

# Virtual Robotics Challenge Rules

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## 1 Introduction

The DARPA Robotics Challenge (DRC) program plans to conduct three competitions (contingent on continued funding):

- The Virtual Robotics Challenge (VRC) in June 2013
- The DARPA Robotics Challenge Trials (DRC Trials) in December 2013
- The DARPA Robotics Challenge Finals (DRC Finals) in December 2014

This document contains the official rules of the Virtual Robotics Challenge (VRC), the first of the three competitions. The rules for DRC Trials and DRC Finals will appear later.

In the VRC, competitors will use software to command and control a simulated robot performing simulated disaster response tasks. Top performers in the event become eligible to receive a robot system with which to compete in DRC Trials. DARPA anticipates providing six (6) robot platforms. DARPA will determine at a future date the disposition of these platforms upon completion of the DRC program.

The website

[http://www.darpa.mil/Our\\_Work/TTO/Programs/DARPA\\_Robotics\\_Challenge.aspx](http://www.darpa.mil/Our_Work/TTO/Programs/DARPA_Robotics_Challenge.aspx) contains links to program documents, including the following:

- The Broad Agency Announcement (BAA) solicitation and amendments
- The BAA questions and answers
- Proposers' Day briefings and transcripts
- Kickoff briefings and transcripts
- Program information

The website [TheRoboticsChallenge.org](http://TheRoboticsChallenge.org) contains links to key documents, including the following:

- Program information, discussion forums, and frequently asked questions
- Pre-registration for Track C and Track D
- Registration for Track C (not implemented yet, to be available by the date indicated in Section 12)

Related documents include the following:

- Virtual Robotics Challenge Technical Guide – Describes the computing environment, how runs will be conducted, and what parameters will be varied for the VRC
- Virtual Robotics Challenge Qualification – Defines procedures and schedule for qualifying for the VRC - Not yet available
- Virtual Robotics Challenge Practice – Defines procedures and schedule for conducting practice runs after qualification and before the VRC – Not yet available

## 2 Scope and Precedence

The rules apply to all participants in the VRC. Nothing in these rules, to include this document and all subsequent rules documents, may be interpreted as modifying the statement of work or

authorizing work outside the terms and conditions of any existing agreements or contracts with DARPA.

DARPA will release additional documents with rules updates, procedures, and other information for teams as needed. These additional documents carry the full authority of the rules in this document.

All documents will be posted on the DARPA Robotics Challenge website, [www.TheRoboticsChallenge.org](http://www.TheRoboticsChallenge.org).

### **3 Rule Modifications**

The development of revolutionary technologies is a primary objective of the VRC. Entrants are invited to communicate directly with DARPA regarding any rule that restricts their ability to demonstrate technical achievement and innovative solutions to robotics for disaster response.

The Chief Judge has the authority to modify the rules at any time. Rules may be modified for many reasons, including accommodation of a promising technical approach that would have been prohibited by the rules. DARPA will communicate any modifications to the rules with an e-mail to all entrants and a statement on the DARPA Robotics Challenge website.

The Chief Judge may revise the schedule at any time and interpret the rules in any manner to best meet DARPA's objectives. The Chief Judge's decisions are based on a number of factors such as fairness, safety, statutes, program goals, and efficient operations.

Requests for rules clarifications should be sent to [TheRoboticsChallenge@darpa.mil](mailto:TheRoboticsChallenge@darpa.mil). DARPA will hold confidential any questions that are designated as team proprietary. DARPA will ensure that answers do not give any team an unfair advantage.

Decisions of the Chief Judge are final.

### **4 Eligibility**

All responsible sources capable of performing the VRC tasks may participate in the VRC. The VRC is open to individual participants, and teams of participants, of all nationalities and of all ages. However, in order to receive the cash prize (after successfully competing in the VRC, the DRC Trials, and the DRC Finals), the winner must provide a U.S. taxpayer identification number (TIN, for example, a social security number). Information on how to obtain a TIN is available on the U.S. Internal Revenue Service website at [www.IRS.gov](http://www.IRS.gov).

Participants who are U.S. citizens or lawful permanent residents under 18 years of age may be required to obtain the consent of a guardian and/or meet other applicable legal requirements as a prerequisite to accepting the prize under this Challenge.

An individual or entity is not eligible to register or otherwise participate if he or she is on the Specially Designated Nationals list promulgated and amended by the Office of Foreign Assets Control of the United States Department of the Treasury (<http://www.treasury.gov/resource-center/sanctions/SDN-List/Pages/default.aspx>). Participants are solely responsible for compliance with all applicable laws and regulations. DARPA expressly disclaims any liability

or responsibility thereto. In case of doubt about applicable laws and regulations, interested parties may choose to consult their legal counsel.

Federal entities and Federal employees acting within the scope of their employment are not eligible to participate.

Federal employees acting outside the scope of their employment should consult their ethics official before participating in the Challenge.

To avoid the appearance of unfairness, DARPA employees and DARPA support contractors and their spouses, dependents, and household members are not eligible to participate.

Teams funded under Track A are not eligible to participate.

