The DARPA Grand Challenge – Participant's Perspective

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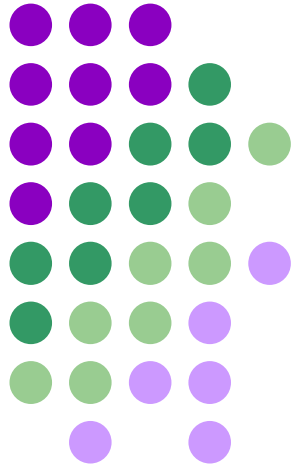
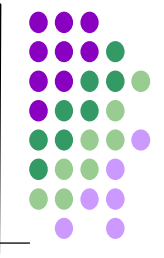
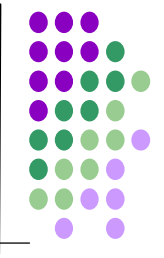


About Presenter



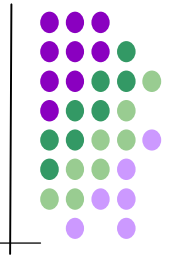
- Physicist, Software Engineer/Scientist.
- Technology interest:
  - Autonomous system (road vehicles).
  - Real-time computer vision applications.
  - Augmented Reality (AR).
  - Mobile and Wearable Computing.
  - Computer vision for computer music.
- Since 1990: computer vision for automated driving (EU project PROMETHEUS).
- Since 1996: Rockwell Scientific (RSC), US
- Since Sept. 2005: Professor of Creative Technology at Leeds Metropolitan University.

The DARPA Grand Challenge



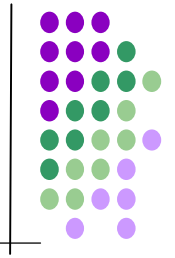
- Competition of Autonomous Ground Vehicles:
  - No driver, no remote control.
  - Through California Mojave desert, on dirt roads and off-road.
  - Maximum route distance: 250 miles.
  - Duration: 10 hours.
  - Exact route is only known 2h before the competition begins.
  - Anyone could participate!
- Prize for winning team: $2 Million.

About DARPA



- DARPA = Defense Advanced Research Projects Agency.
- Inventors of the Internet in the 1960s.
- Annual budget (2003): $2.6 Billion.
- http://www.darpa.mil

Team SciAutonics



- Team was founded in 2003, for the purpose of participating in this competition.
- Organization as “SciAutonics, LLC”.
- Team members: employees of RSC and other engineering companies around Los Angeles.
- Not affiliated with DARPA.

The RASCAL Vehicle

- Robust Autonomous Sensor-Controlled All-Terrain Land-Vehicle = **RASCAL**.

First Grand Challenge

- First time organized in March 2004:
  - No winner.
  - Best vehicle drove 7.4 miles (CMU SandStorm).
  - Vehicles got disabled by various technology failures.

SciAutonics

Elbit Systems Ltd

Auburn University – Research Instruction Extension – For the Advancement of Science and Arts – Established 1856

