ECE 4970W – Department of Electrical and Computer Engineering

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Solar Powered Phone Charging Station

UNIVERSITY OF MISSOURI – COLUMBIA

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

"A PROUD TRADITION, ENGINEERING THE FUTURE!"

Overview

- Part 1: Introduction
- Part 2: Scope
- Part 3:Implementation
- Part 4: Project Evaluation
- Part 5:Financial Costs
- Part 6:Timeline
- Part 7: Summary and Conclusions

Part 1: Introduction

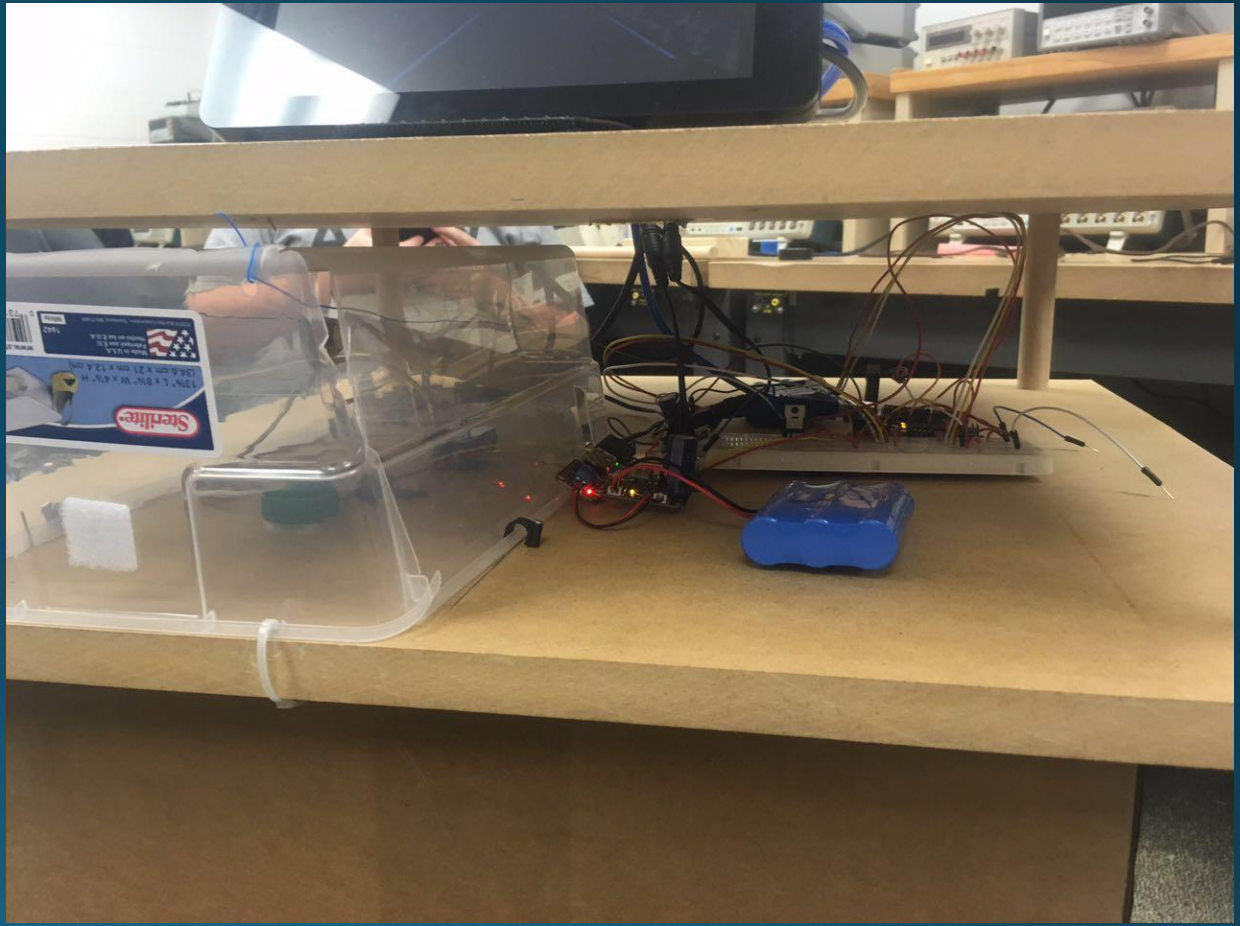
- Rationale
- Prototype Concept
- Engineering Merit

