Project Overview for MEAC

RASC-AL RoboOps Competition

Team 11: Hexcavator

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The Task

- Planetary Rover
- Capable of collecting rock samples
- Controlled over wireless broadband network
- Limited size and weight
- Handle various terrain

Competition Site:
Johnson Space Center Rock yard

Our Solution

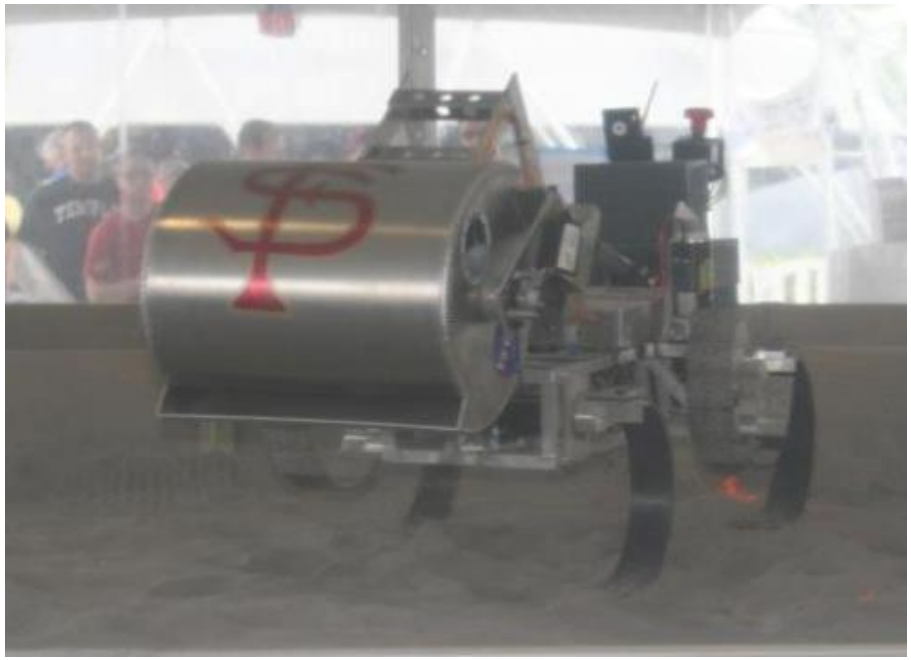
- Hexapedal locomotion
- Optimized sample extraction
- On-board computing

Competition Entry

- **Limited participant slots**
  - **Project proposal due December, determines eligibility**
  - **Up to 8 teams may compete**
  - **Accepted teams receive NASA funding**

Contingency Plan

- **Hexcavator**
  - **2012 Lunabotics competition entry**
  - **Same type of rover**
  - **Uses similar hardware**
  - **Test-bed for current systems**



Public Outreach

- NASA wishes to increase public interest in space exploration
  - Educational events
  - Team website
  - Social media
  - Video reports and documentation of progress

Planned E/PO

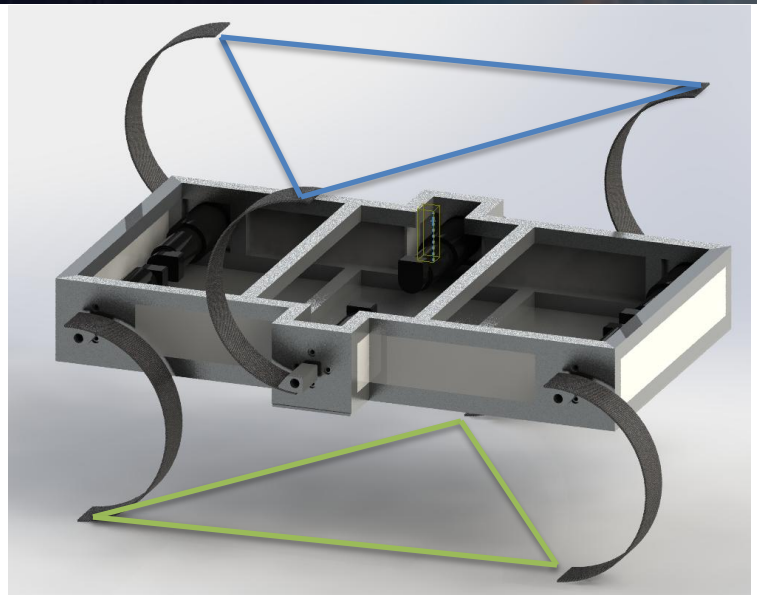
- Challenger Learning Center Demo
- Elementary School Visits
- Like us on facebook!
  - FAMU-FSU Robo Ops

