CHAPTER X. PRIOR EXPERIENCE AND CORPORATE OR ACADEMIC SPONSORSHIP

X.A. Discussion

Based on the author's conclusion that some teams were able to more effectively visualize the interaction of the challenge vehicle with the environment, the author proposed the ability to effectively visualize the interaction of the challenge vehicle with the environment was influenced by experience, sponsorship, or test and evaluation. See paragraph VIII.D.4.

Based on a review of performance during the 2004 GCE:

- Three of nine teams which completed more than zero miles of the 2004 GCE course reported prior experience in the field of autonomous vehicle development and significant (either moderate or extensive, see paragraph X.B., below) corporate or academic sponsorship: Teams 2004-04, 2004-10, and 2004-23.

- Four of the remaining six teams which completed more than zero miles of the 2004 GCE course reported significant corporate or academic sponsorship: Teams 2004-13, 2004-14, 2004-17, and 2004-18.

- The two remaining teams which completed more than zero miles of the 2004 GCE course reported neither prior experience in the field of autonomous vehicle development nor significant corporate or academic sponsorship: Teams 2004-06 and 2004-07.

X.B. Analysis

The author performed a review of published records to evaluate the effect of prior experience and corporate or academic sponsorship. Because the author concluded it would not be possible to estimate the cost of team challenge vehicles from published records (see paragraph V.E.), the author reviewed the published record to determine the primary group identity and level of corporate and/or academic sponsorship for each team which participated in the 2004 QID and GCE or 2005 GCE. Compared to teams which participated in the 2005 GCE, fewer teams which participated in the 2004 QID or GCE reported sponsors via their technical proposals.

Some teams reported sponsors via the team technical proposal or team website. Examples are included throughout this section, and references to the sources of this information are also included. However, to determine the primary group identity and level of corporate and/or academic sponsorship for each team, the author reviewed the Archived Grand Challenge 2004 and 2005 websites ([17] and [19]) and team websites to identify the sponsors were reported by the teams. References to the sources of this information are not cited in Tables LXVI, LXVII, and LXVIII, but may be confirmed by

review of the Archived Grand Challenge 2004 and 2005 websites ([17] and [19]) and team websites.

The author established the following categories of primary group identity:

- Individual. Members of the team do not predominately represent a corporation or academic institution, although they may have a collective identity as a Limited Liability Company (LLC) or similar business structure. Individual members of the team may represent small businesses, individually-owned companies, or consultancies.

- Corporate. Members of the team predominately represent a corporation.

- Academic. Members of the team predominately represent an academic institution such as a university or high school.

The author established the following levels of corporate or academic sponsorship:

- Limited. Equipment donations had a typical value of less than $5,000. Sponsors providing limited support were typically corporations such as AMD, Amphitech, Applanix, C&C Technologies, Crossbow, Delphi, Intel, NavCom, NovAtel, OmniSTAR, and SICK, among others. In general, teams with limited sponsorship were self-funded, or represented small businesses formed for the purpose of participating in the 2004 or 2005 GCE.

- Moderate. Individual sponsor equipment donations had a typical value between $5,000 and $25,000. Sponsors providing moderate support were typically medium to large corporations such as AM General, Caterpillar, Ford, GM, Honda, Honeywell, Oshkosh, and Rockwell Automation. Some teams with moderate sponsorship formed partnerships with small to medium businesses or academic institutions with no history of robotics research.

- Extensive. Individual sponsor equipment donations had a typical value in excess of $25,000. Sponsors providing extensive support were typically large corporations or defense contractors such as Boeing, Northrop Grumman, and SAIC. Some teams with extensive sponsorship formed partnerships with medium to large businesses, including defense contractors, or academic institutions with a history of robotics research and prior experience in the development of autonomous vehicles.

Individual sponsors may have made multiple donations or donations may have been received from multiple individual sponsors. In addition, sponsors may have offered the free use of equipment through loans, “free lease” arrangements, or “like kind” agreements. For this reason, the author focused on evaluating the number and relative

sizes of the sponsors reported by the teams. This analysis was, to an extent, subjective. However, even the limited information available provides some insight.

