



# **DARPA Grand Challenge 2005**

Route Data Definition File

August 3, 2005

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## Route Data Definition File (RDDF)

**Purpose** The RDDF is a formatted file containing waypoints and other track information to specify the route for operation of an autonomous vehicle for the DARPA Grand Challenge (DGC) 2005. RDDFs will be provided to Grand Challenge teams for a multiplicity of purposes. At the National Qualification Event (NQE), RDDFs will be issued to specify multiple routes in the practice areas, to define the short routes used to validate operation of the vehicle E-stop system, and to specify the test course. At the Grand Challenge Event (GCE), RDDFs will be used to specify the route for practice starts as well as the Grand Challenge route.

This document supersedes any earlier guidance regarding the RDDF.

**Availability** A CD with the RDDFs for NQE will be distributed at the Team Leader Welcome Meeting on September 27 at the California Speedway. The RDDF for the practice start at the GCE will be available on the morning of October 7 at the GCE start area. The RDDF for the GCE route will be distributed to each team on the morning of October 8, 2 hours in advance of the assigned start time for the team.

**Loading Requirement** Grand Challenge teams are required to load a given RDDF file promptly (in no more than 5 minutes). To enable smooth and efficient practice area operations, teams must be able to select and load an RDDF on demand without returning to the garage area.

**Format** The RDDF is generated from a spreadsheet exported from Microsoft Excel™ as a CSV (comma delimited) file which is then converted to a text file. DARPA will provide RDDFs as one or more .txt files on a standard PC compact disk (ISO 9660).

There is no header line in the RDDF. Each line in the file consists of five comma-delimited data fields representing waypoint locations and associated information. The data fields represent the *waypoint number* (positive integer, starting with 1), *waypoint latitude* (float with 7 decimal places), *waypoint longitude* (float with 7 decimal places), *lateral boundary offset* (integer), and *course speed* (integer) (see Figure 1). Latitude and longitude are expressed in decimal degrees based on the WGS84 coordinate system. Points in the northern hemisphere and western hemisphere have a positive latitude and a negative longitude.

Waypoints are given in sequence, and route reuse is possible (the same point may appear twice in the file).

The lateral boundary offset (LBO) as defined in the DGC rules, is expressed in feet, and the course speed is expressed in miles per hour. Both the LBO and course speed pertain to the segment following the waypoint.

The total number of waypoints in the GCE RDDF will be between 1,000 and 5,000.

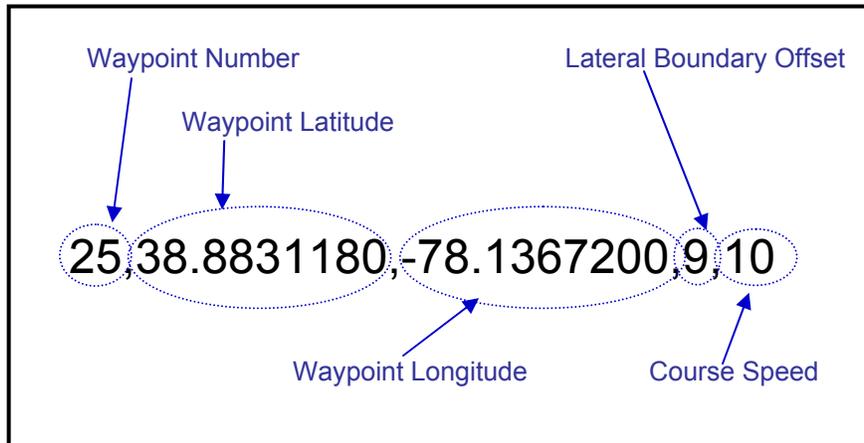


Figure 1. RDDF Line Structure

**Accuracy** The waypoints in the RDDF are obtained using a GPS system with real-time differential corrections. The manufacturer’s specification sheet for the system cites a position error distribution with a standard deviation of 15 cm. The differential GPS receiver was mounted on the centerline of a vehicle to collect waypoints as the vehicle traversed the center of the intended travel corridor. The points were sampled and post-processed to verify consistency, but no additional accuracy claims are implied. The center of the travel corridor from waypoint to waypoint may not be the optimal route for a given vehicle; additional road sensing and processing may be required to find the most suitable travel path.

**Geometry** The entry and exit waypoints, and LBO associated with a segment specify the route in-bounds area. The LBO for a given segment is given by LBO of the entry waypoint. The track line is the line segment that connects the entry and exit waypoints and lies along the centerline of the segment. The outer lateral boundary of the segment is determined by the LBO, which is the perpendicular distance from the track line to the boundary edge. At the endpoints, the boundary is determined by a circle centered on the waypoint with a radius equal to the LBO. The outer boundary of the route is defined by the least restrictive segment boundary. A vehicle is considered out of bounds if any part of it is outside the segment boundary. Figures 2 through 5 are examples of possible configurations.

