2013 NASA/RASC-AL Robo-Ops Competition

Midterm Report

Team Members:

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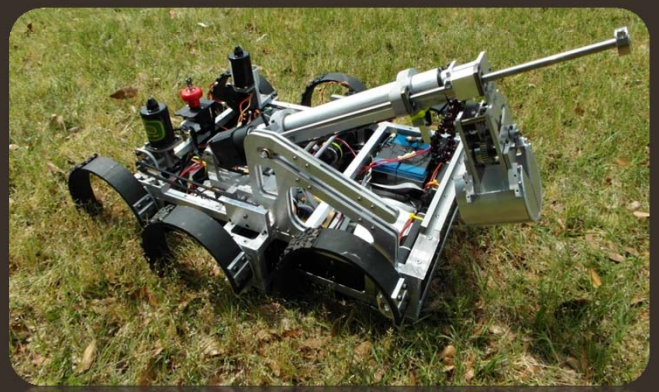
Project Overview

- Objectives
  - Build an innovative rover design capable of competing in the 2014 Robo-Ops competition
  - Capable of traversing environments similar to those on Mars
  - Tele-Operated using wireless communications
  - And Pick up brightly colored rocks using an extraction unit
- Goals for this year's platform
  - Build two smaller rovers
  - Improve Communications Design

Last Year's Platform

- Successes

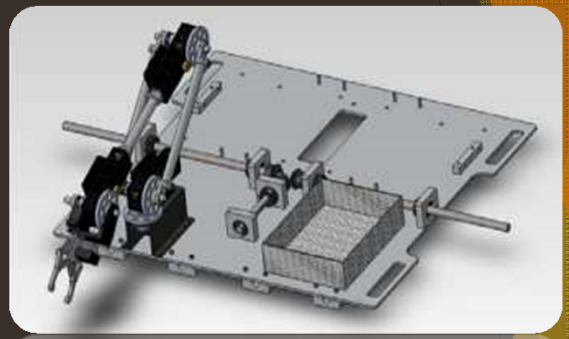
- Area's for Improvement



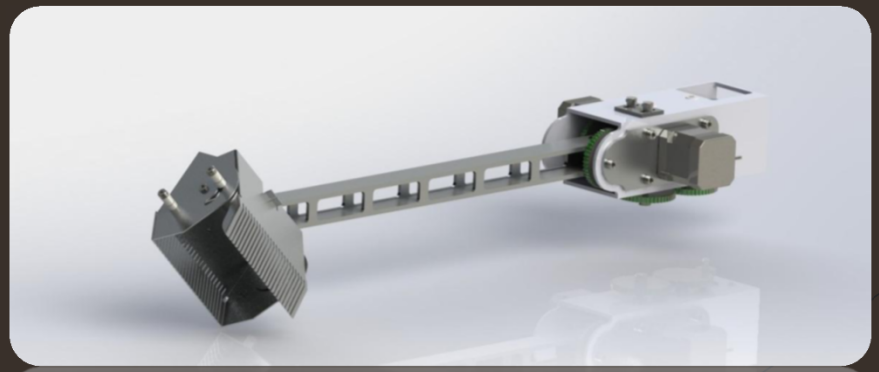
Research

- Studied previous designs from other schools
  - Worchester Polytechnic Institute (WPI)

  - California Institute of Technology (Caltech)



