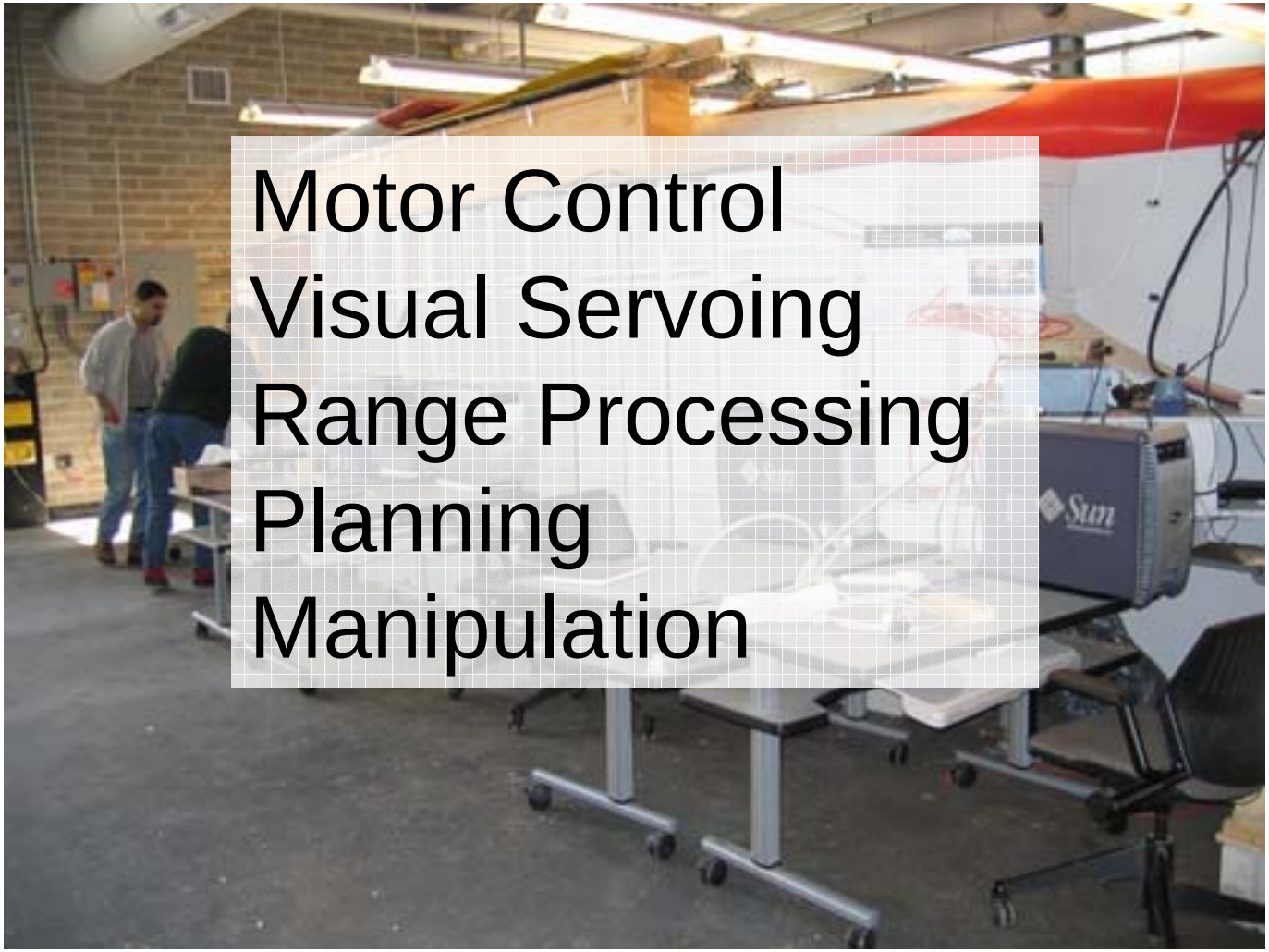
Robotics: Science and Systems II

6.189/2.994/16.401

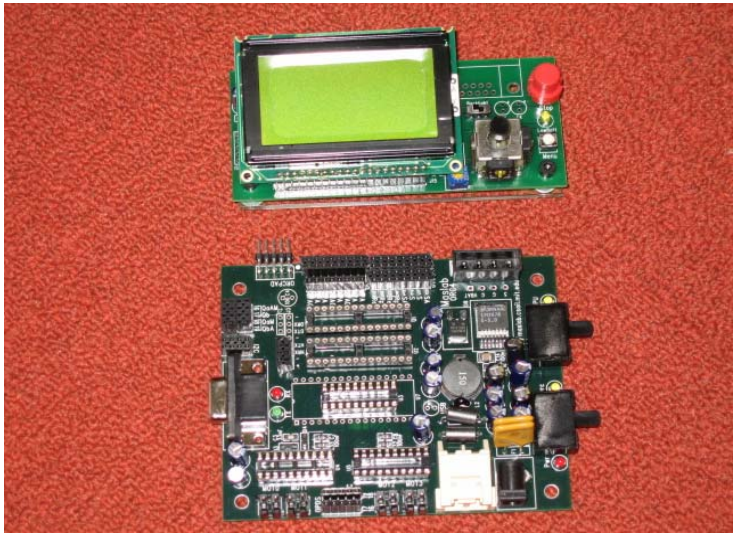
September 7th, 2005

Last Semester…



Lab Progression

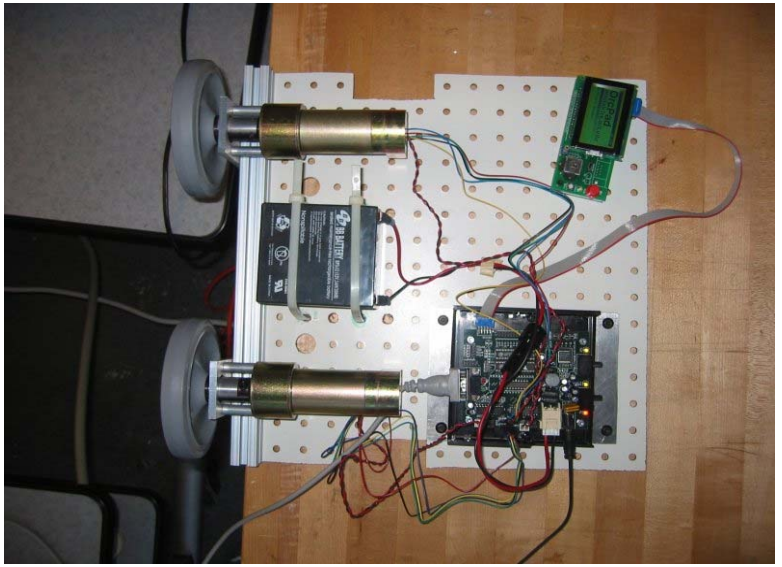
1. Schematics: Layout and Components
    - Learn hardware and software architectures
    - Learn to solder
    - Understand circuit schematic
    - Practice with multimeter `



Lab Progression

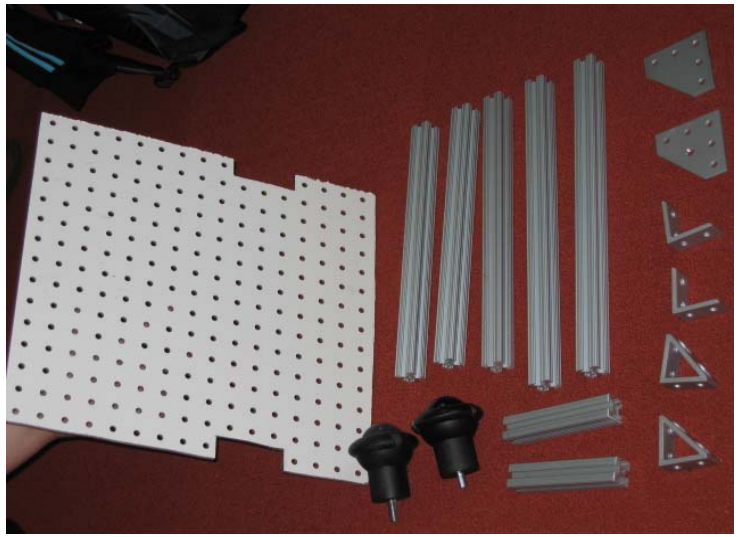
2. Motor Characterization and Control

