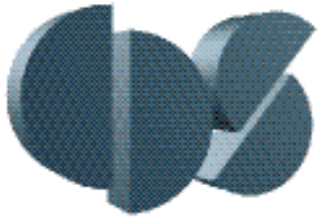
2007 Urban Challenge Information Session



Joel Burdick **Richard Murray** **Pietro Perona**
Engineering and Applied Science
California Institute of Technology

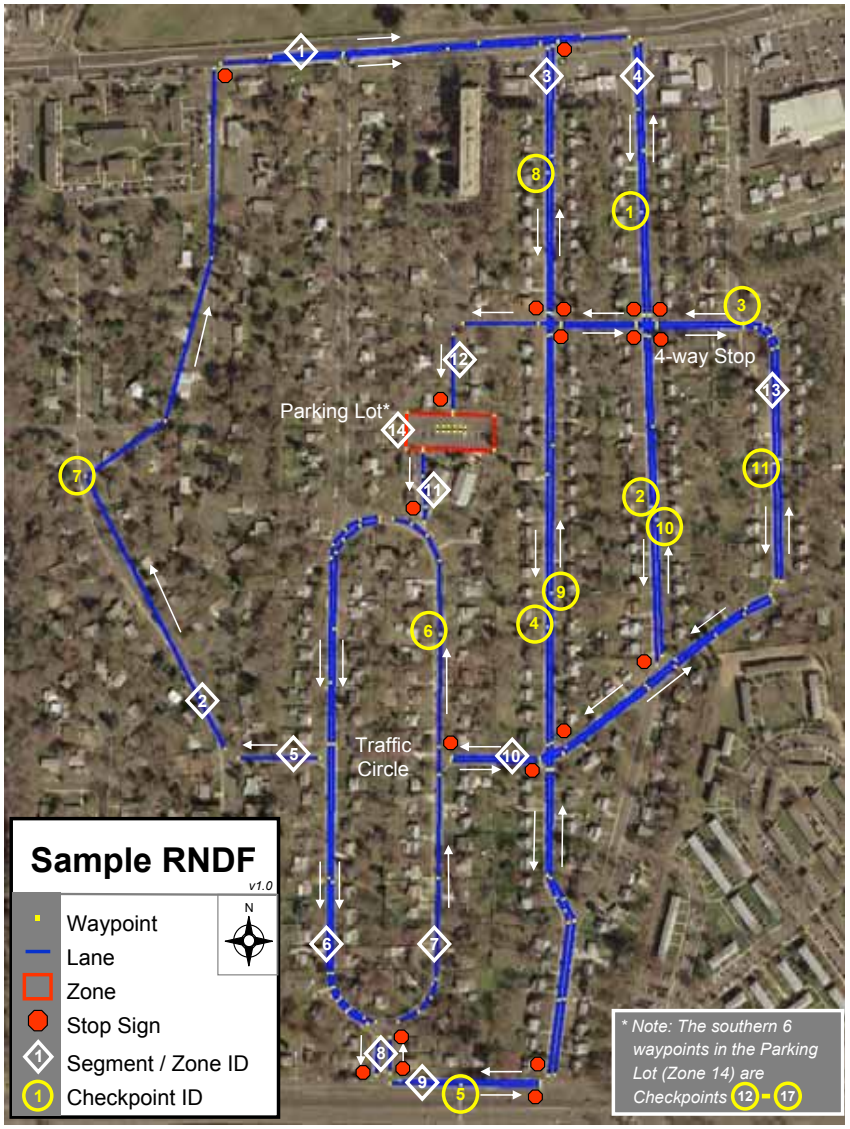
Goals

* Describe what the 2007 Urban Challenge is all about
* Discuss current state of project (quick overview of Alice)
* Describe how different groups can participate in the challenge
* Answer questions and collect feedback on Caltech participation
* Collect interest sheets to estimate participation from different groups

2007 DARPA Grand Challenge (Urban Challenge)

Autonomous Urban Driving

- 60 mile course, less than 6 hours
- City streets, obeying traffic rules
- Follow cars, maintain safe distance
- Pull around stopped, moving vehicles
- Stop and go through intersections
- Navigate in parking lots (w/ other cars)
- U turns, traffic merges, replanning
- Prizes: $2M, $500K, $250K

