DARPA Urban Challenge

Frequently Asked Questions

Technical

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Frequently Asked Questions

A. Event

A.1. *Should teams be concerned with the weather for the Urban Challenge?*

Precipitation, wind, dust, smoke, or fog is possible from natural or artificial sources.

The Chief Judge will weigh a number of considerations including the forecast in making weather-related decisions that affect the event. November 4 has been reserved as a backup day.

B. Vehicle

B.1. *The rules say, "Challenge vehicles may be equipped to receive and process position-determination signals (such as GPS)." Does this include correction signals, such as differential and RTK corrections?*

Yes, signals may be passively received from navigation services. Vehicles may also passively receive radio signals in the environment, such as emissions from FM radio stations.

B.2. *Urban Challenge vehicles are required to have turn signals. Is this only to facilitate operation by humans, or is the vehicle required to flash turn signals when driving autonomously?*

The vehicle turn signals should operate when the vehicle is operating autonomously. The vehicle should signal before initiating a turn.

B.3. *Can a vehicle be used that has a right hand drive system, with the steering wheel and pedal controls on the right side?*

Yes. The location of the steering controls is not an issue.

B.4. *In the Rules, Section 3.2 Vehicle Platform, it states the "Vehicle must be built upon a full-size stock chassis or a full-size chassis with a documented safety record." Does this mean we have to build our vehicle using an existing commercial model? Can we modify it? Or can we build our own vehicle and find a way to obtain the required safety record?*

Vehicles based on a full-size stock chassis must retain the original drive train, brakes, etc from the stock vehicle. Teams may put a new shell on the vehicle, add racks for equipment, and make other modifications that do not compromise the integrity or safety of the original vehicle platform. Teams with vehicles not based on a stock chassis must submit documented vehicle safety test results for DARPA review with their Track B Part 1 application.

B.5. *Concerning the 2,000 lb weight requirement for the vehicle, is this the stock vehicle weight or the race weight after modifications for autonomous operations? Can this requirement be waived where a documented safety record exists for the stock vehicle?*

The weight requirement pertains to the stock vehicle weight, as delivered from the manufacturer. This requirement cannot be waived.

B.6. *In the Rules, Section 3.2, Vehicle Platform, it states the "Vehicle must be convertible to and from autonomous operation and human operation within 5 minutes." For the human operation requirement, may we use a remote control interface as opposed to having a human driver physically in the vehicle?*

Yes, the vehicles may be driven by remote control for staging purposes.

B.7. *What constitutes a "documented safety record"?*

The following criteria for a "documented safety record" may be used to qualify a vehicle:

a. Documentation that the vehicle has passed a state vehicle safety inspection and is registered and insured in the home state of the team
b. Documentation that the vehicle has completed 1000 miles or more of testing on public roads (human driven), to include odometer readings each month during the testing process. The starting odometer reading should be emailed to DARPA.

Teams pursuing this path for vehicle qualification should submit a memorandum and supporting documents to DARPA describing the process that was used. This documentation must be submitted and accepted by DARPA before March 31, 2007.

B.8. *The rules mention radiated RF energy levels but do not discuss the use of spectrum. Is it possible to field experimental equipment for the Urban Challenge?*

Teams must comply with FCC rules and regulations at all times. Teams wishing to apply for an FCC experimental license to operate at the Urban Challenge or have plan to use spectrum in an unconventional way should send details to DARPA at grandchallenge@darpa.mil.

B.9. *Is an externally mounted generator allowed on vehicle?*

No. External fuel tanks are a potential hazard.

B.10. *Can we design our vehicle to flash its hazard lights when it is enabled and in E-Stop PAUSE? The hazard lights would turn off when the vehicle goes into E-Stop RUN and the flashers and sirens would turn on per the vehicle requirements.*

The horn/flashing lights "interface" must be consistent and transparent for any staff member working at the DARPA events. The emergency flashers could potentially create confusion, and confusion causes accidents.

The vehicle must conform strictly to the guidelines and not flash its lights while in E-stop pause at the DARPA events.

B.11. *Can we drop RFID tags from our vehicle to identify places we have been and to aid in path planning on revisited segments? We are considering this as part of addressing the sparsity of the waypoint distribution.*

The jettisoning of materials is explicitly forbidden by the Grand Challenge Rules. From Section 3.2: "Except for normal byproducts of power generation, the intentional jettison of any material from a vehicle is prohibited."

B.12. *Can we setup a fixed RTK base station during NQE and the Final Event that will emit RTK correct signals to our robot?*

RTK signals that are openly or commercially available may be used. Because your proposed RTK base station is not an openly or commercially available service, it cannot be used.

B.13. *Please explain the difference between the E-stop DISABLE and PAUSE modes.*

The E-stop modes should be implemented in a way that makes the most sense for the particular vehicle platform.

PAUSE mode will be used frequently during the event. PAUSE should apply the vehicle brakes to bring the vehicle to a smooth, controlled stop (no skidding). Once the brakes are applied, and the vehicle has stopped, the gear may be put into "park".

DISABLE may be used as an emergency stop and shutdown should PAUSE fail and will also be used at the end of each mission when the vehicles are turned over to the team, and at the finish line. Teams should not rely solely on the operation of PAUSE to stop the vehicle when DISABLE is asserted; the parking brake or some other means should be used in addition to the primary brake system. DISABLE should also take the vehicle out of autonomous mode and shut down electrical systems and fuel flow to ensure the power plant is shut down.

B.14. *Has DARPA released specific requirements (speed, stopping distance) for the Technical Evaluation Criteria D.7 – Emergency braking?*

Technical Evaluation Criteria D.7 has been updated to read, "Autonomous vehicles must continuously monitor and detect dynamic obstacles in their travel path. When a traffic-vehicle pulls unsafely into the travel path from a side-road or driveway, the autonomous vehicle must execute a controlled (non-skidding) emergency stop. The vehicle must come to a safe stop without collision when the anticipated time to collision is 4 seconds or longer. Thus a vehicle traveling 10 miles per hour (4.4 meters per second) must stop in time to avoid collision with an obstacle that enters the vehicle path 17.6 meters in front."

B.15. *Is our vehicle required to stop if it is driving around an obstacle that is only partially blocking its lane?*

Consider that the lane stretches from the road edge to the near edge of the lane divider (double yellow line, for example) in the center of the road. A vehicle need not stop to pass an obstacle as long as it does not leave the lane, that is, no part of the vehicle passes the plane of the lane edge at the center of the road. On the other hand, the vehicle must always stop to check oncoming traffic before it may cross the centerline.

C. Route

C.1. *Section "2.4 Program Milestones...Figure 2" states that the Final Event will have "Passing of moving vehicles". Is this passing with on-coming traffic in the passing lane?*

This is passing in a passing lane without oncoming traffic. Vehicles are not required to pass moving traffic with oncoming traffic in the passing lane. Vehicles may be called on to pass stopped vehicles, however, with oncoming traffic in the passing lane.

C.2. *The rules give distances needed to pass a stopped vehicle. What about passing moving vehicles on a two lane road? Are vehicles allowed/expected to use the lane for oncoming traffic to pass a slow moving vehicle?*

Normal traffic rules apply. It is legal to cross into the oncoming travel lane to pass a stopped vehicle. Passing a moving vehicle may take place only in an area where passing is allowed (2 lanes, broken white line) or in a zone. A slowly moving vehicle (moving well below the minimum speed) may be passed at your own risk.

C.3. *What is the maximum number of road segments and zones that will be used?*

As stated at the Participants Conference, the expected size of the Urban Challenge Final Event (UFE) route network will be some small number (e.g. 3-5) times the size of the sample RNDF.

