

## 2016 IROC-A Challenge Descriptions

The Marine Corps Warfighter Lab (MCWL) is pursuing the Intuitive Robotic Operator Control (IROC) initiative in order to reduce the cognitive burden on operators when using a robotic platform to perform short range search and reconnaissance missions. The robot will assist the Marine in performing reconnaissance tasks within buildings and outside areas. The more autonomous the robot can perform the search and recon mission capabilities, the more desirable to the Marine Corps.

### **Command Recognition Challenge**

The Command Recognition Challenge will be conducted in two parts.

#### Part 1

During Part 1, the participant will describe their system in terms of capabilities, how it works, and how autonomous behaviors are commanded. This session will provide an opportunity for MCWL and other observers to ask questions and learn about the system and its capabilities.

Challenge Conditions:

- 1 hour time limit

#### Part 2

Tasks that the robotic system will be required to accomplish and repeat 3-5 times to demonstrate repeatability. Tasks will include:

1. Command ground robot to travel to a specific location or set distance within line of sight of the operator
2. Command ground robot to enter a room through a doorway
3. Command ground robot to scan and build a map of a room
4. The system may also allow for an object of interest to be located and identified. Participants will not be penalized if their technology is not capable of object detection, classification, and/or identification.
  - Prior to the challenge, vendors will be shown 3 different objects (red ball, orange cone, and one object that will only be revealed on the day of the challenge). The ground robot will be required to scan the room to find one of these objects. Potential methods of accomplishing scan:
    - Preferred: The ground robot locates and identifies the object and alerts the operator that an object of interest was found. This can be using object detection and classification software or other method.
    - Acceptable: Ground robot alerts the operator it is about to begin a scan and the operator watches, from a heads-up display or stow-able display, the live video feed from the ground robot.

- Acceptable: Ground robot conducts the reconnaissance mission and allows the Operator to view suspect objects, location of objects, and video during post mission analysis.
5. Command ground robot to go to rally point

Challenge Conditions:

- Operator may lose line-of-sight (LOS) with ground robot during this challenge
- Operator will be asked to hold a mock rifle in an effective manner during the challenge to demonstrate their system's applicability in an operational setting. Non-adherence to this condition will not affect performance score for this particular challenge.
- Ground robot must be capable of maneuvering through a standard sized doorway (36 inches wide)
- 2 hour time limit

Metric:

- Success rate of accomplishing each individual task.

\*Use of tele-operation (any form of control requiring constant feedback and monitoring from operator to control the ground robot) will not be considered successful for any section of the challenge, where applicable, in which it is used. Contact the IROC event POC, identified in the RFI, if you are unsure how your form of robotic control will be classified.

\*The ideal performance in this challenge would be for each task to be able to be accomplished with a single action or command.

## Object Search Challenge

The Object Search Challenge will be conducted in two parts.

### Part 1

The objective for part 1 of this challenge is to use the ground robot to find an object of interest within a building. This challenge will basically be the combination of all of the tasks within part 2 of the Command Recognition Challenge. Using their system, the operator will be required to command the vehicle to complete the mission to search a room within a building to find an object of interest and then go to a rally point.

Scenario: Operator and ground robot will begin mission at a designated starting point. Operator will need to send the ground robot down a road and enter into a building through a doorway. Once inside, the ground robot will be controlled, manually or autonomously, to scan the room for an object of interest. Similar to part 2 of the Command Recognition Challenge, the operator will be shown three different objects before the start of the challenge, one of which will be the object of interest that will need to be found and identified.

### Challenge Conditions:

- Vendor will lose LOS with the ground robot during this challenge.
- Operator will be asked to hold a mock rifle in an effective manner during the challenge to demonstrate their system's applicability in an operational setting. Non-adherence to this condition will not affect performance score for this particular challenge.
- Room containing object of interest will be uncluttered and will only contain the object of interest.
- Ground robot must be capable of maneuvering through a standard sized doorway (36 inches wide).
- Preferred that operator remain at the starting point for the duration of the challenge, but not required. Operator will, however, not be allowed to enter the same room as the object of interest and will need to remain outside of the room.
- 1 hour time limit

### Metrics:

- Number of commands used or interactions the operator has with the ground robot used to accomplish the entire mission. Objective is to minimize this number.
- Point based system in which points are awarded for completion of sections of the mission and for completing the mission using certain methods.
  - Robot successfully reaches the designated area immediately outside of the building (+1 point).
  - Robot successfully enters the building through the doorway (+1 point).
  - Robot successfully finds the object of interest (+1 point).
  - Robot successfully goes to designated rally point (+1 point).
  - Robot employs object recognition software to automatically identify the object of interest without operator intervention (+1 point).

