Meeting Purpose: System level design of mechanical and electrical potions of the Wandering Ambassador (Part 6) project (P11216).

Materials to be reviewed:

1. Project Description
2. Current System Design – Mechanical
3. Risk Assessment - Mechanical
4. Current System Design – Electrical
5. Risk Assessment - Electrical
6. Integration Plan
7. Customer Needs
8. Engineering Specifications
9. Proposed System Additions – Mechanical
10. Concept Selection Review – Mechanical
11. Personality Framework Outline

Meeting Date: January 14, 2011

Meeting Location: 09-4435

Meeting Time: 12:30-2:00 pm

Timeline:

Meeting Timeline		
Start Time	**Topic of Review**	**Required Attendees**
12:30	Project Description	
12:35	Current Design with P11215	
12:50	Integration of P11216 with P11215	
12:55	Proposed Additions	
1:10	Personality Framework	
1:20	Next Steps + Q&A	

Project #	Project Name	Project Track	Project Family
P11216	Wandering Ambassador (Part 6)	Vehicle/Robotics	Land Vehicle
Start Term	**Team Guide**	**Project Sponsor**	**Doc. Revision**
20102	George Slack	KGCOE EE Dept	2

Project Description

Project Background:

RIT has always been interested in finding new and exciting ways to build interest and showcase student activities on campus. The primary customer conceptualized a robot which slowly moves around campus caring for an onboard plant and runs on sustainable energy. This would serve multiple purposes, which include showing RIT's commitment to sustainable energy, student innovation and technical ability, as well as providing a talking piece for visitors to campus.

*Problem Statement (***Robot Track (2009/2010/2011)***:*

The main goal of this project is to raise awareness of RIT innovation by designing a robot that acts as a guardian of a plant and who acts in a symbiotic relationship with the plant. The robot will support the needs of the plant, as well as its own, by managing sunlight and soil water content.

P11216 will join the P11215 team to evaluate previous development and then develop or mature needed functionality as well as test all robotic functions and continue to refine the design, as needed.

Objectives/Scope:

1. Work with P11215 efficiently to complete robot functions.
    - Improve the robot's navigation functions so that it may wander unattended.
    - Have the robot be able to care for the plant for a period of at least 1 week.
2. Define detailed test routines to uncover reliability issues.
3. Continue the implementation process of debugging hardware and software as the integration process begins. (i.e., characterize and evaluation the various robot sensors and output devices.)
4. Make maximum use of natural conditions by managing sun, shade, temperature, rain, and watering to allow the plant to grow and thrive and robot power to self-sustain.
5. Establishment of an environment which allows software development to proceed before hardware is available and integrates with hardware.
6. Full definition and implementation of software application programming interface to the robot navigation and plant support functions.
7. By the start of the spring quarter, evaluate the test results and issues from the P11215 team, and create a plan to eliminate critical known software issues.
8. Perform outdoor field testing, and debug software issues.

Deliverables:

1. Improved design with improved safety features.
2. Implemented plant care system.
3. Testing routine for drivetrain features including drive transmission and safety issue.
4. Testing routine for transport scheme needs to be evaluated.
5. Testing routine for plant portion of the robot including water reservoir and dispensing.
6. Robot navigates autonomously at the Innovation Festival in spring of 2011.

Expected Project Benefits:

1. Showcase the creativity and technical abilities of RIT's Multidisciplinary Senior Design teams.
2. Navigate autonomously and take care of the plant at RIT's Innovation Festival in Spring 2011.
3. Reinforcement of RIT's devotion to innovation, sustainability projects and energy resources.
4. Excellent demonstration of good testing procedures for integrated systems of its kind.
5. Define robust application programming interfaces for higher-level on-board processing.
6. Work in conjunction with the initial team during the winter term to expand the range of plant maintenance, environment interaction, and navigation functions that are available.

Core Team Members:

Nick Leathe (ME)
Anna Gilgur (ME)
Rui Zhou (EE)
Ken Hertzog (CE)
Joseph Stevens (SE)
Philip Gibson (SE)
Dave Ladner (SE)
Terra McAndrew (ID)
Project Team P11215

Strategy & Approach

Assumptions & Constraints:

