

Grand Challenge 2005

Welcome to the 2005 DARPA Grand Challenge!



Thank you to the teams, their sponsors, the media, and the spectators for being part of this historic event. The DARPA Grand Challenge is about fresh thinking and new approaches to the tough technical problem of developing a truly autonomous ground vehicle. The competing teams have worked many hours to develop their vehicles, and this event demonstrates their vision, creativity, inspiration, and hard work. I am proud of their effort—someday it will save the lives of U.S. men and women in uniform on the battlefield.

Dr. Anthony J. Tether, DARPA Director

DARPA Grand Challenge

The DARPA Grand Challenge will award a \$2 million cash prize for a technical feat that has never been achieved—an autonomous ground vehicle that successfully travels approximately 150 miles in under 10 hours, across rugged desert roads, using only onboard sensors and navigation equipment to find and follow the route and avoid obstacles. The team whose vehicle finishes the route the fastest under the 10-hour limit wins the \$2 million prize. The route is kept secret until 2 hours prior to start.

DARPA is using the Grand Challenge to accelerate autonomous ground vehicle technology that can be used to save the lives of our men and women in uniform who drive vehicles in dangerous missions today. The route distance and time limit are representative of the capabilities needed for military missions.

Grand Challenge 2005 has been underway since August 2004. DARPA received 195 applications to compete, and the 43 teams at the National Qualification Event (NQE) passed a series of qualification tests and are the top teams. At the NQE, those 43 teams will compete for one of the 20 finalist positions. The finalists will be invited to attempt the Grand Challenge route and have a chance at the \$2 million prize on October 8, 2005.

DARPA

The Defense Advanced Research Projects Agency (DARPA) is the central research and development organization for the Department of Defense (DoD). The Agency manages and directs basic and applied research and development projects for DoD, and pursues research and technology where success may provide dramatic advances for traditional military roles and missions.

DARPA's accomplishments include the Saturn V rocket that enabled the Moon landings, the Arpanet (the first Internet), the Stealth Fighter, and the Predator and Global Hawk unmanned aerial vehicles.



National Qualification Event California Speedway, Fontana

Wednesday, September 28

9:00am	Opening ceremony
10:00am	Vehicle inspections begin
1:30pm–6:00pm	Track operations

Thursday, September 29—Saturday, October 1

7:00am–12:00pm	Track operations
12:00pm–1:30pm	Lunch
1:30pm–6:00pm	Track operations

Sunday, October 2

7:00am–12:00pm	Track operations
12:00pm–1:30pm	Lunch
1:30pm–4:00pm	Track operations

Monday, October 3—Tuesday, October 4

7:00am–12:00pm	Track operations
12:00pm–1:30pm	Lunch
1:30pm–6:00pm	Track operations

Wednesday, October 5

7:00am–11:30am	Track operations
TBD	Closing ceremony
<i>Announcement of the Grand Challenge finalists will be made at the closing ceremony after all runs are finished.</i>	

Thursday, October 6

Travel day to Grand Challenge start area in Primm, Nevada	
12:00pm–7:00pm	Teams arrive

Grand Challenge Primm, Nevada

Friday, October 7

4:00pm–7:00pm	Kickoff BBQ*
<i>*Tickets will be available on a limited basis.</i>	

Saturday, October 8

4:00am (approx.)	Teams receive the route
6:00am	Opening ceremony
6:30am	First vehicle launched
9:00am–9:00pm	Concessions open
TBD	Closing ceremony

Grand Challenge 2005 Teams

#1
Mojávaton
Xboxx
 Grand Junction, CO



Mojávaton is a professional team of people with over 150 years of combined experience in custom machine design, electronic controls, and vision system solutions.

Sponsors: Automation Direct, Automotive Customizers, Barney Brothers Off Road, Big "D" Tires, CoorsTek, Copley Controls, Crossbow, DVT Sensors, EarthLCD, Entivity, Genesis Engineered Solutions, General Technics, HD Systems, Hensley Battery, Jim Fuoco Motor Co., NavCom, Pinnacle Engineering, Platinum Signs, Precision Navigation, SICK Sensors, and Visual Expressions.

