MCHE 470: Robotics

Fall 2013

Dr. Joshua Vaughan

Rougeou 225

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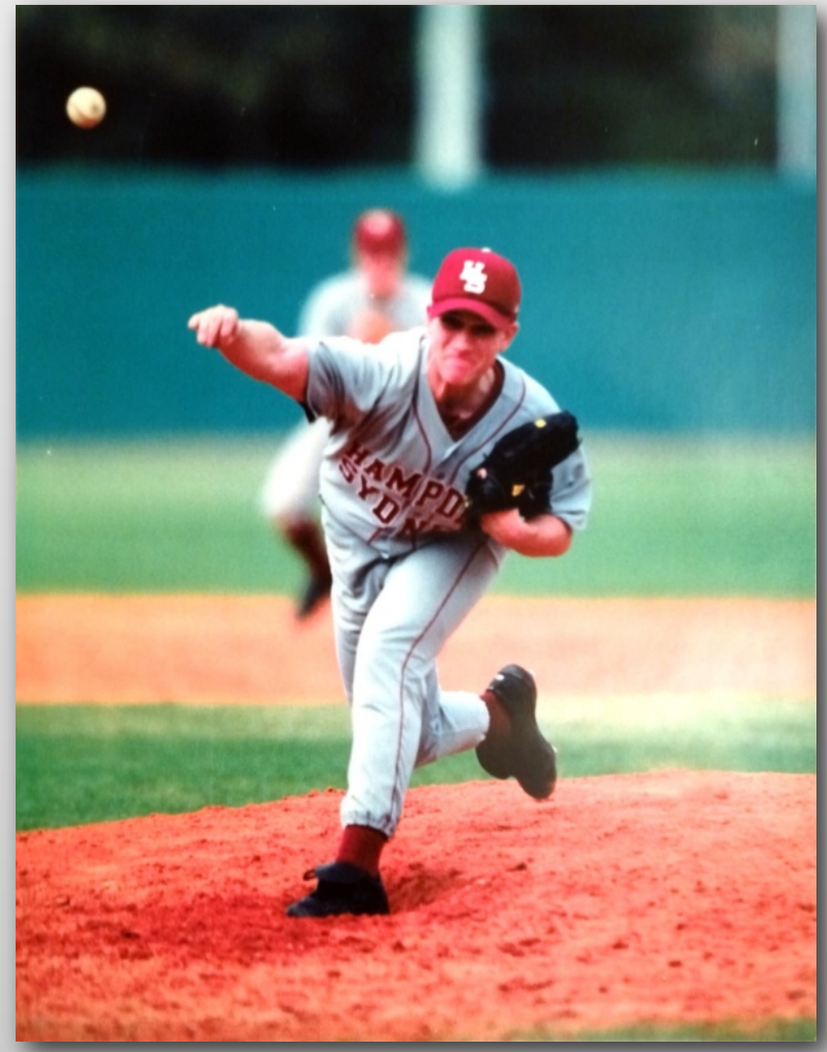
@Doc_Vaughan

First, Some Info on Me

- Grew up in Southern Virginia
- Bachelor's from Hampden-Sydney College in May 2002
  - Double Major: Physics and Applied Math
  - 4-year starting pitcher



Grad. School

- Graduate School at Georgia Tech
  - M.S. in May 2004
    - ✦ Thesis: *Active and Semi-Active Control to Counter Vehicle Payload Variation*
  - Ph.D. in August 2008
    - ✦ Thesis: *Dynamics and Control of Mobile Cranes*
  - Advisor: Dr. William Singhose

Postdoc

- Tokyo Institute of Technology
  - Lab of Dr. Shigeo Hirose

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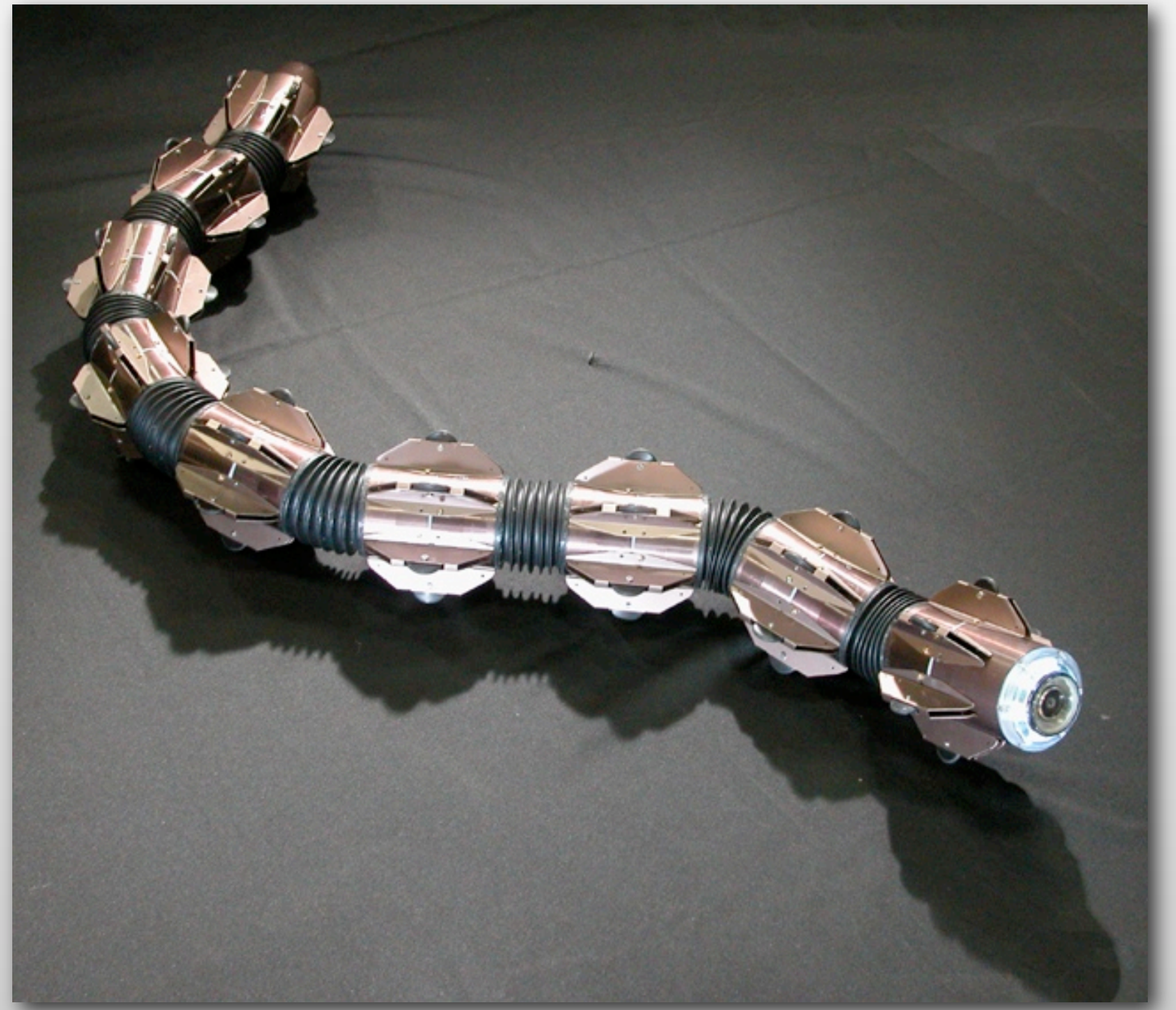