Rockwell Scientific


19






CajunBot
02

04

13
ENSCO

SDTV
TELEPRODUCTIONS

25


14

10



22
22

23

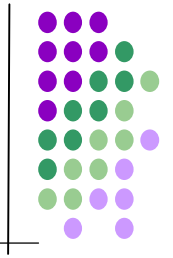
Team Caltech
05

07
TOYOTA

Parker
20
20

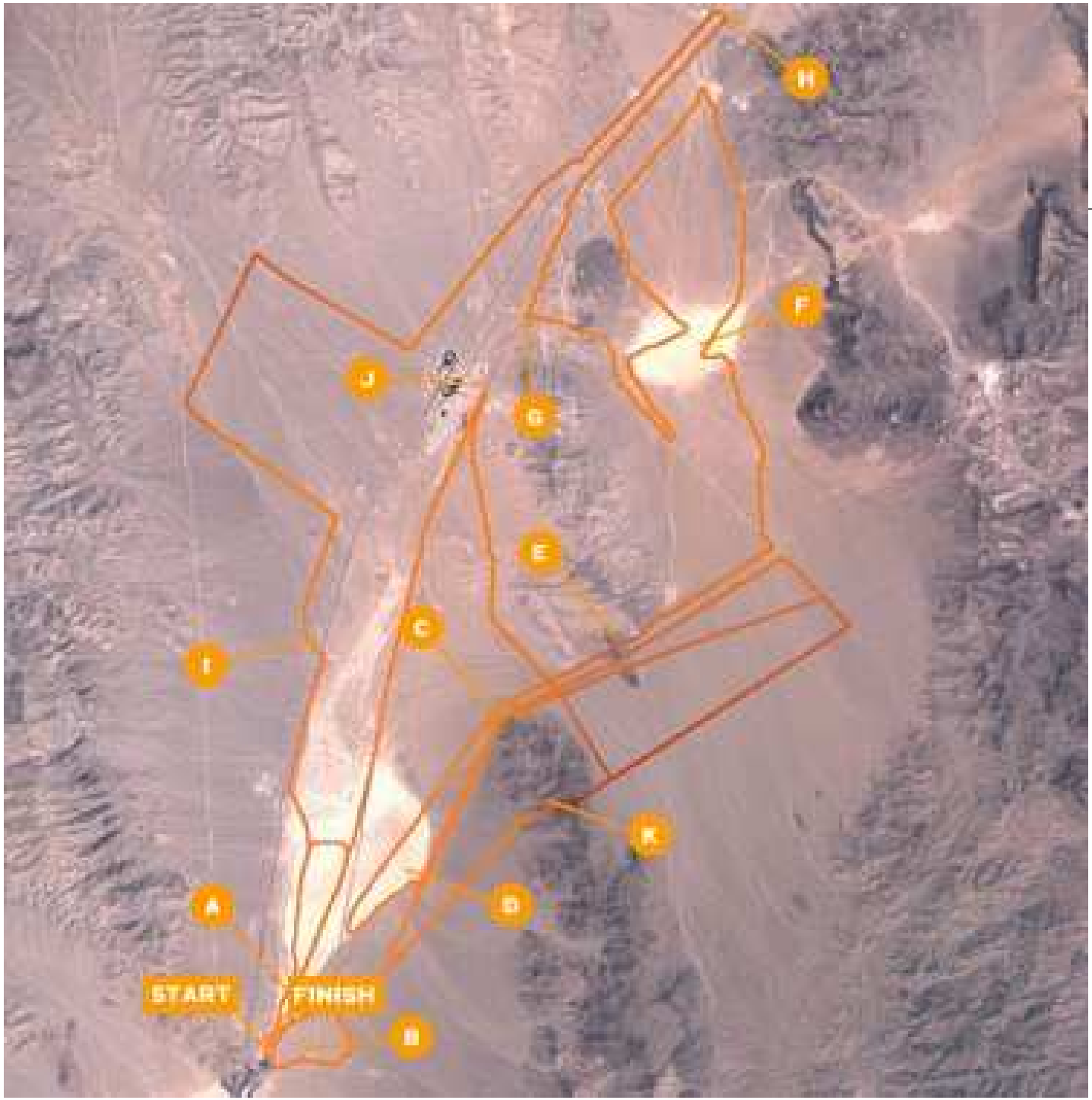

UNOFFICIAL "BOT" POSITIONS
Displayed positions may be different than actual final positions.
FINISH
Naval Air Weapons Station, China Lake
National Training Center, Fort Irwin
Baker
Daggett
BARSTOW
Marine Corps Logistics Base, Barstow
Marine Corp Air Ground Combat Center, 29 Palms
START

2005 Grand Challenge



- Better organisation:
  - Start and end at same location.
  - Easy part in the beginning.
  - Shorter course layout (130 miles).
  - Selection of participating vehicles: stricter criteria. Must have active perception on board.
- Improvements of teams:
  - Technology more robust.

Testing of RASCAL

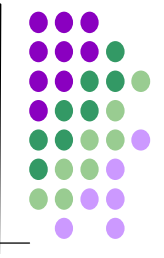


Course map. From DARPA Grand Challenge Web site.