C.4. *Will all the lane boundary lines listed in the course definition (RNDF) actually be present in the physical world?*

DARPA's intent is for the RNDF lane boundary descriptors to match the actual physical lane markings on the ground. However, 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.

C.5. *In a segment with two (or more) lanes with two-way traffic, is it possible that there be a median curb between opposite lanes of a segment? (Which means, one cannot use the lane for oncoming traffic for passing.)*

Yes, this is possible.

C.6. *What kind of equipment may be used to block segments? Would you use cars to block individual lanes? Would K-Rails be used? Or cones? or drums?*

The use of K-rails was suggested at the Participants Conference. It was also indicated that obstacles would be the size of traffic barrels (drums), not the size of cones. Vehicles maybe used to block individual lanes or segments.

C.7. *When blocking a road in the route network, is it safe to assume ALL lanes of a segment will be blocked?*

DARPA has never discussed blocking only one lane, but this is not prohibited by anything that has been written. A vehicle confronting a single blocked lane may use the other lane to get past.

C.8. *Can the information about blocked segments detected in one run be used in following runs? Could we assume that a segment blocked in one run will remain blocked through the whole event?*

DARPA has not stated that a blockage will remain in place for the entire event.

C.9. *Lane 1.1 in the sample RNDF has no entry or exit waypoint. Is this lane accessible?*

The broken white line between lanes 1.1 and 1.2 indicates vehicles may pass freely between lanes without entry or exit waypoints.

C.10. *The current specification of sparse waypoints is extremely unclear and to fully handle anything that could be encountered adds great complexity to the design. If the true intention of the race is to demonstrate intelligent driving behavior and that discovering the route is not the point, then sparse waypoints run counter to that goal. Also, if imagery is provided, then there's no point to having sparse waypoints other than creating more manual work before the event.*

The sparse waypoints situation reflects the reality that a military planner faces. He/she may have imagery that is accurate in some area but may have clouds or other occlusions. Roads change or are moved. It may not be possible to notate every side road or driveway. DARPA is looking for teams who can build vehicles that will overcome these complexities and complete the mission.

C.11. *The example given in the sample RNDF is more like a circular road than a traffic circle. What are the minimum/maximum radii of traffic circles?*

This has not been specified. A sample radius was given in the Participants Conference briefing.

C.12. *Is it safe to assume that traffic circles will have only one way traffic?*

Yes.

C.13. *Can traffic circles have multiple lanes?*

Yes.

C.14. *Can one expect reasonably dense waypoints around the traffic circles?*

This has not been specified.

C.15. *What type of obstacle can be expected in a free zone (hay bale, cones, building, etc)?*

Any of these objects are possible, but obstacles will generally be larger than a traffic cone. Cones may be used, however, to define the perimeter of the zone for human observers, for example.

C.16. *Can we assume that obstacles found in a free zone in one run will remain in the same locations for the whole challenge?*

The assumption is not a good one, as the vehicle might be led to make some dangerous and incorrect assumptions. Although the original obstacle positions might be a good starting point, the vehicle should always be examining the environment for new obstacles or obstacles that have moved or are moving.

C.17.*Parking spots are only in zones. But is it possible that a zone may have no parking spots?*

Yes.

C.18. *Will there be 'spots' (parking) defined for pre-parked vehicles?*

Not necessarily. Vehicles may be present that are not in spots available to the autonomous vehicle.

C.19. *Will the parking area have painted lines or be outlined by cones?*

Parking areas will not necessarily have painted lines or be outlined by cones. The coordinates given in the RNDF should be sufficient.

C.20. *Is it possible that a parking 'spot' is defined without a checkpoint?*

No. Every spot in the RNDF will be defined with two waypoints, one of which is a checkpoint.

C.21. *Would it ever be needed to drive through one or more parking spots to reach our parking spot? Or can we assume that if we treat 'other' parking spots as blocked then there would still be a path to reach a parking spot assigned to us?*

DARPA will not assign your vehicle a parking spot that is impossible to reach or causes your vehicle to drive through another spot to reach. On the other hand, other moving vehicles may be present in the zone and access could be temporarily blocked.

C.22. *What will be used to fill pre-occupied parking slots? Other cars, or could you also use non-cars, such as hay bales? If using hay bales, would they be stacked to simulate the height/width/length of a car?*

The intent of the zone is to emulate a parking lot or staging area that an autonomous vehicle might have to navigate in a realistic scenario. A vehicle could reasonably be expected to avoid obstacles the size of a single hay bale placed anywhere on the ground.

C.23. *What type of paint will be used for lane markings? What condition will the markings be in?*

The paint used for lane markings has not been specified, as correct vehicle operation must be robust to variations in marking type and quality. Vehicles must contend with lane markings that are damaged, incomplete, or of varying quality.

C.24. *Where there are multiple lanes of travel in the same direction, is it permissible to transition between them (to pass a slower moving vehicle, for example) without being at an exit or entry waypoint?*

Yes, it is permissible to transition between travel lanes without being at an exit or entry waypoint, if the lane markings allow. An example of such is provided in the sample RNDF where the transition between Lane 1.2 and Lane 1.1 is allowed for passing indicated by the broken white lane divider between the two.

C.25. *If a competitor vehicle becomes disabled on a checkpoint, does passing that vehicle in the opposite lane count as visiting the checkpoint? In the current rules, it seems it wouldn't.*

Yes, if a checkpoint is blocked by a disabled vehicle, the vehicle may be prudently passed and the checkpoint credited is without penalty. If a lead vehicle slows or pauses at a checkpoint, however, each trailing vehicle should wait its turn.

C.26. *For intersections that are not called out in the RNDF, will the direction to travel through the intersection be obvious, in that it is either straight through or there will be sufficiently dense waypoints to indicate a turn? The example in the competitors briefing is ambiguous.*

In the sample RNDF the ambiguous intersection on the left side of the figure (on Segment 2 above Checkpoint #7) does not give waypoints that are dense enough for a vehicle to follow around the corner. Waypoints <u>are</u> dense enough to unambiguously indicate which path is intended. In this sense, direction through the intersection is "obvious."

C.27. *Are vehicles required to wait 10 seconds before merging with traffic or proceeding at a stop sign.*

No. After coming to a full stop, the vehicle may proceed immediately.

Vehicles are <u>required</u> to pull into a stream of traffic if there is a gap of at least 10 seconds.

C.28. *What do the GPS coordinates for the perimeterpoint_ID represent? Is it the centerline of the boundary, and if so is there an assumed width? Is it the right hand boundary?*

The perimeter points represent the boundary of a zone that vehicles must stay within. The perimeter is a mathematical boundary and does not have a width attribute. Perimeter points are numbered consecutively in a clockwise manner, starting with the northernmost point.

C.29. *If we drive past a Checkpoint without passing over it, may we backup and maneuver over the Checkpoint to achieve it without a penalty?*

You can back up as many as three vehicle lengths to achieve the checkpoint. This maneuver must be conducted safely so as to avoid vehicles and obstacles behind the vehicle. The vehicle moving in reverse must yield to forward-moving vehicles.

C.30. *When parking in a parking spot, will the vehicle be required to drive through the waypoint and then the checkpoint? Or could the vehicle pull through (and stop in) a spot in the opposite direction from that implied by the waypoint/checkpoint order?*

"Pulling through" a parking spot is not allowed. Pulling in and backing out is required using the implied direction of the waypoint/checkpoint order.

C.31. *What types of obstacles might be encountered in a zone?*

Vehicles should detect and avoid any object encountered on a supply mission in an urban area. Typical obstacles include parked vehicles, fire hydrants, light or power poles, loading docks, chain link fence, wooden pallets, bicycles and bicycle racks, rubber tires, street signs, concrete blocks, curbstones, kiosks, tables or chairs, trees or bushes, concrete planters, cardboard boxes, shopping carts, forklifts, traffic barriers, 50-gallon drums, etc. Negative obstacles such as potholes or ditches may also exist and should be avoided.