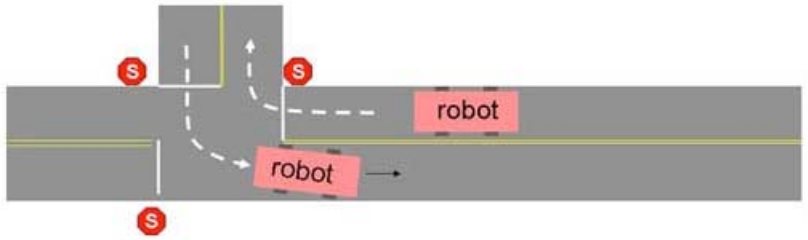


Urban Driving

Basic Navigation

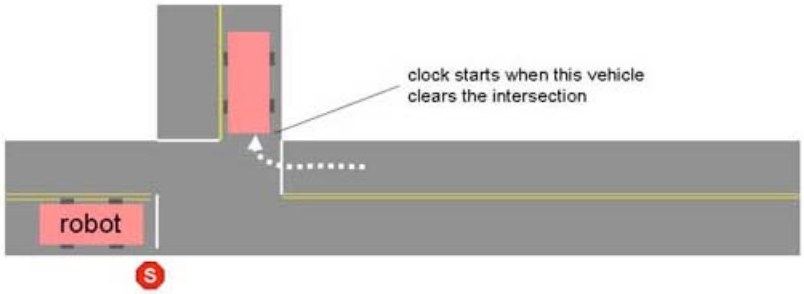
Basic Navigation

Vehicle stays entirely within travel lane around corners.



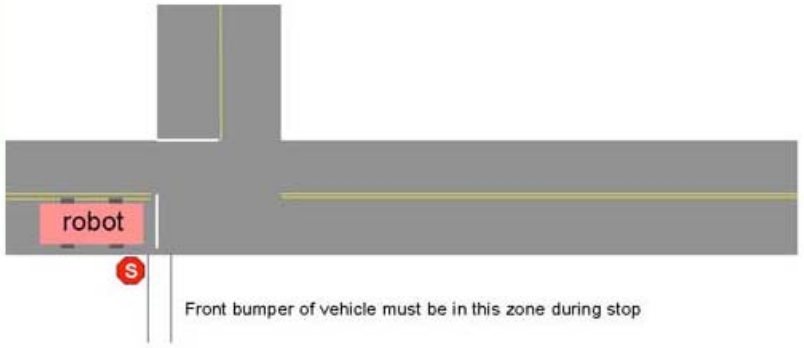
Basic Navigation

Vehicle exhibits less than 10 seconds of delay when intersection is clear.



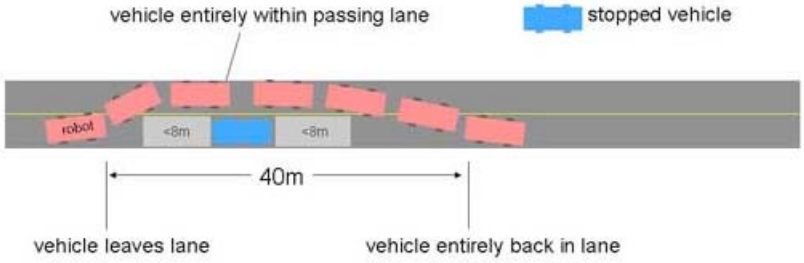
Basic Navigation

Vehicle stops within 1 meter of stop line.

