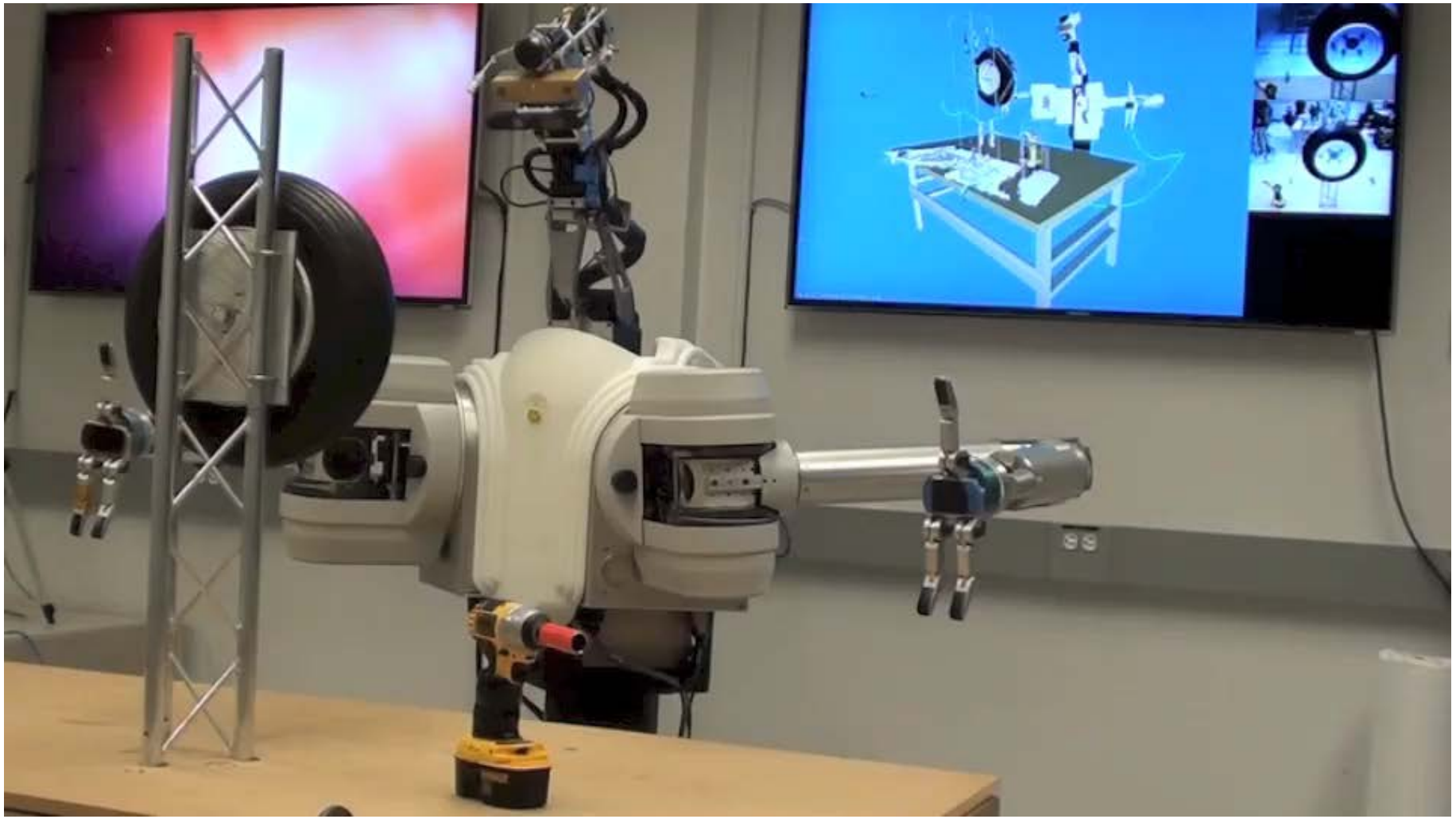
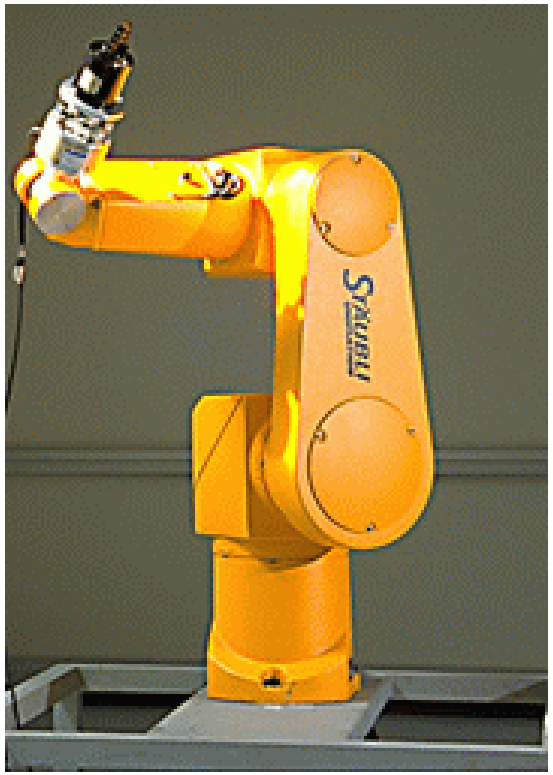
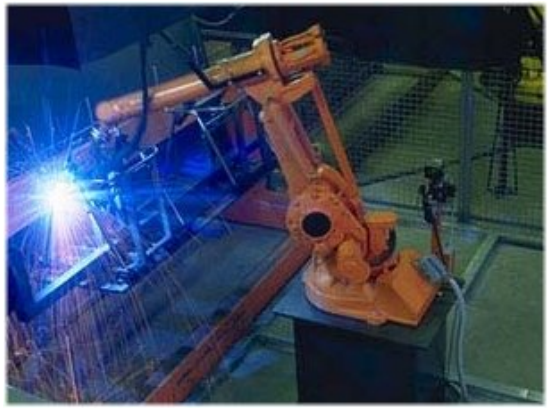
DARPA Autonomous Robot Manipulation

