DARPA Grand Challenge 2005

Rules

August 2, 2004

DARPA invites the public to review this document. E-mail any comments to grandchallenge@darpa.mil by September 1, 2004.

Please follow these guidelines for comment submission:

- Comments may be submitted electronically as e-mail body text or as an e-mail attachment. Plain text files or MS Word files are acceptable. Please provide any instructions that are necessary to read the file.
- Specific comments are the most helpful. If there are rules which are confusing, ambiguous, or incomplete, please cite the specific rules section and identify the language in question. If you have rule additions to suggest, please indicate where in the rules you believe the new rule belongs.
- For suggested rule modifications, please provide a rationale. You may refer to specific situations that took place at last year's event, if applicable. If you believe that rules should be modified to accommodate features of your vehicle, please provide sufficient detail so that DARPA can fully analyze the issue. Please clearly mark proprietary information.
- Contact information is not required, but it will help us reach you for clarification, if necessary. Please provide name, e-mail address and daytime telephone number.

Defense Advanced Research Projects Agency
3701 North Fairfax Drive
Arlington, VA 22203-1714

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1. Introduction

1.1 Purpose of 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 have to 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 generate breakthroughs in performance. The event challenges the most capable and innovative companies, institutions, and entrepreneurs in the United States and from around the world to realize a robust autonomous ground vehicle.

1.2 Date of the 2005 DARPA Grand Challenge Event

The 2005 *Grand Challenge 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 the daylight hours of a single day, DARPA will stop and shut down all *vehicles* (see definition, p.30) 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 2005 Grand Challenge Event

The Grand Challenge will be held in the California / Nevada area. DARPA will

identify the general location of the 2005 Grand Challenge Event in advance of the *National Qualification Event* (NQE)(see definition, p.27).

1.4 Route Description

The *route* (see definition, p.28) will be no longer than 175 miles. It may include paved roads, unpaved roads, trails, and off-road desert areas. The route contains manmade and natural obstacles, both above and below the surface of the average terrain. Examples of obstacles include ditches, washboard, sandy ground, standing water, rocks and boulders, narrow underpasses, construction equipment, concrete safety rails, power line towers, barbed wire fences and cattle guards. Every obstacle on the route can be either traversed by a commercial 4X4 pickup truck or avoided entirely. DARPA will place on the route one or more obstacles that are designed to disable tactical vehicles. These obstacles must be detected and circumnavigated for a vehicle to successfully complete the route. The route will be wide enough for vehicles to bypass these obstacles.

1.5 Rules

The development of revolutionary technology solutions 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 the clarification of issues raised by entrants, 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.

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 safety, legal compliance, fairness, Challenge goals, environmental protection, and efficient operations.

Decisions of the DARPA 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.29) that completes the route with the shortest *corrected time* (see definition, p.25) at or 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.29) 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 qualifies for 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 any previous DARPA Challenge event are not exempt from the application procedures and *qualification process* (see definition, p.28) for any subsequent Challenge.

1.8 Grand Challenge Timeline

The Grand Challenge application process has five parts and two deadlines. The selection and qualification process has three main steps. All events are outlined below. Instructions and templates necessary for participation will be posted on the *Grand Challenge website* (see definition, p.27).

Table 1. Application Process

REQUIRED SUBMITTAL	REMARKS	DEADLINE
Part I - Team Information	Submit by e-mail	February 11, 2005
Part II - Additional Information and Certification of Team Funding and Support	Postal submission	
Part III - Vehicle Specification Sheet	Submit by e-mail	March 11, 2005
Part IV - Video Demonstration	Postal submission	
Part V - Site Visit Agreement	Postal submission	

Table 2. Selection and Qualification Process

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

Announcement of teams selected for National Qualification Event (semifinalists)	Based on results from site visits	June 1, 2005
Announcement of pole positions for National Qualification Event	Posted on Grand Challenge website	June 15, 2005
Tech papers submitted	Required from all semifinalists	August 15, 2005
Meeting with all semifinalist team leaders	Mandatory attendance	September 28, 2005
Step III - National Qualification Event	Semifinalists participate	September 28–October 6, 2005
Announcement of field for Grand Challenge Event (finalists)	Results from National Qualification Event	October 6, 2005
Grand Challenge Event	Finalists participate	October 8, 2005

2. Eligibility

2.1 Team Membership

A team comprises all 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 a US citizen on the date the team applies 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 on the *Site Visit Liability Statement* (see definition, p.29), and must be present at the site visit, the National Qualification Event, 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.