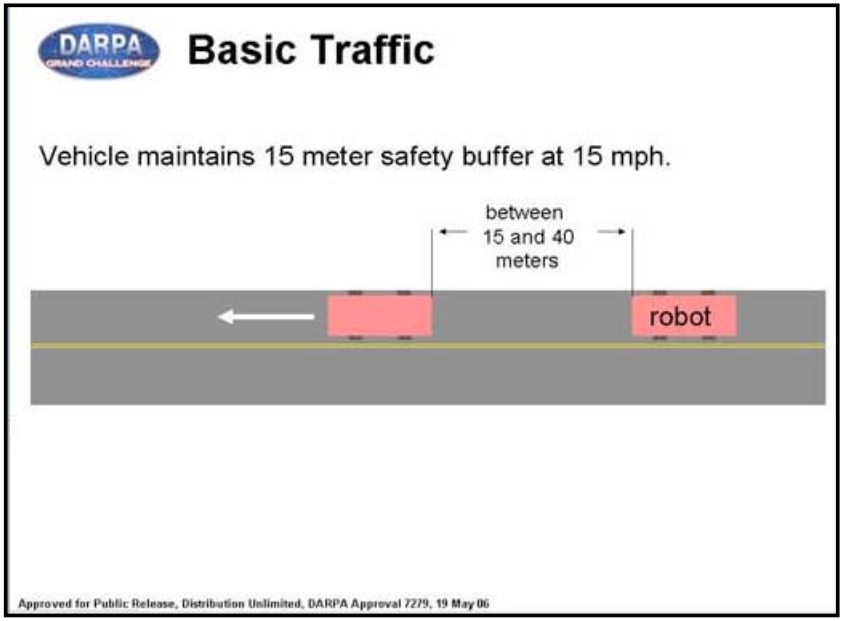


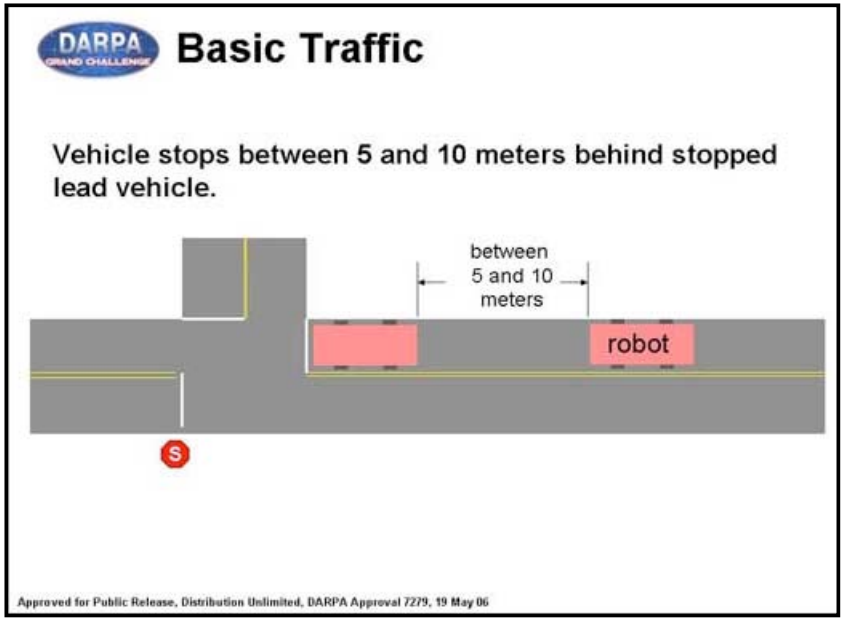
Basic Navigation (selected)

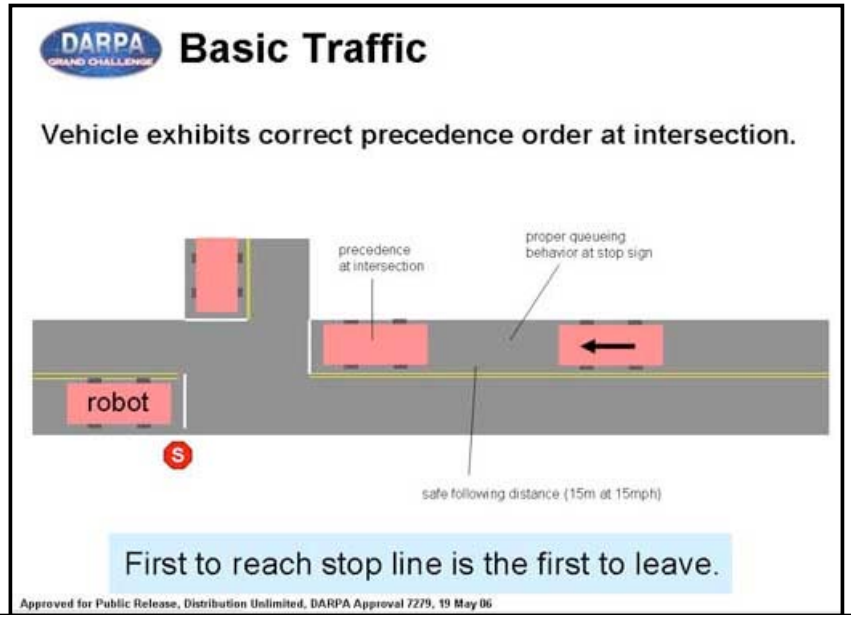
Vehicle completes passing maneuver in 40-meters or less maintaining 8-meter safety buffer



Basic Traffic



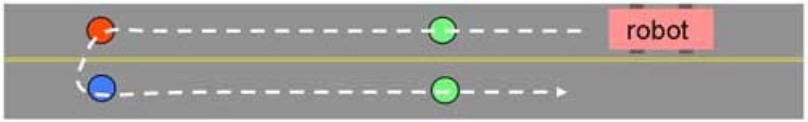




Advanced Navigation

Advanced Navigation

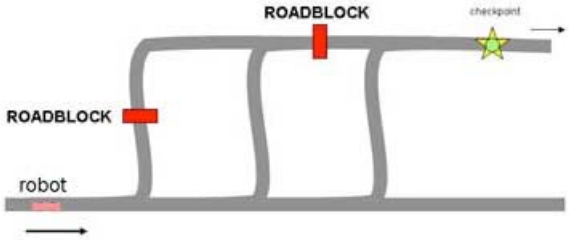
A U-turn may be effected through one or more three-point turns.