\*Use of tele-operation (any form of control requiring constant feedback and monitoring from operator to control the ground robot) will not be considered successful for any section of the challenge, where applicable, in which it is used. Contact the IROC event POC, identified in the RFI, if you are unsure how your form of robotic control will be classified.

\*The ideal performance in this challenge would be for the operator to only issue commands/instructions/set route/etc. at the starting point and to not interact with the ground robot once it leaves the starting point. Viewing and responding to alerts from the ground robot, such as viewing an alert saying that the ground robot is ready to scan the room or viewing a recorded video or live video feed from the ground robot, is not counted as an interaction for this challenge.

### Part 2

The objective for part 2 of this challenge is the same as part 1 except that the room that contains the object of interest will be cluttered and will contain other objects in addition to the object of interest.

#### Challenge Conditions:

- Vendor will lose LOS with the ground robot during this challenge.
- Operator will be asked to hold a mock rifle in an effective manner during the challenge to demonstrate their system's applicability in an operational setting. Non-adherence to this condition will not affect performance score for this particular challenge.
- Room containing object of interest will be cluttered with other, inconsequential, objects.
- Ground robot must be capable of maneuvering through a standard sized doorway (36 inches wide).
- Preferred that operator remain at the starting point for the duration of the challenge, but not required. Operator will, however, not be allowed to enter the same room as the object of interest and will need to remain outside of the room.
- 1 hour time limit

#### Metrics:

- Number of commands used or interactions the operator has with the ground robot used to accomplish the entire mission. Objective is to minimize this number.
- Point based system in which points are awarded for completion of sections of the mission and for completing the mission using certain methods.
  - Robot successfully reaches the designated area immediately outside of the building (+1 point)
  - Robot successfully enters the building through the doorway (+1 point)
  - Robot successfully finds the object of interest (+1 point)
  - Robot successfully goes to designated rally point (+1 point)
  - Robot employs object recognition software to automatically identify the object of interest without operator intervention (+1 point)

\*Use of tele-operation (any form of control requiring constant feedback and monitoring from operator to control the ground robot) will not be considered successful for any section of the challenge, where applicable, in which it is used. Contact the IROC event POC, identified in the RFI, if you are unsure how your form of robotic control will be classified.

\*The ideal performance in this challenge would be for the operator to only issue commands/instructions/set route/etc. at the starting point and to not interact with the ground robot once it leaves the starting point. Viewing and responding to alerts from the ground robot, such as viewing an alert saying that the ground robot is ready to scan the room or viewing a recorded video or live video feed from the ground robot, is not counted as an interaction for this challenge.

## Map Defined Area Challenge

### Part 1

The objective for part 1 of this challenge is to command a ground robot to scan a specific area that is located on a section of road/pathway. Operator will be required to set a subset area of the road/pathway for which the system to scan. The ground robot will need to scan the entire area within the defined boundaries while also locating objects of interest. The defined area will contain an unspecified number of objects of interest (balls, cones, etc.) Setting the bounding box may be accomplished through whatever means the robotic system is capable. "Scan" is defined as the ground robot creating a map (Lidar-map, annotated snapshots with associated meta data, and/or other effective methods) of the entire area within the bounding box with the preferred capability of also recording video for the operator to later review. A primary goal of this mission is also to demonstrate the behavior of effective alerts, such as mission progress, mission complete, or unable to complete mission to allow for effective operator control.

#### Challenge Conditions:

- The scan area may have buildings, cars, piles of rubble, and other debris located within it.
- An unknown number of objects of interest will be located within the scan area.
- Operator may lose LOS with ground robot.
- Operator will be asked to hold a mock rifle in an effective manner during the challenge to demonstrate their system's applicability in an operational setting. Non-adherence to this condition will not affect performance score for this particular challenge.
- Ground robot must be capable of maneuvering through a standard sized doorway (36 inches wide).
- 1 hour time limit

#### Metrics:

- Points awarded for percent completion [X] of scanning the designated area within the bounding box
  - $0\% \leq X \leq 20\%$  (0 points)
  - $20\% < X \leq 40\%$  (1 point)
  - $40\% < X \leq 60\%$  (2 points)
  - $60\% < X \leq 80\%$  (3 points)
  - $80\% < X \leq 100\%$  (4 points)
- Points awarded for locating objects of interest within the designated area within the bounding box
  - Finding any object of interest (1 point)
  - Finding all objects of interest (2 points)
  - Finding all objects of interest and dropping special points (or markers) at their locations (3 points)

\*Use of tele-operation (any form of control requiring constant feedback and monitoring from operator to control the ground robot) will not be considered successful for any section of the challenge, where applicable, in which it is used. Contact the IROC event POC, identified in the RFI, if you are unsure how your form of robotic control will be classified.