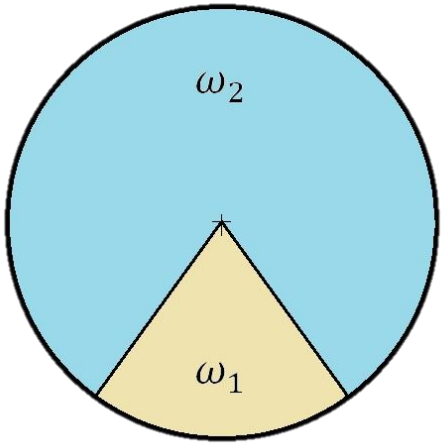
Hexapedal Locomotion

- **Advantages:**
  - **Has been proven in a wide range of terrains**
  - **Negates need for obstacle avoidance**
- **Unique to the RASC-AL ROBO-OPS Competition**

Locomotion – How it works

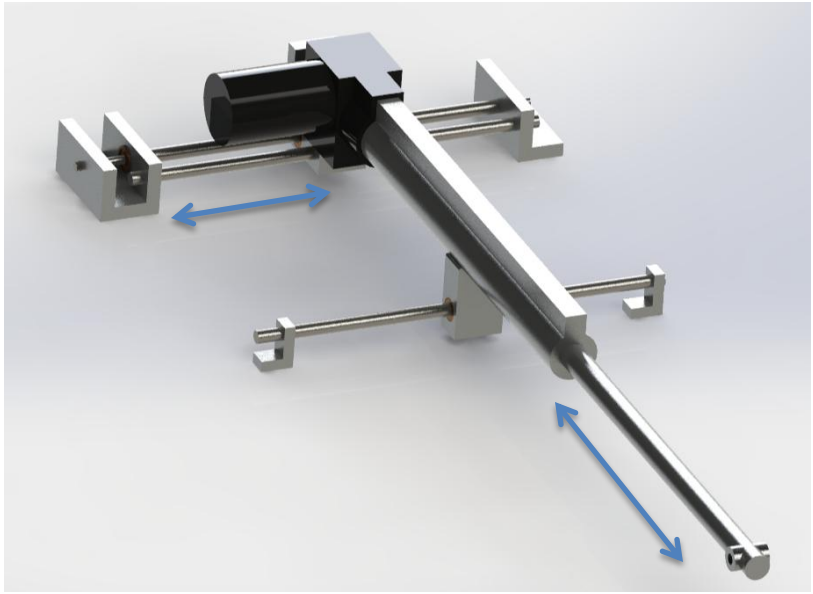
- Legs controlled in triplets
- Buehler Clock





Sample Extraction

- **Planar Arm**
  - **Two linear axes**
  - **Legs provide vertical adjustment**