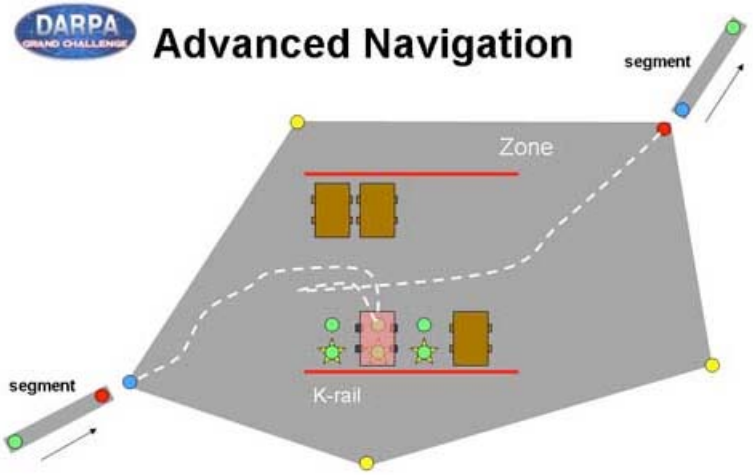
- Waypoint
- Entry waypoint
- Exit waypoint

Advanced Navigation

Vehicle re-plans when primary route is blocked.



Advanced Navigation



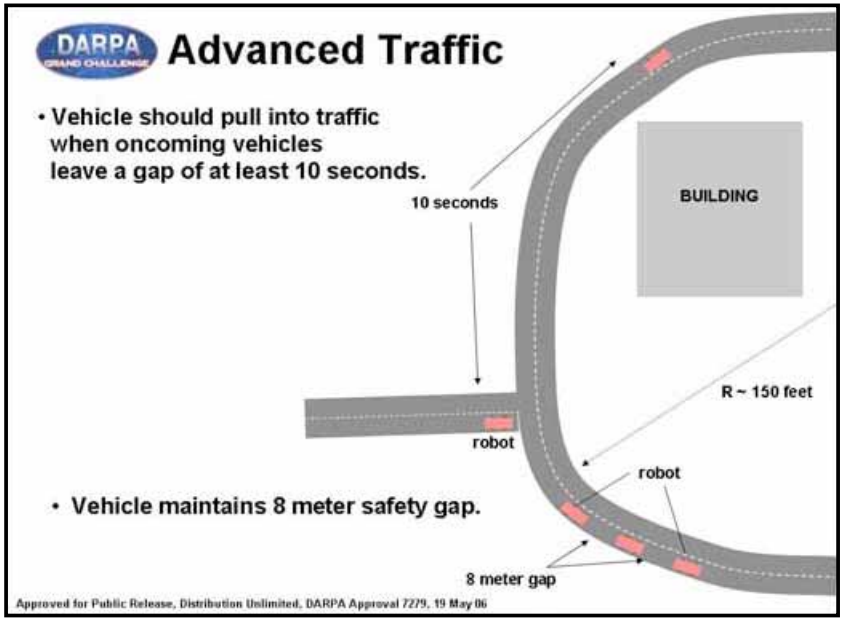
Vehicle exhibits correct parking lot behavior with less than 10 seconds excess delay.