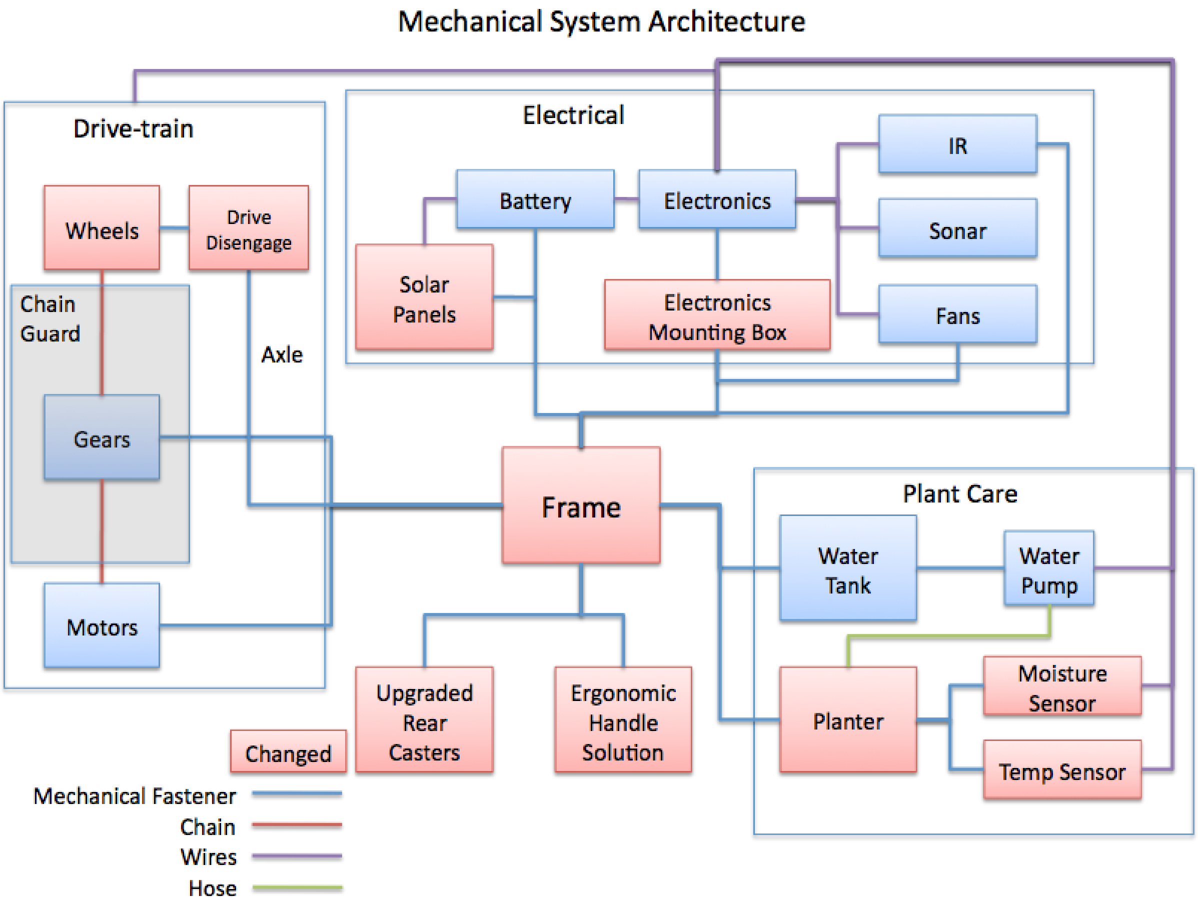
1. The robot will not be a safety hazard to observers and campus visitors.
2. Existing locomotion system and frame will be used as a base for modification.
3. The robot needs to function for 1 week unattended.
4. The robot will take care of the plant.
5. The robot will be able to fit through doors.
6. On-board processing power: dual core single board computer, Linux operating system.
7. Sensors and actuators for robot navigation and status, and plant support and status.
8. Prototype design of software interfaces to the robot navigation and plant support functions.

