

# DARPA Urban Challenge on Autonomous Driving

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## DARPA Grand Challenges

DARPA Grand Challenge I  
Barstow to Primm  
March 13, 2004



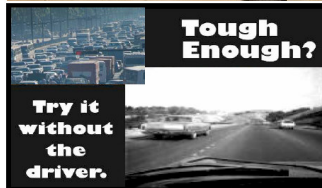
142 miles  
10 hours

DARPA Grand Challenge II  
Desert Classic  
October 8, 2005



132 miles  
10 hours

DARPA Grand Challenge III  
Urban Challenge  
November 3, 2007



60 miles  
6 hours

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## Prizes & Tracks

- First Place: \$ 2,000,000 (if Congress authorizes)
- Second: \$ 500,000 (if authorized)
- Third: \$ 250,000 (if authorized)
  
- **Track A:** Receive up to \$1 million technology development funds. Program ends at end of National Qualifying Event (NQE). Successful qualifiers invited to compete in final event.
- **Track B:** Submit application, send video, get selected for DARPA site visit. Teams that succeed at the site visit receive \$50,000 to participate in NQE. Teams that succeed at NQE receive \$100,000 to participate in final event and compete in final event.

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## A 2005 GC Site Visit



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# National Qualifying Event

California Speedway, Ontario, CA  
September 27 –October 5, 2005



Start Chute



Tunnel



Tank Trap

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## The 2005 GC Course

Narrow Underpass



Lake Beds



Rough Roads



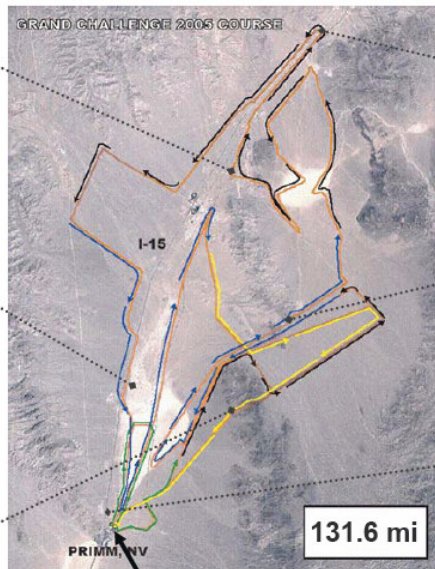
Long Tunnels



Narrow Gates



Close Obstacles



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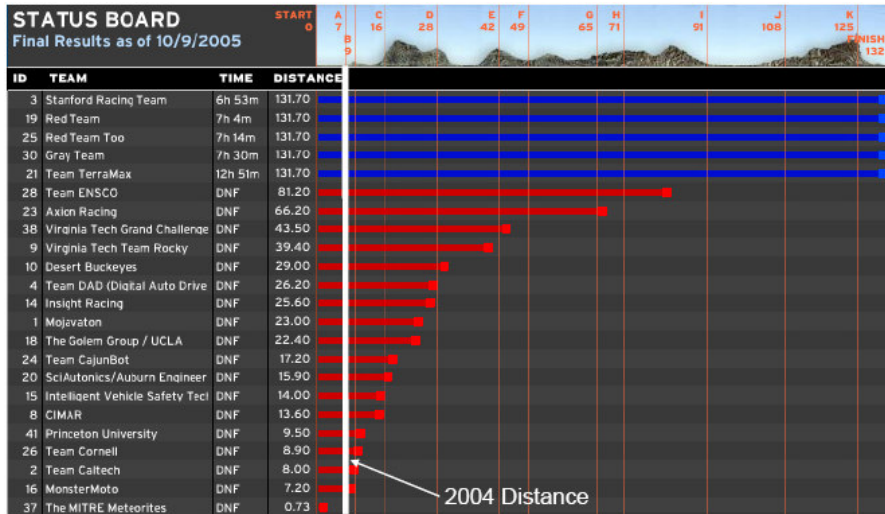
## Beer Bottle Run – 123 miles into course



