



# **DARPA Grand Challenge 2005**

Rules

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**Defense Advanced Research Projects Agency**

3701 North Fairfax Drive

Arlington, VA 22203-1714

# Table of Contents

## [1. Introduction](#)

- 1.1 Purpose of Grand Challenge
- 1.2 Date of the Event
- 1.3 Location of the Event
- 1.4 Route Description
- 1.5 Rules
- 1.6 The Prize
- 1.7 Future Challenges
- 1.8 Grand Challenge 2005 Timeline

## [2. Eligibility](#)

- 2.1 Team Membership
- 2.2 Non-US Participation and Sponsorship
- 2.3 US Federal Government Organization Participation
- 2.4 Team Funding and Support

## [3. Challenge Vehicle Requirements](#)

- 3.1 Autonomous Vehicle Behavior Requirement
- 3.2 Vehicle Limitations
- 3.3 Classified Data and Devices
- 3.4 Tethered Vehicle Systems
- 3.5 Vehicle Identification Number
- 3.6 Vehicle Safety
- 3.7 Towing Requirements
- 3.8 Position Determination Signals
- 3.9 Wireless Signal Restrictions
- 3.10 Vehicle Cooperation
- 3.11 Environmental Impact
- 3.12 Pre-Challenge Testing

## [4. Application Procedure](#)

- 4.1 Basic Requirements
- 4.2 Submission Procedures
- 4.3 Additional Materials
- 4.4 Team Promotional Material

## [5. Qualification Process](#)

- 5.1 Overview
- 5.2 Selection for Site Visit
- 5.3 Site Visit Procedure
- 5.4 Technical Papers
- 5.5 National Qualification Event

## [6. Grand Challenge Event](#)

- 6.1 Departure Area
- 6.2 Vehicle Control
- 6.3 Challenge Route
- 6.4 Obstacles
- 6.5 Intentional Interference and Damage

- 6.6 Improper Vehicle Contact
- 6.7 Jettisoning Material on the Route
- 6.8 Passing
- 6.9 Overnight Operations
- 6.10 Arrival Area
- 6.11 Corrected Time
- 6.12 Disqualification

Appendix. [Definitions](#)

## **1. Introduction**

### **1.1 Purpose of the Grand Challenge**

The Defense Advanced Research Projects Agency (DARPA) seeks to promote innovative technical approaches that will enable the autonomous operation of unmanned ground combat vehicles. These autonomous ground vehicles will navigate from point to point in an intelligent manner to avoid or accommodate obstacles including nearby vehicles and other impediments.

The DARPA Grand Challenge is a field test of autonomous ground vehicles over realistic terrain and sets specific performance goals for distance and speed.

The Grand Challenge draws widespread attention to the technology issues associated with autonomous vehicles and motivates entrants to overcome the obstacles to the realization of truly robust autonomous ground vehicles. The event challenges the most capable and innovative companies, institutions, and entrepreneurs in the United States and from around the world to produce breakthroughs in capability and performance.

### **1.2 Date of the Event**

The *Grand Challenge 2005 Event* (see definition, p.[27](#)) will be held on October 8, 2005. If the Grand Challenge Event cannot be started on this day, it will be run on the next available day, but no later than October 18, 2005.

DARPA plans to conclude the event within the daylight hours of a single day. If for any reason the event cannot be safely completed within this time, DARPA will stop and shut down all *vehicles* (see definition, p.[31](#)) that are on the route and not already disqualified. These remaining vehicles will resume the route from their stopped position the following morning.

### **1.3 Location of the Event**

Grand Challenge 2005 will be held in the southwestern United States. DARPA will announce the location of the Grand Challenge 2005 Event during the summer of 2005. After this announcement, DARPA may restrict entrants' use of the event area until the completion of the Grand Challenge.

### **1.4 Route Description**

The *route* (see definition, p.[28](#)) is no longer than 175 miles. It may include paved roads, unpaved roads, trails, and off-road desert areas. Examples of obstacles include ditches, berms, washboard, sandy ground, standing water, rocks and boulders, narrow underpasses, construction equipment, concrete safety rails,

power line towers, barbed wire fences and cattle guards. The route can be traversed by a commercial 4X4 pickup truck. In addition to the existing natural obstacles, DARPA will place on the route static obstacles that may disable a vehicle if struck. These obstacles must be detected and circumnavigated for a vehicle to successfully complete the route. The route is wide enough for vehicles to bypass these obstacles.

## 1.5 Rules

The development of revolutionary technologies is a key objective of the Grand Challenge. *Entrants* (see definition, p.[26](#)) are invited to communicate directly with DARPA regarding any rule that restricts their ability to demonstrate technical achievement and innovative solutions to intelligent autonomous ground vehicle behavior.

The *Chief Judge* (see definition, p.[25](#)) has the authority to modify the rules at any time. Reasons for rules modifications include, but are not limited to, the accommodation of promising but unexpected technical approaches that would have been prohibited by the rules and the exclusion of approaches that seek to win without demonstrating the desired technical achievement in autonomous vehicle behavior that is the purpose of the Challenge. DARPA will announce any modifications to the rules with an e-mail to all entrants and a statement on the Grand Challenge website under “Rules”.

The Chief Judge may revise the schedule of the Challenge and provide interpretation of the rules at any time and in any manner that is required. The Chief Judge’s decisions regarding the rules are based on a number of factors, such as safety, legal compliance, fairness, Challenge goals, environmental protection, and efficient operations.

At any time prior to the *National Qualification Event* (NQE)(see definition, p.[28](#)), requests for rules clarifications should be sent to: [GrandChallenge@darpa.mil](mailto:GrandChallenge@darpa.mil). DARPA will hold confidential any questions that are designated as team proprietary.

Decisions of the Chief Judge are final.

## 1.6 The Prize

DARPA will award a *prize* (see definition, p.[28](#)) of \$2 million to the *team* (see definition, p.[30](#)) whose vehicle completes the route with the shortest *corrected time* (see definition, p.[24](#)) under 10 hours and complies with all other eligibility requirements. No contract or other incentive is promised as a result of this Challenge. Tax treatment of the prize will be handled in accordance with US Internal Revenue Service guidelines. The *team leader* (see definition, p.[30](#)) will

be required to provide the appropriate US taxpayer identification number for the individual or organization to receive the prize.