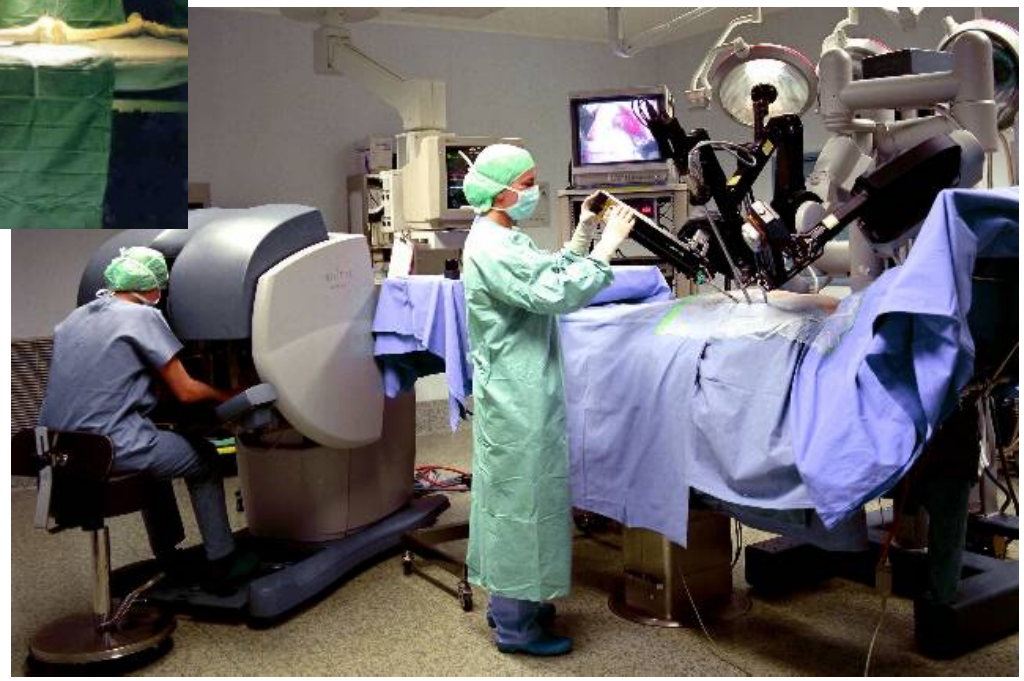



Staubli

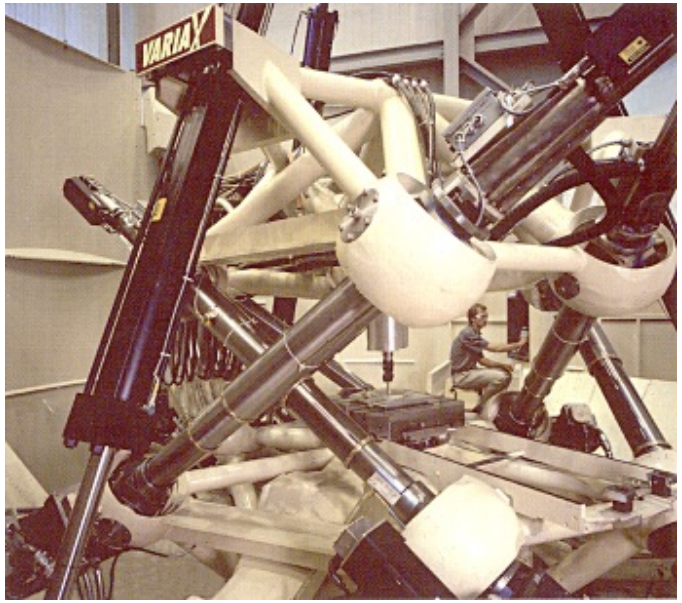


Computer Assisted Surgery

RoboDoc: Hip replacement assistant (accurate bone drilling)

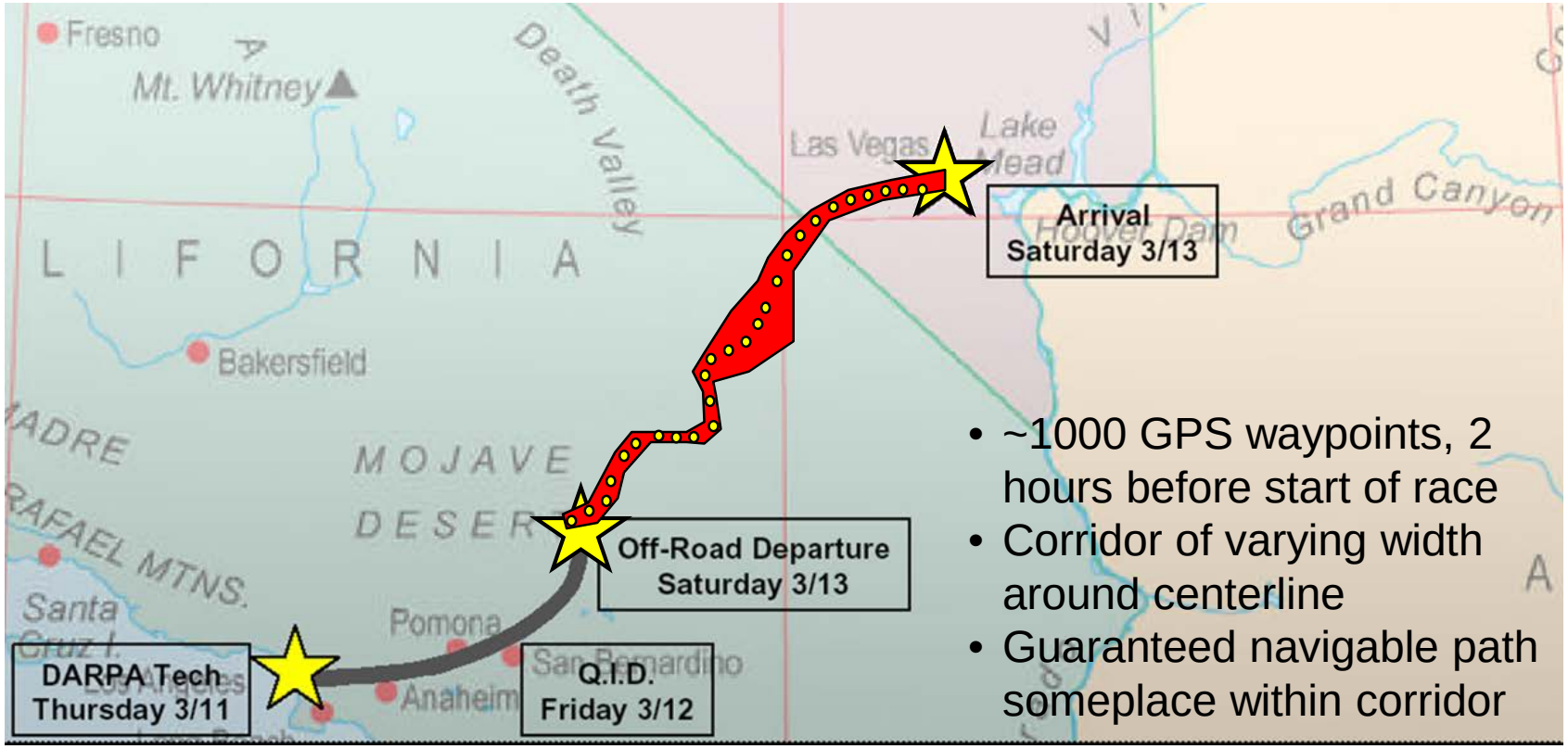


Intuitive Surgical: DaVinci heart surgery (minimally invasive)


