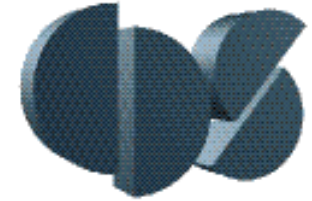


# CS/EE/ME 75b

## Team Caltech Working Meeting



**Richard Murray**

**Elliott Andrews**

**Ben Brantley**

**Joel Burdick**

**Lars Cremean**

**Kristo Kriechbaum**

**Pietro Perona**

**Engineering and Applied Science  
California Institute of Technology**



# Meeting Goals and Agenda

## Goals

- Put together the project goals and timeline for winter term and beyond
- Learn about some methods for program planning and goal setting

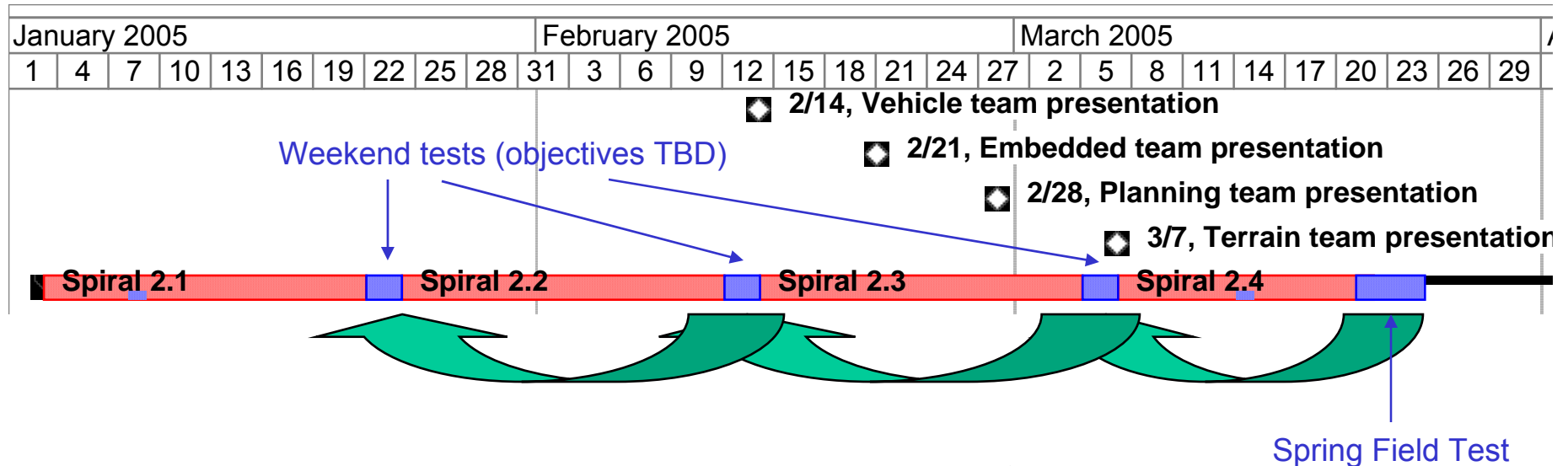
## Output

- Data for project GOTChA chart for winter term (to be presented on Mon)
- Test-focused plan for achieving (& demonstrating) our objectives for the term
- Spiral development plan for capabilities that other teams can build on

## Agenda

- 2:00 Overview and draft test plan for the term
- 2:20 Race team breakouts – spiral development plan for the term
- 3:10 Report outs and discussion
- 3:40 Test team breakouts – revised test plan
- 4:20 Report outs and discussion
- 4:45 Race team breakouts – GOTChA charts (to be presented on Mon)
- 5:00 Adjourn

# Test Plan



## Test-based schedule

- Three weekend test windows: W3, W6, W9
- End of term field test: 10 miles @ 10 mph over representative terrain using prototype race HW and SW (TBD)
- Each test window should be used to demonstrate progress toward end of term test and point out areas that need more work