#2 Team
Caltech
Alice
 Pasadena, CA



The team is primarily composed of undergraduate students from the California Institute of Technology along with graduate students, faculty, and staff.

Sponsors: California Institute of Technology, Northrop Grumman Electronic Systems, Sportsmobile West, American Racing, BF Goodrich, and Wright Tools Technology.

#3 Stanford
Racing Team
Stanford Roadrunner
 Stanford, CA



The team is largely composed of faculty and students from Stanford's School of Engineering, under the leadership of Sebastian Thrun and Michael Montemerlo.

Sponsors: Volkswagen of America Electronic Research Lab, Mohr Davidow Ventures, Android, Intel, Honeywell, Tyzx, Inc, and Coverity Inc.

#4 Team DAD
(Digital Auto Drive)
"DAD, Are We There Yet?"
 Morgan Hill, CA



Team DAD is a research and development organization focused on commercializing automotive vision recognition-based 3D-imaging and navigational technologies.

Sponsors: Texas Instruments, Toyota, and Velodyne.

#5 Autonosys
Autonomobile
 Ottawa, Canada



Autonosys was founded in August 2004 to exploit technology developed by the founders over the last two years.

Sponsors: Logic Supply, Opus Solutions, Apace Wholesale, and Permedia Research Group.

#6 Team
Jefferson
Tommy
 Charlottesville, VA



Team Jefferson is based in Charlottesville, Virginia, with many members sharing a common bond to the home town of our third U.S. President, Thomas Jefferson, and the University of Virginia.

Sponsors: Perrone Robotics, Inc., Sun Microsystems, FairIsaac, Assured Technologies, Inc., CSI Wireless, VIA Technologies, SICK Sensor Intelligence, Sandtec Sand Rails, Bodine Electric Company, Eaton Corporation, OmniSTAR, and M.I.T.S. Corporation.

#7 Blue Team
Ghostrider
 Berkeley, CA



Made up of students from UC Berkeley and Texas A&M, the Blue Team developed the world's first autonomous motorcycle for the first Grand Challenge event in 2004.

Sponsors: AMD, Agilent, Crossbow, Crydom, Dalsa, DRS, EDT, HD Systems, MDK Motorsports, Navitar, PCBExpress, Raytheon, Tyco Electronics, US Digital, and Xilinx.

#8 CIMAR
NaviGATOR
 Gainesville, FL



The team consists of eight graduate students and one alumnus from CIMAR plus the president and six engineers from Autonomous Solutions, Inc.

Sponsors: Smiths Aerospace Autonomous Solutions, University of Florida Eigenpoint, NavCom Technologies, APC, Hy-Impact Signs Gainesville Raceway, and Digi Key.

#9 Virginia
Tech Team
Rocky
 Blacksburg, VA



The team is composed of undergraduate and graduate students working with three faculty advisors and a dedicated group of sponsoring organizations.

Sponsors: Virginia Tech College of Engineering, Virginia Tech Department of Mechanical Engineering, Lab View Technical Resources, Ingersoll-Rand Club Car Division Intermap Technologies, Power One, NovAtel, Quicksilver Technology, North American Signal Company, Enercorp, Bodine Electric, Ford, National Instruments, General Motors, Michelin, Goodyear, Advance Motion Controls, Sensytech, Honeywell and OmniSTAR.

Grand Challenge 2005 Teams

#10 Desert Buckeyes
IDN (Intelligent Off-road Navigator)
 Columbus, OH



The team Desert Buckeyes is outfitting an easily deployable, small and agile vehicle, durable for off-road applications.

Sponsors: The Ohio State University, Transportation Research Center (TRC), and Honda-OSU Partnership.

#11 Team Overbot
Overbot
 Redwood City, CA



Team Overbot is Silicon Valley's entry in the DARPA Grand Challenge, representing Silicon Valley's private sector in the DARPA Grand Challenge.

Sponsors: Advanced Motion Controls, AMPRO, Crossbow, Eaton Vorad, Faulhaber, Newmark Systems, Inc, OmniSTAR, Polaris, Sealevel, Acuity Research, Atheros, BEI, www.fourmilab.ch, LINAK, Maxon Precision Motors, QNX, Tri-M, and Unibrain.

