Multi Autonomous Ground-robotic International Challenge 2010

A US/Australia Initiative

8 -13 November 2010, Australia

Defence, Science & Technology Organisation
Land Operations Division
West Avenue. Edinburgh South Australia 5111

Australian Government
Department of Defence
Defence Science and
Technology Organisation

US ARMY RDECOM

Document Change Summary

Section	Description	Date
	Initial Release	30th June, 2009

Table of Contents

International Challenge (MAGIC) 2010 Down Under

1. Introduction

The Multi-Autonomous Ground-robotic International Challenge (MAGIC) 2010, is jointly sponsored by the US and Australian Departments of Defence; it will be conducted in Australia in conjunction with the Land Warfare Conference 2010. Research awards of US$750,000, US$250,000, and US$100,000 will be provided to the top three finalists that complete a series of increasingly complex assigned autonomous unmanned multi-vehicle intelligence, surveillance and reconnaissance (ISR) tasks within an allotted time limit.

The event, which is designed to demonstrate emerging unmanned technologies necessary to meet a range of current and future requirements, is open to national and international organisations within industry and academia. It will be conducted in two phases: a two step down selection to five teams; followed by a multi-Unmanned Ground Vehicle challenge that features multiple autonomous unmanned vehicles conducting coordinated ISR missions in a mock urban environment.

The ultimate challenge will take place during the week commencing 8-14 November 2010 at a location to be announced (date) within the state of South Australia. The five teams selected to compete will also be invited to attend and present at the Australian Land Warfare Conference in Brisbane, Australia commencing 15-19 November 2010. Down selection will take place in two phases: (i) an initial phase, which will be completed by 16th November 2009, in which ten teams will be initially selected and out of these up to five research awards of $100,000 granted for the maturation of the technology; and (ii) a final phase that takes place in June 2010, when the best five teams regardless of funding are selected to compete.

At the completion of the challenge, the successful teams will have the opportunities to seek funding through the Capability Technology Demonstrator (CTD) programs of Australia and the US.

The challenge is designed to test the ability of the multi-vehicle cooperatives to autonomously and dynamically coordinate, plan and re-plan their task allocation and execution strategies against a changing environment while simultaneously providing a unified situational awareness picture.

To succeed, a minimum of three unmanned ground vehicles (UGVs) supervised by a maximum of two operators must autonomously coordinate their activities to safely, efficiently and effectively explore and map their environment and detect, locate, classify, recognise, track and neutralise a number of static and mobile objects of interest (OOI).

Potential participants are encouraged to register their interest via the website www.dsto.defence.gov.au/MAGIC2010/, where more detailed information will be posted. A series of participants' conferences will also be held in Adelaide, Australia, Frankfurt,

Germany and Warren MI, USA in July/August 2009 to brief interested competitors on all aspects of the challenge. Subject to interest other locations will be considered.

2. Program Goals

This challenge aims to improve the ability of dismounted ground forces to conduct zone reconnaissance in an urban environment by increasing safety and efficiency and reducing cost via the integration of autonomy. It is not about sensor development or vehicle mobility, but about shifting the Unmanned Vehicle System (UVS) state-of-the-art from manual and tele-operation to partial or full autonomy.

It anticipates integration of humans and multiple unmanned vehicle systems (UVS) to autonomously and dynamically coordinate, plan, and re-plan multi-UVS task allocation and execution strategies against changing environments whilst simultaneously providing effective situational awareness to potential users of the information. Increased autonomy, robot-to-robot collaboration and reduced operator workload are rewarded.

Specifically, the program aims to:

- Accelerate the development of autonomous and unmanned vehicle technology in areas that include: task allocation, multi-UVS control, tactical behaviour, machine intelligence, dynamic planning and re-planning, data and sensor fusion, human-machine interfaces, multi-aspect situational awareness, and systems integration.

- Improve the current human-to-vehicle control ratios by demonstrating that multi-UVS cooperatives can operate effectively with limited supervision by humans in realistic environments.

- Shift the perceptions within the technical and operational communities regarding the state-of-the-art of autonomous multi-vehicle control by demonstrating the augmentation of realistic military activity in changing environments.

- Attract and energise a wide community of participants to bring fresh insights to the problem of developing robust autonomous multi-vehicle cooperatives and to identify and transition technologies to meet emerging requirements.

3. Challenge Overview

Teams are challenged to develop a cooperative of unmanned ground vehicles that can coordinate their activities such that they safely, efficiently and effectively explore and map an environment while detecting, locating, classifying, recognising, tracking and neutralising a number of potential Objects Of Interest (OOI). Key information concerning the environment and OOI should then be combined for transmission to the UGV operators and judges for evaluation relative to ground truth information.

A maximum of two operators will be allowed to supervise at least three UGVs., The team will be allowed a total of 3 hours 30 minutes to complete a series of increasingly complex phases, comprising a number of mission tasks designed to test the ability of the UGVs to autonomously and dynamically coordinate, plan and re-plan their task allocation, execution and sensing strategies in changing environments.

The challenge will be conducted in a mock urban environment of the order of 500m x 500m and will comprise sealed roads, paths, buildings, trees, grassed areas, sandy ground, trenches, holes, safety barriers, curbs, and fences. In addition to any natural obstacles, additional obstacles may also be inserted. The buildings will be mainly single or double-storey and of brick construction, with tiled or tin roofs. A representative layout of the area depicting open, restricted and wooded areas, street and road layout, general topography, the location, number, and area of buildings, etc will be provided prior to the challenge in December 2009. However the precise coordinates of the area and location of the obstacles will not be available for distribution. The challenge will be conducted in daylight and illuminated indoor conditions and precipitation of as much as 1mm/hour.

Line of sight between the operators and the unmanned vehicles will not be possible at all times and teams may need to consider communications relay. The terrain may undulate slightly, but will essentially be flat. The UGVs may encounter positive and negative obstacles inside and outside buildings, but will not require special mobility or manipulation characteristics. Access to buildings will be through open doorways at least 0.9m wide. GPS will be available outside the buildings, but subject to the usual physical restrictions imposed by urban infrastructure. GPS will not be relayed inside buildings.

The location of OOI will not be known to teams *a priori*. These objects may be static or mobile and may be located inside or outside buildings. OOI will include humans. Mobile OOI will manoeuvre outdoors in unscripted patterns. Mobile OOI may be either hostile or non-combatants. All hostile OOI have the potential to "damage" and "destroy" a team's vehicles if the UGVs are within their lethality zone. High resolution EO images of all OOI signatures will be made available to teams prior to the event.

During the challenge, the location of all detectable OOI outside buildings will be provided via a real time data feed to simulate the information provided by an Unmanned Aerial Vehicle (UAV). Each UGV cooperative will contain two categories of vehicles: sensor UGVs, which can explore and map the area and detect OOI, and disruptor UGVs, which have the ability to neutralise static OOI.

To complete the challenge the teams must: (i) accurately and completely explore and map the challenge area; (ii) correctly detect, locate, classify, recognise and neutralise all hostile OOI; and (iii) finish all tasks within 3 hours and 30 minutes.

4. Down Selection Process

The down selection process will involve a series of increasingly detailed technical reviews over a one-year period. To be considered for selection, teams are required to submit their initial proposals in electronic form by 2nd October 2009. The initial proposal requires competitors to submit a DVD or video and a written description of their current robotics research programs, experience with development of autonomous systems, search and tracking, multi-UVS concepts, and a technical paper describing the likely capabilities, platforms, architecture, sensors, processing, testing plan, technical specifications, supervision and task allocation strategies, etc that they plan to use in the challenge. Forms and approved formats are available from the website, www.dsto.defence.gov.au/MAGIC2010/ and in Section 13: Guidelines for Submissions.

In October 2009 the initial proposals will be assessed by members of a Technical Assessment Panel (TAP) against criteria that are specified in Section 14: Evaluation of Initial Submissions.

Ten teams will be selected from the applications received and notified of their selection by 19th October 2009. These ten "semi-finalists" will then be asked to submit phased expenditure proposals for the $100,000 awards by 26th October and host site visits by the TAP in November 2009 where they will be invited to provide detailed presentations and demonstrations of capability. Finally, up to five research awards of US$100,000 per team will be granted to the most promising proposals. These will be payable 50% on commencement and 50% following a progress assessment approximately six months later (June 2010). The semi-finalists that do not receive funding may participate in the June 2010 progress assessment using their own resources, but must notify organisers of their intention by 4th December 2009. The TAP will conduct site visits to all competing teams in June 2010 for progress assessment and final down selection to five teams who will compete in MAGIC 2010 in Australia.

If the TAP determines that an insufficient number of initial proposals and/or interim progress demonstrations have satisfied the evaluation criteria, the challenge event will be re-scheduled.