C.32. *After a vehicle has passed some checkpoints in order, is it allowed to go through those, checkpoints again to get to the next valid checkpoint?*

The vehicle must achieve the checkpoints in order and may visit any other checkpoints to accomplish this goal. Thus a vehicle heading from checkpoint A to checkpoint B may visit any combination of checkpoints before visiting A, between visits to A and B, and after visiting B without consequence.

C.33. *The Rules state the starting point will be "at any location within the route network." Does this mean starting and finish points will be checkpoints, lane waypoints, spots, or points within zone?*

Vehicles will start from designated start chutes as shown in Figure 1 below. The start chute and the short distance in front of it lie in a single lane of a single segment. These start chute segments will be defined in the RNDF. One waypoint will be located directly in front of the chute.

Vehicles will leave their start chutes and proceed along their respective start segments to reach Segment X, which they will follow to the test course.

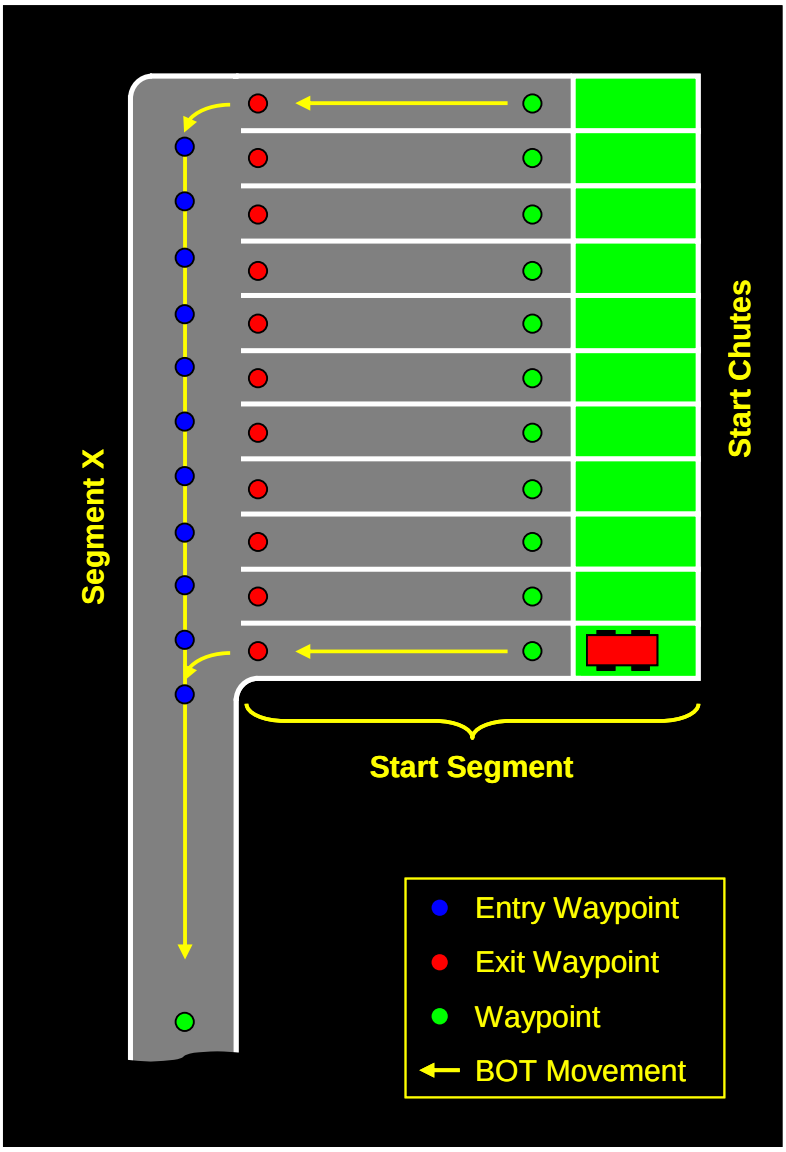

Figure 1. Sample Start Configuration

The last checkpoint in the MDF marks the location of the finish point. The finish line will be located before the finish point, ensuring the vehicle crosses the finish line autonomously (see Figure 2 below). The vehicle must come to a complete stop at the last checkpoint of the MDF.

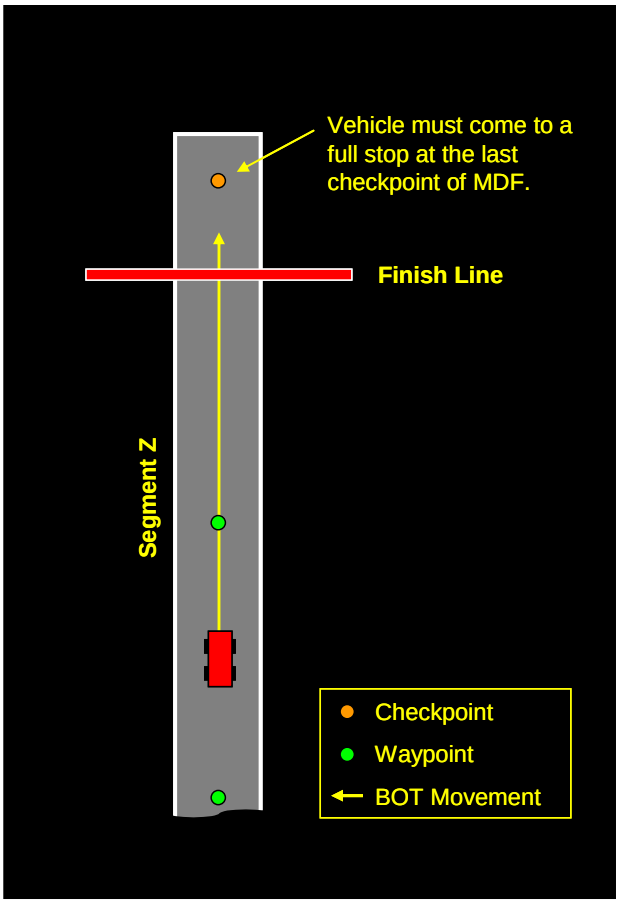

Figure 2. Sample Finish Configuration

C.34. *What is the sequence of events during a 'pit-stop' between missions? What are the allowable team actions during the 'pit-stop' between missions?*

At the end of a mission, DARPA will put the vehicle in E-stop DISABLE mode and the team will take custody of the vehicle and move it in manual-mode to their assigned start chute.

Once in the start chute, teams may perform simple mechanical tasks such as wiping off sensors or inflating tires, but may not take any action that changes the intelligence of the vehicle in any way. Calibrating sensors, changing parameters, or making the vehicle aware of its competitive status is not allowed. Data, video, or other information may not be accessed until DARPA turns the vehicle over to the team at the end of the race.

The team will load the MDF for the next mission provided by DARPA. Teams will review their vehicle-specific MDF loading procedures with a DARPA official prior to the race, and the team will be monitored during the 'pit-stop' to ensure compliance with these procedures.

Once the MDF is loaded, the team will notify DARPA to put the E-stop into PAUSE. The team then places the vehicle into Autonomous mode and leaves the start chute. At this point custody is turned over to the DARPA starting official, who will place the vehicle in RUN mode to start the vehicle's next mission.

C.35. *I would like more information on "safety areas" on the course such as those defined in Technical Criterion A.9. Do safety areas exist only at four-way intersections?*

A safety area exists at every intersection with one or more stop signs. Shown below is the safety area at a T intersection.