DARPA reserves the right to disqualify a participant whose actions are deemed to violate the spirit of the competition for any reason, including but not limited to, the violation of laws or regulations in the course of participation in the Challenge.

## **5 Registration**

Registration for the VRC takes place at the website [www.TheRoboticsChallenge.org](http://www.TheRoboticsChallenge.org). Section 12 documents the registration schedule.

Track B teams must register for the VRC.

Teams that register and are not on Track B are by definition on Track C.

DARPA aims to accommodate all registrants. Because the process of conducting runs will be automated, and therefore does not require personnel, DARPA does not anticipate limiting registration.

In the highly unlikely case that the number of registrants exceeds the computing resources available, DARPA may at the discretion of the Chief Judge conduct a random drawing to select registrants.

DARPA will not use order of registration as a selection criteria. Registration is not on a “first come first served” basis.

In exceptional circumstances, DARPA may accept registration requests after the Registration Closes date.

Registration for or participation in the challenge does not create or imply any contract with DARPA or the United States Government.

## **6 Qualification**

Registered entrants must qualify for the VRC by demonstrating basic functionality prior to the competition.

Each team will be assigned a time slot in which to demonstrate basic robot functionality, such as walking in a straight line. Teams may make any number of attempts within the given time.

Failure to meet this objective by the end of the allotted time slot will result in disqualification from participation in the VRC competition.

Section 12 identifies the overall schedule for the qualification period. DARPA will announce detailed qualification schedules and procedures at a later date.

## 7 Practice

DARPA will provide teams with the opportunity to run their systems using the software and services to be used in the VRC competition, to include access to the cloud service running the onboard robot code and DRC simulation code.

Section 12 identifies the overall schedule for the practice period. DARPA will announce detailed practice schedules and procedures at a later date.

## 8 Competition Tasks

The VRC competition will comprise three<sup>1</sup> tasks:

1. Climb into a utility vehicle, drive along a roadway at no greater than 16 kph (10 mph), and climb out of the utility vehicle.
2. Walk across progressively more difficult terrain, for example, progressing from parking lot to short grass to tall grass to tall grass on slope to ditch to rock field. In the earlier terrain, the GFE Platform balancing and walking behaviors will suffice. In the later terrain, DARPA expects perception and footstep planning will be needed.
3. Connect hose to spigot. This is purely a manipulation task, that is, the robot starts with everything within reach and so does not need to travel to the work site.

Further details about these tasks will be provided in the *Virtual Robotics Challenge Technical Guide*.

## 9 Competition Runs

For each of the three (3) tasks described in Section 8, entrants will perform five (5) runs, for a total of fifteen (15) runs.

Each run will take place with a unique *configuration* specifying the location of all objects in the environment, the starting position of the robot, the communications parameters (including bandwidth, latency, quality of service), contact friction properties, and other relevant parameters.

The five configurations will be distinct from each other. However, each team will have the same five configurations.

The following pseudo-code describes how the runs will take place for a given *team* performing a given *task*:

---

<sup>1</sup> Ideally, one would simulate all of the tasks in DRC-13 and DRC-14. However, in practice, simulating all of the tasks would require excessive time and effort, because of the need for multiple runs of the same task with different configuration settings.

```

Simulate (team, task)
  For configuration (1: 5)
    Spawn simulation in cloud of robot performing task with
      configuration settings
    Spawn instance in cloud of machine running team onboard code
    Start scoring (configuration)
    Team simulates execution of task
    Stop scoring (configuration)
    Compute scores, log results
  Next
End Simulate

```

The expected completion time for a run of any of the three tasks is ten (10) minutes. The time limit for a run of any of the three tasks is thirty (30) minutes.

Time starts when the robot leaves the starting box, that is, when it takes a footstep out of the starting box or moves a hand outside of the starting box. Time ends when the task is achieved or when the maximum allowed time is reached.

If the robot must be reset during a run, for example due to a software process crashing, time continues to accrue and is not reset with the robot.

If the robot must be reset during a run, the robot location and state shall remain unchanged for the resumption of the run (no “teleportation”).

Teams will be allowed to successfully complete a run only once; teams may not perform a run multiple times to obtain a better score.

## 10 Competition Scoring

The scoring criteria, in descending order of importance, are the following:

### 1. Task Completion

- **Percent Complete**
- 100% if the robot crossed the finish line for the driving and walking tasks, or successfully performed the hose task
- 0% if the robot sustained “damage,” defined as three (3) occurrences of exceeding a threshold value for the maximum absolute acceleration of the center of mass
  - The rationale for using this acceleration is to reward operation that results in minimal damage to the robot, thus enabling functioning longer in austere or hazardous environments. Falls and similar high-shock events exhibit large accelerations that are potentially dangerous to personnel and to the robot.
- 0% - 99% otherwise, using the percentage of the distance traveled for the driving and walking tasks, and using the angular travel of the hose collar rotation for the hose task

### 2. Data Communications Volume

- **Sum of bits uplinked and downlinked** to/from the Team Onboard Code machine<sup>2</sup>
- Bits transferred between the simulation machine<sup>3</sup> and the Team Onboard Code machine do not count.
- Note that the only connections allowed from the simulation machine go through the Team Onboard Code machine. In other words, all data going to the Operator Control Unit (OCU) goes from/through the Team Onboard Code machine.
- The rationale for using data volume as a scoring criteria is that communications is a scarce resource and a surrogate for “autonomy”

### 3. Task Completion Time

- **Time** required to complete the task, if the robot completed the task within the time limit
- **Maximum Time** otherwise

The task score shall be the sum of the best four (4) of the five (5) run scores. Table 1 shows three examples of computing the task score, shown in column G, given the run scores shown in columns B through F, for the Task Completion scoring criterion.