VARIAX


METROM

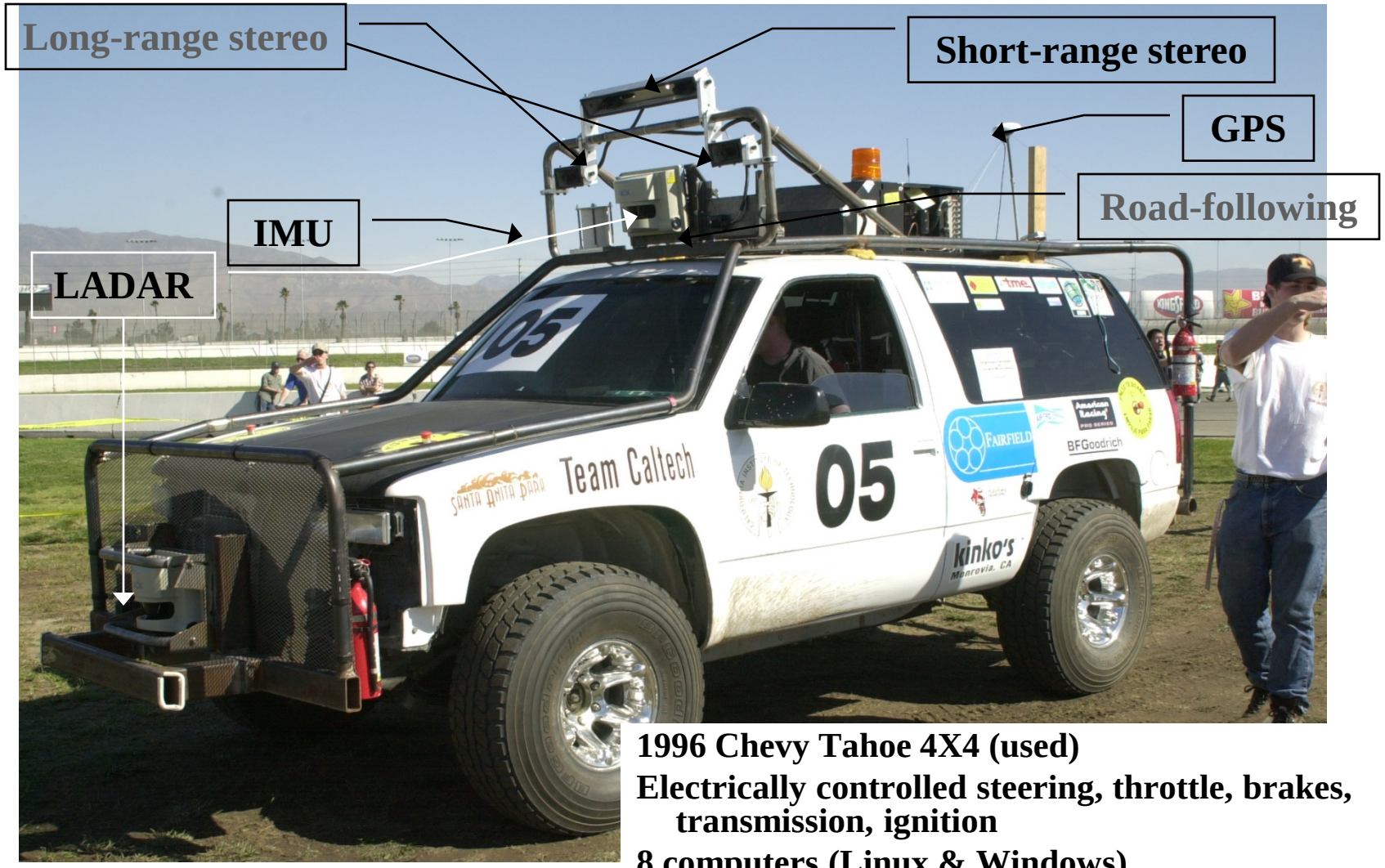
DARPA Grand Challenge #1: Los Angeles to Las Vegas in 10 Hours or Less, No Humans Allowed



- Vehicle must be completely autonomous; no remote control
- Vehicle must be able to avoid obstacles, including other vehicles.
- First vehicle to reach Las Vegas (~250 miles) in <10 hours wins **$1M**

“Bob” & Team Caltech

(organized by Prof. Richard Murray)



1996 Chevy Tahoe 4X4 (used)

Electrically controlled steering, throttle, brakes, transmission, ignition

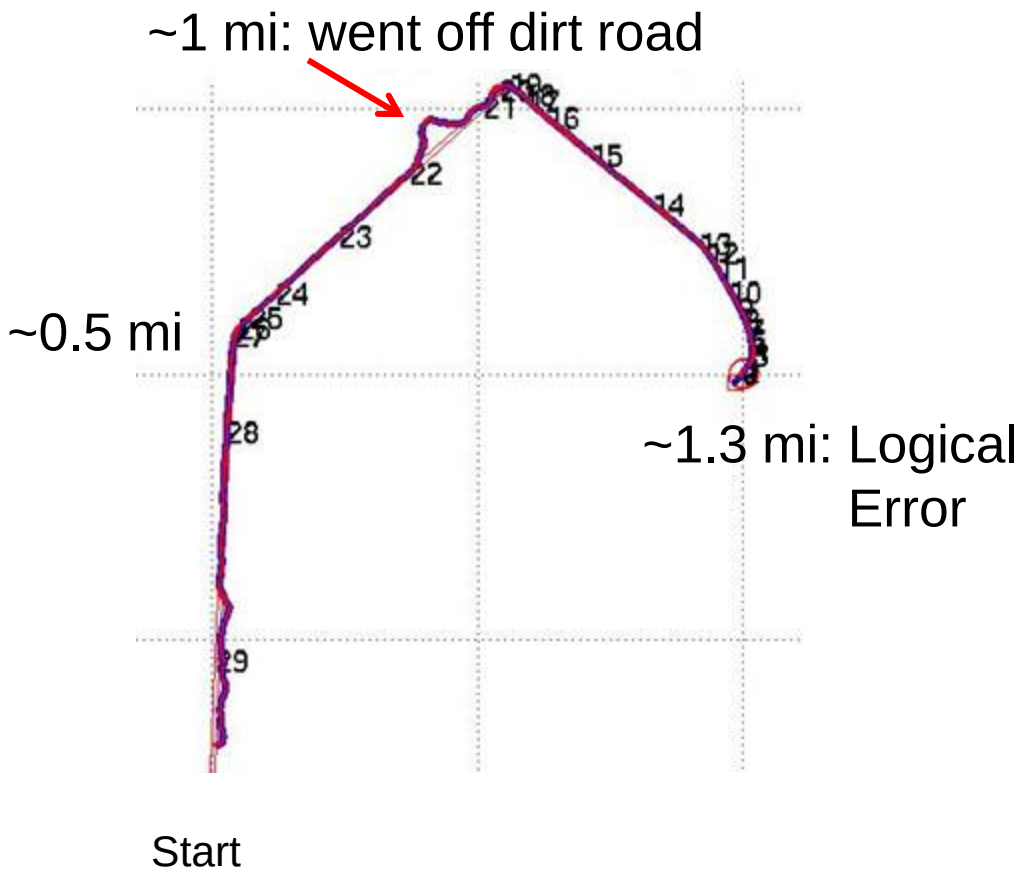
8 computers (Linux & Windows)

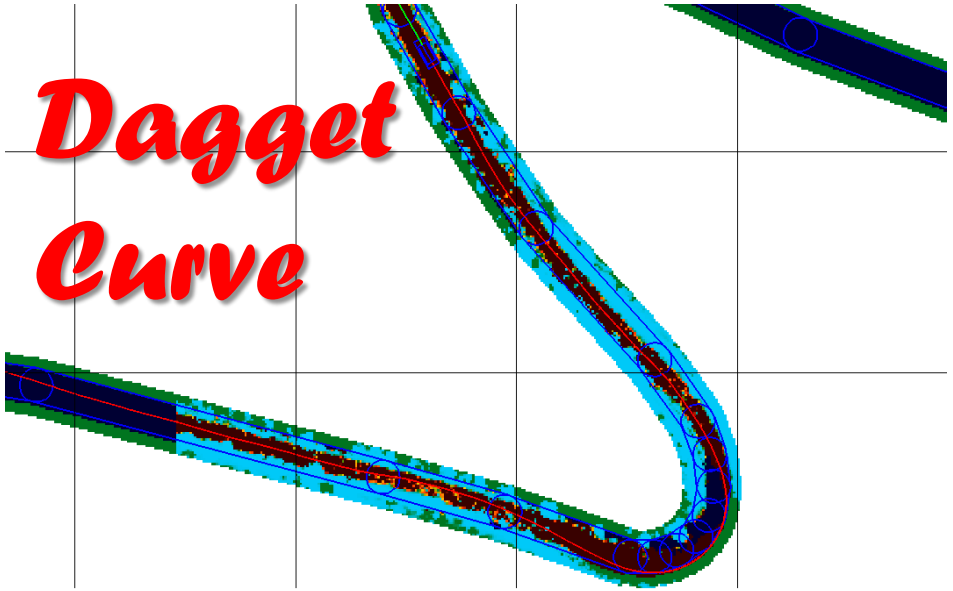
30 Sensors

$500K, > 20,000 person-hours (25-55 undergrads)