GRYPHON Robot

- Humanitarian Demining

Types of Mines

- Anti-tank mines
  - Large, powerful mines
  - Designed to disable/destroy vehicles
  - Typically high metal content

- Anti-personnel mines
  - Small size
  - Designed to injure people
  - Typically low metal content

Demining

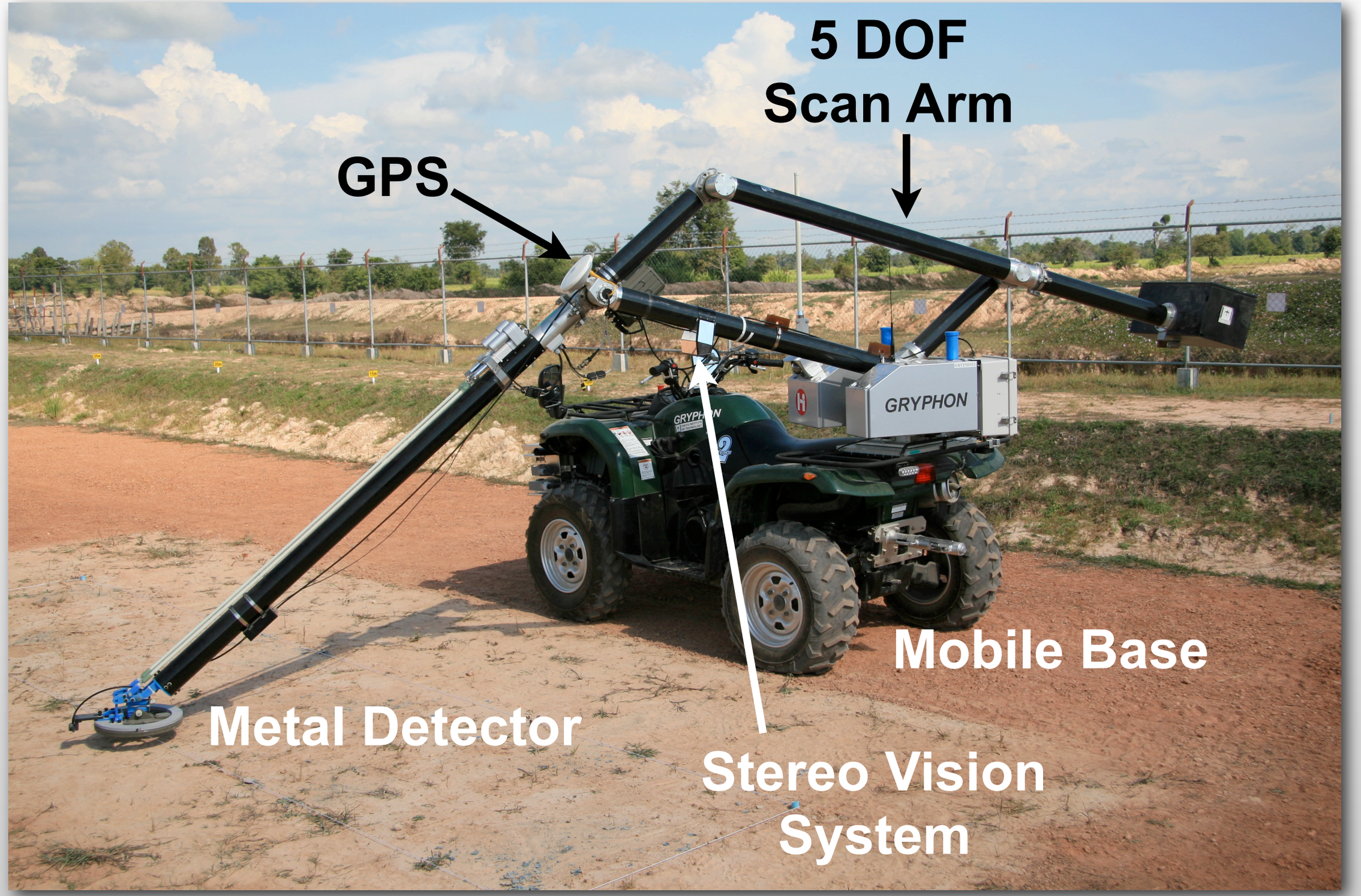
- Military Demining
  - Just clear a path for troops and equipment
  - 100% removal is **NOT** required
  - Primary objective is rapid clearance

- Humanitarian Demining
  - 100% removal is required
  - Speed is minor concern
  - Primary objective is returning land to civilians