Although the number of individuals listed on the team roster is not expressly limited, DARPA will impose a limit as to 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 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 employees may not use US Government travel funds or work-related travel to participate as team members in the Grand Challenge.

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

1. No funding used in the design, development, or operation of my team's Grand Challenge vehicle has been or will be charged to a grant or contract from a government, either directly through contract work or indirectly through government-reimbursable research and development, overhead, or general and administrative accounts. This restriction includes funding to pay for labor, travel, equipment leases, or other services that are applied directly to the design, development, 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 software or hardware that is commercially available or openly available 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 my team's 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 has not been used and will not be used in the design, development, or operation of my team's Grand Challenge vehicle.

For purposes of this certification, *government funding* denotes any form of support from a national or international governmental organization, whether located in the United States of America or in any foreign country or territory. *Openly available* materials are available without charge, such as software that is available for public download.

This certification does not restrict the use of government-sponsored information such as Global Positioning System (GPS) signals, cartographic products, or government-developed numerical software routines that are widely available. This rule also does not restrict the use of any technologies that are commercially available to all teams.

3. Challenge Vehicle Requirements

3.1 Autonomous Vehicle Behavior Requirement

Autonomous behavior and operation is required by a vehicle on the route and during the NQE. No team may cause a signal of any kind (e.g., visual, RF, or sonic) to be sent to a vehicle nor may any vehicle receive or transmit a signal of any kind (except those explicitly permitted in Section 3 of the rules) while on the NQE course or the Challenge route. Vehicles must be unmanned, and no animals are permitted onboard.

3.2 Vehicle Limitations

All computing, intelligence, and sensor processing must be contained onboard while on the route. Apart from the emergency stop feature, tracking signals from DARPA-provided systems, and freely available navigation signals, no external communication is allowed.

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 vehicles must not damage the environment or infrastructure along the 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 at least 10 feet in width and 9 feet in height. The vehicle weight is limited to 20 tons, and any team whose vehicle weighs more than 10 tons must provide its own recovery capability. The vehicle must be able to travel on asphalt pavement in desert temperatures without damaging the pavement surface.

3.3 Classified Data and Devices

No classified data or devices may be used by a team during or in preparation for this 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 shall be either black or white and shall have a solid background either in white or black, respectively, extending at least 3 inches larger than the number. 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 or offensive by the *Officials* (see definition, p.28). A DARPA Grand Challenge 2005 logo may be displayed on each vehicle.

3.6 Vehicle Safety

Notwithstanding any rule or the acceptance by DARPA of any application document, *vehicle specification sheet* (see definition, p.30), video, or any inspection or demonstration required as a condition of participating in the Grand Challenge, DARPA makes no representation as to the safety of any vehicle entered 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 Warning Devices

Each vehicle shall be equipped with audible and visual alarms, that are activated according to the state of the Emergency Stop system. The following table summarizes the expected behavior of the alarms.

E-stop DISABLE mode: No audible alarm. No visual alarm.

E-stop PAUSE mode: No audible alarm. Visual alarm on.

E-stop RUN mode: Audible alarm on. Visual alarm on.

3.6.2.1 Audible Warning–Vehicle Operating

Each vehicle shall produce an intermittent warning sound when, and only when, the vehicle is 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 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.

3.6.2.2 Visual Warning–Vehicle Operating

Each vehicle shall display one or more flashing yellow or 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.

3.6.2.3 Visual Warning–Vehicle Brake

Each vehicle shall display two or more steadily illuminated red warning light(s) 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 a 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 amber lights to permit rapid recognition.

3.6.3 Wireless Emergency 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 in its vehicle. 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 if 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

The E-stop system has three modes: a RUN mode, a PAUSE mode, and a DISABLE mode. The RUN mode enables the vehicle for autonomous movement. The PAUSE mode brings the motion of a vehicle to a prompt stop, ready to resume forward motion when the PAUSE signal is removed. The DISABLE mode brings the vehicle to a prompt halt and shuts down all systems while actively applying and maintaining the brakes. Activation of the DISABLE-mode is anticipated only when the vehicle is disqualified as determined by the Chief Judge.