Inside Bob

Team Caltech: Race Results



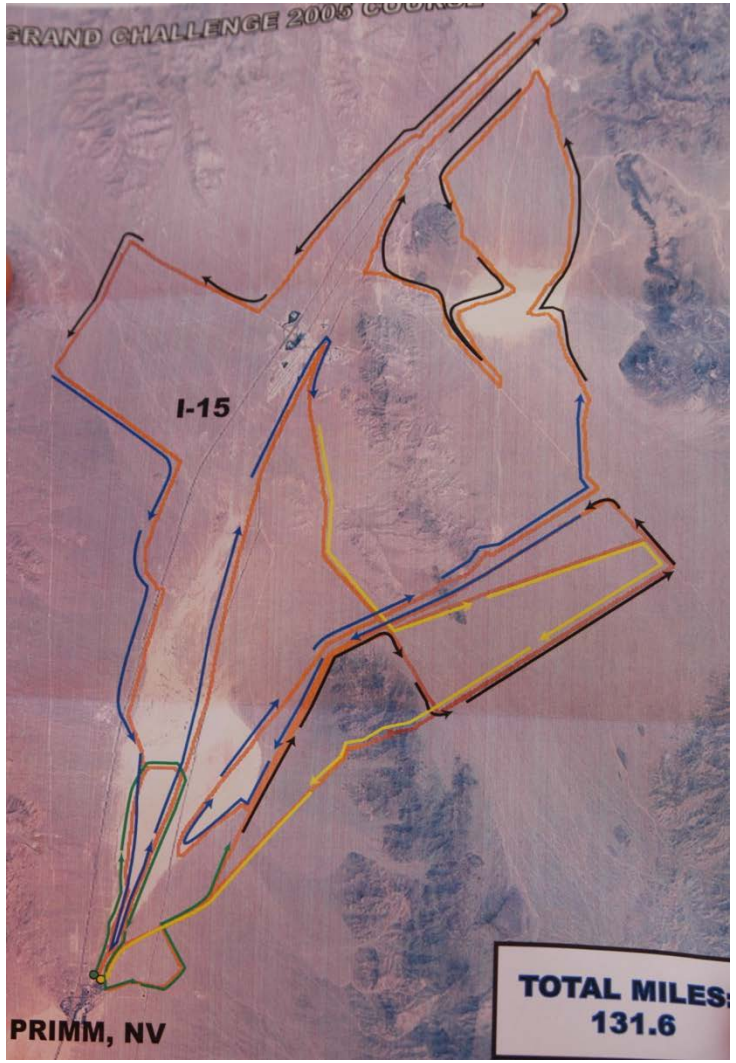


Results:

- 15 teams deemed “safe”
- Caltech placed 5th
- Caltech alums Golem Group placed 4th
- No team covered more than 5% of the distance
- Many important lessons

- A ***PR DISASTER*** for DARPA

DARPA Grand Challenge #2: The Mulligan



Race Day: 8 October 2005

- 198 teams submitted application video
- 118 teams selected for site visit
- 43 teams selected for qualifying event
- 21 qualified for final race
  - Team Caltech in 19th start
  - New Vehicle “Alice”

Alice Overview

Team Caltech

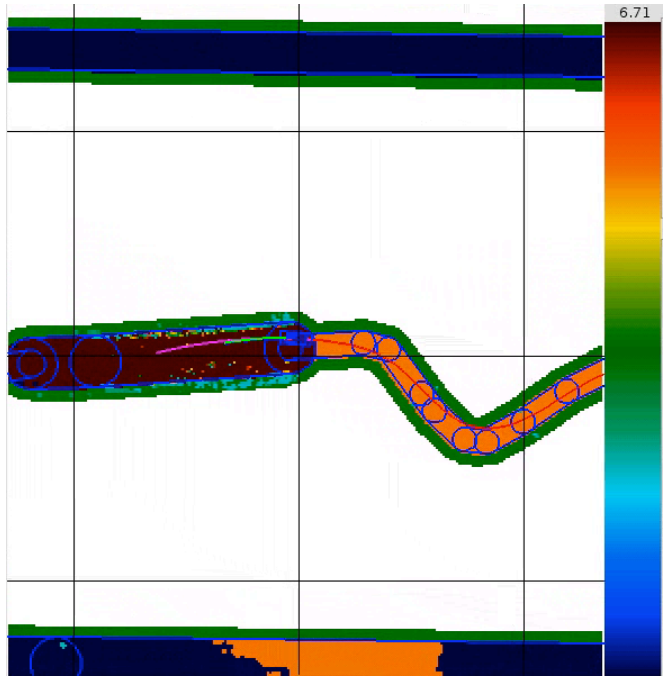
- 50 students worked on Alice over 1 year
- Course credit through CS/EE/ME 75
- Summer team: 20 SURFs + 10 others

Alice

- 2005 Ford E-350 Van
- Sportsmobile 4x4 offroad package
- 5 cameras: 2 stereo pairs + roadfinding
- 5 LADAR : long, medium*2, short, bumper
- 2 GPS units + 1 IMU (LN 200)
- 6 Dell 750 PowerEdge Servers
- 1 IBM Quad Core AMD64 (fast!)
- 1 Gb/s switched ethernet

Software

- 15 programs with ~50 execution threads
- FusionMapper: integrate all sensor data into a speed map for planning
- PlannerModule: optimization-based planning over a 10-20 second horizon