### 1.7 Future Challenges

If no team wins the DARPA Grand Challenge 2005 prize, subsequent Challenges may be held until the prize is awarded or until Congressional authority for the prize expires. The current Congressional authorization expires on September 30, 2007.

Teams that participated in previous DARPA Challenge activities must complete the *qualification process* (see definition, p.[28](#)) to participate in Grand Challenge 2005.

### 1.8 Grand Challenge 2005 Timeline

The Grand Challenge application has five parts and two deadlines, detailed in Table 1 below. Participation in the Grand Challenge Event requires successful passage through the 3 main steps of the selection and qualification process, detailed in Table 2 below. Instructions and templates necessary for participation are posted on the *Grand Challenge website* (see definition, p.[27](#)).

Table 1. Application – Five Parts		
REQUIRED SUBMITTAL	REMARKS	DEADLINE
Part 1 - Team Information	Submit by e-mail	February 11, 2005
Part 2 - Additional Information and Certification of Team Funding and Support	Postal submission	
Part 3 - Vehicle Specification Sheet	Submit by e-mail	March 11, 2005
Part 4 - Video Demonstration	Postal submission	
Part 5 - Site Visit Agreement	Postal submission	

Table 2. Selection and Qualification Process		
EVENT	REMARKS	DATE
<u>Step I</u> – Announcement of teams selected for site visits	Results from review of vehicle specification sheet and video demonstration	April 4, 2005
<u>Step II</u> - Site visits	Conducted by DARPA representatives	May 2–15, 2005 (May 16–21 backup dates)

Table 2. Selection and Qualification Process (cont.)		
EVENT	REMARKS	DATE
Announcement of 40 teams selected for National Qualification Event (semifinalists)	Based on results from site visits	June 1, 2005
Technical papers submitted	Required from all semifinalists	August 15, 2005
Meeting with all semifinalist team leaders	Mandatory attendance at California Speedway	September 27, 2005
<u>Step III</u> - National Qualification Event	Semifinalists participate	September 27– October 6, 2005
Announcement of 20 teams selected for Grand Challenge Event (finalists)	Based on results from National Qualification Event	October 6, 2005
Meeting with all finalist team leaders	Mandatory attendance near departure area	October 7, 2005
Grand Challenge Event	Finalists participate	October 8, 2005

## 2. Eligibility

### 2.1 Team Membership

A team is comprised of the individuals identified to DARPA on the team roster. Only these individuals are *team members* (see definition, p.[30](#)). Each team must designate a single individual to serve as the team leader. The team leader must be at least 21 years of age and must hold US citizenship on the date of application to the Grand Challenge, and must remain a citizen for the duration of the Grand Challenge. Proof of US Citizenship for the team leader must be provided with the application as described in the application instructions. DARPA representatives will verify these documents at the *site visit* (see definition, p.[29](#)).

For each team, the team leader will serve as the primary point of contact with DARPA. The team leader must sign the application, must provide a notarized signature on the *Certification of Team Funding and Support* (see definition, p.[25](#)) and *Site Visit Liability Statement* (see definition, p.[29](#)), and must be present at the site visit, the National Qualification Event (NQE), and the Grand Challenge Event. The team leader will specify the team members and will determine the disposition of the prize should the team be successful. An individual may be the leader of only one team but team members may serve on multiple teams.

Team leadership may be transferred from the team leader to another eligible individual; there may be only one team leader at any time. Transfer of team leadership occurs when DARPA receives a notarized *Change of Team Leader* form. The form is available from DARPA and must be signed by the existing team leader and the new team leader. The new team leader must also submit proof of

citizenship, a notarized Part 2B (Certification of Team Funding and Support), and a notarized Part 5B (Site Visit Liability Statement).

Although the number of individuals listed on the team roster is not expressly limited, DARPA will impose a limit on the number of team members allowed into designated areas at the NQE and the Grand Challenge Event. DARPA will communicate the limit to the team leaders upon notification of selection.

## **2.2 Non-US Participation and Sponsorship**

Individuals holding foreign citizenship are eligible to participate in the Challenge on teams with a team leader who is a US citizen. Foreign corporations and non-governmental organizations may participate as *team sponsors* (see definition, p.[30](#)). Teams receiving funding or any form of support from foreign *governments* (see definition, p.[26](#)) or foreign governmental organizations are not eligible to participate.

## **2.3 US Federal Government Organization Participation**

US Government organizations and agencies are ineligible to participate as team sponsors. However, individuals who are employed by these organizations and agencies, including US Government employees, may participate as team members as long as they do so outside their official responsibilities and not as part of any work-related duty or assignment. US Government travel funds or US Government work-related travel may not be used to support a Grand Challenge team.

## **2.4 Team Funding and Support**

The cost of developing, fielding, and insuring entered vehicles is the sole responsibility of the individual teams. DARPA will not provide funding for the purpose of Grand Challenge entry or participation.

Each team leader must sign and submit a notarized Certification of Team Funding and Support. This document contains the following certifications:

1. No funding used in the design, development, construction, or operation of the vehicle has been or will be charged to a grant, contract, or other transaction from the government, either directly through such work or indirectly through government-reimbursable research and development, government-funded (see definition, p.[27](#)) Independent Research and Development (IR&D), overhead, or general and administrative accounts (known as G&A in the US). This restriction includes funding to pay for labor, travel, equipment leases, or other services that are applied directly to the design, development, construction, or operation of the Challenge vehicle.

2. No portion of the software or hardware used on the vehicle, including the vehicle itself, has been or will be paid for, wholly or in part, using government funding. This exclusion does not apply to government-funded software or hardware that is commercially available (see definition, p.25) or openly available (see definition, p.28) to all teams on June 8, 2004, and through the duration of the Grand Challenge.
3. No patented invention that was developed under government funding is part of the vehicle unless the patented invention is commercially available or is openly available to all Grand Challenge teams on June 8, 2004, and through the duration of the Grand Challenge.
4. Government-owned equipment or facilities have not been used and will not be used in the design, development, or operation of the vehicle unless the equipment or facilities are available to all teams.

