1. The text of the footnote reported by DARPA differs slightly from the text of the Fiscal Year 2001 National Defense Authorization Act, which states: “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.” ([4], p. 46).
2. Several teams participating in the 2004 and 2005 GCE made extensive use of pre-planning or pre-mapping prior to the race to effectively eliminate from consideration for the controlling intelligence all terrain but the actual course defined by the RDDF. The task of the controlling intelligence was therefore made simpler, and became one of distinguishing the course from terrain which had been eliminated from consideration by the team, and avoiding unintended obstacles.
3. Ostensibly, the criteria used to determine which vehicles were of interest to the DOD were reported by DARPA. However, only 25 of the 86 technical proposals received by DARPA are available for review, and it is unclear why 41 teams submitted technical proposals describing vehicles which did not satisfy these criteria. The author proposes the reported criteria were not the only criteria used by DARPA to determine which vehicles were of interest to the DOD, but concluded the published record does not provide enough information to be able to determine what deficiencies or weaknesses caused 41 of 86 teams to be eliminated.
4. DARPA stated: “...DARPA selected 19 teams for advancement to the next phase of the Grand Challenge and established a site visit process to determine the final 6

teams." ([3], p. 4). However, DARPA selected 18 teams to participate in the 2004 QID, in lieu of the 19 claimed. The technical proposal submitted by the ION Team was one of 19 technical proposals described by DARPA as "completely acceptable" on November 13, 2003, approximately four months prior to the 2004 GCE ([8]), but the ION Team was not selected to participate in the 2004 QID.

5. DARPA stated the purpose of the technical inspection was to ensure each challenge vehicle "complied with all rules and was safe to operate". Published records indicate the technical inspection did not identify challenge vehicles which were not safe to operate. For example, DARPA stated ([9]):

```
[Team 2004-02] - Vehicle circled the wrong way in the
start area.  Vehicle was removed from the course.
[Team 2004-09] - Vehicle hit a wall in the start area.
Vehicle was removed from the course.
[Team 2004-16] - Vehicle brushed a wall on its way out
of the chute.  Vehicle has been removed from the
course.
```

Although some time elapsed between the technical inspection and the 2004 GCE, it is unreasonable to conclude changes made by Teams 2004-02, 2004-09, and 2004-16 were responsible for their disqualification.

As a result, the author concluded the purpose of the technical inspection was not to ensure each challenge vehicle "was safe to operate", but that it "complied with all rules" DARPA established concerning devices emitting radiation, warning devices, e-stop requirements, etc.

6. DARPA identified obstacles selected as "representative" ([10]), however published records support a conclusion that obstacles selected as representative were not comprehensive. Several teams selected to participate in the 2004 GCE were eliminated by obstacles not identified as representative, and which teams apparently did not encounter during the 2004 QID, such as wire, fence, brush, or obstacles too small to detect. For example, DARPA stated ([9]):

   `[Team 2004-04] - At mile 0.45, vehicle ran into some wire and got totally wrapped up in it.`

   `[Team 2004-06] - At mile 6.0, vehicle was paused to allow a wrecker to get through, and, upon resuming motion, vehicle was hung up on a football-sized rock.`

   `[Team 2004-17] - At mile 1.3, vehicle veered off course, went through a fence, tried to come back on the road, but couldn't get through the fence again.`

   `[Team 2004-23] - Several times, the vehicle sensed some bushes near the road, backed up and corrected itself.  At mile 1.2, it was not able to proceed further.`

7. DARPA did not publish the point deductions in use during the 2004 QID. It is unclear if, for example, more points were deducted for exceeding the speed limit by 20 mph versus five mph, or if collisions with obstacles were "weighed" by assigning a severity to the collision.

8. DARPA did not request teams participating in the 2004 GCE respond to a

question similar to 2005 GCE SQ 2.5.1.

9. Teams 2004-10 and 2004-11 referred to the use of “simulation” but not a simulation environment similar to the Player Project:

- Team 2004-10 stated: “Post-processing synthesized goodness-maps and facilitated run-simulations in addition to physical testing.” ([32], p. 6).
- Team 2004-11 stated: “Based on the earlier simulation we had written, we are still busy at this date (24 Feb) arriving at an optimum arrangement and timing for the peripherals to 'talk' to each other.” ([33], p. 8).