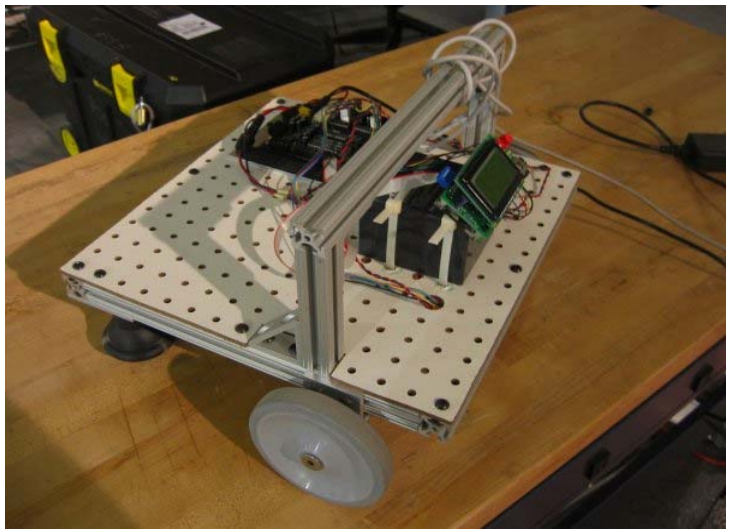
- Become Familiar with Java and Subversion
- Understand Motor Characterization and Control
- Perform Time Accounting and Self-Assessment



Lab Progression

3. Robot Chassis and Driving
    - Construct Robot Chassis
    - Control Robot with Odometry
    - Discuss Errors with Odometry

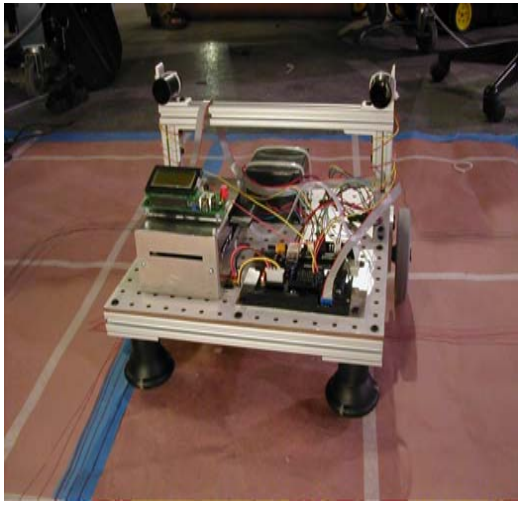




Lab Progression

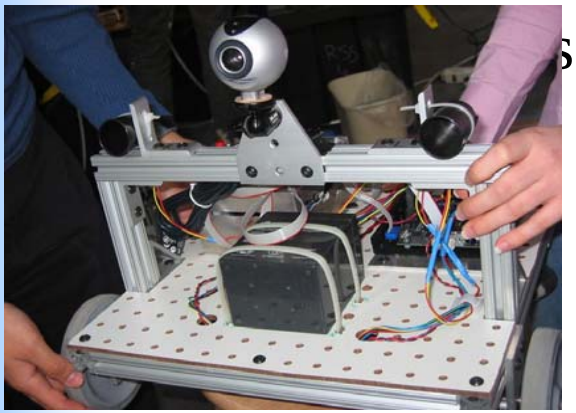
4. Light Sensors and Braitenberg Behaviors

