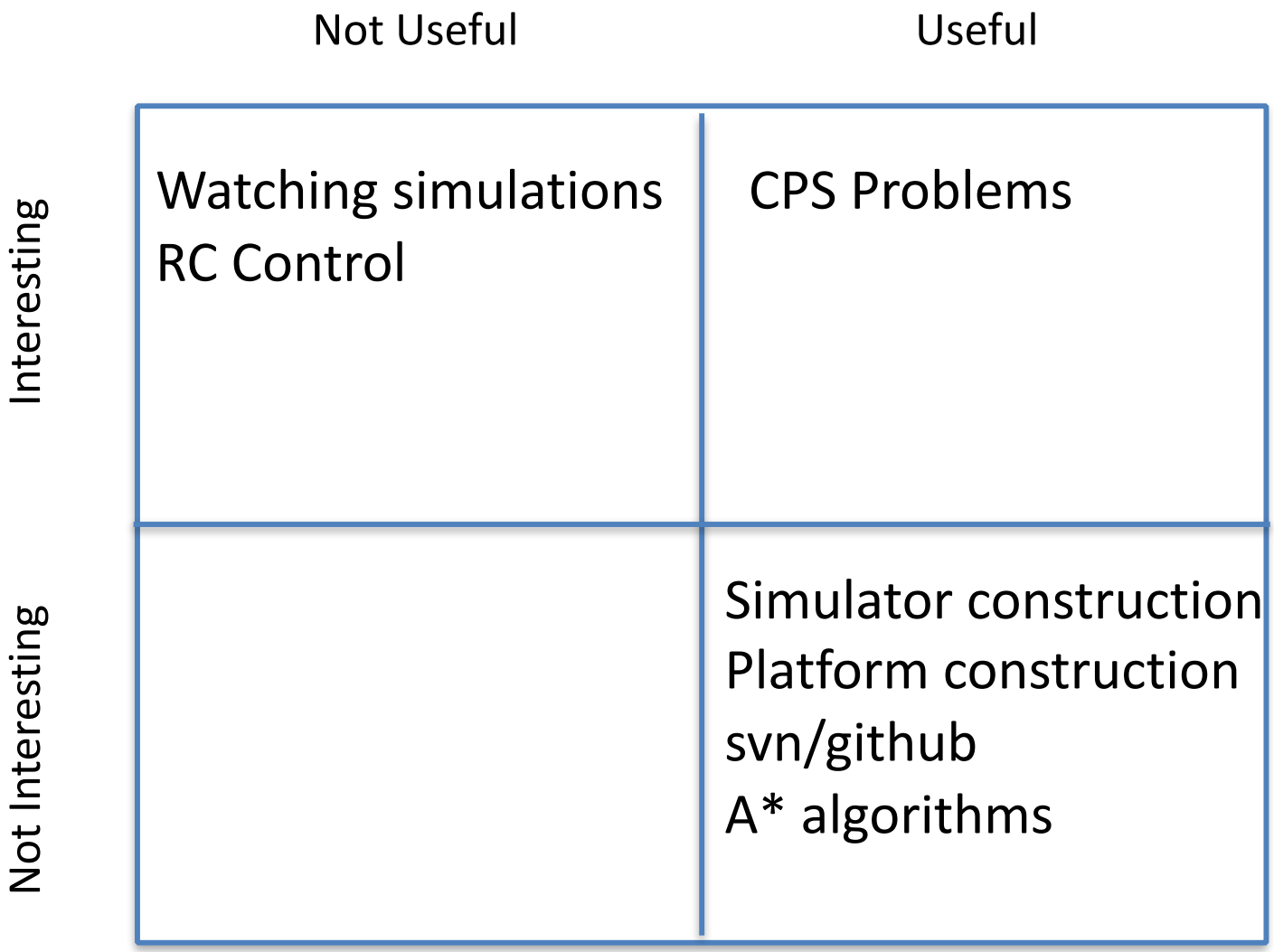
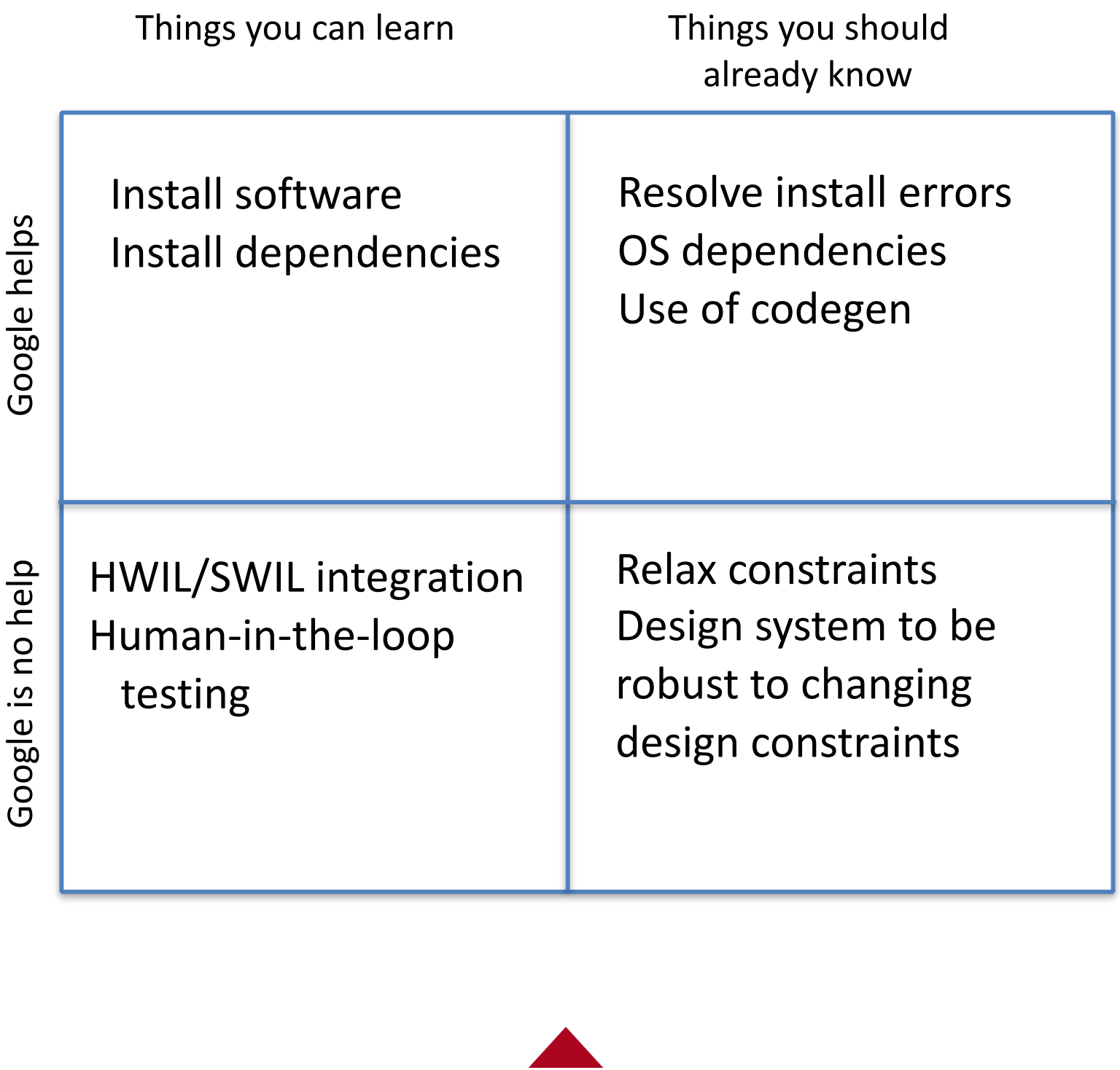
Student Competitions in CPS: A Template

Jonathan Sprinkle
University of Arizona


Not Useful
Useful
Interesting
Not Interesting
Watching simulations
RC Control
CPS Problems
Simulator construction
Platform construction
svn/github
A* algorithms


Things you can learn
Things you should already know
Google helps
Google is no help
Install software
Install dependencies
Resolve install errors
OS dependencies
Use of codegen
HWIL/SWIL integration
Human-in-the-loop testing
Relax constraints
Design system to be robust to changing design constraints

CPS-VO Online Design Competition

Home
Wiki
Activity Stream
Calendar
Members
Search
Forums
Files

COLLABORATE

- Create Bibliographic Reference
- Create Event
- Upload File
- Create Forum Topic
- Create News Item

These challenges will provide engineering students the opportunity to validate their analytic studies through a real-world vehicle design and verification experience.

Student teams will architect, design, fabricate, predict, and demonstrate the flying and maneuvering capabilities of an unmanned, electric and/or non-electric powered, radio controlled or autonomous vehicle that can best meet the specified mission profile. The goal is a balanced design possessing good demonstrated qualities both with a payload and without, with reliable pickup/dropoff of payload, practical and affordable manufacturing requirements, and high overall vehicle performance.