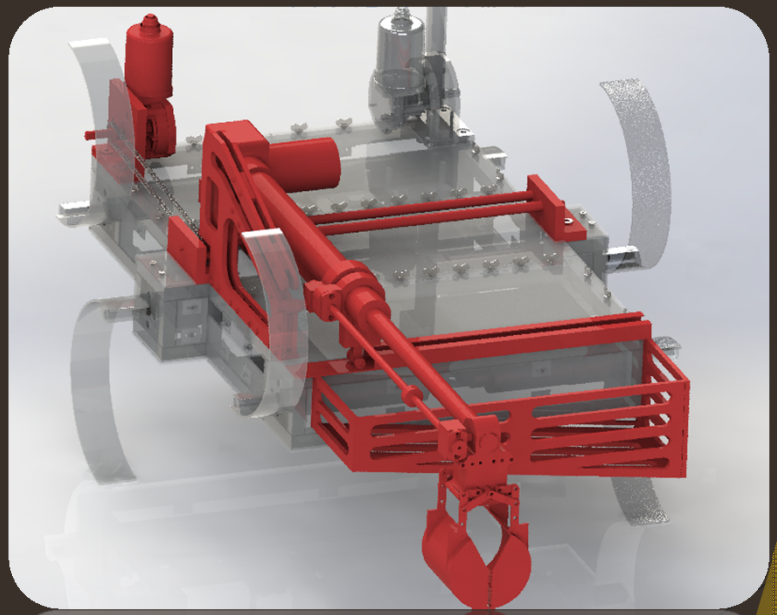
  - University of Massachusetts Lowell (U-Mass Lowell)



Design and Prototyping

Major Design Components

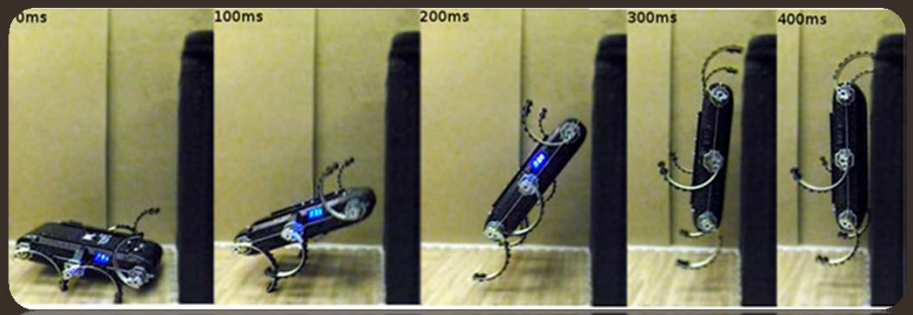
- Rover locomotion system
- Cooling system
- Extraction unit
  - Robotic arm
  - Robotic gripper



Platform for SpaceHex 2013

Rover Design

- RHex Hexapedal Robot
  - Six C-shaped compliant legs
  - Remarkable terrain capabilities
- Multiple vs. Single Rover System
  - Requirements
    - Weight <= 45kg
    - Size = 1m x 1m x 0.5m