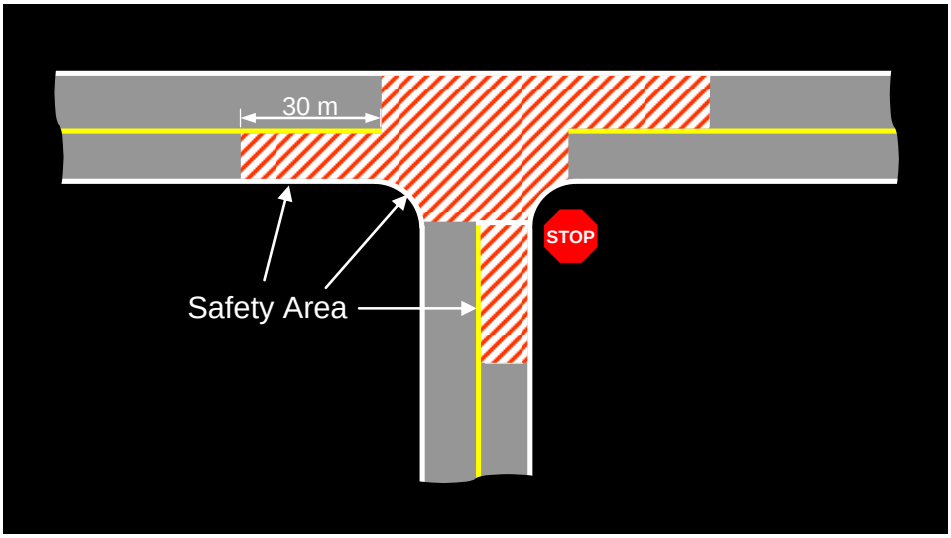

Figure 3. Safety area at a T intersection

C.36. *In the Sample RNDF, are the stop signs at waypoints 2.1.5, 3.1.14, 8.1.2, 9.1.2, and 9.2.3 necessary?*

The vehicle must come to a full stop at all stop signs indicated in the RNDF, even if there are no crossroads at the stop sign. A 30m safety area exists at these stop signs.

C.37. *Some of the lines in the RNDF do not end with a tab character. What is the rule for tab-delimited files?*

The RNDF was created by converting an MS Excel spreadsheet (.xls) to a tab-delimited text file (.txt). This conversion does not always insert a tab character when a new line is present. This same conversion will be used for the event RNDF and MDF.

C.38. *Will the Urban Challenge course have large variations in grade or rapid transitions between zero grade and high grades (i.e., a ramp). For instance, a hilly urban course could have a scenario with a stretch of road at 25 - 35% grade which then intersects another road segment at 0 - 10% grade. Is there any limit to the grade and/or rate of grade change in the terrain we must be able deal with?*

The road grade and its rate of change are not limited by the rules.

C.39. *Will a mission require us to move from one parking spot to another parking spot in the same zone?*

This is permissible under the rules.

C.40. *Can we download and use aerial/satellite imagery available from a public source (i.e. Google maps) after we have received the RNDF?*

This is permissible under the rules.

C.41. *What will be the format, resolution, and quality of the Final Event course imagery DARPA will provide? Will this imagery be similar to the Sample RNDF Map with the course overlaid, or will it be a "clean" image?*

The specifications of any imagery provided by DARPA have not been finalized.

C.42. *Which kind of penalty will we incur if our car stops more than 10s while rebooting a computer or resetting some onboard hardware? If the vehicle creeps forward while rebooting would this prevent a penalty?*

DARPA will publish a table of penalties before the NQE and Final Event. A car that stops once during the race to reboot or reset hardware is likely to receive a very light penalty. A stopped or creeping vehicle would both incur the penalty, and the creeping behavior poses additional safety risks to be avoided.

C.43. *What happens to the DARPA-supplied USB drive while the vehicle runs the course? Is it returned to DARPA?*

After this drive is used to load the MDF on their vehicle, the drive is returned to DARPA. The drive does not remain attached to the vehicle during autonomous operation.

C.44. *Will consecutive checkpoints in an MDF ever be identical?*

No.

C.45. *Consider the case where my vehicle is facing another vehicle at a four-way stop intersection. We are both making right turns, and the other vehicle has precedence. Does my vehicle have to wait to enter the intersection until the other vehicle has cleared the intersection?*

Yes, each robot waiting at an intersection must wait until the intersection box is clear before entering the box.

C.46. *I would like a more precise definition of an intersection. In the sample RNDF it is apparent that at certain locations external roads enter the route area. Do these constitute intersections?*

As a robot travels down a road segment, it is assumed to have the right of way unless it encounters a stop sign. Vehicles may enter the course from connecting roads that are not defined in the RNDF. These vehicles do not have the right of way, but the robot must be prepared to stop for a vehicle that pulls out illegally (technical evaluation criterion D.7).

If the vehicle encounters a stop sign at an intersection, it must come to a full stop and establish its precedence. Intersection roads without stop signs always have highest precedence. Robots at intersection roads with stop signs use stop-line arrival order to establish mutual precedence. If more than one intersection road has a stop sign, the intersection box rule comes into effect. Robots on intersection roads without stop signs need not wait for the intersection box to be clear before entering, but must act at all times to avoid collision.

C.47. *In the RNDF, is it possible for a lane to form a loop? That is, if one drives along the waypoints in a lane, one will come back to the same point?*

The RNDF definition offers a large amount of flexibility in the segmentation a given road network. The definition admits unusual cases where a single segment forms a loop, crosses itself, or even doubles back. In designing the routes for NQE and the UC final event, DARPA will adopt the style established in the RNDF sample. Road segments will generally correspond with named roads or portions of named roads and may cross other road segments. Traffic circles are represented by two or more segments.

C.48. *How much flexibility is there in format for the lat/long coordinates for the RNDF?*

The latitude and longitude format must be precisely as specified in the RNDF definition document. The use of a floating point representation or the use of more than six places past the decimal are not acceptable. Alternative formats (UTM, decimal-minutes, decimal-seconds) are also unacceptable.

C.49. *Technical evaluation criterion A.4 states that the vehicle must remain in the travel lane at all times, at least one meter from the center line. This may not be possible with a wide vehicle and a narrow lane. What is the range of lane widths?*

Every passage on the route created by DARPA is negotiable by vehicles that satisfy the vehicle width requirement. As a general rule, lanes on two-way segments are wide enough for vehicles to maintain the required 1 meter spacing, although there are exceptions. Static obstacles such as parked cars along the lane, parking spaces, or openings in chain-link fence may create narrow areas which the vehicle must traverse by staying in the center of the open lane. Narrow areas may also be created dynamically by the actions of other vehicles.

C.50. *How are checkpoints and waypoints marked on the route?*

Waypoints and checkpoints will not be marked for identification by the vehicle. Markings of checkpoints may be present for use by officials. A vehicle that traverses a lane containing a checkpoint will be credited with the checkpoint. In cases of impeding traffic, a stalled vehicle on the checkpoint, or other similar circumstances, a vehicle may leave the lane to avoid the obstacle and still receive credit for the checkpoint.

C.51. *The solid yellow was recently added to the RNDF specification. What is the difference between double yellow and solid yellow?*

The solid yellow was added to enable teams to use this marking for their site visit courses. From the perspective of the driving rules, there is no difference. Vehicles may not pass other moving vehicles by crossing this line, but may pass static obstacles as described elsewhere in the rules.

C.52. *What are the minimum radii specified for curves?*

No minimum radius has been specified. The roads and intersections have the same general character of those in the sample RNDF. Intersections may not always be exactly at right angles, so turns more acute than 90 degrees are possible.

