Salt-Dispensing Robot for Ice Reduction and Prevention

Design Review

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I. Introduction and Motivation

Our project proposes an alternative to manual salt spreading. Winter weather brings the problem of ice formation on the ground. Reducing traction, ice formation becomes a hazardous condition for many scenarios such as walking on foot or driving in a vehicle. To remedy the danger, people often spread salt manually on their property. Salt effectively lowers the freezing point of water or ice by a few degrees, reducing the probability of ice formation.

To avoid exposure to freezing weather and injuries caused by slipping and falling on the ice, a robot substitute is to be constructed and take care of the salt dispersion instead of a person. With the salt dispensing robot, not only is the problem of ice formation solved, the manual labor under extreme condition is also reduced.

Features :

- Ice Detection feedback to user
- Salt Dispersion at the push of a button by user
- Ability to drive on snow and ice

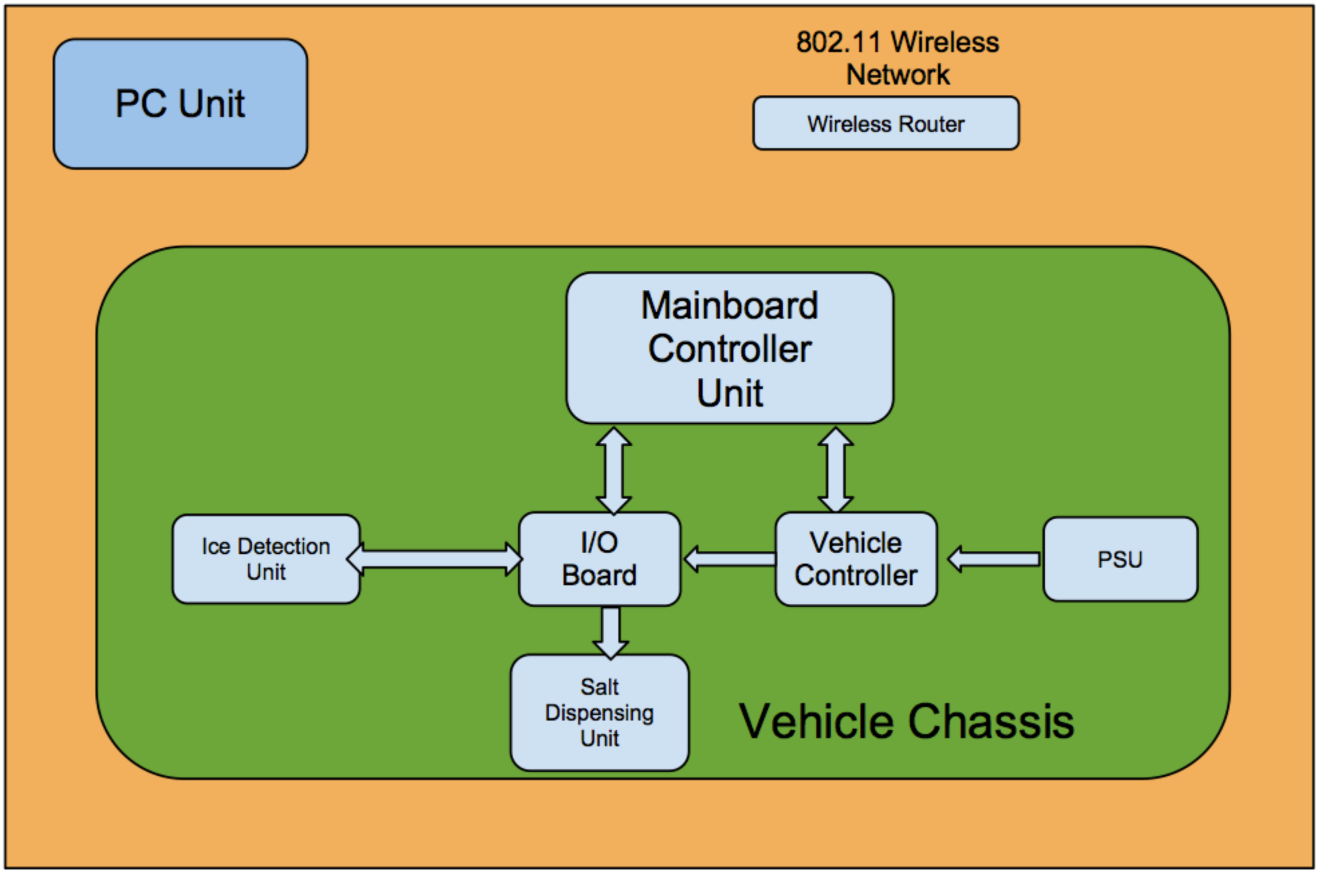
Goals :