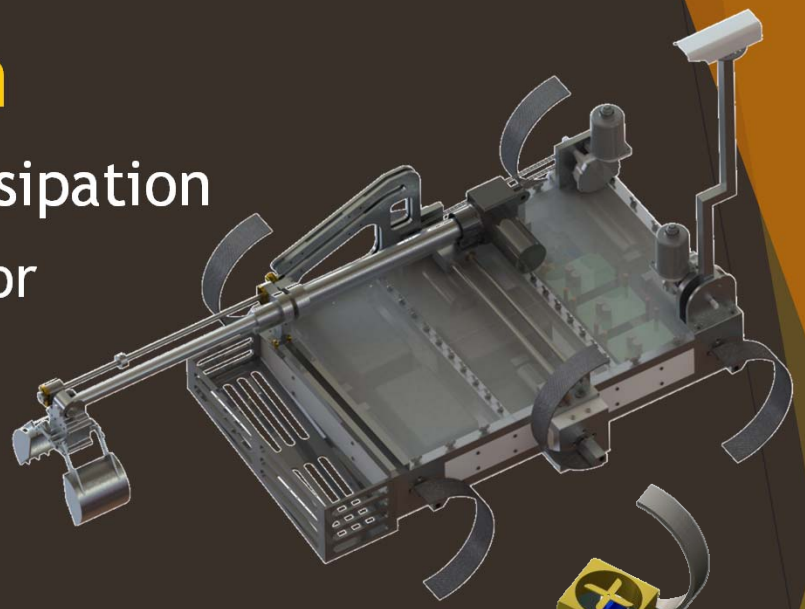


Rhex from Kod* Lab

Rhex from Boston Dynamics

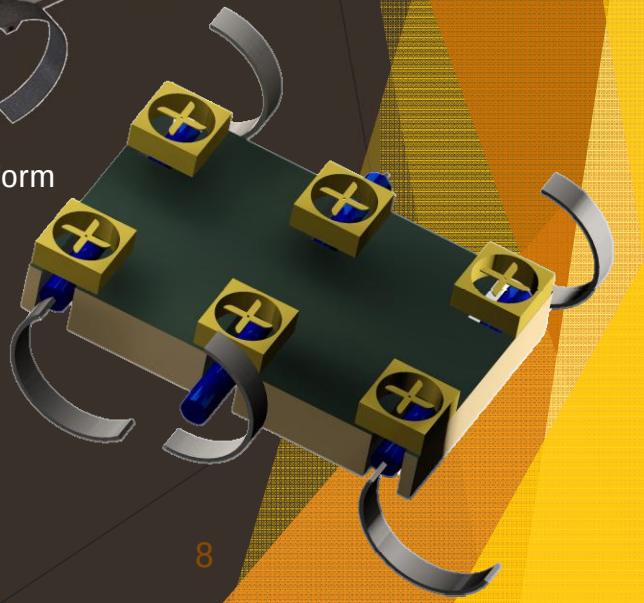
Cooling System Design

- Increase Convective Heat Dissipation
  - Modify frame to expose motor
  - Increase air flow
  - Minimize sand infiltration



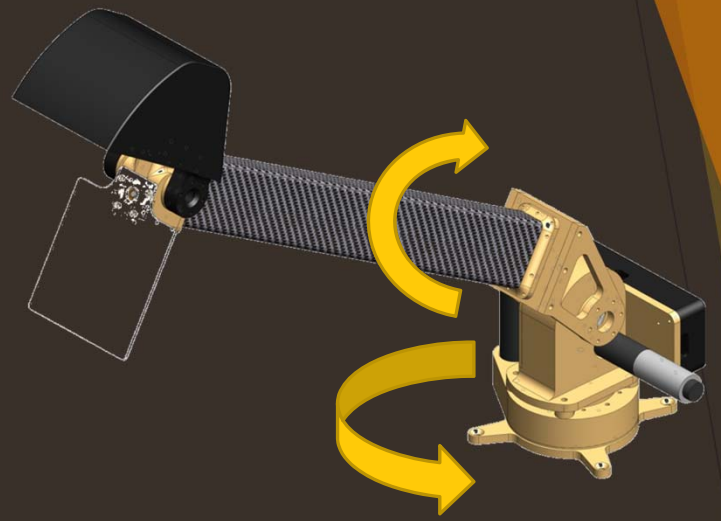
- Liquid Cooling System
  - Proven to increase heat dissipation
  - Enclosed system – eliminate sand infiltration
  - Disadvantage: expensive, weight

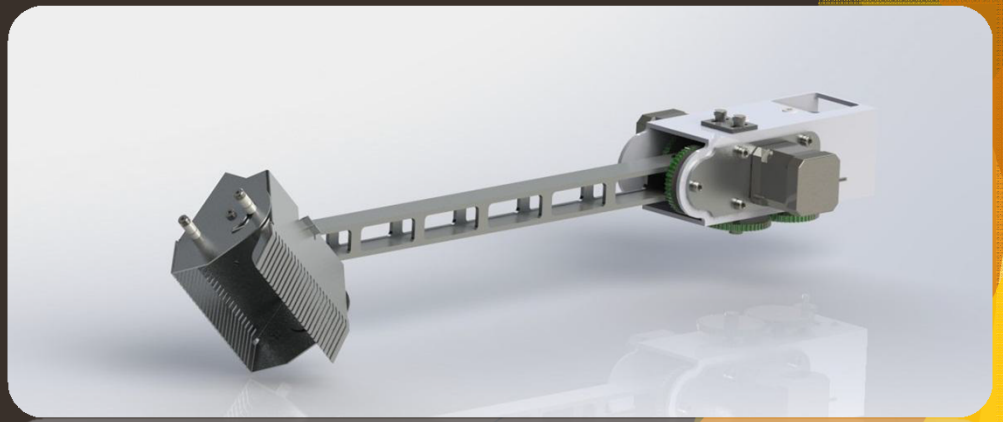
SpaceHex - Enclosed platform



Extraction Arm Design

- **Low degree of freedom (2 DOF)**
  - Roll-Pitch motion
  - Advantages:
    - Simple control
    - Light weight
  - Disadvantages:
    - Small ground coverage
    - Require translational adjustment from the rover platform