As with the LBO, the course speed specified for the entry waypoint applies to a vehicle at any point within the segment. At points that lie within the area of two segments, the least restrictive (i.e., higher) course speed applies.

The distance between successive waypoints will never exceed 1,000 feet and will never be less than 3 feet.

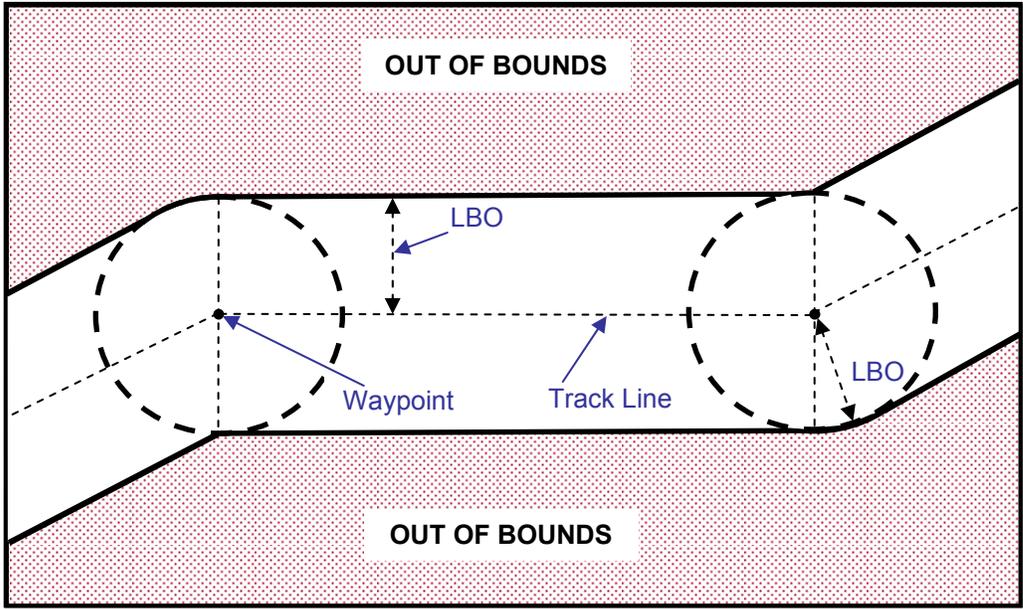


Figure 2. Route geometry

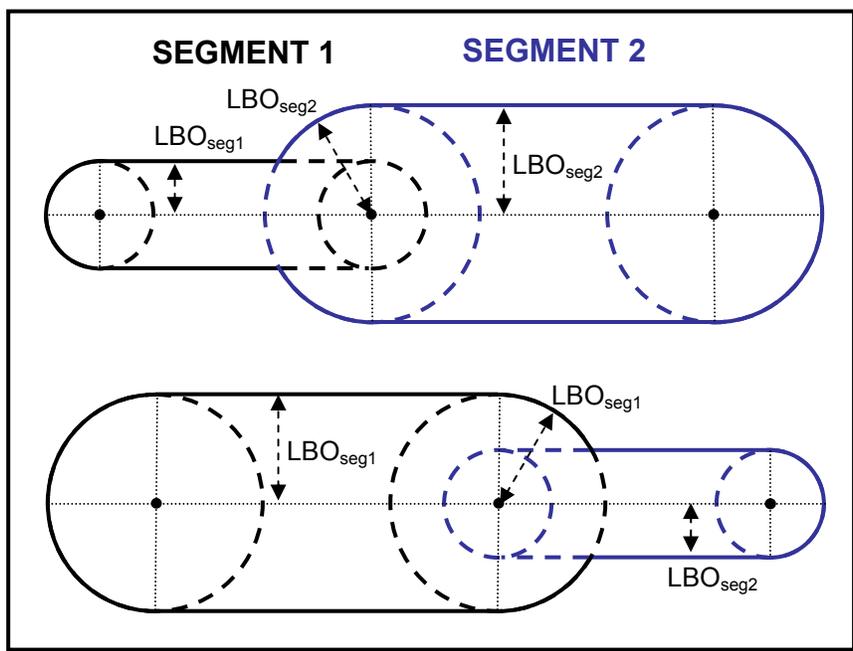


Figure 3. Changing lateral boundary

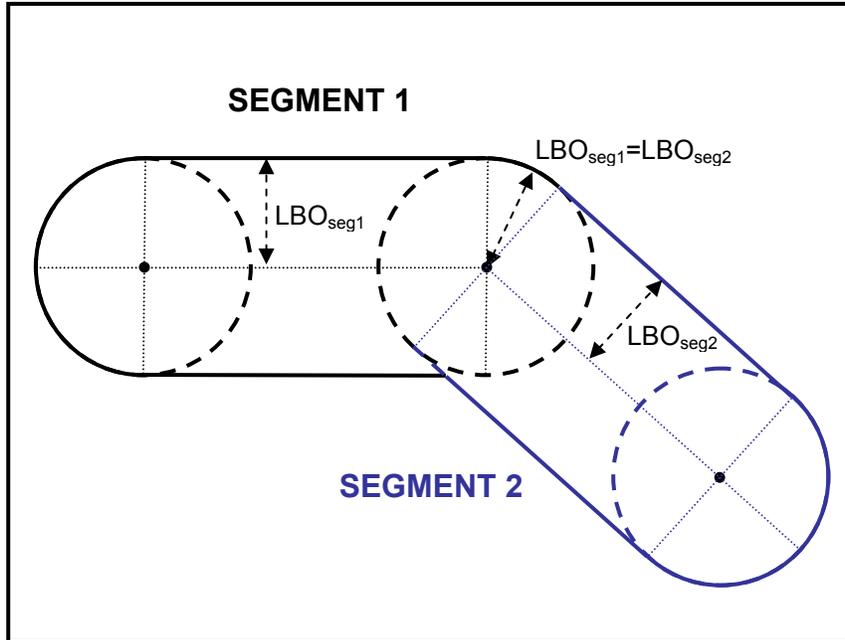


Figure 4. Change in direction (lateral boundary unchanged)

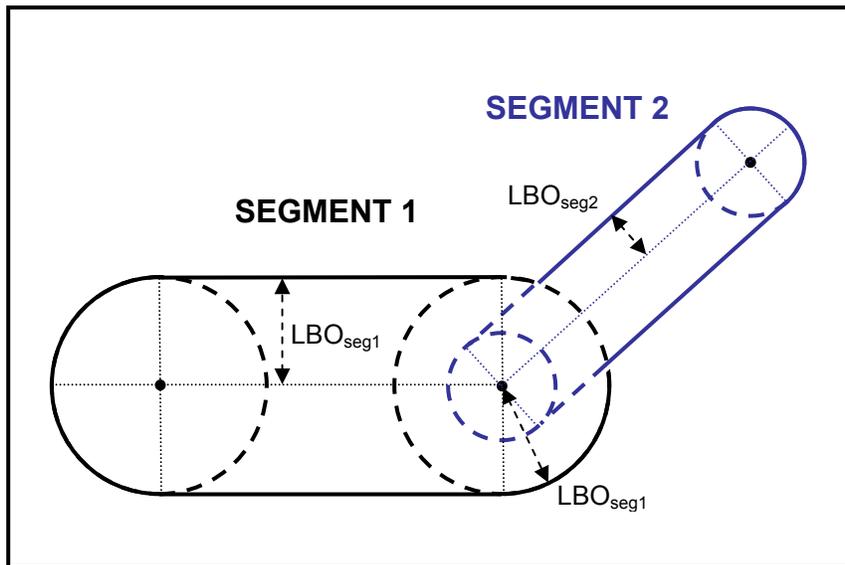


Figure 5. Change in direction and lateral boundary

**First and Last Waypoints** The first waypoint of the GCE route will be approximately 40 feet in front of the start line (see Figure 6). Three start chutes, each with a 12 feet opening and approximately 20 feet in length, will be arranged radially such that a vehicle in any of the chutes would travel the same distance to the first waypoint. The course speed and LBO associated with the route in advance of the first waypoint will be the same as the course speed and LBO of the first segment.

The last waypoint of the route will be approximately 40 feet beyond the arrival line ( see Figure 7). The course speed associated with the last waypoint will be zero to facilitate a complete stop after the completion of the route.