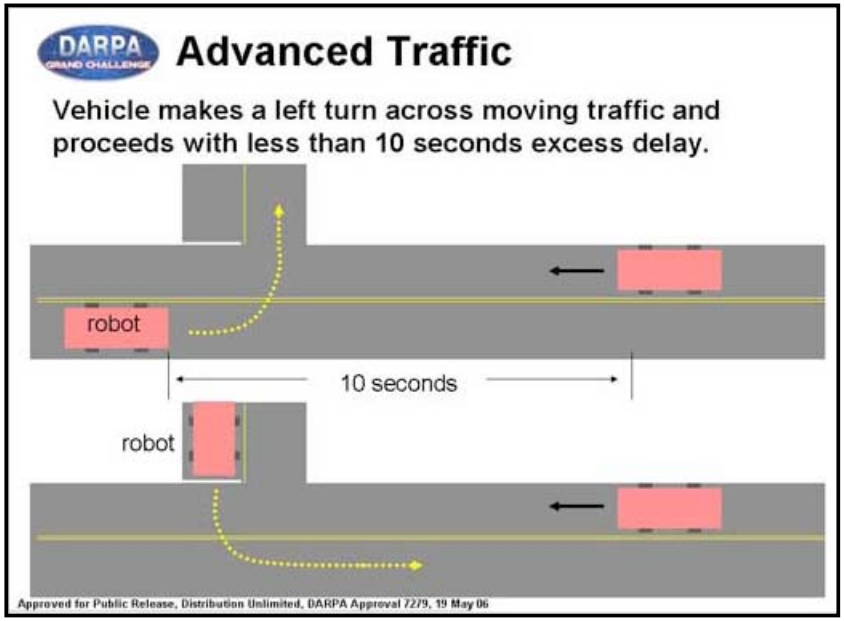
Advanced Navigation

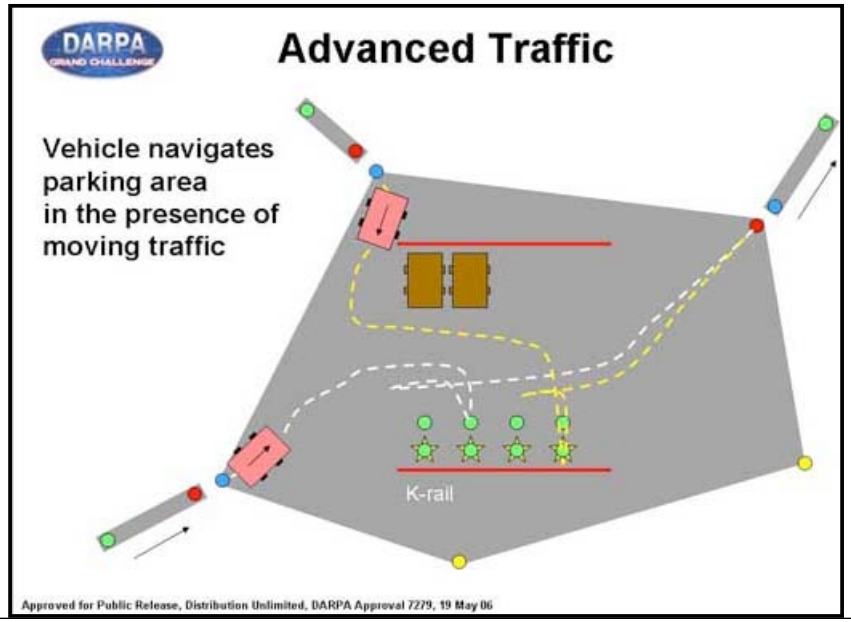
Road-following situations

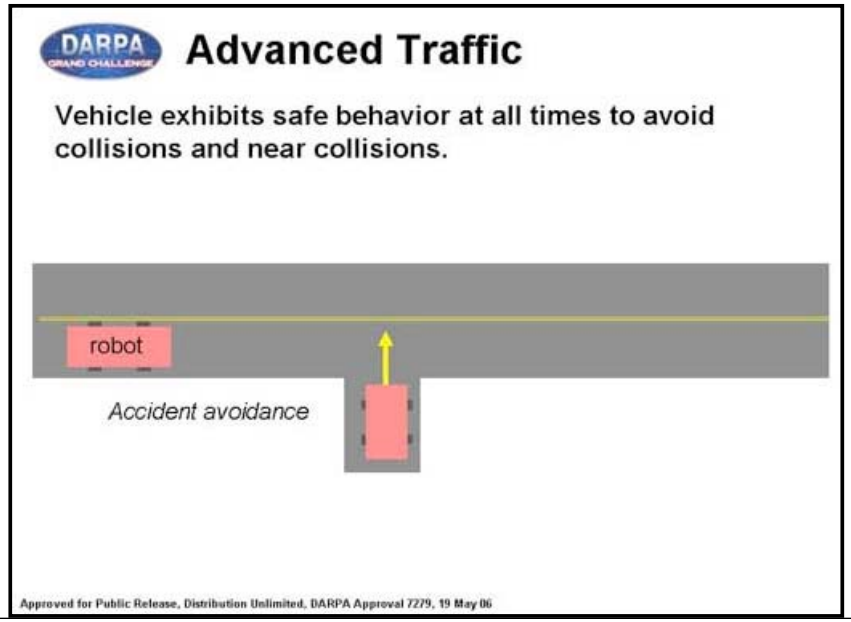
- Curbs, berms, vegetation
- Street lines may be missing
- Winding roads
- Sparse waypoints - may not be in center of road