As a result, teams receiving overall limited sponsorship may have had several limited sponsors described above; teams receiving overall moderate sponsorship may have had a corporate or academic primary group identity, one or more moderate sponsors, or multiple limited sponsors described above; and teams receiving overall extensive sponsorship may have had a corporate or academic primary group identity, one or more extensive sponsors, or multiple moderate and limited sponsors. For example:

- Team 2004-02

Team 2004-02 stated: "Fifteen teams report that they raced in the 2004 DARPA Grand Challenge. Only seven of those team were actually eligible to win the $1 Million prize. [Team 2004-02] was the only self-funded 'Completely Accepted' team to be eligible for the US Senate funded prize at the start of the 2004 DGC race." ([86]).

- Team 2004-18

Team 2004-18 stated: "[Team 2004-18] is sponsored by ENSCO Inc, a privately owned engineering company that specializes in signal processing and data acquisition." and "[Team 2004-18] is employed and sponsored by ENSCO, Inc., which provides engineering, science and advanced technology solutions for the defense, security, transportation, environment, aerospace, and intelligent automation industries." ([48], p. 1).

- Team 2005-01

Team 2005-01 stated: "[Team 2005-01] is a self sponsored autonomous racing team battling large universities, Department of Defense contractors, and large for profit organizations. The team spends five cents or less for every dollar spent by well funded competitors. The team's major sponsor has been the Kehaly family of Westlake Village, California." ([86]). Although Team 2005-01 reported "no sponsors for 2005" on December 11, 2004, the team later reported "working relationships" with Northrop Grumman and Amphitech ([86]) on June 3, 2005.

- Team 2005-05

Team 2005-05 stated: "We would like to thank our sponsors: Mobileye LTD; BEI Technologies, Inc.; Intel Corporation; Federal Signal Corporation; OmniSTAR USA; Kenyon Labs LLC; Prime Resource, Inc.; National Instruments; and Sick, Inc." ([34], p. 13).

- Team 2005-07

Team 2005-07 stated: “Sponsors are: NC State University, IBM, SAS, Red Hat, Ascot Technologies, BDMICRO, Comtrol, Council & Sons Repair Service, Crossbow, Frantz Automotive, Lord Corporation, PC MedEvac, SICK, and Smith Anderson.” ([233]), and “Sponsors: Ascot Technologies, Inc., BDMICRO, Crossbow Technology, Inc., Council & Son Repair Service, Gemini Automotive Care, NC State University, PC MedEvac, and SICK, have provided valuable resources to help [Team 2005-07] reach this important milestone.” ([118])

- Team 2005-08

Team 2005-08 stated: “The core team draws on sponsorship from Ford, Honeywell, Delphi, and PercepTek...” ([173], p. 3).

- Team 2005-09

Team 2005-09 stated: “[Team 2005-09] is sponsored by the MITRE Corporation. MITRE is a collection of Federally Funded Research and Development Centers that support the DoD, FAA, IRS and other federal agencies. MITRE sponsors [Team 2005-09] entirely on discretionary funds and chooses this investment in a belief that many of The MITRE Corporation’s work programs would benefit from an investigation in the technologies that contribute to the DARPA Grand Challenge.” and “While the MITRE Corporation is the primary sponsor, additional companies that provided equipment and services include: ACTTechnico, Concurrent Technologies, Hybricon, Electronic Mobility Controls, Corp.., [*sic*] SuperLift Suspensions, Interco Tire, MSC Software, Top-Soil Precision Ag., OmniStar, PCB Piezotronics, Inc., and Tidewater Communications.” ([175], p. 2).

- Team 2005-10

Team 2005-10 stated: “The support that we received from our more than two dozen sponsors was astounding.” ([176], p. 8). Team 2005-10 reported the following sponsors: “Alpine Powder Coating”, “Automation Direct”, “Automotive Customizers”, “Barney Brothers Off Road”, “Big 'O' Tires”, “CoorsTek”, “Copley Controls”, “Crossbow”, “DVT Sensors”, “Earth LCD”, “Entivity”, “Foxhaven Video”, “Fuoco Motors”, “Galil Controls”, “General Technics”, “Genesis Engineered Solutions”, “Kearfott Navigation”, “Navcom”, “Optech”, “Platinum Signs”, “PNI”, “SICK”, “Tee Time USA”, and “Visual Expressions” ([176], p. 1).

- Team 2005-12

Team 2005-12 stated: “[The Team 2005-12 challenge vehicle] was fortunate to receive product donations from several companies. Rick Spina ’85 helped obtain a salvaged vehicle from General Motors. Trimble Navigation and ALK Technologies

donated GPS receivers. Otherwise, all student summer salaries, graduate student support and equipment was purchased using University endowment funds from the CSX Transportation Research Fund, the Lion Transportation Senior Thesis Fund, and the Kornhauser-Gervasio Graduate Fellowship. The team is also indebted to the generosity of the parents of the undergraduate researchers and Eric Huber." ([185], p. 8).