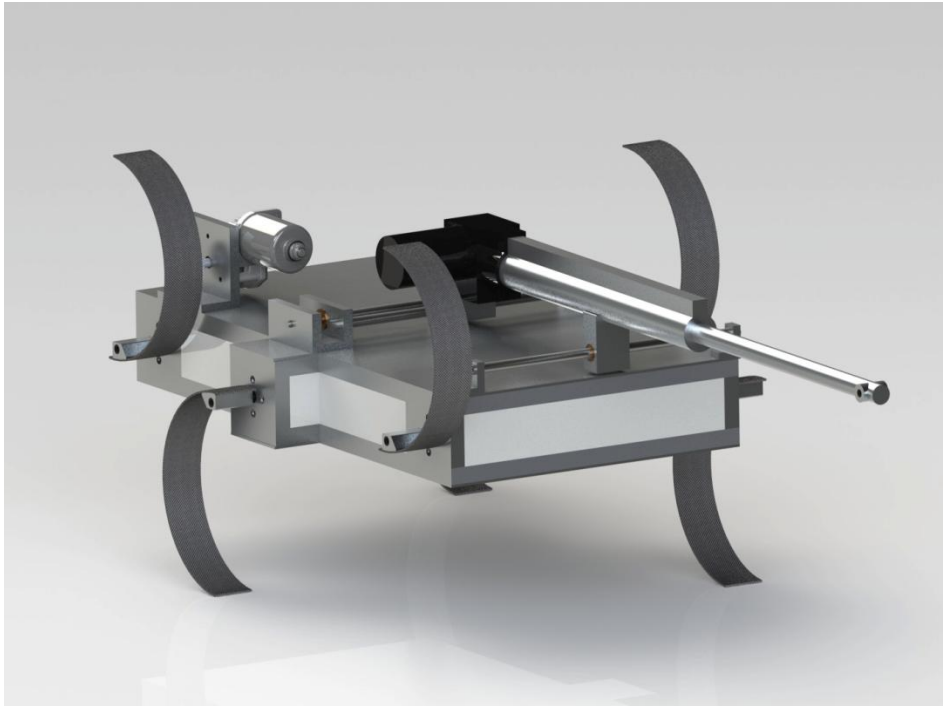


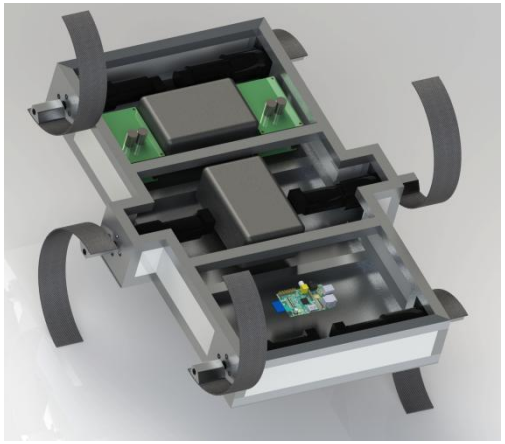
Sample Extraction (cont.)

- **Pincer/Scoop Hybrid Claw**
  - **Combines speed and precision**
  - **Servos for simple control**
  - **Features to enhance effectiveness**
    - **Viewing window, teeth, slots**

Design Validation - Modeling

- Complete CAD Model
- Layout
- Center of Gravity
- Moment of Inertia

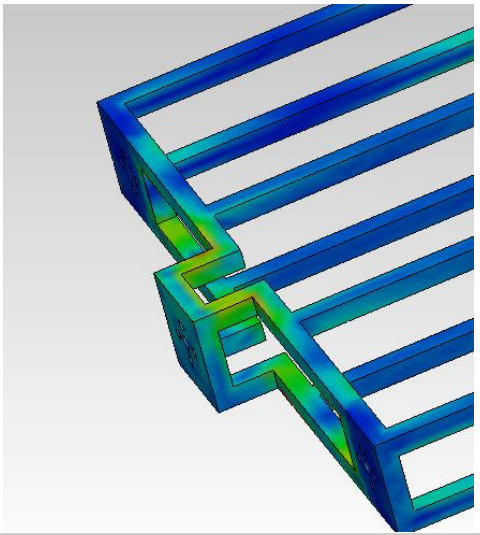


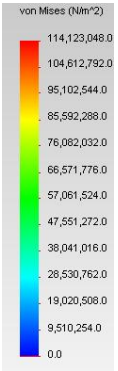


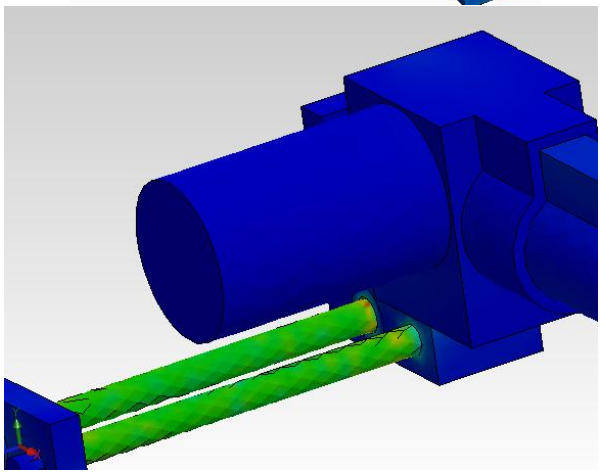
Design Validation - Finite Element Analysis (FEA)

