Goals

- Provide a *brief* description of the Urban Challenge and Team Caltech
- Describe goals and plans for the summer and ways to participate
- Break into groups, meet each other, pick a time to meet next week

Agenda

4:00  2007 Urban Challenge and Team Caltech
4:10  Team Caltech organizational structure
4:20  Plans for the summer: SURF + conceptual design
4:30  Breakouts by team
5:00  Adjourn
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
Baseline Capability: Alice

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
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

DGC Kickoff, 13 Jun 06

Richard M. Murray, Caltech CDS
Team Caltech, 2006-07

Goal: design, build and document an autonomous ground vehicle that can win the 2007 Urban Challenge

2006

Summer Fall Winter Spring Summer Fall

Conceive Design Implement Optimize

Autonomous Vehicles SURF (15)

Conceptual Design & Technology Analysis

CS 11

CDS 110a

CDS 110b

EE/CS 148

ME/CS 132

CS/EE/ME 75 (3-9-6)

DGC SURF (24)

Senior Thesis Projects

Graduate Research

JPL/NGC + additional partners

RACE (3 NOV 07)

Sr Theses

13 Jun 06
DGC Kickoff, 13 Jun 06

Richard M. Murray, Caltech CDS
Organizational Structure

Team Caltech

- Integrate undergraduate, graduate, lab, industry participation across team
- 1 FTE grad student on each team, funded by DARPA (coordinator + technical work)
- Additional grad students, postdocs as members of teams (along with undergrads)
- Each team is probably 10-15 people total (6-8 UG, 2-4 grad/PD, 2-3 JPL/industry)
## Summer 2006 GOTChA Chart

<table>
<thead>
<tr>
<th>Goals</th>
<th>Technical Challenges</th>
</tr>
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<tbody>
<tr>
<td>1. Figure out how we are going to win the 2007 Urban Grand Challenge</td>
<td>1. Little prior experience in urban driving</td>
</tr>
<tr>
<td>2. Learn what others have done and decide what we can import</td>
<td>2. Decision-making layer is beyond anything we have tried</td>
</tr>
<tr>
<td>3. Decide on the key elements of our system so that we are ready to begin the design phase in the fall</td>
<td>3. Architecture choices not clear</td>
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<td></td>
<td>4. Large, diverse, part-time team</td>
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<td></td>
<td>5. Current state estimation is brittle</td>
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<td></td>
<td>6. Need to get to testing phase quickly</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Evaluate specific technologies for urban driving and make recommendations on whether to use them</td>
<td>1. Use SURF projects to evaluate potential technology solutions</td>
</tr>
<tr>
<td>2. Decide on system level architecture to be used for design</td>
<td>2. Exploit expertise at JPL, NGC</td>
</tr>
<tr>
<td>3. Decide on system specifications required to complete the race</td>
<td>3. Use conceptual design groups to survey approaches, inform team</td>
</tr>
<tr>
<td>4. Line up funding ($300K min), equipment, expertise (incl. partners)</td>
<td>4. Drive results via field tests, reviews</td>
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<tr>
<td></td>
<td>5. Identify supporters early &amp; request $$</td>
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# Summer SURF Schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12 Jun</td>
<td>Orientation and (re-)planning</td>
</tr>
<tr>
<td>2</td>
<td>19 Jun</td>
<td></td>
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<tr>
<td>3</td>
<td>26 Jun</td>
<td></td>
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<tr>
<td>4</td>
<td>3 Jul</td>
<td>Institute Holiday</td>
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<tr>
<td>5</td>
<td>10 Jul</td>
<td></td>
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<tr>
<td>6</td>
<td>17 Jul</td>
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<tr>
<td>7</td>
<td>24 Jul</td>
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<tr>
<td>8</td>
<td>31 Jul</td>
<td>CDR</td>
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<tr>
<td>9</td>
<td>7 Aug</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>14 Aug</td>
<td></td>
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<tr>
<td>11</td>
<td>21 Aug</td>
<td></td>
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<tr>
<td>12</td>
<td>28 Aug</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>4 Sep</td>
<td>SURF meeting: Tuesdays @ 4 pm</td>
</tr>
<tr>
<td>14</td>
<td>11 Sep</td>
<td>Team meeting: Mondays @ 6 pm (after 7/1)</td>
</tr>
</tbody>
</table>

- **Field Test #1**
- **Field Test #2**
- **Field Test #3**
- **Field Test #4**
- **PDR**
- **Lab Move**
- **Posters**
- **Surf**
- **CDR**
- **Institute Holiday**
- **EA (4)**
**Conceptual Design - Summer 2007**

Break up into groups in selected areas
- Roughly divide by “race teams”, with each team having multiple groups of 3-6 people
- Each group is responsible for investigating a single area of focus

**Areas we need to cover (and more)**
1. Modeling and simulation
2. Path planning w/ dynamic obstacles
3. Traffic-level planning, tactics
4. State estimation in urban environments
5. Sensor architecture and hardware
6. Detection & tracking of moving objects
7. Software architectures for autonomy
8. Decision-making and planning

**Proposed approach**
- Each race team will create a list of areas it needs to cover
- Richard, Joel and others will resolve conflicts and overlaps
- Teams will break up into subgroups (w/ overlaps if needed) to cover areas
Conceptual Design - Summer 2007

Operations/Testing
- Computer modeling
- Test infrastructure
- Data logging/analysis
- Vehicle hardware
  - Tony Fender

GNC
- Path planning
- Feedback control
- State estimation
- NCS infrastructure
  - Joel Burdick

Sensing and Fusion
- Sensor hardware
- Fusion
- Attention and pointing
- Sensor replay
  - P. Perona/L. Matthies

Mission Planning
- Mission/goal mgmt
- Contingency mgmt
- Learning & adaptation
  - Rich Volpe

Richard Murray
- Ilya Loksha
- Jing Shen
- Ken Fisher
- Albert Wu

Joel Burdick
- Jessica Gonzalez
- Morlan Liu
- Dave Knowles*
- Martin Larsson
- Ling Shi
- Michael Epstein
- Ziad Fares

Pete Trautman
- Laura Lindzey
- Dave Rosen*
- David Bolin
- Johnny Zhang
- Jeremy Ma
- Arlene Cole-Rhodes
- Vijay Gupta*
- Mohamed Aly

Tim Chung/Nok W.
- Josh Feingold
- Shawn Surdyk
- Jose Torres

DGC Kickoff, 13 Jun 06
Richard M. Murray, Caltech CDS
10
Next Steps

Breakout sessions

• If your name is listed on the previous chart, please go to that room
• Otherwise, Pick the team that you are most interested in

1. Introduce yourselves (and what you do)
2. Choose a notetaker & get e-mails of participants
3. Discuss some of the questions we need to answer by the end of the summer (take notes)
4. Pick a time when the group can meet next week (ideally, after 3 pm on Tuesday)
5. Decide what everyone should do between now and then (if anything)

Mailing lists

• If you aren’t on a mailing list and want to stay informed, please sign up:
  http://gc.caltech.edu/mailman/listinfo/team-volunteers

Room Assignments
Operations - 110 Steele
GNC - 114 Steele (library)
Sensing - 102 Steele (here)
Reasoning - 125 Steele