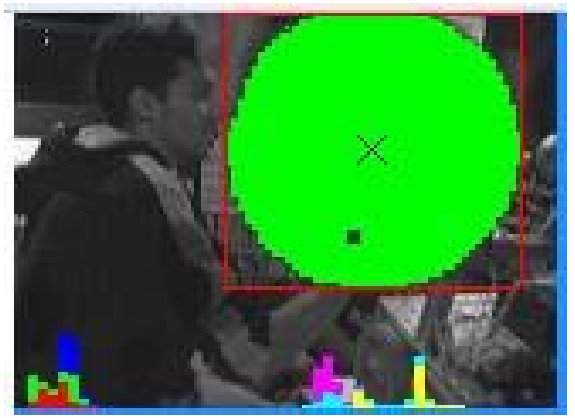
- Incorporate Single Board Computer
- Construct and Calibrate Light Sensors
- Program Braitenberg Behaviors



Lab Progression

5. Carmen Robot Control Package and Visual Servoing
   - Learn to use Carmen
   - On-line digital image acquisition
   - Visual servoing

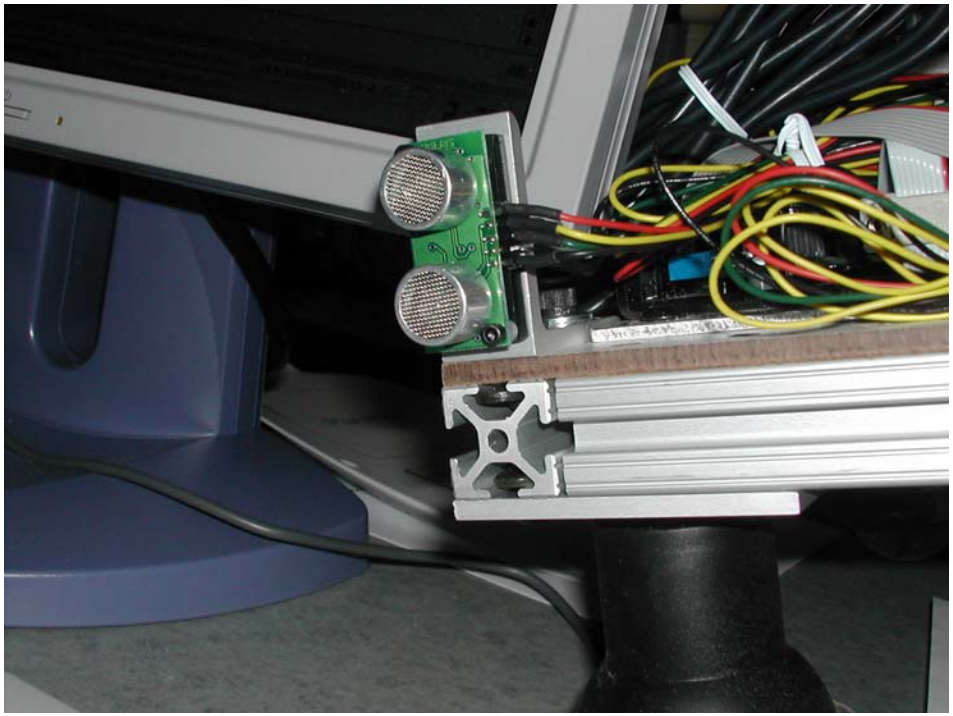




Lab Progression

6. Local Navigation and Error Analysis

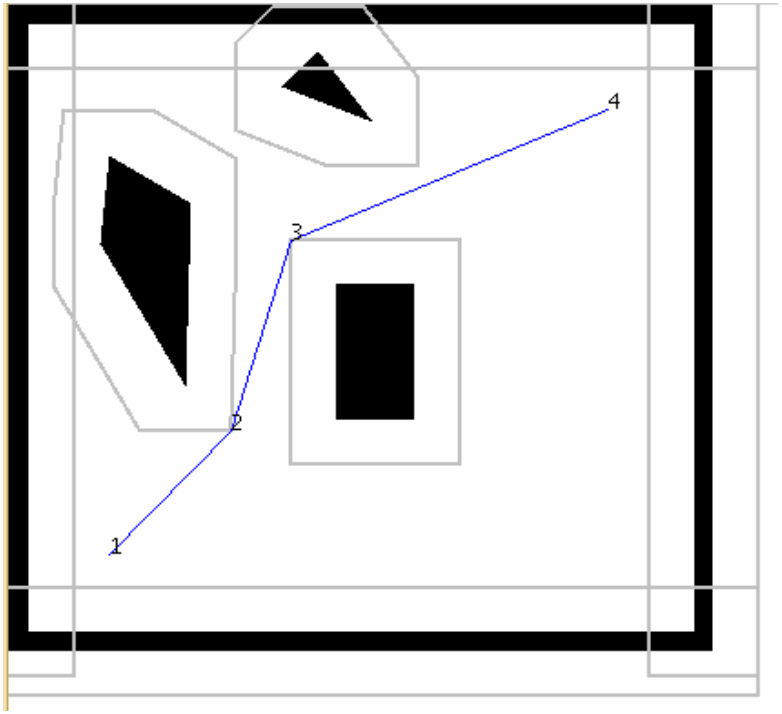
- Install bump and sonar sensors
- Robot reacts to collisions
- Robot creates models of obstacles
- Robot travels around obstacles