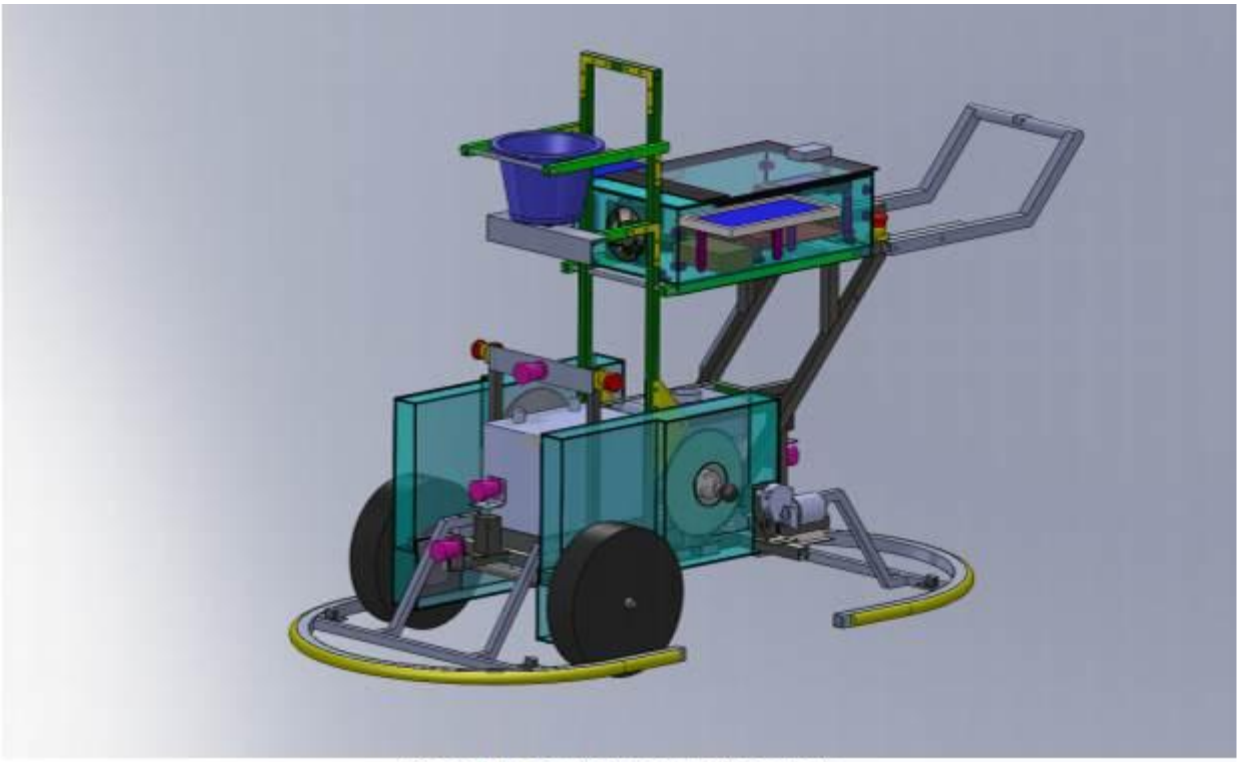
Issues & Risks:

1. Difficulty in software-hardware interaction pervious groups experienced continues to hinder progress.
2. Reliability issues
3. Legacy documentation not fully developed.
4. Sensor blind-spots need to be filled in order to prevent collisions.
5. Additional safety mechanisms are required to make the robot safe for curious children.
6. Conflicting customer needs lead to a failure in creating an interesting project.

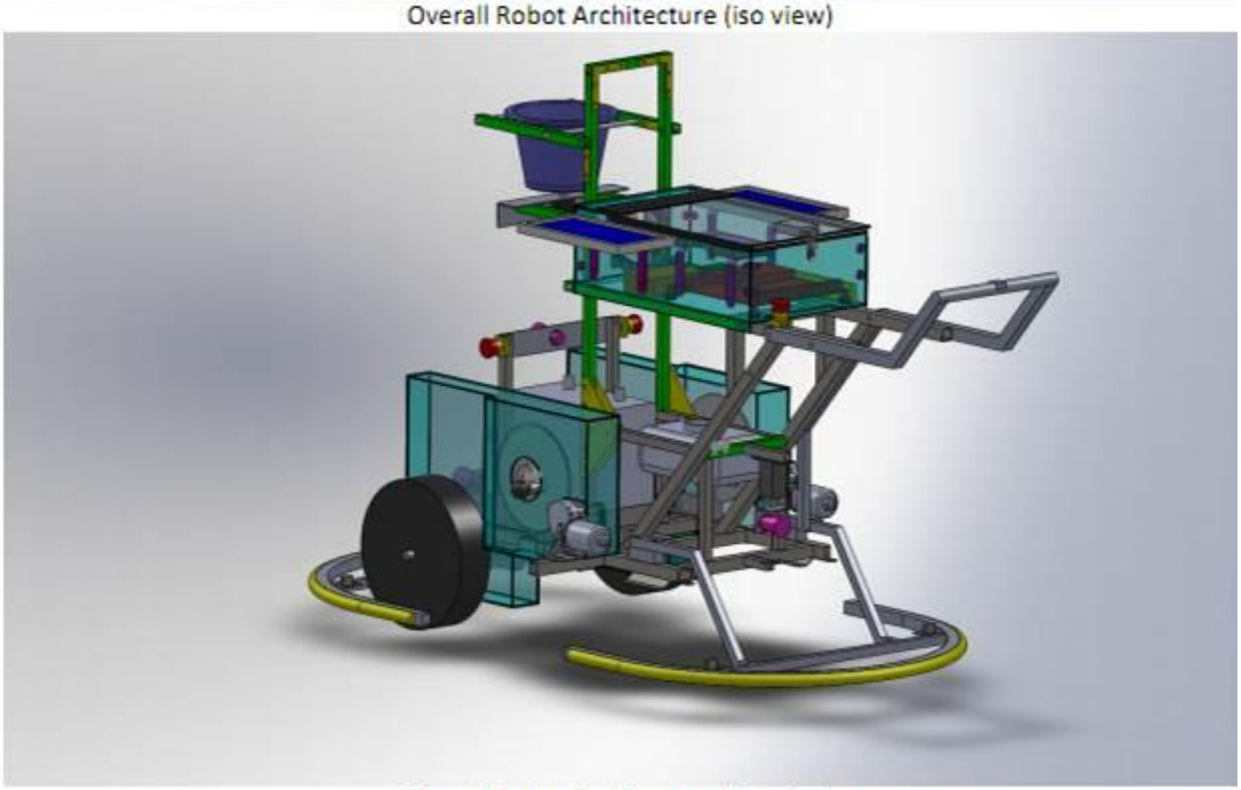
Current Design with P11215:

