2014 NASA/RASC-AL Robo-Ops Competition

Fall Final Presentation

Team 11 Members:

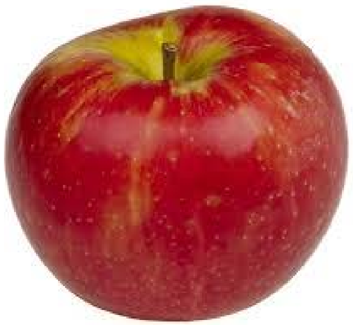
Boris Barreto	-	Electrical and Computer Engineering
Jason Brown	-	Mechanical Engineering
Justin Houdeshell	-	Mechanical Engineering
Linus Nandati	-	Electrical Engineering
Tsung Lun Yang	-	Mechanical Engineering

Team 11 Advisors:

Dr. Jonathan Clark – Mechanical Engineering
Dr. Uwe H. Meyer-Baese – Electrical Engineering

Competition Requirements

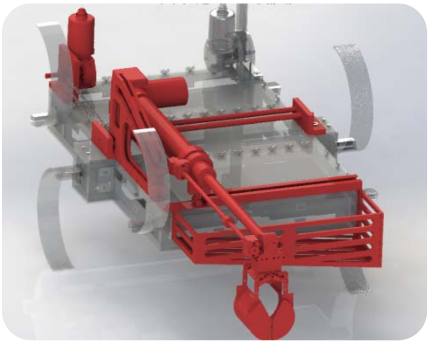
- Rover Physical Constraints
  - No larger than 1m x 1m x 0.5m
  - Less than or equal to 45kg.
    - Lowest Weight Goes Last in Competition
  - Traverse over obstacles up to 10cm in height.
  - Pick up rocks ranging from 2 to 8 cm in diameter and masses ranging from 20 to 150 gm.
  - The rover(s) will be controlled remotely based from the home campus of the university



Jason Brown

Project Scope

- While goal was to create own platform
  - Produce multiple smaller versions of previous year's platform
  - Previous design fully functional and locomotion performed exceptionally well
- Past Year's Performance 4 Areas for development
  - Sample Extraction Module
  - Gripper Mechanism
  - Controls
  - Communications



