



# Urban Challenge

## Rules

December 11, 2006

## Document Change Summary

<b>Section</b>	<b>Description</b>	<b>Date</b>
1.4	Text added to describe approved cash prizes	December 11, 2006
5.1	Table 3 updated	December 11, 2006
5.4	Deleted reference to Application Part 4	December 11, 2006
Appendix	Definition of Prizes added	December 11, 2006

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# 1. Introduction

## 1.1. Scope and Precedence

The rules apply to all participants in the Urban Challenge. Nothing in these rules, to include this document and all subsequent rules documents, may be interpreted as modifying the statement of work or authorizing work outside the terms and conditions of any existing agreements or contracts with DARPA.

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

Additional documents to be released include the following, at a minimum:

- Master Schedule
- Route Network Definition File (RNDF) and Mission Data File (MDF) Formats
- Technical Evaluation Criteria
- Video Demonstration Guidelines
- Technical Paper Guidelines
- Site Visit Procedures
- E-stop Guidelines
- Rules of the Road
- National Qualification Event (NQE) Procedures
- NQE Route Network Definition File
- Final Event Procedures
- Urban Challenge Final Event (UFE) Route Network Definition File

All documents will be posted on the Grand Challenge website, [www.darpa.mil/grandchallenge](http://www.darpa.mil/grandchallenge).

## 1.2. Vision

The Urban Challenge is the third DARPA Grand Challenge program and an outgrowth of the DARPA Grand Challenge 2005 autonomous vehicle competition conducted in October 2005. This event focused on the development of autonomous vehicles that operate in an off-road environment with only limited interaction with other vehicles. Urban Challenge extends this concept to autonomous vehicles that safely execute missions in a complex urban environment with moving traffic.

The Grand Challenge draws widespread attention to the technology issues associated with autonomous ground vehicles and motivates entrants to overcome the technical challenges to realize truly robust autonomous ground vehicles. These events challenge the most capable and innovative companies, institutions, and entrepreneurs in the United States to produce breakthroughs in capability and performance.

In the National Defense Authorization Act for Fiscal Year 2001, Congress mandated in Section 220 that “It shall be a goal of the Armed Forces to achieve the fielding of unmanned, remotely

controlled technology such that . . . by 2015, one-third of the operational ground combat vehicles are unmanned.” With the Urban Challenge, DARPA is focused on the advancement of technology to address the operational challenges implicit in the Congressional mandate. Safe and effective operation in moving traffic is a basic requirement for all future military missions for ground autonomous vehicles.

### **1.3. Overview**

The Urban Challenge is a research and development program conducted in a competitive format to address the most challenging aspects of autonomous vehicle operation. Moreover, the Urban Challenge makes use of an open format to draw on a technical talent pool that is both broad and deep.

Teams participate on one of two tracks, Track A or Track B.

To participate on Track A, teams submit proposals under BAA 06-36 to qualify to receive technology development funding awards up to \$1,000,000. Vehicle capability is evaluated at four milestone events to ensure adequate progress for continuation in the program. Full details for Track A are given at [www.darpa.mil/baa](http://www.darpa.mil/baa). Teams who are not selected for Track A may follow the guidelines described on the Grand Challenge website and apply to participate on Track B.

Teams are evaluated with identical technical criteria at the site visit, NQE and UFE ensuring that the level of technical performance on each track is the same.

The Urban Challenge course tests the vehicle’s ability to operate safely and effectively with other vehicles in and around an urban environment. The course will be nominally 60 miles in total distance, with a time objective of 6 hours. The road surface will range in quality from new pavement to potholes and broken pavement. Sections of dirt roads with low berms may also be encountered. The vehicle may negotiate sharp curbs, downed branches, traffic barrels, drains, hydrants, rocks, brush, construction equipment, concrete safety rails, power line poles, and other stationary items likely to be found in an urban environment. Vehicles will obey traffic laws as they negotiate traffic circles, intersections, and merge with moving traffic. Traffic on the route may be provided by manned vehicles, tele-operated vehicles, and other autonomous vehicles. Static vehicles may also be parked or stopped along the route. Roads may be blocked by DARPA during the course of the event. Trees and buildings along the route may interfere with GPS. Along some road segments there may be significant distances between waypoints, requiring vehicles to use their sensors to stay in the travel lane.

To complete the Urban Challenge, a vehicle must negotiate all hazards, re-plan for alternate routes, and avoid static and dynamic obstacles while completing a complex, multi-part mission at speeds of up to 30 mph, resulting in an average speed of at least 10 mph.

## 1.4. Prizes

Participants from both tracks are eligible for the Urban Challenge grand prizes, which are first place: \$2,000,000; second place: \$1,000,000; and third place: \$500,000. No other prizes will be awarded by DARPA.

Tax treatment of prizes will be handled in accordance with U.S. Internal Revenue Service guidelines. Winning organizations are required to provide a U.S. taxpayer identification number to receive a prize.

## 1.5. Track A and B Distinction

The Track A participation process is summarized in the BAA 06-36 and PIP, available from [www.darpa.mil/baa](http://www.darpa.mil/baa). Successful Track A participants do not submit applications and do not win prizes for becoming Urban Challenge semi-finalists or finalists. However, Tracks A and B are parallel paths for qualifying and participating in the Urban Challenge and the technical criteria to advance on Track A at Milestones 2, 3, and 4 are the same as Track B.