This certification does not prohibit:

- the use of government-sponsored information such as Global Positioning System (GPS) signals, cartographic products, or government-developed numerical software routines that are openly available
- the use of any technologies that are commercially available to all teams
- the use of facilities, services, or equipment supplied by DARPA to teams for Grand Challenge
- the use of paid vacation time by US government employees and contract employees to support a Challenge team

### **3. Challenge Vehicle Requirements**

#### **3.1 Autonomous Vehicle Behavior Requirement**

Participating vehicles must demonstrate fully autonomous behavior and operation at all times during the NQE and Grand Challenge Event. Vehicles must be unmanned, and no animals are permitted onboard.

#### **3.2 Vehicle Limitations**

The entry must be a ground vehicle that is propelled and steered principally by traction with the ground. The type of ground contact devices (such as tires, treads, and legs) is not restricted. The vehicle must not damage the environment or infrastructure at the NQE or along the Grand Challenge route. Vehicle operation must conform to any regulations or restrictions imposed by the applicable land-use authority.

The vehicle must be able to pass through any underpasses encountered on the route. The clear opening of the smallest underpass will measure no less than 10 feet in width and 9 feet in height. Maximum vehicle weight is 20 tons; any team whose vehicle weighs more than 10 tons must provide its own off-road recovery

capability. The vehicle must be able to travel on asphalt pavement without damaging the pavement surface.

### **3.3 Classified Data and Devices**

No classified data or devices may be used by a team in preparation for or during the Grand Challenge.

### **3.4 Tethered Vehicle Systems**

Only individual, independent, untethered ground vehicles are eligible to participate in the Grand Challenge.

A system comprising a single ground vehicle and one or more subsystems (such as sensors) that are physically tethered to that ground vehicle is permitted provided that the tethered subsystems are not propelled or maneuvered independently of the ground vehicle (as would, for example, an aircraft or steerable balloon or kite). Tethered subsystems that are specifically permitted include those that (1) are rigid, telescoping, or on an articulating mast; and (2) move only in response to relative wind and vehicle motion, such as balloons or kites. Tethered subsystems that are designed to extend more than 10 feet above the surface must be painted so as to enhance their visibility to helicopter pilots that may need to land near a Challenge vehicle. Entrants are advised that the Federal Aviation Administration, particularly in 14 CFR 101, regulates the operation of moored (tethered) balloons. Entrants are advised that the route may be adjacent to utility and power structures and high-voltage power lines.

### **3.5 Vehicle Identification Number**

Each *semifinalist* (see definition, p.[29](#)) team will be assigned a unique identification number that shall be displayed on its vehicle at least 12 inches in height on its sides, front, back, and top. The number should be either black or white and have a solid background that extends at least 3 inches larger than the number. The color of the background should contrast with the number such that the number is clearly visible and distinguishable from other signage or symbols on the vehicle. A vehicle that can operate when flipped over shall also display the number on its underside.

Teams are allowed to obtain sponsorships and to display advertising if such advertisements are not considered inappropriate by the *Officials* (see definition, p.[28](#)). The DARPA Grand Challenge 2005 logo may be displayed on each vehicle.

## **3.6 Vehicle Safety**

DARPA makes no representation as to the safety of any vehicle entered in the Grand Challenge notwithstanding any rule or the acceptance by DARPA of any application document, *vehicle specification sheet* (see definition, p.31), video demonstration, or any inspection or demonstration required as a condition of participating in the Grand Challenge.

### *3.6.1 Radiated Energy Safety Standards*

#### *3.6.1.1 Laser Safety Standards*

All parties are directed to [OSHA 29 CFR 1926.54](#) and [OSHA Technical Manual \(TED 1-0.15A\), Section III - Chapter 6](#) (1999, January 20) for relevant laser safety standards. Challenge vehicles must comply with all applicable local, state, and federal laser safety regulations.

#### *3.6.1.2 RF Radiation Standards*

All parties are directed to [OSHA 29 CFR 1910.97](#) (Non-ionizing Radiation) and [Department of Defense Instruction 6055.11](#) (1995, February 21) for relevant RF safety standards. All Challenge vehicles must comply with all applicable local, state, and federal RF safety regulations.

#### *3.6.1.3 Acoustic Safety Standards*

All parties are directed to [OSHA 29 CFR 1910.95](#) (Occupational Noise Control) and [OSHA Technical Manual \(TED 1-0.15A\), Section III - Chapter 5](#) (1999, January 20) for relevant acoustic safety standards. All Challenge vehicles must comply with all applicable local, state, and federal acoustic safety regulations.

### *3.6.2 Wireless Emergency Stop (E-stop) Units*

DARPA will supply each semifinalist team one government-owned E-stop system consisting of a controller and a vehicle receiver. It is the sole responsibility of the team to properly install the E-stop system in its vehicle. Detailed specifications for the integration of the E-stop system will be provided on the Grand Challenge website. Limited technical assistance for this installation will be available. DARPA shall not, however, incur any liability from the semifinalist's use of this technical assistance. Use of this technical assistance is solely at the discretion of the team leader.

Semifinalists have 10 calendar days following receipt of the E-stop to notify DARPA that the unit is damaged or otherwise not in working condition. After that period, the semifinalist assumes responsibility for the E-stop, and DARPA will not be responsible for repairs to the E-stop or replacement of damaged units.

DARPA reserves the right, solely within its discretion and assuming equipment availability, to provide the team with a replacement unit. Each E-stop must be fully functional for the semifinalist to be eligible to participate in the NQE and Grand Challenge Event.

Each team shall return its E-stop to DARPA within 24 hours from the date of any of the following events:

- The vehicle is eliminated from participation in the Grand Challenge
- The vehicle is disqualified from the Grand Challenge
- The vehicle is withdrawn from the Grand Challenge
- Completion of the Grand Challenge

If any of these events occur during the NQE or Grand Challenge, the equipment shall be returned to the proper DARPA official on-site.

The E-stop system has three modes: a RUN mode, a PAUSE mode, and a DISABLE mode. Teams must integrate the E-stop equipment so that the vehicle responds to the E-stop outputs as follows:

- E-stop RUN mode enables the vehicle for autonomous movement.
- E-stop PAUSE mode brings the motion of the vehicle to a prompt stop, with brakes applied to hold the vehicle even if it is on a slope. The vehicle should be ready to resume forward motion when the E-stop re-enters RUN mode.
- E-stop DISABLE mode brings the vehicle to a prompt halt and shuts down all propulsion systems while actively applying and maintaining the brakes.