- Design scale models to develop programming and test design viability

Jason Brown

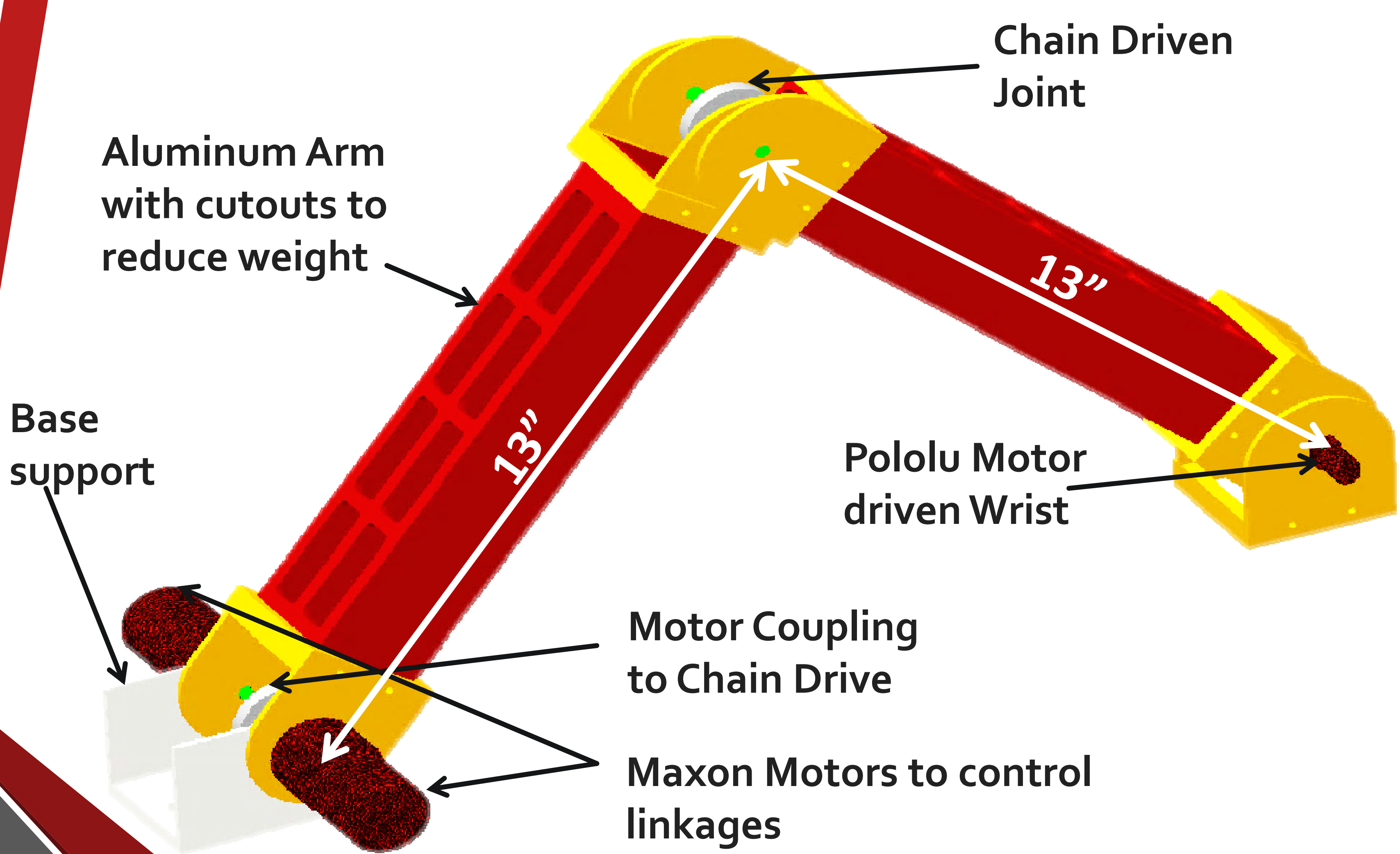
Breakdown of Project Plan

- Prototype Design Ideas
  - Arm
  - Gripper
  - Locomotion Control Development and Testing
  - Communications Design and Testing

- Have some additional plans if accepted into Competition
  - Improved Chassis (Reduce weight by 2kg)
  - Arm Design(Reduces weight by 4 kg, but could be reduced further)

Jason Brown

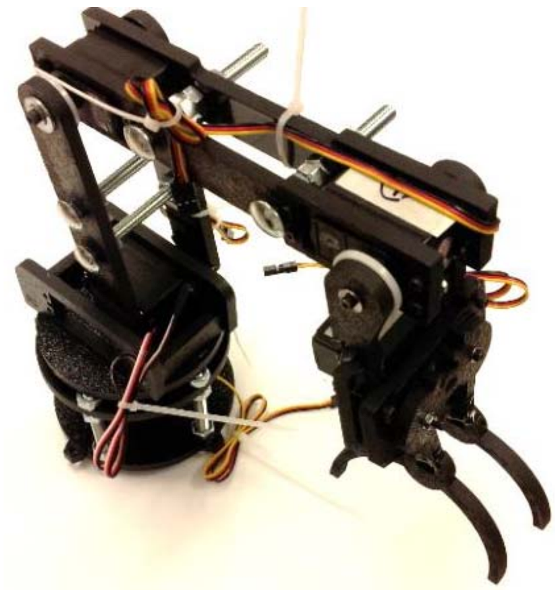
Extraction Arm



Justin Houdeshell

Extraction Arm

- Five-degree of freedom (3 Arm DOF)
- Initial Goal 3 feet Reach
  - Determined Reach Unnecessary
  - Base Motor Struggled
  - Redesigned to reduce weight away from base
  - Designed for minimal deflection
    - Important for control