Detecting Mines - Current Methods

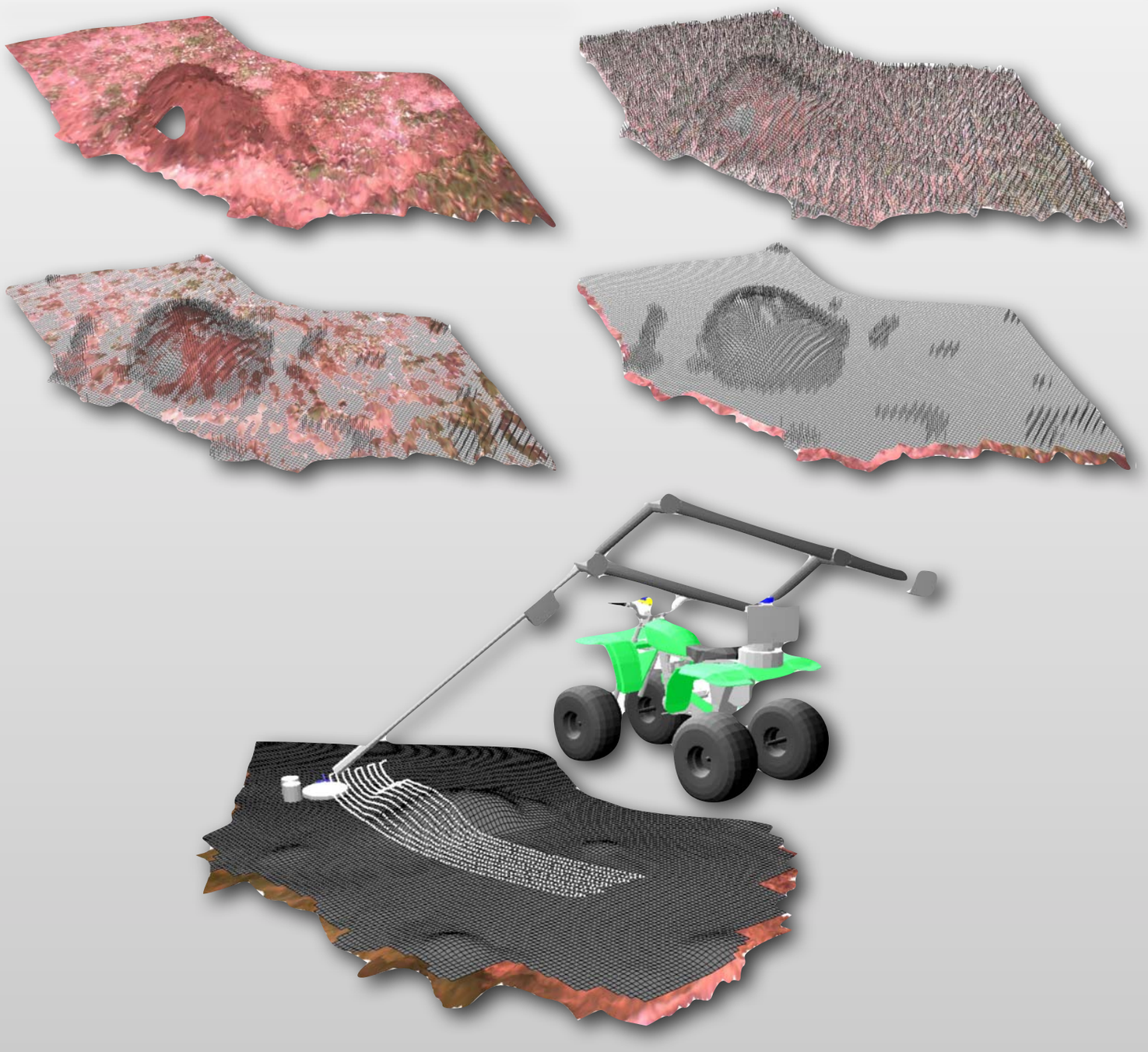
- Human operated metal detector
- Animals
  - Dogs
  - Pigs
  - Rats