The wireless E-stop unit will produce two binary outputs—one each for the PAUSE and DISABLE modes. 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 PAUSE mode to be cycled on or off so that the vehicle can be stopped and resumed during the Challenge. The DISABLE mode should be latched so that its state cannot be changed after initiation except by a manual unlatch switch.

A demonstration of the wireless E-stop capability will be required as part of the NQE.

Teams should anticipate that their vehicle may receive the E-stop (PAUSE) signal numerous times, and that the duration of any individual 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.

3.6.4 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 DISABLE mode. At least one actuator and its labeling must be easily visible and accessible by an average human standing 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 will be required as part of the NQE.

3.7 Neutral Gear

All vehicles must have a neutral gear. The mechanism for placing the vehicle into neutral gear must be readily accessible and clearly marked. Any disabled vehicle will be moved aside if it is impeding another vehicle. Teams should provide vehicle tow points at which attachment can be made for towing their vehicle. The tow points shall be shown to the inspection team at the NQE inspection.

3.8 Electrical Provisions

Challenge vehicles will need to accommodate the DARPA-provided E-stop receiver and tracking unit with associated antennas. The E-stop receiver will require a nominal 12 VDC power input which can range from a minimum of 10 VDC to a maximum of 14 VDC. The tracking beacon will receive power from the E-stop receiver. The combined power requirement will be less than 50 W. Any mounting plates or interfacing connections for DARPA equipment will be supplied to all semifinalists with the E-stop units.

Portions of the route may run next to high tension lines, with the associated potential for electromagnetic interference.

3.9 Position Determination Equipment

Challenge vehicles may be equipped to receive and process electronic position-determination signals (such as GPS) that are freely available to all teams. Teams desiring to use position-determination signals that are not freely available (such as subscription services) must state their intention to do so in the vehicle specification sheet submitted as part of the application. Any costs associated with any subscription services are borne by the team. GPS signals might not be available throughout the route at all times (such as in an underpass).

Any position-determination device (such as a beacon) that is not aboard the vehicle and that is placed in proximity to the route for navigation purposes is prohibited.

GPS alone will not provide adequate navigation information to a vehicle. There will be dust, smoke, and other visual obscurants on the route, and visual-spectrum-only sensing may not be adequate under these conditions.

3.10 Telemetry

This section does not apply to the E-stop system or to any DARPA-supplied system.

No telemetry to or from a vehicle is permitted on the NQE or Grand Challenge Event route. Vehicles may record video or other data on-board for review after

conclusion of the event. Any data recorded on the NQE course or the route may not be shared between teams.

A wireless connection is permitted for vehicle movement at the NQE to and from the start area, finish area, and practice area and at the Grand Challenge Event for movement to the start area.

Any wireless systems 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.

3.11 Vehicle Cooperation

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

3.12 Environmental Impact

Any vehicle or associated team activities that have an unacceptable impact on the environment will not be allowed. These activities include overtly destructive vehicle systems or behavior, the use of abnormally hazardous substances or materials, and generally reckless operation. Any potentially hazardous equipment or activities that are not disclosed at the site visit and in the vehicle specification sheet and offered to DARPA for review are cause for team disqualification.

3.13 Pre-Challenge Testing

Testing of Challenge vehicles or components is the sole responsibility of each team. Any 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 capability are necessary to complete the application. Primary communication with DARPA and administration of the event will take place through these means.

The application consists of five parts:

- Part I: Team Information

- Part II: Additional Information and Certification of Team Funding and Support
- Part III: Vehicle Specification Sheet
- Part IV: Video Demonstration
- Part V: 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. Application materials received after their respective deadline will not be considered, and will be destroyed by DARPA.

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

Application Parts III, IV, and V 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:

grandchallenge@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 vehicles, and a photograph of the team.

4.4 Team Promotional Material

Contact information for each team including team leader name, e-mail address, and team URL will be posted on the Grand Challenge website to enable contacts from potential sponsors, other teams, and media. Promotional material 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 paper*s (see definition, p.30) will be published on the Grand Challenge website.