DATE	TRACK A MILESTONE	TRACK B EVENTS
October 2006	Milestone 1	not applicable
June- July 2007	Milestone 2	Site Visit
October 21-31, 2007	Milestone 3	NQE Advanced Navigation Test
October 21-31, 2007	Milestone 4	NQE Advanced Traffic Test and UFE start

**Table 1. Track A milestones and Track B Events**

As shown, in Table 1 above, three of the four Track A milestones are the same as Track B events. Track A and B teams that successfully pass the NQE Advanced Traffic test will be invited to participate in the UFE. If no teams are able to pass this test, the UFE may be cancelled or postponed at DARPA's discretion.

## 1.6. Rules Modifications

The development of revolutionary technologies is a key objective of the Grand Challenge. Entrants 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 has the authority to modify the rules at any time. Rules may be modified for many reasons, including accommodation of a promising technical approach that would have been prohibited by the rules. DARPA will communicate any modifications to the rules with an e-mail to all entrants and a statement on the Grand Challenge website under "Rules".

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

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.

## 1.7. Objectives

The objective of this program is safe and correct autonomous driving capability in traffic at 20 mph. To do this, vehicles will demonstrate the following capabilities:

- Complete a mission defined by an ordered series of checkpoints in a complex route network. The vehicle will have 5 minutes to process a mission description before attempting the course.
- Interpret static lane markings (e.g., white and yellow lines) provided with the route network definition file and behave in accordance with applicable traffic laws and conventions. DARPA's intent is for the RNDF lane boundary descriptors to match the physical lane markings on the ground. DARPA cannot ensure that this will be the case in all areas, and as such the RNDF shall take precedence over the physical ground markings in conflicting areas.
- Exhibit context-dependent speed control to ensure safe operation, including adherence to speed limits.
- Exhibit safe-following behavior when approaching other vehicles from behind in a traffic lane. This includes maintaining a safe-following distance.
- Exhibit safe check-and-go behavior when pulling around a stopped vehicle, pulling out of parking spot, moving through intersections, and in situations where collision is possible.
- Stay on the road and in a legal and appropriate travel lane while en route, including around sharp turns, through intersections, and while passing. The route network definition file will specify the GPS coordinates of the stop signs. The RNDF specifies the location of stop lines on the ground. On paved areas, each stop line will be represented by a painted stop line on the pavement. Physical stop signs, however, may or may not be present at the stop line locations.
- Navigate safely in areas where GPS signals are partially or entirely blocked.
- Follow paved and unpaved roads and stay in lane with very sparse or low accuracy GPS waypoints.
- Change lanes safely when legal and appropriate, such as when passing a vehicle or entering an opposing traffic lane to pass a stopped vehicle. Vehicles must not pass other vehicles queued at an intersection.
- Merge safely with traffic moving in one or more lanes after stopping at an intersection.
- Pull across one lane of moving traffic to merge with moving traffic in the opposing lane.
- Stop safely within 1 meter of the stop line at a stop sign intersection and proceed without excessive delay (less than 10 seconds) according to intersection precedence rules.

- Exhibit proper queue behavior at an intersection, including stopping at a safe distance from other vehicles and stop-and-go procession to the stop line without excessive delay.
- Navigate toward a destination in a large, open area where minimal or no GPS points are provided, as in loading dock areas or parking lots. These areas may contain fixed obstacles such as parked vehicles and moving obstacles including other vehicles.
- Safely pull into and back out of a specified parking space in a parking lot.
- Safely execute one or more three-point turning maneuvers to effect a U-turn.
- Dynamically re-plan and execute the route to a destination if the primary route is blocked or impassable.

The following behaviors or capabilities are outside the scope of this program:

- Recognition of external traffic signals such as traffic lights and stop signs, through the use of sensors.
- Recognition of pedestrians and pedestrian avoidance.
- Behaviors necessary for highway driving such as high speed passing or high speed merge at an onramp. Speed limits for the Urban Challenge will be 30 mph or less.
- Driving in difficult off-road terrain is outside the scope of the program. Off-road navigation in an unpaved area, travel along roads with potholes, and travel along a dirt road are within scope.

## **1.8. Route**

To complete the requirements for the Urban Challenge, each vehicle will complete multiple missions over a defined route network. The route network definition specifies accessible roads and all areas in which the vehicle may travel. A mission is a series of checkpoint locations that must be passed over sequentially by the vehicle. The path between checkpoints is not specified.

DARPA will provide the Route Network Definition File (RNDF) that includes all accessible road segments and provides information such as waypoints, stop sign locations, lane widths, checkpoint locations, and parking spot locations. The route network has no implied start or end points. Road blockages will not be indicated in the RNDF.

DARPA will also provide a Mission Data File (MDF) containing the checkpoints that must be reached and minimum and maximum speed limits for the road segments. MDFs will be provided by DARPA for all Urban Challenge test events.

A document specifying the format of the RNDF and MDF is available at [www.darpa.mil/grandchallenge](http://www.darpa.mil/grandchallenge).