Specifications regarding size, weight, power, output voltage, current, connectors, and other relevant details will be furnished to semifinalists.

The required integration of the E-stop system enables the E-stop PAUSE mode to be cycled on or off so that the vehicle can be stopped and resumed during the Challenge. The E-stop DISABLE mode should be latched so that its state cannot be changed after initiation except by a manual unlatch switch.

The vehicle and its systems must not interfere with the proper functioning of the E-stop device. A demonstration of the wireless E-stop capability is required as part of the NQE.

Teams should anticipate that their vehicle may receive the E-stop PAUSE signal numerous times during the Grand Challenge Event, and that the duration of any individual E-stop PAUSE event may be as long as several hours. Teams should ensure that all electrical connections to the E-stop are ruggedized and tested to provide assured electrical connectivity after exposure to adverse (damp or dusty) environmental conditions and a high vibration environment.

### *3.6.3 Manual Emergency Stop Unit*

Each vehicle must be additionally equipped with an externally-actuated manual emergency stop capability. Activating the manual emergency stop must promptly bring the vehicle to a complete halt in the E-stop DISABLE mode. At least one actuator and its labeling must be easily visible and accessible from anywhere around the vehicle. The manual emergency stop must be easy to identify and activate safely, even if the vehicle is moving at a walking pace. The operation instructions for manual emergency stop actuators must be clearly labeled in English and Spanish. The instructions must not be interfered with by any other labeling or advertising. A demonstration of the manual emergency stop capability is required as part of the NQE.

### *3.6.4 Warning Devices*

Each vehicle shall be equipped with audible and visual alarms that are activated according to the state of the E-stop system. The following is a summary of the required behavior of the alarms.

- E-stop RUN mode: Audible alarm on. Visual alarm on.
- E-stop PAUSE mode: No audible alarm. Visual alarm on.
- E-stop DISABLE mode: No audible alarm. No visual alarm.

#### *3.6.4.1 Audible Warning–Vehicle Operating*

Each vehicle shall produce an intermittent warning sound when, and only when, the vehicle is in E-stop RUN mode. The vehicle may not commence movement until the warning sound has been in operation for 5 seconds.

The warning sound shall produce at least 85 dBA at 10 feet in front of the vehicle, and shall be loud enough to be clearly heard over the normal vehicle engine noise. The audible warning shall not produce sounds that can be confused with those of public-safety vehicles such as law-enforcement, fire, or ambulance.

#### *3.6.4.2 Visual Warning–Vehicle Operating*

Each vehicle shall display one or more flashing amber warning lights, the combination of which results in visibility 360 degrees azimuthally around the vehicle. The warning light shall operate when, and only when, the vehicle is in E-stop RUN or E-stop PAUSE mode. The vehicle may not commence movement until the warning light has been in operation for 5 seconds.

The warning light(s) shall comply with SAE Class 1 standards for warning lights and shall not produce light(s) than can be confused with those of public safety vehicles such as law enforcement, fire, or ambulance.

### 3.6.4.3 Visual Warning–Vehicle Brake

Each vehicle shall display two or more steadily illuminated red warning lights on the rear of the vehicle and visible within a 90-degree cone that illuminates when, and only when, the vehicle's dynamic braking system (not the parking brake) is activated. The purpose of this light is to indicate that the vehicle is braking. The placement of this light should be mounted high and sufficiently distant from the flashing amber warning lights to permit rapid recognition.

## 3.7 Towing Requirements

Each vehicle must be designed to facilitate removal from the route should the vehicle be disabled. The vehicle must have tow points front and rear, or if the vehicle design precludes towing, the vehicle must have hoist points. Wheeled or tracked vehicles must have a free-wheel mechanism that enables the wheels or tracks to spin freely in order to enable towing. The free-wheel mechanism must be readily accessible and clearly marked.

## 3.8 Position Determination Signals

Challenge vehicles may be equipped to receive and process electronic position-determination signals (such as GPS) that are openly or commercially available to all teams. Position-determination signals that are neither openly available nor commercially available to all teams are prohibited.

## 3.9 Wireless Signal Restrictions

All computing, intelligence, and sensor processing must be contained onboard the vehicle while on the NQE course or the Challenge route. Apart from the control and tracking signals from DARPA-provided systems and openly or commercially available navigation signals, the emission or reception of communication signals is prohibited.

On-board wireless connections are prohibited. A vehicle may emit and receive signals to sense the environment. Vehicles may record video or other data on-board for review after the conclusion of the event. Any data recorded on the NQE course may not be shared among teams until the conclusion of the NQE. Any data recorded during the Grand Challenge Event may not be shared among teams until all vehicles have finished the route or have been disqualified.

Any wireless system used for vehicle movement or testing must be disconnected prior to the *departure signal* (see definition, p.[26](#)) at the NQE and Grand Challenge Event. The wireless hardware must be easily accessible and capable of being inspected. This includes systems for monitoring, control, or intra-vehicle communication.

### **3.10 Vehicle Cooperation**

Cooperation of any kind among vehicles on the NQE course or the Grand Challenge Event route is prohibited.

### **3.11 Environmental Impact**

Any aspect of vehicle activity or operation that has an unacceptable impact on the environment is prohibited. These activities include destructive vehicle behavior, the use of abnormally hazardous substances or materials, and generally reckless operation. Potentially hazardous equipment or activities must be identified to DARPA for review in the vehicle specification sheet and at the site visit.

### **3.12 Pre-Challenge Testing**

Testing of Challenge vehicles or components is the sole responsibility of each team. The use of public lands for this purpose is at the team's own risk and must be in accordance with applicable local, state, and Federal guidelines.

## **4. Application Procedure**

### **4.1 Basic Requirements**

Applications will be accepted beginning August 14, 2004. There is no fee for entry.

World Wide Web access, e-mail access, and basic word processing are necessary to complete and submit the application and for communication with the DARPA Grand Challenge staff.

The application consists of five parts:

- Part 1: Team Information
- Part 2: Additional Information and Certification of Team Funding and Support
- Part 3: Vehicle Specification Sheet
- Part 4: Video Demonstration
- Part 5: Site Visit Agreement

Instructions for obtaining Grand Challenge application materials and for proper submission are on the Grand Challenge [website](#).