- Replace manual ice dispersion with a convenient, remote way
- Be a building block to a future project of completely automated salt dispersion

Benefits :

- Remove the danger of slipping and falling on ice
- Remove exposure to cold weather by staying inside and controlling the robot
- Potentially expedite the ice dispersion when compared to manual dispersion

II. Design Block Diagram:



Block Descriptions

- ### PC Unit

PC is a simple Windows-based setup which users will interface with. There will be a GUI that allows the user to control the robot. PC generates control signals FORWARD, TURN LEFT, TURN RIGHT, REVERSE, and DISPERSE SALT. There will an initialization mode and an autonomous mode in addition to manual control. The PC communicates with the Mainboard Controller Unit over a 802.11 wireless network, so the PC must be within the wireless router's range.

- ### Wireless Router

The wireless router is going to be generate the medium through which the PC Unit and the Mainboard Controlelr Unit will communicate. In our testing environment, we will use WRT54GL wireless router.

- ### Mainboard Controller Unit

This will be the brains of the ground vehicle. It will be in direct communication with the PC Unit. The hardware used in this unit is a Pandaboard Embedded Computer. It will run Linux and have sufficient processing capabilites to not only talk to the PC thorugh socket programming, but communicate to the I/O Board and Vehicle Controller Unit as well. The connection between the MCU and I/O Board will be USB, as will the connection between the

MCU and VCU.

- ## Vehicle Controller Unit

The VCU is made of two physically connected components, a microcontroller and a motion control unit. The controller is designed for use with the Wild Thumper Chassis and similar setups.

VCU microcontroller:

The VCU microcontroller will receive commands from the MCU to drive the vehicle. It is a microcontroller housing an Atmel ATmega168 processing chip. The unit is based off the Arduino development platform that has become popular recently. It interfaces the receiver, the ice detection unit, and the motion control with its I/O ports. The connection to the Mainboard Controller Unit will be USB.

VCU motion control:

The motion control unit is responsible for the motion of the vehicle. It consists of two H bridges for both left and right motors, and two 15A slow blow fuses to protect the H bridges. This will interface with the motors directly.

- ## I/O Board

The I/O Board will consist of a Teensy microcontroller. We chose to do our I/O on a separate microcontroller then the one included in the VCU because of the amount of I/O pins we need. It will send ice detection results back to the Mainboard controller unit, which forwards the information. It will also control the salt dispensing mechanism. The connection to the mainboard will be USB.

- ## Power Supply

A 7.2V sub C battery pack is served as a power source that powers the MCU, I/O Board, VCU, dispensing unit, ice detection unit, and the receiver. The 5A Low-dropout regulator built-in in the controller will supply power for logic, servos and sensors.

- ## Salt Dispensing Unit

The unit is responsible for mechanically dispensing the salt. It consists of the rock salt to be dispensed, a container for the rock salt, a motor to control the outflow of the rock salt, and a weight monitoring circuit. Rock salt will be placed inside a container that has an extended opening that is tilted and narrow. The outflow of rock salt will be determined by how fast the trap door by the opening is being lifted/closed by a servo that will be supplied form the PSU.