- Team 2005-15

Teams 2004-13 and 2004-14 were co-participants during the 2004 GCE. See paragraphs V.C.13. and V.C.14. Team 2004-13 participated in the 2005 GCE as Team 2005-15, and the Team 2004-13 challenge vehicle continued to the 2005 GCE. The Team 2004-14 challenge vehicle did not continue to the 2005 GCE.

Team 2005-15 stated ([53], pp. 2 - 3):

> Our fundraising approach is to invite companies and individuals, including many of our volunteers, to invest... Key investors are Rockwell Scientific and ATV Corporation... Amgen, a Thousand Oaks based biotechnology company, has provided computing hardware for [the Team 2005-15 challenge vehicle] and several Amgen employees are team members. Another key partner is the Engineering School of Auburn University who has developed the vehicle closed loop control system... Finally, we have also teamed with ARC Seibersdorf who has provided their stereovision system for feature detection.
>
> Support for our mapping task and waypoint file creation comes from volunteers employed by Vestra, Inc, ESRI and the City of Thousand Oaks.

Team 2005-15 later stated: "[Team 2005-15] formed to compete in the initial DARPA Grand Challenge in 2004. The core technical team was initially comprised mainly of engineers at Rockwell Scientific Corporation (RSC) and received a large portion of its funding from RSC." ([133], p. 580).

- Team 2005-16

Team 2005-16 stated: "[Team 2005-16] is sponsored through four *Primary Supporters*: Volkswagen of America's Electronic Research Lab, Mohr Davidow Ventures, Android, and Red Bull... [Team 2005-16] has also received support from Intel Research, Honeywell, Tyzx, Inc., and Coverty, Inc. Generous financial contributions were made by the David Cheriton [*sic*], the Johnson Family, and Vint Cerf." ([195], p. 3).

- Team 2005-17

Team 2005-17 stated: “We are thankful to the following companies and individuals for their support of the project: C&C Technologies, Lafayette, LA; Ray Majors and family, Melville, LA; MedExpress Ambulance Service, Alexandria, LA; Oxford Technology Solutions and Brendel Associates; SOLA Communications, Lafayette, LA; Lafayette Motors, Lafayette, LA; BEGNAUD Manufacturing, Lafayette, LA; Louisiana Department of Transportation; Recreative Industries, Buffalo, NY.; FireFly Digital, Lafayette; and Pixus Printing, Lafayette.” ([140], p. 11).

- Team 2005-20

Team 2005-20 stated: “The team is sponsored by ENSCO, Inc., which provides engineering, science and advanced technology solutions for the defense, security, transportation, environment, aerospace, and intelligent automation industries.” ([56], p. 2).

X.C. Results

Tabulated results are presented by Tables LXVI and LXVII. A comparison of sponsorship of teams which participated in both the 2004 and 2005 GCE is presented by Table LXVIII.

X.C.1. Experience

- Three teams which participated in the 2004 GCE reported prior experience in the development of autonomous vehicles: Teams 2004-04, 2004-10, and 2004-23.

  The Team 2004-04 sponsoring university stated: “The Center for Intelligent Machines and Robotics was founded in the 1970's... to be a leading center for interdisciplinary basic and applied research related to the many aspects of robotics.” ([234]).

  The Team 2004-10 sponsoring university stated: “The Robotics Institute at Carnegie Mellon University was established in 1979 to conduct basic and applied research in robotics technologies relevant to industrial and societal tasks.” ([235]).

  Team 2004-23 reported participating in the “1996 Ground Robotics competition”, “Demo’97” where “OSU autonomous cars were driven 70 mph and performed autonomous lane change and passing”, and “Demo’99” where “OSU cars performed GPS and map based driving” ([159]).

  Several other teams reported participation in events similar to the Grand Challenge but of such limited scope that the author did not consider the experience relevant for the purposes of this analysis. For example, Team 2004-25 stated: “...[the Team 2004-25 sponsoring university] won 1st and 2nd place in the

Autonomous Challenge at the 2003 Intelligent Ground Vehicle Competition.", but also stated: "...the speeds are slower (limited to 5 mph)" ([49], p. 13). Figures 14 and 15 ("Test Vehicle from the Intelligent Ground Vehicle Competition") of the team technical proposal ([49], p. 14) depict a three-wheeled vehicle slightly larger than, but not otherwise dissimilar to, the Pioneer series of robots popular in robotics research.