Recent News

Updated Virtual Machine
The SITL multicopter simultation virtual machine referenced in the... more

CPS-VO Space for Students
The newly minted competition collaboration space is ready for review/... more

more ▶

Recent Forum Topics

Simulation Outputs
distance clarification for system mission 1
Map format
Individual mosquito trap coverage
Bullet M2 interface with UAV
issue connecting to UAV via telemetry module
Issue with Pixhawk output to ESCs
Would a human be able to access the UAV after a trap is dropped off?
Are we supposed to drop and then pick up the trap at a waypoint?
NUC WiFi and Bluetooth

Upcoming Events

04/12/16
CS3892-02

04/14/16
CS3892-02

04/19/16
CS3892-02

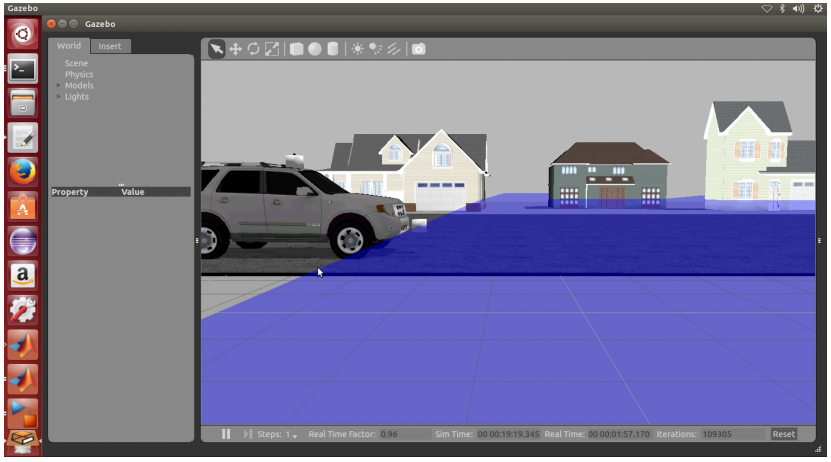
04/21/16
CS3892-02

more ▶

Feedback

Anatomy of a CPS-VO Competition

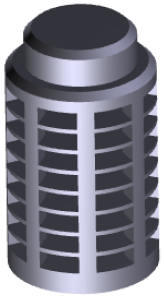
- Necessary: common testing framework—simulators and tools
- Necessary: common hardware framework to reduce design space exploration and debugging
- Goal: support different team sizes/scales
  - Challenges should have hooks, with optional involvement
- Goal: support long/short course involvement
  - Challenges should support refinement over a longer term
- Goal: enable transformative experiences for participants
  - Final meetup with external sponsorship for qualified teams



CPS-VO Student Competition 2016

Sponsored by

Microsoft

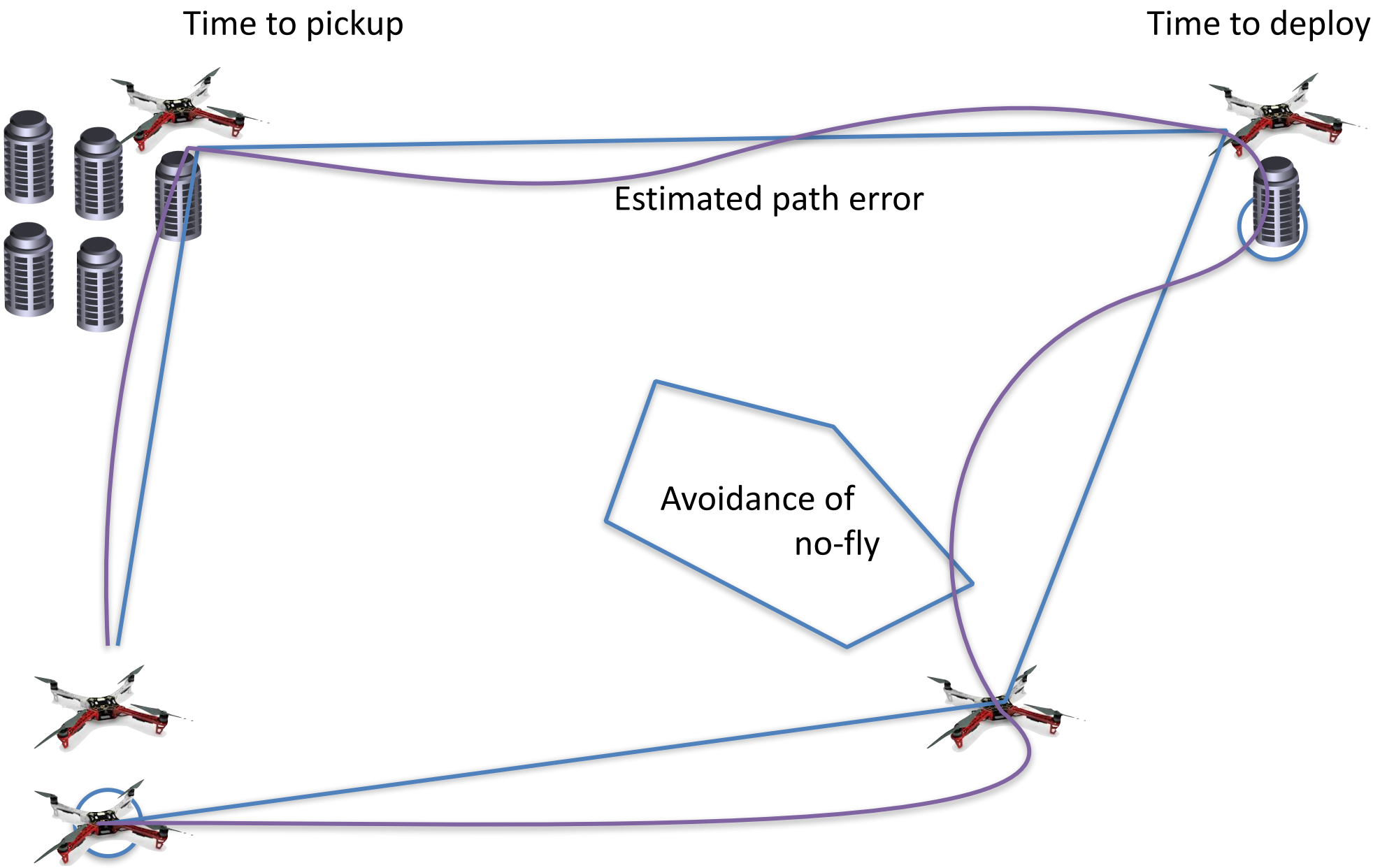


Ucla

VANDERBILT

ARIZONA

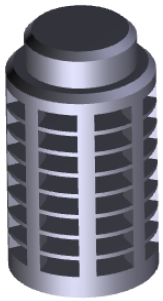
LEGES SINE MORIBUS VANAE



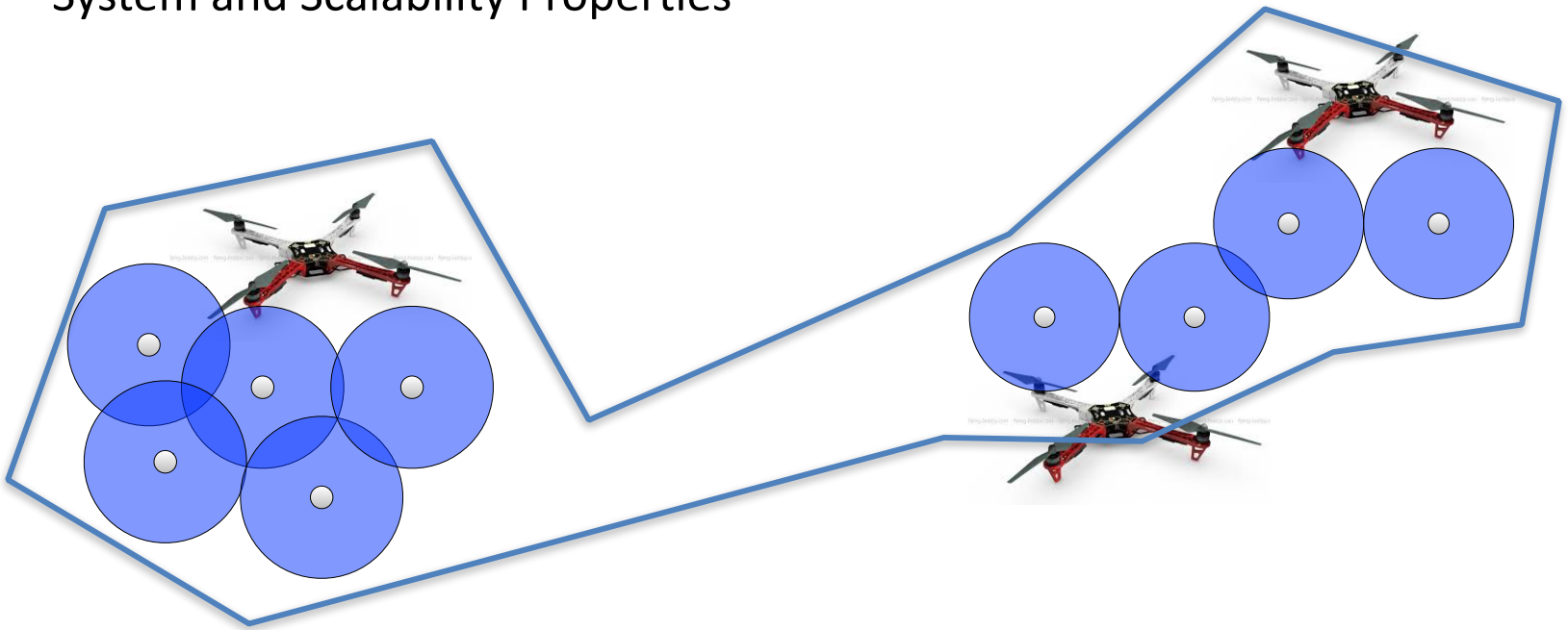
How much time do you require human control?