Advanced Traffic

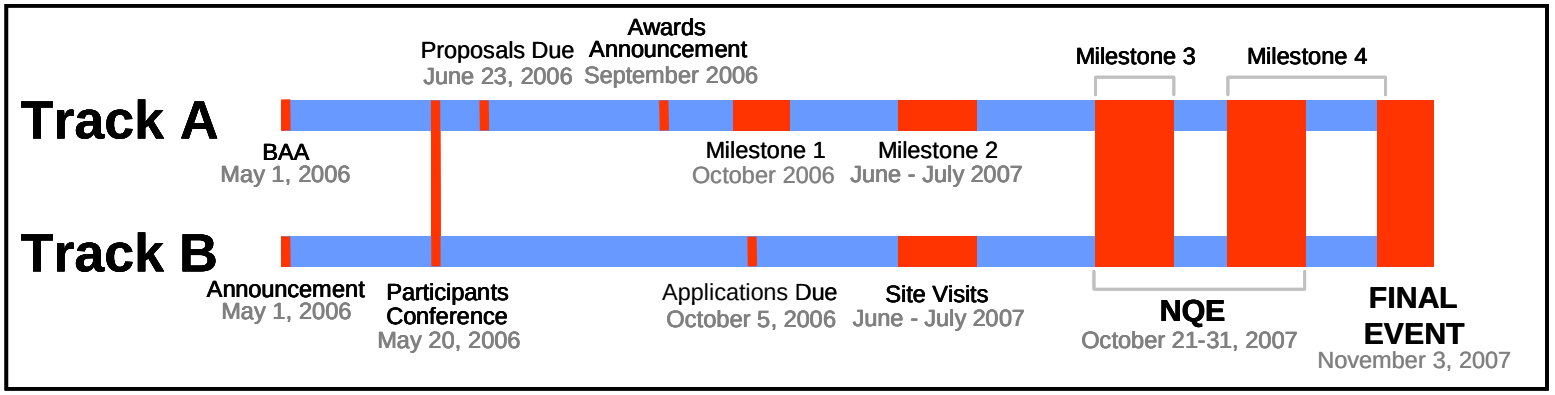








2007 Urban Challenge Participation



Track A: $1M grant from DARPA

- Proposal due 23 June 2006; up to $1M + any additional fundraising
- Award based on technical approach, management and funding plan, strength of team

Track B: no DARPA funding; similar to last year (application, site visit, NQE, GCE)

- $50K award for getting to NQE, $100K award for getting to race
- Application due 5 Oct, with video, technical paper due in Feb 07; site visits in Jun 07

Changes from last year

- Use of government resources OK with permission from sponsors

All participants in the race are eligible for 1st, 2nd or 3rd prize cash

Team Caltech

Team Caltech

- Started in 2003, for DGC04
- Over 100 undergraduates + grad students, faculty and volunteers

Alice

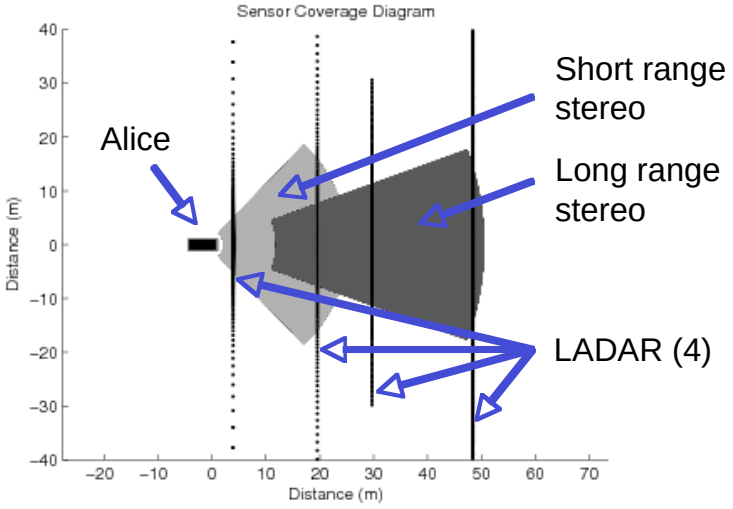
- 2005 Ford E-350 Van
- 5 cameras: 2 stereo pairs, roadfinding
- 5 LADARs: long, med*2, short, bumper
- 2 GPS units + 1 IMU (LN 200)

Computing

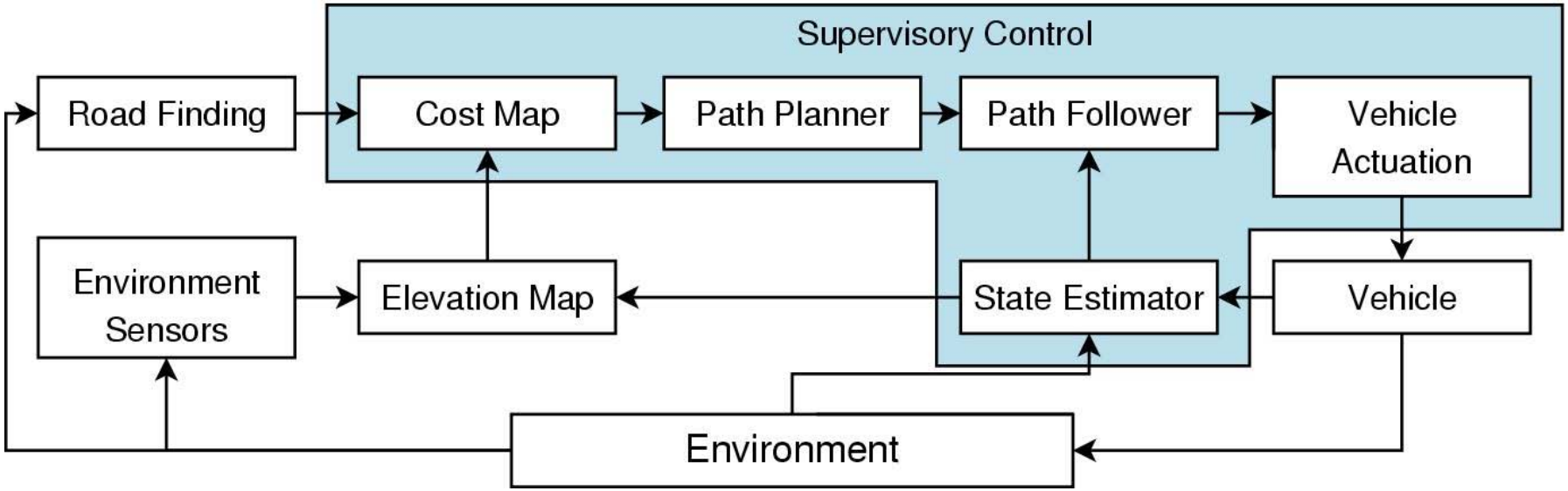
- 6 Dell PowerEdge Servers (P4, 3GHz)
- 1 IBM Quad Core AMD64 (fast!)
- 1 Gb/s switched ethernet