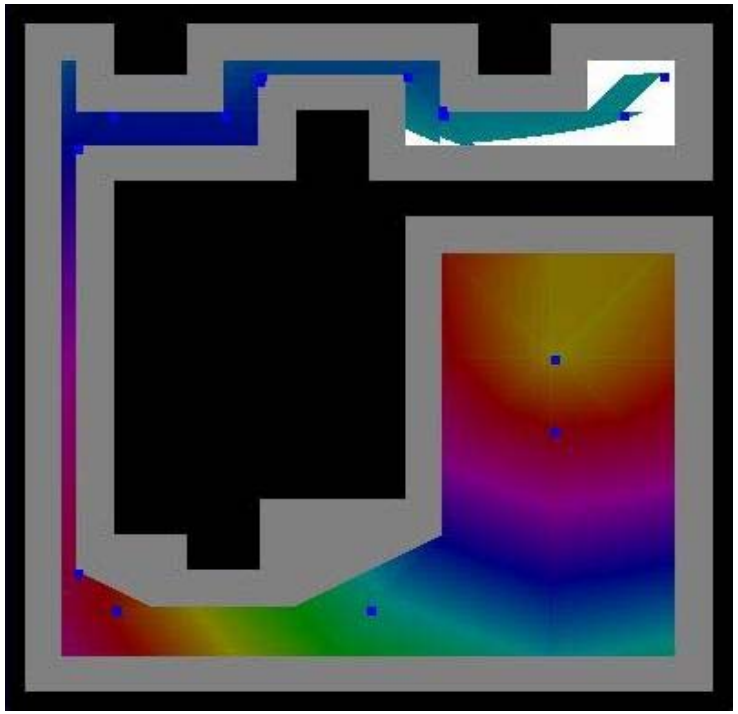


Lab Progression

7. Motion Planning and Global Navigation

- Building configuration space
- Path planning
- Waypoint navigation

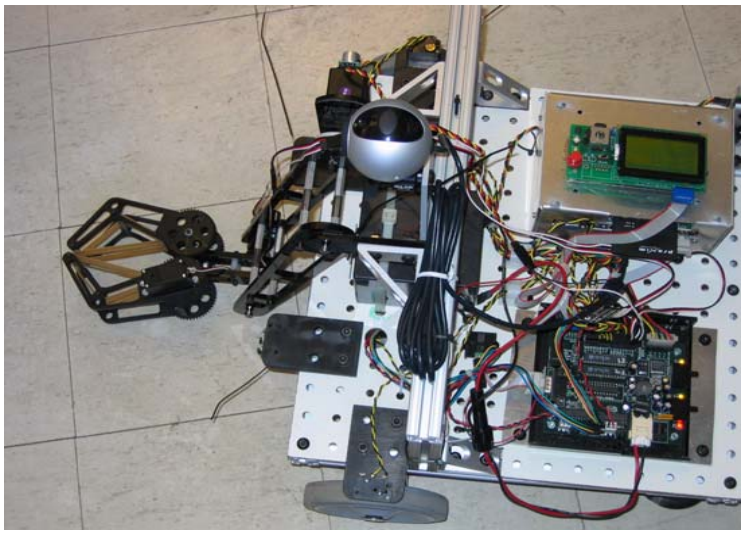




Lab Progression

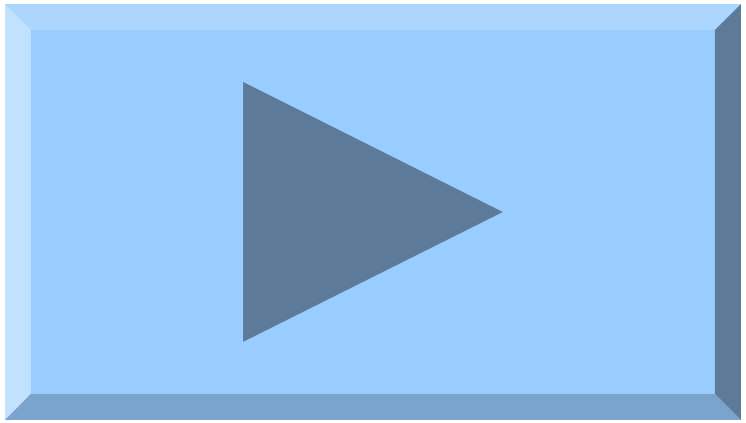
8. Grasping and Object Transport

- Build arm with gripper
- Understand grasp synthesis
- Pick up and transport objects