#12 Indiana Robotic Navigation
Spirit of Christianity
 Greenwood, IN



Indiana Robotic Navigation is led by team leader, Hugh Meyer, vice president of Meyer Material Handling Products in Indianapolis, Indiana.

Sponsors: Almac Engineering Company, Meyer Material Handling Products, Inc, NavCom Technology, Inc, Point Research Corporation, and SICK.

#13 Team UCF
Knight Rider
 Orlando, FL



Team UCF is a University initiative involving representatives from various departments within the College of Engineering and Computer Science and the College of Optics and Photonics.

Sponsors: Financial support for Team UCF is being provided entirely from unrestricted university funds.

#14 Insight Racing
Desert Rat
 Cary, NC



Insight Racing, consisting of members from industry as well as North Carolina State University students, has been working for more than 5 years in international robotics competitions.

Sponsors: NC State University, Ascot Technologies, Inc., BDMicro, Sick, Crossbow, Comtrol, PC MedEvac, Gemini Automotive Care, and Council & Son Repair Service.

#15 Intelligent Vehicle Safety Technologies I
Desert Tortoise
 Littleton, CO



The Intelligent Vehicle Safety Technologies I (IVSTI) team is composed of technical experts in vehicle platforms, navigation, sensors, perception, and autonomy.

Sponsors: Delphi, Ford, Honeywell, and Perceptek.

#16 MonsterMoto
JackBot
 Cedar Park, TX



Team MonsterMoto combines the talents of a small but experienced group of engineers, off-road racers and supportive pit-babes.

Sponsors: MonsterMoto Productions, Full Circle Cycle, Novatel, OmniSTAR, ITM, Tilcon Software, UT-Austin's Robotic Research Group, SICK, Hermann Racing, Roboteg, Cloud Cap Technology, and DuraBlue.

#17 Oregon WAVE (Willamette Autonomous Vehicles Enterprise)
WAVE Runner
 Corvallis, OR



The Oregon WAVE team is a partnership between Oregon State University faculty and students and outstanding engineers from the surrounding community.

Sponsors: Oregon State University, Mentor Graphics, MicroStrain HP, Polaris, OSU TekBots, OSU, SAE (Society for Automotive Engineering), Mini-Baja Racing Team, and NW Tech Ventures.

#18 The Golem Group/UCLA
Golem 2
 Santa Monica, CA



Taken from the Hebrew word meaning "unfinished" and defined as a robot, the team includes representatives from The Golem Group, UCLA Henry Samueli School of Engineering and Applied Science and the Computer Science department of the Hebrew University of Jerusalem.

Sponsors: MobilEye, BEI Technologies, OmniSTAR, Kenyon Labs Federal Signal Corporation, and Prime Resource, Inc.

Teams are listed sequentially by their vehicle number.

Grand Challenge 2005 Teams

#19 Red Team
Sandstorm
Pittsburgh, PA



The Red Team is an alliance of individuals, non-profits, and for-profits. Members include students, volunteers, and professionals embedded from our corporate sponsors.

Sponsors: The Boeing Company, Science Applications International Corporation, Caterpillar, Intel, AM General, TTTech, Applanix, HD Systems, Duke University, KVH, Snap On, Chip Ganassi Racing, Google, CM Labs, HMR Magazine, and Wired Magazine.

#22 Team AION
AION (Artificially Intelligent Object Navigation)
Carlsbad, CA



Representatives come from Oshkosh Truck Corporation, Rockwell Collins, Rockwell Scientific, University of Parma, and Auburn University.

Sponsors: Dataczar Automation, Roboteq, and Rayco Fabrication.

#25 Red Team Too
Highlander
Pittsburgh, PA



The Red Team Too is an alliance of individuals, non-profits, and for-profits. Members include students, volunteers, and professionals embedded from our corporate sponsors.

Sponsors: The Boeing Company, Science Applications International Corporation, Caterpillar, Intel, AM General, TTTech, Applanix, HD Systems, Duke University, KVH, Snap On, Chip Ganassi Racing, Google, CM Labs, HMR Magazine, and Wired Magazine.