Rationale to our Prototype

- Smartphone usage is vital for people all over the world
- Phone dying = unfortunate inconvenience
- Electrical outlets typically indoors
- Phone chargers rely on electric grid = coal and natural gas
- Search for solutions to phone charging while mindful of resource impact

Prototype Concept

- Solar powered
- Self-sustaining
- Charge multiple phones at a time
- Commercially available
- Located in high traffic areas


ARMY


Engineering Merit

- Solar power
- Security of private property
- Charging storage bins
- Public, open source use
- Combination of these => our prototype

Part 2: Scope

- Goals and Objectives
- Critical Specifications
- Constraints
- Standards & Assumptions

Individual Goals and Objectives

- **SMART GOAL: Consider power system that can adequately charge all devices in the prototype**
- Specific: The prototype needs to produce enough power to power multiple phones, an Arduino, raspberry pi, and a LCD monitor. The best possible action that is efficient and cost-effective will be chosen.
- Measurable: Each will have their own input voltage and current, requiring us to design our system focusing on these aspects.
- Achievable: This will be achieved by consulting professors within the ECE department as well as researching power electronics and sustainable energy
- Relevant: This will allow the prototype to fulfill its goal as a self-sustaining device off the grid
- Time-Based: This process must be considered first and implemented first in order for the other hardware and software functions to do their duties.

Individual Goals and Objectives

- **SMART GOAL: Successfully create software system to protect prototype**
- Specific: Monitor system attributes and theft using alarms, temperature sensors, and scales
- Measurable: The sensor data that is monitoring the power system will be used as input to control internal protection system.
- Achievable: This can be achieved working with university professors and prior knowledge from previous courses
- Relevant: In the modern age of technology, safety is a number one priority for consumers regarding cyber security. Safety from fire hazards is also of great importance.
- Time-Based: This goal can be accomplished throughout the project and can be adjusted according the prototypes needs.

Individual Goals and Objectives

- **SMART GOAL: Provide means to improve our customers experience with our prototype**
- Specific: Keep track of charging data for each cellphone user that uses our prototype and use that data to improve their experience
- Measurable: Record time each phone takes to charge and their type of phone, and use that data to adjust the charging rate.
- Achievable: Consulting with Computer Science Professors at the university will be of utmost importance.
- Relevant: Users should have a positive experience using the prototype
- Time-Based: The production of this application will take an estimate seven days to complete.

Individual Goals and Objectives

- **SMART GOAL:** Making sure the temperature of the battery is within safe area, and the force sensor is sensitive enough
- Specific: The temperature of battery should be kept under 30° , and the force sensor can sense the phone above it
- Measurable: The data from temperature sensors and force sensor is transmitted to computer, it can be used to calibrate the sensors
- Achievable: This can be achieved by searching the Internet
- Relevant: It is about the safety and efficiency of the station
- Time-Based: This goal can be achieved in an estimate two weeks, and they can be adjusted according to the prototype needs

Customer – Centric Goal

- **SMART GOAL:** Prototype should provide convenience and security to the private property of the consumer
- Specific: Prototype should have features that make the usage by the customer feasible and pleasurable.
- Measurable: Set standard to what we want to make prototype safe and marketable
- Achievable: Research online sources, consult professors
- Relevant: The prototype puts the burden of safety on us, and we need to make sure our users property are protected and safe
- Time-Based: This will take the entire length of the project to keep for consideration and adjustments

Engineering Goals

- Sustainability: Prototype should be self-sustaining in terms of power generation and safety protocols
- Environmental: Prototype will rely on zero power from energy grid
- Social: Prototype offers USB charging access in populated areas
- Manufacturability: Prototype can be produced and accommodated to different demands
- Economic: Charger can be used in as perk of being student, no extra cost to the consumer

Sustainability

- **SMART GOAL:** Prototype should be self-sustaining in terms of power generation and safety protocols
- Specific: Keep track of amount of power consumed by Rasperry Pi, touchscreen, and Arduinos
- Measurable: Record the amount of power over time the Raspberry Pi and Arduinos consume under different conditions of stress.
- Achievable: We've consulted with Dr. Fischer about using his tools to measure voltage and current in a non-invasive manner.
- Relevant: The prototype should be able to operate under bare minimum power conditions
- Time-Based: This will take the entire length of the project, plus additional time to retrieve data after the prototype has been built

