent orientation or relative positioning. The discrete views will be monitored by software to look for common points that allow the views to be rationalized and merged, but the operator may be involved in validating some of these operations. Note that this class of functionality is a research topic in itself and will not be present in initial implementations. It should merely be considered so as not to preclude introduction of those capabilities.

3.3 Mission Planning Tools

The operator will require tools to define a “mission” for individual UGVs or for a group of UGVs operating collectively. In the manner of a tasking order to a manned unit, a mission for an autonomous UGV will have several elements. These elements will include, but are not necessarily limited to the following:

- specification of the mission objective. For the purpose of a recce platform, we will assume that the objective is associated with either an area that should be reconnoitred, an area that should be placed under surveillance, or a movement objective for the UGV platform. Reconnaissance areas may be defined:
  - as a route (linear feature defined by waypoints, and a width for each line segment - optionally a linear feature and an associated area on one or both sides defined by line of sight to the feature);
  - a point (a location on the ground within an associated “radius” of interest / uncertainty); or
  - as an area (an area defined by a closed polygon, or as an observation point and a radius of interest within a specified arc – to line of sight limits within that arc).

  Mission objectives may be simply be elements that are transferred from the ODB representing orders from higher command, potentially with elaboration by the UGV operator.
- specification of the mission timeline.
- specification of the mission priority.
- specification of operational limits of movement.
- specification of a nominal route either to the objective, or between objectives.
- selectable transfer of elements from the ODB such as suspected enemy location, locations of friendly forces, known changes to cultural features (bridges missing, obstacles, etc).

- definition of enemy order of battle / target characteristics (i.e. expected enemy vehicle types and formation structures). This may be a definition in itself, or merely identification of changes to a default or previously defined data base.

- identification of reporting guidelines and priority targets for the remote units. Depending on the mission objectives, the threat environment, and available bandwidth, the operator may need to alter the level of detail in the reports that the remote units transmit. Note the reporting guidelines to the operator may differ from those exercised between remote units depending on relative communication "costs".

It must be noted that the mission plan is not static. It must be expected to require alteration as changes occur in external direction, weather, or as information is developed in the execution of the mission that alters the mission priorities or the operator's perception of how the mission can be executed.

3.4 Remote Unit Configuration and Checkout

Prior to any mission the operator will likely need to be able to exercise and review the results of built in test diagnostics. He may also need tools to configure system parameters. In some instances, these tools may also need to be accessible during mission execution to assist in troubleshooting system failures. This aspect of the interface will likely be specific to the vehicle type deployed, although common approaches to presenting information for all vehicle types needs to be encouraged.

3.5 System Error Monitor and Display

During mission execution it should be expected that system errors will occur, or conditions that meet thresholds for alerting the operator will occur. Errors from all remote units and subsystems should be handled consistently with prioritization of events evident to the operator. The monitor may also be used to allow the operator access to more detailed diagnostic information about the error or to tools that allow him to undertake corrective action.

As an example, the display of an alert from a vehicle that has had to stop due to an inability to determine a viable path to its objective would incorporate a link for the operator to readily assume control of the vehicle. The display of an alert associated with a sub-system failure would incorporate a link to appropriate diagnostics displays for that sub-system.

Alerts / diagnostics may be generated solely on-board the vehicle, or they may be generated in the control station. The control station may be expected to have two generic classes of error monitoring. The first class would be vehicle specific error monitoring. In this instance the control station will monitor any telemetry stream from the vehicle and decode and display error indicators. It may also implement a secondary error monitor that would analyze the general vehicle telemetry to look for unexpected or inconsistent behaviour. The second class of error monitoring would assess achieved mission performance in the context of planned mission performance and alert the operator to anomalies. Alert conditions might include remote vehicles advancing too quickly / slowly, or fuel consumption that will not allow the mission objective to be completed.

3.6 Remote Unit Status Monitoring

Throughout the mission the operator will need to have an indication of the progress of the remote units towards the mission objectives and the ongoing status of each of the units. The operator will need to know the position of the unit and a summary status display of its operational status. For simplicity, it may be possible to incorporate both aspects on the “map board” display. Icons representing the remote units can be displayed at the units reported position and the icon symbol and colour can be changed to indicate the current status of the unit. Note that change in the vehicle state that affect mission performance can not be communicated solely by icon state changes, but would also have to be reported through the error / alert display mechanism.