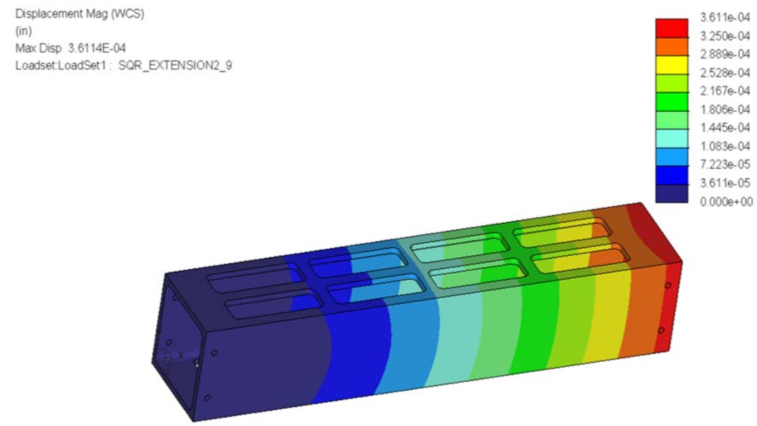
Initial Design Prototype

Initial Arm Module CAD Design

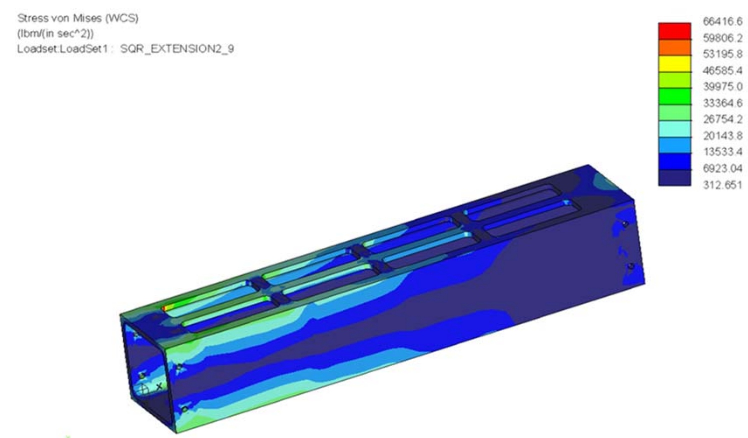
Justin Houdeshell

Link Material and Configuration

- Workspace of 2 feet in front of the rover balanced weight and reach
  - Flexibility in rover placement while acquiring samples
  - Requires more powerful motors
  - This set link length of slightly over one foot
- Determined Aluminum 6063 suitable material
  - Deflection was calculated with approximate load of 2.5 lbf
  - Also performed Stress analysis to ensure sample would not fail



7.5 in^3 (slightly more volume)
Displaced .000 36 in (half of the smaller beam)



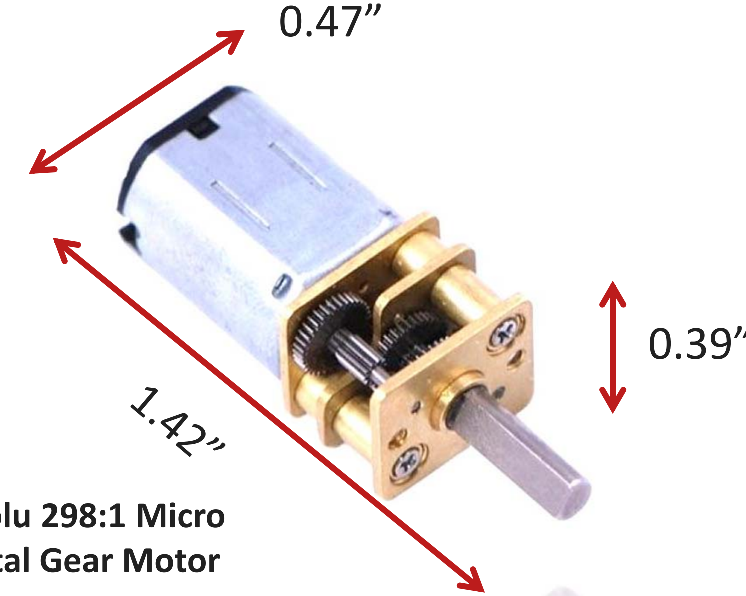
2”x2”x0.125” x 10.5”