The Course Challenge

Integration
Localization
Richer Planning



The Grand Challenge

Mobile Agents

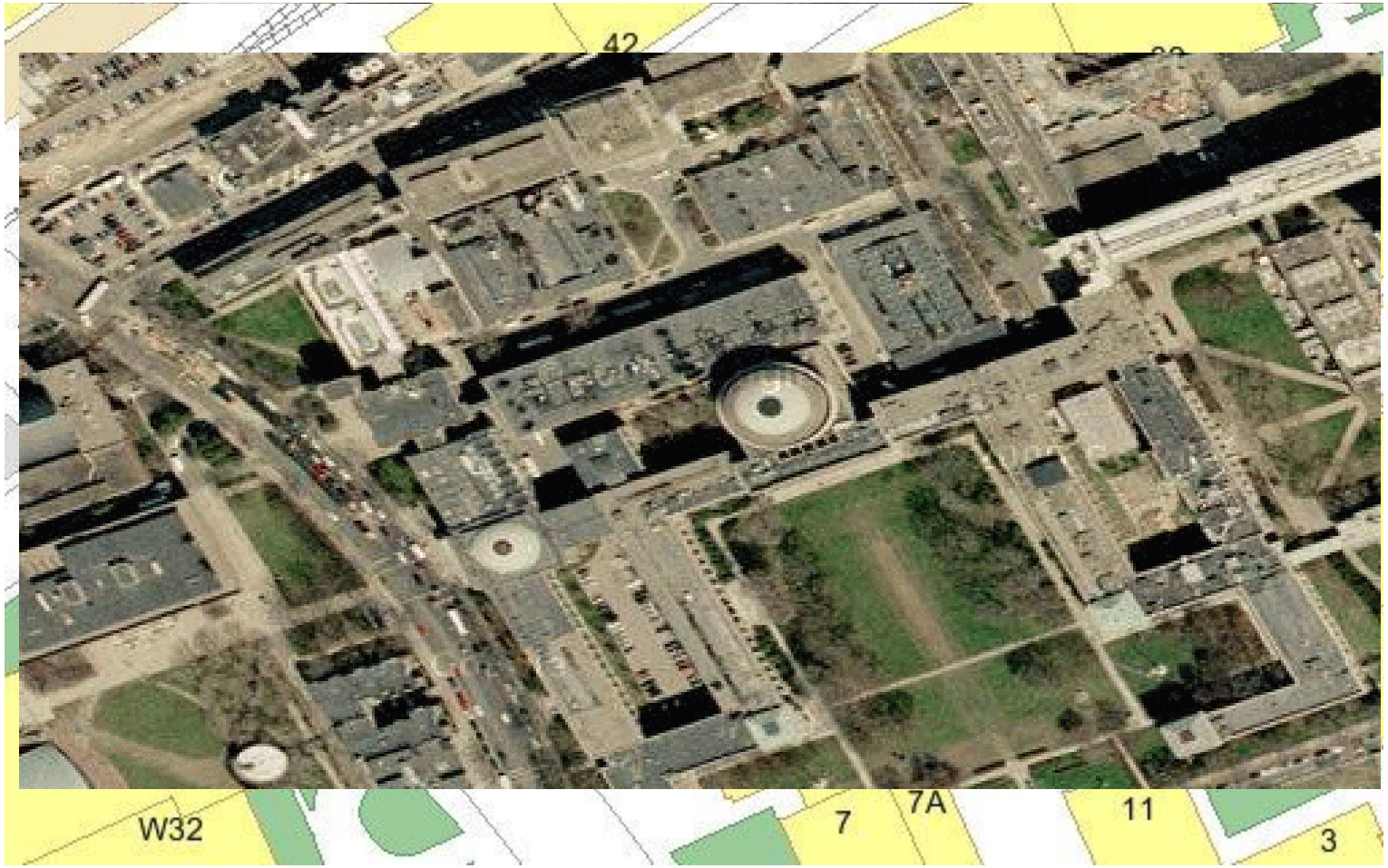
Images courtesy of B. William

Movie courtesy of S. Thrun

The Research Grand Challenge

Photo copyright MIT Alumni Association

Collect Building Materials

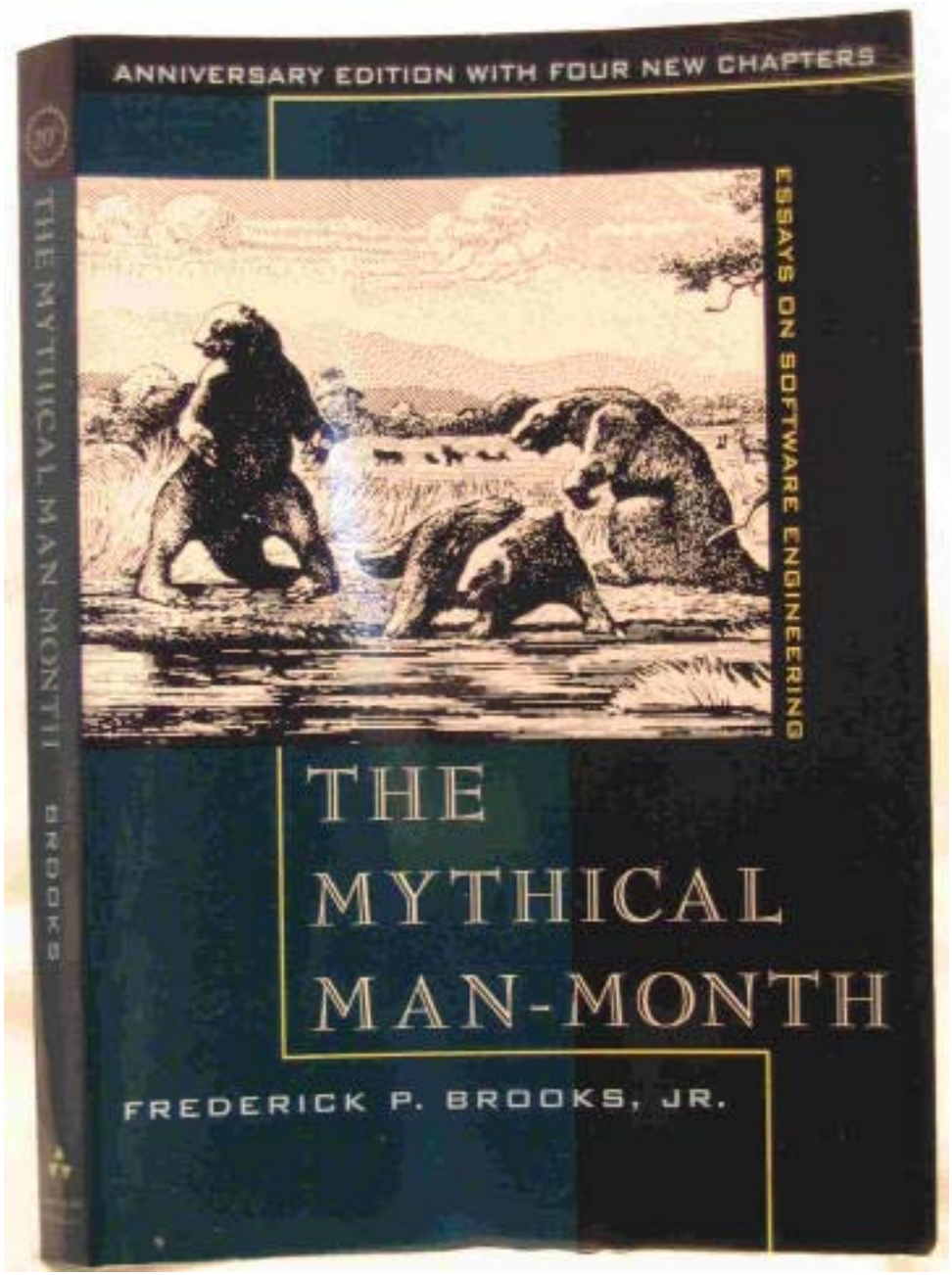


What you know how to do

- Local path planning
- Object detection and tracking
- Visual servoing
- Object grasping

Why is this Hard?

- How can we organize ourselves?


ANNIVERSARY EDITION WITH FOUR NEW CHAPTERS
ESSAYS ON SOFTWARE ENGINEERING
THE MYTHICAL MAN-MONTH
FREDERICK P. BROOKS, JR.
THE MYTHICAL MAN-MONTH
BROOKS