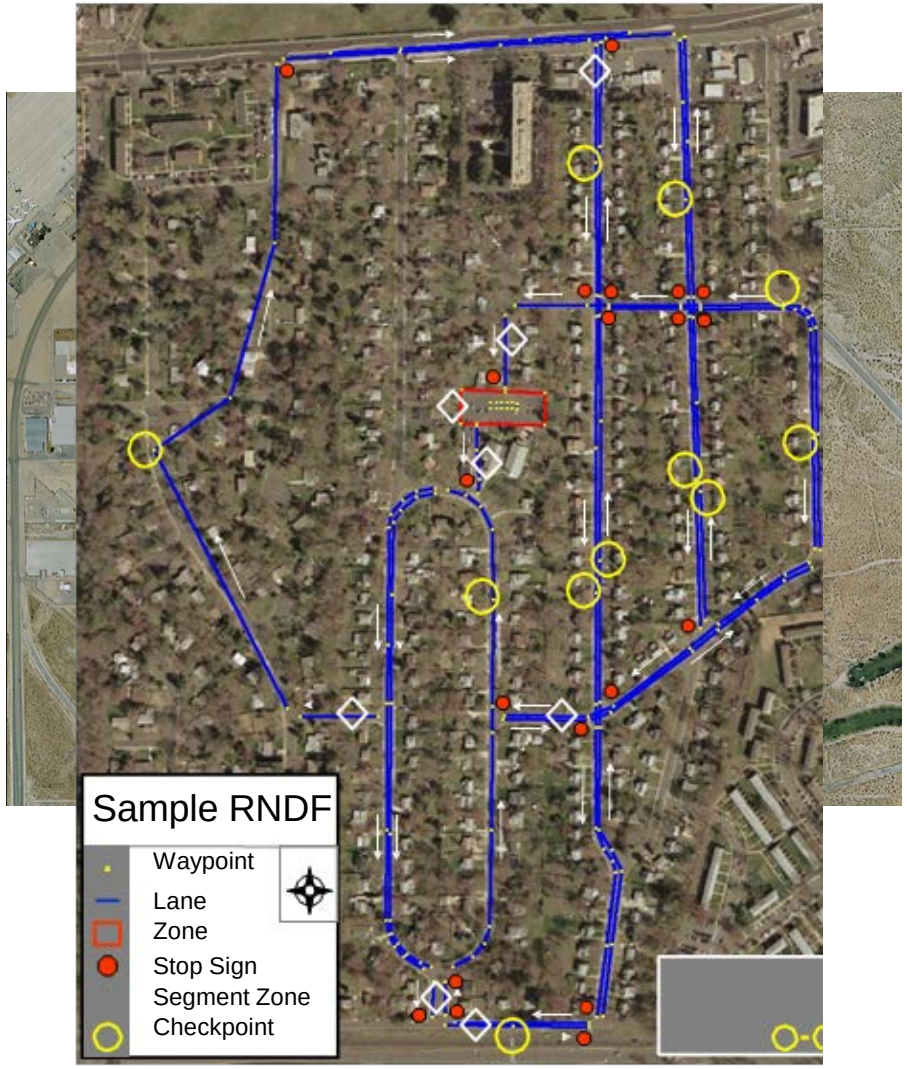
Alice’s Media Debut

Alice’s Media Debut

Slashdot | DARPA GC Updates, 8 Oct 05. 2:45 pm

Most interesting one so far is … Caltech's Alice

DARPA Grand Challenge #3: The Urban Challenge

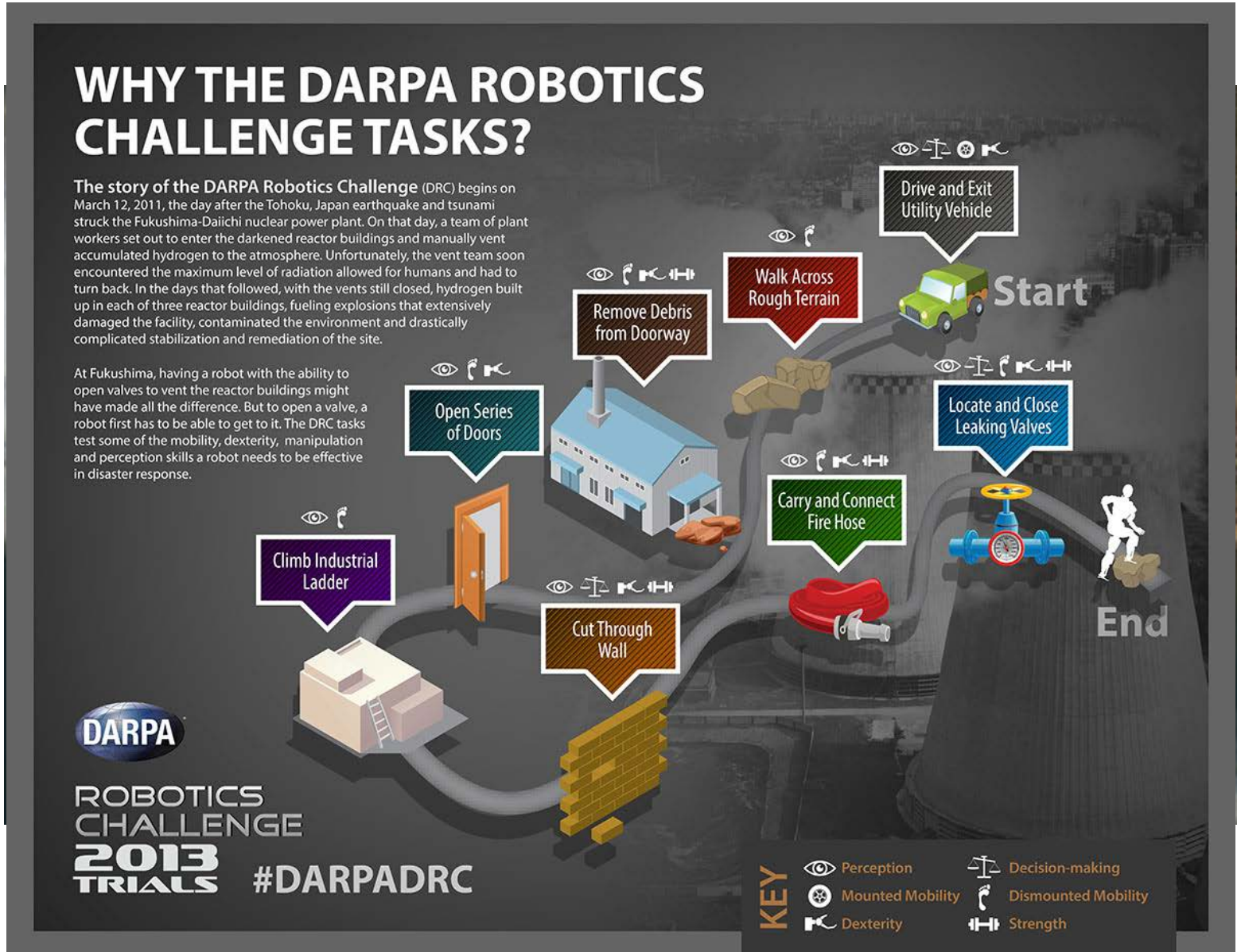


Autonomous Urban Driving

- Mock “city” in old air base
- 60 mile course in < 6 hours
- City streets, intersections
- Obey traffic rules with other robot cars and human operated cars)
- Pull around stopped vehicles
- Navigate in parking lots (with cars)
- U-turns, traffic merges, replanning
- **Prizes: $2M, $1M, $500K**

- 12 Teams given $1M budget

The DARPA Robotics Challenge (DRC)
(www.theroboticschallenge.org)



The DARPA Robotics Challenge (DRC)
(www.theroboticschallenge.org)