\*If available, MCWL is interested in seeing the participating robotic systems produce an in-sync map (showing robot's location and/or meta data)/ video that is viewable from operator interface display. This in-sync map/ video would be useful in an operational setting since it allows the operator to know the location of the ground robot, the direction it is facing, and what it sees at any given time. This will not be scored as part of the challenge but is a desired capability.

## Part 2

The objective for part 2 of this challenge is a duplicate of part 1 with one difference; there will be an obstacle located within the bounding box that will prevent the ground robot from completing the mission. It will not be able to access a section of the designated scan area. Objective for this challenge is for the ground robot to search as much of the bounding box that is accessible, then notify the operator that it cannot complete the scan of the entire bounding box, and identify the un-scanned region. Goal of this mission is to demonstrate the behavior of the autonomy providing effective status, alerts and communication to allow for effective operator control.

### Challenge Conditions:

- The scan area may have buildings, cars, piles of rubble, and other debris located within it.
- An unknown number of objects of interest will be located within the scan area.
- Operator may lose LOS with ground robot.
- Operator will be asked to hold a mock rifle in an effective manner during the challenge to demonstrate their system's applicability in an operational setting. Non-adherence to this condition will not affect performance score for this particular challenge.
- Ground robot must be capable of maneuvering through a standard sized doorway (36 inches wide).
- 1 hour time limit

### Metrics:

- Number of commands used or interactions the operator has with the ground robot used to accomplish the entire mission. Objective is to minimize this number.
- Points awarded for percent completion [X] of scanning the accessible designated area within the bounding box
  - $0\% \leq X \leq 20\%$  (0 points)
  - $20\% < X \leq 40\%$  (1 point)
  - $40\% < X \leq 60\%$  (2 points)
  - $60\% < X \leq 80\%$  (3 points)
  - $80\% < X \leq 100\%$  (4 points)

- Points awarded for locating objects of interest within the accessible designated area within the bounding box
  - Finding any object of interest (1 point)
  - Finding all objects of interest (2 points)
  - Finding all objects of interest and dropping special points (or markers) at their locations (3 points)

\*Use of tele-operation (any form of control requiring constant feedback and monitoring from operator to control the ground robot) will not be considered successful for any section of the challenge, where applicable, in which it is used. Contact the IROC event POC, identified in the RFI, if you are unsure how your form of robotic control will be classified.

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## Additional Demonstration Opportunities

MCWL is interested in viewing additional mission execution capabilities if the participant has the means to demonstrate them. These additional demonstrations will not be scored as part of the challenges.

Examples:

- **Loss of Communications Demonstration - Ground robot behavior in a loss of communication signal situation:**
  - Will the ground robot trace its steps to a location where it had previously had a signal with the operator?
  - Will ground robot finish its current mission and then return to operator?
- **Low Battery Test - Ground robot behavior when its battery is low.**
  - Will the ground robot be able to know when it needs to return to the operator or risk running out of battery?

## Demonstration Environment

Participants can expect to perform any of the challenges under the following conditions:

- Participants may expect to operate in conditions of limited visibility (darkness or simulated smoke) and loud noises (simulated crowd or combat noise).
- Rain will not preclude operation in outdoor events.

## **Q&A Session**

MCWL will host a teleconference 2 weeks prior to the whitepaper due date so that interested parties may ask any questions they may have. This will be an open forum. All relevant questions, along with their answers, will be posted along with their answers to the IROC-A website under the Frequently Asked Questions section. Dial-in information and further details on the date and time of the Q&A session will be posted on the IROC-A website at least 3 weeks prior to the whitepaper due date.

## **Disclaimer:**

- (1) If your system is not capable of demonstrating its utility within the described challenges or may not necessarily perform well under the defined metrics, though could still provide an operational advantage within a tactically-relevant environment, MCWL is still interested in viewing a whitepaper describing your system. There may be an opportunity during the week of the event for you to provide a demonstration of your system.
- (2) The stated metrics for each challenge are subject to change based off of the responses MCWL receives to the RFI and the types of robotic technologies that will be present at the event. Event participants will be promptly notified in the event that this occurs.
- (3) The decision process to be used when determining if any participants should receive funding from MCWL will be based off of a combination of the performance metrics and MCWL's assessment of the practicality of the system within a real-world tactical environment.
- (4) To provide a fair and transparent challenge environment for all participants, all relevant questions that prospective participants may ask, whether in the Q&A session or through other means, will be posted along with their answers to the IROC-A website under the Frequently Asked Questions section.