System Development

- 5 teams, each with a faculty advisor
- Each team chooses one research area
- One possible division of labour:
  - Planning
  - Control
  - Mapping and navigation
  - Manipulation
  - Vision

Development Timeline

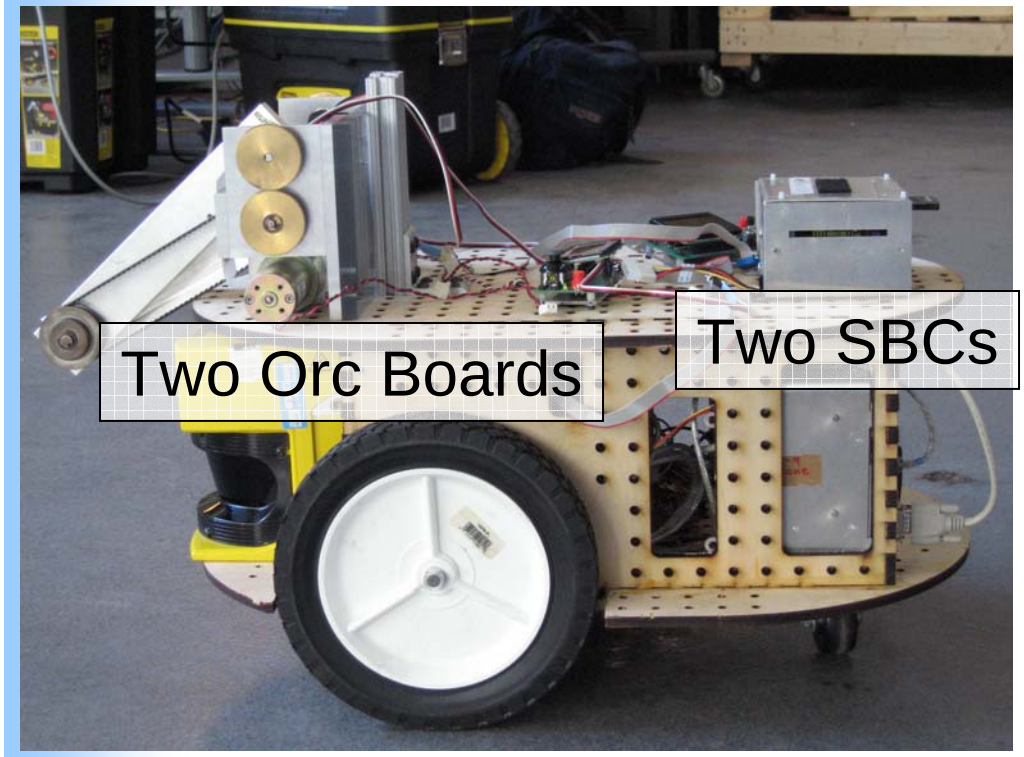
- Weeks 1-3: Recover your microbots, return to R:SS I functionality
- Weeks 3-6:
  - Decide on system architecture as a class
  - Design reviews
  - Each team proposes a Java API
  - October 17th: Interfaces and classes frozen
- Weeks 7-10:
  - Design reviews
  - Implement algorithm
  - November 1: Test integration
  - November 8: Test deployment
- Weeks 11-15
  - Debug, test, evaluate loop