- Keeps weight to a minimum
- Ensures proper factor of safety

- FEA done on:
  - Frame
  - Linear Supports for Arm

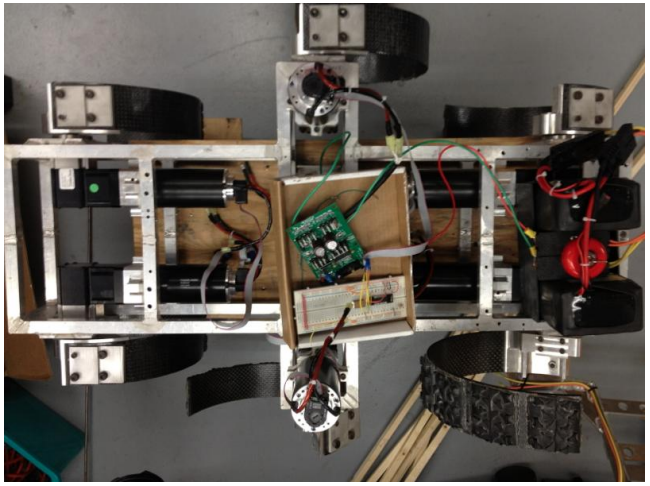


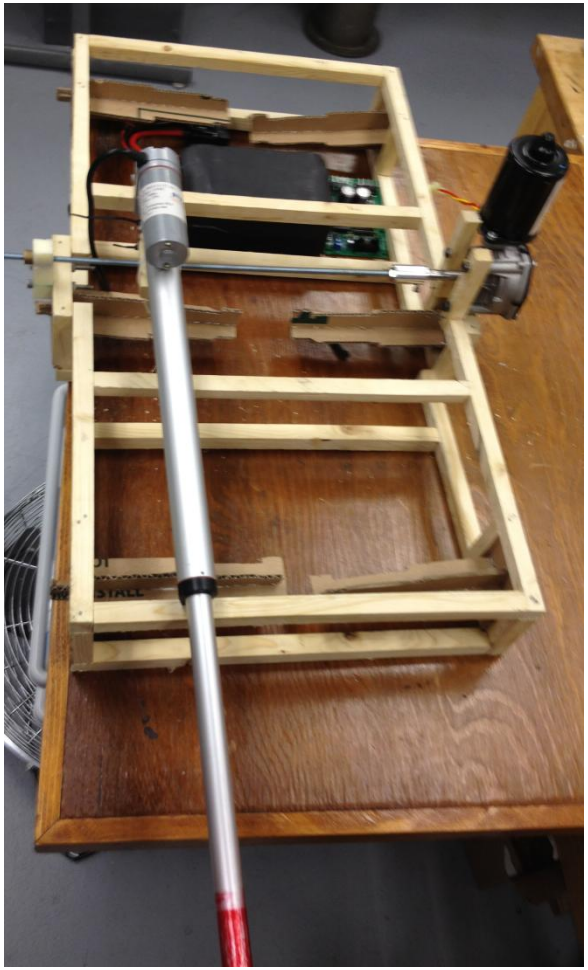




Design Validation - Prototyping

- Frame
- Arm/Gripper
- 2012 Lunabotics Platform





Vision System

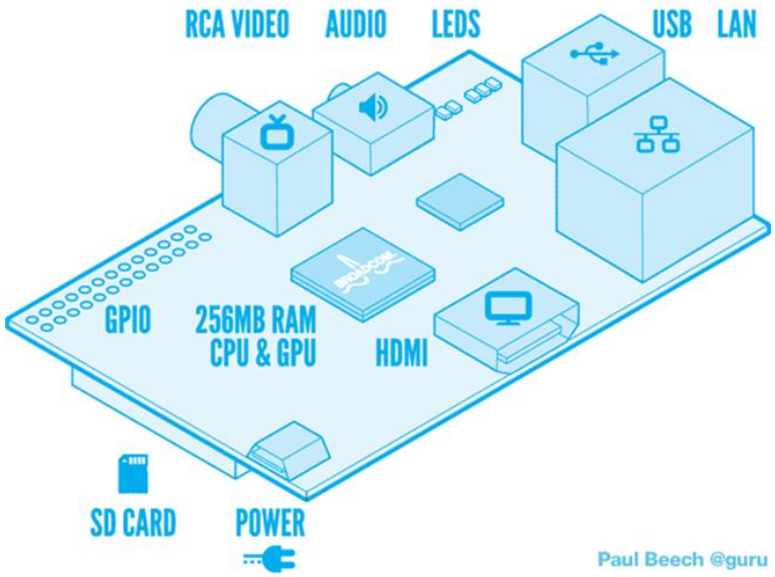
- **Navigation camera**
  - **Boom mounted pan/tilt Internet Protocol camera**
- **Sample extraction camera**
  - **Webcam fixed to arm**