Environmental

- **SMART GOAL:** Prototype will rely on zero power from energy grid
- Specific: Keep track of amount of power consumed by batteries and supplied by solar panels.
- Measurable: Record the time it takes to fully charge and fully drain the batteries, as well as the rate of power supplied by the solar panels at different times of the day and under different weather conditions.
- Achievable: We've consulted with Dr. Fischer about using his equipment to read current and voltage from solar panels.
- Relevant: Solar panels are a very clean and efficient source of energy.
- Time-Based: The production of this application will take the entire length of building the prototype, and we will continue to measure the amount of power supplied after the prototype has been built.

Social

- **SMART GOAL:** Prototype offers USB charging access in populated areas
- Specific: Take data on how useful our services are to smartphone users
- Measureable: Survey users of our service on convenience and accessibility of prototype.
- Achievable: We will need to test our prototype areas of high traffic on campus
- Relevant: Understanding the usefulness of our project can help us to better improve certain aspects
- Time-Based: This will take no more than a week, and will be done after the building of our prototype.

Manufacturability

- **SMART GOAL:** Prototype can be produced and accommodated to different demands
- Specific: Better understand the amount of demand our prototype has in certain areas and under certain conditions
- Measureable: Record the amount of people that desire to use our services along with a timestamp
- Achievable: We will code in a method to record the time, date, and increment a number to keep track of the amount of users
- Relevant: Knowing how many people use our services can allow us to modify our prototype to accommodate more phones at a time
- Time-Based: This will be done after our prototype has been built, and will take no less than a week

Economic

- **SMART GOAL:** Charger can be used in as perk of being student, no extra cost to the consumer
- Specific: We can market our prototype to Universities or businesses that can offer our prototype to their students/employees
- Measureable: Survey students and employees on how likely they are to use our prototype if it were provided to them for free
- Achievable: We will test our prototype near campuses and business locations
- Relevant: This would allow for our services to be provided to people who need them at no cost
- Time-Based: This will be completed after our prototype has been built

Prototype Specifications

- 4 Elements: Software, solar energy harnessing, battery charging / regulation, phone charging

- Software:
  - Raspberry Pi : 5.1 VDC, 700mA
  - Arduino Uno : 9-12 VDC, 250mA
  - Computer Monitor: Sunfounder 7in HD, 12 VDC, 6W

Prototype Specifications

- Solar Energy Harnessing
  - 2Photovoltaic Solar panels: 6v, 3.5W each, 3.69W at peak power
  - Parallel circuitry for maximum power while retaining 6V necessary for charger
  - USB, Solar, Lithium Ion charger will regulate 3.7V to avoid damage to battery
  - Lithium Ion Battery 3.7V at 15600mAh (six 18650 batteries in parallel)

- Battery Charging / Regulating
  - USB, Solar, Lithium Ion charger will regulate 3.7V to avoid damage to battery
  - Lithium Ion Battery 3.7V at 15600mAh (six 18650 batteries in parallel)

Prototype Specifications

- Phone Charging
  - DC/DC Boost Converter to produce 5V at 1000mA to meet charging requirements
  - Wireless Charger / Charging Base
  - Force Sensors for reading .04g/mm to 4.5kg/mm
  - Average charging device: 200g to 500g
  - Electronic Lock: Micro Servo with Arduino
    - 3 to 6 V from DC/DC Boost
    - Torque 1.6kg/cm
    - 90 degree rotation

Constraints?

- Wireless Access
- Self Powering
- Outdoor Durability
- Waterproof
- Additional Modules
- Battery Sustainability
- Weather (Testing / Real use)

Standards, Assumptions, Safety

- ANSI Z535
- OSHA
- PSES IEEE

⚠WARNING

SHOCK HAZARD! High currents are possible during testing. Ensure the device under test is turned off and the power supply's capacitors are fully discharged before attaching or removing test leads as you perform this test procedure.

⚠WARNING

FIRE HAZARD! Lithium ion batteries can catch fire or explode if subjected to short circuiting or prolonged exposure to high current. Lithium ion batteries can burn up to 1000°F. Ensure that the lithium ion batteries do not come in contact with any pieces of metal, are kept under 100°F, and are not exposed to any current or voltage other than what is rated.