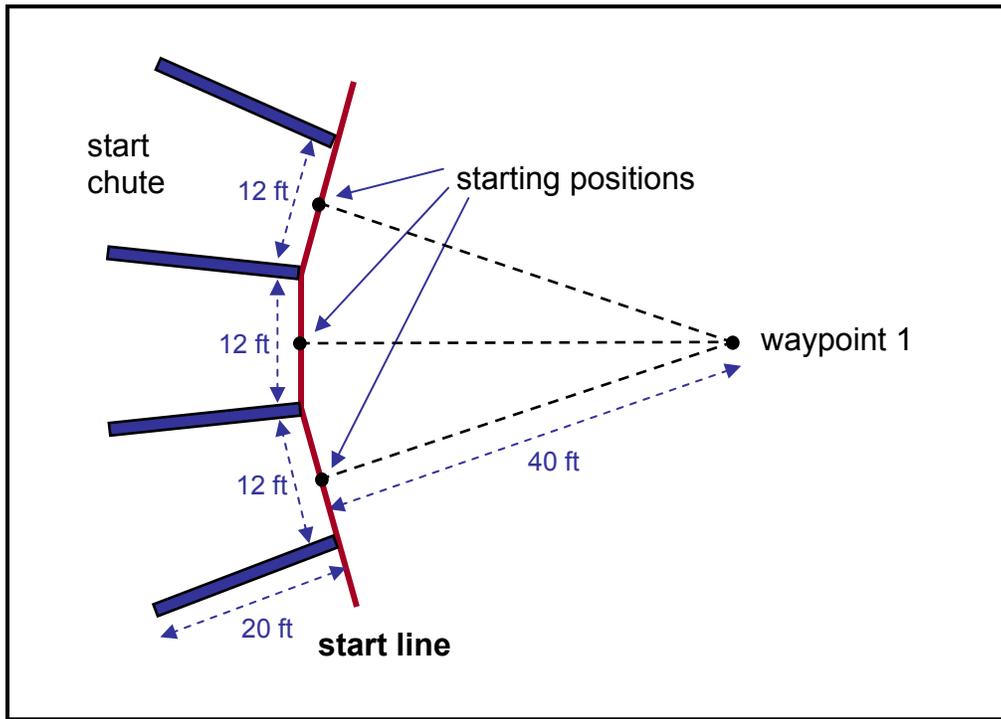


Figure 6. First waypoint and start line

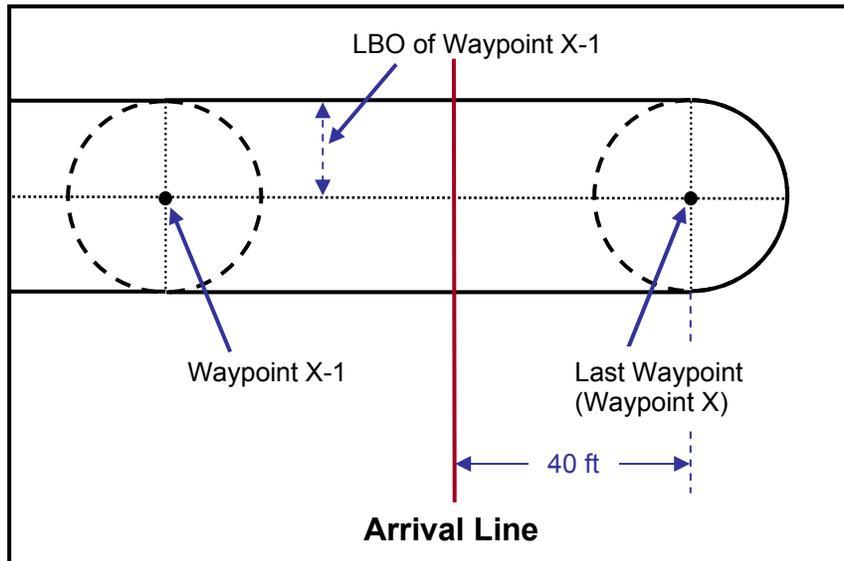


Figure 7. Last waypoint and arrival line

**Course Speeds** All vehicles on the DGC route should stay within the specified travel corridor, avoid obstacles (such as cars being passed) and travel safely along the specified route. Vehicles operating recklessly or in a manner that creates a hazard to event participants, other vehicles, or to the environment will be disqualified solely at the discretion of the Chief Judge. The course speeds provided as part of the RDDF are intended to aid in the safe conduct of the event.

Course speeds that are less than 25 mph are **mandatory** speed limits. In addition, a 50 mph mandatory course-wide speed limit is in effect under all conditions at all points on the route. The minimum course speed in the RDDF is 5 mph. Course speeds that are between 26mph and 50 mph (inclusive) are **advisory** and are provided for guidance purposes. No course speed will exceed 50 mph.

A vehicle that runs the course without ever exceeding the course speeds in the RDDF will be able to complete the course well under the 10-hour limit.

In situations where the course speed slows considerably over a short distance, speeds will be reduced gradually over several waypoints to aid in slowing vehicles. (See the sample RDDF.)

**Passing** The passing of one autonomous vehicle by another on the route during the event is coordinated by event personnel through the use of the E-stop pause command. To pass slower vehicles, all vehicles must be able to detect and maneuver around one or more stationary obstacles and stay within the LBO. Passing will be conducted only in areas with a route speed of 5 mph and a large LBO.

Please direct questions or comments to [grandchallenge@darpa.mil](mailto:grandchallenge@darpa.mil)