2 DOF Extraction Arm Modules

Extraction Arm Design

- **Multi-degree of freedom (3+ DOF)**
  - Roll-Pitch-Pitch motion
  - Advantages:
    - Great ground coverage
    - Good extraction angle
  - Disadvantages:
    - More complex control
    - Potentially heavier
    - Usually slower than low DOF arms

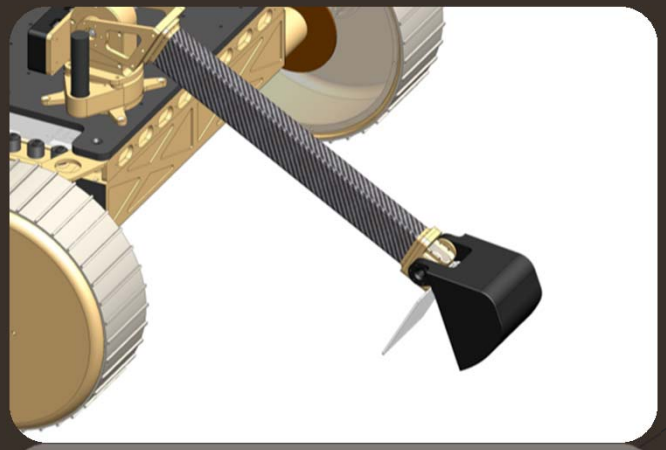
Multi-DOF Arm Modules

Initial Arm Module CAD Design

Extraction Gripper Design

- Pincher Gripper
  - Precise
  - Orientation sensitive
  - Complex control
- Scooper
  - Low precision requirement
  - Simple mechanism
  - Large contact area
- Compliant Gripper
  - Strong shape/orientation adaptation
  - High power consumption

Pincher Gripper



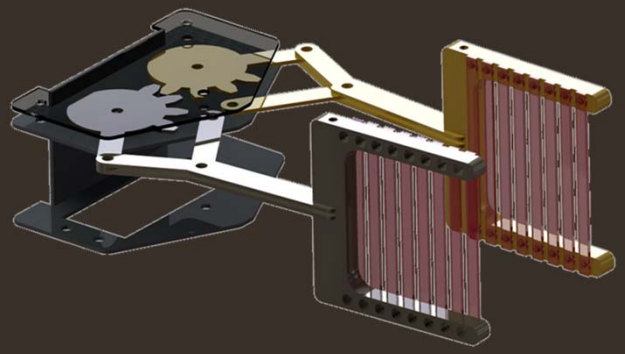
Scooper

Universal Gripper

Extraction Gripper Design

- Elastic Pincher
  - Two pronged pincher design
  - Elastic material end effector conforms to sample shape
  - Balance between precision and traction