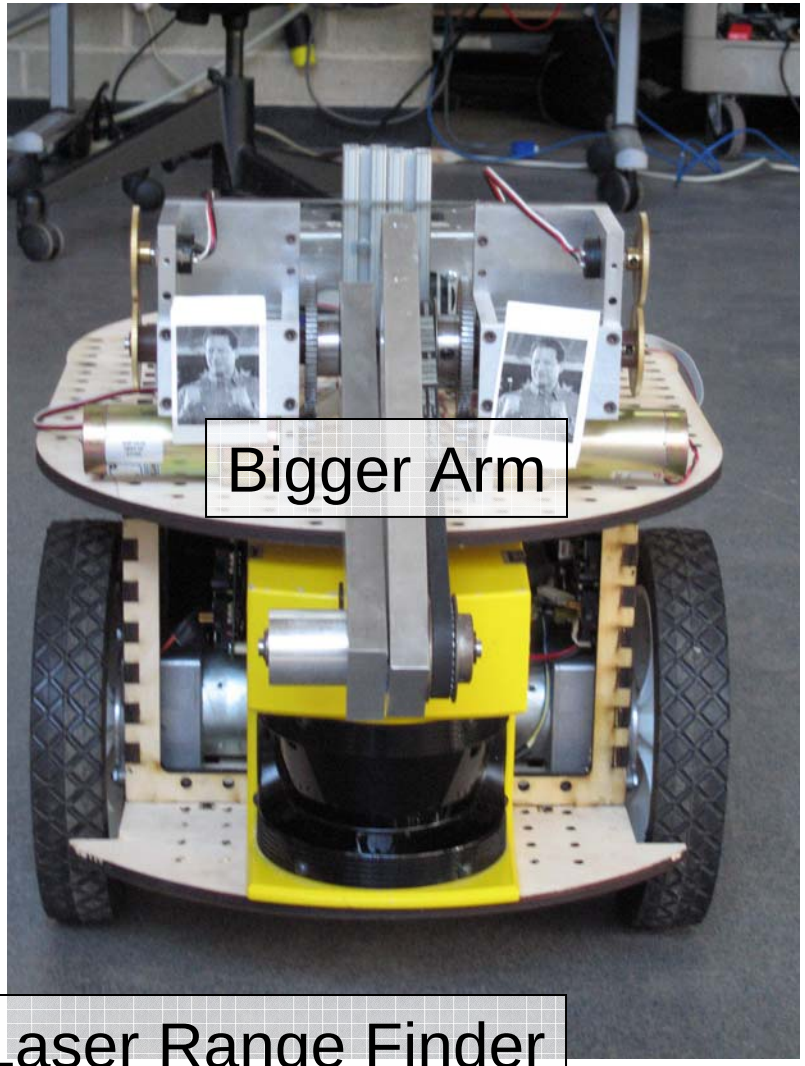
Why is this Hard?

- Where can the robots go?
- What can they sense?

- How can we organize ourselves?

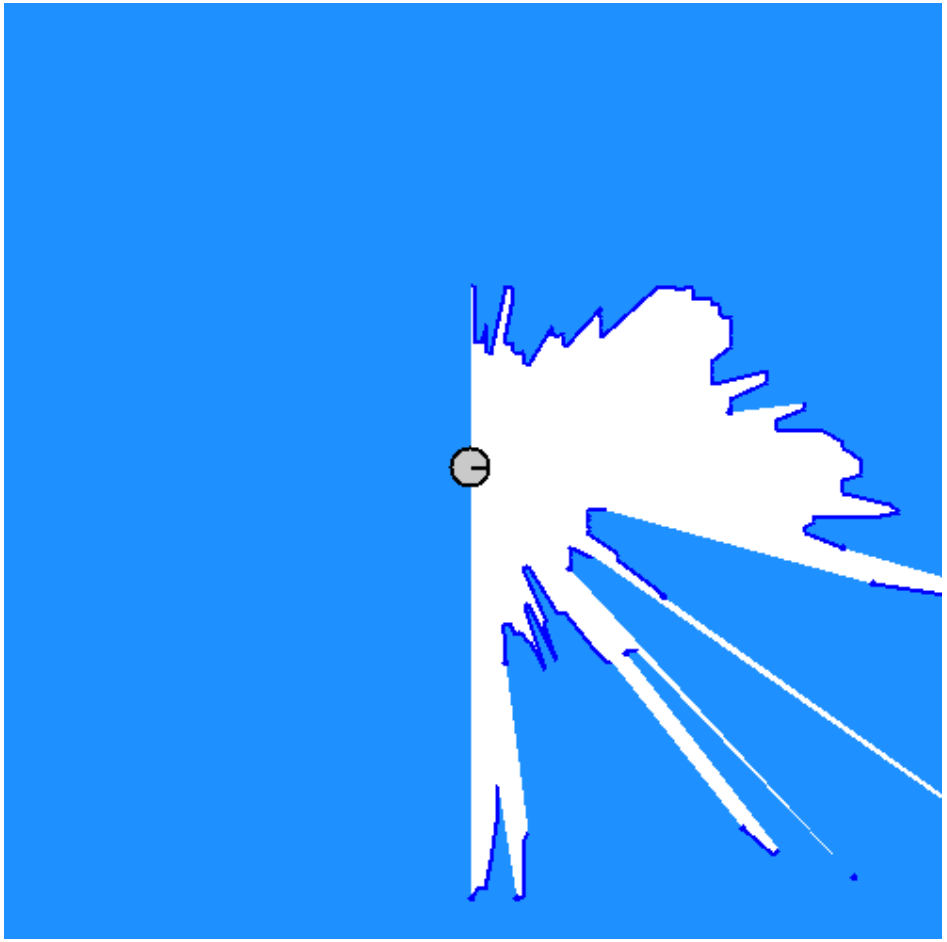
Splinter





Laser Range Finder

High precision, high accuracy range and bearing sensor



Why is this Hard?

- How can the robot localize?
- How can the robot plan?
- How can the robot construct a shelter?

- Where can the robots go?
- What can they sense?
- How can we organize ourselves?