## 2. Eligibility (Track B Only)

### 2.1. Track B Team Membership

A team is comprised of three elements:

1. Team leader: The team leader will serve as the primary point of contact with DARPA and must be present at the site visit, NQE, and UFE. The team leader will sign the team's application for the Urban Challenge and the Waiver and Release of Indemnity and Liability form. The team leader must satisfy all of the following criteria:
  - a. The team leader may be only on one Urban Challenge team
  - b. The team leader must be at least 21 years of age on the date of application to the Urban Challenge
  - c. The team leader must hold US citizenship on the date of application to the Urban Challenge and must remain a citizen for the duration of the Urban Challenge. Proof of U.S. Citizenship for the team leader must be provided with the application by one of the following methods:
    - i. U.S. passport
    - ii. Current U.S. drivers license and birth certificate
  - d. The team leader must be a U.S. resident on the date of application to the Urban Challenge. Team leader U.S. residency must be documented by two of the following methods:
    - i. Payroll stub issued by employer in the last 2 months
    - ii. Utility bill not more than 2 months old issued to team leader (gas, electric, sewer, water, cable phone but not cell)
    - iii. Receipt for personal property taxes or real estate taxes paid within the last year to a U.S. state, commonwealth, or locality
    - iv. Current automobile or life insurance bill (cards or policies not accepted)
    - v. Voter Registration Card from U.S. state or commonwealth
    - vi. Deed, mortgage, monthly mortgage statement, or residential rental/lease agreement
2. Team members: These individuals are identified to DARPA on the team roster. The number of team members is not limited by DARPA. Team members may be on only one team roster, but may switch teams should a team fail to qualify.
3. Team sponsors: Sponsoring organizations are welcome at all events.

DARPA seeks distinct technology solutions with each entry. Entries from closely affiliated teams offering similar technology solutions may be considered a single entry, at DARPA's discretion.

Federal Government organizations may not respond to BAA 06-36. These organizations may compete on Track B, provided such competition is within the organization's charter and consistent with applicable statutes. State and local government organizations, such as public universities, may compete on either Track A or B.

Team leadership may be transferred from the team leader to another eligible individual upon receipt by DARPA of a notarized Change of Team Leader form from the team leader. The form, available at [www.darpa.mil/grandchallenge](http://www.darpa.mil/grandchallenge), must be signed by current and proposed team leaders and submitted with proof of U.S. citizenship and residency.

## **2.2. Non-U.S. Participation**

The rules do not restrict the citizenship of any member of the team, except the team leader. All Urban Challenge events and meetings take place in the United States.

## **2.3. Team Funding and Support**

Sources of team funding and support are not restricted for the Urban Challenge.

If the team is paid under a Government contract and the team is using assets from that program for the Urban Challenge, the team is required to obtain authorization from their Government Program Manager.

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

# **3. Vehicle Requirements**

The vehicle is required to exhibit a set of complex behaviors, executed in a manner that ensures the safety of spectators, staff, other vehicles, objects in the environment, and the vehicle itself. The following detailed requirements apply at all Urban Challenge events.

## **3.1. Autonomous Vehicle Behavior**

Participating vehicles must demonstrate fully autonomous, unmanned, and safe operation during the site visit, NQE and UFE. Vehicles may be tele-operated for staging purposes, but during demonstration or testing all processing and navigation must be done by systems aboard the vehicle. Cooperation of any kind among vehicles during the site visit, NQE or the UFE events is prohibited.

## **3.2. Vehicle Platform**

Vehicle must be built upon a full-size stock chassis or a full-size chassis with a documented safety record. Vehicles smaller than a midsize commercial automobile such as golf cart-type or all-terrain vehicles (ATVs) do not meet this requirement. Vehicle must weigh between 2,000 and 30,000 lbs. unladen (as delivered from the manufacturer) and fully fueled. The wheelbase must be a minimum of 72 inches, front axle to rear axle, and the vehicle shall be no more than 9 feet in width and 12 feet in height.

The vehicle must be able to travel autonomously forward and in reverse on a flat road. It must be able to perform a U-turn (with a series of 3 point turns if necessary) on an urban street 30 feet wide without climbing the curbs on either side.

Only individual, independent, ground vehicles are eligible to participate. Vehicles must have tires; tracked vehicles are not allowed. Vehicle must have at least 4 wheels and front and rear bumpers. The vehicle must be able to travel on asphalt pavement without damaging the pavement surface. All sensors and navigation equipment must be fully contained within, or securely attached to, the vehicle. All computing, intelligence, and sensor processing must be contained onboard the vehicle.

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 materials, equipment or activities must be brought to the attention of DARPA officials for review on the vehicle specification sheet and at the site visit. Except for normal byproducts of power generation, the intentional jettison of any material from a vehicle is prohibited. A smokescreen or any other obscurant intentionally discharged from a vehicle is specifically prohibited.

A team may bring an identically configured backup vehicle for use at NQE, however only one vehicle may be used during the UFE. The backup vehicle is subject to the same inspection and safety demonstration criteria as the primary vehicle.

Vehicle must be capable of loading a mission data file via a standard USB 2.0 flash drive. Vehicle must be convertible to and from autonomous operation and human operation within 5 minutes.

### **3.3. Vehicle Identification Number**

Each semi-finalist will be assigned a unique identification number to be displayed on its vehicle at least 12 inches in height on its sides, front, back, and top. The number must be clearly visible and distinguishable from other signage or symbols on the vehicle. The DARPA Grand Challenge logo should be displayed on each vehicle. A high-resolution version of this logo will be available from DARPA prior to the site visits.

Teams are allowed to display advertising on their vehicle if such advertisements are considered appropriate by the officials. Advertising will be reviewed during the safety inspection at NQE. Teams may submit proposed advertising copy or images to [grandchallenge@darpa.mil](mailto:grandchallenge@darpa.mil) for review.

### **3.4. Vehicle Safety**

DARPA makes no representation as to the safety of any vehicle entered in the Urban Challenge notwithstanding acceptance by DARPA of any application document, vehicle specification sheet, video demonstration, or any inspection or demonstration performed as a condition of participating in the Urban Challenge.

### 3.4.1. *Radiated Energy Safety Standards*

Teams 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.

Teams 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.