#20 SciAutonics/Auburn Engineering
RASCAL (Robust Autonomous Sensor-Controlled All-Terrain Land Vehicle)
Thousand Oaks, CA



The SciAutonics/Auburn Engineering Team resulted from the collaboration among scientists, engineers, and consultants of various backgrounds from SciAutonics LLC and Auburn University.

Sponsors: Rockwell Scientific Company, Auburn University, ATV Corporation, Rockwell Collins, Rockwell Automation, and ESRI.

#23 Axion Racing
Spirit Westlake
Village, CA



Axion Racing has developed a California street-legal Jeep built to exacting specifications using autonomous tools and a patented reactive sensory enclosure (RSE). The latest tools include a 3D MMW RADAR and a Northrop Grumman LN-270 INS.

Sponsors: Amphitech and SICK.

#26 Team Cornell
Name Spider
Ithaca, NY



Cornell University students and faculty are lead by faculty advisors Professor Garcia and Professor Lipsen, and technical advisors Professor Selman and Professor Huttenlocher.

Sponsors: The Math Works, Singapore Technologies-Kinetics, Northrop Grumman, Advanced Micro Devices (AMD), Tektronix, Dana, Moog, Analog Devices, Cornell University College of Engineering, Avalanche Engineering, Maxon Motor, Trimble, Kionix, Sway-A-Way, Vicor, CSA Engineering, KC HiLites, Gidel, Texas Instruments, Point Research, Altera, SICK, Traquair, Howe Performance Power Steering, OmniSTAR, Cooper Bussman, BGF Industries, Freescale Semiconductor, Alpha Wire Company, and Communication Components.

#21 Team TerraMax
TerraMax
Oshkosh, WI



Representatives from Oshkosh Truck Corporation, Rockwell Collins, Rockwell Scientific, University of Parma, and Auburn University.

Sponsors: ArvinMeritor, Inc., Fastenal Company, Oxford Technical Solutions, Parker Hannifin, Inc., Ricoh Corporation, Caterpillar, Inc., Landstar System, Inc., MMCL Industries, Inc., Michelin Group, Transpro, Inc.

#24 Team CajunBot
CajunBot
Lafayette, LA



The brains behind the machine are a volunteer team of professors, students and staff from the University of Louisiana at Lafayette, and professionals from the community working together to enhance and improve CajunBot.

Sponsors: The University of Louisiana at Lafayette, C & C Technologies, Lafayette Motors, and MedExpress.

#27 Team Banzai
Racer X
Irvine, CA



With a foundation in Computational Neurobiology and innovative cross-discipline problem-solving strategies, Team Banzai plans to leverage its exceptional team of scientists and engineers to address the challenge.

Sponsors: Banzai Research Institute.

Grand Challenge 2005 Teams

#28 Team ENSCO

*DEXTER (Deployable
EXtreme Terrain
Enabled Robot)*
Springfield, VA



This is a volunteer group of ENSCO's brightest researchers and engineers. They are joined by friends of ENSCO employees and students from Thomas Jefferson High School for Science and Technology.

Sponsors: National Instruments, MathWorks, Expert Choice, Inc., SICK, Vicor, Whelen Engineering, OmniSTAR and Optima Batteries.

29 BJB Engineering Quadrivium Willoughby Hills, OH



As the BJB Engineering team, Brian Beal and two friends, Dennis Shaffer, an electrician, and Tom Shea, a human resources manager, have been working since March 2004 to remake the family vehicle.

Sponsors: Measurement Computing Corporation, Thales Navigation, LINAK, Senix Corporation, Tormach LLC, Banner Engineering, and B&B Electronics.

#30 Gray Team GrayBot Metairie, LA



The Gray Team has many years of experience in yachting, sailing, aeronautics, robotics, mechanical engineering, and computer science. The synergy has resulted in innovative solutions, including everything from vehicle and sensor selection to software and network design

Sponsors: The Gray Insurance Company.

#31 Team Juggernaut Desert Juggernaut Sandy, UT



Team Juggernaut consists of full-time and part-time professionals with over 20 years of experience in ruggedized systems design and manufacturing in a variety of industries.

Sponsors: DesignJug, Software Toolbox, FreeWave Technologies, FeatureCam, IronCad, Precision Navigation, EuroTech, Delcom Engineering, Castle Studios, Tyco Electronics, EarthLCD, Mathnet Solutions, Bonneville Seabase, Driving Systems Incorporated, WestCAMP, Setpoint Engineering, and SpaceAge Control.