All parts of the application must be received at DARPA before the specified deadlines for a team to become eligible for participation in the Grand Challenge.

Materials received after their respective deadlines will not be considered, and will be destroyed by DARPA.

Application Parts 1 and 2 must be received by DARPA no later than 5:00 PM EST on February 11, 2005.

Application Parts 3, 4, and 5 must be received by DARPA no later than 5:00 PM EST on March 11, 2005.

## **4.2 Submission Procedures**

Application documents must be submitted using the transmittal instructions on the forms. The receipt of application documents will be promptly acknowledged by DARPA. Delivery information and official time of receipt will be recorded as follows:

Application materials remitted using US Postal Service, courier, or overnight delivery service should be addressed to:

DARPA  
Attn: Grand Challenge  
3701 N. Fairfax Drive  
Arlington, VA 22203-1714

The time of receipt for each package will be logged as recorded in the DARPA mailroom.

E-mailed application materials should be addressed to:

[GCapplication@darpa.mil](mailto:GCapplication@darpa.mil)

The time of receipt for each document will be logged by the DARPA e-mail system.

## **4.3 Additional Materials**

DARPA may request additional information from the teams after the receipt of the application materials. Examples of additional required information include an updated team roster, photographs of the Challenge vehicle, and a photograph of the team.

## **4.4 Team Promotional Material**

Contact information for each team including team leader name, team e-mail address, and team URL will be posted on the Grand Challenge [website](#) to enable contact from potential sponsors, other teams, and media. Promotional materials

provided by the teams such as the team description paragraph, team sponsor list, team picture and vehicle picture will also be published on the [website](#). Following the conclusion of the Grand Challenge Event, team *technical papers* (see definition, p.[30](#)) will also be published on the [website](#).

## 5. Qualification Process

### 5.1 Overview

All steps of the qualification process must be completed by teams that wish to compete in the Grand Challenge Event. A team that has submitted parts 1 and 2 of the application by the deadline and has received acknowledgement from DARPA becomes a Grand Challenge entrant. A team must submit parts 3, 4, and 5 of the application by the deadline in order to remain an entrant. A team selected for the NQE become a semifinalist, and a team selected for the Grand Challenge Event is a *finalist* (see definition, p.[26](#)).

### 5.2 Selection for Site Visit

DARPA will review each team's *video demonstration* (see definition, p.[31](#)) and vehicle specification sheet submitted as part of the application. Applications will be evaluated on the basis of:

- Conformance with the rules
- Possession of a vehicle
- Possession of sensor equipment
- Possession of navigation equipment
- Capability of vehicle to complete the Grand Challenge Event route
- Demonstration of navigation and sensor capabilities necessary for completion of the Grand Challenge.

Instructions for the Video and the vehicle specification sheet are provided on the application form available on the Grand Challenge [website](#).

On April 4, 2005 DARPA will notify all teams of the results of the review process based on the vehicle specification sheet and video demonstration. Selected entrants will be notified of DARPA's intent to conduct a site visit. Only teams selected for a site visit will continue as Grand Challenge entrants.

### 5.3 Site Visit Procedure

Site visits will take place at an appropriate testing location in the United States specified by the entrant. The Site Visit Liability Statement (Part 5B of application) must be on file with DARPA before a site visit can be scheduled. Because of scheduling limitations, mandatory schedule dates and times will be set by DARPA. If rescheduling is necessary due to DARPA's inability to keep the

primary scheduled meeting, DARPA will work with the team to find a mutually agreeable new date. Inability to find a mutually agreeable new date may result in removal from further participation. Site visits are scheduled to take place May 2–15, 2005, with backup days May 16–21, 2005.

The team leader and vehicle must be present at the site visit. The inspection team will verify the proof of US citizenship of the team leader. Site visit guidelines will be available on the Grand Challenge [website](#).

Based on the results of the site visits, DARPA will select and invite teams to participate in the NQE. Teams that accept this invitation must submit a technical paper describing their vehicle. Teams that are not selected are no longer eligible for participation in DARPA Grand Challenge 2005.

#### **5.4 Technical Papers**

A technical paper describing the vehicle of each semifinalist must be received at DARPA by August 15, 2005. A description of the subjects that must be addressed in the technical paper will be available on the Grand Challenge [website](#). DARPA will withhold the technical papers until the conclusion of Grand Challenge 2005, at which time the papers will be made available to the public.

Other than the required technical paper and information already in the public domain, DARPA will not publicly release information regarding a team's technical approach without permission from the team leader.

DARPA claims no intellectual property (IP) rights from entrants, semifinalists, finalists, or the *winner* (see definition, p.31). All trade secrets, copyrights, patent rights, and software rights will remain with each respective team.

#### **5.5 National Qualification Event (NQE)**

The NQE will be held September 27, 2005 to October 6, 2005 at the California Speedway in Fontana, California. A detailed schedule will be published on the Grand Challenge [website](#) and instructions for semifinalists will be distributed.

Semifinalist teams will transport their vehicles to the California Speedway on September 27, 2005 for team check-in and the NQE start.

##### *5.5.1 Static Inspection*

The first phase of the NQE is a static technical and safety inspection of all vehicles to ensure compliance with all rules, to verify the details of vehicle operation described in the vehicle specification sheet, and to ensure safe vehicle operation. Any deviations will be identified to the team leader for immediate

action to bring the vehicle into compliance. If a vehicle cannot be brought into compliance it may be disqualified.

### *5.5.2 Demonstration*

The NQE is used to select finalists to compete in the Grand Challenge Event. Teams are given two opportunities on the NQE course. Additional opportunities are at the discretion of DARPA. A team's final score is derived from its best two attempts.

Vehicle control procedures, autonomous vehicle requirements, and the route definition will be based upon those of the Grand Challenge Event. Details are provided in section 6.

### *5.5.3 Restrictions on Vehicle Operation*

Operation of semifinalist vehicles is limited to DARPA-specified events and operation within DARPA-specified practice areas from the first day of the NQE until the vehicle is returned to the team.