5. Information Dissemination Process

A series of participants' conferences will be held in Adelaide, Australia (31st July 2009), Frankfurt, Germany (4th August) and Warren MI, United States of America (6th August 2009) to discuss all aspects of the challenge. Subject to interest, locations in Asia are also being considered. These conferences are open to any interested parties that may wish to participate in the challenge and are aimed at allowing the potential participants to meet directly with US and Australian Defence representatives to discuss all aspects of the challenge. In particular, suggestions and comments on the draft set of rules will be invited to ensure they are both clear and consistent. The conference will comprise an overall description of the challenge, a rules briefing, and a simulation of the event mission scenario, as well as Q&A sessions on FAQ, R&D proposals, the website, information dissemination, the CCR/DUNS process, and funding. It will also permit networking, teaming and information-sharing between attendees.

A website www.dsto.defence.gov.au/MAGIC2010/ and an email distribution list for teams submitting applications will be established as part of the meeting. The website will be the forum through which all information concerning rules, rule interpretations, and informational updates are communicated to participants. The email list will simply assist in information dissemination (i.e. remaining up to date with the latest rules, etc is the responsibility of the participants). Those teams that are unable to attend the conference can download a video of the event and register for the email distribution list at the MAGIC 2010 website.

6. Timeline

Date	Event
1 July 2009	Official Announcement of Competition
31 July 2009 4 Aug 2009 6 Aug 2009	Participants Conference [DSTO – Adelaide] Participants Conference [Frankfurt, Germany] Participants Conference [TARDEC, Warren, MI]
4 Sept 2009	Submission of Intention to Compete forms
2 Oct 2009	Technical submissions (video/DVD, technical paper, etc)
19 Oct 2009	Teams notified of down selection and scheduling of site visits
26 Oct 2009	Ten down selected teams submit budget proposals
26 Oct2009	CCR/DUNS application & registration submitted
2-13 Nov 2009	Site visits by TAP – detailed technical assessments
16 Nov 2009	Five $100,000 research awards granted (50% funding paid)
7-21 Jun 2010	Site visits by assessment panel Progress assessments (50% funding paid)
22 Oct 2010	Submission of Challenge Technical Paper
8-14 Nov 2010	MAGIC 2010 Grand Challenge Event
15-19 Nov 2010	Land Warfare Conference, Brisbane (winners announced)

7. Location of the Event

MAGIC 2010 will be held in the State of South Australia. The organisers will announce the exact location of the event in June 2010. No entrants will be permitted to use or access the site until the challenge commences.

8. Expenses and Reimbursements

The organisers will fund economy class air travel to/from the location of the challenge event and the Land Warfare Conference in Brisbane, Australia for three members of each competing team. Hotel accommodation and meals or meals allowance for three people will also be provided for the duration of their participation in accordance with Joint Federal Travel Regulations. Organisers will reimburse freight costs up to a maximum of US$3,000 per team. Organisers will also reimburse the hire of one rental van per team for the period of the challenge event.

9 General Rules of Entry

9.1 All UGVs must be autonomous, weigh less than 40kg (including fuel). For reasons of safety, maximum vehicle speed will be limited to 10 km/hr

9.2 Communications between the operations team and their UVS may be by radio, infra-red, acoustic or other means so long as they are considered safe by the Technical Assessment Panel (TAP). No umbilical links are permitted.

9.3 Any sort of propulsion for the UGVs is acceptable if the design is deemed safe by the TAP during the review process.

9.4 After considering an application organisers may direct safety improvements that must be made in order to compete in the challenge.

9.5 Each UGV must be equipped with a termination mechanism ("E-Stop") that can be triggered remotely on a judge's command.

9.6 Each UGV must be equipped with a "Freeze" (i.e. administrative stop) mechanism that can be triggered remotely on the judges' command. Freezing a vehicle means stopping the vehicle and immediately disabling any contribution that the vehicle can make to its own or the operators' overall situational awareness picture. The vehicle may continue to draw and generate power.

9.7 In the event of equipment failure, UGVs must be able to be easily and safely disabled mechanically and electrically by organisers so that they may be lifted and transported out of the challenge area using four-wheel push carts.

9.8 The perimeter of the challenge area will be designated by a series of waypoints provided to teams immediately before the challenge. Vehicles manoeuvring outside the designated challenge area or in an unsafe manner must be brought back under control or terminated on the command of the judges.

9.9 Teams must supply all of their own vehicles and infrastructure such as ground control stations, communications, etc. 240VAC ~50Hz power will be available on site.

9.10 Organisers will provide teams with passive RF tags for each vehicle. These will be used by judges for determining true vehicle position during the challenge. The location information will be used for adjudication, safety and spectator-display purposes. Any use of this ground truth information for navigation or other situational awareness tasks is strictly forbidden.

9.11 Teams must record the navigation and mapping solutions of their UGVs at 1 Hz and provide it to facilitators in the appropriate format in WGS84 coordinates. Gaps in any mapping information will be considered to be areas that were not properly explored. This information may be provided to judges at the end of each phase, in real time, with latency, or intermittently, as appropriate.

9.12 Teams must also provide an output feed for each operator display used during the challenge. These feeds will be used to capture and display the operator interface to the judges and spectators on organizer provided displays. This output feed should contain all content on the operator display in standard SVGA format.

9.13 All participants are asked to complete an *Intention to Compete* form and submit it to the organisers by Friday 4 September 2009, preferably or as soon as possible. This form is available at www.dsto.defence.gov.au/MAGIC2010/ and should be transmitted by email to [MAGIC2010@dsto.defence.gov.au]. Submission of the *Intention to Compete* is not a pre-requisite for application submission.

9.14 All teams must submit a completed *MAGIC 2010 Application Form* on or before 2 October 2009 electronically by e-mail [MAGIC2010@dsto.defence.gov.au]. The application form is available at www.dsto.defence.gov.au/MAGIC2010/ website The exact requirements of the submission are detailed on the website, but include a DVD/video and a written description of their current research programs and a technical paper describing the vehicles, architecture, sensors, processing, testing plan, technical specifications, supervision and task allocation strategies, etc.

9.15 Challenge finalists must submit a follow-on Technical Paper by 22 October 2010 describing the technical details of their proposal.

9.16 Teams must comply with all relevant national technology import/export policies. For Australia these are available from http://www.customs.gov.au/site/page.cfm?u=4226

9.17 All communications with organisers and judges must be in English.

10. **Challenge Rules**

10.1 To complete each challenge phase a team must declare that it has:

a. Accurately and completely explored and mapped the entire phase area; and
b. Correctly located, classified, recognised and neutralised all OOI in the phase.

10.2 To complete the entire challenge a team must declare that it has completed all three phases of the challenge within the 3 hours 30 minute time limit.

10.3 Teams may use a maximum of two operators to control or supervise the multi-UGV cooperatives, which must contain a minimum of three UGVs.

10.4 Each UGV cooperative must comprise a ratio of at least two “sensor” UGVs to one “disruptor” UGV. Teams are limited to a maximum of three disruptor UGVs, but may have as many sensor UGVs as they wish

10.5 A sensor UGV may carry sensors and payloads that contribute to the overall mapping, object location, classification, recognition and operator situational awareness process and they may transmit information that may be shared between the other UGVs.

10.6 A disruptor UGV must be used to neutralise static OOI. It must carry an eye-safe laser pointer for designating these objects. A disruptor UGV may also carry sensors and payloads that contribute to its own navigation and situational awareness and this information may be transmitted to the operators. However, this information may not be transmitted to or shared with other UGVs and it may not contribute to the overall exploration and mapping process.

10.7 The disruptor and sensor functions may not be transferred between UGVs. Teams must make each class of UGV readily discernible to judges, both on the situational awareness displays and visually in the challenge area.

10.8 Mobile OOI and non-combatants will manoeuvre outside buildings at a maximum velocity of 6km/hour. They may stop, turn, about face, reverse or continue manoeuvring. They may also be located inside buildings, but when inside will remain stationary.

10.9 Mobile OOI has detection and lethality zones of 10m diameter, subject to building occlusion. The detection/lethality zone of mobile OOI will also be bounded by the walls of buildings such that entities inside a building cannot be detected or damaged by an OOI outside and vice versa. The zones are similarly bounded by the internal structure of buildings.

10.10 Any UGV entering the lethality zone of a mobile OOI will be deemed to have been detected and damaged. Judges will immediately command teams to “freeze” the UGV until the end of the phase.

10.11 Mobile OOI must be neutralized to complete the challenge. To neutralise a mobile OOI two UGVs must simultaneously view it. The lead operator must then clearly and correctly identify its location to judges and request that the OOI be neutralised. The OOI must then be continuously viewed and tracked by both UGVs for a period of 15 seconds. If this operation is carried out successfully the judges will announce that the OOI has been neutralised.

10.12 During one or more phases of the challenge at least one UGV will be lost to enemy "sniper" action. Snipers cannot be detected. The affected UGVs will be deemed to have been damaged and judges will command teams to "freeze" the UGV until the end of the phase.