32 Autonomous Vehicle Systems Flying Fox San Diego, CA



Autonomous Vehicle Systems LLC is a team of industry professionals and scientific researchers with expertise in advanced sensor development, UAV development, autonomous navigation and control, software development, automated machine control, and high performance vehicle modifications

Sponsors: Michigan State University, UCSD Jacobs School of Engineering, PPE, RTI, AIAA, Enidine, Active Silicon, ExelTech, Teletronics International, Inc., Eltron Engineering, Microchip, SpaceAge Control, igus, OmniSTAR, QNX, NavAtel, Prestolite Electric, SICK Sensor Intelligence, Orange County Broaching, Weird Solutions, Minarik, SBS Technologies, and Mountain Optech, Inc.

#33 Team Tormenta The Black Pearl Los Angeles Area, CA



Team Tormenta (Spanish for "storm") includes undergrad, masters, and PhD candidates, along with advisors from the University of Southern California.

Sponsors: Measurement Computing Corporation, LK Motorsports, Videre Design, Island Pacific Jeep, 80/20 Inc., Prime Resource, Inc., Columbus Technologies and Services, Inc.

#34 Indy Robot Racing Team IRV Indianapolis, IN



Team Indiana includes a diverse group of successful entrepreneurs, professors and students from Indiana University, Purdue University and other Indiana universities, as well as, technical and marketing professionals throughout the state.

Sponsors: Ahnafield Corporation, SICK Corporation, NavCom Technology, Computer Renaissance, Champion Chrysler Jeep, Temporal Dynamics, and Bitwise Solutions.

#35 Terra Engineering TerraHawk Rancho Palos Verdes, CA



Members are from various industries and academic backgrounds and include retirees.

Sponsors: NavCom GPS Systems and SICK Laser Scanners.

#36 Palos Verdes High School Road Warriors Doom Buggy Palos Verdes, CA



The team consists of approximately 40 academically advanced and gifted high school students, parent mentors, and well-known professionals.

Sponsors: Power Acura of South Bay, EMC, Analog devices, Greer & Associates, AIA architects, Honda, Boeing, AIAA, Good Year, Gorilla Equipment, Infinity Micro, PVHS Booster Club, and DesiPharm.

Grand Challenge 2005 Teams

#37 The MITRE Meteorites
The Meteor
McLean, VA



Engineering professionals work in robotics, signal processing, software and systems largely sponsored by The MITRE Corporation, a not-for-profit national resource.

Sponsors: The MITRE Corporation, SuperLift, EMC, ACT/Technico, Hybricon, West Group, Concurrent Technologies, Interco Tire, MSC Software, Top-Soil Precision AG, OmniSTAR, ACTTechnico, PCB Piezotronics, Inc., and Tidewater Communications.

#38 Virginia Tech Grand Challenge Team
Cliff
Blacksburg, VA



This team includes Virginia Tech undergraduate students, graduate students and faculty advisors.

Sponsors: The Virginia Tech College of Engineering, Virginia Tech Department of Mechanical Engineering, Lab View Technical Resources, Ingersoll-Rand Club Car Division, Intermap Technologies, Power One, NovAtel, Quicksilver Technology, North American Signal Company, Enercorp, Bodine Electric, Ford, National Instruments, General Motors, Michelin, Goodyear, Advance Motion Controls, Sensytech, Honeywell, and OmniSTAR.

#39 CyberRider
CyberRider!
San Juan Capistrano, CA



Team CyberRider is a diverse collection of individuals with a common goal, to create a vehicle that will win the 2005 DARPA Grand Challenge and make a contribution to the autonomous robotic community.

Sponsors: Aquatec Water Systems.

#40 A.I. Motorvators
"IT"... Came from the Garage
Los Angeles, CA



A.I. Motorvators is a Southern California based team of engineers, racers, and hot-rodders turning automotive race know-how and programming savvy into advanced vehicle technology.

Sponsors: Digital Globe, Radarsat International, Bendy Music, Trimble Agricultural Division, and OmniSTAR.