Mechanical:

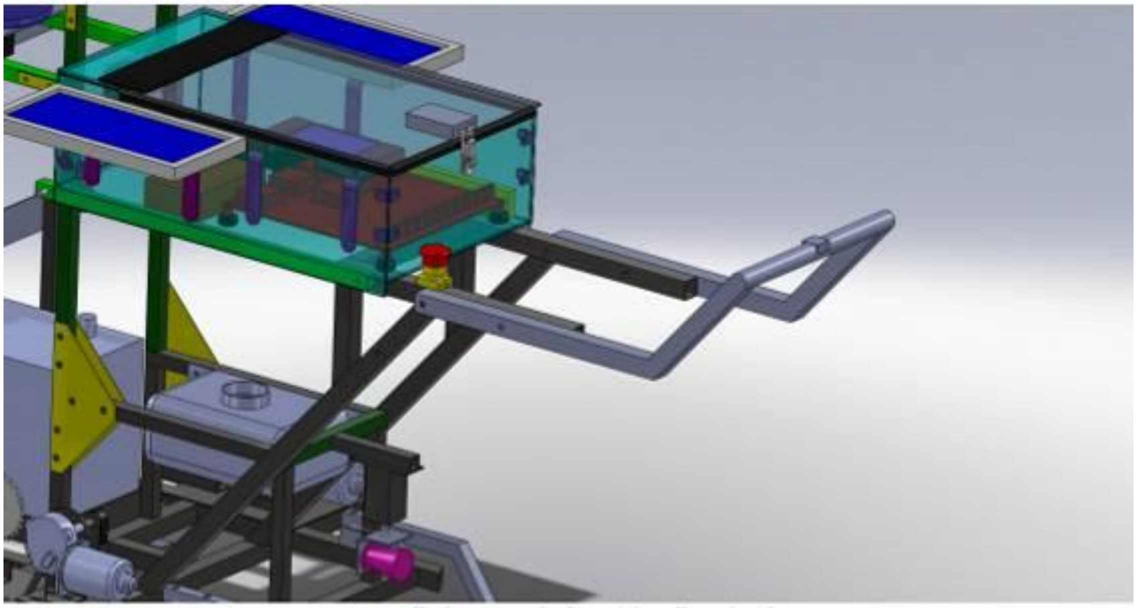




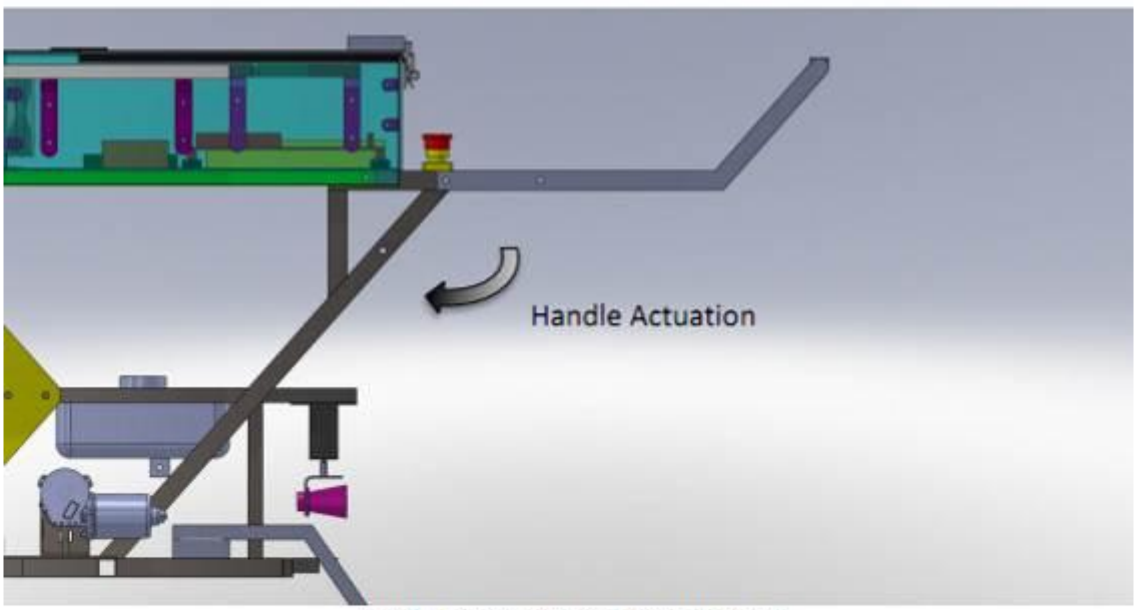
Overall Robot Architecture (iso view)