Mapping and Navigation

- Map is incomplete for position tracking
- Map is not GPS-registered
- GPS has dead spots
- Map is (probably) wrong in many places

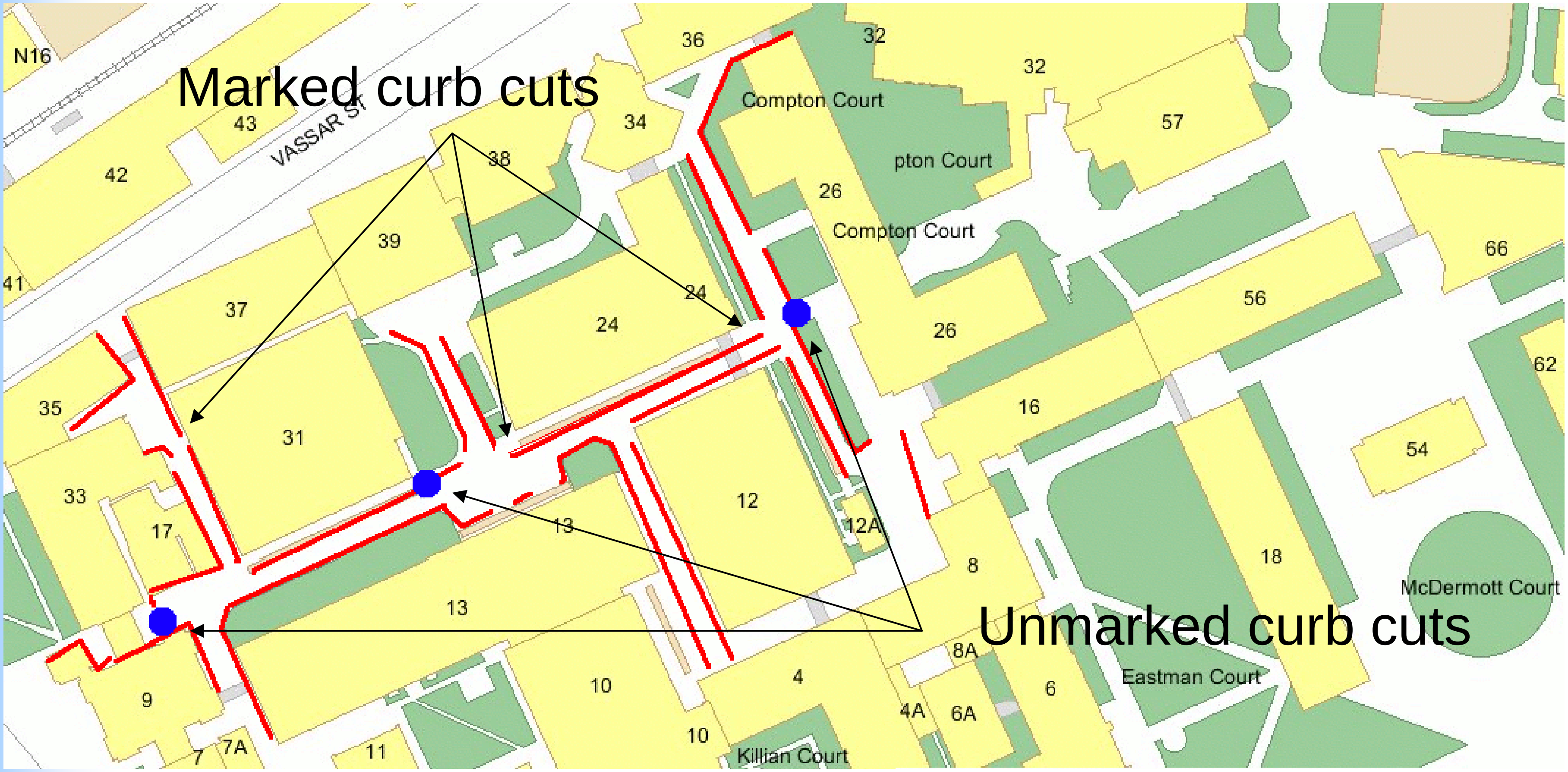
Large-scale Motion Planning

- Map is incomplete for position tracking
- Area of motion is large
- Map is 2-D
- World has dynamics

Vision-Based Object Detection, Tracking, Servoing

- Lots of kinds of objects (bricks, curbs, curb cuts, obstacles)
- Highly variable lighting conditions
- Need to register objects in visual field with map and estimated position

Curb Cuts


Marked curb cuts
Unmarked curb cuts
N16
43
VASSAR ST
42
41
36
32
32
34
38
Compton Court
pton Court
Compton Court
57
26
26
39
37
24
24
66
56
35
31
16
62
54
33
12
12A
17
13
13
8
18
McDermott Court
8A
9
10
4
6
Eastman Court
4A
6A
10
7
7A
11
Killian Court

Constructing with Intelligent Bricks

- Bricks cannot be picked up at any orientation
- Bricks must be placed precisely
- Bricks must be collected in order

Behaviour-Based Task Control

- Arbitration of:
  - Reactive obstacle avoidance
  - Reactive execution of high-level motion plan
  - Reactive execution of visual servoing
- Requires interaction with all other modules

Wireless Networking

- Last semester, networking was a major problem
- This year, we could use WiFi as part of the task
  - Localization via WiFi
  - Maps annotated with WiFi boundaries
  - Motion planning that minimizes a combination of path length and WiFi loss
- You must be robust to network problems. We will test this.

Self Evaluation

- Design review presentations
  - You **must** evaluate each other's designs!
- Test review presentations
  - You must know how each team is testing their code
  - You **must** suggest tests that show how your code will interact


...blah...blah...right-handed co-ordinate systems...
THE MYTHICAL MAN-MONTH
FREDERICK P. BROOKS, JR.
M.I.T.