Teams 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 vehicles must comply with all applicable local, state, and federal acoustic safety regulations.

### 3.4.2. *Emergency Stop (E-stop) Units*

Each team must outfit its vehicle with a wireless emergency stop (E-stop) system for use at the site visit demonstration. This unit must be capable of operating in a moving vehicle following the autonomous vehicle. The team-supplied E-stop should bring the vehicle to a controlled stop on command to ensure the safety of vehicles and personnel in the vicinity.

DARPA will supply each semi-finalist team with one Government-owned E-stop system consisting of a controller, vehicle receiver, and tracking unit. It is the sole responsibility of the team to properly integrate the E-stop system in its vehicle. Detailed specifications for 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 or non-use of this technical assistance.

Semi-finalists 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 is not responsible for repairs to the E-stop or replacement of damaged units. DARPA reserves the right, solely at 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 UFE.

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 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 stop 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 semi-finalists.

The required integration of the E-stop system enables the E-stop PAUSE mode to be cycled on and off so that the vehicle can be stopped and resumed. The E-stop DISABLE mode shall 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 with the Government-supplied unit is required as part of the safety inspection at NQE.

Teams should anticipate that their vehicle may receive the E-stop PAUSE signal numerous times during the UFE, 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 environmental conditions including high shock and vibration.

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 Urban Challenge
- The vehicle is disqualified from the Urban Challenge or does not pass a milestone.
- The vehicle is withdrawn from the Urban Challenge
- Completion of the Urban Challenge

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. One easily-visible, easily-accessible labeled actuator must be installed on both sides of the vehicle. The manual emergency stop must be easy to identify and activate safely, even if the vehicle is moving at a walking pace. Advertising and other markings shall not interfere with the labeling of the manual emergency stop switch. A demonstration of the manual emergency stop capability is required as part of the safety inspection at NQE.

### **3.4.3. *Warning Devices***

Each vehicle shall be equipped with an audible alarm and warning light that are activated according to the state of the E-stop system.

Each vehicle shall produce an intermittent audible alarm when, and only when, the vehicle is in E-stop RUN mode. The vehicle may not commence movement until the audible alarm has been in operation for a safety delay interval of 5 seconds. The audible alarm 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 alarm shall not produce sounds that can be confused with those of public-safety vehicles such as law-enforcement, fire, or ambulance.

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(s) shall operate when, and only when, the vehicle is in E-stop RUN 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) that can be confused with those of public safety vehicles such as law enforcement, fire, or ambulance.

The following is a summary of the required behavior of the alarms.

- E-stop RUN mode: Audible alarm on. Warning light on.
- E-stop PAUSE mode: No audible alarm. Warning light off.
- E-stop DISABLE mode: No audible alarm. Warning light off.

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 braking system (not the parking brake) is activated.

The vehicle shall display directional signals in the front and back. These lights should be illuminated in advance of turning maneuvers and extinguished when the turning maneuver is complete. In addition, the vehicle shall display two reverse lights to be illuminated with the vehicle has engaged the reverse gear.

#### **3.4.4. *Wireless Signal Restrictions***

Challenge vehicles may be equipped to receive and process position-determination signals (such as GPS). On-board wireless connections are prohibited during site visit, NQE and UFE event operations. A vehicle may emit and receive signals to sense the environment. Except for the control and tracking signals from DARPA E-stop system and openly or commercially available navigation signals, the emission or reception of communication signals is prohibited. Inter-vehicle communications are prohibited.

Any wireless system used for vehicle movement or testing must be disconnected or disabled prior to the departure signal at the NQE and UFE. The wireless hardware must be easily accessible and capable of being inspected. This includes systems for monitoring, control, or intra-vehicle communication.

Vehicles may record video or other data on-board for review after the conclusion of the event, however wireless transmission of data during the NQE and UFE is prohibited. Any data recorded on the NQE course may not be shared among teams until the conclusion of the NQE. Any data recorded during the UFE may not be shared among teams until all vehicles have finished the route or have been disqualified. Teams may not retrieve information from their vehicle between missions at UFE.

### 3.5. Pre-Challenge Testing and Route Pre-Running

Testing of Urban 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.

The Urban Challenge is intended to be a fair test of vehicle capabilities using only the advance knowledge of the route provided by DARPA. Team activities to discover or exploit information about the course that is not openly available, by pre-running or any other means, may result in disqualification. DARPA may announce the closure of the route area anytime prior to UFE.

## 4. Application (Track B only)

Track A teams are selected on the basis of proposals submitted in response to BAA 06-36. Track B teams submit applications as described below.

### 4.1. Procedure

Internet access, e-mail access, and basic word processing are necessary to complete and submit the application and for communication with DARPA.

There is no fee for entry. The application procedure is a four-step process as summarized in Table 2. All parts of the application must be received before their respective deadlines. Materials received after their deadlines will be destroyed without consideration.

<b>TRACK B APPLICATION COMPONENT</b>	<b>SUBMISSION</b>	<b>DEADLINE</b>
Part 1 - Team Information	E-mail	October 13, 2006
Part 2 – Liability Form and Proof of Citizenship	Postal	October 13, 2006
Part 3 – Site Visit Information	Email	March 2, 2007
Part 4 – Video Demonstration	Postal	April 13, 2007

**Table 2. Track B Application process.**

Application materials are available on the Grand Challenge website and must be submitted using the transmittal instructions on the forms. The receipt of application documents will be promptly acknowledged by DARPA.

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

DARPA  
Attn: Urban Challenge  
3701 North 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. The time of receipt for each document will be logged by the DARPA e-mail system.