C.53. *If a road marking is not specified, does that imply that it is a road edge?*

The RNDF will reflect the situation that exists on the ground. If a lane has a right hand edge that is defined by a white line this will be specified, although the line may not be uniform or easily visible along the entire length. If segment has a centerline, this will be indicated; otherwise no lane edge will be specified.

C.54. *Are teams allowed to use aerial imagery to assist with areas that have sparse waypoints?*

High quality geo-registered aerial imagery will be provided with the RNDF, although the team will not have access to the course to check ground truth in advance of the event.

The limited portion of the course with sparse waypoints will take place on roads that are not visible in the aerial imagery. The vehicle should be able to recognize and follow turns in a graded road with sparse waypoints.

C.55. *How hilly is the Final Event course area?*

The course is traversable by a passenger automobile and with a few exceptions is not considered hilly terrain. The elevation difference from the highest to the lowest point on the course is approximately 50 meters.

C.56. *Over what fraction of the course should we expect to lose GPS coverage?*

GPS is available over most, but not all, of the course. Although the GPS dropouts are not extensive, the possibility remains that a vehicle could wait in a line of traffic in an area with a dropout, or that the vehicle could be E-stopped in an area with a dropout while a situation is resolved elsewhere on the course. GPS will not be electronically jammed by DARPA.

C.57. *The technical evaluation criteria describe a segment that includes a single waypoint. Is this possible elsewhere on the course?*

Technical evaluation criteria A.2 shows that the segment in each start chute may have only a single waypoint. Elsewhere on the course, every segment will have at least 2 waypoints.

C.58. *Is it legal to pull forward to exit a parking spot? Is local sensing required in the parking lot?*

A vehicle may drive through other parking spots to find its own spot. The path forward out of the assigned spot will be blocked, and reverse maneuvering is required. The vehicle must have the ability to sense the environment behind the vehicle, backup when the way is clear, and proceed forward to the next waypoint. Both static vehicles and moving vehicles will be present in the lot, and teams should expect their vehicle to be able to pull safely into and out of a parking spot with static vehicles in parking spots to the right and left.

C.59. *Will a vehicle ever be restarted off the course or in an intersection? Is it safe to assume that no low-lying obstacles will lie in front of the vehicle that would be difficult for even a human driver to detect?*

DARPA will use the "all-pause" capability of the E-stop system to manage situations that develop on the course. During this process it is conceivable that a vehicle involved in an altercation could be repositioned on the course and allowed to continue. This vehicle would be positioned away from obstacles that might be difficult to detect. It is conceivable that at other points on the course, vehicles could be paused in the middle of an intersection, or pulling into moving traffic. At the intersection, all vehicles must retain knowledge of the precedence order and proceed accordingly when they are allowed to continue. In all cases, vehicles should proceed cautiously upon restart.

C.60. *If the vehicle is positioned such that the first waypoint is behind the vehicle, determination of the best path to the next checkpoint gets complicated. Is it reasonable to assume that we will be facing our first waypoint on a mission start or restart, or will we be tasked to determine the first waypoint within our lane?*

Mission starts will take place as depicted schematically in technical evaluation criterion A.2and FAQ C.33, where the RNDF provides at least one unique waypoint for each start chute and a first check point that is on a subsequent segment. Restarts may take place on the course as well. In the case of a vehicle that swerves to avoid an accident and leaves the course, DARPA may issue an "all-pause" command to resolve the incident. The Chief Judge may decide that a wrecker should be used to reposition a vehicle back on the course in the direction it was traveling. In this case the vehicle would be required to resume its mission from its repositioned location.

C.61. *We understand that the segment's waypoints are ordered, and this determines segment direction. This information is good when we are in that lane, however multiple lanes running adjacent to each other and running in the same direction are not explicitly indicated in the RNDF. Would it be possible to create a grouping of lanes running in the same direction in the RNDF?*

Two contiguous lanes traveling in the same direction are always part of the same segment, and are always denoted by the broken_white lane boundary indication. The number of lanes will stay fixed throughout an entire segment.

C.62. *The RNDF description of zone perimeter points it talks about them being in clockwise order. Will all zones have their perimeters defined in clockwise order, or is the clockwise ordering specific to the example RNDF?*

Clockwise point ordering of the zone perimeter is a property of all zones.

C.63. *What are the rules at the four-way stop intersection? Will our vehicle be penalized for "excessive delay"?*

When the robot arrives at the stop line, it must come to a full stop within one meter of the stop line and the brake lights should come on. Traffic vehicles that are present at the intersection before the robot arrives have higher precedence, and should be tracked by the robot as they pass through the intersection. The robot must be prepared to wait indefinitely for vehicles with higher precedence. Only after the last traffic vehicle with higher precedence has passed completely through the intersection, may the robot cross the stop line and enter the intersection. The robot has 10 seconds to initiate this process, from the moment the intersection is clear to the moment the robot crosses the stop line. If the vehicle in the intersection is turning, the directional signals should come on.

C.64. *Are checkpoints always given in order? Will checkpoints ever be skipped?*

The robot should be capable of plotting and navigating the route from any checkpoint to any other checkpoint in the site visit course, without being provided the intermediate checkpoints.

C.65. *I understand from Technical Evaluation Criterion A.10 that vehicles may not pass other vehicles in the safety areas but only in travel areas. Does the entire passing maneuver have to take place in the travel area?*

The key is the location of the vehicle being passed. Stopped vehicles entirely or partially in safety areas may not be passed. This does not restrict the area in which the maneuver starts or finishes.

D. Qualification

D.1. *Will safety riders be allowed at NQE and the Final Event?*

No. Safety riders are allowed only for the traffic runs at the site visit.

D.2. *According to the description of the RNDF in the Site Visit Guidelines, waypoints in neighboring lanes lie on a line perpendicular to the direction of travel. Will waypoints at NQE and the Final Event follow this format?*

This specification for waypoints is only applicable at the site visit, and will not necessarily apply to the NQE or Final Event RNDF.

D.3. *Our vehicle was not designed to accommodate a safety rider. How can we conform to the site visit requirements?*

As indicated in the Site Visit Guidelines, the traffic vehicles and their drivers will be in the path of the autonomous vehicle during the course of the traffic runs at the site visit. Each team is required to have a tested emergency stop system to be used if an autonomous vehicle poses a hazard. As an additional layer of protection during these runs, teams are allowed to place a safety rider inside the autonomous vehicle.

Some teams' autonomous vehicle configurations may not accommodate a safety rider. These teams should submit an alternative configuration they are confident will result in a safe demonstration. The alternative configuration should not change the nature of the test, but may include fail-safe E-stop systems, safety equipment for the drivers, etc.

D.4. *The Video Guidelines call for side and rear sensors. How are these to be demonstrated in the video?*

The full complement of sensors should be integrated on the vehicle and visible during the vehicle tour. A demonstration of these sensors is not required.

D.5. *In the Site Visit and Video Demonstration Guidelines, the constraints regarding the speed of the vehicle are unclear. In the video the vehicle must be shown autonomously navigating the course with a target average speed range of 5 to 15 mph and returning to the start location. For the site visit, speed is not mentioned. Do we need to demonstrate the Basic Navigation and Basic Traffic capabilities with speed range of 5 to 15 mph?*

For the Video Demonstration, the teams shall decide the speed which to execute the course safely. DARPA has set a target range of 5 to 15 mph and will judge the video against this criterion.

For the Site Visit, the speed is communicated to the vehicle via the MDF, which the DARPA officials supply for the Site Visit runs. Speed is one of the factors evaluated at the Site Visit.

D.6. *Will further instructions be released on how the site visit will be evaluated?*

The site visit will be evaluated against the basic navigation and basic traffic criteria. Vehicles that consistently demonstrate the ability to satisfy these criteria at the site visit will be rated highly. There is no plan to release additional information at this time.