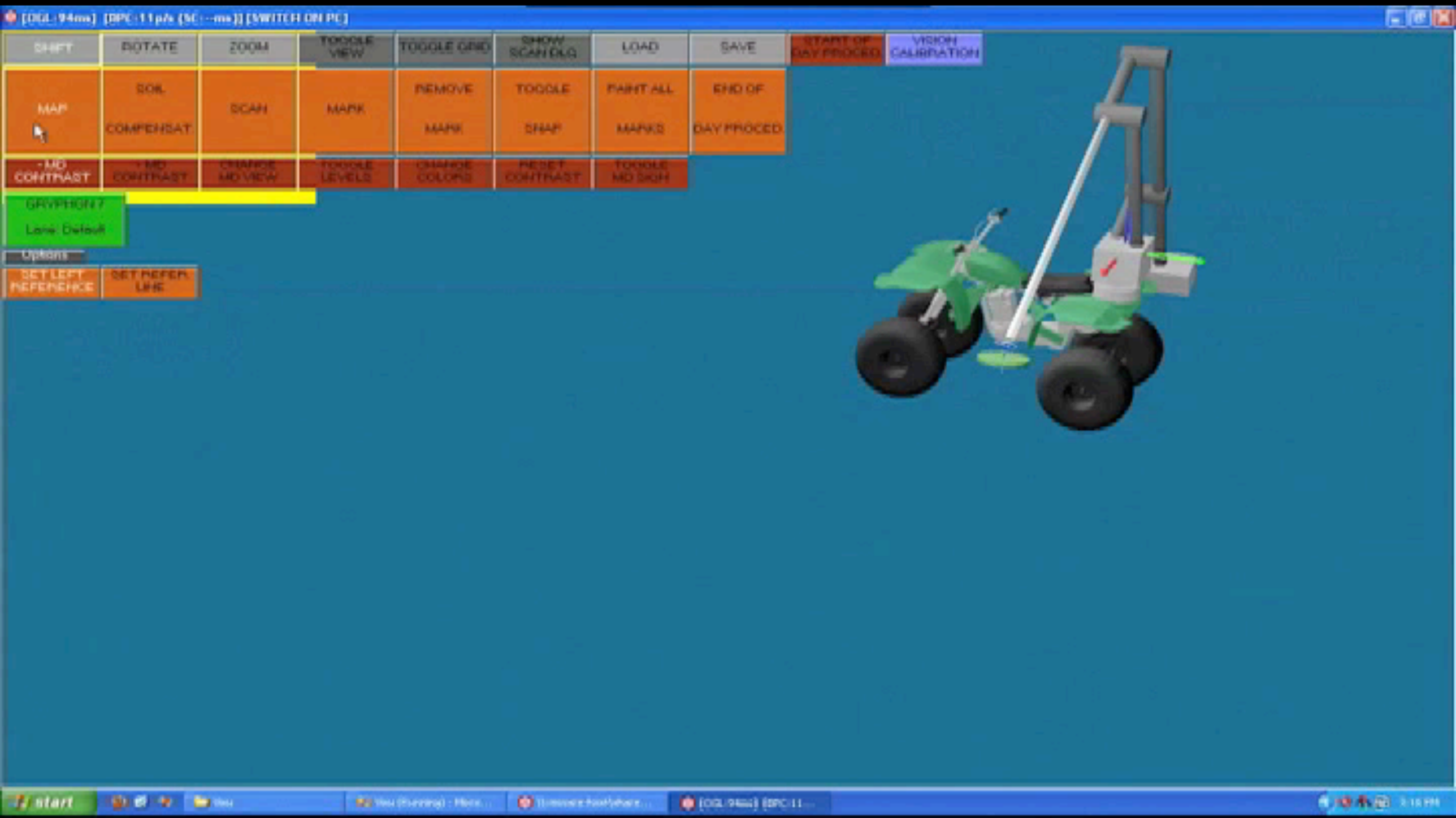
GRYPHON


5 DOF
Scan Arm
GPS
GRYPHON
Mobile Base
Metal Detector
Stereo Vision
System

Mapping the Scan Area

- Stereo vision system
- Generate height field to track





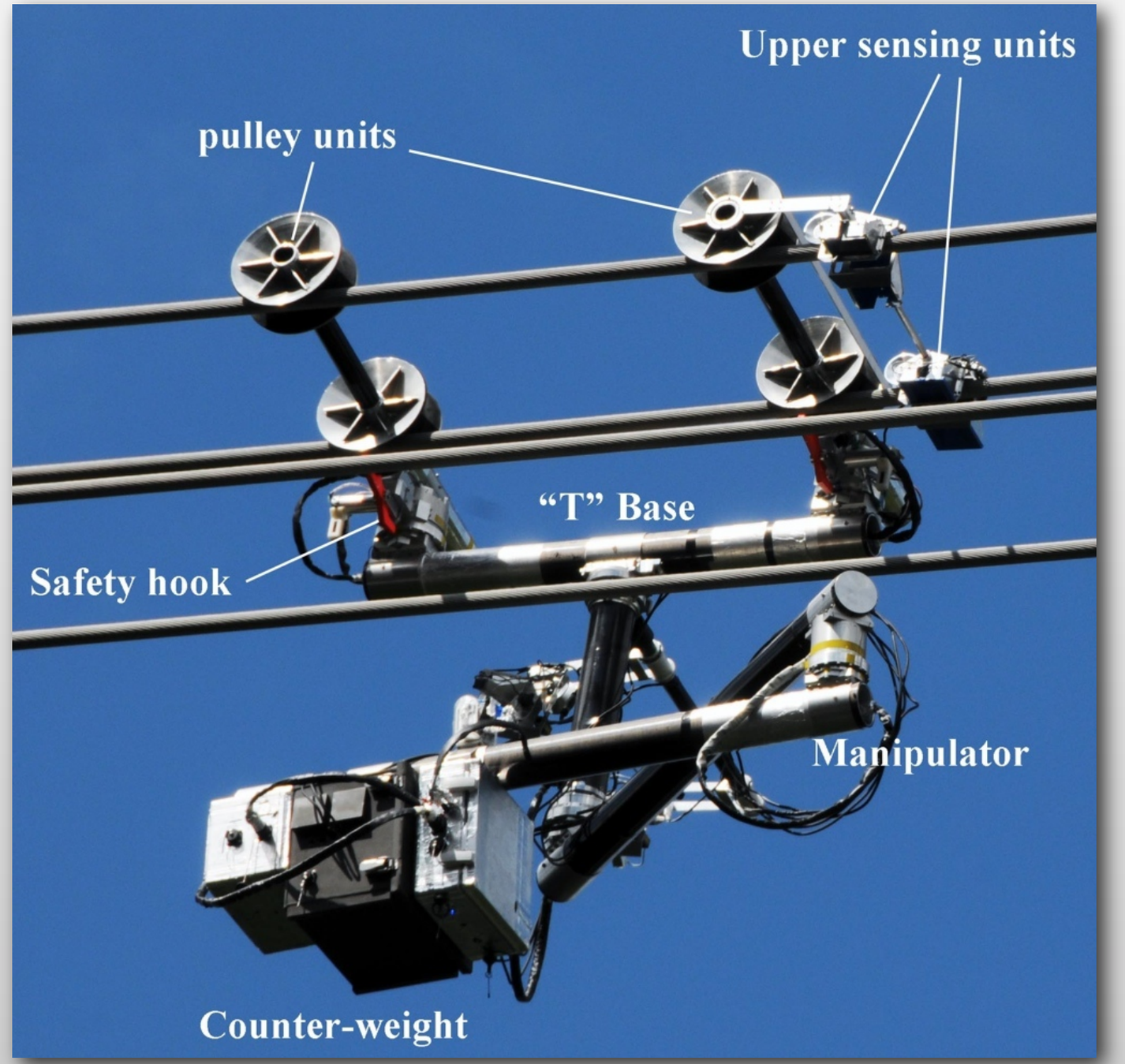
Gryphon Terrain Mapping

High-voltage Power Lines

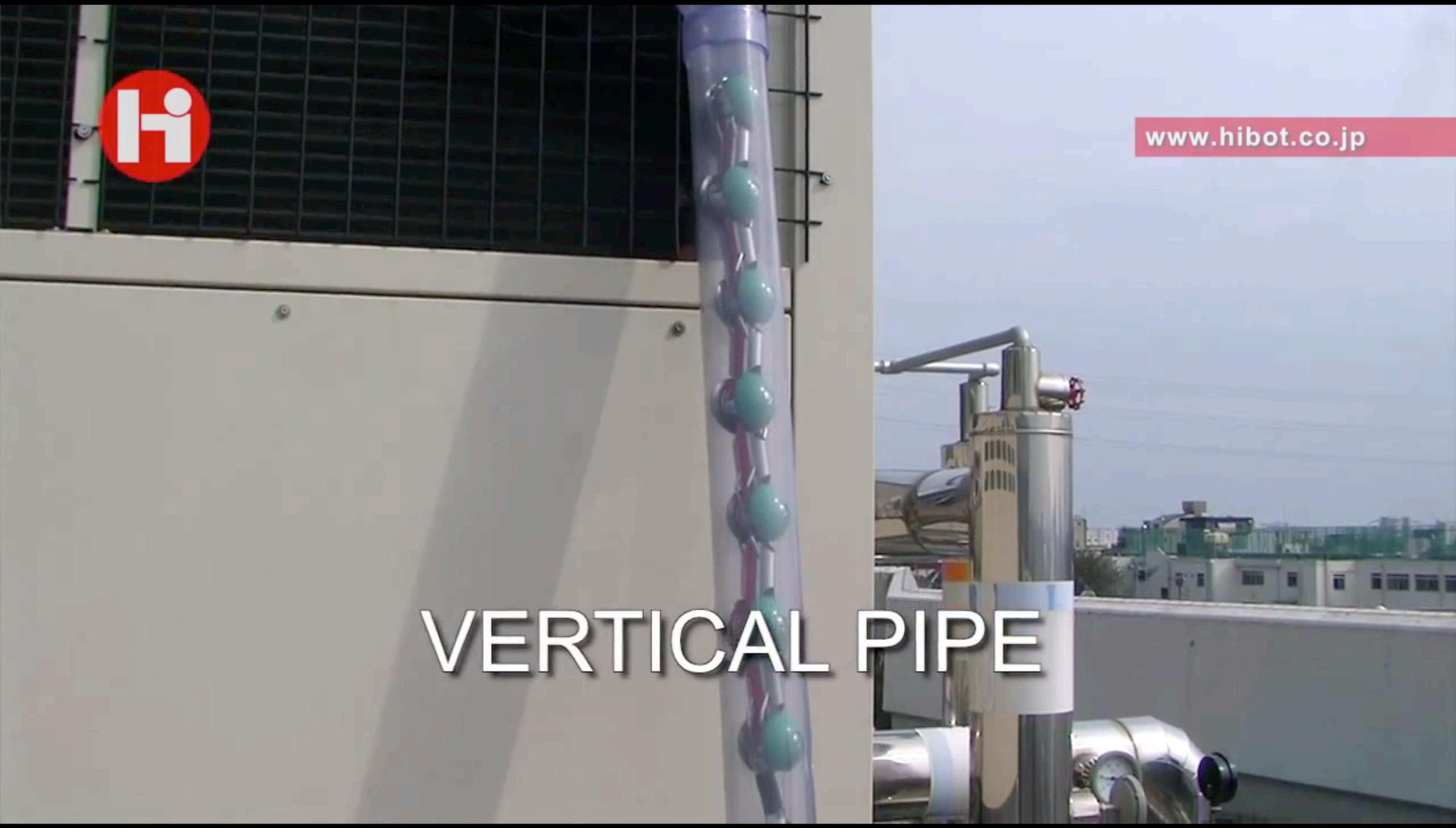
- How would you inspect these?