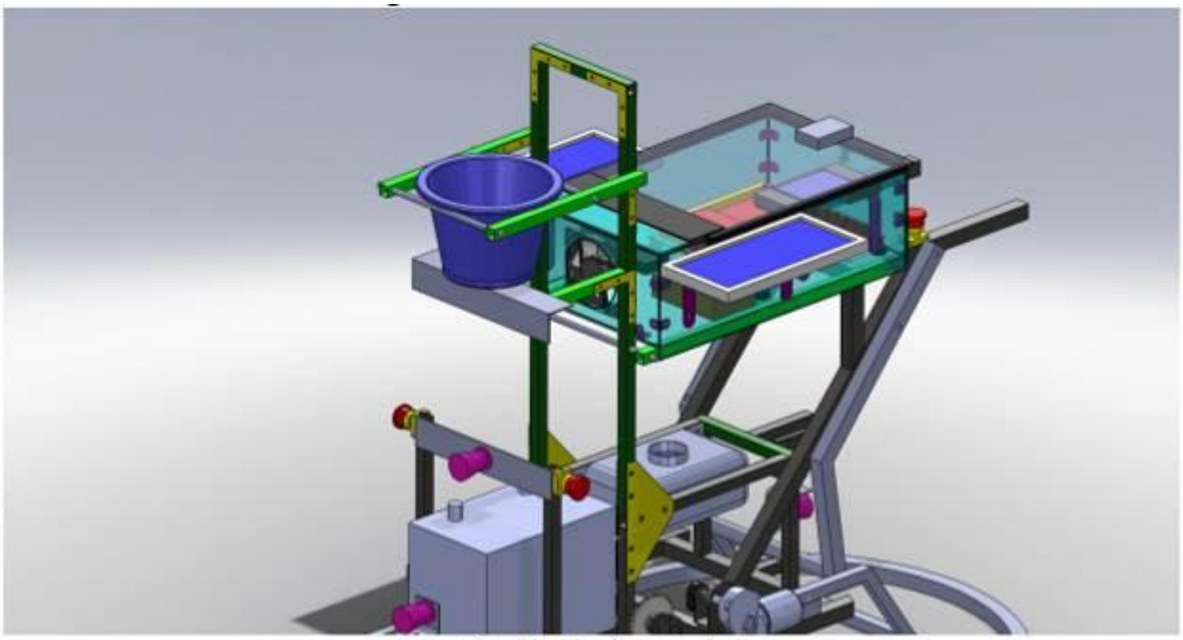
Overall Robot Architecture (iso view)



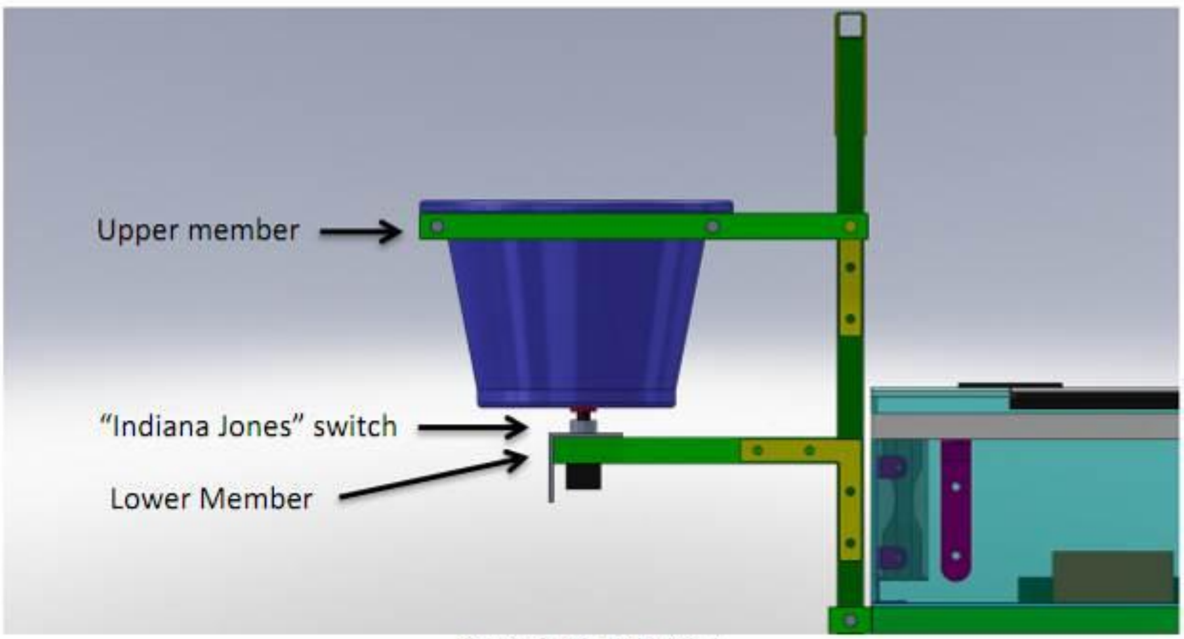
Handle in extended position (iso view)