10. Teams 2005-13 and 2005-14 originally proposed using seven LIDAR sensors during the 2005 GCE.

11. Other body and geom primitives supported by Gazebo include: `box`, `cylinder`, `sphere`, `trimesh`, `cone`, `heightmap`, and `plane`.

12. This was not possible with the representative challenge vehicle. By default, Gazebo places the CG of a body at its center. Use of a trimesh geom primitive for the representative challenge vehicle model would have placed the model CG higher than the representative challenge vehicle CG, resulting in simulated vehicle dynamics which inaccurately model real world vehicle dynamics.

13. The field-of-view of the Navtech DS2000 RADAR is 360 degrees. However, Teams 2005-13 and 2005-14 stated: “Most of the RADAR’s scan is obscured by the vehicle or brush guard. Its effective field of view is 70 degrees 40-70 meters in front of the vehicle.” ([19], p. 8 and [20], p. 8).

14. Sensors with a maximum effective range greater than 20 m (corresponding to a

stopping distance of 19.3 m at a maximum velocity of 25 mph) were not required for a team challenge vehicle to complete the 2004 or 2005 GCE course in less than ten hours. However, the effective use of complementary sensors to extend obstacle detection range and allow driving at higher speeds provided a competitive advantage to teams with significant experience and several potentially disruptive teams. Team 2005-16 was the most successful team to use complementary sensors.

15. DARPA did not identify which team proposed this. However, Teams 2004-11 and 2004-20 reported technologies which were similar in concept:

- Team 2004-11 stated: "In addition, we have kept the odometer on the axle with no brakes. This allows us to sense a skid or inadequate braking impulse. We have no algorithm for the former." ([33], p. 2).
- Team 2004-20 stated: "Vehicle speed as measured by the radar speedometer is compared with vehicle speed as measured at the driveshaft to detect slippage." ([52], p. 6).

16. Ironically, DARPA did not request teams participating in the 2004 QID or GCE or 2005 GCE describe how they would handle the loss of any other sensors.

17. Although not directly related to navigation sensors, several teams reported the potential military deployment of autonomous ground vehicles was a consideration in their selection of obstacle and path detection sensors. For example, Team 2005-12 stated: "Passive sensing offers advantages in both a military context, where undetectable sensors are crucial for effective operation and in a civilian

context, in which multiple autonomous vehicles must not interfere with one another." ([60], p. 2).

18. Teams 2005-16 and 2005-21 described calibration of sensors which was similar in concept. However, calibration of sensors was performed by the team. The challenge vehicle controlling intelligence was not taught to learn to interpret sensor data.

- Team 2005-16 stated: "...the sensors are periodically calibrated using data of dedicated obstacles of known dimensions. Calibration is an offline process which involves human labeling of sensor data. The calibration process adjusts the exact pointing directions of the individual sensors by minimizing a quadratic error, defined through multiple sightings of the same calibration obstacle." ([49], p. 8).
- Team 2005-21 stated: "Thanks to a precise calibration of the cameras – performed on a graduated grid – the three degrees of freedom specifying cameras orientation are fixed to known values, and in particular – in order to ease the subsequent processing – the yaw and roll angles are fixed to zero for all cameras." ([30], p. 10).

19. Team 2005-12 later stated: "...[The challenge vehicle] suffered a communications failure between the GPS unit and the guidance computer just before Beer Bottle Pass, a mountain pass near the end of the course, that would have ended a fully autonomous attempt." ([73], p. 753). Obviously, a similar communications failure during the 2005 GCE would have resulted in a similar outcome. However, the author is here attempting to distinguish between potentially-disruptive teams

which proposed competent system integration at a reasonable procurement cost and other teams, and there is no evidence supporting a conclusion a similar communications failure would have occurred during the 2005 GCE if Team 2005-12 had not failed to complete the 2005 GCE due to the programming error reported.

20. Teams are listed in alphabetical order, based on the alphabetizing scheme utilized by DARPA, in which the words "a", "an", or "the" are not considered significant ([75]). DARPA established an alternate alphabetizing scheme which treats the word "team" as "a", "an" or "the" ([76]). The original alphabetizing scheme was retained so that the teams would appear in the same order when referenced herein.

    In addition, to preserve alphabetical order, the occurrence of the team names "MonsterMoto" and "Mojavaton", in the order presented by [76], was reversed.