Justin Houdeshell

Motor Selection for Arm

- Selected Maxon Motor with 113:1 gearbox for the base joint and elbow joint
  - Weight: 480 grams for motor
  - Output Torque: 15 Nm
- Selected Pololu 298:1 Micro Metal Gearmotor for wrist and gripper actuation
  - Weight: 10 grams
  - Torque: 6.5 kg-cm
  - 1.42" x 0.39" x 0.47"

RE 40 Ø40 mm, Graphite Brushes, 150 Watt Maxon Motor



Pololu 298:1 Micro Metal Gear Motor

Justin Houdeshell

Extraction End Effector

Scooper Design

- Large contact area
- Simple control

Worcester Polytechnic Institute

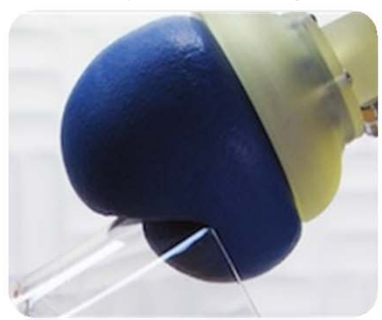
Pincher Design

- Precise
- Orientation sensitive

West Virginia University

Compliant Design

- Strong shape/orientation tolerance
- High power consumption



University of Chicago

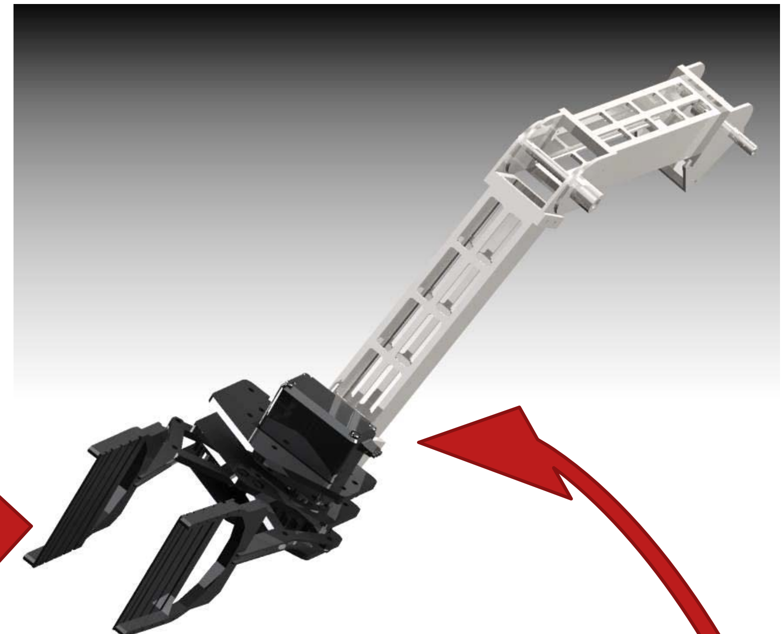
Elastic Pincher Design

3rd Generation Prototype

Tsung Lun "Chris" Yang

Extraction End Effector

- Elastic Pincher
  - Two pronged pincher design
  - Passive elastic material end effector conforms to sample shape
  - Size:
    - L 23 cm x W 14cm x H 14 cm
    - 10 cm x 10 cm opening
- Components:
  - 298:1 Pololu Motor
  - Silicon Rubber for Gripper Material
  - ABS Plastic for the Frame



3rd Generation Elastic Pincher

Silicon Rubber

298:1 Pololu Motor

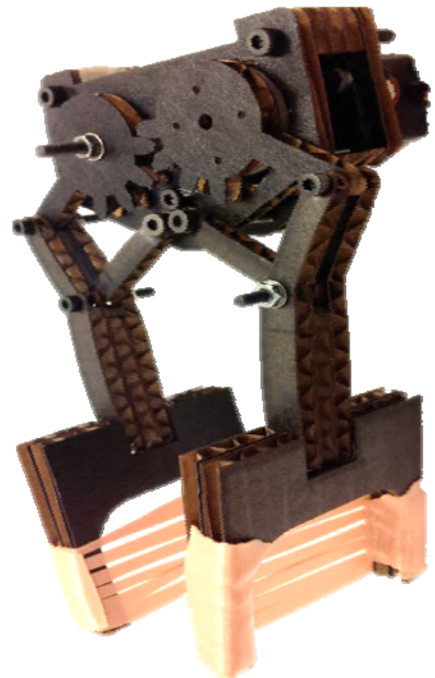
Tsung Lun "Chris" Yang

Extraction End Effector Prototype

1st Generation Prototype

- Elastic material viable
- Improve linkage mechanism

2nd Generation Prototype



- New elastic material: First Aid tape
- Increase elastic surface area

3rd Generation Prototype

- Mars suitable elastic material finalized: Silicone Rubber
  - Temperature range: -120C to 300C