Handle in extended position (side view)



Plant holder (iso view)



Plant holder (side view)

Mechanical Risks:

Risk	Name	Effect	Cause	Importance (L*S)	Action Taken to Minimize Risk
RT1	Robot not built on time	Incomplete MSD project	poor planning, procrastination	30	Create Detailed MSD II schedule and hold to it
RE7	Blind spots exists in sensors field of view	Robot unable to detect obstacles in blind spots	Poor sensor location choice	36	Add more sensors or repostion already exists
RM1	The Robot fails due to weather conditions	Circuit shorting - circuit damage	Improper / inadequeate weather resistance measures	25	Designed electronics enclosure for weather resistnace
RM4	Chains, motor and sprockets don't align	Robot can't move / turn	Improper design	10	Design in adjustability
RM9	IR sensor placement is not optimal to sense obstacles	Robot cant detect terrain changes	Poor sensor placement	40	Place IR sensor towards extremeitys of robot footprint
RM12	Bump detection failure	Robot continues to apply power on impact - Component damage / injury	Poor design of bump detection system	40	Obstacle Detection Hierachry - 4 layers of defense
RM13	Drivetrain disengagement failure	Drive can no longer be activated / deactivated	Under-designed pin-system	27	Design with high factor of safety
RM14	Handle is not easy to use for transport mode	Failure to meet customer need	Improperly designed handle system	21	Handle Kinematic Analysis to prove ease of access
RM15	Actual robot platform doesn't dimensionally match CAD	Newly designed parts don't fit properly	Inaccurate fabrication by previous teams	56	Analyze robot platform to identify fabrication errors before new parts are cut
RM16	Satellite electrical components fail due to weather conditions	Sensor failure / false sensor readings	Components not protected by enclosure	49	Create weather resistance package for each sensor - spec waterproof sensors
RS1	Finger injury from entanglement	Finer entangled in chain while driving	Poor chain gaurds	30	Fully enclose drivetrain components

Electrical/Computer:

QNX and MP430s
The base QNX system currently boots, but adding required functionality such as I2C and compilers is causing issues. Our Angstrum Linux build is being maintained as a backup plan if QNX cannot ultimately be used. The I2C software issues have been resolved in the Angstrum build and it is now functioning correctly. However, the level translator circuit that is meant to replace the blown IC chip is not working correctly and the CE and EE members are currently debugging the issue.

The MP430s are working properly with the sensors, however the software for the MP430s written by old teams is functioning, but needs to be reworked to fit the current needs of the project. This is noted in the categories below. The MP430s currently translate the raw sensor values into numeric values, a task that needs to be offset to the software on the BeagleBoard.

LCD
The BeagleBoard can output the data to the LCD, but the LCD input touches needs to be registered. The communication between the LCD and the BeagleBoard is the key point. A USB interface should sufficiently communicate touches from screen to the BeagleBoard. Also, a suitable touch screen LCD should have no conflicts with the I2C port or the lengthening of the LCD cable.

Navigation
The code for navigation MSP430 is incomplete, but the firmware runs on MSP430 and the sensors have been obtained. The code for obtaining the sensor data and passing it onto the BeagleBoard is incomplete. Debugging and troubleshooting for the sonar sensors needs to be done and the PWM output pins need to be checked. The IR sensors need to be attached in the right position in accordance to the bump sensors (2) and the IR sensors and sonar sensors need to be connected accordingly. Our design suggested that connecting sonar sensor to the Fred PCB to use the previous working mode would be a good idea. Thus, we should take advantage of the PWM output pins keeping the Fred PCB connection the same.

Battery Level LEDs
The battery level LEDs are not working because the battery sensor code on the MSP430 has not been written yet. The battery indicator is wired to the MSP430, so that the plant MSP430 can report the battery level. The customer suggested that the BeagleBoard should be able to convert the ADC values. The MSP430 that observes the plant's data will be modified to update the raw ADC value, while the BeagleBoard will translate the percentage into the battery life and send values to the MSP430.