Platform Design and Implementation

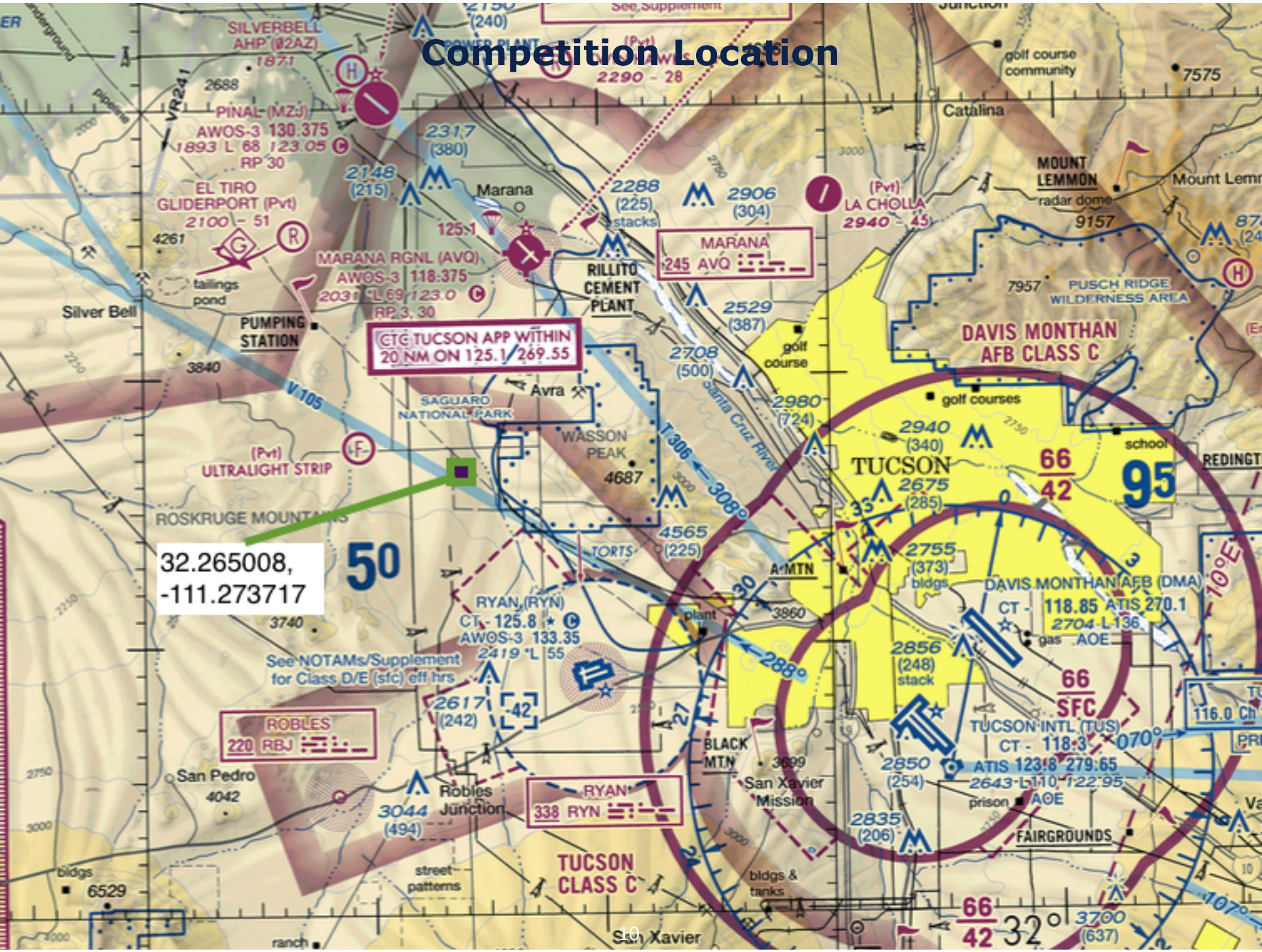
Trap pickup/dropoff mechanisms



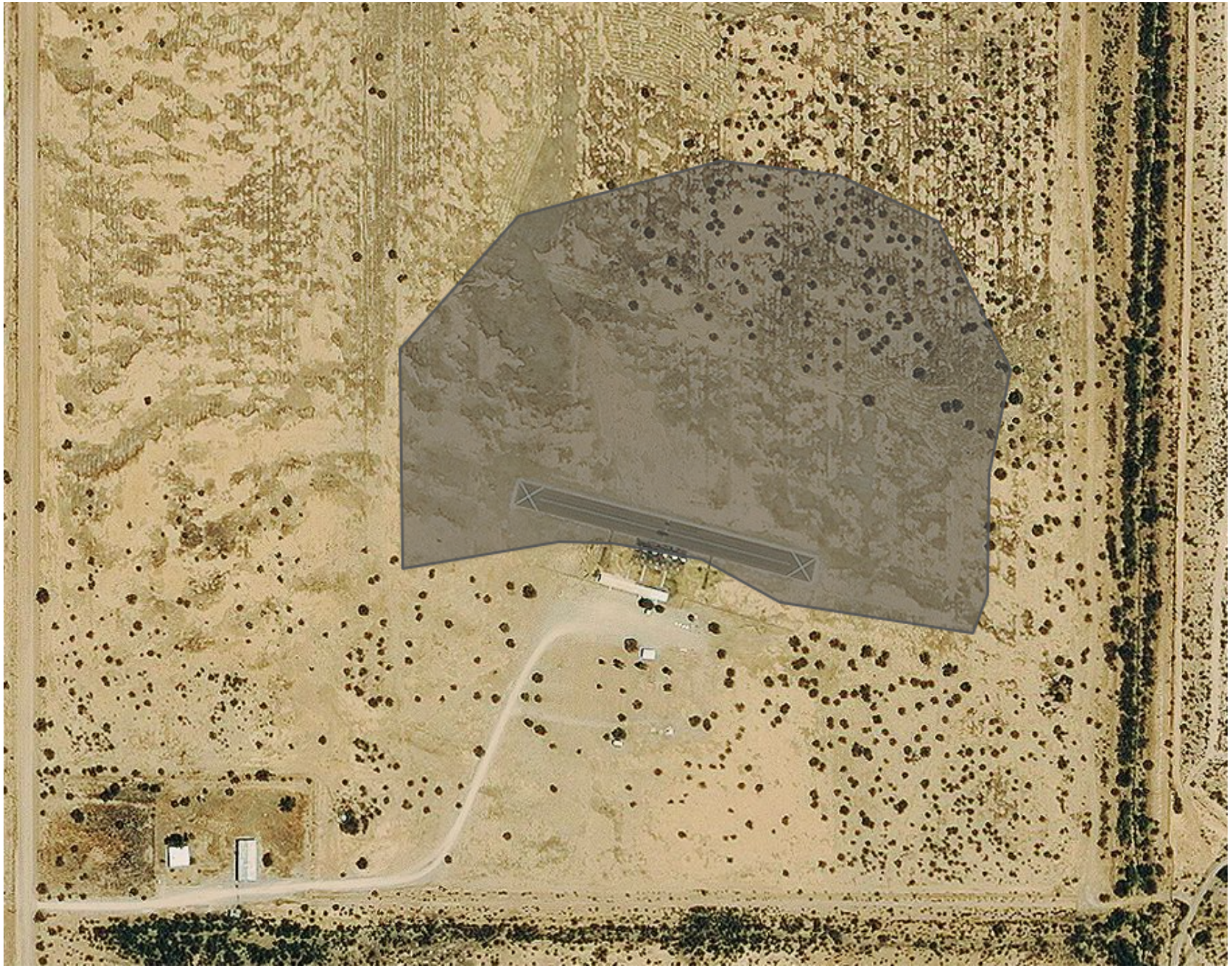
System and Scalability Properties



Competition Location



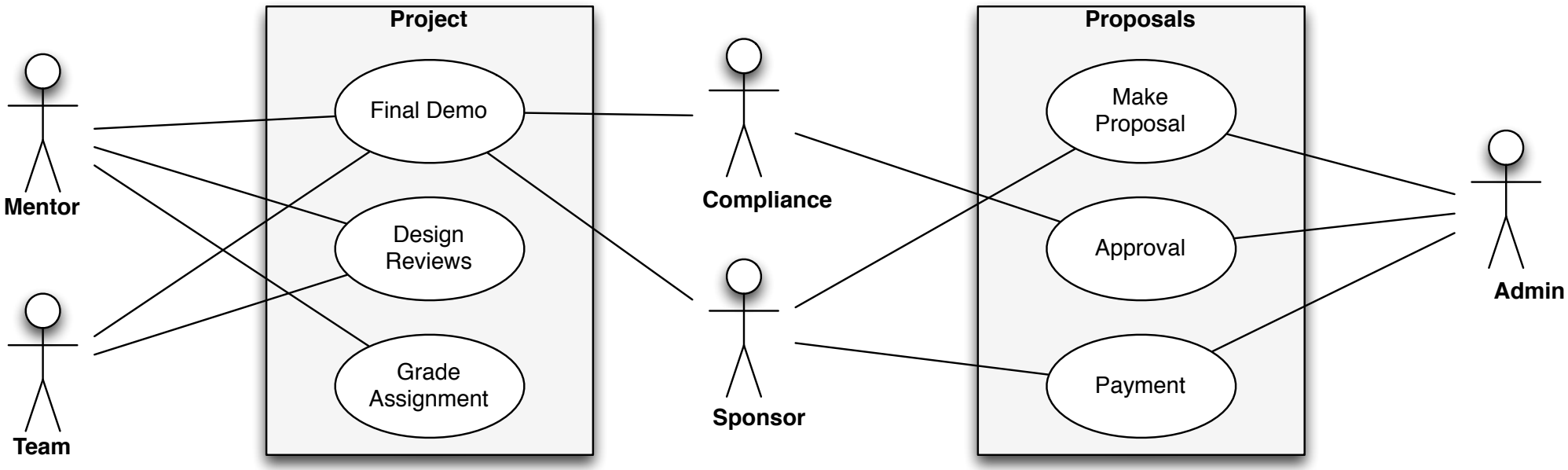
Competition Location



Conclusions of the Pilot

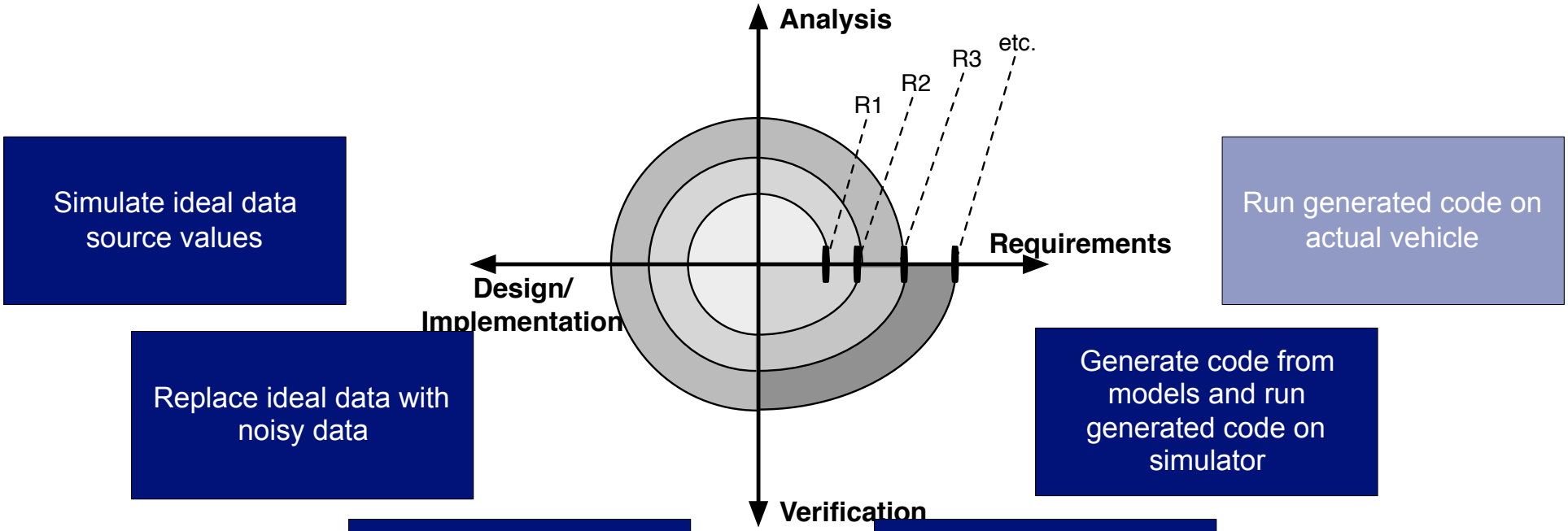
Interaction based on Design Course Constraints

- Waterfall and externally-managed design courses require concise, fixed conditions and rules



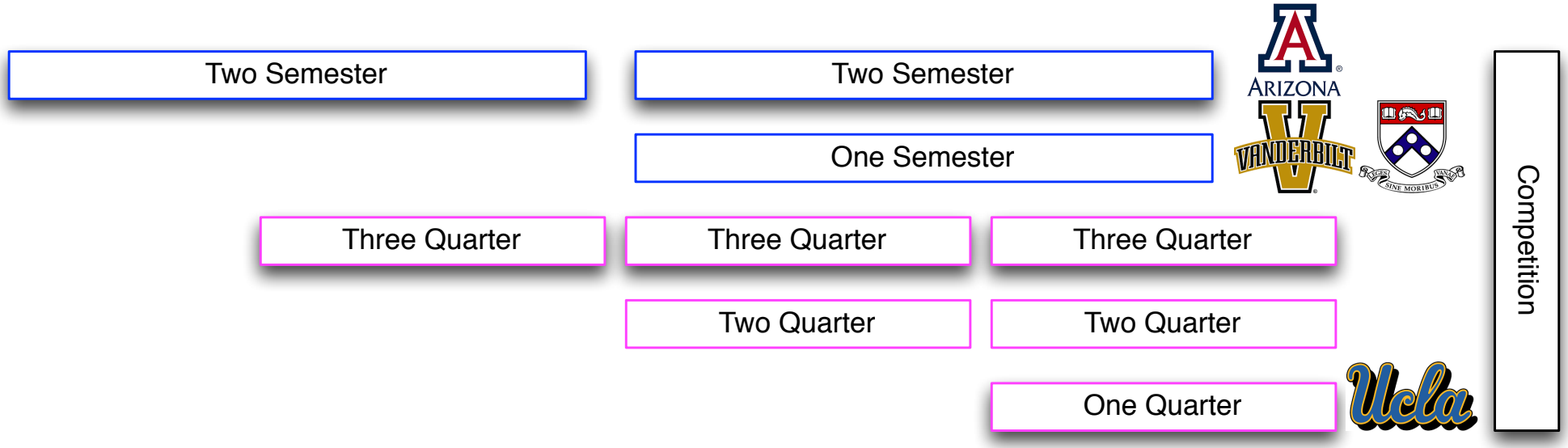
Interaction based on Design Course Constraints

- Some schools permit equipment purchase; others do not require it