- ## Ice Detection Unit

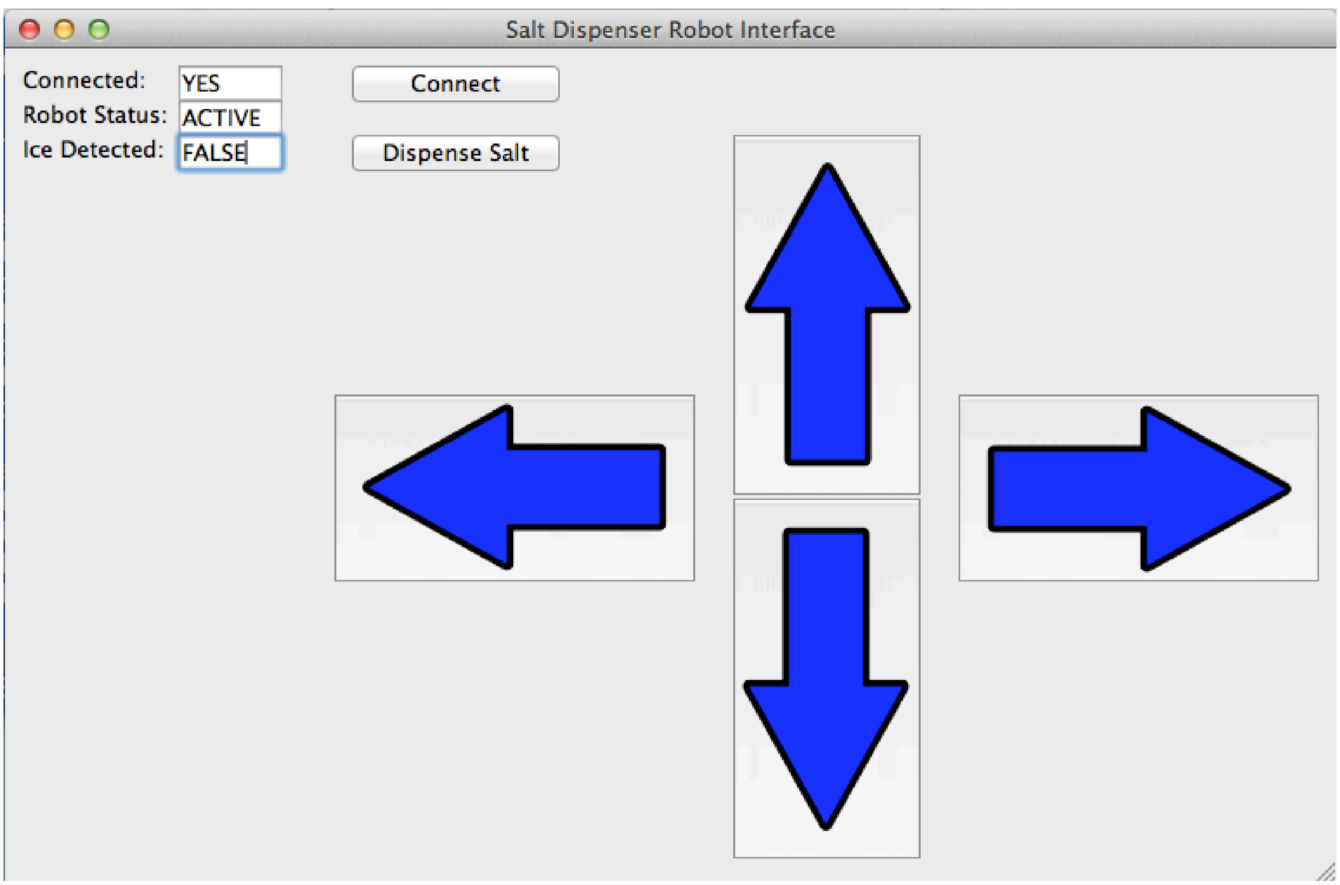
Mounted at the front of the robot, the unit notifies the I/O Board whether there is ice infornt of the vehicle or not. Consisting of IR emitters, an array of IR sensor and some circuitry that protect the integrity of the signal, the unit will determine the presence of ice by comparing the amount of IR signal detected by the sensor array. The IR emitters will send out light signals that will then be reflected by the ground below. The sensor array, monitoring the IR signals reflected by the ground below, should pick up sufficient IR reflection, amplify it, and deliver the information to the I/O Board. After I/O Board processes the data, data will be sent the to user to decide whether or not to dispense rock salt.