#41 Princeton University
Prospect II
Princeton, NJ



The interdisciplinary team is an ensemble of undergraduate students assisted by a couple of graduate students and supervised by an interdisciplinary team of eight faculty members.

Sponsors: Financial support for the team comes entirely from unrestricted gifts to the University and proceeds from the University's endowment.

#42 Austin Robot Technology
MARVIN the Land Robot
Austin, TX



Austin Robot Technology is a team of volunteers, with a wide range of expertise in hardware, software and mechanical systems. We have succeeded in building a very strong team, recruiting many team members and advisors from top Texas universities such as Rice University, The University of Texas at Austin, and St. Edwards University, as well as drawing talent from many other universities such as Brown, Cornell, and Rensselaer.

Sponsors: Suzuki-Isuzu of Austin.

#43 Team Underdawn
Underdawn
San Jose, CA



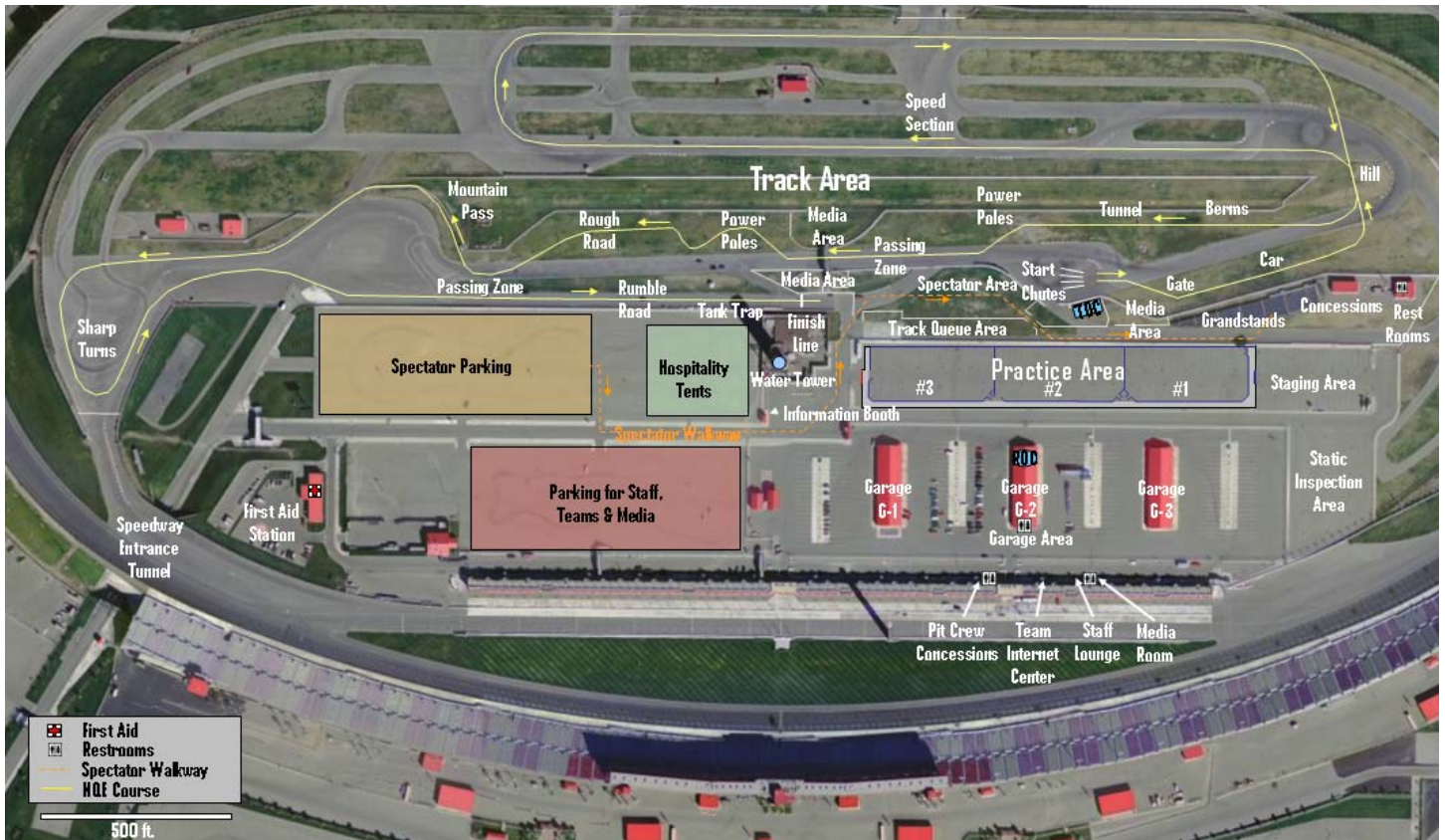
This team consists of engineers and software developers from the San Francisco Bay Area.