A	B	C	D	E	F	G
Completion	Run 1	Run 2	Run 3	Run 4	Run 5	Score
Task 1	0.0	0.5	0.5	0.5	0.5	2.0
Task 2	0.0	1.0	0.0	1.0	0.0	2.0
Task 3	1.0	1.0	1.0	1.0	1.0	4.0
Overall	-	-	-	-	-	8.0

Table 1. Examples of computing the task score for the Task Completion scoring criterion

If all teams have different scores for the first criterion (task completion), then the scores determine a unique ranking of team performance, with the highest score performing best and the lowest score performing worst.

If two or more teams have equal scores for the first criterion(task completion), then the scoring procedure uses the second criterion (data communications volume). If all these teams have different scores for the second criterion, then those scores determine a unique ranking, with the lowest score (smallest data volume) performing best and the highest score (largest data volume) performing worst. (Note the change in “polarity” from the first to the second criterion.)

<sup>2</sup> Loosely, the machine running the team perception, planning, and control code. See the “Virtual Robotics Challenge Technical Guide” document for a detailed description.

<sup>3</sup> Loosely, the machine running the simulation of the robot acting in the environment. See the “Virtual Robotics Challenge Technical Guide” document for a detailed description.

If two or more teams have equal scores for the first and the second criteria, then the scoring procedure uses the third criterion (task completion time). If all these teams have different scores for the third criterion, then those scores determine a unique ranking, with the lowest score (shortest time) performing best and the highest score (longest time) performing worst.

If two or more teams have equal scores for the first and the second and the third criteria, then the Chief Judge will determine how to resolve the matter, possibly by conducting additional runs.

## 11 Competition Non-Disclosure

The Competition Non-Disclosure Period is the period beginning when an entrant begins their first competition run, and ending when the VRC results are announced.

During the Competition Non-Disclosure Period, entrants may not disclose the configuration settings used for the competition runs.

Violation of the non-disclosure rule will result in disqualification of the entrant who disclosed the configuration settings, and may result in re-runs or disqualification of the entrant who received the disclosed information.

## 12 Schedule

Table 2 identifies significant VRC dates.

Event	Date	Remarks
VRC Pre-Registration Opens	October 24, 2012	Used for purposes of sizing cloud resources
VRC Rules Drafted	November 12, 2012	
VRC Registration Opens	December 3, 2013	Used for official entry
VRC Registration Closes	December 14, 2012	
VRC Registration Notification	December 31, 2012	
VRC Rules Release 1	December 31, 2012	
VRC Qualification	May 1, 2013 – May 15, 2013	
VRC Practice	May 28, 2013 – June 7, 2013	
VRC Competition	June 10, 2013 – June 24, 2013	

Table 2. VRC Schedule



## Appendix: Definitions

### *Chief Judge*

The Chief Judge is the DARPA Program Manager or an official designated by the DARPA Program Manager. The Chief Judge is the final authority on all matters referred to in the rules and on all matters pertaining to the VRC that are not explicitly referred to in the rules.

### *DARPA Robotics Challenge Website*

Application forms and the most authoritative and up-to-date information about the DARPA Robotics Challenge program in general, and the VRC in particular, can be obtained at [TheRoboticsChallenge.org](http://TheRoboticsChallenge.org).

### *Entrant*

An entrant is a team on Track B or Track C that has not been disqualified.

### *Media Representative*

A media representative is anyone who is accredited by DARPA as such.

### *OCU*

Operator Control Unit. This refers to the control station for the robot at the performer site, and for the VRC is equivalent to the Team Offboard Code.

### *Official*

An official is a person designated by DARPA for the purpose of administering or monitoring any aspect of the VRC.

### *Qualification*

The qualification process performs an initial check in advance of VRC to guarantee that teams can demonstrate basic functionality in order to be allocated resources on the cloud.

### *Rules*

The rules posted on the DARPA VRC website are the official governing set of regulations and guidelines of the DARPA VRC and apply to all participants. The rules include this document as well as subsequent procedure documents and rules updates that are released on the website. The Chief Judge is the final authority on all rules and all aspects of the DARPA VRC.

### *Run*

A trial of a simulated task with a particular configuration (including but not limited to starting position, starting orientation, and communication parameters)

*Team Leader*

A team leader is the individual identified to DARPA during the application process and is responsible for acting as the primary point of contact for team communication with DARPA.

*Team Member*

A team member is a team leader or individual who has been designated by the team leader as a team member.

*Team Sponsor*

A team sponsor is an organization that contributes labor, materials, services, equipment, or funds to a team.

*VRC*

Virtual Robotics Challenge