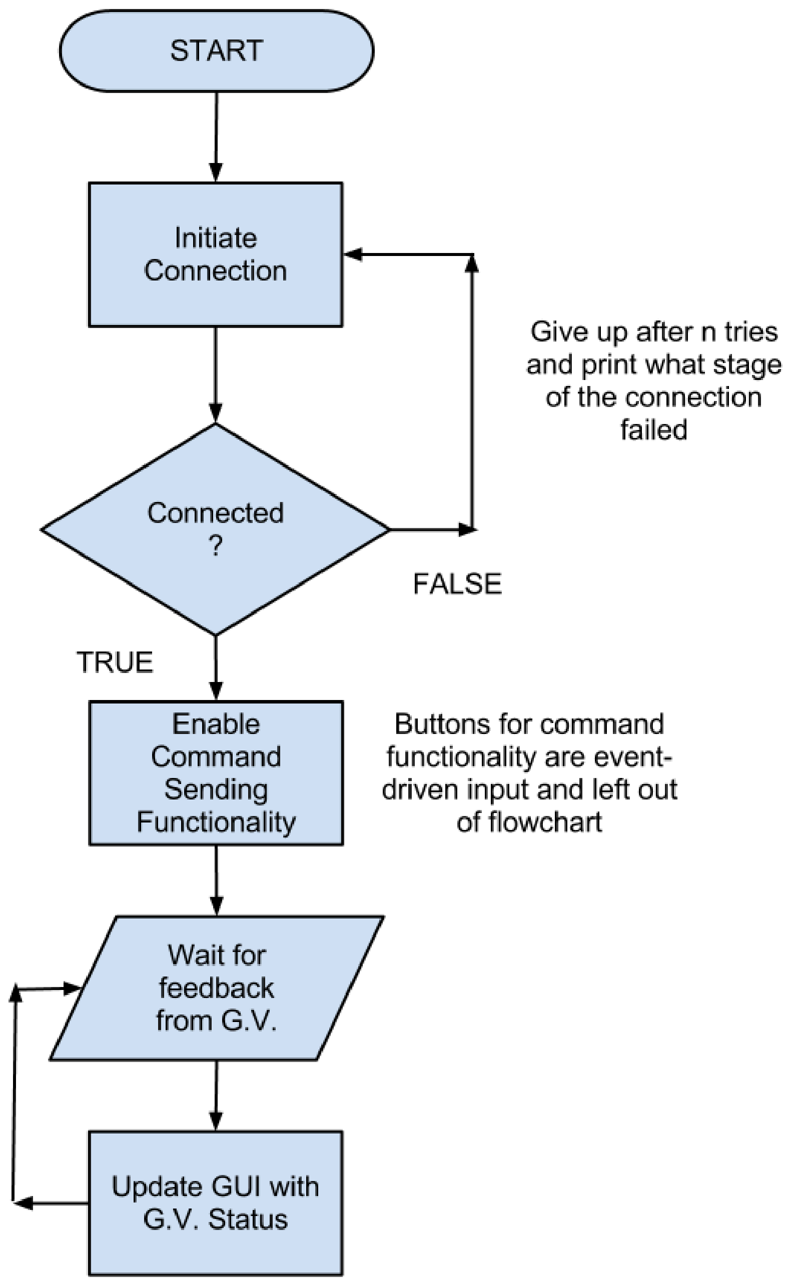
III. Schematics and Specifications

PC / User Side

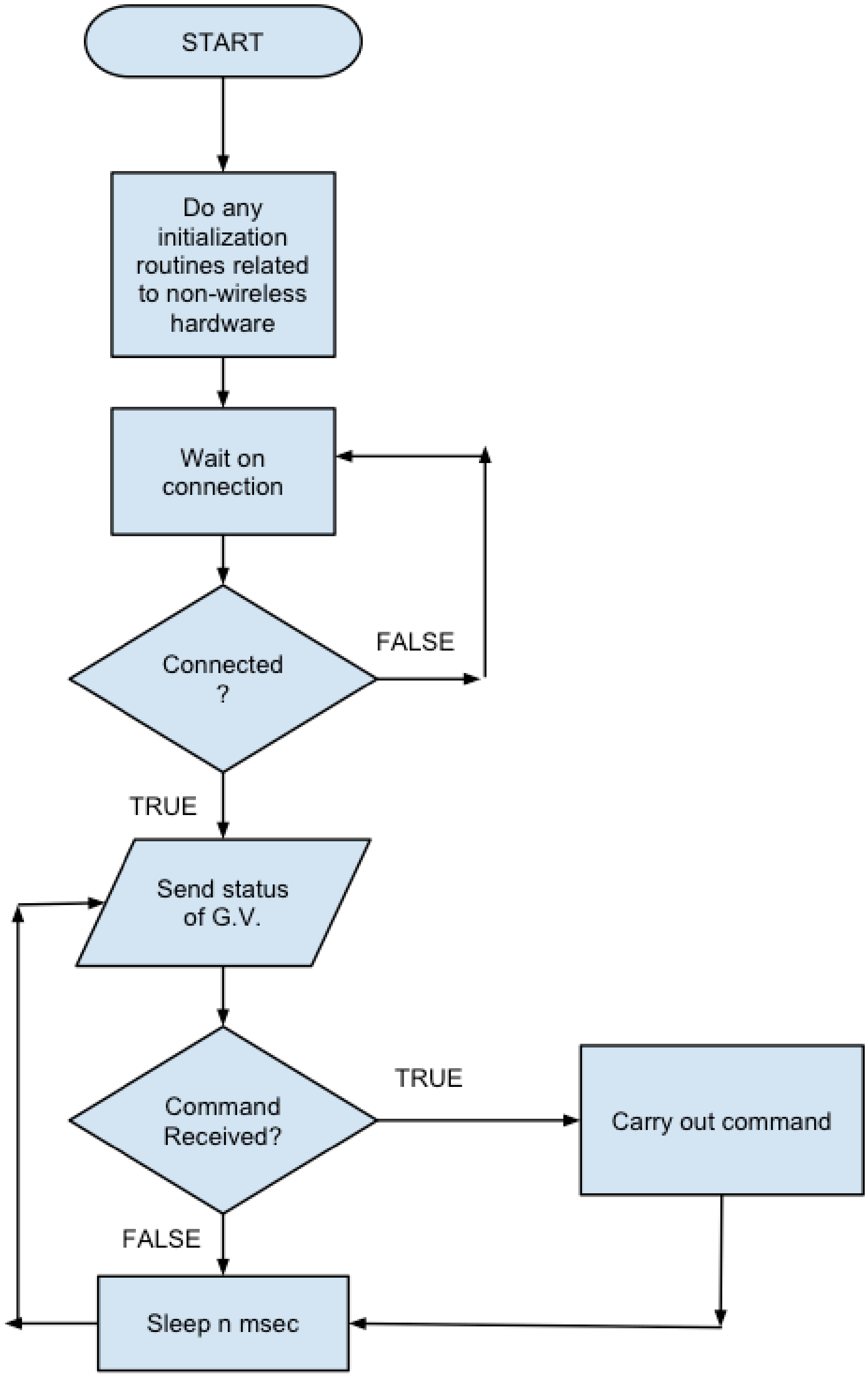
We plan on building a GUI interface that allows users to interface with the ground vehicle. This GUI will be written in Python using wxPython library and will use some routines written in C to do the low-level communication work. A mockup GUI is pictured below.

Mockup Graphical User Interface:

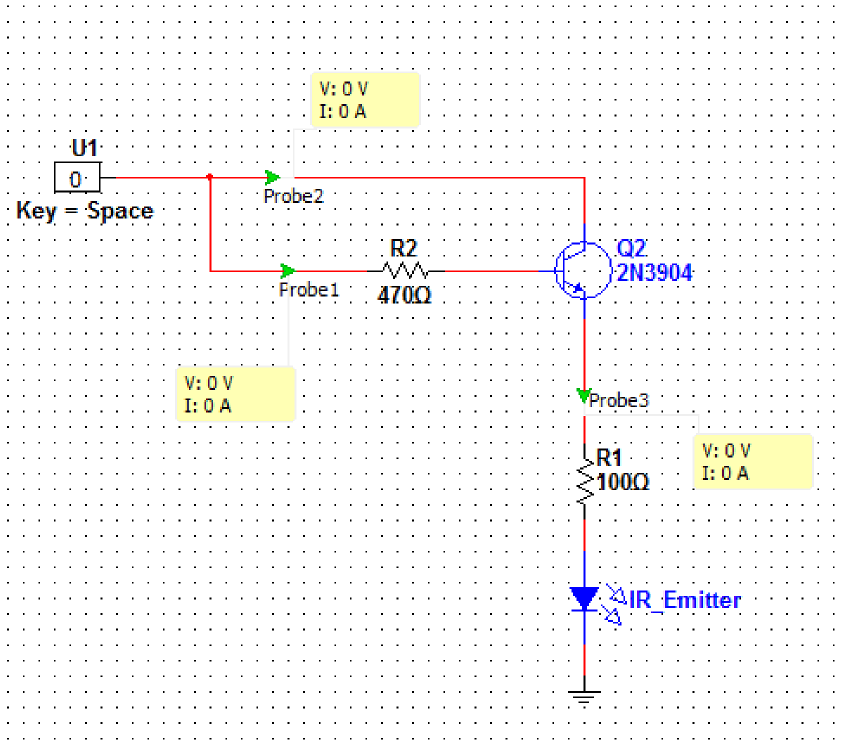


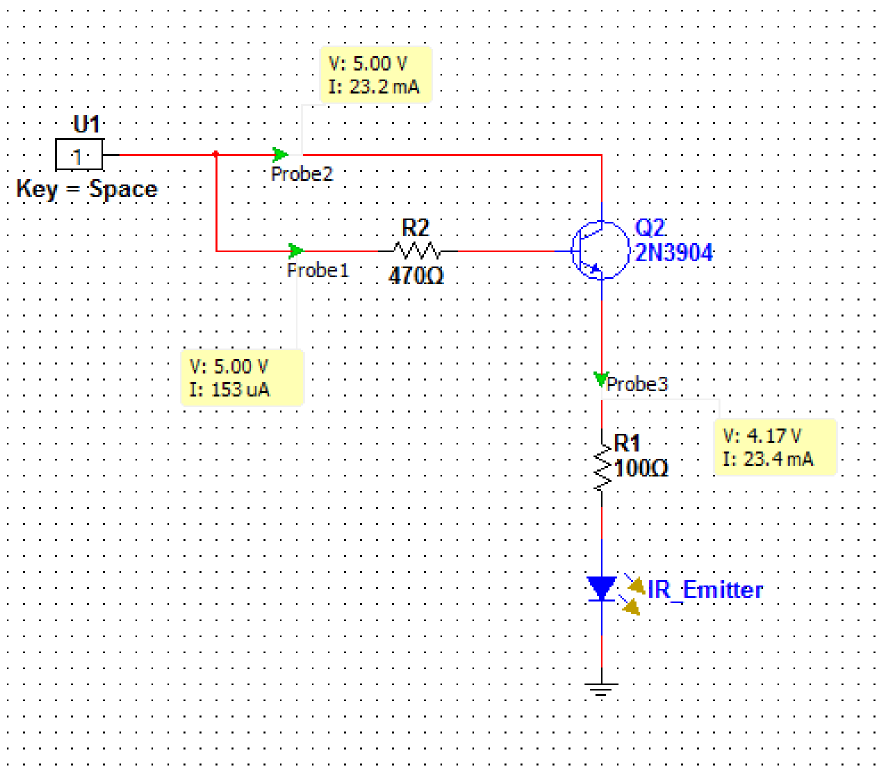


ROBOT-SIDE Software Flowchart

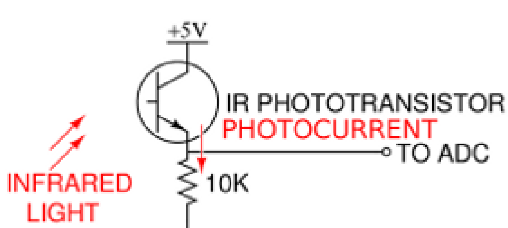


Ice Detection Unit emitter schematic with simulation:





Ice Detection Unit sensor schematic:



IV. Performance Requirement and Verification

Unit Under Test	**Requirement**	**Verification**
Ice detection	1. IR emitter (LTE-302) turns on and emits IR light when powered. 2. IR photo-transistor (LTR-301) induces 20mA current when Vce is biased at 5V and 1mW/cm2 IR light is present	IR emitter and photo-transistor will be placed in a "black box" when performing the following test 1. Current measurement at the cathode of IR emitter should read 20mA when a forward Voltage of 1.2V is supplied. 2. As the emitter is forward biased with 1.2V, the collector current measurement of biased photo-transistor should read 20mA.
Salt dispensing	1. Motor responses as the signal is sent.	1. A square wave will be generated from a signal generator, the current measurement of the motor should read 0.07A when square wave is high.
Mainboard Controller Unit (Pandaboard)	1. Needs to be powered on 2. Be able to detect I/O Board 3. Setup a communication protocol between I/O Board and Mainboard.	1. Connect HDMI out to a monitor and see bootup screen 2. Run test program on I/O Board and listen

		on the USB port that it is connected to. 3. Setup the protocol and pass a series of test messages (ex. a command to Dispense will result in the LED blinking).
I/O board (Teensy)	1. Teensy should be turned on when connected to power.	1. The voltage measurement of Vcc of teensy should read 5V.
Vehicle Controller (Wild Thumper Controller)	1. Communication protocol between VCU and MCU	1. A command sent from the MCU should be received by VCU, so we will send driving.
Power supply	1. should supply 7.2 volt to the vehicle controller.	1. Voltage measurement across the terminal of battery should read 7.2V.
PC	See Network	
Network	1. PC and Mainboard can go network and see each other. 2. PC and Mainboard can talk: PC can send commands, Mainboard can receive them, Mainboard can send status messages and PC and receive them. 3. Replace commandline interface on PC used for the above with a GUI interface.	1. Get them to run a server-client PoC. 2. Expand the server-client code PoC to include a secondary protocol and successfully transmit a series of test messages. Testmessages will include ice detection positives, various command sequences, etc.