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## 2005 GC Results



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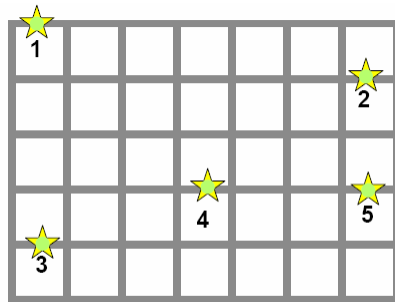
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## 2007 DARPA Urban Challenge

### Autonomous Driving Within City Limits

- Obey traffic laws
- Safe entry into traffic flow
- Safe passage through busy intersections
- Safe following or passage of moving vehicles
- Safe passage of a stopped vehicle
- Drive an alternate route when the primary route is blocked
- Safe U-turn (3-point turn)

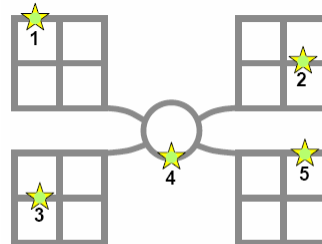
## Competition



Urban Route Network

★ Checkpoints

All vehicles on the course together, completing equivalent missions by visiting checkpoints.



1 4 3 4 2 4 5  $\cong$  5 4 2 4 1 4 3

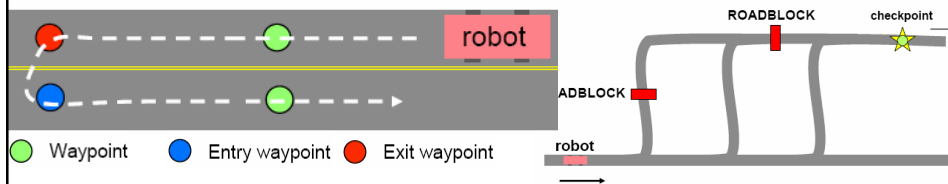
# The "Easy" Case



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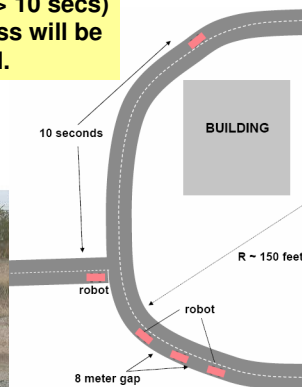
# Other Cases



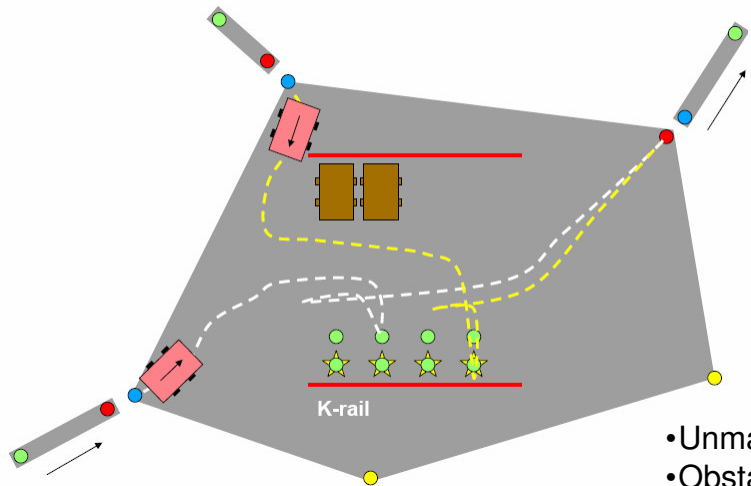
Taxicab Algorithm



Excessive delay (> 10 secs) in making progress will be penalized.



# The "Difficult" Case



- Unmarked
- Obstacles
- Moving traffic

# It's NOT a Demo



## Summary of Challenges

### Technical Challenges

- Mission planning
  - Sequence of missions
- Situational awareness and vehicle behaviors
  - Excessive aggression vs. caution
- Perception and multi-sensor fusion
- Real-time actuator control

### System Challenges

- Develop **and** integrate multiple technologies
- It's real
  - Things will go wrong
- Have multiple groups and cultures work together productively
- Do it all in 15 months

## DARPA Urban Challenge and CMU

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- CMU and General Motors have submitted a Track A team proposal
- Participants:
  - CMU Robotics Institute researchers
  - General Motors R&D
  - GM-CMU Collaborative Research Lab
- Other sponsors are currently being solicited
  - Google, CAT, ...