Software

- 15 programs with ~100 exec threads
- 100,000+ lines of executable code (good programmer does <100/day)



How Alice Drives

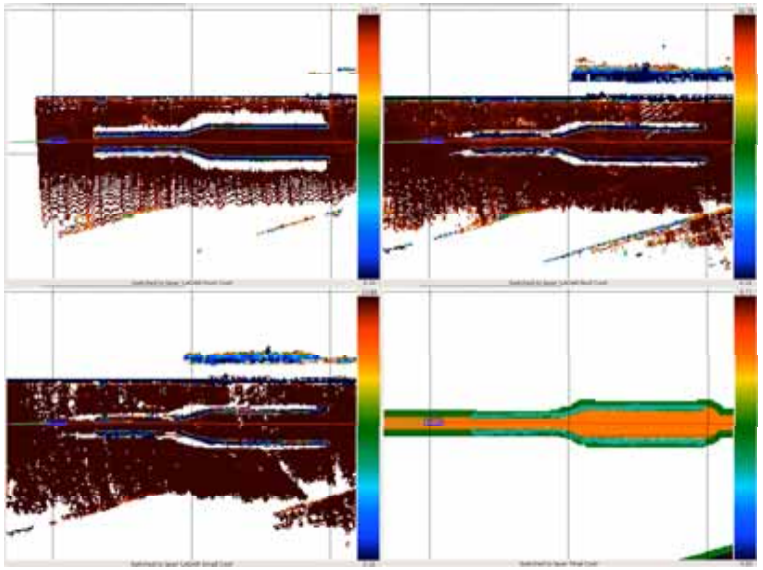


Current architecuture

- Optimization-based motion planning based on fused terrain data
- Supervisory controller handles contingencies (device failures, unseen obstacles, etc)

What's missing

- Can't currently handle moving obstacles (assumes environment is static)
- No understanding of rules of the road