HiBot Expliner Robot

- High Voltage Power Line Inspection and Repair
  - Collaboration with HiBot Corp.

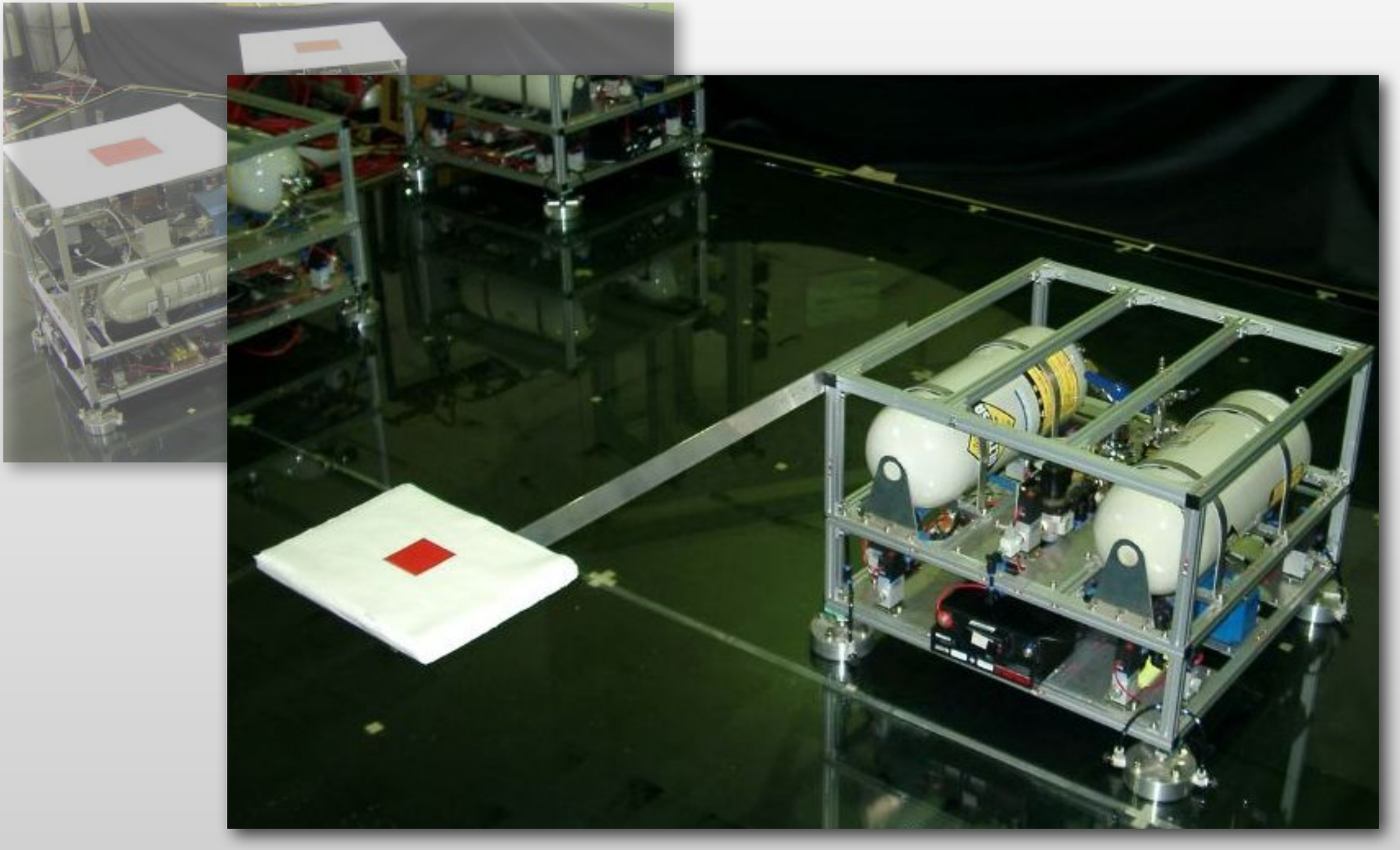


How would you inspect these?


www.hibot.co.jp
VERTICAL PIPE

Flexible Satellites

- Tokyo Institute of Technology



Course Info

- Official Description:

  "*This course will cover the fundamentals of robot design and control, with focus on application. Students will implement fundamental robotics algorithms on a variety of robots. A large portion of the course will be the design and build of a robot for participation in a class competition. Prereq: ENGR 313, MCHE 363.*"

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In other words, we will play with robots and hopefully learn something in the process.

Course Info (cont)

- TR 4:30-5:45pm, CLR 313
- Some mini-project exercises in my lab, CLR 110
- http://www.ucs.louisiana.edu/~jev9637/MCHE470.html
- No set office hours (yet)
- Prereqs: ENGR 313, MCHE 363

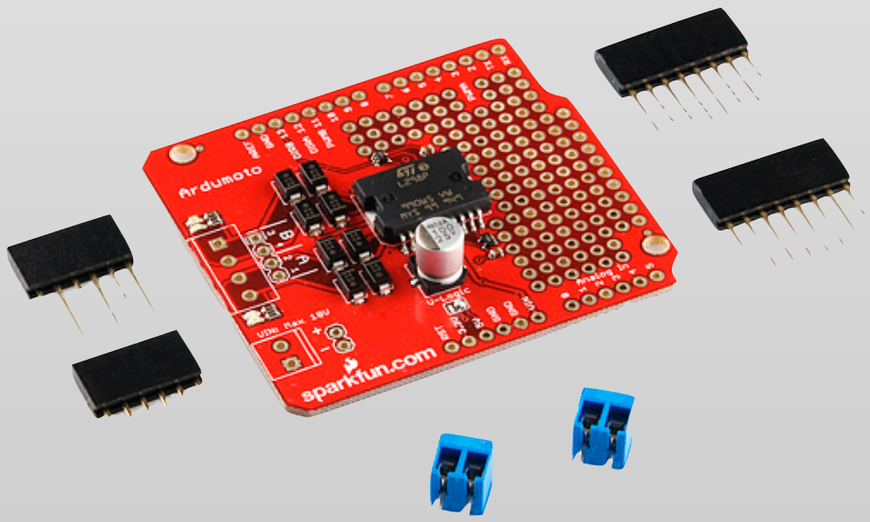
My Contact Info

- Rougeou 225
- joshua.vaughan@louisiana.edu
- @Doc_Vaughan on Twitter
- For more: http://www.ucs.louisiana.edu/~jev9637