Vehicles that may be selected as Grand Challenge finalists must remain at the NQE until October 6, 2005. Teams that choose not to participate in the Grand Challenge Event may remove their vehicles at any time. Teams may petition DARPA if major repairs are needed that require expertise that is only available offsite.

### *5.5.4 Security*

#### *5.5.4.1 Access Control*

Grand Challenge semifinalist teams and DARPA-accredited *media representatives* (see definition, p.[27](#)) will be issued access-control passes that are required for entry into controlled areas at the NQE.

#### *5.5.4.2 Team Security*

DARPA will control access to the garage area at the NQE but DARPA assumes no responsibility for the security of team equipment or supplies.

### *5.5.5 General Safety*

A Safety Standard Operating Procedures (SOP) Manual will be distributed to each semifinalist team prior to the NQE. The SOP will provide specific instructions for the administration of activities as well as emergency procedures and instructions for handling other contingencies. Compliance with the SOP is

mandatory whenever the team or its vehicle is within DARPA-controlled areas. Failure to comply with the SOP may result in disqualification.

## **6. Grand Challenge Event**

On October 6, 2005, each finalist team will transport its vehicle to the Grand Challenge *departure area* (see definition, p.[26](#)) to make final preparations for the Grand Challenge Event. On October 7, 2005, DARPA will host a meeting with teams to make final preparations for the start. The time and place for this meeting will be provided to the finalists at the NQE.

Each team will receive a compact disc (CD) containing the RDDF at least 2 hours prior to the start of the event.

The first vehicle starts the route after first light on October 8, 2005.

DARPA maintains control of all vehicles for safety and operational purposes using the E-stop system. While vehicles are on the route, DARPA officials follow each vehicle in a dedicated *control vehicle* (see definition, p.[25](#)) equipped with an E-stop transmitter.

### **6.1 Departure Area**

When instructed to do so, each team must move its vehicle promptly to the *start chute* (see definition, p.[29](#)). Challenge vehicles start in sequential order at specified time intervals. Start order is announced at the end of NQE.

Each vehicle must be enabled for autonomous operation within 5 minutes after entering the start chute. Vehicles must be prepared to wait in E-stop PAUSE mode in the start chute for up to 1 hour without manual intervention.

Before each start, an official places the vehicle in E-stop PAUSE mode. At the designated start time an official switches the E-stop from PAUSE to RUN and the vehicle must depart the start area promptly after the mandatory 5 second delay for the audible alarm.

### **6.2 Vehicle Control**

An official may place any vehicle in E-stop PAUSE mode for safety or operational reasons. The official later returns the vehicle to E-stop RUN mode so that it may continue. Time spent in E-stop PAUSE mode does not contribute to a team's corrected time.

If a vehicle does not progress within 10 minutes of resuming E-stop RUN mode, it may be disqualified.

If dangerous or destructive behavior by a vehicle is imminent, an official places the vehicle in E-stop PAUSE mode and the vehicle may be disqualified. If necessary to stop it, the official places the vehicle in E-stop DISABLE mode.

DARPA will take measures to stop a vehicle that does not respond to an E-stop command, even if these measures may result in damage to the vehicle.

### 6.3 Challenge Route

A team may not intervene in any aspect of vehicle operation or participate in vehicle tracking from the time the vehicle clears the start chute until it is returned to the team. A vehicle is returned to the team after it is disqualified from the event or after it clears the *arrival line* (see definition, p.[25](#)) and is inspected. Refueling of vehicles is not permitted.

Teams may not operate any ground vehicles or position any team members along or near the route during the Grand Challenge Event except at designated viewing areas.

Each vehicle must remain within the route boundary from its departure from the start chute to its arrival at the last *waypoint* (see definition, p.[31](#)).

If a vehicle is in E-stop RUN mode and the vehicle does not progress for longer than 10 minutes, it may be disqualified.

If DARPA officials determine that it is not possible for a vehicle on the route to finish in less than 10 hours while traveling at the maximum speed limit over the remaining segments of the route and allowing the vehicle to continue would hinder Grand Challenge operations, the vehicle may be disqualified.

#### 6.3.1 Route Definition

The route definition data file (RDDF)(see definition, p.[29](#)) is the official definition of the route and defines the corridor through which all vehicles are required to travel. The RDDF contains *waypoints*, *lateral boundary offsets* (LBO)(see definition, p.[27](#)), and maximum speed limits. Vehicles may traverse any area within the route boundary but must detect and avoid obstacles therein. Navigability directly along the track line connecting successive waypoints is not guaranteed; vehicles must determine for themselves the best way to travel from one waypoint to the next while staying within the lateral boundaries.

Vehicles encounter the first waypoint after departing the start chute. The last waypoint is beyond the arrival line.

The LBO is specified from any point on a *track line* (see definition, p.[31](#)) and applies to the route segment defined by the associated waypoint to the next

sequential waypoint. Boundaries may be marked with concrete barriers, plastic snow fencing, or by other similar means along limited portions of the route. Any vehicle that leaves the route may be disqualified.

A maximum speed limit is specified for each segment of the route. Any vehicle that exceeds the speed limit may be disqualified. A specified speed limit does not imply that it is a safe or achievable speed. Speed limits are specified in the RDDF and apply to the route segment defined by the associated waypoint to the next sequential waypoint. Between the start chutes and the first waypoint, vehicles may not exceed the speed limit of the first route segment. In the area where two route segments overlap, the least restrictive (i.e., higher) speed limit applies.

### 6.3.2 RDDF Format

The RDDF is a comma-delimited text file distributed on a PC-formatted CD and contains the following data fields: the number of each waypoint, the latitude of each waypoint, the longitude of each waypoint, the lateral boundary offset of each segment (feet), and the maximum speed of each segment (mph).

Each waypoint marks the start of a segment. The first waypoint is number 1 and subsequent waypoints follow in sequence. Latitude and longitude are specified in decimal degrees with seven decimal places. The applicable datum is WGS 84. The accuracy of the waypoint locations is +/- 15 cm. The 7<sup>th</sup> decimal figure does not connote an additional degree of accuracy. Segments with unspecified maximum speed are indicated by 999.