Communications

- On board communications
  - Raspberry Pi is interfaced with peripherals (motors, sensors, decoders) using SPI (Serial Peripheral Interface)
- Wireless communication
  - Robot network connected through 3G/4G USB network adapter
  - SSH used to control on-board computer

Computing

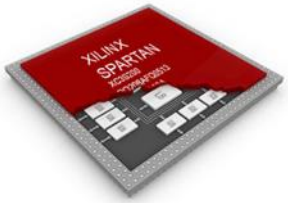
- **Control Requirements**
  - Wireless connectivity
  - Video streaming/processing
  - Motor control
    - Buehler algorithm
    - Pulse width modulation
    - Quadrature decoders
- **Need on-board computer**

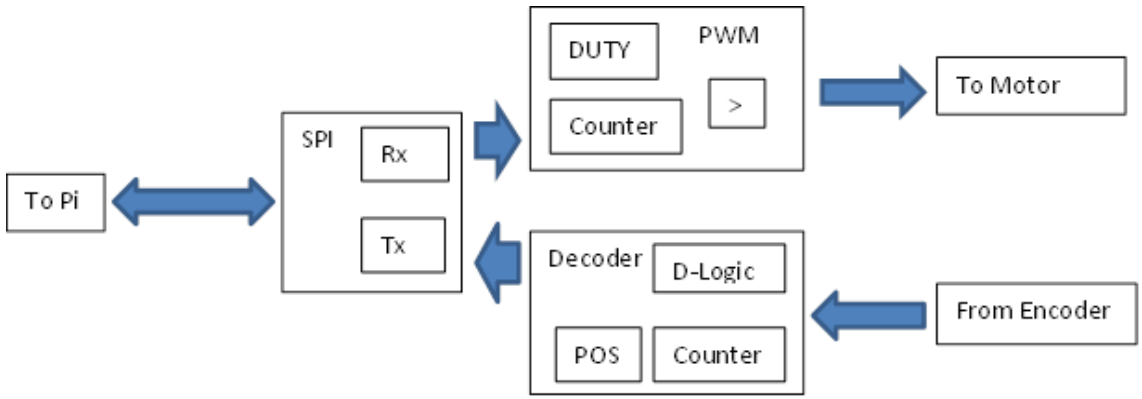


Raspberry Pi (Linux)