Our Textbook(s)

- SparkFun Inventor's Kit - v3

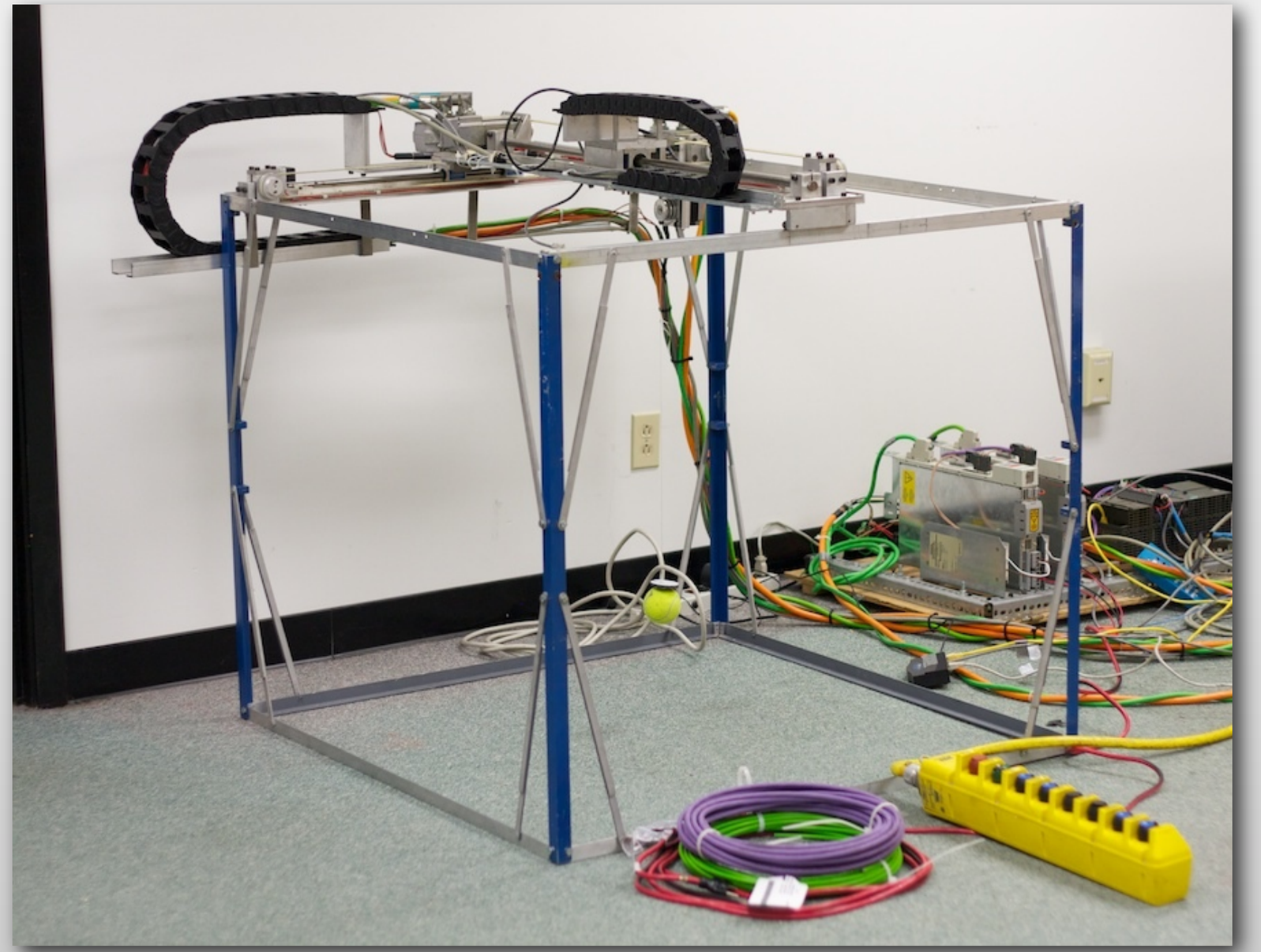
- Ardumoto - Motor Driver Shield



Photos from SparkFun.com

In the *C.R.A.W.LAB*

- Scale Bridge Crane
  - Siemens PLC and Cognex machine vision
  - Remotely operable via the Internet