- Twelve teams participated in both the 2004 and 2005 GCE, which itself forms the basis for a claim of prior experience. See Table LXVIII. Teams 2004-04, 2004-10, and 2004-23 participated in the 2005 GCE as Teams 2005-02, 2005-04, 2005-13, and 2005-21, respectively[25].

  Several teams which participated in both the 2004 and 2005 GCE reported lessons learned from the 2004 GCE in their technical proposals for the 2005 GCE. For example, Team 2005-05 participated in the 2004 GCE as Team 2004-07. Team 2005-05 stated: "Reviewing the outcome of the 2004 Grand Challenge..." ([34], p. 2) and reported the rationale for several decisions made as a result of their experience during the 2004 GCE.

  However, the average number of miles of the 2005 GCE completed was not significantly different for teams which participated in the 2005 GCE but not the 2004 GCE and teams which participated in both the 2004 and 2005 GCE. See paragraph X.D.

- Two teams which participated in the 2005 GCE but not the 2004 GCE reported experience prior to the 2004 GCE: Teams 2005-14 and 2005-16.

X.C.2. Corporate sponsorship

- Three of 25 teams (12 percent) which participated in the 2004 GCE did not report corporate sponsorship was received by the team: Teams 2004-12, 2004-22, and 2004-24.

- All teams which participated in the 2005 GCE reported corporate sponsorship was received by the team.

- Between 2004 and 2005, a minor shift in levels of corporate sponsorship was reported: the number of teams receiving overall limited sponsorship decreased from 2004 to 2005 from 11 of 22 teams (50 percent) to eight of 23 teams (35 percent), while the number of teams receiving overall moderate sponsorship increased from nine of 22 teams (41 percent) to 12 of 23 teams (52 percent). The number of teams receiving extensive sponsorship increased slightly from two of 22 teams (9 percent) to three of 23 teams (13 percent). The author does not consider this increase to be significant because it is due entirely to Team 2005-14. Teams 2005-13 and 2005-14 were co-participants in the 2005 GCE.

X.C.3. Academic sponsorship

- Nine of 25 teams (36 percent) which participated in the 2004 GCE reported academic sponsorship.

- Fourteen of 23 teams (61 percent) which participated in the 2005 GCE reported academic sponsorship.

- Between 2004 and 2005, a significant shift in levels of academic sponsorship was reported: the number of teams receiving overall limited sponsorship decreased from 2004 to 2005 from four of nine teams (44 percent) to two of 14 teams (14 percent), the number of teams receiving overall moderate sponsorship increased from three of nine teams (33 percent) to seven of 14 teams (50 percent), and the number of teams receiving overall extensive sponsorship increased from two of nine teams (22 percent) to five of 14 teams (36 percent).

X.D. Conclusions

X.D.1. The effect of experience

Two teams which participated in the 2004 GCE but had no prior experience, limited sponsorship, and a primary group identity of "Individual" distinguished themselves by achieving the third- and fourth-greatest distances traveled: Teams 2004-06 and 2004-07, with 6.0 and 5.2 miles completed respectively. However, this performance was exceeded by teams which participated in the 2005 GCE but also had no prior experience, limited sponsorship, and a primary group identity of "Individual": Teams 2005-10 and 2005-11, with 23.0 and 7.2 miles completed respectively. The author considers this demonstrates the performance achieved by Teams 2004-06 and 2004-07 during the 2004 GCE was achievable by teams with similar levels of experience and sponsorship, and was not extraordinary, however extraordinary it may have seemed at the time of the 2004 GCE.

On average:

- Teams which participated in the 2005 GCE completed 48.3 miles of the 2005 GCE course.

- Teams which participated in both the 2004 and 2005 GCE completed 48.6 miles of the 2005 GCE course.

- Teams which participated in the 2005 GCE but not the 2004 GCE completed 47.9 miles of the 2005 GCE course.

Because teams which participated in the 2005 GCE but not the 2004 GCE completed as many miles of the 2005 GCE course as teams which participated in both the 2004 and 2005 GCE, the author concluded experience gained from participation in the

2004 GCE was not a contributing factor to the increase in the average number of miles of the 2005 GCE course which were completed. Based on the results, the author concluded experience prior to the 2004 GCE was much more important, providing a clear advantage to Teams 2004-04 and 2005-02, 2004-10 and 2005-13, 2005-14, 2005-16, and 2004-23 and 2005-21. With the exception of Teams 2004-04 and 2005-02, these teams completed the 2005 GCE. Teams 2004-10 and 2005-13, 2005-14, and 2005-16 were successful.