First Generation Prototype



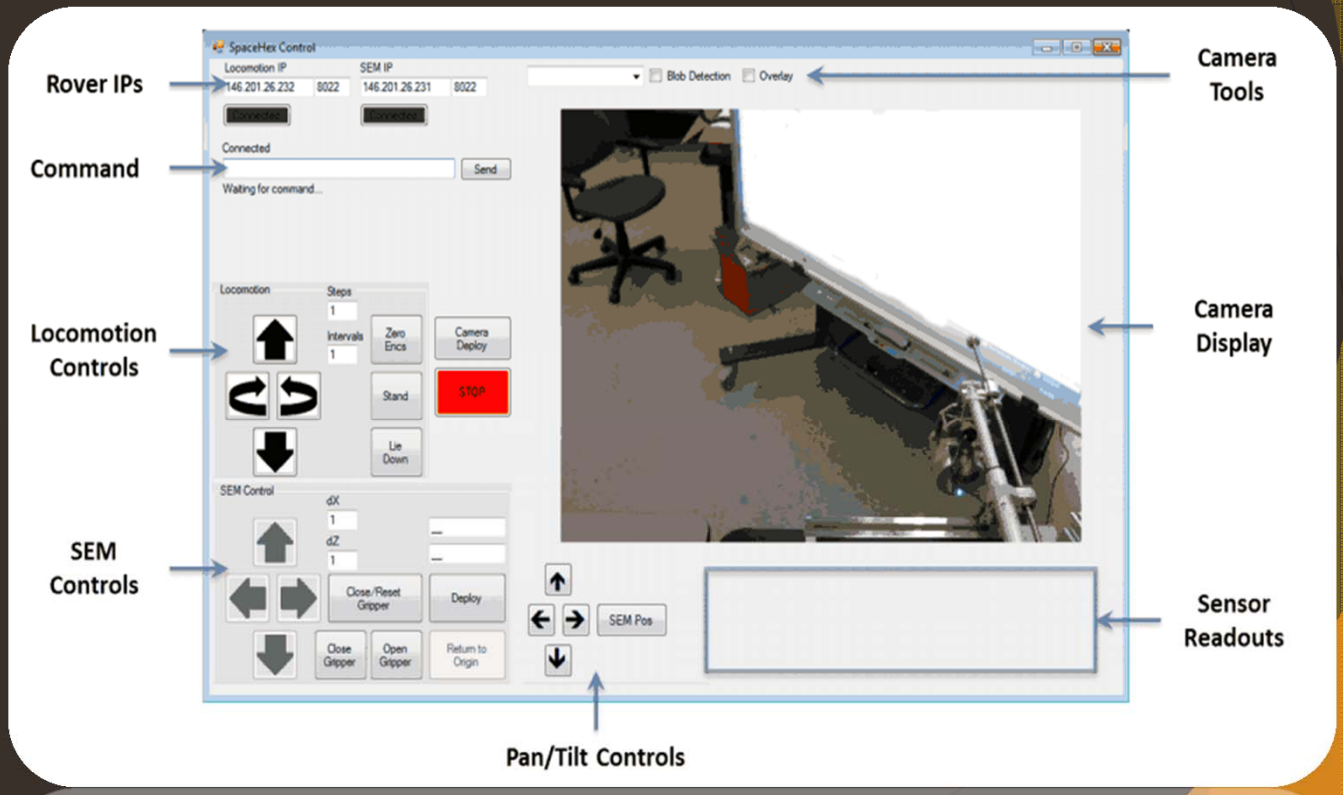
Second Gen. Prototype CAD Model

Second Generation Prototype

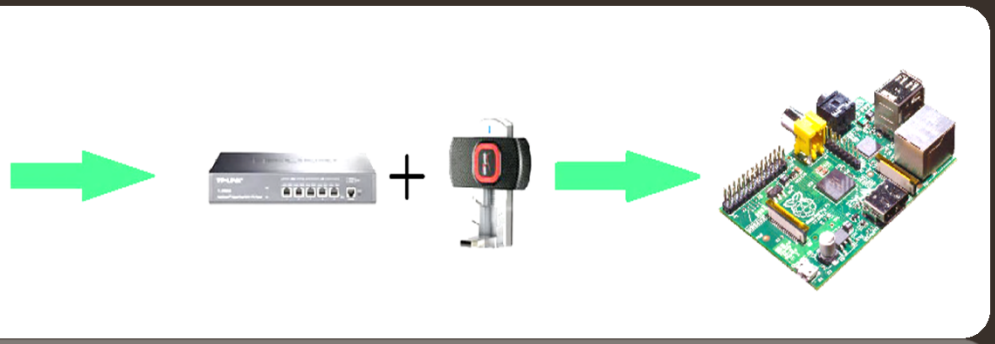
COMMUNICATIONS AND CONTROLS

GUI

- Lots of input information needed from user
  - Look to make more user friendly



Communication Layout



- User Routers with more Bandwidth
- Upgrade from 3G to 4G
  - Verzion 4G up to 8 times faster than 3G
- Use AT&T's 4G Network as Backup for redundancy