10.13 Static OOI have a lethality zone of 20m diameter, subject to building occlusion. If detonated, any UGV, OOI or non-combatant within the lethality zone will be deemed to have been damaged or killed. The lethality zone of static OOI is bounded by the walls of the buildings such that entities inside a building cannot be damaged by an OOI outside and vice versa. The lethality zone is similarly bounded by the internal structure of buildings.

10.14 Static OOI have an activation zone of 5m diameter, subject to building occlusion. Any UGV entering the activation zone of a static OOI will cause it to detonate. The activation zone of static OOI is bounded by the walls of buildings such that a UGV inside a building cannot activate an OOI outside and vice versa. The activation zone is similarly bounded by the internal structure of buildings.

10.15 Any UGV entering the activation zone of an OOI that has not already detonated or been neutralised will cause the OOI to detonate and the UGV will be deemed to have been damaged. Judges will immediately command teams to "freeze" the UGV until the end of the phase.

10.16 To neutralise an OOI one or more sensor UGVs must locate and classify it and the team leader must communicate this information to judges. A disruptor UGV must then approach the OOI to within 2m of its activation zone and remain stationary while designating the OOI with an eye-safe laser "pointer" continuously for at least 30 sec The team leader must then request that the object be neutralised and the judges must concur before the OOI is deemed neutralised.

10.17 When static OOI detonate they affect all entities within their lethality zone, which is a cylinder not a sphere. OOI do not pose a threat once they detonate or have been neutralised. Mobile OOI do not activate static OOI.

10.18 False attempts to neutralise static OOI incur only the time penalty of the neutralisation process. Penalties will be imposed if non-combatants are in the lethality zone of a stationary OOI when it is activated or are incorrectly identified as a mobile OOI and neutralised.

10.19 The team leader must inform judges when they have completed each phase. Teams may not score points for any tasks associated with a phase once it has been declared concluded. At the conclusion of each phase, UGVs may access the next designated servicing zone (DSZ).

10.20 The challenge will be conducted under daylight conditions and precipitation of as much as 1mm/hour. Should the weather fall outside these conditions, the challenge will be interrupted (challenge time will stop) until conditions are once again within these limits. Teams will not be penalised for such outages.

10.21 Powering up, re-charging or replacing energy sources are permitted only at the completion of each phase. However, this may only be undertaken by the operations or support staff and within the designated servicing zones.

10.22 Minor repairs such as re-attaching a cable, electronic re-booting, or replacing a faulty payload module are permitted within the DSZ, but only after consultation with and under the direct supervision of the judges. Items must be of an identical configuration to those being replaced. Major repairs or modifications may not be carried out at any stage during the 3.5 hour challenge.

10.23 Any number of computers and communications sites may be set up at the ground control station (GCS). Computers and communications relay sites may not be set up elsewhere, but may be carried by UGVs participating in the challenge. Only the operations team may be located at the GCS. The support team may only be located at the DSL and/or DSZ.

10.24 Operators and support staff may not leave their designated zones during the challenge without permission from the judges. Operators and support staff may not exchange roles during the challenge.

All communications with judges must be via the team leader, except when a member of the service team wishes to service or affect a minor repair to a UGV within a DSZ or at the DSL. Under these circumstances, the designated representative within these areas may ask permission of the local/supervising judge.

11. An Example Timeline

In conjunction with Figures 1 & 2, which graphically represents a potential challenge area (together with OOI and non-combatants) the following describes a possible scenario. The pre-briefing and rehearsal sessions are assumed to have already taken place.

11.1 Preparation by Challenge Support Staff: Static OOI will be deployed inside and outside buildings prior to the commencement of the 3.5 hour challenge. Mobile OOI and non-combatants will start manoeuvring through the streets, or may already be located in buildings.

11.2 Challenge Start: The judges will call "start."

11.3 Teams Create an Operational Picture for Planning: Based on information from the simulated UAV feed, teams might generate a registered overhead situational awareness picture containing the location and activity of any potential mobile OOI relative to the known infrastructure of the challenge area and any other a priori information provided by facilitators during the pre-briefing session, such as building access points.

11.4 Initial Planning for First Challenge Phase: Using this aerial situational awareness picture, autonomous mission planning and task allocation software might generate mission guidance for the UGV collective such that the finite resources of the UGV cooperative are tasked to explore and map the challenge area to locate, track, recognise, identify and neutralise OOI. The guidance might be optimised based on constraints such as: the location, orientation and type of terrain, accessible buildings and OOI present within the environment; the observed and potential motion of OOI; the robustness of the proposed solution to OOI and/or environmental uncertainties; the need to enter buildings; the individual capabilities of the participating UGVs; the benefits that derive from the association of UGVs into teams; communications or sensor scheduling requirements between the UGVs to enable this cooperation; any "no-go" or "difficult-to-go" zones; the need to manage power and access to servicing zones; UGV safety and deconfliction requirements; the prospect of losing particular classes of UGVs; the need to continually monitor specific areas or access points for other UGVs to carry out their missions, etc.

11.5 UGVs Begin Executing Plan: The sensor UGVs might then begin to explore their environment, searching for static and mobile OOI inside and outside buildings. As the sensor UGVs progressively explore and map their environment the aerial and ground situational awareness views could be fused to provide a single, more complete picture. This information might also be fused and integrated with applications such as geospatial information, track data, imagery and visualisation tools to provide enhanced situational awareness to the team leader.

11.6 OOI Detection: A sensor UGV might autonomously detect a static OOI and coordinate with a disruptor UGV to neutralise it. Based on the simulated UAV feed, another sensor UGV might be cross-cued to approach a potential mobile OOI and, while remaining at a safe distance, discriminate it from a non-combatant. Once this UGV has

performed this task, it might then continue to track and possibly pursue the mobile OOI while simultaneously disseminating this information throughout the cooperative in order to task other sensor UGVs to confirm its identity and location for the purposes of neutralisation. While either or both of these activities are taking place a mobile OOI or a non-combatant may be detected by a sensor UGV (or the UAV) having emerged from a location previously unobservable by the cooperative's sensors. The system might then respond by autonomously and dynamically re-tasking all of the UGVs, re-calculating their objectives, re-directing payload activity based on the automatic manipulation and fusion of the data in order to classify the nature of the OOI and its trajectory. Alternatively, a series of feasible options might be presented to the operators who might select one.

11.7 Communications Network Dropout: A UGV might detect that it is losing communications with its operators and/or other UGVs and another UGV might be tasked autonomously to act as a temporary radio relay station. Alternatively, a UGV might be lost to enemy sniper fire or a static or mobile OOI that it did not detect. The cooperative might then be autonomously re-tasked to accommodate the loss of this unit.

11.8 Phase Completion: Over time, the UGV cooperative might progressively explore and map the entire phase area, ensuring that static and mobile OOI are neutralised. When teams believe they have fully explored and mapped all of the phase area (inside and outside buildings) and detected, recognised, classified and neutralised (as appropriate) all OOI the team leader will notify the judges that the phase is complete.

11.9 Servicing of Vehicles: All UGVs, including the frozen ones, may then be "un-frozen" and manoeuvred to the DSL/DSZ for servicing within either the DSL or the newly achieved DSZ. The team leader might also request that organizers collect some of the UGVs that have unexpectedly stopped working so that they may be serviced in the DSZ.. Alternatively, teams may immediately task some or all of their UGVs to continue with the next phase without servicing.

11.10 Successive Phases: The next phase can be expected to be more complex than the previous one. For example, the number of OOI may increase, their location may be more difficult to detect and the environments may become more navigationally complex and cluttered.