5. Qualification Process

5.1 Overview

All steps of the qualification process must be completed by all teams that wish to compete in the Grand Challenge Event. Teams that have completed the application process and received acknowledgement from DARPA become Grand Challenge entrants. Teams selected for the NQE become semifinalists, and teams selected for the Grand Challenge Event are *finalists* (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 sheets submitted as part of the application. Applications will be evaluated on the basis of:

- Conformance with the rules
- 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 entrants selected for a site visit will remain eligible for participation in the Grand Challenge.

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 VB 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, this will be done through mutual agreement with the team. Inability to reach a mutually agreeable time 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 as described below. Teams that are not selected are no longer eligible for participation in the 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 mandatory subjects to be addressed in the technical paper will be available on the Grand Challenge website. DARPA will withhold the technical papers until the conclusion of the 2005 Challenge, 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, no public release of information regarding a team's technical approach will be made without the expressed permission of 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 28, 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 for the NQE start that will occur on September 28, 2005. Team arrival and check-in is scheduled for September 27, 2005.

5.5.1 Static Inspection

The first phase of the NQE will be a static technical 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 the general safety of the vehicle. 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 conformance it will be disqualified.

5.5.2 Demonstration

The NQE will be used to select the finalists to compete in the Grand Challenge Event. Teams will be given at least two opportunities on the NQE course. A team's final score will be derived from its best two attempts.

5.5.3 Restrictions on Vehicle Operation

From the first day of the NQE until the day of the Grand Challenge Event, operation of semifinalist vehicles is limited to DARPA-specified events and operation within DARPA-specified practice areas.

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 the Chief Judge if major repairs are needed requiring expertise that is only available offsite.

5.5.4 Security

5.5.4.1 Access Control

Grand Challenge semifinalists, 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 assumes no responsibility for the security of team equipment and 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 adhere to safety procedures may result in disqualification from the DARPA Grand Challenge 2005.

6. Grand Challenge Event

6.1 Departure Procedures

On October 6, 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 the morning of 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 an electronic *route definition data file* (RDDF)(see definition, p.28) on CD at least 2 hours prior to the Start.

When instructed to do so, teams must be able to move their vehicle to the *start chute* (see definition, p.29) promptly. Challenge vehicles will start in sequential order at specified time intervals. Start order will be announced at the end of NQE.

Teams must ready their vehicle for autonomous operation within 5 minutes after being positioned in the start chute. During this time, teams must disable or remove all wireless remote control or telemetry equipment for inspection by the officials in the start chute.

Teams must be prepared to wait in PAUSE mode in the start chute for up to 1 hour without manual intervention.

The Event will start shortly after sunrise on October 8, 2005.

Approximately 5 minutes before each start, the vehicle will be placed in autonomous mode with E-stop in PAUSE mode. At the designated start time the E-stop will be switched from PAUSE to RUN and the vehicle should depart the start area promptly after the mandatory 5 second delay for the audible alarm.

From the time a vehicle clears the start chute until the time it clears the *arrival line* (see definition, p.25), DARPA is responsible for all aspects of vehicle tracking and operation. DARPA will continuously observe and control the vehicles for safety and judging purposes during this time. The E-stop units will be used by DARPA to PAUSE and DISABLE vehicles as required.

Teams may follow the progress of their vehicles at designated areas near the beginning and end of the route. Teams may not operate any ground vehicles or position any team members along or near the route during the Grand Challenge Event. Exceptions must be approved by the Chief Judge (e.g., to recover a disqualified vehicle).

Teams should be prepared to recover their vehicles anywhere on the route in the event of disqualification.

6.2 Challenge Route

All vehicles must remain within the route from the time they leave the start chute until the time they reach the last *waypoint* (see definition, p.31). If a vehicle's E-stop is in RUN mode and the vehicle is immobile for longer than 10 minutes, it may be disqualified.

6.2.1 Waypoints

The combination of the waypoints and the *lateral boundary offsets* (see definition, p.27) defines the corridor through which the vehicles are required to travel. For portions of the route, the boundaries may be narrower than the accuracy of some radio-positioning systems, and intelligent sensing and behavior will be required for the vehicle to remain on the route.