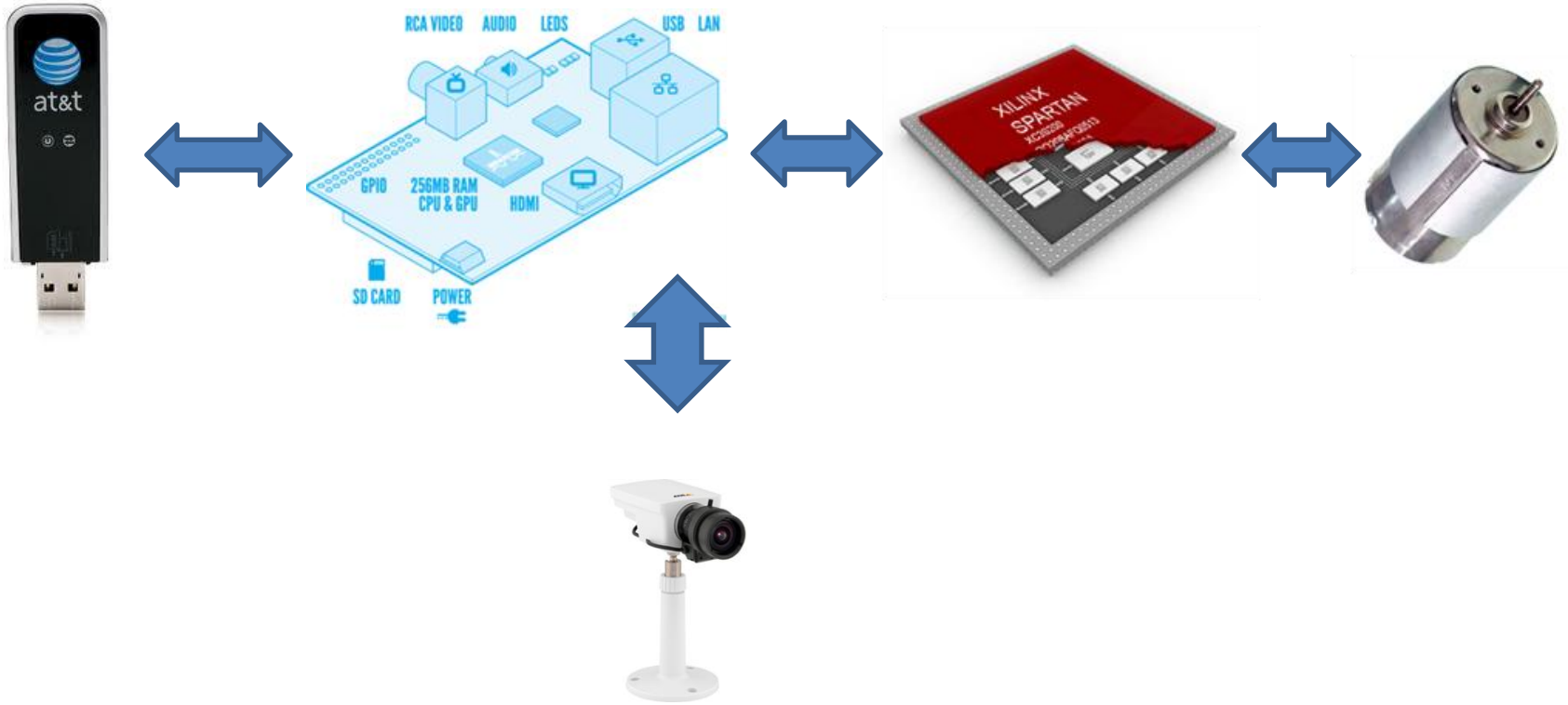
Controls Hardware

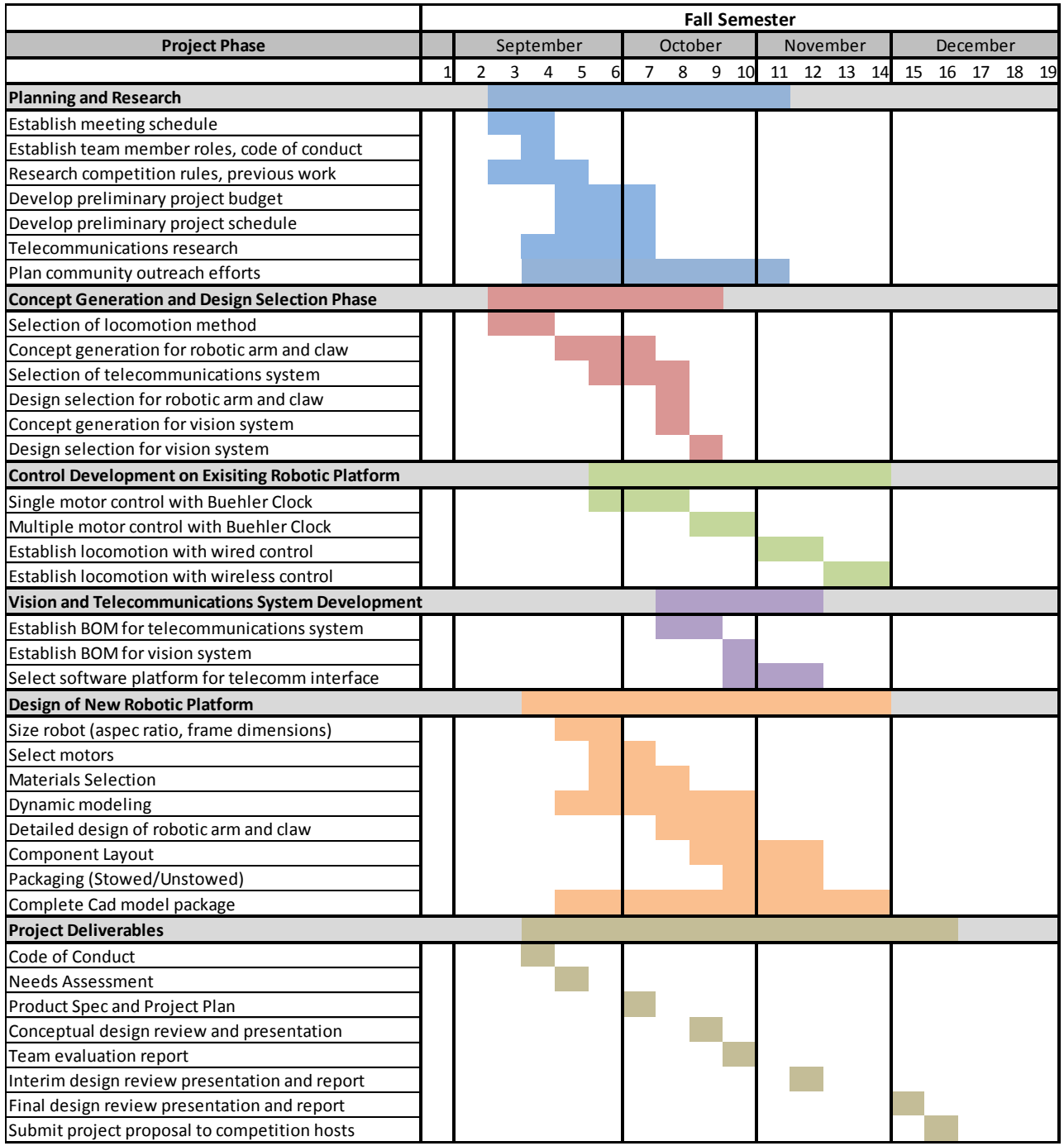
- Need minimum 6 PWMs and decoders
- Designing Hardware with VHDL (VHSIC Hardware Description Language)
  - Provides customizable logic
- Xilinx Spartan 3E