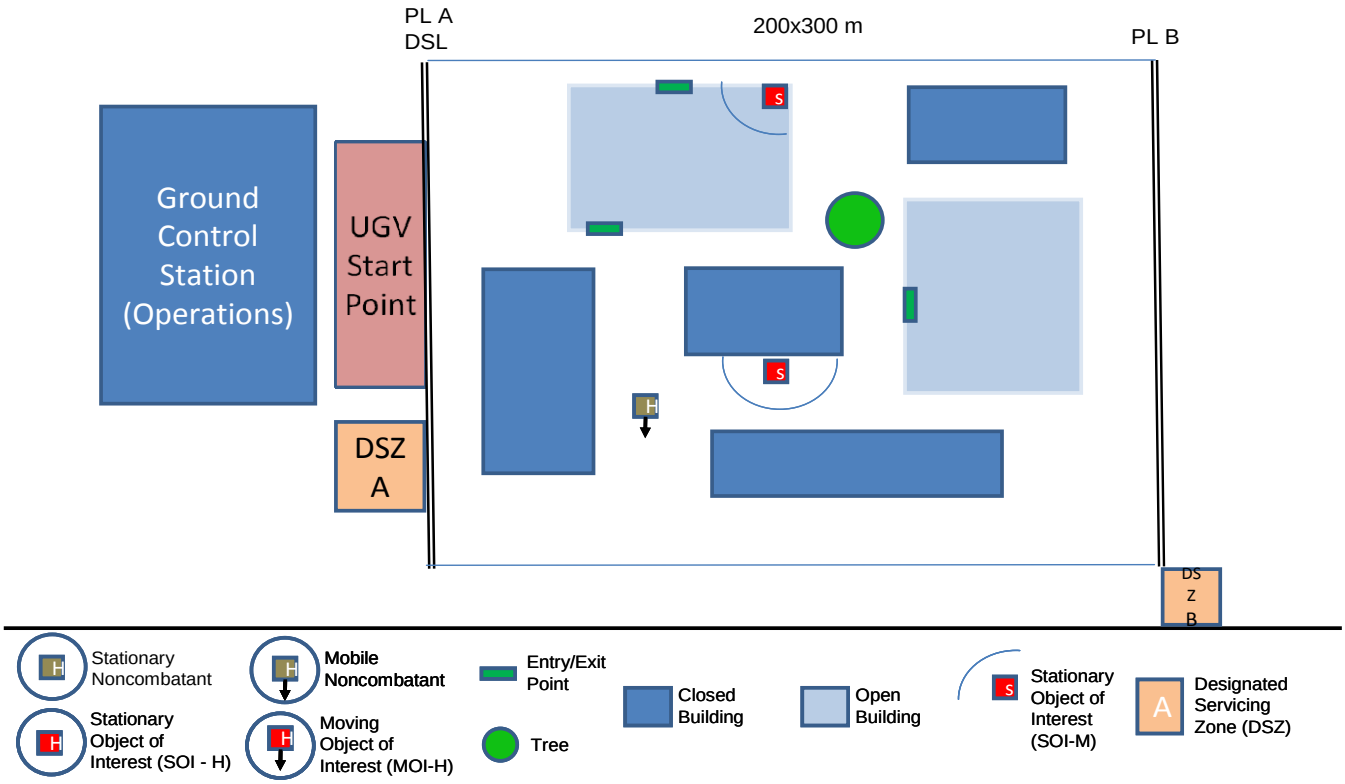

Figure 1: MAGIC 2010 – Phase I Graphic

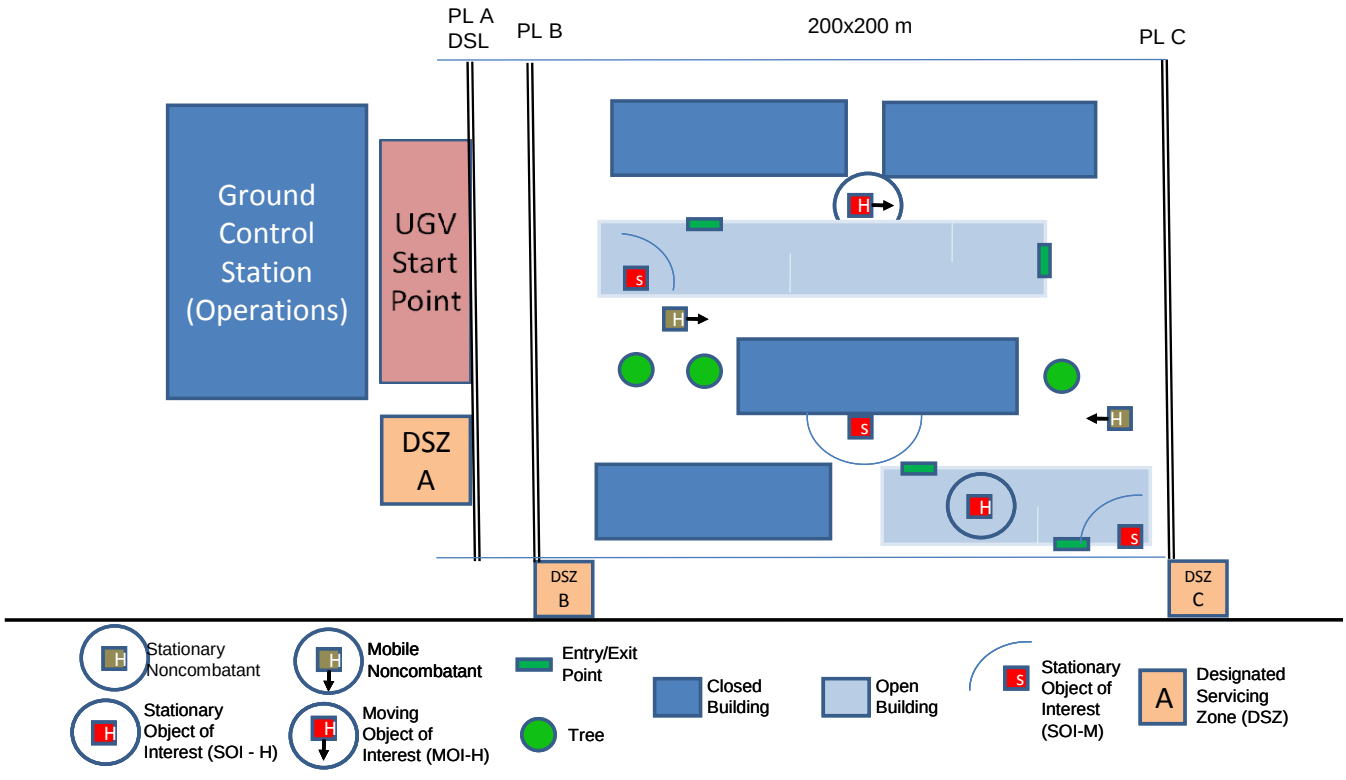

Figure 2: MAGIC 2010 – Phase II Graphic

12. Additional Information

In cases of discrepancy, the Challenge Rules takes precedence over this information.

12.1 Preparation

Teams will receive warning calls of 30 minutes, 10 minutes and 5 minutes to start. They will then be notified when the challenge has commenced. The challenge clock will then run for 3 hours and 30 minutes or until the team leader states that the team has ceased to compete.

12.2 Servicing, Repairs, DSL and DSZ

A UGV may only enter the challenge for the first time from the DSL. Once it has crossed the DSL the UGV will be deemed to have entered the phase, although it may enter subsequent phases from either the DSL or DSZ to which the team has earned access. To enter the challenge from a DSZ, the UGV must first have exited the phase area at this DSZ. When a team earns the right to access a DSZ from the phase area obstacles blocking its access will be removed.

Vehicles may only be serviced within these zones. Servicing is defined as powering up or powering down the UGV and/or re-fuelling, replacing or re-charging batteries, etc. Teams may also affect minor repairs such as electronic re-booting, cable re-attachment and/or the replacement of damaged or ineffective external payload modules.

As a guide, minor repairs are defined as those that are quick to enact (< 60 seconds of manipulation), require no specialist equipment, and may easily be performed by untrained staff. “Opening up” or modifying a UGV or its configuration for any reason constitutes a major repair and is not permitted. All servicing and repair activities must be conducted in consultation with and under the direct supervision of the judges, who must be notified in advance and agree to any procedures being carried out.

Transferring data between UGVs entering and leaving the DSZ is also permitted, but both UGVs and their software systems must be configured to allow automatic pre-processing of any data without the need for human inspection of the data. The data may be copied to/from a flash drive onto the incoming UGV or via a communications protocol such as 802.11g or Bluetooth immediately prior to its entrance into the competition. No software may be transferred and no computer or other diagnostic hardware may be connected to either UGV until the challenge is declared complete. Other than that specified above or expressly permitted by the judges, UGV hardware and software may not be repaired or modified during the challenge.

12.3 Challenge Data

An approximate layout of the challenge area, including topography, nature of accessible areas, streets, the number and size of buildings, entry/exit points, etc will be provided to teams prior to the challenge.

Precise data and coordinates will be delivered to teams during their pre-brief on a USB 2.0 flash drive in formats previously described to teams. The individual vehicles,

cooperative, and software systems must be configured to allow automatic pre-processing of any data without the need for human-inspection of the data. The data may be copied from the flash drive onto team computers and/or disseminated among the vehicles. The data must not be removed from the challenge site.

Most data (challenge area information, required data formats, the signatures of OOI, etc) will be released to teams in or around December 2009.

12.4 UAV Imagery and Metadata

A static, geo-registered aerial image of the challenge area will be provided to teams at the pre-brief in a format previously released to teams.

During the challenge the location of mobile OOI and non-combatants that are visible to the UAV will also be provided to teams in real time in WGS84 coordinates at an update rate of approximately 1Hz.

The feed may be unintentionally interrupted for short periods and teams should have the capacity to cope with these outages and adjust their schemes when the signal is re-acquired.

Longer interruptions, for example that might result from equipment failure, are not anticipated, but should they occur the challenge will be suspended until the metadata feeds are restored. Penalties will not be imposed for such outages.