GPS reception at waypoints is not guaranteed.

6.2.2 Route Boundaries

The lateral boundary offsets will be specified in feet from any point on a *track line* (see definition, p.30). Vehicles are free to traverse any area within the defined corridor. The width of the corridor defined by the boundaries will vary but will be no less than 10 feet at any point. When the width is less than the accuracy achievable by radio positioning, other sensors will be required to keep the vehicle on the route. In areas of particular safety or environmental concern where the route edges may not be sufficiently clear, the boundaries may be marked with concrete barriers, plastic snow fencing, or other similar material. Any vehicle that crosses a lateral boundary may be immediately E-stopped and disqualified from the Challenge.

6.2.3 Speed Limits

Speed limits will be mandatory for certain segments of the route. Speed limits will be specified in the RDDF in miles per hour and will apply for the route segment defined by the associated waypoint to the next sequential waypoint. In the area where two route segments overlap, the least restrictive (i.e., higher) speed limit will apply. A specified speed limit does not imply that it has been tested or that it

is a safe or achievable speed. Exceeding the speed limit along any segment may be cause for disqualification.

6.2.4 Route Definition Data File

The RDDF specifies the official route. The RDDF is a comma delimited text file on a PC-formatted CD-ROM. Data fields will include waypoint number, waypoint latitude, waypoint longitude, lateral boundary offset (in feet), and speed limit (in mph). Waypoint latitude and longitude are specified in decimal degrees with seven decimal places. The applicable datum is WGS 84. Unlimited speed limits will be indicated by 999. The following are example lines:

WP Number	WP LAT	WP	LB	Speed Limit
10	38.2228914	-110.4790771	20	55
11	38.2224215	-110.4793187	20	55
12	38.2216479	-110.4799700	30	55

NOTE: This data is for format example only. It does not represent points, separation, or parameters that are part of the actual event.

The above data would be formatted in the RDDF as:

10,38.2228914,-110.4790771,20,55
11,38.2224215,-110.4793187,20,55
12,38.2216479,-110.47997,30,55

The accuracy of the waypoint locations is +/- 15 cm. The 7th decimal figure should not be confused as an additional degree of accuracy..

6.3 Obstacles

DARPA cannot guarantee the absence of traffic, obstacles, or pedestrians on the route. Vehicle sensing and navigation systems must enable the vehicle to avoid collisions with any obstacle, moving or static, that may exist on the route. DARPA will place obstacles along the route to test vehicle obstacle avoidance capabilities. Vehicles that hit any obstacle along the route may be disqualified. Obstacle avoidance and detection is a requirement for every vehicle entering the Challenge.

6.4 Intentional Interference and Damage

Intentional interference with other vehicles is prohibited. Intentional interference is any physical action or emission which, in the opinion of the Chief Judge, is intended to degrade another vehicle's ability to compete. If such activity is observed, the offending vehicle may be disqualified.

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.

6.5 Improper Vehicle Contact

A team may not make or cause physical contact with its vehicle after it has started and before it has finished the route (including the post-route inspection). Contact with the vehicle may be permitted if the vehicle has been disqualified or second-day procedures have been enacted as determined by the officials. Physical contact includes indirect contact with tools and human-commanded contact using remotely controlled or electronic equipment. Minor and inadvertent contact with a team's own vehicle may be accepted based on the judgment of the Chief Judge.

6.6 Jettisoning Material on the Route

Except for normal byproducts of power generation, the intentional jettison of any material from a vehicle is prohibited and will 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.

6.7 Passing

A slow moving (impeding) vehicle may be paused by a DARPA official in areas wide enough to allow a faster (overtaking) vehicle to pass with its associated *control vehicle* (see definition, p.25). The overtaking vehicle must have the ability to sense the stopped vehicle and safely navigate around it.

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 insufficient for passing, and the impeding vehicle is moving, a DARPA official will E-stop (PAUSE mode) the overtaking vehicle 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 will E-stop (PAUSE) any other approaching vehicles. Once the route is clear, DARPA officials will place waiting vehicles in RUN mode. Time spent waiting to pass the impeding vehicle shall be credited to the overtaking vehicle's corrected time.