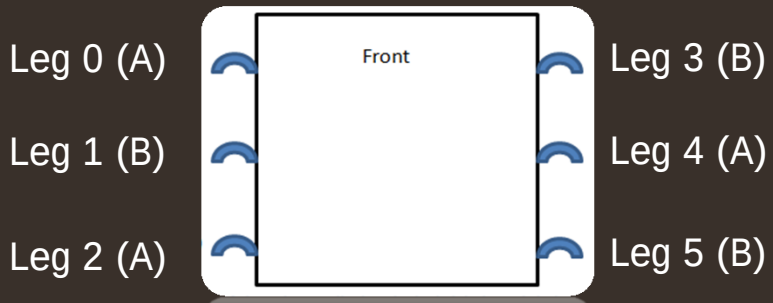
Left: Type G Router Right: Type N Router

Verizon 4G USB Stick

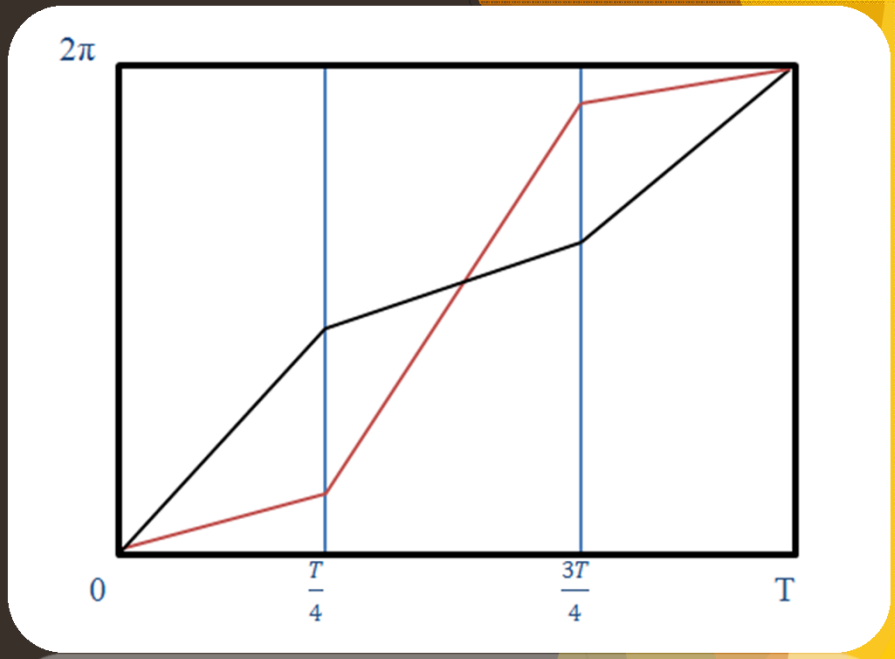
AT&T 4G USB Stick

Control Development

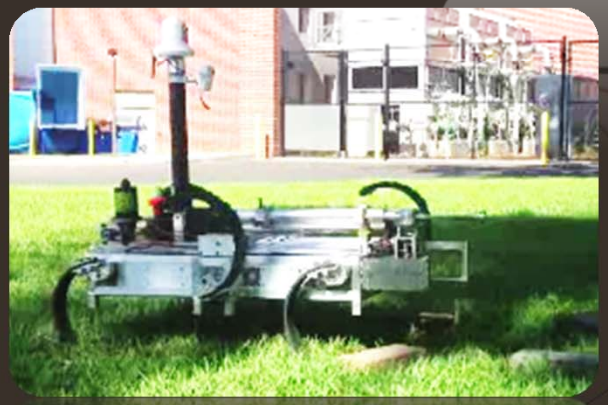
- Buehler Clock Locomotion



- Turn While Walking



- Turn While Climbing



Advanced Controls

- "Lay-Down-Nudge" Function

- Operation through Gaming Controller

THANK YOU

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