12.5 Ground Truth

The ground truth data will be superimposed by the organisers onto an accurately geo-registered map display and used by the judges for the purposes of adjudication, spectator-display and safety. Teams will not have access to the ground truth information. Interruptions in the flow of ground truth data caused by teams or their UGVs may result in penalties or operations being suspended for safety reasons.

12.6 UGV Identification

Teams must provide a simple UGV identification scheme that visually, uniquely, clearly and continuously identifies each UGV and its class to the judges in the challenge area and observing the situational awareness displays. Teams will be expected to demonstrate this during the mid-term review in June 2010. The scheme must be consistent across any situational awareness and ground truth displays.

12.7 UGV Endurance

The target endurance of any single UGV (i.e. the duration of the longest phase) should be about 90 minutes, but may be less. UGVs with longer endurance will obviously provide teams with a potential time advantage.

12.8 End of Phase

To complete a phase of the challenge a team must declare that it has accurately and completely explored and mapped the entire phase area and correctly located, classified, recognised and neutralised all OOI in the area.

Teams may also use their discretion and declare that they are moving onto the next phase before they complete the current phase. However, teams may not return to an earlier phase at a later stage of the challenge. For instance, a team may declare phase end when all UGVs have broken down or been damaged.

Once a phase is declared complete, all OOI within that phase are considered inert and they do not impact on the next phase.

At the end of each phase, teams may elect to service their UGVs at the DSL (or within the DSZ that they have just achieved), to continue with the next phase without stopping, or some combination of the above. At this point, all UGVs will also be un-frozen. These UGVs must be returned to the DSL or a DSZ. It is permissible for teams to use tele-operation for this muster process without penalty or to request that facilitators collect any broken or frozen UGVs and bring them to the DSZ's, whereupon they may be serviced. However, teams may not enter the course themselves. Challenge time will continue to run during this period.

Organisers will lift and transport the UGVs out of the challenge area using four-wheel push carts. All attempts will be made to ensure that the UGVs are not damaged in any way, but ultimate responsibility for the design of a UGV that is robust to this process rests with teams.

12.9 Speed Limits

Maximum speed limits are imposed for safety reasons. Minor and inadvertent excursions may be tolerated (i.e. < 10% for periods of 5sec or less and twice per phase), but major or repeated excursions (i.e. > 10%, periods longer than 5sec or more than twice per phase) will result in a UGV being "frozen" or disqualified. Judges will use ground truth data to determine this information. Judges will inform teams of any speeding violations. Teams are able to complete the challenge without exceeding the speed limit.

12.10 Obstacles and Collision Avoidance

Effective navigation while avoiding collisions with obstacles and other UGVs is one of the primary guiding principles for this challenge. UGVs are expected to continuously monitor the path ahead and surrounding area for OOI, other UGVs and obstacles. Vehicles should not assume that either the UGV ahead or the mobile OOI are entirely predictable.

Collision with an obstacle is defined as the main body of a UGV contacting an obstacle. "Feelers" that sense and make contact with an obstacle do not constitute a collision.

12.11 GPS and DGPS

GPS is expected to be continuously available within the DSL and DSZ. GPS will also be available within the challenge area, but subject to the naturally occurring physical restrictions and environmental conditions imposed by buildings, trees, etc. No GPS signals will be relayed inside buildings.

Teams are permitted to set up their own DGPS service or use a commercially available one, but must declare to organisers that they intend to do so in their proposals and provide details of the service, any spectrum allocation requirements, etc. DGPS ground stations may only be set up during the set-up and rehearsal phases and in the OCS. Once the challenge has commenced teams may not interact with their DGPS infrastructure.

Sufficient GPS waypoints will be provided to allow UVS to uniquely identify key aspects of the challenge area (boundaries, buildings, etc). However, UGVs should also use perception-based navigation to negotiate obstacles and the inside of buildings, to traverse areas where the waypoints are not dense, and to detect variations in ground conditions.

12.12 GPS/DGPS & Outages

Vehicles should not exhibit excessive delays or erratically vary their direction of travel due to the intermittent loss of GPS/DGPS signals. Operation with degraded GPS/DGPS due to foliage or buildings is a requirement of the challenge. An inertial navigation system or another technique should be used to “fly-wheel” the UGVs safely and effectively through any such outages. A vehicle should attempt to re-acquire GPS rather than allow its map or derived situational awareness picture to “drift” or become distorted.

12.13 UGV Mobility

It will not be necessary for the UGVs to negotiate obstacles such as steps or doors, but it may be an advantage for them to be able to mount small discontinuous obstacles (e.g. 10cm curbs) as this may provide teams with a time advantage. Similarly, UGVs that cannot demonstrate adequate mobility across the different types of terrain (which will include tarmac roads, gravel paths, sandy areas and grass) may be disadvantaged.

12.14 Disruptor and Sensor UGVs

The sensor and disruptor UGVs must be easily identifiable to judges. For example, they might be discriminated electronically through the use of colour coding on the situational awareness display and physically using clearly visible different coloured flags on top of the different classes of UGV. The discrimination technique must be demonstrated to the TAP during the relevant site visits.

Disruptor UGVs must carry an eye-safe laser pointer for designating static OOI in order to simulate their neutralisation. This payload may be manually controlled by operators through tele-operation, but more points will be awarded if the process is automated.

12.15 Narrow or Restricted Access

Access to all buildings and other challenge areas will be through entrances that are at least 0.9m wide. For safety reasons UGVs should not touch the sides of doorways with the main body of the UGV and will be penalised if they do so.

During the pre-brief all potential access points to buildings will be identified. However, not all of the doors will necessarily be open or be able to be opened. Similarly, a number of obstacles will be put in place prior to the commencement of the challenge. These obstacles will not be moved or altered dynamically during the challenge.

12.16 Queueing

If multiple UGVs need to pass through a narrow gap they should demonstrate sufficient collaborative behaviour to form a physical or virtual queue. UGVs should not collide with one another while negotiating the gap.

12.17 Objects of Interest (OOI) and Signatures

High resolution images of all classes of OOI and organizer obstacles will be provided to the teams well in advance of the challenge (date).

Static OOI will be placed on the ground throughout the challenge area, both inside and outside buildings. They will not be reported in the simulated UAV feed, but are expected to be detectable by the UGVs using commercially available software and electro-optic sensors. For example, they may be represented by a backpack or a 15cm coloured disk that is readily distinguishable from its background.

Mobile OOI and non-combatants will manoeuvre throughout the outdoor challenge area. Where their position will be captured and transmitted by the simulated UAV feed(i.e. subject to building eave or tree-canopy occlusion) Mobile OOI and non-combatants will be detectable, classifiable and recognisable from a ground perspective using commercially available software and electro-optic sensors. Distinctive colour and pattern markings will distinguish mobile OOI from non-combatants and human inside buildings. Judges and safety officers will also wear distinctive attire.

OOI and non-combatants may be located inside buildings, but they will not be mobile. Humans inside buildings may not be neutralised, but must be located and positively identified.

During the neutralisation process for mobile OOI, UGVs are themselves vulnerable to detection and damage. If one or both UGVs taking part in the process are damaged during the 20sec neutralisation process, the neutralisation process must be re-started.

12.18 Sniper Action

At some point during the challenge at least one UGV will be lost to enemy “sniper” fire. Teams will know that their UGVs have been damaged when a judge declares that “UGV X has been damaged by sniper fire. Freeze UGV X.” This UGV must then immediately be frozen and may take no further part in the phase.

The performance of the UGV cooperative within the phase will then be evaluated from this point forward. Snipers cannot be detected by UAVs or UGVs.

12.19 Operator-to-Vehicle Interaction

Teams may not tele-operate any UGV in regard to their key low-level or moment-to-moment control tasks such as navigation or collision avoidance unless they first request permission from the judges that they be allowed to perform such actions. Significant point penalties will be applied for any such intervention.

Once judges have acceded to a tele-op request, operators are permitted to tele-operate their UGV. However, it is anticipated that such requests will only be to extract a UGV from a difficult or ambiguous situation and/or to assist it in resolving some conflict. Any such actions must be performed remotely (i.e. through the use of tele-operation as team members are not permitted to leave or enter the challenge area). UGVs that are unresponsive to operator commands and cannot be extracted by tele-operation must remain *in situ* until the end of the phase.

Teams are permitted to manually control the payloads and sensors onboard their UGVs and may assist UGVs with higher-order tasks such as mission allocation, multi-UGV coordination, trajectory optimisation, route/path deconfliction, and OOI detection and recognition. However, they will not score as highly as teams that carry out the challenge fully autonomously.

Human-UGV interaction on the higher-order tasks is expected to be limited to an operator selecting from or confirming a number of alternative strategies presented to him. At a physical level, such interactions are expected to take place (for example) through map-based interfaces in a “point-and-click” fashion, through interactive voice commands, or other modalities. The effectiveness of the modality of this interaction will be assessed in the judging criteria.