D.7. *Page 3 of Site Visit Guidelines states the following: "Success or failure in meeting milestones in a contracted effort does not determine success or failure in becoming an Urban Challenge semifinalist."*
Does this statement imply that even if a Track A team fails to meet the Milestone 2 requirements, they may still become a UC semifinalist?

Track A teams will be tested at the Site Visit against the Milestone 2 criteria laid out in their contracts or agreement with the Government. Their success or failure in meeting the Milestone 2 criteria is solely determined by the terms of the contract or agreement, irrespective of the performance of other teams.

The performance record of the Track A team at the Site Visit will, in addition, be used competitively against the performance of other teams from both tracks to determine qualification as a semi-finalist. All teams are judged against the same criteria and ranked against all other performers in determining semifinalist selections.

The contracted effort and the competition are related, but distinct, and the results of a team's milestone

D.8. *We are looking for a suitable location to host our Site Visit. Do you have any suggestions?*

Southwest Research Institute is offering a course at their facility in San Antonio, Texas. Southwest Research Institute's UC Site Visit Course

This facility is not affiliated with the DARPA Urban Challenge program.

D.9. *Section 5.1 of the Site Visit Guidelines states, "The minimum distance between any two right angle turns on the closed loop course is 40 meters." How will you be measuring the distance between the turns? Will it be from the apex of each turn or will you be measuring from the corner gates?*

The 40 meter requirement applies to the distance measured between corner gates.

D.10. *Section 5.1 of the Site Visit Guidelines states that the Site Visit course shall have lane widths of 4.5 meters, which is 14.7 feet. However, the RNDF specification requires that lane widths be specified in integer feet. What lane width should we specify in our RNDF?*

Teams may specify lane widths of either 14 or 15 feet in their Site Visit RNDF.

D.11. *Section 5.1 of the Site Visit Guidelines states that any vehicle eligibility issues, such as the submission of safety record documentation, must be resolved by March 31, 2007. How do I know if my vehicle has eligibility issues?*

FAQ B.4 above states the basic vehicle requirements. Vehicles that don't meet this requirement and do not have a stock chassis must meet the safety record requirements stated in FAQ B.7.

D.12. *For the Site Visit, would an alternate route configuration such as depicted below be allowed?*

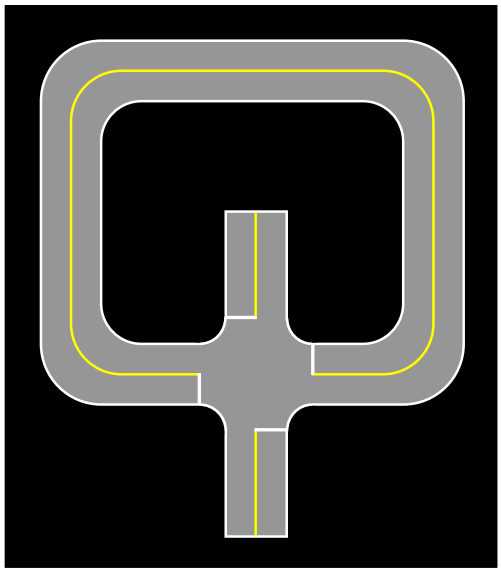

Figure 4. Unallowable Site Visit Course Configuration

No, this configuration is not allowed. The stub roads must be at right angles to one another.

D.13. *The video guidelines and FAQ indicate we need to have a full complement of forward, side, and rear sensors mounted. We will have a full set of sensors mounted, but are (and could still be at video time) working on sensitivity and optimal coverage. We may in fact be still testing a new sensor at that time.*
Could you confirm that sensor locations could be changed and new sensors could be added after video submission?

Sensors may be added or relocated after the video submission, subject to inspection at the Site Visit and NQE.

D.14. *Can we submit a primary and a secondary site for the site visit information? The reason is that our primary site may have construction issues during the site visit period and we want to have a backup site ready.*

Submit the site visit information for your primary site by the March 16 deadline. If the primary site becomes unavailable, contact grandchallenge@darpa.mil.

D.15. *Is a site visit course allowed if the lanes are significantly narrower than 4.5 meters (e.g., a city road, with 10-12ft lanes)?*

Narrower lanes may be used, but performance will be scored the same as on a course with standard with lanes. All lane edge markings should be placed at the edge of the narrower lanes.

D.16. *The site visit guidelines state that moving traffic will not be encountered during navigation runs. Will disabled vehicles or other static obstacles be present?*

Static obstacles may be present during these runs.

D.17. *At the site visit, will the vehicle be required to demonstrate the behavior of passing a disabled vehicle with oncoming traffic in the passing lane as described in Technical FAQ C.1?*

At the site visit, vehicles will not be required to pass with oncoming traffic in the passing lane.

D.18. *What type of detail does DARPA want in our site visit course submission? Is it possible to modify the RNDF of our site visit course after it is submitted? Is it possible to change the site visit location? Can we submit an RNDF for a backup course?*

The submission should include a "best guess" at the site visit course the team intends to use. The course must satisfy all the requirements, including a right angle intersection, three right angle turns, stub roads at right angles to one another, and lengths that conform to the requirements. A course that is slightly longer (20%) than the requirements is acceptable, and lanes that are narrower than 4.5m may be used. The RNDF should conform to the RNDF format guidelines, including fixed point decimal-degree representation for latitude and longitude with exactly six places to the right of the decimal point. The file should be tab-delimited.

The course may be realized with one or more segments. The stub roads need not be straight, although teams should be cognizant of the difficulties of executing U-turns on a sharply curving road. Teams should determine in advance their plan for demonstrating the correct operation of their E-stop.

Although the submissions are reviewed by DARPA, this does not guarantee that the course conforms to the published guidelines, that the file conforms to the RNDF guidelines, or that the team's software will correctly read the RNDFs provided by DARPA for the qualification events.

The site visit location should be finalized and communicated to DARPA before the May 10 announcement of teams to receive a site visit.

D.19. *The course described in the Site Visit Guidelines is much simpler than the course at the Participants Conference? Has DARPA reduced the technical scope of the Urban Challenge?*

The scope of the event has not varied from that described at the Participants Conference. The site visit will test the team's achievements against the basic navigation and basic traffic technical evaluation criteria. Although the configuration is not complex, DARPA believes that the site visit course will offer the appropriate level of difficulty for determination of the Urban Challenge semi-finalists.

D.20. *The guidelines call for an entry and exit point to be placed at the end of the stub roads on the site visit test course. Where should these points be located, precisely?*

The points should be placed to enable a U-turn on either of the stub roads, within 15 meters of the end of the road end. Sharply bending stub roads may make the U-turn difficult, so this should be considered in laying out the course.

D.21. *How many segments should be used to define the site visit RNDF?*

The number of segments is at the prerogative of the team. The course may be defined by a single segment, or broken into multiple segments.

D.22. *What is the longest course allowed for the site visit?*

The target range is 250 – 500 meters. DARPA will accept courses no shorter than 250 meters and no longer than 600 meters.

D.23. *Is pavement required for the site visit course?*

Pavement is recommended, but not required.

D.24. *Should we assume that the stub roads will function as "start chutes" for the site visit?*

Technical evaluation requirement A.2 stipulates that the vehicle must be able to initiate a mission from any point on the route network. For this reason, it should not be assumed that the stub roads will function as start chutes.

D.25. *We have not marked our site yet. Is site marking mandatory for the photo to be submitted with the SVIS?*

Site marking is not mandatory. An aerial photo showing the course layout would be appreciated.