DARPA will assign a team reference number upon receipt of each team’s Urban Challenge Application: Part 1. This number should be included on all team correspondence with DARPA.

## 4.2. Team Promotional Material

The following materials will be posted in the Grand Challenge website:

- Contact information for each team, including team leader name, team e-mail address, and team URL
- Promotional materials provided by the teams such as the team description paragraph, team sponsor list, team picture and vehicle picture
- Team technical papers (after the conclusion of the UFE)

## 5. Qualification Process

### 5.1. Overview

Table 3 summarizes the qualification process. Autonomous vehicles will be evaluated at the site visit, the NQE Advanced Navigation Test, and the NQE Advanced Traffic Test. Vehicles that meet all the criteria for each test will proceed to the next level. DARPA may invite additional teams to participate at its discretion.

ACTIVITY	DATE	LOCATION	DELIVERABLE	CRITERIA
Video (Track B only)	April 13, 2007	N/A	5 minute Video	Video Guidelines
Technical Paper (Track A)	April 13, 2007	N/A	Technical Paper	Technical Paper criteria
Technical Paper (Track B)	June 1, 2007	N/A	Technical Paper	Technical Paper criteria
Site Visit	June 11–July 20, 2007	Performer course	U.S. Citizenship documentation	Safety Basic Traffic Basic Navigation
NQE Advanced Navigation	October 21-31, 2007	NQE course	none	Safety Advanced Navigation
NQE Advanced Traffic	October 21-31, 2007	NQE course	none	Advanced Traffic
UFE	November 3, 2007	UFE course	none	60 miles in 6 hours or less

**Table 3. Qualification Process**

### 5.2. Evaluation Criteria

The following criteria will be used for evaluation of autonomous vehicle capability for the video demonstration, site visit, and NQE.

The technical criteria for the Urban Challenge are organized as a four hierarchical sets of criteria, each subsuming all previous requirements. Generally speaking, the Basic Navigation and Basic Traffic criteria are required for the site visit, the Advanced Navigation criteria are required for the NQE navigation test, and the Advanced Traffic criteria are required for the NQE traffic test.

### 5.2.1. *Safety*

E-stop brings the vehicle traveling at 20 mph to a smooth, controlled, and complete rolling stop in less than 20 meters after E-stop activation

### 5.2.2. *Basic Navigation*

The basic navigation criteria apply for all qualification events at all times.

- A.1. **Preparation for run:** Vehicle is in autonomous mode and ready to begin run less than 5 minutes after receipt of the Mission Data File (MDF) from DARPA.
- A.2. **Mission start:** Vehicle follows checkpoints in the DARPA MDF starting at any location in the route network.
- A.3. **Checkpoints:** Vehicle front bumper passes over each checkpoint in the MDF in the correct lane or spot and in the correct sequence.
- A.4. **Stay in lane:** Vehicle remains entirely in travel lane at all times except when performing a legal traffic maneuver such as a left turn or maneuvering to avoid an obstacle.
- A.5. **Speed limits:** Vehicle speed conforms to minimum and maximum limits.
- A.6. **Excess delay:** Vehicle exhibits less than 10 seconds of excess delay on route as judged by DARPA.
- A.7. **Collisions:** Vehicle acts to avoid collisions and near-collisions at all times, as judged by DARPA.
- A.8. **Stop line:** Vehicle stops so front bumper is within 1 meter of stop line at intersection.
- A.9. **Vehicle Separation:** Vehicle maintains a minimum standoff of 1-meter on the sides and rear from all obstacles and vehicles in all areas. In safety areas, vehicle maintains a minimum forward vehicle separation equal to 2-meters. In travel areas, vehicle maintains a minimum forward vehicle separation of one vehicle length for every 10 miles-per-hour of speed, one vehicle length minimum.
- A.10. **Leaving lane to pass:** Vehicle maintains a forward vehicle separation of one vehicle length when leaving lane to initiate a passing maneuver in a travel area.
- A.11. **Returning to lane after pass:** Vehicle returns to travel lane between one and four vehicle lengths when completing a passing maneuver.
- A.12. **U-Turn:** Vehicle exhibits ability to perform a U-turn on a 9 meter wide road within a 30-meter road length.

### 5.2.3. *Basic Traffic*

- B.1. **Basic Navigation:** Vehicle satisfies all basic navigation test criteria.
- B.2. **Intersection precedence:** Vehicle respects precedence order at intersections and does not proceed out of turn.
- B.3. **Minimum following distance:** When following a moving traffic-vehicle, autonomous vehicle maintains the required forward vehicle separation distance.

- B.4. **Queueing:** Vehicle exhibits correct stop-and-go queueing behavior in a line of stopped vehicles, always maintaining a minimum spacing equal to the forward vehicle separation distance and a maximum spacing of two vehicle lengths.

#### 5.2.4. *Advanced Navigation*

- C.1. **Basic Traffic:** Vehicle satisfies all basic traffic test criteria.
- C.2. **Obstacle field:** Vehicle demonstrates ability to negotiate obstacle field safely and effectively.
- C.3. **Parking lot:** Vehicle exhibits correct parking lot behavior and demonstrates the ability to pull forward into and reverse out of a specified parking spot.
- C.4. **Dynamic re-planning:** Vehicle exhibits behaviors necessary to achieve objective checkpoints when roads are blocked.
- C.5. **Road following:** Vehicle navigates roads with sparse waypoints and stays in travel lane through road-following by sensing berms or road edges, or by any other sensor-based technique.
- C.6. **GPS outage:** Vehicle does not exhibit excess delay or leave travel lane due to intermittent loss of navigation signals such as GPS.