12.20 Automatic Target Detection/Recognition

Operators may assist UGVs in regard to initiating or confirming their detection, recognition and classification of OOI offered by automatic target detection/recognition (ATD/ATR) software. The aim of the challenge is not to test the detection or processing capabilities of the sensors *per se*, but ATD/ATR will be rewarded as this will reduce the cognitive load on the operators and allow superior autonomous tracking of static and mobile OOI.

12.21 Tracking and Locating Objects of Interest

Tracking an OOI is defined as keeping a sensor oriented on it for a continuous period of time and performing feature extraction and registration processing sufficient to continuously locate the OOI. It does not imply a need to control a vehicle’s sensor head in a pan-tilt sense. It does, however, mean that the relevant features of an OOI are recognised and tracked within the field of view of the sensor; panning and tilting the

sensor is optional. Teams will be expected to explain and demonstrate their detection, location and tracking strategies during the site visits.

Tracking an OOI is not expected to involve operator interaction beyond any initial detection or confirmation that detection has taken place. Automatic target re-acquisition will be rewarded relative to manual re-acquisition.

OOI must be located, recorded and identified to judges using WGS84 coordinates.

12.22 In-Brief, Setup and Rehearsal

Teams will be required to give a technical presentation to judges outlining their technology development and mission plans. They will then receive a detailed in-brief and the UGVs will be weighed. The following morning, teams will set up and test their equipment at the challenge site. During this period, in addition to their own system tests, teams will be expected to perform a number of safety, "freeze" and ground truth tests for judges. There will also be a period set aside for a rehearsal, followed by a short period of "reset" where teams may re-fuel, replace energy sources, etc. The trial run will then commence.

Day	Time	Team 1	Team 2	Teams 3
Sun	06:30-08:00			
	08:00-09:00			
	09:00-09:30			
	09:30-13:00			
	13:00-13:30			
	13:30-15:30			
	15:30-17:30	Tech presentation		
	17:30-19:00	In-brief/weigh-in		
Mon	06:30-08:00	Setup/system test		
	08:00-09:00	Trial run/rehearsal		
	09:00-09:30	Final reset period		
	09:30-13:00	Challenge run		
	13:00-13:30	Rest break & lunch		
	13:30-15:30	After action review		
	15:30-17:30		Tech presentation	
	17:30-19:00		In-brief/weigh-in	
Tues	06:30-08:00		Setup/system test	
	08:00-09:00		Prelim. rehearsal	
	09:00-09:30		Final reset period	
	09:30-13:00		Challenge run	
	13:00-13:30		Rest break & lunch	
	13:30-15:30		After action review	
	15:30-17:30			Tech presentation
	17:30-19:00			In-brief/weigh-in
Wed	06:30-08:00			Setup/system test
	08:00-09:00			Prelim. rehearsal

	09:00-09:30 09:30-13:00 13:00-13:30 13:30-15:30 15:30-17:30 17:30-19:00			Final reset period Challenge run Rest break & lunch After action review
Thurs/Fri				Etc – Team 4 & 5
Sat/Sun	Reserved as Contingency Days			

12.23 Sacrificial Use of UGVs

The use of UGVs to intentionally or sacrificially detonate mines is permitted, but risks killing non-combatants, which will be penalised.

12.24 Indoor Lighting and Infrastructure

Lighting conditions inside buildings are expected to be brighter than 100lux [TBC], whereas lighting conditions outside buildings are expected no brighter than 75klux [TBC].

Buildings may be expected to contain a range of internal infrastructure such as walls and other fixed obstacles, but no doors that require opening. All OOI will be placed on the ground, not on walls or on or under any infrastructure.

12.25 Cognitive Loads on Operators

Systems with autonomous navigation capabilities that coordinate and evenly distribute their mapping and OOI servicing tasks within the UGV cooperative and that impose low physical and cognitive demands on their operators will generate most points in this evaluation area.

12.26 Classified Data

No classified data or devices may be used in preparation for or during the challenge.

12.27 Vehicle Safety

RF safety standards, laser safety standards, acoustic safety standards and wireless E-stop units will be assessed by the TAP during down selection in June 2010. The TAP may suggest safety improvements that must be made in order to compete.

12.28 Autonomous Vehicle Configuration

All vehicles must be unmanned and no animals are permitted onboard. Only independent, untethered ground vehicles are eligible to participate in the challenge. The ground vehicles must be propelled and steered principally by traction with the ground. The type of ground contact (e.g. tyres, tracks, legs, etc or hovercraft) is not restricted. If hovercraft are used the maximum hover height is less than or equal to 1 “effective” rotor disk off the ground. Additional rules with regard to the safety of jumping and hovering UGV will be developed in the event that a team using this technology is selected.

The vehicles must not damage the environment or infrastructure in the challenge area and vehicle operation must conform to any regulations or restrictions imposed by the

applicable land-use authority. The vehicle must be able to travel on asphalt, concrete and paved surfaces without damaging these surfaces.

A system comprising UGVs and one or more sub-systems that are not physically tethered to the UGVs is permitted provided the sub-systems are not propelled or manoeuvred independently of the UGVs (as would be the case with a UAV). For safety reasons, the maximum height of any UGV (including any tethered or extending sub-system) must not extend more than 2m above the surface.

Any aspect of vehicle activity or operation that has an unacceptable impact on the environment is prohibited. Such activities might include destructive vehicle behaviour, the use of abnormally hazardous materials, and/or generally reckless operation. All potentially hazardous equipment or activities must be identified to organisers for review during site visits and the pre-mission-brief.

12.29 Team Disqualification and Technology Demonstration

In the event that a team is disqualified or the rules forbid it from meaningfully continuing to compete (e.g. equipment failure precipitating a major repair or modification) the team leader may request permission to be allowed to repair/modify its equipment and compete against the phase/challenge tasks. However, the team will not be eligible for any of the cash awards.

13. Guidelines for Submissions

Instructions for obtaining application materials and for correct submission are contained on the website www.dsto.defence.gov.au/MAGIC2010/.

13.1 Initial Submissions – 2nd October 2009

All initial applications must be received by challenge organisers no later than 5:00pm EST on Friday, 2nd October 2009. All parts of the application must be received by challenge organisers before the specified deadlines for a team to become eligible for participation in the challenge. Materials received after their respective deadlines will not be considered and will be destroyed.

The initial submission should consist of five (5) parts and be in the following format:

Technical Submission
For
[Title, Organization]

Point of contact details (Team Leader):

Name, email address, phone number, mailing address
Alternate POC, email address, phone number, mailing address

1 Technical Proposal (not to exceed 15 pages).

a. Abstract
b. Introduction
    i. Statement of the problem.
    ii. Conceptual solution proposed
    iii. Graphic overview of overall systems architecture
    iv. Work breakdown and milestones
c. Ground vehicle component & systems
d. UVS autonomy & coordination strategy (by task)
e. Sensors, processing & mapping for UGVs
f. Operations in GPS-denied environments
g. Processing and fusion of provided Metadata (from UAV)
h. Human-machine interface (HMI)
i. Operational approach/missions operations strategy
j. Risk reduction strategy
    i. EMI/RFI & electrical
    ii. Vibration & physical
    iii. Modelling & Simulation
    iv. Safety, E-Stop, Freeze & lost-link
    v. Communications architecture
    vi. Spectrum plan & usage
    vii. Test Plan
k. Summary.

2 A written summary describing [Not to exceed 5 pages]:
Source of resources and budget, sponsorship (if applicable), team composition (organisations), personnel and experience, and facilities

3 Enclosure A: A video showing current research projects

4 Enclosure B: Certificate of Team Funding & Support

5 Enclosure C: Site Visit Liability Statement.

Signature of Team Leader & Date

13.2 Site Visits & Technical Presentations (2-13 November 2009)

Teams will be notified of their down selection to host a site visit by 19 October 2009.

Ten teams will be asked to host site visits in November 2009. They will be expected to provide more detailed technical presentations lasting an hour. This will be followed by up to an hour of questions. Teams will also be allowed a further two hours to demonstrate any current autonomous or UGV research/technology relevant to MAGIC 2010.

Presentations are expected to focus on convincing the TAP that teams have a good extant knowledge of: autonomous unmanned ground vehicle design; multi-UGV autonomy and coordination; signal, sensor and image processing; navigation and mapping; processing and fusion from the simulated UAV feed; situational awareness and information fusion; human-machine interfaces; and mission operations relevant to the challenge.