Interaction based on Design Course Constraints

- Two-term, two-quarter, and 1-term must each have a suitable challenge(s)



Ex: Two Semester teams with large classes participate in all challenges

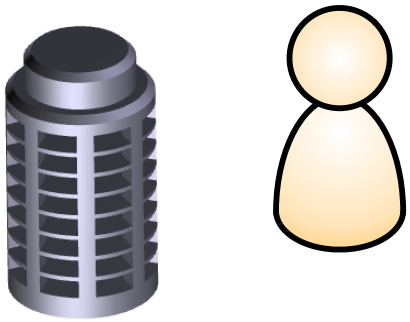
Ex: Two Semester team of 5 participates in only vehicle challenges

Ex: One Semester large course of 40 students fields 5 teams, one for each challenge problem

Ex: Two Quarter independent study course (10 students) works only Simulation Missions 1, 3

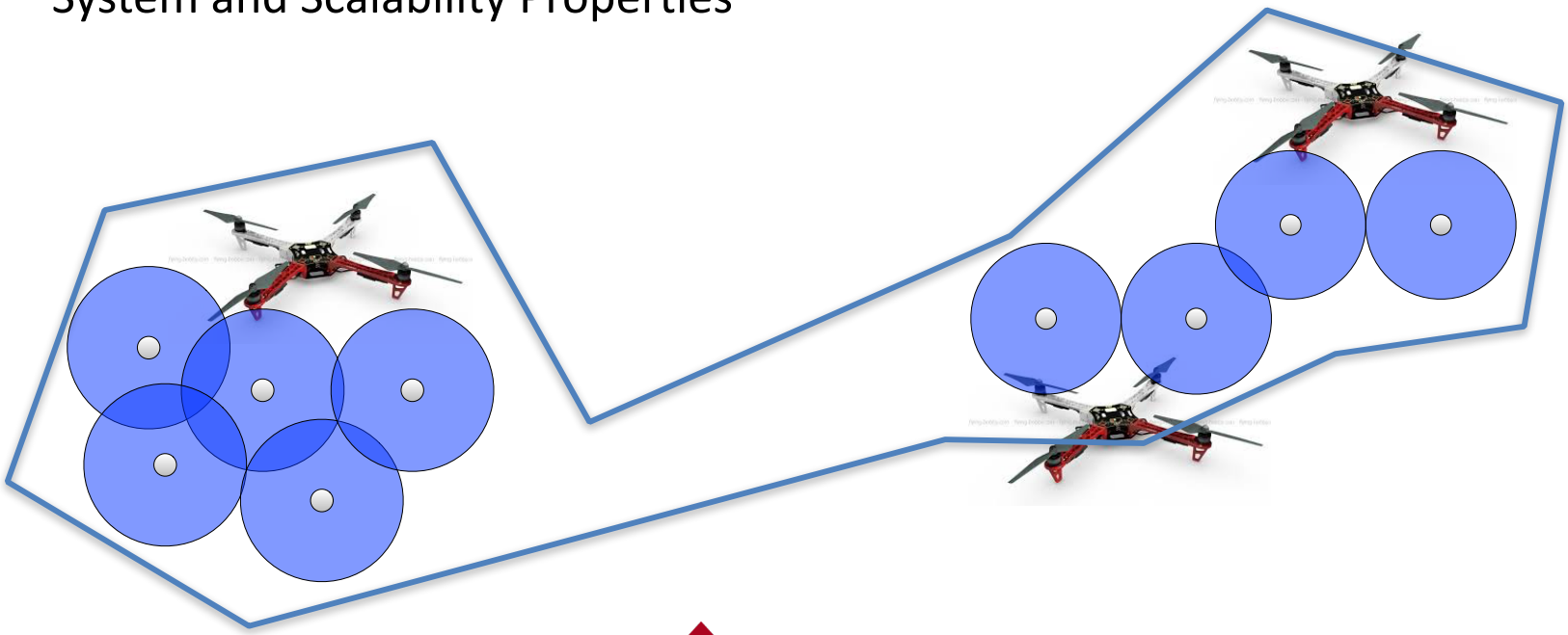
Interdisciplinary Courses: small teams (3-5 students)