The DARPA Robotics Challenge (DRC)
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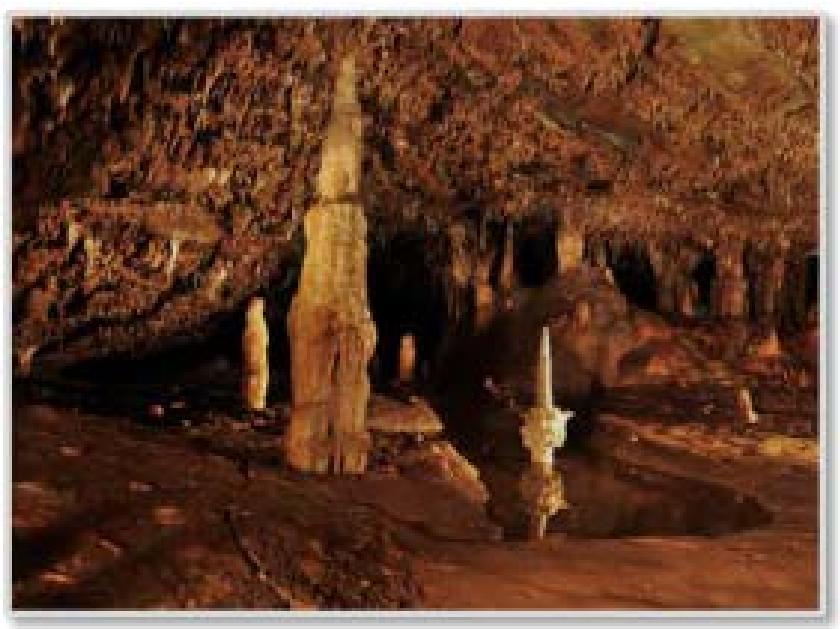
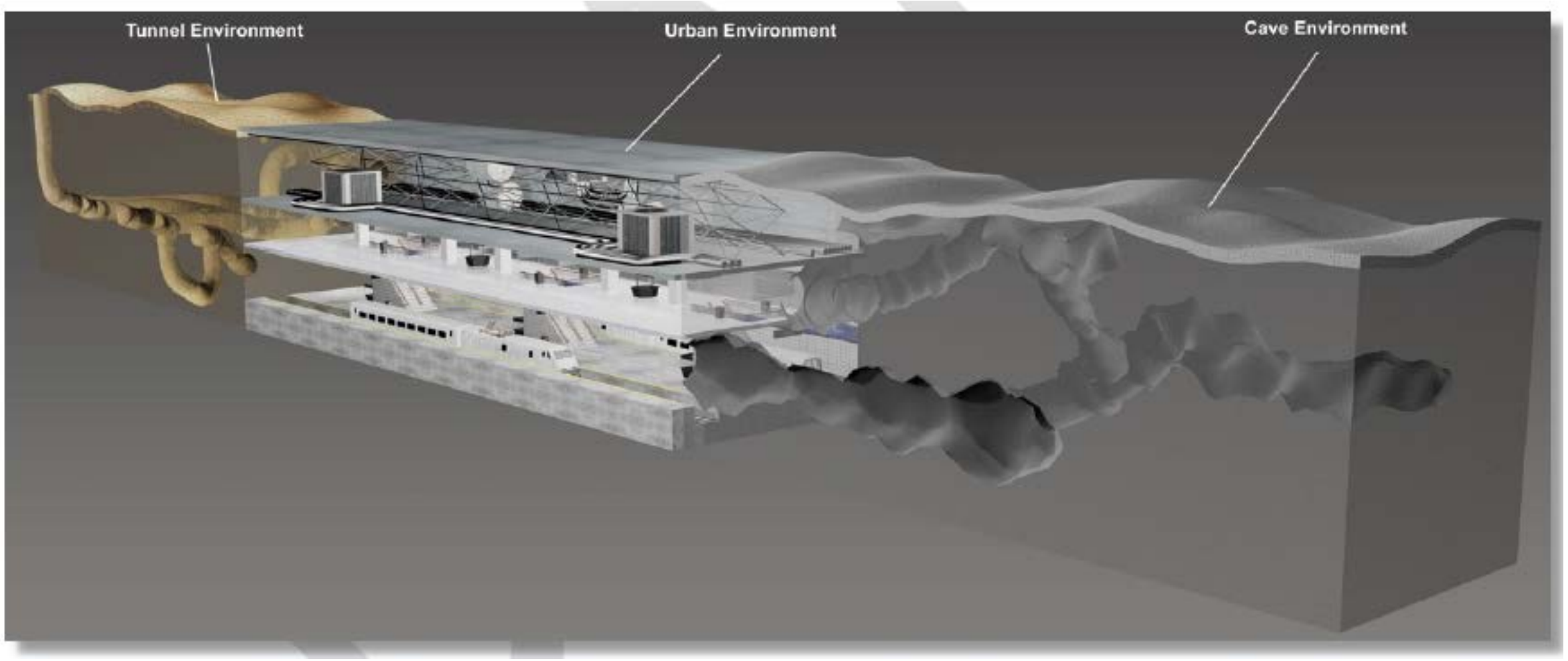
Brief review of DARPA Subterranean Challenge

3 environments



Final event



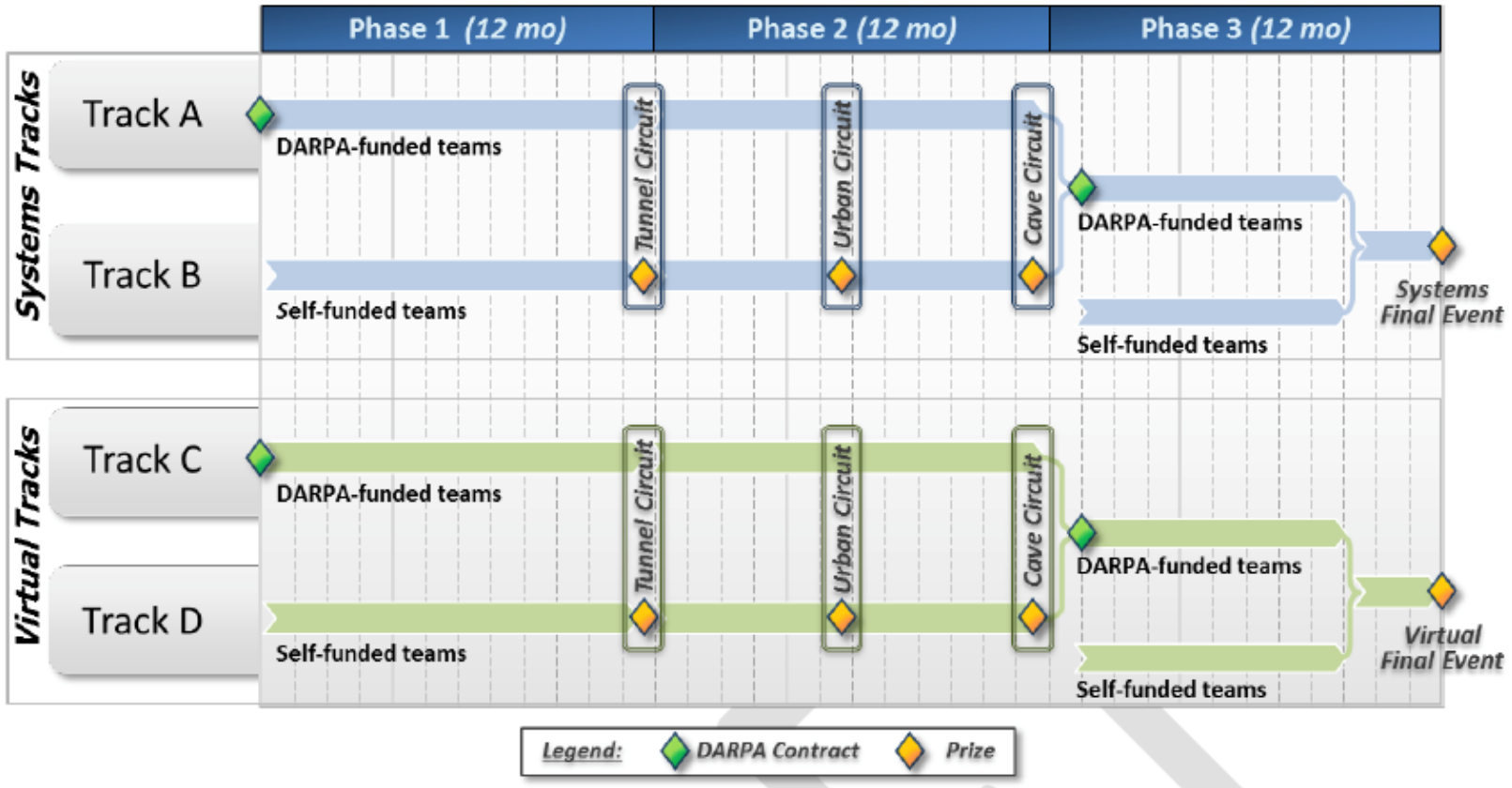
Scoring/metrics

- Positive
  - Complete the mission
  - Map the environment (10cm resolution)
  - Geo-locate objects (1m error in 1Km)
  - Network latency (1s per 500m path length)
  - Endurance (4 hours is ideal)
- Negative
  - Human intervention