Control System Diagram




Fall Semester
Project Phase
September
October
November
December
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Planning and Research
Establish meeting schedule
Establish team member roles, code of conduct
Research competition rules, previous work
Develop preliminary project budget
Develop preliminary project schedule
Telecommunications research
Plan community outreach efforts
Concept Generation and Design Selection Phase
Selection of locomotion method
Concept generation for robotic arm and claw
Selection of telecommunications system
Design selection for robotic arm and claw
Concept generation for vision system
Design selection for vision system
Control Development on Exisiting Robotic Platform
Single motor control with Buehler Clock
Multiple motor control with Buehler Clock
Establish locomotion with wired control
Establish locomotion with wireless control
Vision and Telecommunications System Development
Establish BOM for telecommunications system
Establish BOM for vision system
Select software platform for telecomm interface
Design of New Robotic Platform
Size robot (aspec ratio, frame dimensions)
Select motors
Materials Selection
Dynamic modeling
Detailed design of robotic arm and claw
Component Layout
Packaging (Stowed/Unstowed)
Complete Cad model package
Project Deliverables
Code of Conduct
Needs Assessment
Product Spec and Project Plan
Conceptual design review and presentation
Team evaluation report
Interim design review presentation and report
Final design review presentation and report
Submit project proposal to competition hosts

Completed Phases

- Research
  - XRL, NASA, Hexcavator, 2011-2012
- Product Specification
  - Rules
- Concept Generation
  - Manipulator, Chassis, Vision, Computing
- Feasibility assessment
  - Costing, Sponsorship, Components

Current Phase

Currently Undergoing Preliminary Design

- Refining sample acquisition system
- Refining chassis design per motor selection
- Integrating motor controller with computing hardware
- Testing control algorithms
- Selecting cameras and establishing configuration for vision system
- Drafting proposal for NASA

Sponsorship

Sponsor	Donation
Florida Space Grant Consortium	$1000 Grant
Scansorial and Terrestrial Robotics and Integrated Design Lab	Laboratory space and use of tools
Center for Intelligent Systems, Controls and Robotics	$3000 Grant
MISUMI USA	$1,300 Store Credit
Progressive Automation	Linear Actuator
Maxon Motors	40% off MSRP
Solidworks	6 Licenses

Goals

Fall 2012

- Establish communications
- Develop control algorithms to get Hexcavator walking
- Finalize design
- Gain entry into competition

Spring 2013

- Manufacture rover (Jan.-Feb.)
- System tests (Mar.-May)
- Refine locomotion
- Compete
- Win!