Trap pickup/dropoff mechanisms



Platform Design and Implementation

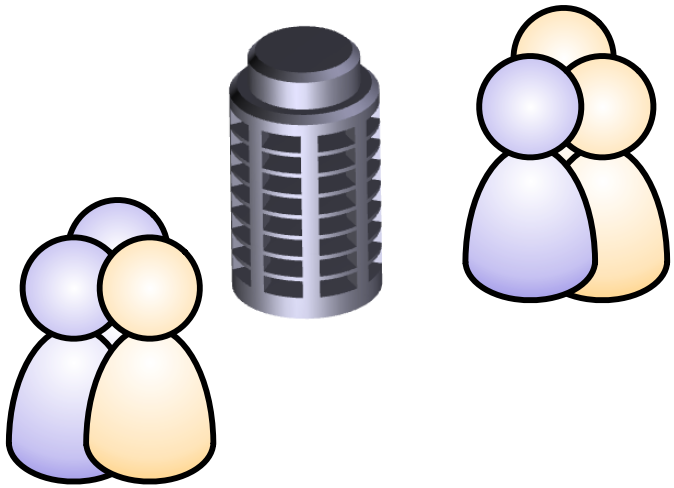
System and Scalability Properties



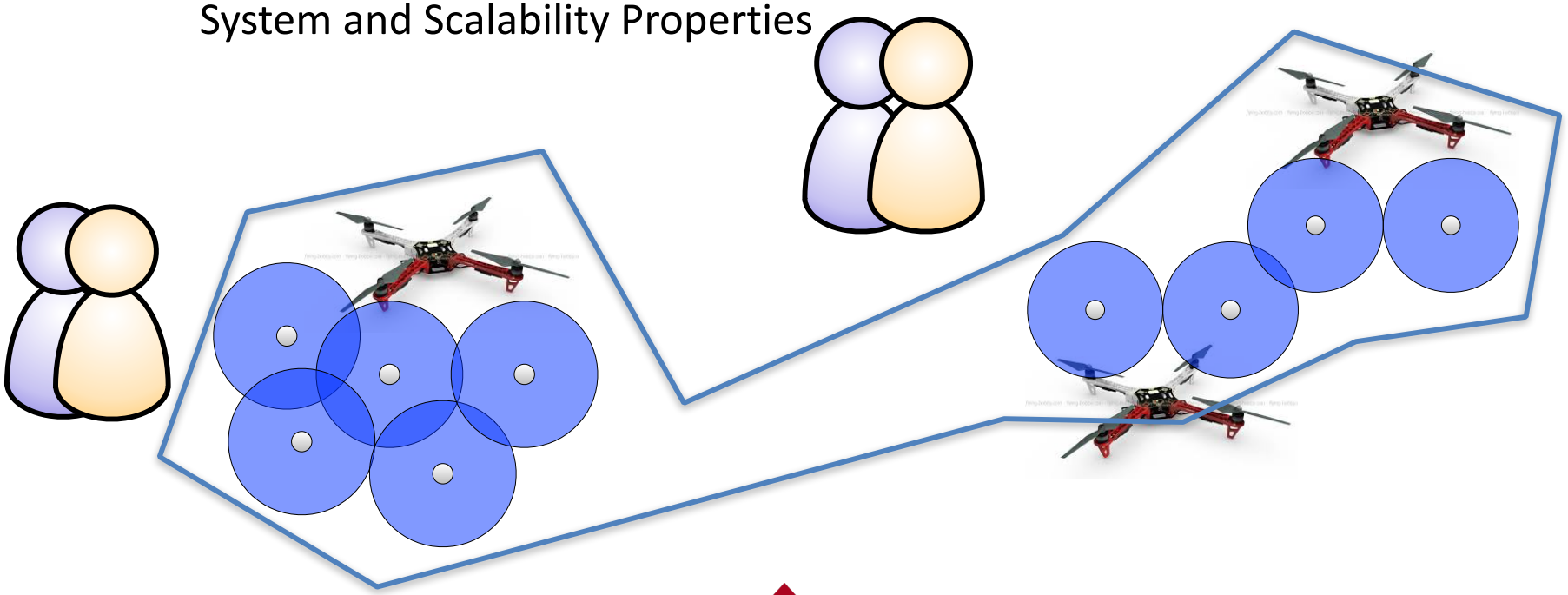
Interdisciplinary Courses: medium teams (10+ students)

Platform Design and Implementation

Trap pickup/dropoff mechanisms



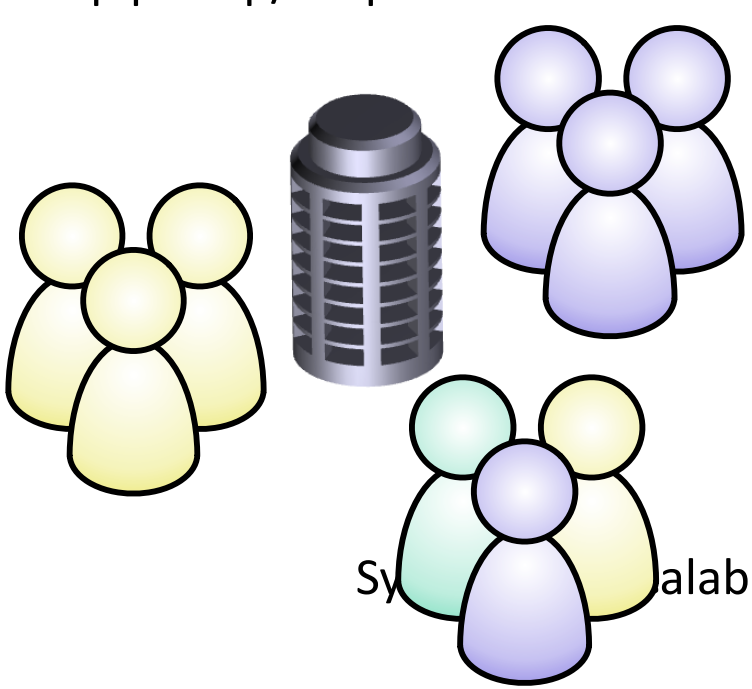
System and Scalability Properties



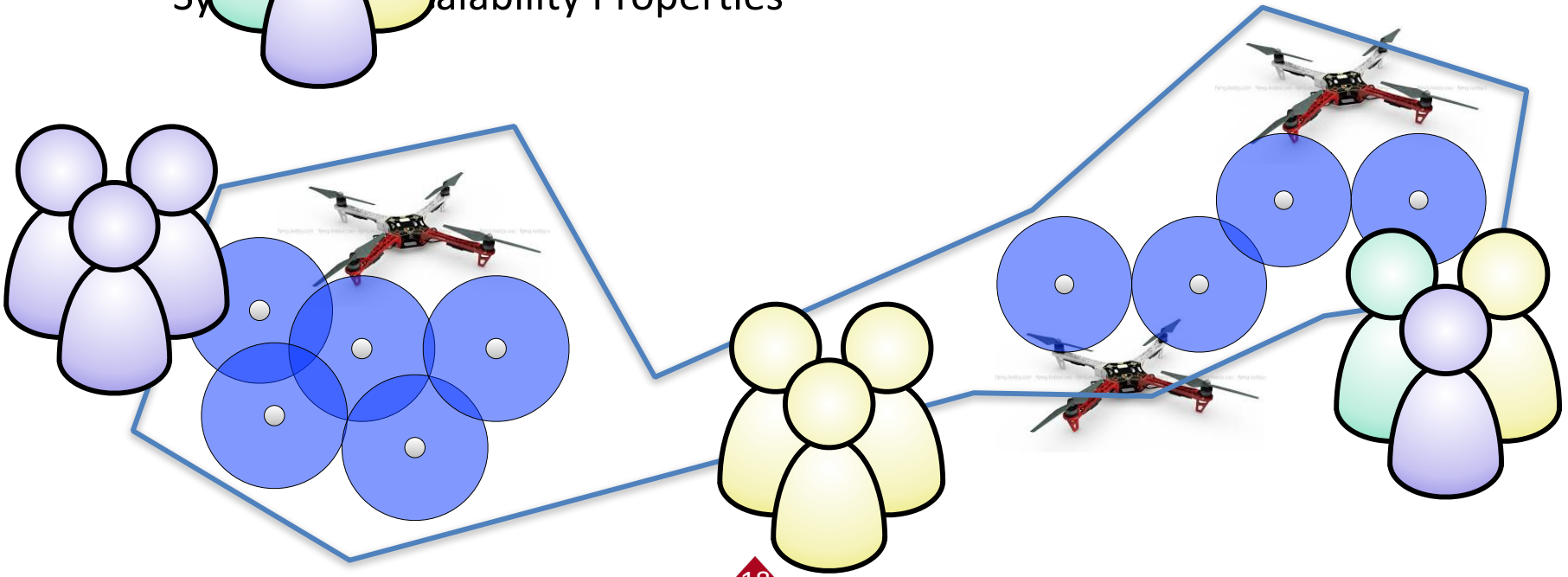
Interdisciplinary Courses: large teams (20+ students)

Platform Design and Implementation

Trap pickup/dropoff mechanisms



Sy alability Properties



Final Competition Needs Breathing Room

- Proposed schedule:
  - Day 0: reassemble your vehicles after shipping, and fly under human control
  - Day 1: safety checkout flights, ensure minimum qualifications
  - Day 2: simulator-based portion of the competition

Design Competition 2017

Two Upcoming Challenges

Fall 2017

Spring 2018

Two Semester

Two Semester

One Semester

Three Quarter

Three Quarter

Thre

Two Quarter

Two

One Quarter

Competition

Spring 2017

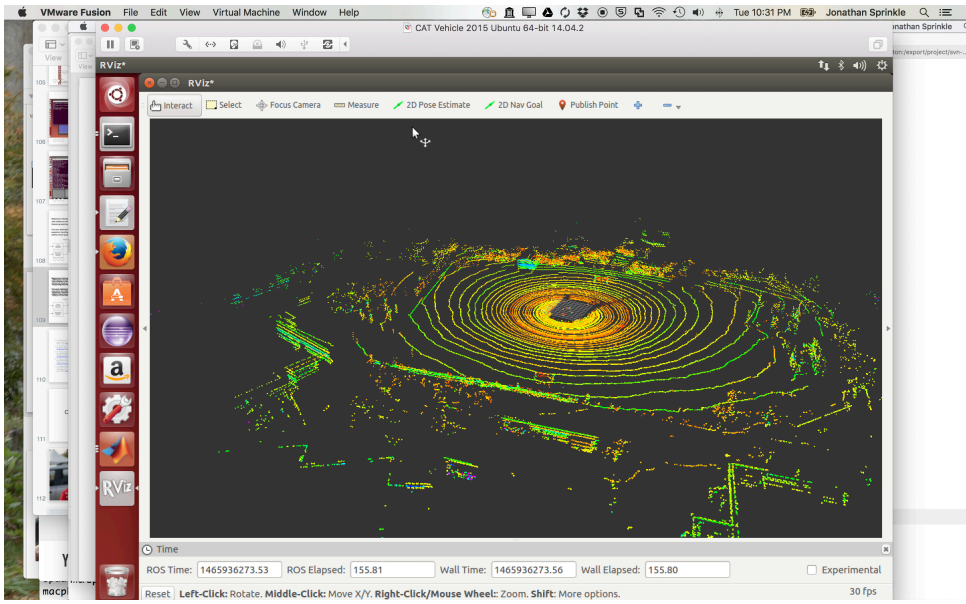
One Semester

Two Quarter

Two

One Quarter

Competition



Two-Track Competition

- Track 1: UAV missions (9 months, Fall 2017-Spring 2018)
  - Continue in track where teams can build their own platforms
  - Continue to utilize shared simulation engines and developed models
  - Successful teams invited to final Challenge Site
- Track 2: Ground-vehicle missions (3 months, Spring 2017)
  - Based on car-like robot (CAT Vehicle)
  - Software- and perception-based competition
  - Successful teams will get their experiments run on the physical platform