		3. Verify the GUI works with the server-client PoC + secondary protocol simply by seeing if if messaging is still working.

VI. Tolerance Analysis

Tolerance analysis will be performed on the micro-controller unit. Since the controller is the brain of the entire system and will be placed under extremely cold weather, we decide to perform a tolerance analysis on it.

Testing:

The mentioned systems will be placed in

1) A household refrigerator at 3 to 5 °C and
2) Freezer (at -18°C) for 30 minute (assumed salt dispensing job time).

Expectation:

The system should be able to perform after the 30 minute in the refrigerator.

VII. Cost

Part	**Unit Cost**	**Quantity**	**Subtotal**
Wild Thumper 6WD Chassis	$249.95	1	$249.95
Wild Thumper Robot Controller	$74.95	1	$74.95
Pandaboard	$200	1	$200.00
Teensy Microcontroller	$16	1	$16.00
Breadboard	$15.00	3	$45.00
LTE-302 IR Emitter	$1.95	2	$3.90
LTR-301 IR Photo-detector	$1.95	4	$7.80
2N3904 General purpose amplifier	$0.10	2	$0.20
DC motor	$1.95	1	$8.95

* = Only 1 will be part of final design; 2 are needed to test PC + XBee < -- > XBee + PC communication. This is one of our preliminary steps.

Total part cost: $606.75

Labor cost

So far we have devoted 20-25 hours into the project, and we are about a third way through. We then approximate that we will both put in around 80 hours of work into this project. We approximate our salary to be $50/hour. A simple calculation, salary per hour times hours worked times number of workers, yields the total labor cost.

Member	**Salary/hour**	**Hours**	**x2.5**	**Total**

Naman	$50	80		$10000
Chun-Ting	$50	80		$10000

Total labor cost $20,000.00

Total cost

Summation of the total part cost and total labor cost yields the total cost.

Labor cost	Part Cost	Total
$20,000.00	$606.75	$20606.75

VIII. Ethical considerations

To honor the code of ethics on "avoiding injuring others," safety of pedestrians while the product is on the road is a major ethical issue. It is our goal to design a safe salt dispensing robot that will not put others in a state of potential danger. To accomplish the goal, fuses are ben placed on the wild thumper controller to prevent possible fire caused by high current driving the motor.

IX. Schedule (subject to change)

Week	Task PoC = Proof of Concept	Member*
3/5	• Start writing secondary communication protocol between PC and MCU and make sure commands sent from PC are received by MCU, and messages from MCU are received by PC. • Set up teensy micro-controller, start experimenting with IR sensors and collect data to find best configuration for detection	Naman **Chun-Ting**
3/12	• Wrap the PC-side up with a GUI interface • Start testing secondary protocol and make sure the MCU carries out commands (drives, acknowledges commands that aren't mechanically implemented yet). This means secondary protocol between MCU and I/O Board and another protocol between MCU and VCU. • Set up teensy micro-controller, start experimenting with salt dispensing motor	**Naman** Chun-Ting
3/19	• Add on minor components like flashlight, indication LEDs, and have MCU control them • Make sure the software works with the system as a whole (is the GUI displaying the correct system status? Are my button pressed directing the Robot correctly?) • Complete the input output communication between teensy and VCU	Naman **Chun-Ting**
3/26	*First Demo*	
4/2	*Mockup Presentation* • Debug and Enhance any issues or unfinished requirements • Figure out how to move the wiring and analog components from the breadboard onto a custom PCB.	**Naman** Chun-Ting

4/9	• Start final report • Finalize PCB design and talk to machine shop	Naman **Chun-Ting**
4/16	*Demo and Presentation Signup Begins*	
4/23	*Demo Week*	
4/30	*Presentations*	

* Bolded name indicates the member in charge at a given week.

X. References

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3. IEEE Code of Ethics: http://www.ieee.org/about/corporate/governance/p7-8.html
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5. The Linux Kernel Module Programming Guide. http://tldp.org/LDP/lkmpg/2.6/html/lkmpg.html
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