The following are sample RDDF lines:

WP_NUMBER	WP_LAT	WP_LON	LBO	MAX_SPEED
1	38.2228914	-110.4790771	20	10
2	38.2224215	-110.4793187	20	55
3	38.2216479	-110.4799700	30	55

The above data would be formatted in the RDDF as:

```
1,38.2228914,-110.4790771,20,10  
2,38.2224215,-110.4793187,20,55  
3,38.2216479,-110.47997,30,55
```

### 6.4 Obstacles

The vehicle must avoid collisions with any obstacle, moving or static, on the route. DARPA will place obstacles along the route to test obstacle avoidance capabilities. Vehicles that collide with any other vehicle or obstacle along the

route may be disqualified. Incidental or non-damaging contact with obstacles may not result in disqualification.

## **6.5 Intentional Interference and Damage**

Intentional interference with other vehicles is prohibited. Intentional interference is any activity that, in the opinion of the Chief Judge, is intended to degrade another vehicle's ability to compete.

Any team responsible for the intentional damage of property that does not belong to that team may be disqualified. Intentional damage includes damage that occurs as a result of failure to prevent damage that could have been foreseen and includes damage that adversely and materially affects the performance of another team. The Chief Judge will have the final say in all matters involving damage.

## **6.6 Improper Vehicle Contact**

A team may not make or cause physical contact with its vehicle after it has departed the start chute and before it is returned to the team. Contact with the vehicle may be permitted if the vehicle has been disqualified or overnight procedures have been enacted as determined by the officials. Physical contact includes indirect contact with tools and human-initiated contact using remotely controlled or electronic equipment.

## **6.7 Jettisoning Material on the Route**

Except for normal byproducts of power generation, the intentional jettison of any material from a vehicle is prohibited and may result in disqualification. If a portion of a vehicle unintentionally falls from the vehicle while on the route, DARPA will notify that team, and the team is responsible to recover such debris once all qualified vehicles have cleared the affected area.

A smokescreen or any other obscurant intentionally discharged from a vehicle is specifically prohibited.

## **6.8 Passing**

DARPA officials determine when and where vehicles pass.

No vehicle may intentionally operate to hinder another vehicle that is trying to pass it. The overtaking vehicle has the burden of responsibility for collision avoidance and must remain within the route boundary.

If the width of a route segment is sufficient for passing, DARPA officials may place a slow moving (impeding) vehicle in E-stop PAUSE mode to allow a faster

(overtaking) vehicle to pass with its associated control vehicle. The overtaking vehicle must sense all stopped vehicles and navigate around them.

If the width of a route segment is insufficient for passing, and the impeding vehicle is moving, a DARPA official places the overtaking vehicle in E-stop PAUSE mode until there is sufficient room to pass.

If the width of a route segment is insufficient for passing and a vehicle is immobile and blocking the route such that no other vehicles can pass, DARPA officials place any approaching vehicles in E-stop PAUSE mode until the route is clear.

## **6.9 Overnight Operations**

If necessary, the event will continue beyond October 8, 2005. DARPA will distribute procedures for overnight operations that address corrected time computation, vehicle shut down and restart, security, and safety.

## **6.10 Arrival Area**

After a vehicle crosses the arrival line it is impounded for an inspection. Teams may not interact with their vehicle until it is released by a DARPA official.

## **6.11 Corrected Time**

*Elapsed time* for each vehicle begins at the departure signal and ends when the entire vehicle clears the arrival line from the direction of the previous waypoint. Elapsed time will not be maintained for disqualified vehicles.

Corrected time is computed by subtracting corrections for time spent in E-stop PAUSE mode from the elapsed time.

A vehicle must have a corrected time of 10 hours or less to be eligible for the prize.

## **6.12 Disqualification**

A disqualified vehicle may not continue on the route. DARPA will coordinate with the team to recover the vehicle from the route. Teams will enter the route area only when so directed by DARPA officials.

## **Appendix**

### **Definitions**

#### *Arrival Area*

The arrival area is that area behind the arrival line, and within the boundaries designated for that purpose. The arrival area is not part of the route.

#### *Arrival Line*

The arrival line is a line near the last waypoint that will cross perpendicular to the final track line. The elapsed time for a vehicle is taken when a vehicle has completely cleared the arrival line.

#### *Certification of Team Funding and Support*

Applicants are required to sign and submit a notarized document stating that no aspect of the design, development and construction of a team's vehicle is government-funded. Forms are available on the Grand Challenge [website](#) as part of the application.

#### *Chief Judge*

The Chief Judge is the official designated by the DARPA Director as such. The Chief Judge is the final authority on all matters referred to in the rules, and on all matters affecting the operation of the Grand Challenge that are not explicitly referred to in the rules.

#### *Commercially Available*

Commercially available refers to services or materials that are sold, leased, or licensed to the general public.

#### *Control Vehicle*

A control vehicle (CV) follows each vehicle while on the Grand Challenge route. This enables a DARPA official to control each vehicle for safety and operational purposes. Team members do not occupy control vehicles during the Grand Challenge.

#### *Corrected Time*

See page [24](#).

### *Departure Area*

The departure area is that area behind the departure line, and within the boundaries designated for that purpose. The departure area is not part of the route.

### *Departure Line*

The departure line is near the first waypoint and perpendicular to the first track line. It defines part of the boundary of the departure area.

### *Departure Signal*

The departure signal is given sequentially to each vehicle by enabling it for operation via the RUN mode on the E-stop system.

### *Elapsed Time*

See page [24](#).

### *Entrant*

An entrant is a team that meets the eligibility requirements and has satisfactorily submitted parts 1 and 2 of the application (receipt of which has been acknowledged by DARPA). A team not selected for a site visit, to participate in the NQE, or to participate in the Grand Challenge Event ceases to be an entrant but may attend the Grand Challenge as a spectator.

### *Finalist*

A finalist is a semifinalist selected by DARPA after the NQE to compete in the Grand Challenge 2005 Event on October 8, 2005.

### *Government*

For purposes of these rules, government refers to national or international governing bodies and all official agencies that are directly responsible to them. It includes the US Government, all US military organizations, the European Union, and all other foreign governments and foreign government agencies. Government explicitly does not refer to sub-national organizations such as state or local governments.

### *Government Funding*

Government funding refers to compensation in the form of salary or travel expenses and any other form of funding, supplies, equipment or reimbursement that is paid for by national or international government direct contractual efforts or through any form of overhead account, Independent Research and Development (IR&D), General and Administrative (G&A) 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 or international governmental organizations, whether located in the United States of America or in any other country or territory.