Track 1: UAV Missions

- Technically:
  - Reinforces tight coupling of hardware and software
  - Low reliance on simulation for critical system
  - High reliance on simulation for algorithms at scale
  - "Real" system interaction *from very early in process*
- Administratively:
  - Projects with hardware purchase
  - Institutions with Part 107 pilots or indoor flying facilities
  - Timelines suitable for replacement parts

Track 1: UAV Missions

- Vehicle Missions:
  1. Payload pickup/dropoff (HIL)
  2. Location scouting (A)
- System Missions (all in simulation):
  1. Location scouting at scale (A)
  2. Disease tracking at scale (A)

(A) Autonomous
(HIL) Human-in-the-loop with Autonomy

Track 2: Ground-vehicle missions

- Technically:
  - Enables longer missions (no batteries to recharge)
  - High reliance on simulation for testing of critical system
  - Enables distributed computation models
  - "Real" system interaction *only at conclusion*
- Administratively:
  - Projects with no required hardware purchase
  - Institutions with low tolerance for risk in project demonstrations
  - Single-discipline courses

Track 2: Ground-vehicle missions

- Vehicle Missions:
  1. Identify objects in environment (A)
  2. Modify velocity to improve object identification (A)
- System Missions:
  1. Synthesize simulation environment from "run" (A)
  2. Reduce sensors needed for correct observations (A)

(A) Autonomous
(HIL) Human-in-the-loop with Autonomy

Competition Timelines for UAV Track

- Competition Rules released April 2017
- To be held on University of Arizona's Mall
- Focus is on autonomous pickup of mosquito traps

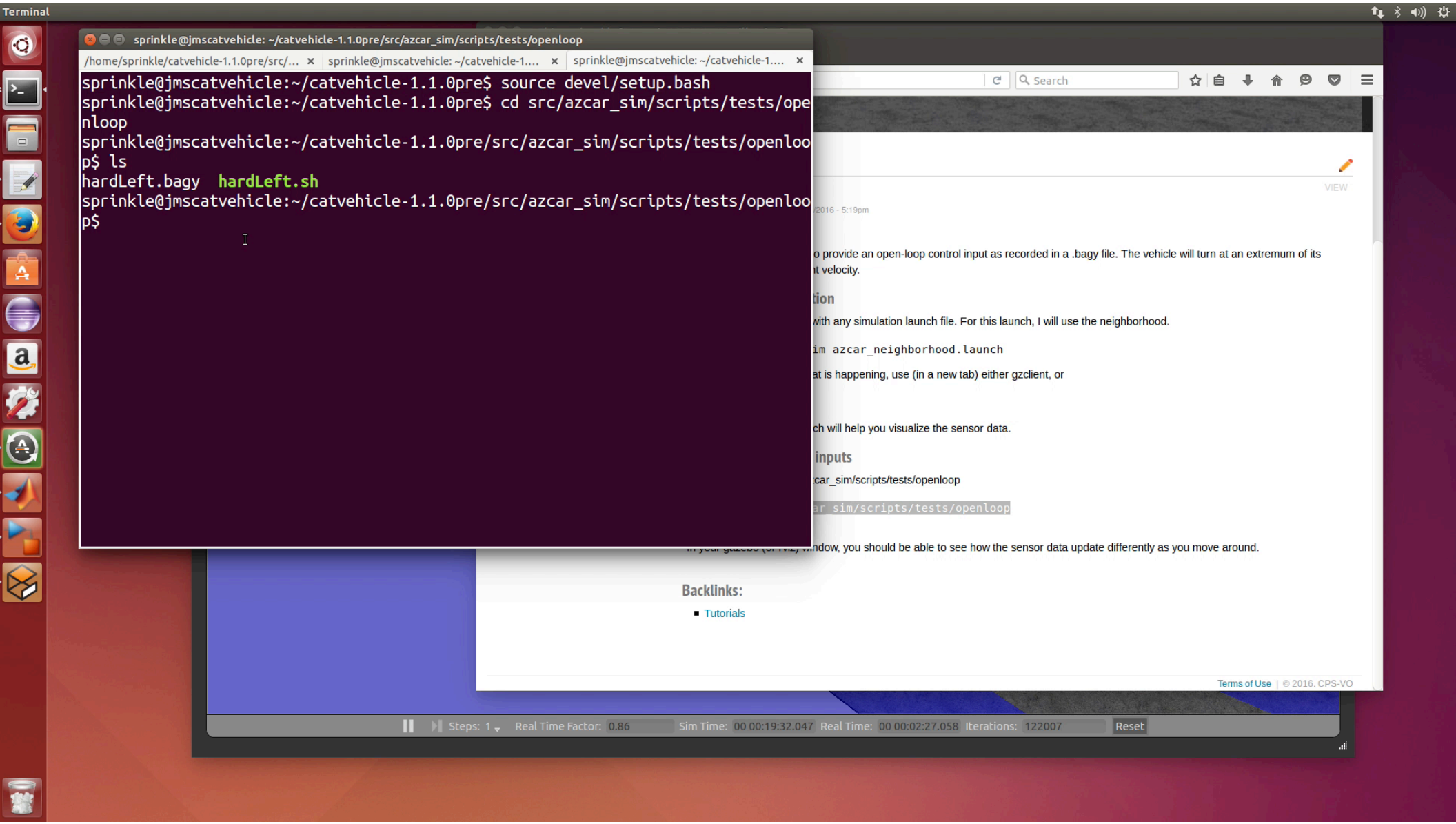
Competition Timelines for CAT Vehicle Track

- Enrolling teams now @
  2017 CAT Vehicle CPS-VO Challenge

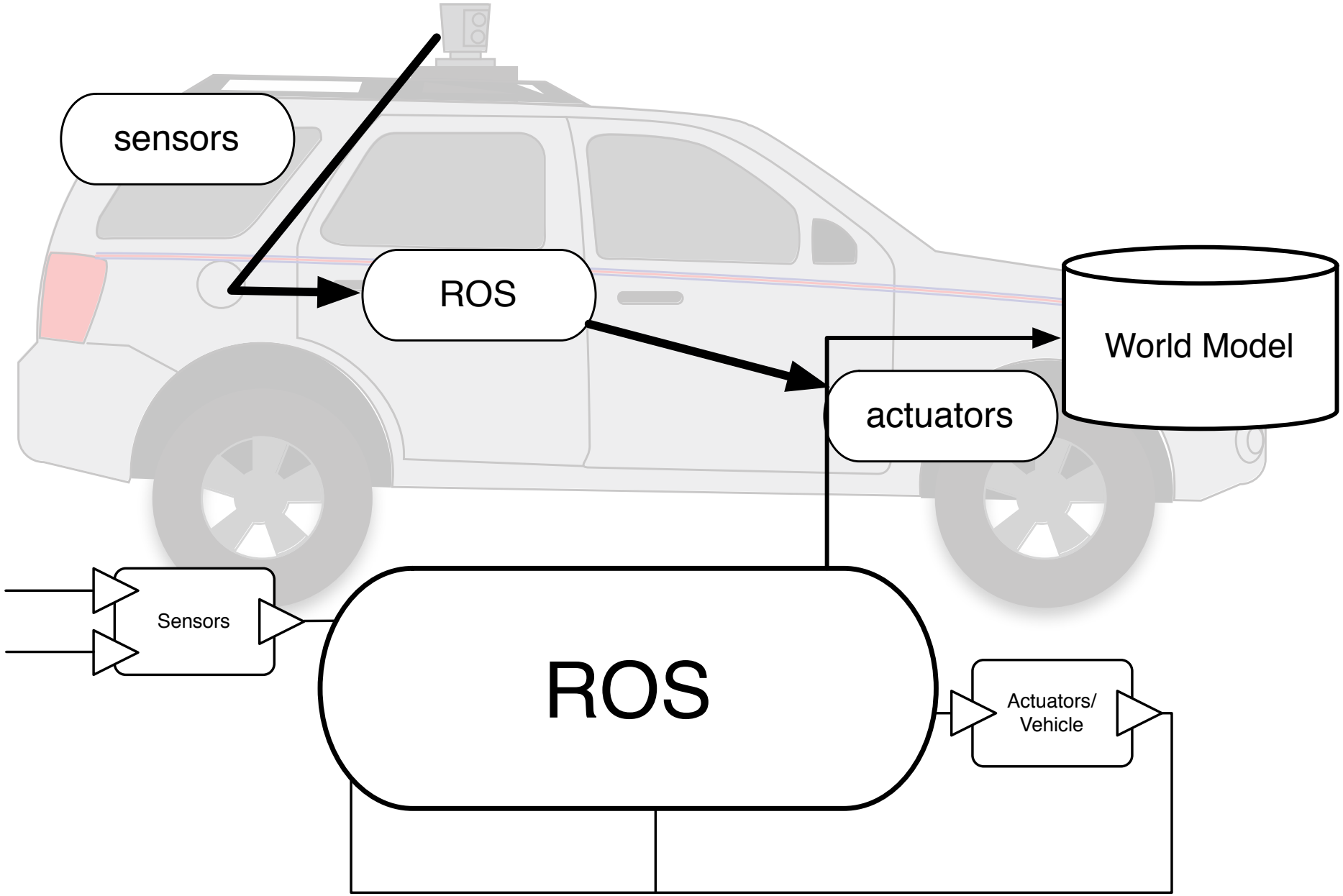
October 31, 2016	Announce the Challenge and its timelines at the NSF Cyber-Physical Systems PI Meeting
January 31, 2017	Deadline for Phase 1 entries
March 11, 2017	Deadline for Phase 2 entries
March 31, 2017	Deadline for Phase 3 entries
Week of April 24, 2017	Final Challenge to be held on the University of Arizona campus