Sponsors: Android, Digital Turbulence, Mike McCool, Stark Consulting, Thales Navigation, Videre Design.

E-stop System / Control Vehicle

Each of the autonomous vehicles is equipped with an emergency stop (E-stop) system that DARPA provided to the teams before the NQE. The E-stop system is used to convey commands from a DARPA control vehicle to the autonomous vehicle to run or stop, and in some situations, to shut down the engine. You will see the DARPA control vehicle follow the autonomous vehicle as it attempts the NQE course.





National Qualification Event

The National Qualification Event (NQE) is an eight-day competition to select the top 20 teams that will compete as Grand Challenge finalists. DARPA designed a 2.2-mile course on the Speedway's infield area with features that simulate the challenges a vehicle will encounter on the Grand Challenge desert route. The vehicles will be judged on their abilities to navigate and complete a specified course; remain within course boundaries; avoid obstacles while remaining within course boundaries; complete the course expeditiously while complying with course speeds; and correctly respond to E-stop commands. Each vehicle must operate in a fully autonomous mode—navigating the NQE course and determining an obstacle-avoidance path using only onboard navigation and sensors.

The Course

From the start line, the autonomous vehicles will:

- Travel through a narrow gate that is similar to a cattle guard gate,
- Avoid a stationary car near the course,
- Climb a hill and then travel on paved roads with increased speed,
- Slow down and travel at 10mph, travel down a hill, execute a tight 90-degree turn,
- Travel through a narrow path that has debris on each side,
- Travel through a tunnel where GPS loss and low light conditions occur,
- Avoid poles that are in front of the vehicle but outside the prescribed path,

- Avoid a vehicle that is stopped within the course boundaries,
- Avoid poles in front of the vehicle,
- Execute a series of tight turns,
- Find an optimum path through a debris field,
- Remain within a narrow corridor, where there is a vertical wall present on one side of the corridor,
- Speed up, slow down, and execute a series of tight turns,
- Avoid two vehicles that are within the course boundaries, and
- Travel over a series of speed bumps and avoid a tank-trap obstacle within the path.

The estimated time to complete the course is 11 to 12 minutes. DARPA may alter the course at any time by changing the path, sequence of events, and obstacles.

Runs

Vehicle runs occur approximately every 20 minutes, depending on track conditions. Each team will perform a number of runs on the NQE course. All runs will be timed, and the vehicle's performance staying within boundaries, overcoming challenges, and avoiding obstacles will be graded. The schedule of vehicle runs is posted in the Resource Operations Center.

Viewing

Several viewing locations along the NQE course offer a view of the autonomous vehicles in action.



Grand Challenge Event

The start and finish lines are located in Primm, Nevada. The 20 finalists will receive the Grand Challenge route at approximately 4:00am on October 8, and line up to start the course 2 hours later. The start chutes are located immediately in front of the grandstands, and the first vehicle will start the launch at sunrise. There will be 5 minutes between starts, and each vehicle will be followed by a Control Vehicle that is manned by DARPA staff. Media, team members, and spectators are not allowed on the course. Vehicle progress will be provided throughout the day through announcements, and there is a 3-D display of vehicle progress near the media tent. Video highlights will be provided from monitoring points on the course. As vehicles finish or are removed from the course, the vehicles will be placed on display near the grandstands. Refreshments are available in the casino or from nearby concession stands.



Follow the vehicles on the Grand Challenge 2005 website (<http://www.darpa.mil/grandchallenge>) for a closer look at:

- Real-time tracking as the vehicles tackle the Grand Challenge course,
- Team and vehicle information, and
- Team blogs.