To say: "The advantage belongs to experienced teams." provides *a* perspective. However, to say: "Lack of experience is a significant barrier to entry" provides the correct perspective. One of the first deficiencies which must be overcome if inexperienced teams want to compete with more experienced teams is their overall lack of experience. The 2004 and 2005 GCE clearly favored teams with prior experience. For example:

- Four of the five teams which completed the 2005 GCE course had prior experience in the field of robotics: Teams 2005-13, 2005-14, 2005-16, and 2005-21. Teams 2005-13, 2005-14, and 2005-16 were successful.

- Three of the five teams which completed the 2005 GCE course participated in the 2004 GCE, which itself forms the basis for a claim of prior experience: Teams 2005-13, 2005-14, and 2005-21.

- Only one of the four teams which successfully completed the 2005 GCE course had neither prior experience nor participated in the 2004 GCE: Team 2005-06.

- Including 2005 GCE co-participants, one of which participated in the 2004 GCE (Teams 2005-13 and 2005-14 and Teams 2005-22 and 2005-23), 14 of the 23 teams which participated in the 2004 GCE completed more than 7.4 miles of the 2005 GCE course, more than the maximum number of miles completed by any team which participated in the 2004 GCE.

- Including 2005 GCE co-participants, one of which participated in the 2004 GCE (Teams 2005-13 and 2005-14 and Teams 2005-22 and 2005-23), seven of the nine teams which completed more than 25 percent of the 2005 GCE course (32.9 miles) were participants in the 2004 GCE. The exceptions were Teams 2005-06 and 2005-16, both of which successfully completed the 2005 GCE.

The author concluded prior experience was the equivalent of a "force multiplier", which informed team decisions throughout development of a challenge vehicle, allowing teams to bypass unproductive areas of research, guiding team decisions to procure high-quality components and use robust software development methodologies, and highlighting or underscoring the need to perform adequate test and evaluation.

In addition, the basis for team selection was not objective. The evidence supports a conclusion that DARPA selected some teams not on the basis of their ability to develop

an autonomous vehicle capable of successfully completing the 2004 or 2005 GCE, but on the basis of a novel technology proposed by the team. This had the effect of "muddying the waters" by advancing teams not capable of competing with other, more experienced teams. See Appendix C, paragraph I.A.5.

For example, DARPA stated: "DARPA used experts in the fields of robotics and sensing technology to evaluate the technologies utilized by the teams seeking to participate in the Grand Challenge and to recognize relevant technological highlights and innovative ideas of potential interest to DoD. The independent technical evaluation team identified the following technology from Grand Challenge 2004 noteworthy..." ([3], p. 10). The list of "technological highlights and innovative ideas" includes several "wrong problems" variously solved by teams participating in the 2004 QID or GCE including "Custom hardware solution for low-cost, real-time stereo algorithm with reflexive planning", "Dynamically balancing motorcycles", and "Rotating ladar for foveal sensing". See paragraph XIV.A.

X.D.2. The effect of sponsorship

Although the author was unable to determine an estimate for the total cost of team challenge vehicles, available evidence supports a conclusion that sponsorship was more a predictor of success than any factor other than experience.

Significant sponsorship increased the number of available options, broadening the potential scope of team solutions to the fundamental problem. Teams with significant sponsorship were able to procure high-quality computing hardware and sensors, reduce complexity by procuring components to eliminate the development of sub-systems such as challenge vehicle controls or INS, and devote additional resources to software development and performance of adequate test and evaluation. Significant sponsorship also caused some teams to lose focus and divert resources to problems other than the fundamental problem.

Limited or no sponsorship resulted in lack of resources such as labor, high-quality sensors, and computing equipment, and limited team use of COTS technologies such as integrated challenge vehicle controls and COTS components used to integrate navigation sensors which had a very real and very direct impact on some teams. For example:

- Team 2004-08

Team 2004-08 was selected to participate in the 2004 QID, but was unable to participate due to limited sponsorship. Team 2004-08 participated in the 2005 GCE as Team 2005-07. Team 2005-07 stated: "[Team 2004-07] is a finalist for the second year in a row. However, last year they were unable to compete due to lack of . This year they were able to develop a number of sponsors who made participation possible and whose logos cover the vehicle... Sponsors are: NC State University, IBM, SAS, Red Hat, Ascot

Technologies, BDMICRO, Comtrol, Council & Sons Repair Service, Crossbow, Frantz Automotive, Lord Corporation, PC MedEvac, SICK, and Smith Anderson." ([233]).