http://cps-vo.org/group/2017CATVehicleChallenge

2017 CAT Vehicle CPS-VO Challenge

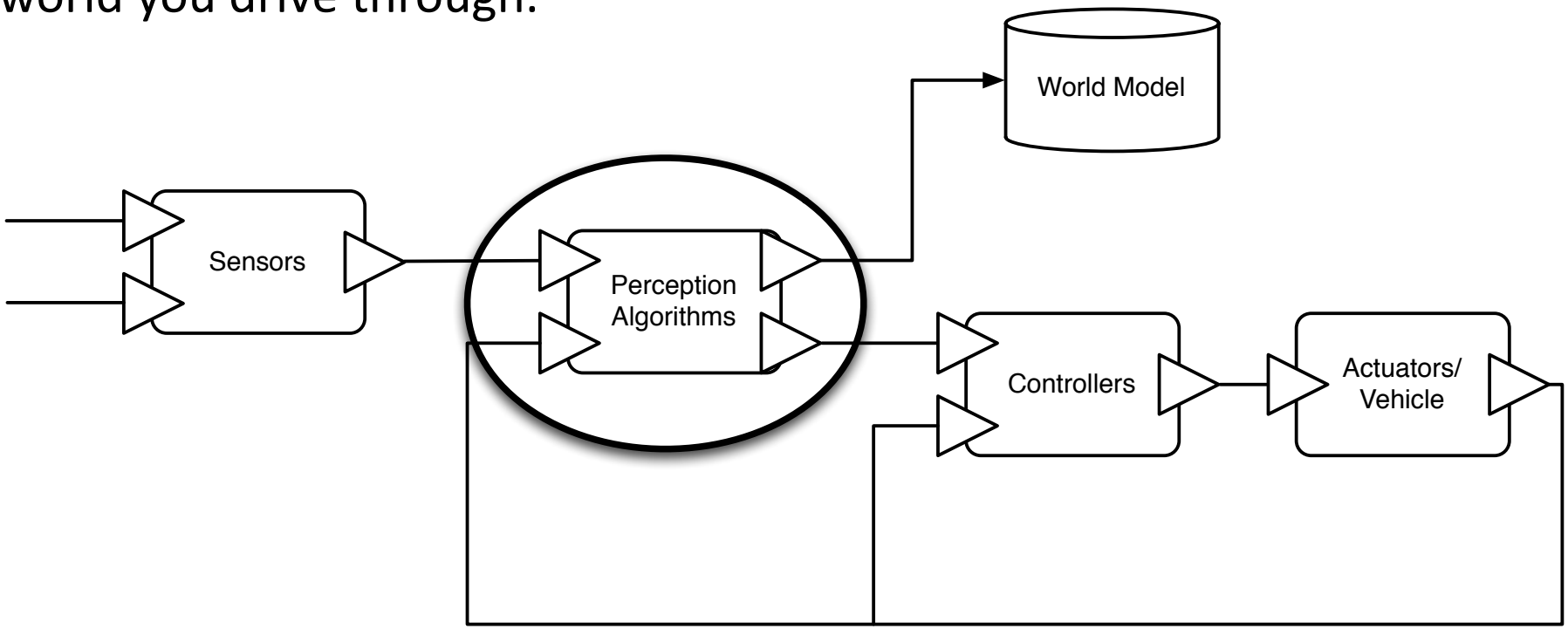


Objectives:


sensors
ROS
World Model
actuators
Sensors
ROS
Actuators/
Vehicle

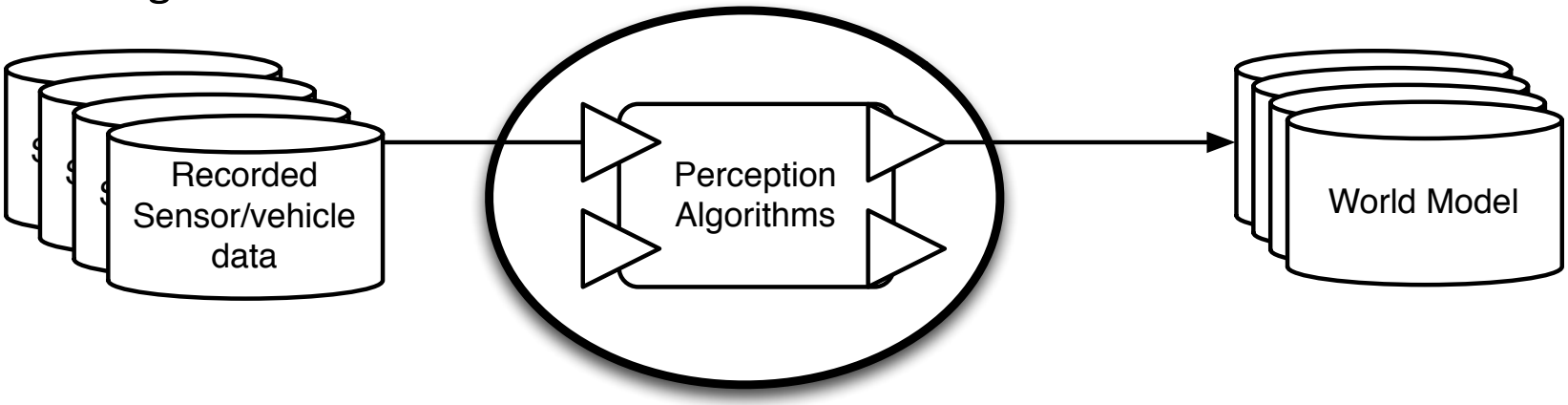
Requirements

Replace our perception algorithms with yours, in order to generate a model of the world you drive through.