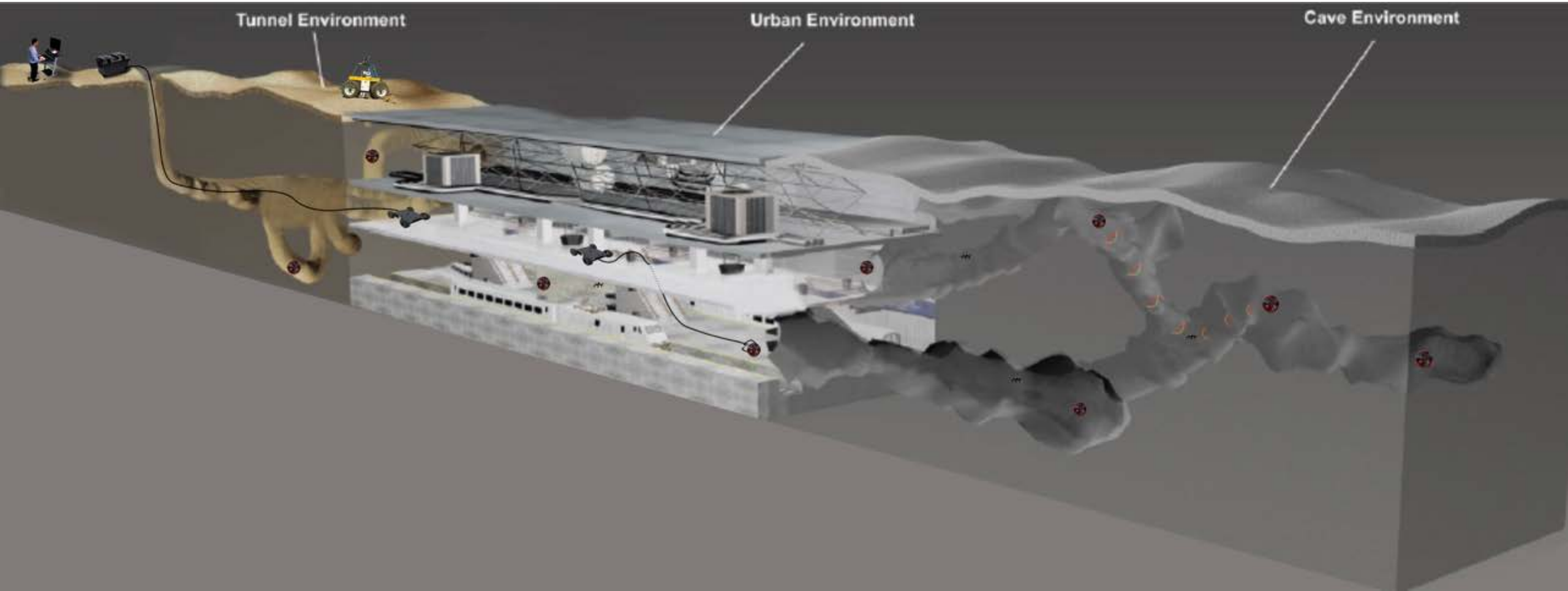
Rules/details

- Entrance/exit is known
- No humans can enter the tunnel
- One human operator. But, with very high penalty
- No manipulation is required
- The length of tunnel, size of obstacles will be announced ahead of the competition.
- Narrow passages: different sizes – minimum human crawlable
  - Hvac vents
  - Storm drain

Timeline

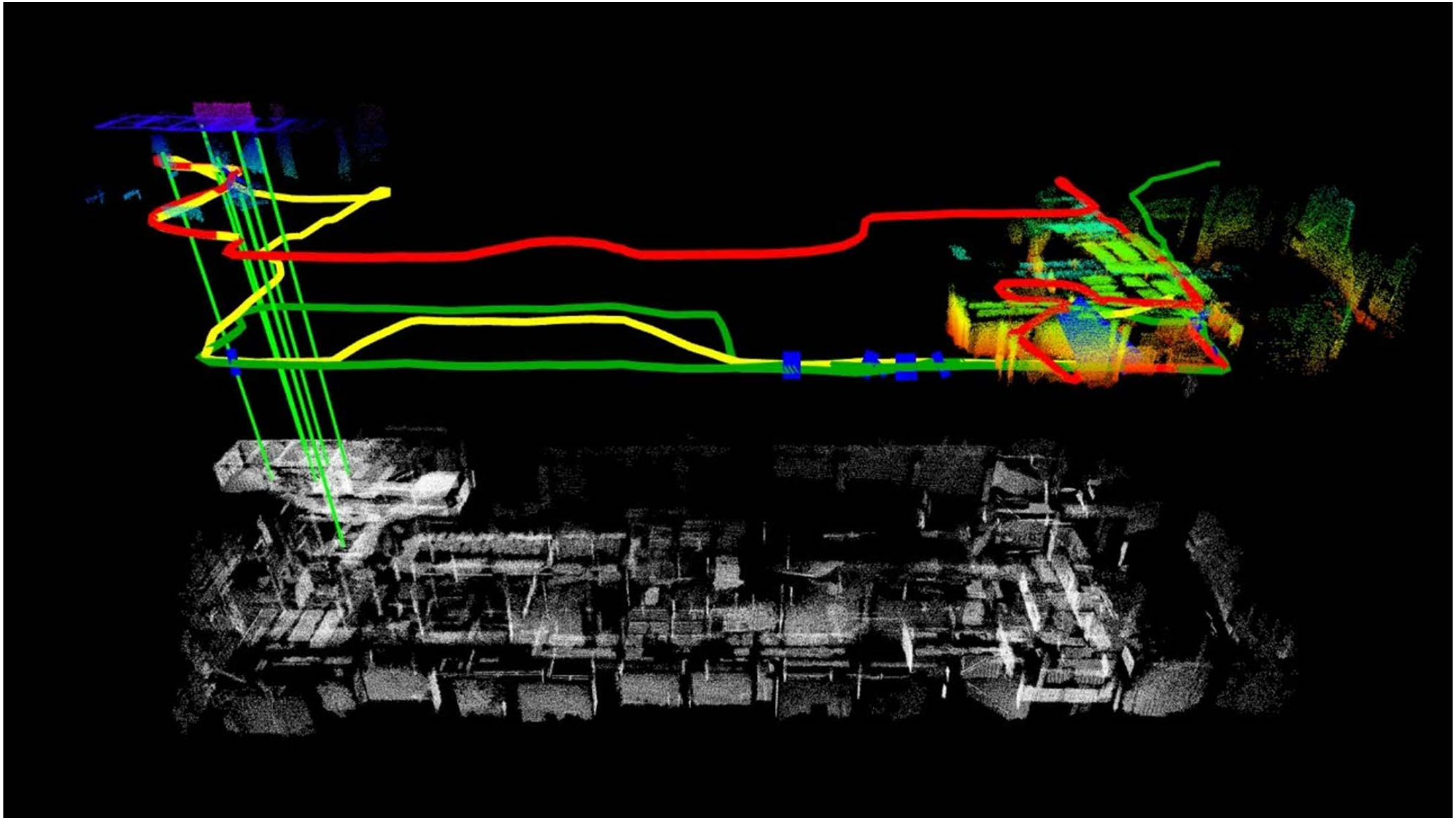

Phase 1 (12 mo)
Phase 2 (12 mo)
Phase 3 (12 mo)
Systems Tracks
Track A
DARPA-funded teams
Track B
Self-funded teams
Tunnel Circuit
Urban Circuit
Cave Circuit
DARPA-funded teams
Self-funded teams
Systems Final Event
Virtual Tracks
Track C
DARPA-funded teams
Track D
Self-funded teams
Tunnel Circuit
Urban Circuit
Cave Circuit
DARPA-funded teams
Self-funded teams
Virtual Final Event
Legend:
DARPA Contract
Prize