As in the case of the error monitor display, it should be possible to “interact” with the basic vehicle status monitor to trigger the display of more detailed information about the remote unit status. The same interaction mechanism may also be used to allow the operate to assume control of the vehicle or to alter the mission plan that the vehicle is executing. Due to display space constraints, it is assumed that comprehensive vehicle state information will only be displayed on demand.

For each unit there will be a requirement for a vehicle specific state / status display. This may include many items, including:

- a display of relevant vehicle status information, such as system health, fuel level and possibly heading / attitude.
- an image / video window from the vehicle driving camera;
- a graphic showing vehicle configuration (for vehicles with adaptive configurations; and,
- an image / graphical display of the vehicle’s perception of its environment (local obstacle / estimated trafficability map).

It will generally be desirable to allow the display of historical data for that vehicle. As an example the operator may need to see frames from the last few moments of video in order to interpret the current imagery from the driving camera or to make sense of the obstacle map.

3.7 Remote Unit Control

There may be times in the execution of a mission where it becomes necessary for the remote operator to assume control of the vehicle in a tele-operated mode. This may result from a failure in sub-systems providing higher level control, from an inability of the vehicle to interpret its surroundings well enough to move, or from a desire by the operator to perform a specific manoeuvre with the vehicle (such as moving slightly to achieve a better line of sight for a surveillance imager). In these instances, the operator will need some level of conventional tele-operated control. Direct control of throttle, steering and brakes in the manner of a conventional vehicle is unlikely. Control options are expected to be limited to speed and direction demands.

The remote unit may, or may not have a driving camera. When one is installed it may be required to provide steering directions for this as well as for the vehicle.

3.8 Remote System Status Monitoring

In some proposed UGV system configurations the individual remote units will operate as a collective. They will pass information back and forth between units and alter the assignment of individual vehicles without direct operator intervention, or even communication with the control station. In this instance the operator, while monitoring the progress of individual vehicles, will need to monitor the activities of the group as well. At this point in time it is expected that most of the operator interaction will remain much the same, however, rather than establishing mission plans or supervising individual units, the operator will be altering the mission objectives for a group of vehicles.

3.9 Remote Unit Payload Monitoring / Control

In reconnaissance roles the remote units are expected to carry some class of sensor. It may be a “cueing sensor” such as a radar or acoustic array, or it may be a “target acquisition sensor” such as a narrow field of view electro-optical imager. The primary distinction between types of sensors would be the ability to identify and localize a target. Cueing sensors may not provide definitive target identification and may have lower resolution in target localization. The level of sensor control, monitoring and interpretation will be different for each type of sensor. Despite this, certain common functionality can be identified. The common functions will need to be implemented as a minimum, and a framework for adding sensor specific displays and controls will need to be considered.

For an imaging sensor, the operator will need to display either video or still images. The operator may need to be able to select enhancement utilities prior to display. Some enhancement utilities may include configurable options, that the operator may wish to alter. The operator may require tools to see the same image before and after enhancement, either in adjacent windows or sequentially in a single display window.

Some imaging sensors may also have common display / processing alternatives that need to be readily selectable. As an example an infrared imager will be to be capable of displaying in either white hot, or black hot modes. Imaging sensors also need to be pointed / steered. This may be accomplished by the operator designating the area of interest in a geographical context, or it may be from the operator providing steering commands to the imager mount(up/down/ left / right, zoom in / out, etc). In a surveillance application the operator will need the “system” (either the control station or the payload controller) to “memorize” a view point trajectory to allow an arbitrary area (such as a wood line) to be maintained under surveillance. The operator will need to be able to suspend scanning of the viewpoint trajectory, provide steering / zoom commands and then resume the trajectory scan at a later time.