#### 5.2.5. *Advanced Traffic*

- D.1. **Advanced Navigation:** Vehicle satisfies all advanced navigation test criteria.
- D.2. **Merge:** Vehicle always merges into moving traffic when there is a delay of 10 seconds or more before the arrival of the next traffic-vehicle. Vehicle may pull into a gap of less than 10 seconds when conditions permit.
- D.3. **Vehicle separation during merge:** Vehicle merges between two vehicles into a lane of moving traffic. Vehicle maintains the forward vehicle separation distance to the leading vehicle, and the trailing vehicle does not slow or stop.
- D.4. **Left turn:** Vehicle always completes a left turn across a lane carrying oncoming traffic when there is a delay of 10 seconds or more before the passing of the next on-coming vehicle. Vehicle may complete turn when the delay is less than 10 seconds when conditions permit.
- D.5. **Vehicle separation during left turn:** Vehicle makes a left turn across a lane of oncoming traffic while preserving forward vehicle separation distances to vehicles in its lane. Vehicle must maintain a two vehicle minimum safety separation from oncoming traffic, without causing oncoming traffic to slow or stop.
- D.6. **Zones:** Vehicle navigates zones safely and effectively in the presence of moving traffic and other obstacles.
- D.7. **Emergency braking:** Vehicle comes to a complete and safe stop to avoid collision when a moving obstacle suddenly moves into the travel lane.
- D.8. **Defensive driving:** Vehicle performs defensive driving maneuvers to avoid impending head-on collision and maintains the required forward vehicle separation distance.

D.9. **Traffic jam:** When encountering a partially-blocked intersection, vehicle maneuvers to make forward progress and avoids collisions.

### **5.3. Video Demonstration (Track B only)**

The application and video demonstration are evaluated to determine the Urban Challenge Track B teams to receive site visits. The video demonstration (Part 4 of the application) is due on April 13, 2007. Each team will submit a video demonstrating the vehicle's ability to satisfy the safety test criteria, basic navigation criteria, and basic traffic criteria listed in section 5.2. The video (.wmv format) must be no more than 5 minutes in length and should show the vehicle entered in the Urban Challenge operating fully autonomously and performing all required maneuvers. Teams should use the audio track to explain the significance of each segment of the video. DARPA will release the Video Demonstration Guidelines on or before January 19, 2007.

DARPA will evaluate video demonstrations based on conformance with the rules in accordance with the safety, basic navigation, and basic traffic test criteria.

It is the sole responsibility of each team to ensure that activities undertaken in preparation for the Urban Challenge, including preparation of the video demonstration, are conducted safely and legally. All submissions become the property of DARPA and will not be returned.

### **5.4. Site Visit**

All Track A teams that pass Milestone 1 will receive site visits.

DARPA will review Track B applications and notify teams regarding site visit selections on or before May 11, 2007. Only teams selected for a site visit will continue as Urban Challenge entrants. DARPA will release the Site Visit Guidelines on or before January 19, 2007, including course layout and demonstration format.

Teams are required to create a site visit course at a location of their choosing according to DARPA's specifications. Teams must submit an RNDF for this course by e-mail to grandchallenge@darpa.mil before March 2, 2007. For Track B teams, this is required by Part 3 of the Urban Challenge application.

Site visits will take place during the period June 11- July 20, 2007 at team testing locations. 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.

The team leader and vehicle must be present at the site visit. The team leader must present the original U.S. citizenship and residency documents for examination by the DARPA team at the site visit. DARPA will assess vehicle performance against the site visit criteria listed in Table 3.

The Technical Paper Guidelines will be released by DARPA on or before January 19, 2007. The technical paper should be structured and formatted as for publication in a professional journal and should describe the vehicle design including detailed descriptions of architecture, theory of

operation, major subsystems, and vehicle behavior. The document should offer the reader a complete understanding of the performer's technical accomplishment. The technical paper evaluation will be weighted as 25% of the site visit score.

Based on the site visit and technical paper evaluations, DARPA will invite teams to participate as semi-finalists at NQE. Teams that are not selected may not participate further in the Urban Challenge.

DARPA will withhold technical papers until the conclusion of the Urban Challenge, at which time they will be released 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.

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

NQE will be held at a location in the western United States from October 21-31, 2007. National Qualification Event (NQE) Procedures will be published on the Grand Challenge website.

At the beginning of NQE, a safety test will be conducted to verify the proper integration and operation of the E-stop system. This test will use the criteria from section 5.2. RUN, PAUSE and DISABLE E-stop modes will be verified, as well as manual E-stop operation. Vehicles must pass these tests to continue in the competition.

NQE will consist of two phases. In the first phase, the Advanced Navigation Test, the vehicle will demonstrate the ability to satisfy the advanced navigation criteria (section 5.2). Vehicles in this test will not interact with other moving vehicles but will demonstrate safe operation in a complex urban environment. DARPA will provide the RNDF and MDF for these tests. Vehicles that are able to complete all course runs and satisfy all test criteria will move to the next level. DARPA may allow other vehicles to continue in the competition at its discretion.

In the second phase of NQE, the Advanced Traffic Test, the vehicle will demonstrate the ability to satisfy the advanced traffic criteria (section 5.2). This set of individual tests will evaluate the vehicles ability to travel safely over the course in the presence of other moving vehicles. The tests are designed to simulate situations that the vehicle will encounter in the UFE. DARPA will provide a RNDF and MDF for these tests and will operate the traffic vehicles. Vehicles that satisfy all technical criteria for these tests will be invited to participate in the Urban Challenge final event as finalists. DARPA may invite additional vehicles to participate at its discretion.