Tsung Lun "Chris" Yang

Control Development

- Buehler Clock Locomotion

- Turn While Walking

- Turn While Climbing

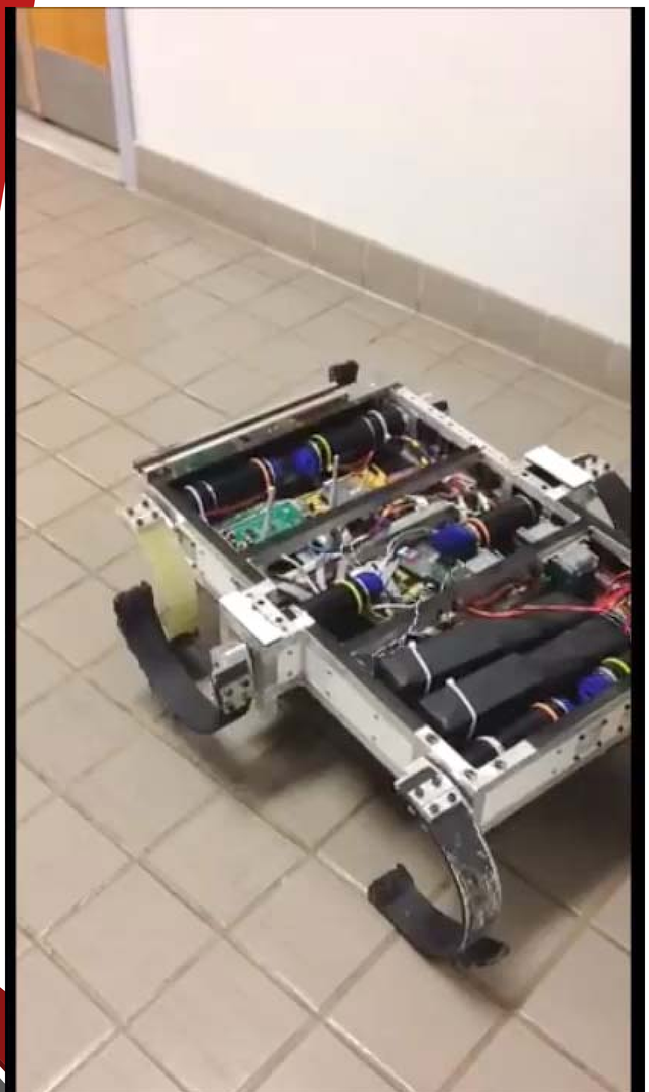
Boris Barreto

Advanced Controls

- “Lay-Down-Nudge” Function
- Operation through Gaming Controller

Boris Barreto

Motivation



Boris Barreto

XPadder and SDL

- Xpadder is a software application which emulates a computers keyboard using any controller.
- Once the controller is mapped to the keyboard, the program must be able to interact with it.
- SDL is a predefined C library which provides keyboard input to a program and event handling.

SDL
Simple Directmedia Layer

Boris Barreto

XBOX Controller Mapping

- Gaming controllers excel at giving the users a huge range of control while staying intuitive