In addition to the information in Initial Submission, the presentation should also include:

- Justification for (phased) expenditure of the $100,000 from the contract
- A description of a phased plan of execution for the challenge mission
- An explanation of the key operational tasks/techniques for:
  - Level of human UGV interaction should be highlighted for each task
  - Autonomous target hand-over between sensor & disruptor UGVs
  - Automatic target detection, classification and recognition
  - Collaborative target tracking and target cross-cueing
  - Determination of cleared buildings and phase areas
  - Automatic/optimal route planning for the UGVs
  - Communications relay (if appropriate)

All teams invited to give technical presentations to the TAP in November 2009 must also apply for a DUNS (Data Universal Number System) number (available from http://fedgov.dnb.com/webform) and once received complete CCR (Central Contracts Registration) registration (available from http://www.ccr.gov/), which will enable them to become a research contractor to the organisers should they be short listed. The CCR Registration should be submitted no later than 26 October 2009. Any questions on the CCR/DUNS registration or contracting process should be directed to Ms. Michi Sawa at the US Army International Technology Center Pacific (ITC-PAC), Akasaka Press Center, Tokyo, Japan (Telephone: +81-3-6385-3453 and Email: michi.sawa@us.army.mil).

13.3 Site Visits (June 2010)

At the site visit in June 2010 the TAP will evaluate progress towards proposed objectives. During this visit, teams will also be expected to demonstrate a range of UGV functionality that includes the integration of ground truth systems, E-stop and “freeze” termination mechanisms for their UGVs. Emphasis will be given to partial or complete demonstrations of each of the detection, recognition, identification, localisation and neutralisation tasks. Partially or fully functional user interfaces will also be evaluated for integration of the mobile OOI indicator data into a situational awareness display. Method of multi-UGV control and UGV collaboration will also be discussed in detail.

14. Evaluation of Initial Submissions

The following equally weighted factors will be used in evaluating the initial submissions:

- Completeness of application and conformity to the Guidelines for Submissions outlined in this document.
- Demonstration of a strong grasp of the problems associated with the challenge and an articulation of a clear, credible and complete approach to overcoming them.
- Demonstration of a deep quantitative understanding of the key design points relating to autonomous multi-UVS cooperatives and presentation of a reasoned, optimised design based on preliminary results.
- Description of a testing methodology that will be used to demonstrate the performance of the proposed multi-UVS cooperative.
- Team composition, resources, facilities and experience capable of addressing the multiple and interdependent human, technology and systems integration problems posed by this challenge.

The papers will be evaluated by multiple reviewers, who will provide a quantitative score for each evaluation factor using the following scale:

- 4 Points – No weaknesses; all elements are presented clearly and convincingly.
- 3 Points – Minor weaknesses or shortfalls; all of the required elements are covered, but theory or justification is not entirely clear or complete.
- 2 Points – Modest weaknesses or multiple minor shortfalls; the required elements are substantially covered, but there are a number of theories or justifications that are not entirely clear or complete.
- 1 Point – Major weaknesses or multiple serious shortfalls; the submission is not complete and does not fully explain or justify several assertions.
- 0 Points – Sections are entirely missing; technical assertions are not supported.

The reviewer's score for each submission is computed as the total score for each of the five criteria (i.e. maximum value 20 points). The composite score is the average of the reviewer's scores.

The Technical Assessment Panel will then meet to review, compare and adjudicate the relative experience of the teams and the technical merits of the most successful proposals relative to the challenge goals.

15. Judging and Determination of a Winner

An international panel of judges will verify compliance with all rules.

Teams must provide the navigation and mapping solutions of their UGVs as well as the identity and locations of all OOI at the end of each phase. This information may be provided in real time, with latency, or intermittently, as appropriate, although real time at an update rate of approximately 1 Hz or faster is preferred and rewarded.

To complete the challenge the judges must consider that a team:

a. Has accurately and completely explored and mapped each phase area
b. Correctly located, classified, recognised and neutralised all OOI, and
c. Achieved the above within a total time of 3 hours 30 minutes.

Teams will be awarded a maximum of 800 points for their challenge operations and a further 200 points for their technical submission and presentations to judges, making a total possible score of 1,000 points.

The challenge operations will be judged against three over-arching sets of criteria: mission level, systems level and technical success. Broadly, high levels of individual and collaborative autonomy will be rewarded and human intervention penalised. Also, the degree to which the UGV cooperative is able to share the workload successfully will be rewarded (i.e. a cooperative of 10 UGVs each mapping 10% of the area will score more points than one in which one UGV maps 90% of the area).

At a mission level, criteria such as the percentage of targets correctly and incorrectly detected, located, recognised, and neutralised, the percentage of phase area explored and mapped, and the accuracy and timeliness with which this is achieved will be used. Teams will receive a maximum of 400 points for their mission level assessment. Greater weight will be placed on the later phases, which will be more complex.

At a systems level, criteria such as the number of UGVs handled by teams, the workload experienced by teams, the human-machine interface, the amount of time spent interacting with the cooperative, the number and nature of these interventions, and the degree to which UGVs autonomously and successfully share and coordinate their various activities will be used. Teams will receive a maximum of 300 points for their systems level assessment.

At a technical level, criteria such as the robustness, reliability and survivability of a team's UGVs, the capacity of the UGVs to autonomously plan, re-plan, and then execute their tasks against dynamically changing priorities, and the navigation and mobility capabilities of the individual UGVs will be used. Teams will receive a maximum of 100 points for their systems level assessment.

In the event that no team achieves adequate performance the cash awards may not be made. However, the judges may also present non-monetary awards for: innovation, best individual UGV performance and best multi-UGV coordination strategy.

15.1 Final Technical Paper and Presentation – 2010

All teams down selected to compete in the challenge must also submit a detailed technical paper by 22 October 2010 [Max 25 pages]. This paper will serve as an outline for the technical presentations given by each team the evening prior to their demonstration and should describe the detailed technical approach of their solution. Judges will be anticipating this paper and the presentation to cover all of the sections above (see Initial Submissions and Technical Presentations).

A maximum of 200 points will be awarded for the technical paper and final presentation and should be framed such that a reader can understand the team's entire approach/design without having seen previous papers or designs.

Based on a team's technical presentation judges may award 100 points for:

- Overall format, completeness and readability/clarity (10 points)
- Innovation and elegance of overall technical solution (35 points)
- Mission strategy, vehicle-operator ratio and user workload (25 points)
- Craftsmanship, durability, portability of UGVs (10 points)
- Systems integration and testing (20 points)

The Final Technical paper should include [Max 25 pages]

- Abstract
- Introduction
  - Statement of the problem
  - Conceptual solution proposed
  - Overall systems architecture
- Ground vehicle component & systems
- UVS autonomy & coordination strategy (by task)
- Sensors, processing & mapping for UGVs
- Operations in GPS-denied environments
- Processing & fusion (from the simulated UAV feed)
- Situational awareness tools
- Human-machine interface
- Mission operations strategy
- Risk reduction strategy
  - EMI/RFI & electrical
  - Vibration & physical
  - Modelling & Simulation
  - Safety, E-stop, Freeze & lost link
  - Communications architecture
  - Spectrum plan & usage
  - Test plan
- Summary

All papers submitted in October 2010 will be published on the website and as part of the Proceedings of the Land Warfare Conference and potentially in a special issue of an archival robotics journal.

16 Eligibility

16.1 Team Membership

A team comprises individuals identified to the challenge organisers on the team roster. There are no limits to the number of individuals that may be listed on the team. However, there are limits to the number of individuals allowed into the designated areas of the challenge. The team roster may be changed, but organisers must be notified in writing that this has occurred.

Each team must designate an individual to serve as a Team Leader. The team leader must be at least 21 years of age and will act as the primary point of contact with challenge organisers during the challenge. The team leader will sign the application, is responsible for providing a Certificate of Team Funding and Support and Site Visit Liability Statement (available from www.dsto.defence.gov.au/MAGIC2010/), and must be present at the Technical Presentation and November/June Site Visits.

The team leader is the only person authorized to directly communicate with the judges and organizers with regards to the selection process, funding, and to discuss judging decisions.

Team leadership may be transferred from the team leader to another eligible individual, although there may only be one team leader at a time. Transfer of leadership occurs when the organisers have received and acknowledged transfer of team leadership in writing.

During the challenge there will be two participating components of the challenge team: an operations team, and a support team. Team leadership and membership of operations and support teams may not be changed (other than in exceptional circumstances) after June 2010. Any such applications must be made in writing, with strong justification, to the challenge organisers.

16.2 Operations Team Membership

The operations team comprises up to 2 individuals identified to the challenge organisers on the team roster. Only these individuals are allowed to enter the designated operator's zone and/or operate/supervise the multi-UVS cooperative during the challenge. They may not leave the operator's zone, but are permitted to power up, re-charge or replace energy sources on the UGVs that are in the operator's zone. Operations team members may also affect minor repairs after permission has been granted by the judges as per normal repair judging procedures.

Each team shall designate an individual to serve as its Operations Team Leader during the actual challenge event. The team leader must be at least 21 years of age and is the

only member of the operations team permitted to interact with the judges during the event. The operations team leader may be the team leader.