- Team 2004-15

Team 2004-15 was selected to participate in the 2004 QID, but was unable to participate due to limited sponsorship. Team 2004-15 stated: "Although the team has worked diligently and sacrificed much in our effort to have [the challenge vehicle] ready for the March Grand Challenge, it is not to be. We made great strides and were on the right track as evidenced by our inclusion in the first group invited to the QID. Unfortunately, we fell victim to everyone's problem of 'not enough time' and 'not enough money'." ([136]).

- Team 2005-11

Team 2005-11 was selected to participate in the 2005 GCE, and completed 7.2 miles of the 2005 GCE course. Team 2005-11 had limited sponsorship and stated: "...procuring equipment, skilled labor, and sufficient funding also provided formidable challenges for the team." ([182], p. 9).

Although no team which participated in the 2004 GCE completed more than 7.4 miles of the 2004 GCE course, only two teams which participated in the 2005 GCE completed *less than* 7.4 miles of the 2005 GCE. The author considers the increase in sponsorship a contributing factor to the increase in the average number of miles of 2005 GCE course completed, but does not consider the evidence supports a conclusion that sponsorship alone is responsible for the increase in the number of miles of the 2005 GCE course completed.

Based on a comparison of sponsorship of teams which participated in both the 2004 and 2005 GCE (see Table LXVIII), the author concluded there was no significant change in levels of sponsorship, although there was a significant change in the number of miles of the 2005 GCE course completed. Only two teams which participated in both the 2004 and 2005 GCE reported an increase in levels of sponsorship from 2004 to 2005, both of which reported partnership with an academic sponsor: Teams 2004-07 and 2005-05, and 2004-13 and 2005-15.

The author concluded the overall increase in levels of corporate and academic sponsorship cannot account for the increase in average number of miles of the 2005 GCE course completed because the level of sponsorship for teams which participated in both the 2004 and 2005 GCE did not generally increase and teams which participated in the 2005 GCE but not the 2004 GCE completed as many miles of the 2005 GCE course as teams which participated in both the 2004 and 2005 GCE. See paragraph X.D.1. The author also concluded corporate and academic sponsorship allowed teams which

participated in the 2005 GCE but not the 2004 GCE to effectively "buy in" by providing access to resources such as labor, high-quality sensors, and computing equipment, and COTS technologies such as integrated challenge vehicle controls and COTS components used to integrate navigation sensors.

In addition to reducing the difficulty of the 2005 GCE course compared to the 2004 GCE course, the author proposes an increase in the number of high-quality sensors in use by the teams, use of a COTS component and Kalman filter to integrate navigation sensors, and performance of adequate test and evaluation was ultimately responsible for the increase in the average number of miles of the 2005 GCE course completed. These issues are explored in more detail throughout this technical report.

X.D.3. Overall conclusions

Prior to the 2005 GCE, in response to a question about the use of government-reimbursed Independent Research and Development ("IR&D") funding, DARPA stated: "...the funding restriction exists to give all equal opportunity at winning..." ([236], p. 3). However, the evidence does not support a conclusion that all teams had an "equal opportunity at winning", despite the funding restrictions established by DARPA.

Overall, the author concluded prior experience and significant corporate or academic sponsorship were key factors. Lack of experience was a significant barrier to entry. Sponsorship was more a predictor of success than any factor other than experience. As one of the more extreme examples, Team 2005-07 stated: "[Team 2005-07] is a finalist for the second year in a row. However, last year they were unable to compete due to lack of funding. This year they were able to develop a number of sponsors who made participation possible..." ([233]), and "While invited to the QID for the 2004 Grand Challenge we were unable to compete due to earlier financial constraints. We have continued to develop our technologies and sponsorships and we are now in a position to compete in this year's challenge..." ([118]).

As a result, the author defined the phrase "potentially disruptive team" to identify teams with no prior experience in the field of autonomous vehicle development and neither extensive corporate nor academic sponsorship which implemented key factors. See Chapter XV. No team with prior experience and extensive corporate or academic sponsorship was considered potentially disruptive, consistent with the author's interest. Therefore, these key factors are a negative selector, and were not evaluated for potentially disruptive teams in later sections of this technical report.