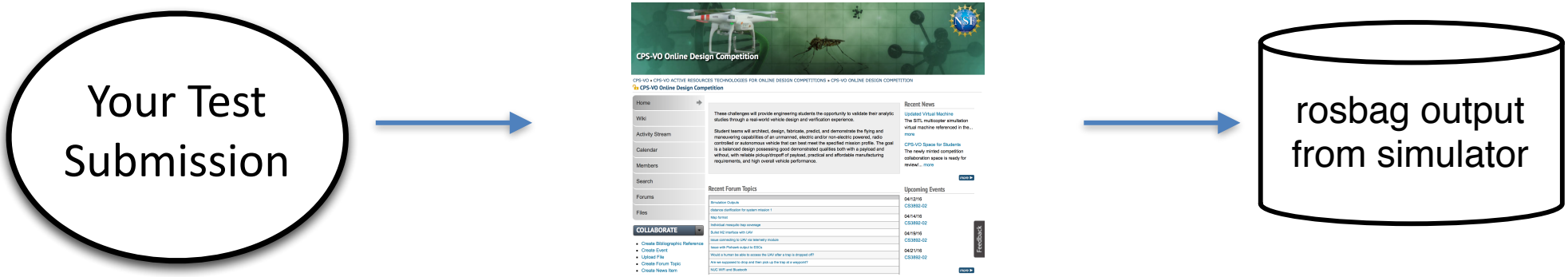


Methods

Design and training

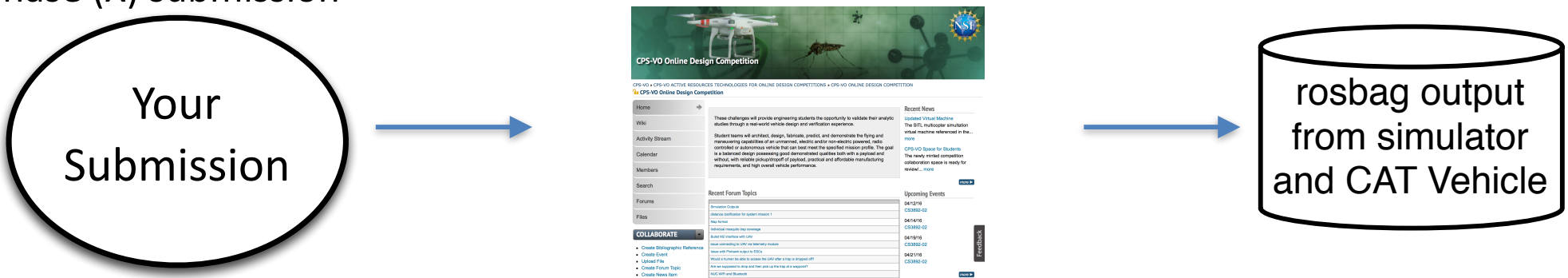


Testing to confirm interfaces

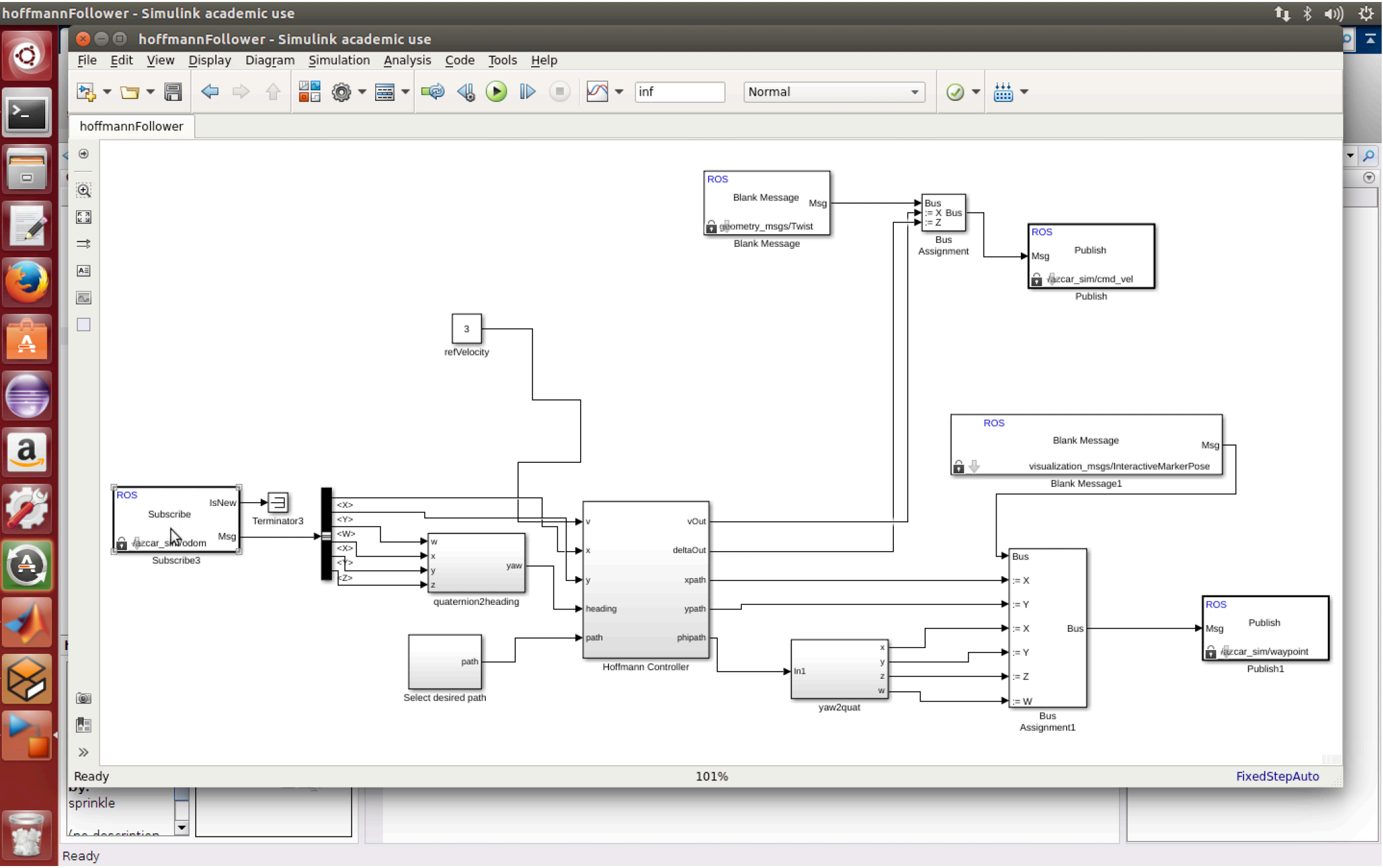


CPS-VO Cloud Resources

Phase (X) submission



Approach: Model-Based Design of ROS with Simulink



Phases

Phase 1: Can you RTFM* to **run the tutorial experiments and make your team's first submission** on the CPS-VO?

Phase 2: Submit models and software that **consume rosbag files, and output interesting objects**.

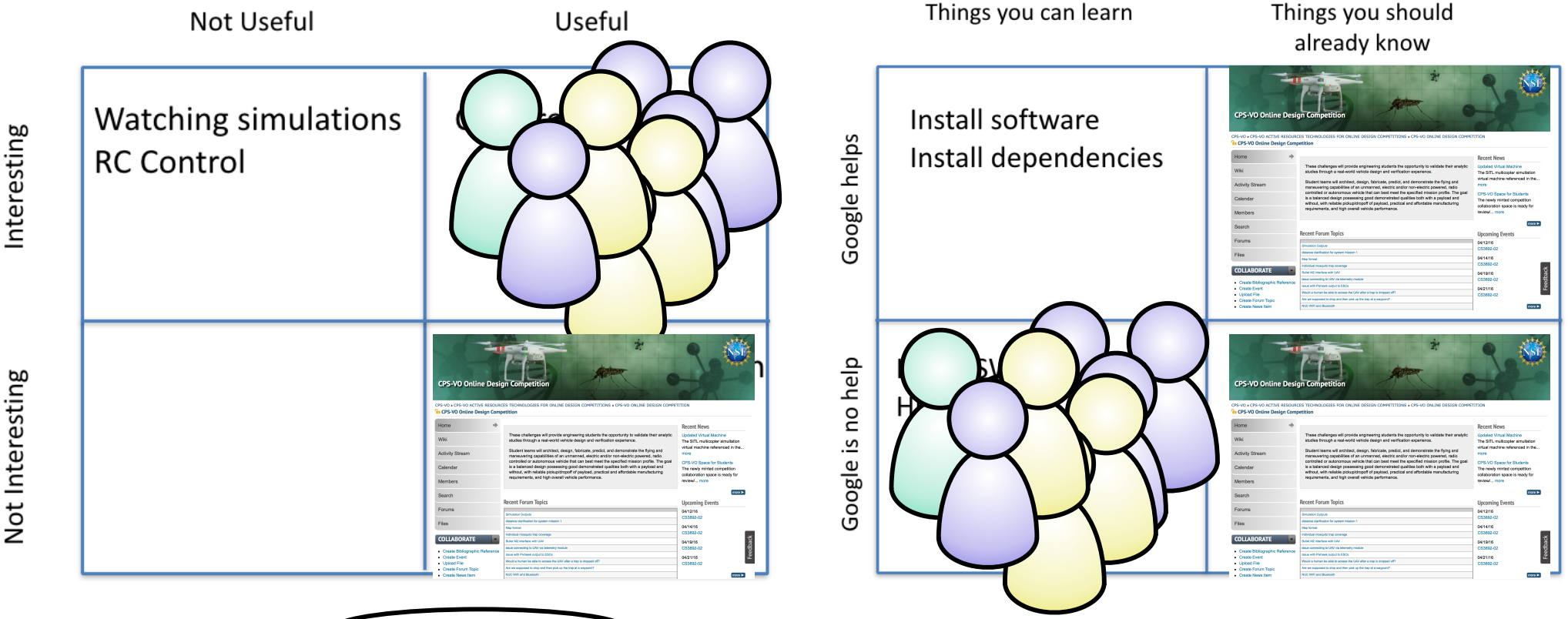
Phase 3: Teams must submit models and software that **consume vehicle and sensor data, control the velocity of the vehicle, and produce an output Gazebo world file**.

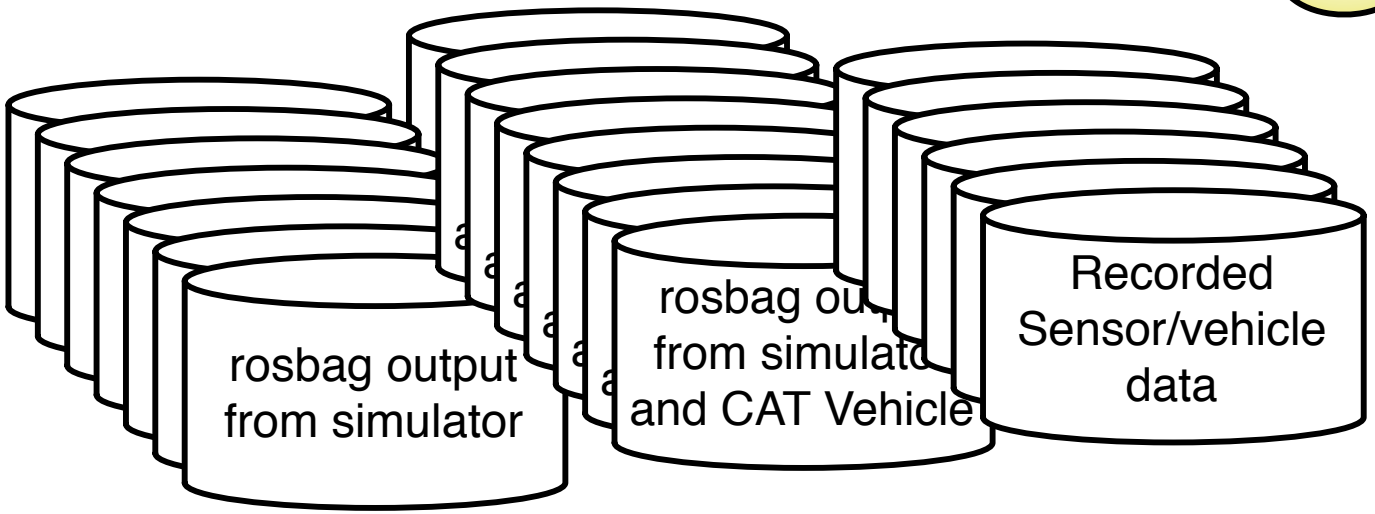
Final Challenge: Teams will have an opportunity to **modify and then re-run their Phase 3 models on the CAT Vehicle in Tucson, AZ**, over a period of 2-3 days**.

* Read The Freely-available Model-based design tutorials on the CPS-VO

** Pending final sponsorship agreement

Enabled by the CPS-VO Active Resources





New models, databases, sensor output, algorithms, and software infrastructures now live on the VO, where other researchers can now actively use them.