16.3 Support Team Membership

The support team comprises up to 3 individuals identified to the challenge organisers on the team roster. Only these individuals are allowed to enter the designated servicing zones during the challenge. They may not leave the designated servicing zones during the challenge, but are permitted to power up, re-charge or replace energy sources on a UGV. Teams may also affect minor repairs such after permission has been granted by the judges. Support teams must designate a single individual in each DSZ/DSL to serve as the support team leader to communicate with judges.

16.4 Participation & Sponsorship

Corporations and non-government organisations may participate as teams or as sponsors.

Universities, university research centres, colleges of learning, polytechnics, schools, their employees and graduate and undergraduate students may participate in this competition unless they receive direct funding or support through a grant, contract or other transaction for the purposes of participating in or developing equipment for this challenge. This does not prohibit support or funding provided by the organisers of this challenge.

Teams receiving direct funding or support for this competition from national or state governments, government agencies or other state or federal government organisations are not eligible to participate. However, individuals employed by these agencies or organisations may participate as team members as long as they do so outside their official responsibilities and not as part of some work-related duty or assignment. Government travel funds and government-related travel may not be used to support the challenge team.

16.5 Team Funding & Support

The cost of developing, fielding, and insuring entered vehicles is the sole responsibility of the individual teams.

Teams must submit formal proposals to receive the $100,000 research awards granted by the organisers during the down selection process. Teams may use additional funds, but must identify the amount and source of this funding during the technical presentations and down selection process.

Each team leader must sign and submit a Certificate of Team Funding and Support which will contain the following certifications (forms are available from the challenge website at www.dsto.defence.gov.au/MAGIC2010/)

- No funding used in the foreground design, development, construction or operation of the systems employed in this challenge has been or will be charged to a grant, contract or other transaction from any national government, either directly through such work or indirectly through government-reimbursable R&D, government-funded independent R&D, overhead or general and administrative accounts. This restriction includes funding to pay for labour, travel, equipment

leases, or other services that are applied directly to the design, development, construction or operation of the challenge vehicles.
- No portion of the Foreground IP used in the UGV systems (including the GCS) has been paid for or will be paid for, wholly or in part, using direct government funding. This exclusion does not apply to Third Party IP.
- Government-owned equipment or facilities have not been used and will not be used in the design, development or operation of the UGVs unless the equipment or facilities are made available on a cost-reimbursable basis.

This certification does not prohibit:
- The use of government-sponsored information such as GPS signals, cartographic products, or government-developed software routines that are openly available.
- The use of any technologies that are commercially available to all teams.
- The use of facilities, services, equipment or funding supplied to the teams by the organisers of the challenge.
- The use of paid vacation time by government employees and contract employees to support a challenge team.

Each team leader must also sign and submit a Site Visit Liability Statement which will contain the following certifications (forms are available on the website):
- The location chosen for the site visit complies with all site visit specifications,
- The team holds harmless and indemnifies the US and Australian Governments and their employees and any MAGIC 2010 contractors for all claims of liability arising from the site visit, and
- The test location, test UGV, and test activities are in accordance with national, state and local laws and regulations.

16.6 Definitions

Government Funding – Government funding refers to compensation in the form of salary or travel expenses and any form of funding, supplies, equipment or reimbursement that is paid for by a national government, direct contractual efforts or through any form of overhead account, independent R&D grant, general and administrative account or other similar means funded by any national or international government entity. Funds received in the form of a grant that originated with a government shall also be considered government funding. Prize money awarded in a government-sponsored, publicly open competition shall not be considered government funding. This definition covers national and international government organisations, whether located in the United States, Australia, or in any other country or territory.

Commercially Available – Commercially available refers to services and materials sold, leased or licensed to the general public.

Openly Available – Openly available refers to refers to services and materials that are available to anyone without charge, such as software that is available for public download or GPS signals.

Intellectual Property - Intellectual Property or IP means all copyright (including moral rights) and all rights in relation to inventions (including patent rights), registered and unregistered trademarks (including service marks), registered and unregistered designs, confidential information (including trade secrets and know-how), and circuit layouts, and any other rights resulting from intellectual activity in the industrial, scientific, literary and artistic fields recognised in domestic law anywhere in the world.

Foreground IP – Foreground IP means IP which is not Background IP and which is created under or otherwise in connection with this challenge or any approved subcontract, other than Third Party IP.

Third Party IP - Third Party IP means that IP which is owned by a party other than the Commonwealth Government of Australia, the Federal Government of the United States, the Challenge Participants or their approved sub-contractors.

Background IP – Background IP means IP, other than Third Party IP that is in existence at the date of the challenge announcement or is subsequently brought into existence other than as a result of a Team's participation in this challenge.

Team – A team comprises two parts: a qualified team leader and any other individuals who may have been appropriately designated by the team leader as team members in the application. Team members may contribute their individual labour, individually-owned materials and equipment, and individual funds to a team.

Team Leader – A team leader is an individual identified to the challenge organisers on the team roster responsible for the following: primary point of contact for team communication with challenge organisers, signatory of the Certificate of team funding and Support, signatory of the Site Visit Liability Statement, [contract signature], and who will be present at all site visits

Team Member – A team member is a team leader or individual who has been identified on the team roster by the team leader as a team member during the submission process.

Team Sponsor – a team sponsor is an organisation that contributes labour, materials, services, facilities, equipment or funds to a team.

17 Rules & Interpretations

The rules posted on the website [http://www.dsto.defence.gov.au/MAGIC2010/] are the official governing set of regulations and guidelines of the Joint US-Australian Autonomous UVS Challenge 2010. At any time prior to the event, requests for rules clarifications should be sent to [MAGIC2010@dsto.defence.gov.au]. In general, these clarifications will be placed on the website. However, organisers will hold confidential any questions that are designated as team-proprietary.

The chairman of the judges is the final authority on all rules and mission execution of MAGIC 2010. The chairman of the judges has the authority to change aspects of the

mission execution and provide interpretation of the rules at any time and in any manner that is required. The chairman will ensure that all interpretations are made available to all teams to maximum extent possible under the team-proprietary guidelines. The MAGIC 2010 organizing IPT retains the decision-making authority on all prize and contract awards pending recommendations of the chairman of the judges. The chairman's decisions regarding the rules are expected to be based on a number of factors including: safety, compliance, fairness, challenge goals, environmental protection and efficiency.

17.1 Complaints Process

All complaints will be investigated by a committee of judges, which must include at least three judges who are not involved with the specific issue or any persons in any complaint.

Teams raising legitimate complaints will not be disadvantaged in any way. However, teams falsely or deliberately fabricating a complaint may be penalised or disqualified.

There are three approaches available when a team has firmly established in its mind that it has reason to complain. These are:

- Direct approach which, if unresolved, can lead to an informal complaint which, if unresolved, can lead to a formal complaint, or
- An informal complaint which, if unresolved, can lead to a formal complaint.
- A formal complaint.

The direct approach, which is from one team leader to another, is preferred. However, if either party is not comfortable with this approach for any reason, then it may seek to have the matter addressed by either of the other two approaches.

An informal complaint may be made by any of the team leaders to any of the judges. It is the responsibility of the judge on the receipt of the complaint to discuss the concerns and issues involving the incident(s) and explore possible options with both parties for resolving the complaint informally. If informed that a team wishes to make an informal complaint, the judge should make brief notes of the following:

- Date and time
- Name of team lodging complaint
- Names of the team or person(s) alleged to be offending
- Brief points relating to the alleged incident

If, after mediation, the team that has complained determines the outcome to be acceptable and indicates that the complaint will not progress any further the judge's notes are to be kept confidential and retained until the end of the competition. In the event that the complaint proceeds, the judge and the notes may be called upon as evidence.

If the above process fails to satisfy the team which has made the complaint and the problem remains unresolved, then the team lodging the complaint should be informed

that they may lodge a formal complaint [and has a further 24 hours to decide whether to proceed with that complaint].

A formal complaint may only be made by a team leader to the chairman of the judging committee in writing. The chairman of the judges must then decide whether the matter is one for investigation. The formal complaint should outline:

- Particulars relating to date, time, place, etc
- Names and individuals involved, judge who conducted mediation, etc
- Nature of the incident(s), preferably in chronological order
- Any witnesses, supporting evidence, other matters, etc

The chairman of the judges will then

- Convene a suitable panel of judges
- Collate all material pertinent to the complaint
- Disseminate all this information to all parties
- Arrange and liaise with all parties to arrange a suitable meeting time/location

Only the complaints committee, the team that is alleging the offence has occurred and the parties alleged to have committed the offence may attend the hearing.

The investigation by the committee of judges will establish whether the complaint is:

- Substantiated (i.e. the event did happen)
- Unsubstantiated (i.e. insufficient evidence for a determination)
- Proven false (i.e. the event did not happen)

Depending upon the outcome of the investigation the chairman of the judges may choose to disqualify, penalise or counsel the parties involved. Any penalty imposed is entirely at the discretion of the chairman and should be based on the recommendation of the committee.