D.26. *We need to know the time and date of the site visit to secure a site. Can you tell us when our site visit will be?*

Once videos are reviewed, DARPA will commence the process of scheduling teams for site visits. Most site visits will take place in the last two weeks of June.

D.27. *We are creating our video and are confused by the following paragraph from the video guidelines:*

> *"All videos must be marked prominently in the onscreen material to reflect the appropriate copyright notice and the existence of the Government license, citing specifically to the terms of the DARPA 2006 Urban Challenge Video Demonstration Guidelines."*
>
> *Can you provide an example of wording that would satisfy this requirement?*

The following satisfies this requirement:

"Copyright 2007 by Team Yourname. Team Yourname has granted DARPA a license for use of this video in accordance with the Urban Challenge Video Demonstration Guidelines."

D.28. *What is required for the E-stop test at the Site Visit?*

The team must demonstrate the pause, disable, and run functionalities of their E-stop. The intended behavior of the vehicle should be discussed with the DARPA officials in advance. The team may use a customized RNDF and MDF for this demonstration. The vehicle must be in autonomous mode for this test, without a safety rider. A demonstration in which the vehicle is put in autonomous mode, issued a RUN command, stopped with a PAUSE command, issued a second RUN command, then stopped with a DISABLE command is sufficient. After the test, the vehicle may be moved under human control to a start point, and a new RNDF and MDF loaded as directed by DARPA officials.

D.29. *We are considering the use of the course shown below for our site visit. The stub roads are folded inside the course to save space. The dimensions of the course satisfy all the requirements in the guidelines document. Is this course configuration acceptable as a site visit course?*

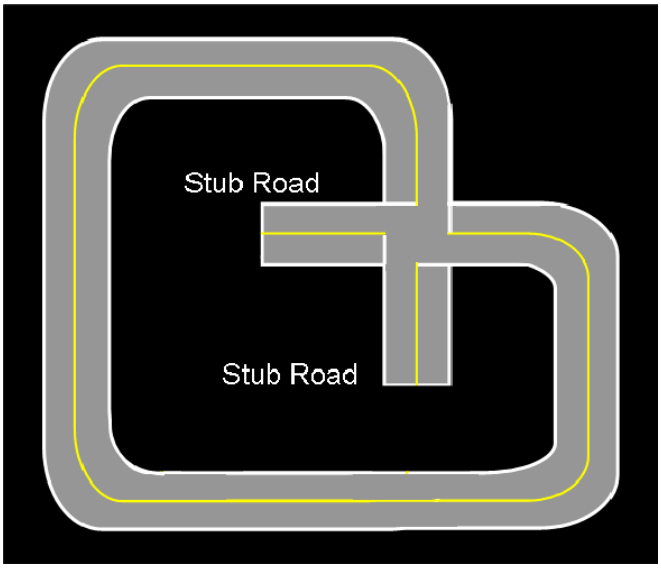

Figure 5. Allowable Site Visit Course Configuration

Yes, this course configuration is acceptable.

D.30. *Shortening the length of our 35 page technical paper to 25 pages will involve leaving out some analysis and results. Is it OK to submit the longer paper? Can we reduce the font size?*

Having a fixed length and uniform font size for the technical paper creates a level playing field; papers are reviewed competitively as part of the Site Visit score. Teams should conform to the guidelines so reviewers can perform a fair comparison.

D.31. *Our team has selected a location for the site visit, but to ensure safety at this site we feel a safety rider is required for the navigation runs as well as the traffic runs. Is this acceptable?*

The team must take whatever steps are necessary to ensure safety at the Site Visit – if a safety rider is the only way this can be achieved then the team must use a safety rider to meet DARPA's overriding requirement that the Site Visit be safe. The DARPA officials present at the Site Visit will note the use of a safety rider, as well as any other means used to validate that the safety rider never exercised control over the vehicle (in-vehicle video for example).

D.32. *Figures 3 and 5 of the Site Visit Guidelines seem to show waypoints at the location of the corner gates on the site visit course. Is this a requirement? Is it possible to put waypoints between corner gates near the apex of a turn?*

Waypoints are not required at the corner gates. Figure 5 of the Site Visit Guidelines has been changed to make this clear. Waypoints may be placed near the apex of the turns provided the entire set of waypoints satisfies the 10-25m spacing requirements between waypoints in the same lane.

D.33. *Are computer-controlled directional signals required for the site visit?*

At the site visit the vehicle must actuate the directional signals before turning at an intersection and before making a lane change. The brake light must be actuated whenever the brake is applied. The vehicle must also display the visible and audible warning devices according to the state of the E-stop system, as described in section 3.4.3 of the rules.

D.34. *What is required for the E-stop test at the site visit?*

The team is responsible for designing and conducting the E-stop test. The following describes test procedures that together are adequate for this purpose:

> **Manual E-stop:** Vehicle is put into autonomous mode (PAUSE) as indicated by warning light and sound. Vehicle does not move. Team member actuates E-stop button on side of vehicle which cuts engine.
>
> **Wireless E-stop:** All spectators and observers are positioned in safe locations. Vehicle is configured and positioned to run on a straight portion of the site visit course using an MDF supplied by the team. Two lines are marked on the course spaced by 40 meters. Vehicle is put in RUN mode (wirelessly), crosses the first line, and is PAUSED (wirelessly) as it crosses the second line. Team uses a stopwatch to measure the time required to pass between the two lines (establishing speed) and verifies by measurement that the vehicle stops within 20 meters beyond the second line. Vehicle is DISABLED (wirelessly) which cuts engine.

D.35. *Is it permissible to use RTK GPS for the site visit?*

RTK may not be used for the site visit. The site visit should use the same navigation systems that are permissible for NQE and the final event.

D.36. *For the site visit, is our vehicle expected to deal with non-vehicle obstacles in the intersection?*

The general rule is that a vehicle should not hit an obstacle of any kind at any time, including trash cans, traffic barrels, hay bales, or pedestrians. This applies at site visits, NQE, and the final event. The predominant type of obstacle at the site visit will be other vehicles.

D.37. *Do the edges of the site visit course have to be marked?*

If the site visit course runs along a road with curbs or a well defined road edge, the outer road edge does not need additional marking. If there is no pre-existing road edge (as in an open parking lot), the team should consider marking the course for clarity.

D.38. *What should we use to mark the gates on the site visit course?*

18-inch or 28-inch traffic cones are ideal for gate marking.

D.39. *According to the site visit guidelines, the site visit has both navigation runs and traffic runs. Is the vehicle required to exhibit Basic Traffic behavior during the navigation runs?*

The team is responsible for all the basic navigation and basic traffic behaviors for the site visit. This is not to say that everything will necessarily be tested, but anything that could be tested on the course that are on these lists are in scope. Anything on either of these two lists is fair game at any time, i.e., teams should not plan turn behaviors on and off based on whether they are attempting a navigation run or a traffic run.

D.40. *What are the restrictions on vehicle motion at the site visit? Can we do U-turns? Can we go in reverse? How fast can we go?*

The use of U-turns is restricted to the stub roads on the site visit course, where this is explicitly indicated in the RNDF. U-turns are not allowed on the loop section of the course or in the intersection. The use of reverse gear is limited to short distances as described in Technical Evaluation Criterion C.4. Reverse may also be used as part of a U-turn as described in Technical Evaluation Criterion A.12. The speed limit for the site visit is 5 mph (minimum) and 15 mph (maximum).

D.41. *Do we need to bring signed copies of the Site Visit Liability Release form for all members of the site visit test crew?*

The team should bring unsigned copies for each member of the test crew. These forms are signed on-site in the presence of the DARPA officials at the start of the site visit.