Illustrative asset distribution



HyTAQ & Rollocopter

- Hybrid Terrestrial and Aerial vehicle



Heavy payload mobility systems

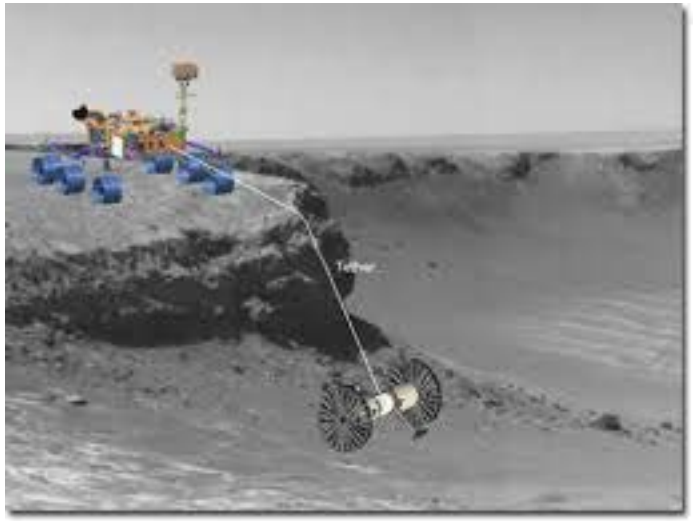
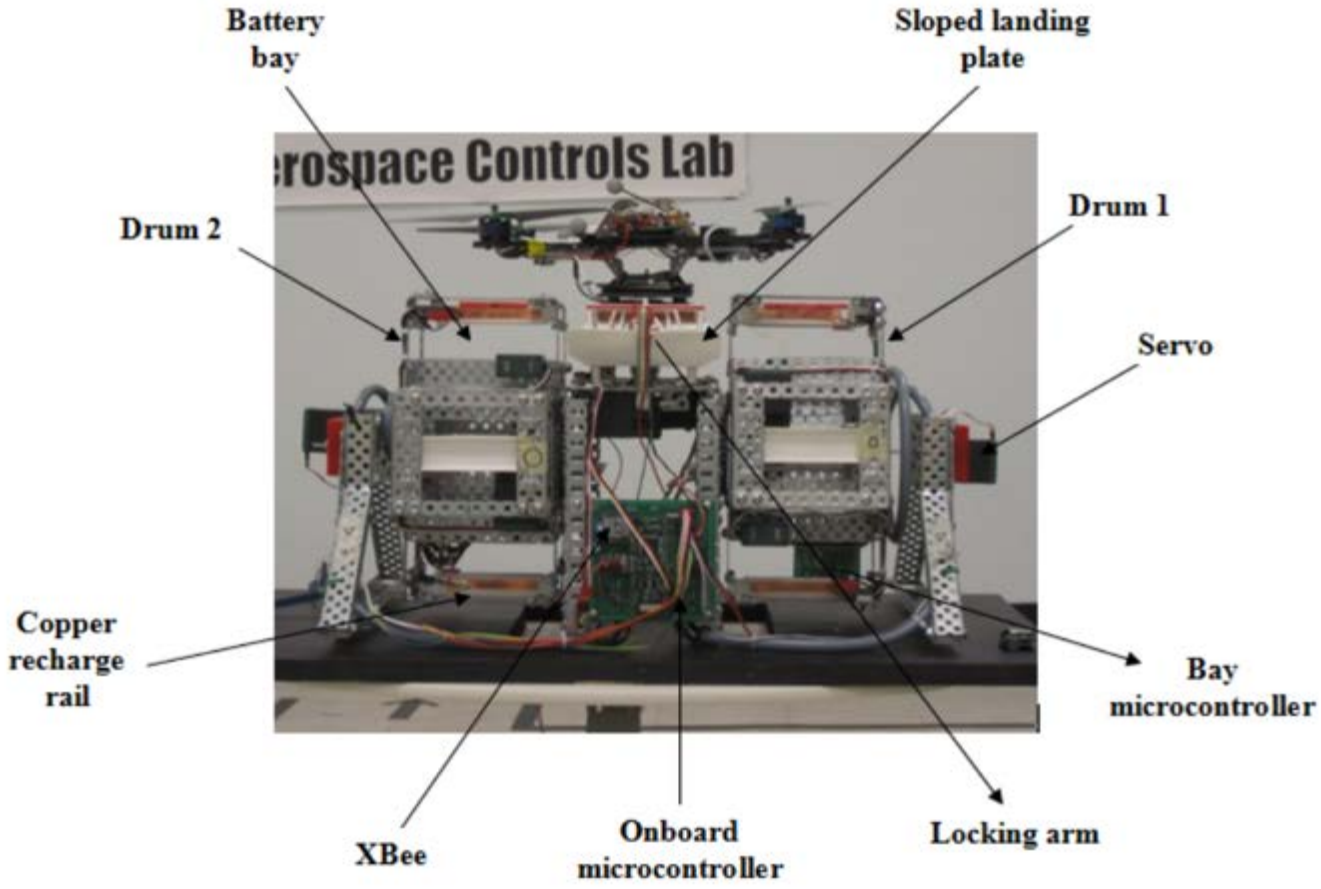


Figure 143: Rock Crawler mobility platform ascending and descending piles of different material types (pea gravel, 1-inch limestone, pea river rock, 3-inch river rock).

Battery swap/ recharging technology



Interest in CS/EE/ME75 ?

CS/EE/ME 75 abc. Multidisciplinary Systems Engineering. *3 units (2-0-1), 6 units (2-0-4), or 9 units (2-0-7) first term; 6 units (2-3-1), 9 units (2-6-1), or 12 units (2-9-1) second and third terms; units according to project selected.* This course presents the fundamentals of modern multidisciplinary systems engineering in the context of a substantial design project. Students from a variety of disciplines will conceive, design, implement, and operate a system involving electrical, information, and mechanical engineering components. Specific tools will be provided for setting project goals and objectives, managing interfaces between component subsystems, working in design teams, and tracking progress against tasks. Students will be expected to apply knowledge from other courses at Caltech in designing and implementing specific subsystems. During the first two terms of the course, students will attend project meetings and learn some basic tools for project design, while taking courses in CS, EE, and ME that are related to the course project. During the third term, the entire team will build, document, and demonstrate the course design project, which will differ from year to year. Freshmen must receive permission from the lead instructor to enroll. Instructor: ***Not offered 2018–19.***

Interest in CS/EE/ME75 ?

Tentative Schedule

- 3 hours/week of lecture (MWF 3-4 pm) + labs
- 1 hour/week of lecture (try to be contiguous with one meeting) + team project meetings