Winner: Stanley (Stanford U.)

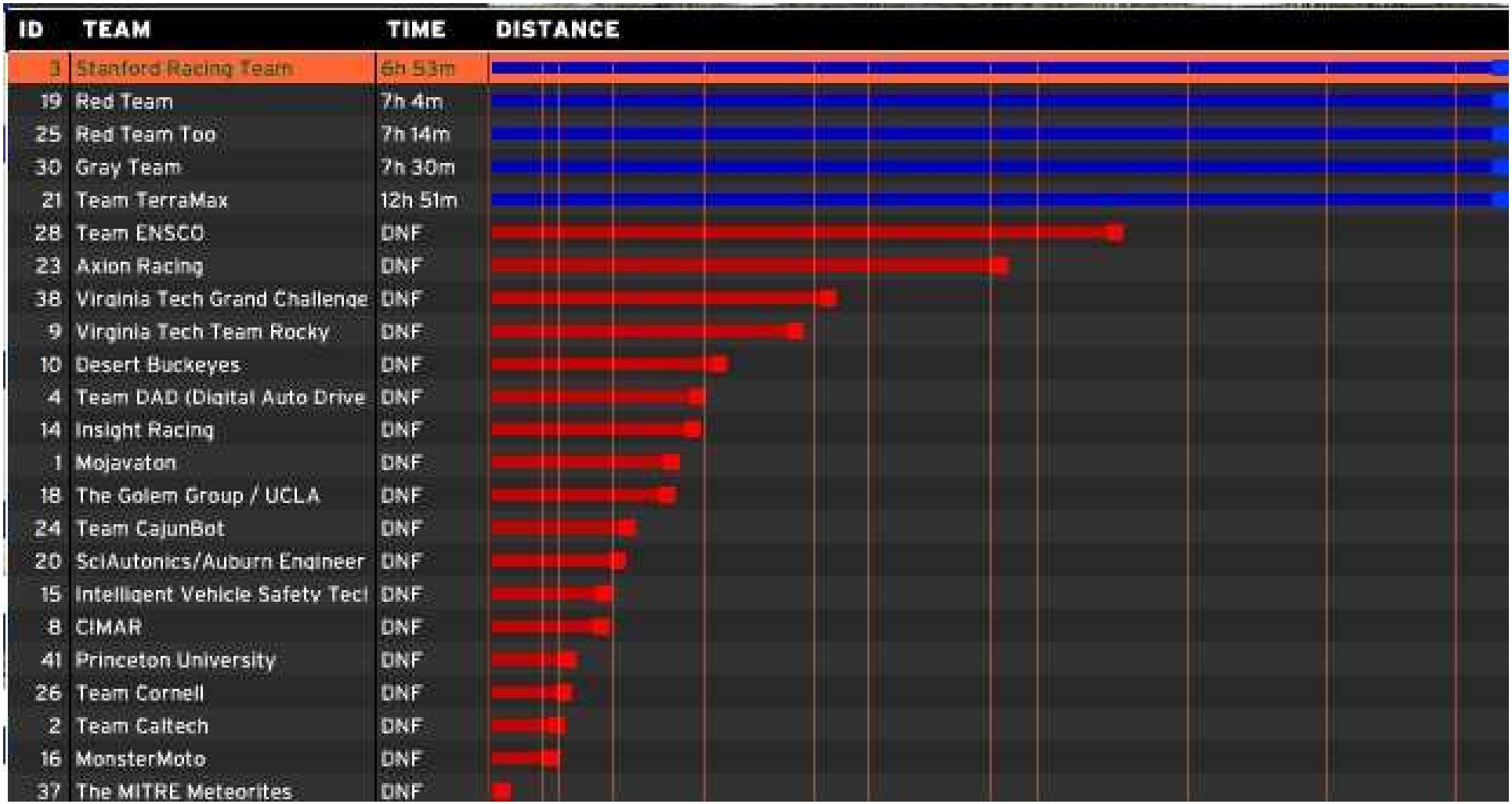
Picture from DARPA Grand Challenge Website