## **6. Urban Challenge Final Event**

### **6.1. Overview**

Vehicles competing in the UFE will execute two or more missions in an urban area with moving traffic. Mission completion entails visiting a set of checkpoints interconnected by a route network. Unique, but equivalent, missions are assigned to each team to distribute vehicular traffic over the urban area. The vehicle's path over the network to accomplish this task is not specified.

All autonomous vehicle entries will operate on the route simultaneously, interacting with one another in addition to static or moving vehicles operated by DARPA. Vehicles are required to obey all traffic laws and course rules. DARPA will impose penalties on vehicles for rules infractions, ranging from time penalties for traffic infractions to disqualification for a vehicle that causes a collision.

The UFE site will be announced in advance of NQE to ensure all teams have time to make travel arrangements.

## **6.2. Preparation**

Teams are responsible for transporting their vehicles from the NQE site to the UFE site, to arrive on November 1, 2007. On November 2, 2007, teams will participate in mandatory practice starts and safety inspections. DARPA will release Final Event Procedures to enable team planning.

## **6.3. Event Operations**

UFE vehicle starts will commence at approximately 7:30 AM on November 3, 2007. The event will be conducted during daylight hours. Vehicles will be pre-staged in an array of start chutes for a sequential start.

At the completion of all missions except the last, the final mission waypoint will be located in the vicinity of the start area. The vehicle will stop at this point and be taken out of autonomous mode. DARPA will turn custody of the vehicle over to the team's pit crew. The pit crew will bring the vehicle back to the start chute, load the next mission, and prepare the vehicle for autonomous operation. Custody of the vehicle will be returned to DARPA to start the next mission. Teams will be allowed to perform simple mechanical tasks such as wiping off sensors or inflating tires, but may not download data from the vehicle until the vehicle finishes the UFE course or is disqualified.

E-stops will be used during the course of the event to halt traffic for race management purposes (such as clearing a stalled vehicle). E-stop control will not be used to prevent vehicle collisions on the course. If a vehicle is disqualified, the vehicle will be placed in E-stop DISABLE mode and removed from the course.

Teams may not intervene in any aspect of vehicle operation when the vehicle is on the course. Team members may view the event at designated viewing areas but may not touch, direct, or interact with the vehicle in any way when it is on the course.

If a vehicle is making insufficient progress on the course or is otherwise hindering race operations it may be disqualified at DARPA's discretion.

## **6.4. Route**

### **6.4.1. *Route Network Definition File (RNDF)***

The Route Network Definition File (RNDF) specifies accessible road segments and provides information such as waypoints, stop sign locations, lane widths, checkpoint locations, and

parking spot locations. The route network has no implied start or end point. In addition to road segments, the RNDF specifies free-travel ‘zones’ with a defined perimeter, for which no interior waypoints are provided. Zones are used to represent parking lots and open areas with moving or stationary obstacles. Road blockages created by DARPA will not be indicated in the RNDF.

The UFE RNDF will be provided to teams at least 24 hours in advance of the start. For more details and a sample RNDF, teams are directed to the Route Network Definition File (RNDF) and Mission Data File (MDF) Formats document posted on the Grand Challenge website.

### **6.4.2**      *Mission Data File (MDF)*

The MDF specifies the sequence of checkpoints to be visited by the vehicle for a given mission. The MDF specifies minimum and maximum speed limits for all segments in the RNDF; speed limits may vary with each mission over the same route network. MDFs will be provided by DARPA for all Urban Challenge test events on USB 2.0 flash drives. Teams shall be prepared to load an MDF and move autonomously in 5 minutes or less.

For more details and a sample MDF, teams are directed to the Route Network Definition File (RNDF) and Mission Data File (MDF) Formats document posted on the Grand Challenge website.

## **6.5. Course Rules**

### **6.5.1.**      *Traffic Laws*

The vehicle must observe California state traffic laws and conventions at all times on the course. The vehicle must travel in the proper travel lane except during maneuvers such as U-turns and passing static vehicles. Vehicle speeds must conform to the speed limits in the MDF.

Specific definitions and enforcement metrics will be detailed in the Rules of the Road document to be posted on the Grand Challenge website. This document will include definitions for the following:

- Lane Boundaries
- Checkpoints
- Passing
- Safe following
- Stop sign intersections
- Merging into moving traffic
- Traffic circles
- Left turns
- Zones and parking

### **6.5.2.**      *Obstacles and Collisions*

The vehicle must avoid collisions with both moving and static obstacles on the route. DARPA may place obstacles along the route to test obstacle avoidance capabilities.

DARPA officials will monitor route activities to observe vehicle behavior. Should a collision take place, the Chief Judge will assess the responsibility of each party involved. A vehicle determined to be at-fault in causing a collision will be disqualified and stopped. Incidental or non-damaging contact with obstacles will not necessarily result in disqualification.

A vehicle that is damaged in a collision may be returned to the start area, at the discretion of DARPA. The team may attempt minor repairs and the vehicle may be allowed to return to the course to resume completion of the mission, at DARPA's discretion. Repairs that take longer than 30 minutes are not minor repairs. Vehicles that are damaged in a collision and cannot be repaired are disqualified from the event. More details will be released in the Rules of the Road document.

### **6.5.3. *Penalties and Disqualification***

Vehicles committing minor traffic infractions may be allowed to continue operation but will be assessed a time penalty. This penalty will be added to the vehicle's corrected time (section 6.6).