In the *C.R.A.W.LAB*

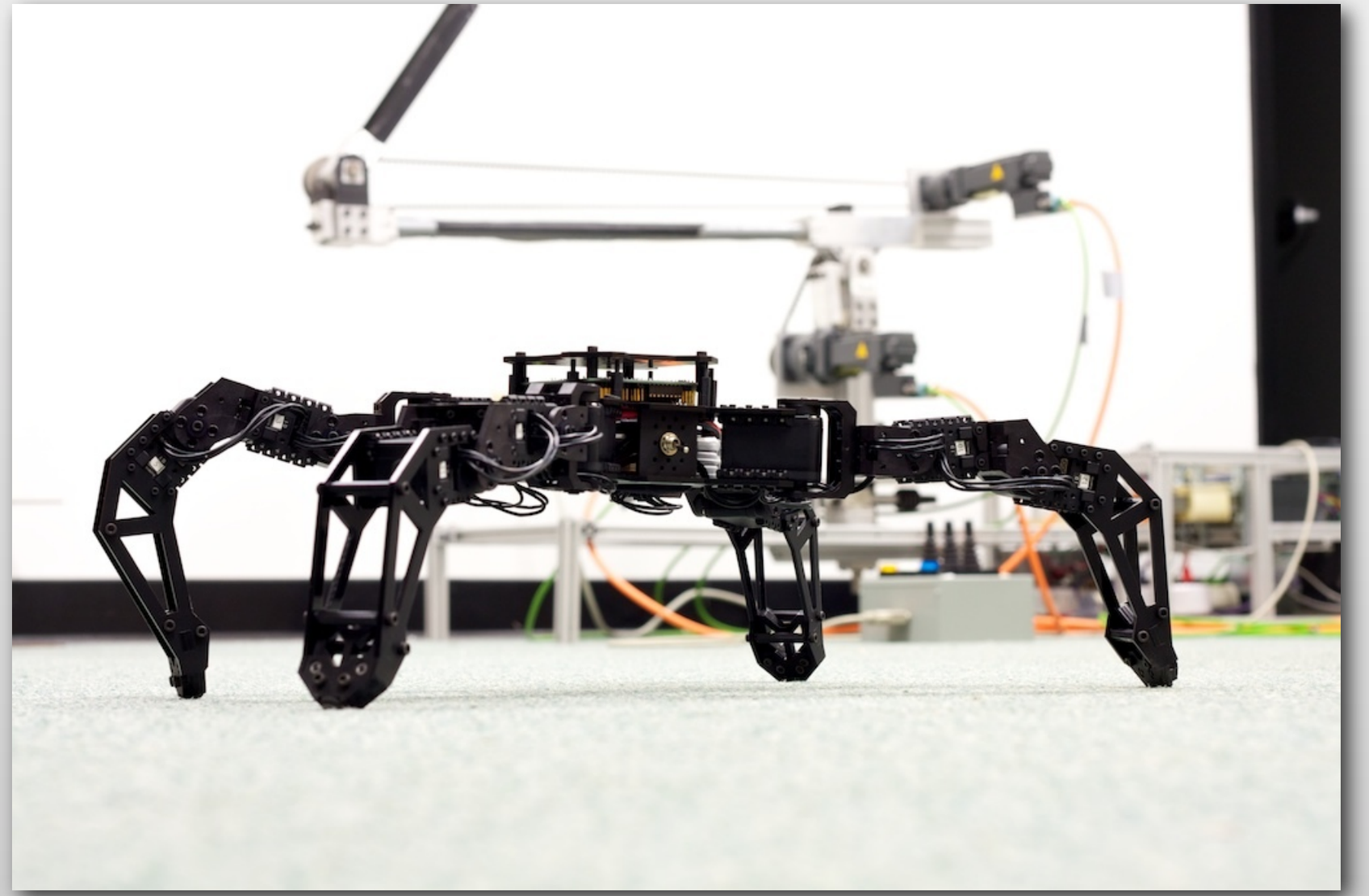
- TurtleBot 2
  - Runs ROS
  - Microsoft Kinect as the main sensor

In the *C.R.A.W.LAB*

- Clearpath Robotics Husky
  - GPS, IMU, and laser-based navigation
  - 75 kg max payload capacity

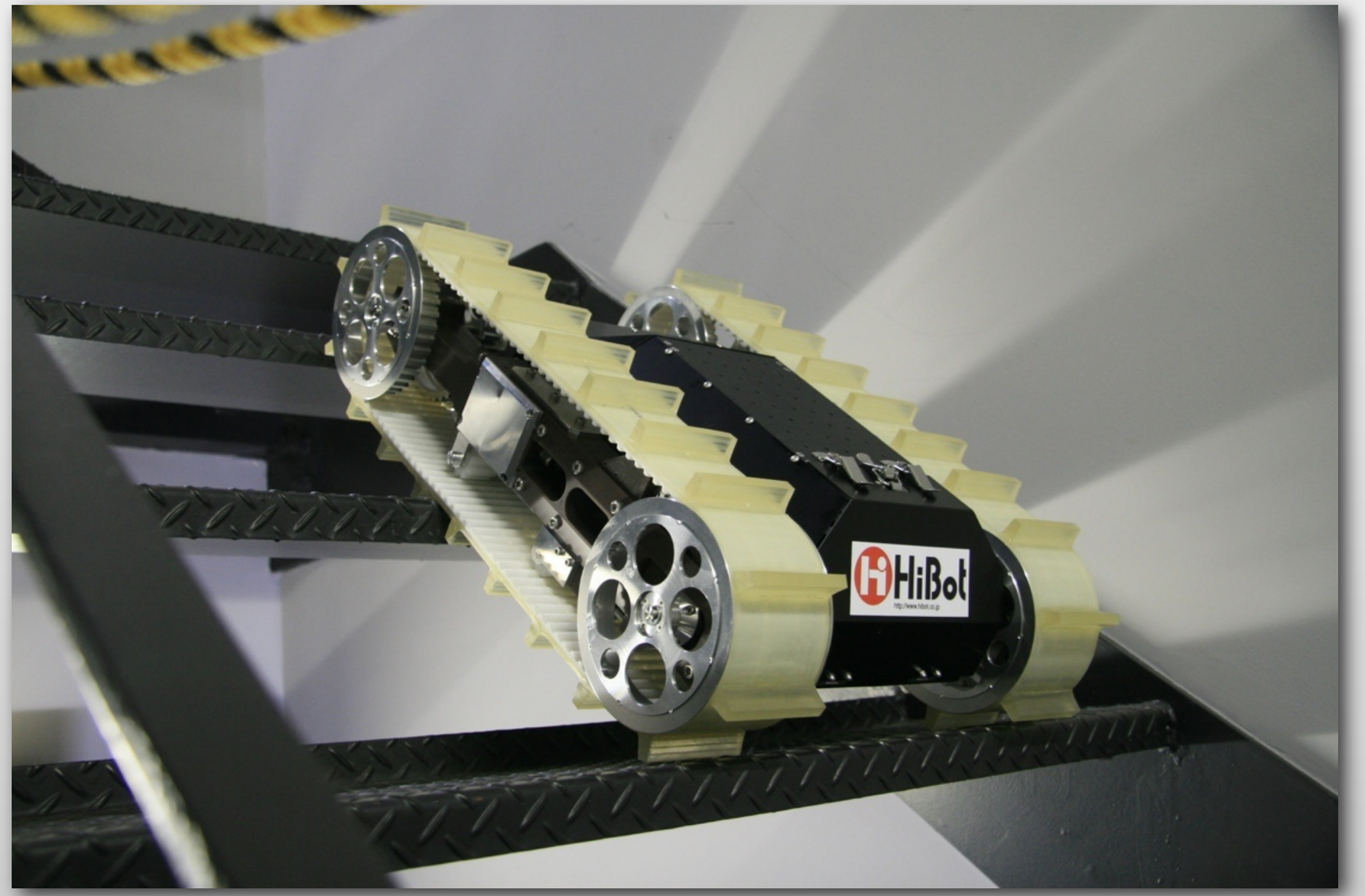
In the *C.R.A.W.LAB*

- Trossen Robotics Quadruped
  - Replacing legs with compliant versions
  - Concurrent design of the legs and jumping/running commands