Summarized Table:

Component	***Problems/Targets***
BeagleBoard/I^2C	Interconnection between the new chip and the I^2C
LCD	Successfully Interface the inputs (touches) of the LCD to the BeagleBoard without conflicts with I^2C
Navigation	Sensor data code needs to be written
Battery Level LEDs	Battery sensor code needs to be written for MSP430

Electrical/Computer Risks:

Risk	Name	Effect	Cause	Importance (L*S)	Action Taken to Minimize Risk
RT4	Major software incompatibility	Revamp of entire software architecture	Poor choices from previous MSD teams	100	Deep dive into what works
RE1	Loss of communication w/ navigation	Robot is unaware of where it is	Software incompatibility, poor satellite reception, loss of line of sight	25	Build in a failsafe mode
RE6	Parts come DOD (Dead on Delivery)	Circuits not able to be built on time	Poor vendor choice / bad luck	24	Order from a reputable supplier; leave budget padding for backup
RE11	Circuit clean sheet designs don't work	Robot function impaired	Improper engineering	40	Simulate before hardware is built/bought
RSW2	Touchscreen is harder to utilize than anticipated	Non-functional touch-screen	Unable to interface with LCD hardware properly	40	Utilize new Linux distro to simplify LCD integration
RSW5	Software crashes while roving	Robot stops working / requires reboot	Software / electrical instability	20	Extensive testing
RSW7	Beagleboard - MSP430 Interfacing Fails	High-level software cannot interface with sensors and motors	Operating system choice	60	Develop 'Plan B' to implement new OS
RSW9	Unfamiliarity with technologies used in previous designs	Additional learning curve to deal with before work can be completed	Technologies chosen by previous teams I2C	40	Scope project realistically
RE12	Unable to prove MSP430 is reading sensors	Robot loses sensor functionality	Improper debugging	50	Prove MSP430 function by end of senior design

Integration of P11216 with P11215:

Task	Responsible	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Senior Design 2
Become even more familiar with EE/CE systems	*Rui, Ken*	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
Testing (Mechanical)	*P11215, Nick, Anna*			XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
Testing(Electrical/Computer)	*P11215, Ken, Rui*			XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX
Get up to date CAD drawings	*Nick, Chris*						XXXXX			
Get up to date electrical schematics	*Rui, Nick, P11215*						XXXXX			
Fully accept project	*P11216*							XXXXX	XXXXX	XXXXX

Currently, the project is in the build and debug stage. The electrical, software, and computer engineers from both groups have been working together in an attempt to get I2C functioning with the QNX BeagleBoard, while the mechanical engineers from P11215 have been constructing the robot, and P11216 mechanical engineers have been designed components. By the end of the quarter, it is expected that the robot's construction will be completed and that P11216's main focus will be on software development and the debugging of issues as they arise.

Critical Customer Needs:

Customer Need Number	Importance	Description	Comments/Status
CN1	1	Improve Sonar Range and Area of Vision	
CN2	1	Increase Adjustability of plant mount	
CN3	1	Test Bumpers	Determine force to complete circuit
CN4	1	Physical deterrence for alarm	Water sprinkler on top
CN9	1	QNX loaded on BeagleBoard	
CN10	1	Store sensor input in registers	Possibly Completed
CN13	1	Water plant when moisture low	
CN18	1	Does not fall off ledges	
CN19	1	Software senses people and objects with sonar/bump, does not run into them	
CN20	1	Personality Modes- Curious, Friendly, Apathetic, Super-sustain, Angry, Diagnostic, and Test	Apathetic, Test, and Diagnostic modes are primary needs

Critical Engineering Specifications:

Engineering Specification Number	Importance	Source	Specification	Unit of Measure	Marginal Value	Ideal Value	Comments Status
ES1	1	CN4	Range of physical deterrence	Ft	0.5	2	
ES2	1	CN4	Pressure from physical deterrance	kPa	100	200	
ES3	1	CN4	Duration of physical deterrance	S	5	20	
ES9	1	CN20 though CN27	Has personalities	Binary	N	Y	
ES10	1	CN19	Does not bump into people/objects	Things bumped/hour	6	0	
ES13	1	CN18	Does not fall of ledges	Ledges fallen off/day	1	0	
ES14	1	CN1	Increased field of vision	Percent	0	100	
ES15	1	CN2	Varying sizes of plants can be carried	Binary	N	Y	
ES16	1	CN3	Determine force required to activate sen	Binary	Y	Y	
ES18	1	CN9	QNX loaded	Binary	Y	Y	
ES19	1	CN10	Sensor input stored in registers	Binary	Y	Y	
ES21	1	CN13	Sense when plant soil moisture is low	Binary	Y	Y	
ES26	1	CN20	Number of Personalities/Modes	Number	3	7	
ES27	1	CN13	Waters plant when soil moisture is low	Binary	Y	Y	