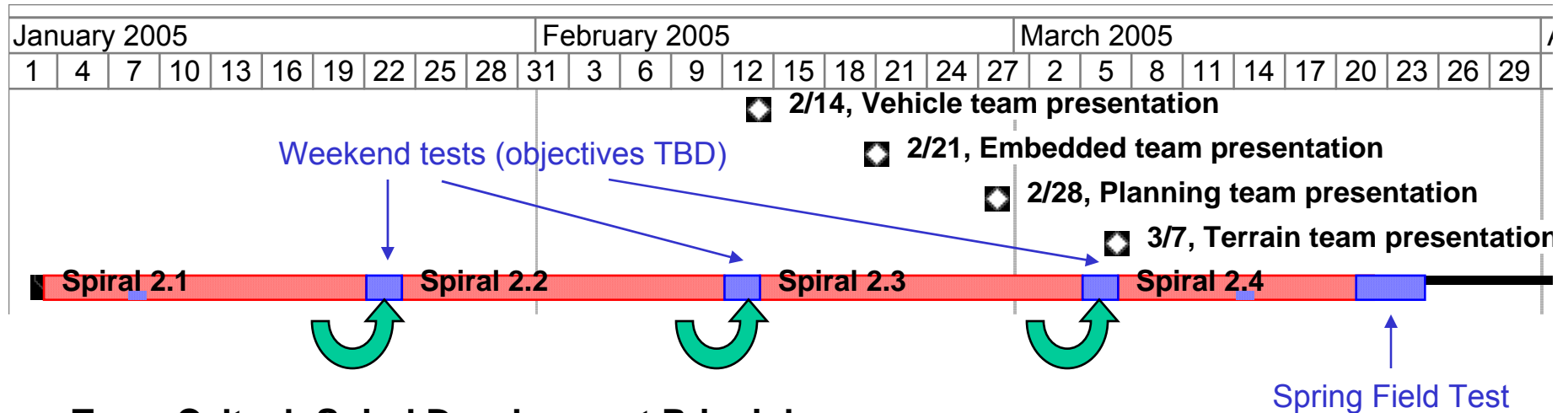
## Right to Left Plan

- Start with our goal for the end of the term and ask what we need to do to get there
- Define a right to left plan that starts at the end and identifies what needs to be done in stages
- Make each test a *critical* demonstration (use to down select approaches and guide how we spend our time between tests)

## DRAFT test plan (to start discussion)

Week 3 Field Test	Week 6 Field Test	Week 9 Field Test	Spring Field Test
<p><b>Alice:</b></p> <ul style="list-style-type: none"> <li>record human driven trajectory and re-execute open loop commands through actuators, recording new trajectory.</li> </ul>	<p><b>Alice:</b></p> <ul style="list-style-type: none"> <li>Path following on Alice at Santa Anita, using Skynet, SDS</li> </ul>	<p><b>Alice:</b></p> <ul style="list-style-type: none"> <li>integrated demonstration of deliberative, mode management, path following on Alice.</li> <li>Sensor suite installed and collecting data on race HW</li> <li>DARPA video</li> </ul>	<p><b>Alice:</b></p> <ul style="list-style-type: none"> <li>10 miles autonomous driving at 10 mph average speed, using race hardware and software.</li> </ul>
<p><b>Bob:</b></p> <ul style="list-style-type: none"> <li>Use path follower to follow pre-recorded suite of pre-determined trajectories.</li> </ul>	<p><b>Bob:</b></p> <ul style="list-style-type: none"> <li>integrated demonstration of RDDF path gen (multiple, non-identical sent paths), mode management and path following on Santa Anita RDDF #3</li> <li>DARPA backup</li> </ul>	<p><b>Bob:</b></p> <ul style="list-style-type: none"> <li>Backup (use for video if Alice is not working or available)</li> </ul>	<p><b>Bob:</b></p> <ul style="list-style-type: none"> <li>Spectate.</li> </ul>
<p><b>Offline:</b></p> <ul style="list-style-type: none"> <li>get desired suite of RDDFs/dense trajectories to follow.</li> </ul>	<p><b>Offline:</b></p> <ul style="list-style-type: none"> <li>Road detection using previously recorded race data</li> </ul>	<p><b>In advance</b></p> <ul style="list-style-type: none"> <li>None</li> </ul>	<p><b>In advance</b></p> <ul style="list-style-type: none"> <li>Demonstration of all components working in shop</li> </ul>