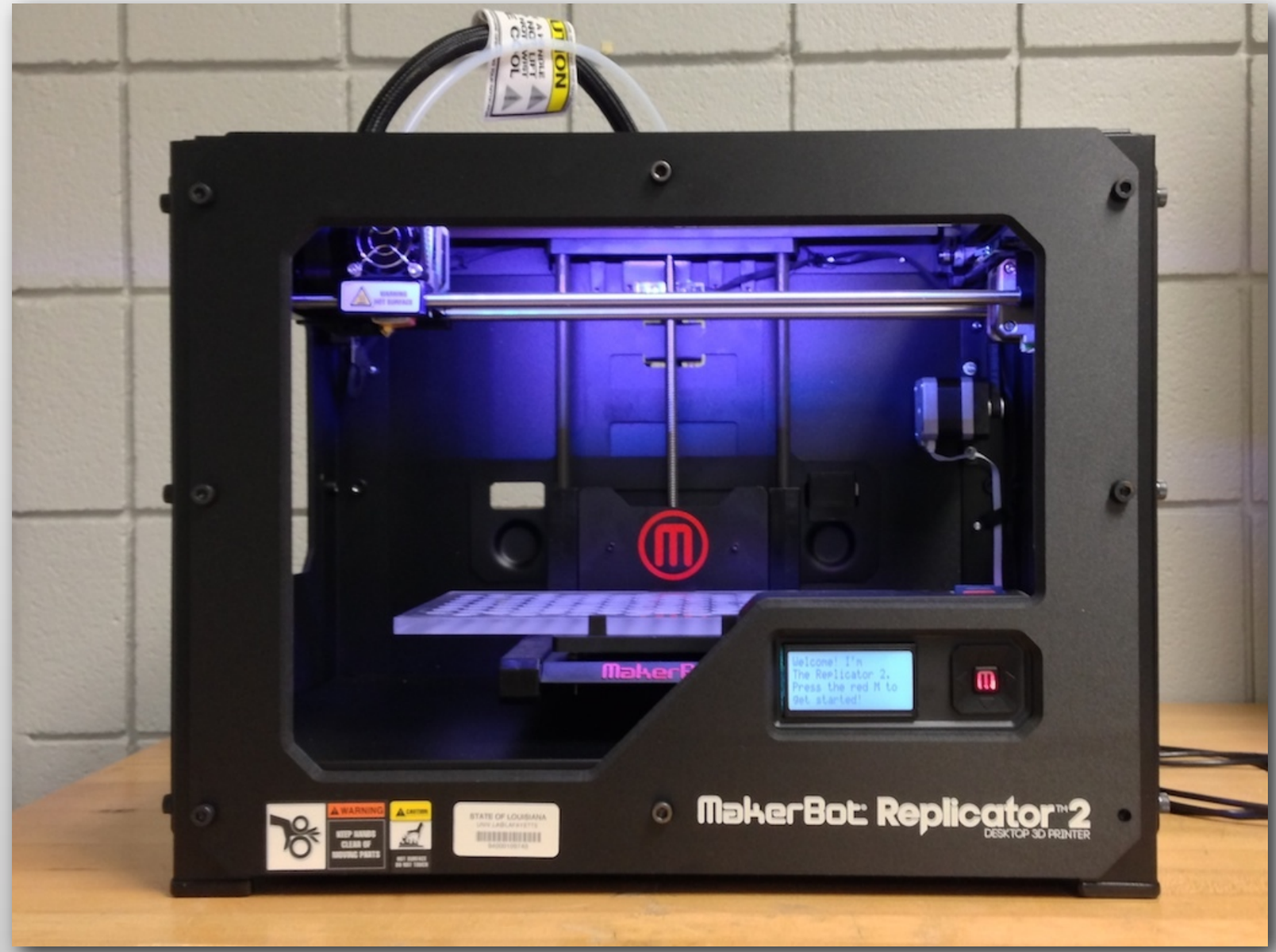
In the *C.R.A.W.LAB*

- Helios Carrier
  - General-purpose tracked carrier



In the *C.R.A.W.LAB*

- MakerBot Replicator 2
  - Desktop 3D printer
  - Prototyping of small parts



Tentative Schedule

	Tuesday		Thursday	
August	27	Course Overview and Intro	29	Arduino Intro 1
September	3	Arduino Intro 2	5	The Design Process 1
	10	The Design Process 2	12	Technical Communication
	17	Applied PID Control	19	PID Control for Vibration
	24	Command Generation	26	Input Shaping 1 - Basics
October	1	Input Shaping 2	3	Input Shaping 3
	8	**Midterm**	10	**Fall Break**
	15	Real World Sensing	17	Applied Estimation
	22	Machine Vision 1	24	Machine Vision 2
	29	PLCs with Special Guest	31	PLCs with Special Guest

Tentative Schedule (Cont.)

	Tuesday		Thursday	
November	5	Navigation 1	7	**Prelim. Competition**
	12	Navigation 2	14	Navigation 3
	19	Machine Learning 1	21	**Final Competition**
	26	Machine Learning 2	28	**Thanksgiving Break**
December	3	Human Factors 1	5	Human Factors 2
	Final Exam - TBD			

Grading

- Mini-Projects - 45%
  - 5–10% each
  - Due approximately bi-weekly
  - Electronic submission only

- Mid-Term Exam - 10%

- Final Project - 25%
  - Competition results
  - Design report

- Final Exam - 20%

General Rules/Advice

- Be responsible for your own learning
  - If you have a question, ask
  - Try to understand, not memorize

- Be respectful of yourself and others (and my robots)

Intro Modules Overview

- Arduino Intro
  - Basic Arduino programming
  - Working through the simple projects in the SparkFun kit

- The (Objective) Design Process
  - What are the *actual* requirements?
  - How do we choose the best design?

- Technical Communication

Controls Modules Overview

- PID Control
  - How do we actually apply it?
  - What are some “real world” concerns?

- PID for vibration control

- Command Generation
  - How to intelligently choose what we ask our robot to do?
  - The command matters!

Input Shaping Module Overview

- Basic Input Shaping
  - Open-loop vibration reduction magic
  - How do we use it in practice?

- Robust Input Shaping
  - What if our system parameters are changing?
  - What if we don’t know our system parameters?

- Multi-mode Input Shaping

Sensing Module Overview

- Real world sensing concerns
  - How do we deal with sensor noise?
  - What about sensor drift?

- Applied Estimation - the Kalman Filter

- Machine Vision

Advanced Modules Overview

- Navigation
- Machine Learning
- Human Factors

Before next class

- Order your kit, if you haven't already (see email for coupon code)
- Download the Sparkfun Inventor's Kit (SIK) Guide and SIK Code Library
- Download and install the Arduino Software and SIK library
  - http://arduino.cc
  - Installation explained in the SIK
- Complete the "Blinking an LED" exercise in the SIK Guide, at minimum
- Complete prereq. form and bring to next class