Proposed Additions:

Physical Deterrence

		Physical Deternce Concepts									
	Segment	(reference) None		360° Sprinkler		Mister		Water Jet		Pulsing Jet	
Selection Criteria	Weight	Rating	Wtd	Rating	Wtd	Rating	Wtd	Rating	Wtd	Rating	Wtd
Rate of water use	20%	5	1.00	3	0.60	4	0.80	1	0.20	2	0.40
Fabrication	10%	5	0.50	4	0.40	3	0.30	2	0.20	2	0.20
Programming Complexity	10%	5	0.50	5	0.50	5	0.50	2	0.20	1	0.10
Cost	5%	5	0.25	3	0.15	3	0.15	3	0.15	3	0.15
Pump Strength Required	10%	5	0.50	4	0.40	4	0.40	3	0.30	3	0.30
Range	20%	1	0.20	5	1.00	3	0.60	5	1.00	5	1.00
Robustness	5%	5	0.25	5	0.25	5	0.25	5	0.25	5	0.25
Implimentation	10%	5	0.50	5	0.50	2	0.20	3	0.30	3	0.30
Effectiveness	10%	1	0.10	5	0.50	2	0.20	5	0.50	5	0.50
	Total Score	3.80		4.30		3.40		3.10		3.20	
	Rank	2		1		3		5		4	
	Continue?			Yes							

Based on the table, the 360° sprinkler as the physical deterrence is the best option. Two possible designs for this option are displayed below. Image 1 is a water vane sprinkler. Image 2 is a fire sprinkler that will be implemented upside-down. Issues with this design selection include, but are not limited to: water usage and controlling water within the reservoir, reservoir size, pump strength, pump feed and tubing required, cost, and additional software and current system implementation.

Image 1: [Water Vane Sprinkler]

Image 2: [Fire Sprinkler]

Adjustable Plant Holder:

Adjustable Plant Holder Concepts

	Segment	(reference) None		Metal Band		Sets of Brackets		Brackets with Sliders		Rubber Straps		One Larger Pot	
Selection Criteria	Weight	Rating	Wtd	Rating	Wtd	Rating	Wtd	Rating	Wtd	Rating	Wtd	Rating	Wtd
Feasibility	15%	5	0.75	5	0.75	5	0.75	5	0.75	5	0.75	1	0.15
Fabrication	15%	5	0.75	4	0.60	3	0.45	4	0.60	5	0.75	5	0.75
Adjustability	20%	1	0.20	5	1.00	4	0.80	4	0.80	4	0.80	4	0.80
Cost	10%	5	0.50	4	0.40	3	0.30	3	0.30	4	0.40	4	0.40
Implementation	15%	5	0.75	3	0.45	4	0.60	4	0.60	3	0.45	2	0.30
Effectiveness	10%	1	0.10	5	0.50	4	0.40	4	0.40	3	0.30	2	0.20
Ease of Change	10%	1	0.10	5	0.50	3	0.30	4	0.40	3	0.30	5	0.50
Robustness	5%	5	0.25	4	0.20	5	0.25	4	0.20	1	0.05	5	0.25
	Total Score	3.40		4.40		3.85		4.05		3.80		3.35	
	Rank	5		1		3		2		4		6	
	Continue?			Yes									

Below is an example of an adjustable metal loop. This is the direction the vision of the plant holder is headed based on the concept selection matrix. Issues involved in the fabrication and implementation of this design include, but are not limited to: size, cost, interface with current design, and ease of use.

Image 3: Adjustable Metal Loop

Personality Framework:

The current design of the Wandering Ambassador allows for personalities to determine the way that the robot will interact with the environment. Some of these personalities will have environmental triggers, such as the plant being stolen, while others will most likely need to be activated with the LCD screen. Below are two tables: the first includes a list of actions or ways for the robot to demonstrate its mood, while the second table is a summary of the five personality concepts.

Output Options/Actions:	
Forward Movement	Sensor Servos (Possibly)
Backward Movement	LCD Touch Screen
Leftward Spin	Alarm System
Rightward Spin	Water Sprinkler

Personality	**Activation:**	**Reactions**
Angry	Plant Stolen	Active Alarm/Sprinkler Return to Housing No Movement
Apathetic	LCD Screen	Move at random Ignore inputs -(Except plant)
Curious	LCD Screen	Follow but keep a set distance from people
Happy	LCD Screen	Chirp? Move in circles Be social
Super Care	Plant Dying/Low Water	Water plant Seek out light