Vehicles that cause collisions, exhibit reckless or destructive behavior, or are unable to conform to the Rules of the Road will be disqualified. The assessment of penalties is at the discretion of the Chief Judge, whose decisions are final.

## **6.6. Event Timing**

Elapsed time for each vehicle begins when the vehicle is given the first E-stop RUN command and ends when the vehicle completes the final UFE mission.

Corrected time is computed from elapsed time by subtracting corrections and adding penalties. A correction will be subtracted to compensate for the unequal distances from the start chutes. Time spent during E-stop pauses on the course will be subtracted including the 5-second safety delay interval. Time spent in the pits between missions will not be subtracted. A vehicle must have a corrected time of 6 hours or less to be eligible for a prize.

## **6.7. Finish Area**

After a vehicle crosses the finish line, it will be impounded for inspection. Teams may not approach their vehicle until it is released by a DARPA official. Prize determinations will be made after all vehicles have finished and corrected times have been analyzed by DARPA officials.

## Appendix: Definitions

### *Chief Judge*

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

### *Corrected Time*

Corrected time is the elapsed time plus any time penalties minus time credits for E-stop pauses, start line offset, or any other factor as determined by DARPA.

### *Course*

The Urban Challenge course is the urban road network as defined by the RNDF. This is sometimes referred to as the route or the route network.

### *Elapsed Time*

Elapsed time is the total time from when a vehicle is first put in RUN mode to the time it completes the final mission of UFE.

### *Entrant*

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

### *Finalist*

A finalist is a team that attempts the UFE course.

### *Grand Challenge*

The Urban Challenge is the third Grand Challenge (also “DARPA Grand Challenge” and the “Challenge”). DARPA may conduct other Grand Challenge events that do not involve autonomous vehicles.

### *Grand Challenge Website*

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

### *Lane*

Lanes are travel paths defined with respect to a road segment. Lanes are comprised of a series of waypoints ordered in the direction of travel.

### *Lane Width*

Lane width is defined as the lateral distance between the parallel lane boundaries in feet. This may be measured curb-to-curb on a single lane road or from the lane boundary (solid or dashed line) to the curb on a two-lane road.

### *Lane Boundary*

Lane boundaries are associated with a lane in the RNDF and identify the painted road markings such as solid white, broken white, double yellow. The markings identified in the RNDF always exist on the actual course pavement, although markings may exist that are not identified in the RNDF.

### *Media Representative*

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

### *Mission Data File (MDF)*

DARPA provides a set of checkpoints and speed limits to teams in the Mission Data File (MDF). Teams will receive unique MDFs before each event.

### *National Qualification Event (NQE)*

The National Qualification Event (NQE) is the final qualification stage in the Urban Challenge and will be held at a location to be announced in the western United States. Semifinalists will demonstrate their vehicles at the NQE and vie for selection for the Urban Challenge Final Event.

### *Official*

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

### *Prizes*

DARPA will award \$2,000,000 for first place, \$1,000,000 for second place, and \$500,000 for third place at the UFE.

### *Qualification Process*

The qualification process refers to the sequence of steps a team must successfully complete to be selected for the Urban Challenge Final Event, including the site visit and the National Qualification Event.

### *Route Network*

The road network consists of the set of roads identified by DARPA in the RNDF.

### *Route Network Definition File (RNDF)*

The Road Network Definition File (RNDF) specifies the network of road segments and zones that are accessible to vehicles, including checkpoints, waypoints, lane marking, stop signs, and lane boundaries. The RNDF is a tab-delimited text file that will be distributed at least 24 hours before the event.

### *Rules*

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

### *Safety Delay Interval*

When a vehicle's E-stop is put in RUN mode, the vehicle must operate the amber warning light and audible alarm for a 5-second safety delay interval before commencing motion.

### *Semi-finalist*

A semi-finalist is a team that has been selected by DARPA to participate in the National Qualification Event, and whose vehicle competes at NQE.

### *Site Visit*

Based upon a technical review of the vehicle specification sheet and the video demonstration, DARPA will select Track B teams 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.

### *Team Leader*

A team leader is the individual US citizen identified to DARPA during the application process and is responsible for acting as the primary point of contact for team communication with DARPA. The team leader must be present at all stages in the Qualification process.

### *Team Member*

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

### *Team Sponsor*

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

### *Technical Paper*

A formal document describing the engineering details of the vehicle design and operation. The technical paper will be evaluated as part of the site visit. Final versions of these papers will be published on the DARPA Grand Challenge website following the conclusion of the UFE. Information on technical paper content and required format will be available on the website.

### *Traffic Circle*

A traffic circle is a road junction at which traffic streams around a central island. Vehicles within a traffic circle have right-of-way over traffic merging into the circle from connecting road segments.

### *Urban Challenge Final Event (UFE)*

The Urban Challenge Final Event, which is the culminating demonstration of the Urban Challenge program.

### *Video Demonstration*

The video demonstration is a filmed vehicle test submitted as part of the Track B application. Video demonstration requirements will be posted to the Grand Challenge website including formats, content guidelines, and submission deadline.

### *Waiver and Release of Indemnity and Liability Form*

The Waiver and Release of Indemnity and Liability form is a required part of the Urban Challenge application and must be notarized and submitted by all applicants before the applicable deadline. Forms are available on the Grand Challenge website.

### *Waypoints*

Waypoints are uniquely identified two-dimensional locations on the surface of the Earth, identified in the RNDF by their latitude and longitude in the WGS84 datum. Waypoints are numbered consecutively in the direction of travel within individual lanes.