Triggers will control speed

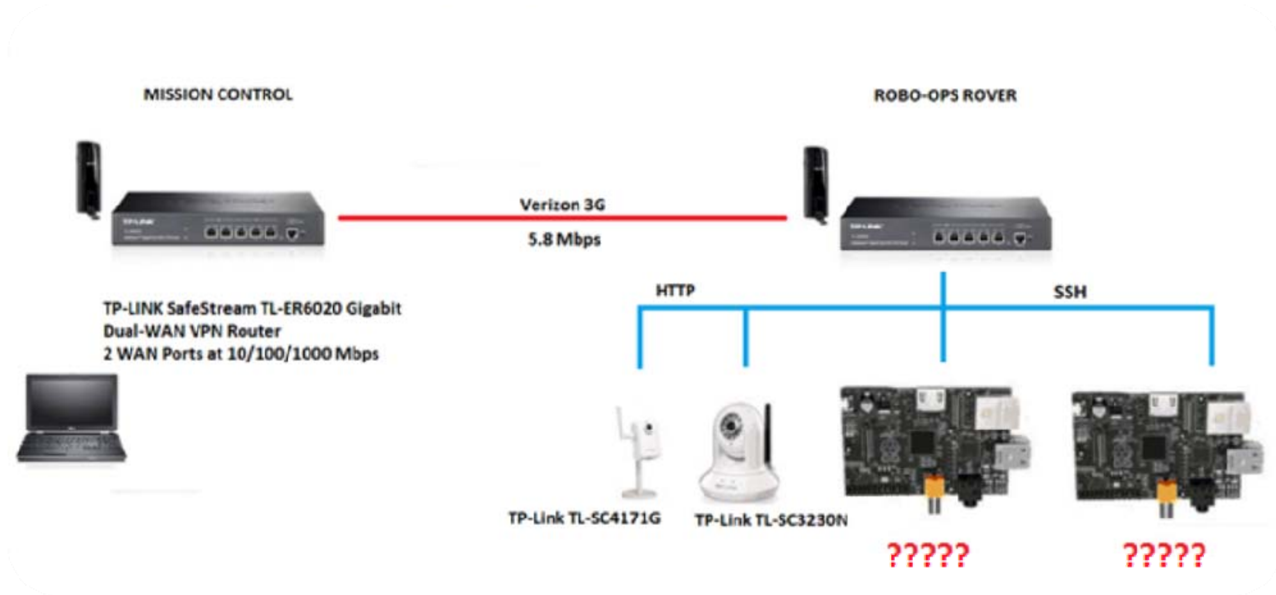
Bumpers will control turn (while walking) angle