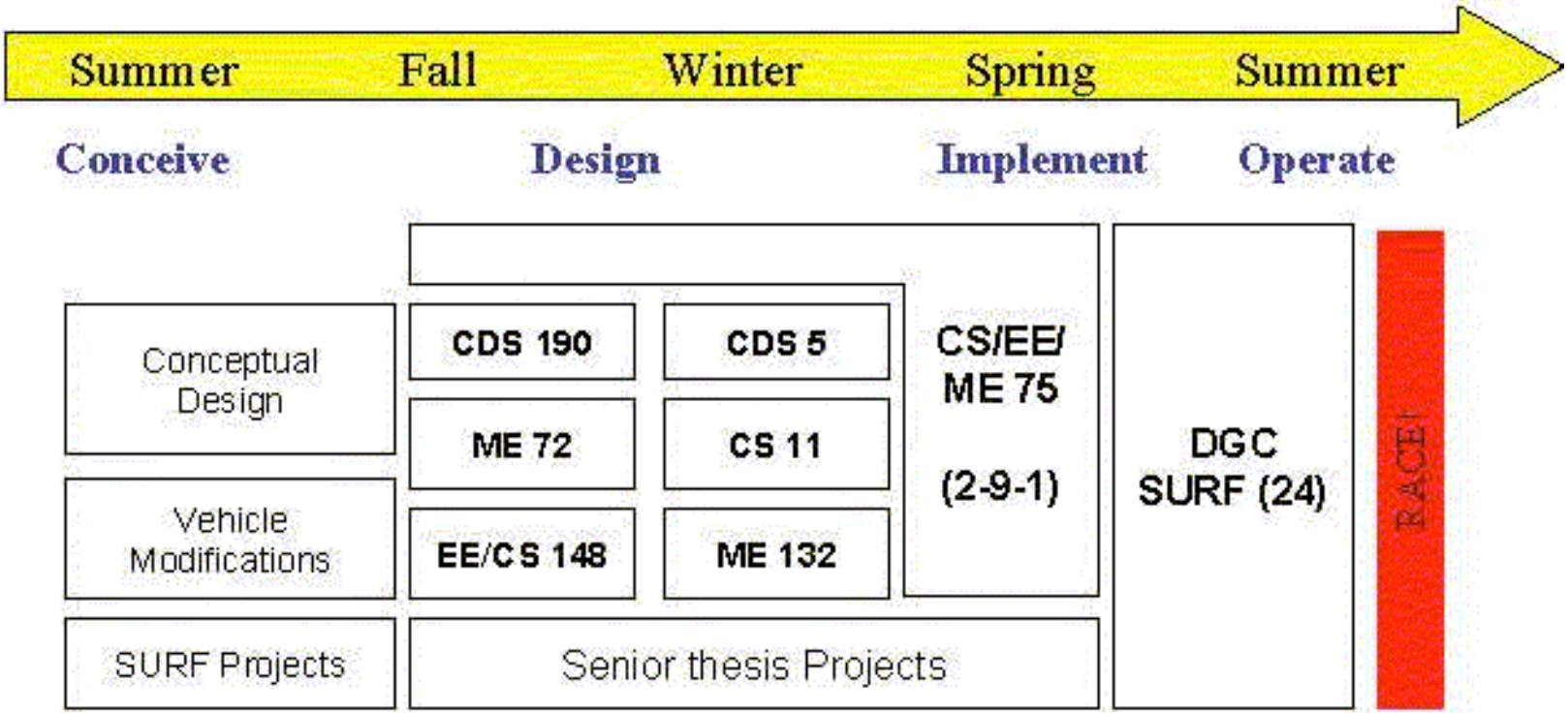


Team Caltech and the Urban Challenge

Possible mechanisms for Caltech participation in the Urban Challenge

- Undergraduate-only team (similar to last year): tie to courses, SURF program
- Mixed graduate/undergrad team: integrate current research from Caltech students
- Student-oriented team with lab/industry partners: include JPL and industry partners

CS/EE/ME 75 Course Structure



Planned Next Steps (DRAFT)

Summer 2006

- 13 undergraduates + 3-4 grad students working in SURF + grad research projects
  - Demonstrate basic navigation and traffic abilities (already planned)
- Conceptual design study: read literature, study rules, work through design examples
  - Need to make decisions about basic architecture no later than 1 Sep
  - Would like to evaluate key technologies to assess readiness as well
  - Should be possible for most people who are interested to participate in study
- Fundraising: submit DARPA proposal (23 Jun) + identify partners and support
- Go/no go decision by 15 September based on interest, funding, and plan

Academic year 2006-07

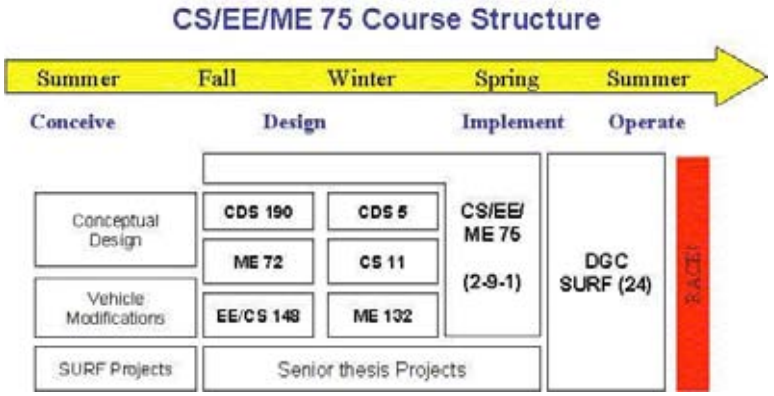
- CS/EE/ME 75 + linked courses: design and implementation
  - CS/EE/ME 75 focused on team activities; other work done through courses
  - Example: CDS 110 - control design for gimbaled sensor platform + sensor fusion
  - Integrate with graduate research and partner (JPL + industry) technical work
- Demonstrate advanced navigation by Jan 07, advanced traffic by Apr 07
- End of academic year goal: 60 mile demonstration in mock city, with resets

Summer 2007: optimized design and testing

How To Participate

Undergraduates

- Summer design study
- CS/EE/ME 75 and linked courses
- Senior theses and 2007 SURF
- Work study (subject to funding)



Graduate students/postdocs/faculty

- Implement graduate research projects on Alice (subject to advisor approval)
- TA positions for CS/EE/ME 75 + possible DARPA-funded graduate research
- Integrate DGC07 technical challenges into course HW, projects (linked courses)

JPL researchers and engineers

- Participate on design reviews, provide expert advise, participate on design teams, ...
- Exploring joint activities with various group and section leaders (starting this summer)

Industry Partners, Alumni

- Technical: feedback through reviews, advise to students, design work, etc
- Monetary: funds to support students, equipment donations, facilities and test sites

Non-Caltech individuals and groups: talk to Richard

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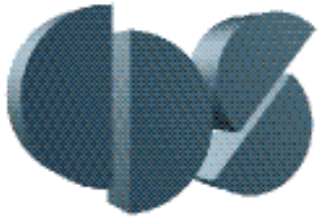

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