Once an image is displayed, the operator will need to be able to designate an object of interest in the scene. This may be an object chosen completely by the operator, or it may be selection of a particular object in the scene, previously identified by an automated scene interpreter (automatic target detector (ATD) or automatic target recognizer (ATR)). In any instance the operator will wish to establish a geo-location for the target (based on object bearing relative to the remote vehicle and the terrain data base – Note that the localization may be limited to a bearing in some terrain geometries). The operator will also need to associate the target location with a description. The target description may be solely a target “tag” assigned by the ATD (or the operator) or it may be a description of the target. Target description may be entered by the operator, or the description may be based on one description generated by an ATR program.

The operator may also need to operate a co-axially mounted laser range finder (LRF) to allow the target to be more accurately geo-located. This would require the LRF to be triggered (possibly at an offset from the target). Alternately the operator may need to associate target designations (with only target bearings) from multiple remote vehicles to allow targets to be geo-located through triangulation.

It should be noted that, as in the case of the image enhancement algorithms, the operator may wish to enable or disable any ATD / ATR functionality, and may need to configure parameters associated with the ATR / ATD routines.

Other types of payloads have not been as well defined. In the event that a weapon payload is carried, the vehicle may have a target acquisition class of sensor payload as well. The weapon system control could then be added to the sensor display functionality. Specific weapon functions would likely include ammunition selection, weapon arming and weapon release. Non-line of sight weapons would require target location designation and likely monitoring of an on-board camera to ensure that the weapon was free of obstructions for firing.

3.10 Mission Reporting / Fire Direction

As the mission progresses the UGV operator will need to report progress or results within his unit, or to supporting / supported formations. These reports may be solely progress snapshots, indicating that the mission is still on schedule and that nothing unexpected has been encountered, or they may take the form of target reports. Target reports may be utilized as input into the generation of an intelligence picture or they may be used to direct fire onto a target.

At some point the operator may be called upon to aggregate discrete target reports giving the location of individual vehicles or small units into a report / data base entry that describes the formation under observation. This level of first line analysis may be required to lessen the burden on the intelligence component of the command and control system.

In the normal course of events, target (or formation) reports generated in a surveillance asset will be fed into the local copy of the object data base (ODB). Command and control software associated with the ODB would determine which data will be exported for consideration in the formation of the overall intelligence picture (the common operating picture (COP)). In some instances, however, the targets identified will be of particular interest to another unit, or will be engaged immediately. In these instances, specific target / contact reports will be generated by the control station. These reports will be formatted text messages. Most fields in the message will be extracted automatically from the ODB, however in some instances the operator may need to add additional comments or descriptions. In some instances the remote unit will require that selected images or video segments be attached to the report.

4. Summary

The operator control requirements for a UGV deployed as a component of an operational unit, involved in combat operations, will be significantly different from those requirements previously developed for UGVs in specialist roles. The requirement to integrate with the command and control network is significant. The integration is required to:

- receive and interpret orders;
- transfer elements of those orders to the mission plan for the system;
- transfer other intelligence data to the system for exploitation in the conduct of operations; and,
- report the progress and the results of the mission.

The pace of combat operations doesn't allow for the use of ad hoc mechanisms for the information transfer required, hence, these functions need to be considered as an integral component of the overall UGV operator role.

The operator requirements identified above have been introduced at a very high level. Significant further work is required to fully identify the functions associated with each of these high level tasks. Further, the capabilities of the unmanned systems need to be better defined so that the functionality assumed in the design of the interface parallels the capabilities of the systems under control. While any generic operator control interface will have to map or merge vehicle system specific functions into common capabilities, there are limits to the extent this is possible, especially if the control station assumes a significant level of autonomy in target vehicle systems. If that autonomy does not, if fact, exist it will be difficult (and possibly impossible) for the control station to replicate that functionality.

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Autonomous unmanned ground vehicles (UGVs) in military roles require a level of oversight and supervision, no matter the level of autonomy assumed. A “Directive Interface” is required to establish the goals for the autonomous system, monitor progress toward those goals, and to receive and interpret the information generated by the system. Components of the operator interface will relate to the supervision and monitoring of the unmanned vehicle, but in a military context, a significant element of the operator role is to merge the operations of the autonomous system into the command and control hierarchy that a military force applies to all units. This paper presents the high level requirements for a directive interface for autonomous UGVs in a military context; focussing on UGVs applied to surveillance roles.

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UGV, Reconnaissance, Surveillance, Operator Interface, Autonomous