Left joystick will move forward, backwards, left and right

Buttons will control simple commands such as stand/Lie down

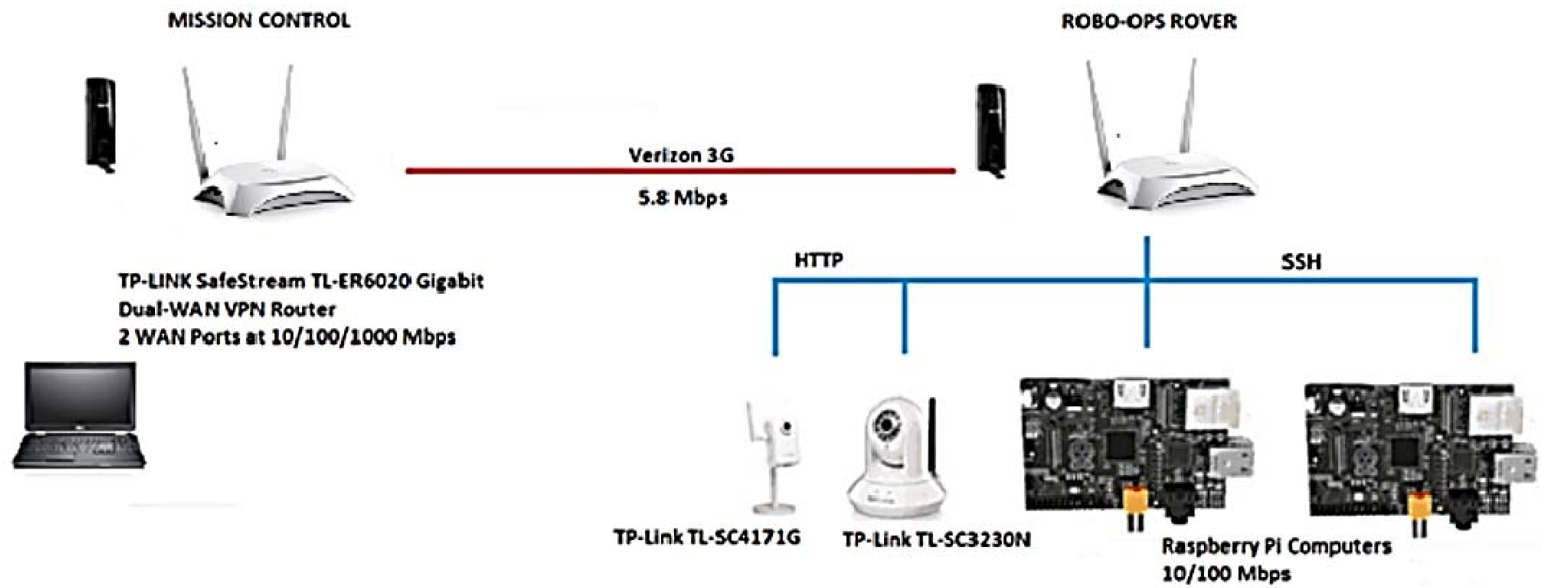
Right joystick will control Arm

Communications and Network



Linus Nandati

Existing Design



- 10/100 Mbps ports limiting
- Upload speed to WAN from LANs does matter
- Data processed and transferred in WAN different than LAN
- Testing to do before December
  - If not sufficient, changes to be made

Upgrades

1. Network Upgrade
   -redundancy of Networks

2. Router Upgrade
   -VPN Security and Client Mode
   -DPNS enabling

3. Mini Computer Upgrades

Bandwidth Issues

- Typical 480p hour long video is 300 MB
  - Or 2400 Mbits

- 2 Video feeds and controls

- Larger Bandwidth beneficial, issues also arise with router capabilities

Procurement

Sponsor	**Amount Pledged**	**Note**	**Use for Sponsorship**
Misumi	$2,000	"In Kind" sponsorship	Mechanical Components for Sample Extraction Module
Space Grant Consortium	$1,000	Currently working through Florida State to receive grant	Communication and Networking Electronics
Robo-Ops NASA	$10,000	Must be accepted to the competition	Sample Extraction Module Motors, Travel expenses, and Misc. Hardware

Jason Brown

Project Procurement

	Item	Vendor	Part Number	Cost	Quantity	Total
Chasis	Carbon Fiber Roll	US Composites	FG-PW5750	$430	3	(optional) $ 1290
	Carbon Fiber Resin	US Composites	FASC-11025	$21.25	4	(optional) $ 85
	Subtotal					(Optional) $1,375
Arm	Driving Motors	Maxon Motors	397172	$317.75	2	$636
	Gearbox	Maxon Motors	326661	$ 253.50	2	$507
	Encoders	Maxon Motors	110512	$131.50	2	$263
	Pololu 298:1 Micro Metal Gear Motor	RobotShop	RB-Pol-64	$15.95	4	$64
	Square Aluminum Tubing	Misumi	HFHQ5050-2-[50-4000/1]	$40.95	4	$164
	Subtotal					$1,634
Electronics	TP-Link N Type Wireless Router	Amazon		$129.99	1	$ 129.99
	TP-Link Cameras	Amazon		74.99	1	$74.99
	Subtotal					$204.98
	Miscellaneous					$ 1,000
	Subtotal					$ 1,000
Travel						(Competition) $5,000
TOTAL						($9,500) $2,800

Jason Brown

PROJECT SUMMARY

Competition Status	NASA project proposal due 12/8 – completed/revising
	Competition selection announcement 12/28
Rover Locomotion	Upgrade existing platform
	Improved locomotion control (turn while walking)
Extraction Module	Lightweight, Aluminum frame manipulator with 3 DOF
	Elastic pincher proven viable
Communication	Dual 4G network wireless adaptor (AT&T/Verizon)
	TP Link ER-6020 router (10/100/1000 Mbps, VPN)
Future plans	Continue procurement process
	Start Manufacturing/Assembly on Spring term

Jason Brown

References

- http://www.maxonmotorusa.com/maxon/view/product/motor/dcmotor/re/re40/148867
- http://www.robotshop.com/en/pololu-298-to-1-micro-gear-motor-hp.html
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- http://www.tp-link.us/products/?categoryid=202
- http://www.raspberrypi.org/

Question/Comment?