D.42. *What type of proof of citizenship documentation is required at the site visit?*

The team leader must be present at the site visit (alternate not accepted). The team leader should present either a US passport (expired is OK) or a birth certificate with and U.S. driver's license (expired is not OK – must be up to date).

D.43. *We are using 28 inch cones to mark the location of the midpoint and corner gates on the site visit course. Where do we place the base of the cones?*

At the center of the road, the cones should be placed at the exact road center on a marked location. The base of the cone can be traced with chalk, for example, to make the location. At the edge of the road, the center of the cone should be placed on the lane edge. If the road has curbs, the cone should be placed on the travel surface, not on top of the curb. These locations should also be marked to facilitate placement of the cones should they be moved.

D.44. *Is it permissible to log data during the site visit using a wireless network?*

No.

Vehicles at the site visit should be configured as they would be for NQE. As described in the rules, no wireless links to the vehicle are allowed during the test (except for GPS and other navigation signals as described in the Rules). On-vehicle data logging, however, is permitted.

D.45. *At the site visit, does the vehicle have to do an auto-start without human intervention?*

Human intervention may be used to ready the vehicle for autonomous operation. Once the vehicle is ready, the DARPA officials will give a USB drive to the team containing multiple MDFs, and will instruct the team which MDF is to be used for the current test. The team has five minutes after receiving the USB drive to signal the DARPA officials that the vehicle is in autonomous mode (E-Stop PAUSE) and ready to run. The USB drive is returned to the DARPA officials at that point, and the team must wait for direction from DARPA before starting the run.

D.46. *Since the site visit RNDF does not contain start chutes like those described in FAQ C.33, will the vehicle be on the course or behind the stub roads at the start of each site visit mission? If not, is there a guarantee that the vehicle will not start in the four-way stop intersection?*

At the start of the site visit mission, the vehicle will be on the course, either on the loop or on a stub road. The vehicle will not start a mission in the intersection.

Note, however, that during the course of a mission (either at the site visit, NQE, or the final event) the vehicle may be E-stopped for one of many reasons including safety. The vehicle may happen to be in an intersection when this takes place. When E-stop RUN is reasserted, the vehicle must be able to recover and complete the course from the point where it was E-Stop PAUSED.

D.47. *The MDF format described by DARPA references an RNDF name. What RNDF name will be referenced in the MDF provided by DARPA at the site visit?*

All MDFs provided by DARPA at the site visit will reference "site_visit_rndf.txt".

D.48. *We want to make sure that we are able to read the MDF file provided by DARPA. Can you send us a sample based on our RNDF?*

The site visit test will consist of multiple missions, each with its own MDF. All MDFs will be dated June 1, and will reference the same RNDF (see D.47). All segments will have speed limits between 5 mph (minimum) and 15 mph (maximum).

The first site visit mission will consist of a single counterclockwise loop, starting from and returning to a stub road. A prototypical site visit course consisting of two segments is depicted below with labeled checkpoints. An MDF file is provided here that references these checkpoints and is representative of the MDFs that will provided by DARPA for the site visit test.

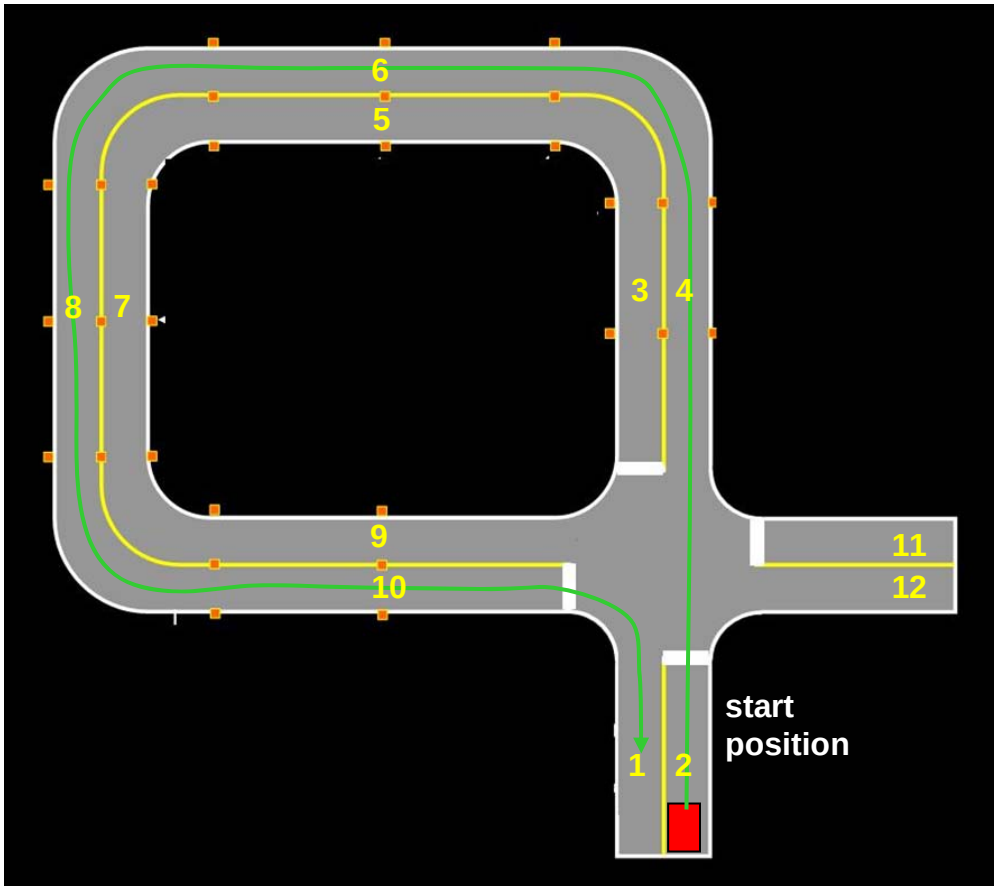

Figure 6. Sample SV MDF

D.49. *The Basic Navigation Technical Criteria for "Leaving lane to pass" (A.10) states that the vehicle should come to a complete stop and check for oncoming traffic before crossing a double yellow line to drive around a stopped car. The center line of our site visit RNDF, however, is not a double yellow line (unless perhaps it is intended to be). And in the*

FAQ, we are reassured that there will not actually be oncoming traffic when passing at the site visit.

All these things considered, is the vehicle required/desired to come to a complete stop before driving around a stopped car at the site visit, or not?

The vehicle must come to a complete stop before driving around a stopped car at the site visit.

D.50. *It would be helpful to have a bit more information about how the MDF files (and RNDF file) will be "delivered" at the site visit. Specifically:*

a. Will we be given MDF files individually at the beginning of each test or will all files be provided at one time on a single USB drive?

b. What will the naming convention be for the MDF files? Will an MDF filename ever be reused within the site visit?

c. Will we use the RNDF file that we supplied to DARPA or will a new RNDF file (presumably equivalent) to supplied to us?

a. MDFs will be provided individually for each mission, 5 minutes before mission start.

b. The MDF for the first mission will be named "mdf_1.txt". The "1" is replaced by a "2" for the second mission, etc. Teams should expect four missions.

c. The team will use the RNDF that was previously checked by DARPA.

D.51. *Technical Evaluation Criterion A.6 requires that a vehicle not exhibit excessive delay on the course. Is this rule in effect for the site visit? Will traffic vehicles be allowed to exhibit excessive delay?*

Technical Evaluation Criterion A.6 is in effect at the site visit. An autonomous vehicle must proceed within 10 seconds, for example, when it has precedence at the intersection. Traffic vehicles are not subject to this same constraint. Autonomous vehicles must respect the precedence order even if traffic vehicles linger at the intersection for times much longer than 10 seconds.