# Spiral Development



## Team Caltech Spiral Development Principles

- Spiral development between test periods
- System should be operational when spiral 2.x is released
- Each team should develop specific objectives for each spiral + tests to validate

System type	Spiral 0 (summer)	Spiral 1 (fall)	Spiral 2 (winter)	Spiral 3 (spring)
<b>General</b>	Parts available	Remote control	<b>Autonomous ops</b>	Race ready
<b>Vehicle</b>	• HW received	• Computer control	• Desert capable	• Robust ops
<b>Embedded</b>	• Tools in place	• Basic functionality	• Final interfaces	• Robust ops
<b>Planning</b>	• Architecture	• Path generation	• Reactive motion	• Robust ops
<b>Terrain</b>	• Specs availabl	• Terrain → DEM	• Real-time maps	• Degraded ops

# Breakout #1

## Output from breakout group

- Each team should come back with a description of objectives for 2.x spirals
- For each spiral, define pre-requisites from other teams, if any
- Identify any tests that you don't think can be met in the time available

## How to get started

- Within your group, decide on a scribe who will write things on the board and present results during the discussion
  - Use one board per test; don't erase
- Start with W3 tests and define what your team must have working and what you need from other teams
- Move on to W6, W9 and spring tests; try to spend about 5-10 minutes on each

## Schedule

- 2:20 Spiral development discussion
- 3:00 Take pictures of board (RMM)
- 3:10 Meet in 206 Thomas
  - Each team to present spiral plan (5 minutes *max*)
- 3:40 Done

## Breakout groups: race teams

- Vehicle – room 214B
- Embedded – room 08
- Planning – room 06
- Terrain – room 301

## Additional comments

- Objectives should be integration oriented –test linkages b/w components
- Be realistic about time available. We need to define achievable spirals

# Breakout #2

## Output from breakout group

- Each team should come back with a revised description of the W3, W6, W9 tests
- For each test, make sure that the objectives from each team's spirals are exercised

## How to get started

- Introduce yourselves: name, option, year, race team, component responsibilities
- Within your group, decide on a scribe who will write things on the board
- Start with draft test plan and identify objectives that can't be met by one or more team's spirals; shift objectives right if needed (remember that spring test can't shift)
- Add additional tests if needed to verify objectives

## Schedule

- 3:40 Introductions
- 3:45 Test plan discussion
- 4:15 Take pictures of board (RMM)
- 4:20 Meet in 206 Thomas  
Each team to present test plan (5 minutes *max*)
- 3:30 Done

## Breakout groups

- Group 1: Rosen, Hines, Jeanty, Berch, Kriechbaum, Lindzey, Zerrade
- Group 2: Gillula, Stewart, Cable, Burdick, Brantley, Yosinski, Costa, Cossel
- Group 3: Gao, Andrews, Barnor, Craig, Cady, Cremean, Foote

# Project GOTChA Chart (Winter 2004 - DRAFT)

## Goals

- Design, build and test a vehicle (Alice) with basic autonomous capability
- Establish design specifications, engineering design plan and tests for a race-winning autonomous vehicle

## Objectives

- Field tests of spiral 2 technologies on final system architecture
  - 10 miles autonomous desert driving with 10 mph average speed on Alice
- Performance and interface specs for each component, with measurable performance tests defined
- Engineering design plan for taking vehicle to race-capable level
- System design review by team of outside experts

## Technical Challenges

- Systems integration and configuration management, especially SW
- Perception: high speed, unstructured
- Decision-making: robust planning
- Technical driving: accurate path following

## Approach

- CS/EE/ME 75: team-based design
- CS 11: embedded programming
- CDS 110: control and estimator design
- ME/CS 132: path planning algorithms
- Make use of JPL expertise