Results



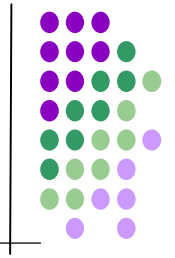
- Three vehicles managed to drive within 10 hours on the first day:
  - Stanford University (6h 53 min)
  - 2x Carnegie Mellon University (7h 04m, 7h 13m)
- One other team completed the course on the next day:
  - Gray Team (7h 30 min)
- And another team completed course beyond the 10 h limit:
  - TerraMax (12h 51 min)

All Results



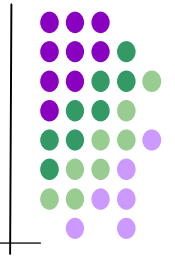
ID	TEAM	TIME	DISTANCE
3	Stanford Racing Team	6h 53m	
19	Red Team	7h 4m	
25	Red Team Too	7h 14m	
30	Gray Team	7h 30m	
21	Team TerraMax	12h 51m	
28	Team ENSCO	DNF	
23	Axion Racing	DNF	
38	Virginia Tech Grand Challenge	DNF	
9	Virginia Tech Team Rocky	DNF	
10	Desert Buckeyes	DNF	
4	Team DAD (Digital Auto Drive	DNF	
14	Insight Racing	DNF	
1	Mojavaton	DNF	
18	The Golem Group / UCLA	DNF	
24	Team CajunBot	DNF	
20	SciAutonics/Auburn Engineer	DNF	
15	Intelligent Vehicle Safety Teci	DNF	
8	CIMAR	DNF	
41	Princeton University	DNF	
26	Team Cornell	DNF	
2	Team Caltech	DNF	
16	MonsterMoto	DNF	
37	The MITRE Meteorites	DNF	

Motivation for DARPA



- Challenge organization:
  - New way of obtaining results from many teams working unpaid.
  - Harnessing ingenuity from non-traditional participants.
- Long-term goal:
  - Unmanned vehicles in military missions.

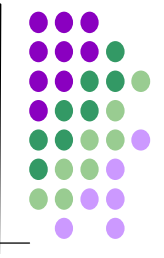
Motivation for Teams



- Competitive sporting event: try to win the race.
- Interest in developing new technology.
- Forming a new business.
- Have fun.

Other Motivation

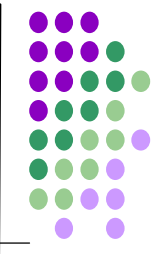
Ethics



- Automatic vehicle technology can safe lives.
  - Planned application: unmanned transport convoys.

- But: lowers the threshold of military conflict.
- Future systems in preparation:
  - Automatic shooter systems.
    - These were highly controversial when installed at the German-German border.
    - Issues for being used in wars?
    - Scope of discussion gets broader, into general discussion on war and military conflict.

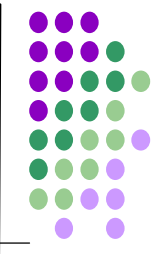
Suggestion re. Roadmap



- Legislative action (binding guidelines) is not promising:
  - Countries consider themselves sovereign.
  - Enforcement is difficult.

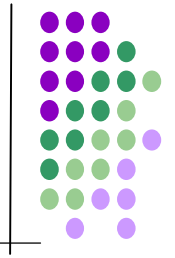
- Alternative:
  - Similar to the “oath of Hippocrates” a personal individual “oath of the robotist”, for the individual researcher / scientist / developer who is working on intelligent autonomous systems, to implement Asimov’s three Laws of Robotics (or others).

Future Outlook



- R&D in Military domain can greatly enhance robotic capabilities, also for non-military purposes.
- Situation similar to development of Nuclear Bomb in the 1940s:
  - Since then, physicists have heightened awareness of the dangerous possibilities of their field.
- When will the “Hiroshima of Information Technology” come?

Conclusions



- DARPA Grand Challenge brought robotic vehicles research significantly further.

- Roadmap and guidelines are helpful for channeling robotics efforts into beneficial developments.