6.8 Arrival Area

After a vehicle has crossed the arrival line it shall be impounded for a post-route inspection. Teams may not interact with their vehicle until released from this impound by a DARPA official.

6.9 Vehicle Control

Vehicles that do not exhibit mobility within 10 minutes of reestablishing the normal-mode E-stop link may be considered disqualified and disabled for the purposes of physically moving them to avoid obstructing Challenge or control vehicles from passing.

An official may, without penalty, E-stop (PAUSE) any vehicle for safety reasons not related to the undesired behavior of the vehicle. After the safety issue is resolved, the vehicle may continue with the Challenge, and the time of the stop will be credited to the corrected time of the vehicle.

If an E-stop is performed because of a loss of visual contact or loss of wireless link between the vehicle and an official, the vehicle may resume the Challenge when the E-stop link is reestablished; and the time of the stop will be credited to the corrected time of the vehicle.

If the E-stop is performed to prevent undesired behavior (e.g., driving off a bridge or out of bounds) by the vehicle, the team may be disqualified.

DARPA reserves the right to take any measures necessary to stop a vehicle that does not respond to an E-stop. These measures may result in damage to the vehicle.

6.10 Corrected Time

Elapsed time (see definition, p.26) will be computed as the difference between the arrival Time and the Departure Time for each vehicle.

Corrected time will be computed by subtracting the duration of all E-stop Pauses from the elapsed time. Additional time corrections may be applied at the discretion of the Chief Judge.

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

6.11 Disqualification

A disqualified vehicle may not continue on the route. The vehicle location will be provided to the disqualified team to enable recovery of the vehicle.

At any time prior to the NQE, requests for rules clarifications should be sent to: GrandChallenge@darpa.mil. DARPA will keep confidential any questions that are designated as team proprietary.

The Chief Judge will be responsible for all aspects of the prize award process.

Appendix A. 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 have notarized a 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 DARPA 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.

Control Vehicle

For safety and judging purposes, a DARPA control vehicle (CV) will follow each vehicle. This will enable a DARPA official to maintain visual contact with each vehicle while it is on the route. Team members may not occupy a control vehicle during the Grand Challenge. DARPA is solely responsible for the operation of control vehicles.

Corrected Time

The corrected time is the elapsed time for a vehicle including any time adjustments as prescribed in the rules. Corrected time will not be maintained for disqualified Challenge vehicles.

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. This denotes the beginning of the Challenge.

Elapsed Time

Elapsed time is the time for a vehicle beginning at that vehicle's departure signal and ending when that vehicle has cleared the arrival line from the direction of the previous waypoint. Elapsed time will not be maintained for disqualified vehicles.

Entrant

An entrant is a team that meets the eligibility requirements and has satisfactorily completed all parts of the application process (receipt of which has been acknowledged by DARPA). An entrant that has not been selected for a site visit or to participate in the NQE may attend the Grand Challenge Event as a spectator.

Finalist

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

Government

For purposes of these rules, government refers to national or supranational governing bodies and all official agencies that are directly responsible. 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 includes compensation in the form of salary or travel expenses, and any other form of funding, supplies, equipment or reimbursement paid for by national or supranational government direct contractual efforts or through any form of overhead account, Internal Research and Development (IR&D), General and Administrative (G&A) account or other similar means. Funds received in the form of a grant that originates 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.

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 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 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 depending on safety and environmental limitations.

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.

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 at or 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 (or 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 on a PC formatted CD. Data fields will include waypoint number, waypoint latitude, waypoint longitude, lateral boundary offset, and speed limit.

Rules

The final 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 which will be available on the Grand Challenge website; 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. It is protected on all sides by safety barriers or safety straps. A team must place their 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 and Grand Challenge Events areas will be designated for spectator viewing.

Team

A team (or 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 single 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 (or 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 dissemination. 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 (or 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 (or video) 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 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, with their related boundaries, define the Challenge route. A waypoint includes the area within a radius equal to the lateral boundary offset associated with that waypoint.

Winner

The winner is the finalist whose vehicle has completed the prescribed route with the lowest corrected time at or under ten hours.