### *Grand Challenge*

The Grand Challenge (also “DARPA Grand Challenge” and the “Challenge”) refers to the Grand Challenge Event and the entire qualification process including the National Qualification Event.

### *Grand Challenge Event*

The Grand Challenge Event (also “the event”) is the culminating field test of the Grand Challenge, scheduled to start on October 8, 2005.

### *Grand Challenge Website*

Application forms and the most authoritative and up-to-date information about the DARPA Grand Challenge can be obtained at the URL:  
<http://www.darpa.mil/grandchallenge>.

### *Lateral Boundary Offset*

The lateral boundary offset (LBO) is the distance in any direction from the track line (including a radius at the end points) that defines the corridor in which vehicles are permitted to travel. The width of this corridor will vary according to safety, environmental, and passing considerations.

### *Media Representative*

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

### *National Qualification Event*

The National Qualification Event (NQE) is the final qualification stage in the Grand Challenge and will be held with a limited field of contestants at the California Speedway in Fontana, California. It will feature a course that measures and tests vehicle capabilities. Semifinalists will attend the NQE and vie for selection for the Grand Challenge Event.

### *Official*

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

### *Openly Available*

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

### *Prize*

The \$2 Million prize that will be awarded to an eligible and qualified finalist team whose vehicle completes the route in the shortest corrected time under 10 hours.

### *Qualification Process*

The qualification process refers to the sequence of steps a team must successfully complete to be selected for the Grand Challenge Event. This includes submission of the application, submission of an acceptable vehicle specification sheet and video demonstration, successful performance at the site visit, selection for the National Qualification Event, submission of an appropriate technical paper and successful performance at the NQE.

### *Route*

The route (also “Challenge route”) consists of a departure line, an arrival line, a lateral boundary offset, and a set of waypoints. The route is the area included within boundaries specified by DARPA in the route definition data file (RDDF). The route does not include the start chute or the arrival area.

### *Route Definition Data File*

The route definition data file (RDDF) specifies the official Challenge route. The RDDF is a comma-delimited text file distributed on a PC-formatted CD. Data fields will include waypoint number, waypoint latitude, waypoint longitude, lateral boundary offset, and speed limit.

### *Rules*

The rules posted on the Grand Challenge [website](#) are the official governing set of regulations and guidelines of the DARPA Grand Challenge 2005. The Chief Judge is the final authority on all rules and all aspects of the DARPA Grand Challenge 2005.

### *Semifinalist*

A semifinalist is a team that has completed the application process, has received a site visit, and has been selected by DARPA to participate in the National Qualification Event.

### *Site Visit*

Based upon a technical review of the vehicle specification sheet and the video demonstration, DARPA will select entrants for a site visit. One or more officials appointed by DARPA will meet with the team leader and team members at a location within the United States specified by the team leader, at a date and time specified by DARPA. The site visit will be used for inspection and demonstration of the vehicle capabilities.

### *Site Visit Liability Statement*

Team leaders are required to sign, have notarized, and send to DARPA a document stating that: 1) the location chosen for the site visit complies with all DARPA site visit specifications; 2) the team holds harmless and indemnifies the U.S. Government and its employees, and Grand Challenge contractors and their employees for all claims of liability arising from the site visit; and 3) the test location, test vehicle, and test activities are in compliance with federal, state, and local laws and regulations. Forms are available on the Grand Challenge [website](#) as part of the application.

### *Start Chute*

The start chute is an area at the NQE and Grand Challenge Event directly behind the departure line. A team must place its vehicle in the start chute prior to enabling it for autonomous operation.

### *Spectator*

A spectator is any person who is not a semifinalist, finalist, official, or media representative. During the National Qualification Event and Grand Challenge Event, areas will be designated for spectators.

### *Team*

A team (also “Challenge team”) comprises two parts: a qualified team leader and any other individuals who have been appropriately designated by the team leader as team members in the application. Corporations or other organizations may participate as sponsors only. Team members may contribute their individual labor, individually-owned materials and equipment, and individual funds to a team. Individuals holding foreign citizenship may participate only as members of a team led by a US citizen. Modifications to the team roster may be submitted to DARPA with submission of the technical paper.

### *Team Leader*

A team leader is the individual US Citizen identified to DARPA during the application process responsible for the following: primary point of contact for team communication with DARPA, signatory of the Certification of Team Funding and Support, signatory of the site visit Agreement, presence at all stages in the Qualification process, and identification of prize disposition (should the team be successful).

### *Team Member*

A team member (also “Challenge team member”) is a team leader or individual who has been pre-designated by the team leader as a team member in the application process.

### *Team Sponsor*

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

### *Technical Paper*

A formal document describing the engineering details of the vehicle design and operation, a technical paper is required for all teams selected for the NQE. Final versions of these Papers will be published on the DARPA Grand Challenge [website](#) following the conclusion of the event for purposes of information interchange. Information on technical paper

content and required format will be available on the Grand Challenge [website](#).

### *Track Line*

The track line is a straight line from the center of a specific waypoint to the center of the next sequential waypoint.

### *Vehicle*

A vehicle (also “Challenge vehicle”) is the fully autonomous ground vehicle system that has been entered by a team for the Challenge.

### *Vehicle Specification Sheet*

The vehicle specification sheet is a mandatory part of the application, and part of the qualification process. This submission describes the basic capabilities of the vehicle for planning, safety, and selection purposes. This form is available on the Grand Challenge [website](#). Failure to complete this form properly and submit it before the deadline may result in disqualification.

### *Video Demonstration*

The video demonstration is a mandatory part of the application and part of the qualification process. Video demonstration requirements are available on the Grand Challenge [website](#) including optional formats, content guidelines, and submission deadline. Failure to submit a video demonstration that conforms to these guidelines before the deadline may remove a team from further participation in the Grand Challenge.

### *Waypoints*

Waypoints are two-dimensional locations (latitude, longitude) that define the beginning of each route segment. A waypoint includes the area within a radius equal to the lateral boundary offset associated with that waypoint.

### *Winner*

The winner is the team whose vehicle has completed the prescribed route with the lowest corrected time under ten hours and has complied with all rules.