NOTICE

DO NOT dispose lithium ion batteries in the trash. Instead, contact your local waste facility and ask if they can handle disposing lithium ion batteries.

Part 3: Implementation

- Proposed Implementation
- Demonstrated Implementation

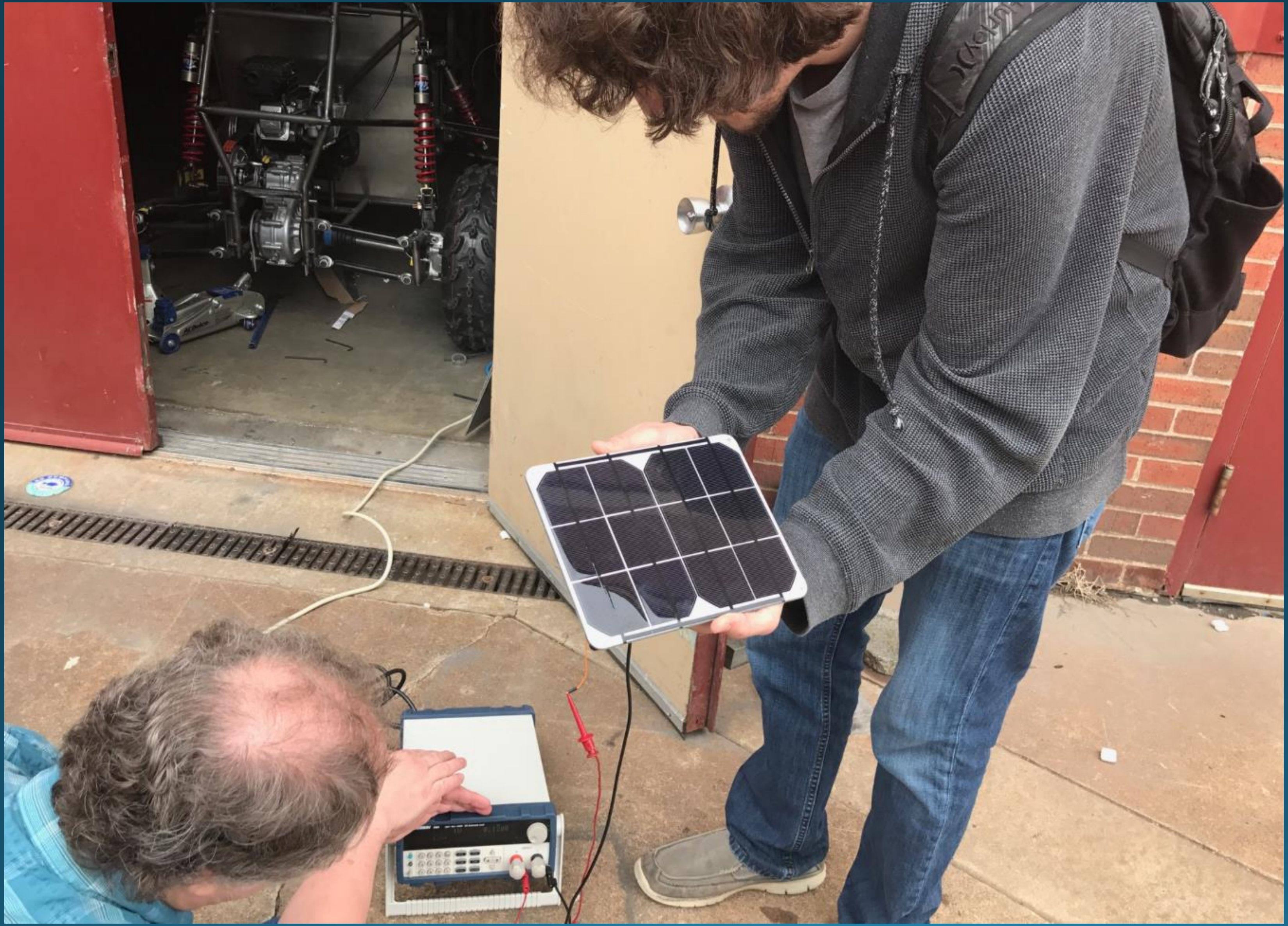
Proposed Implementation

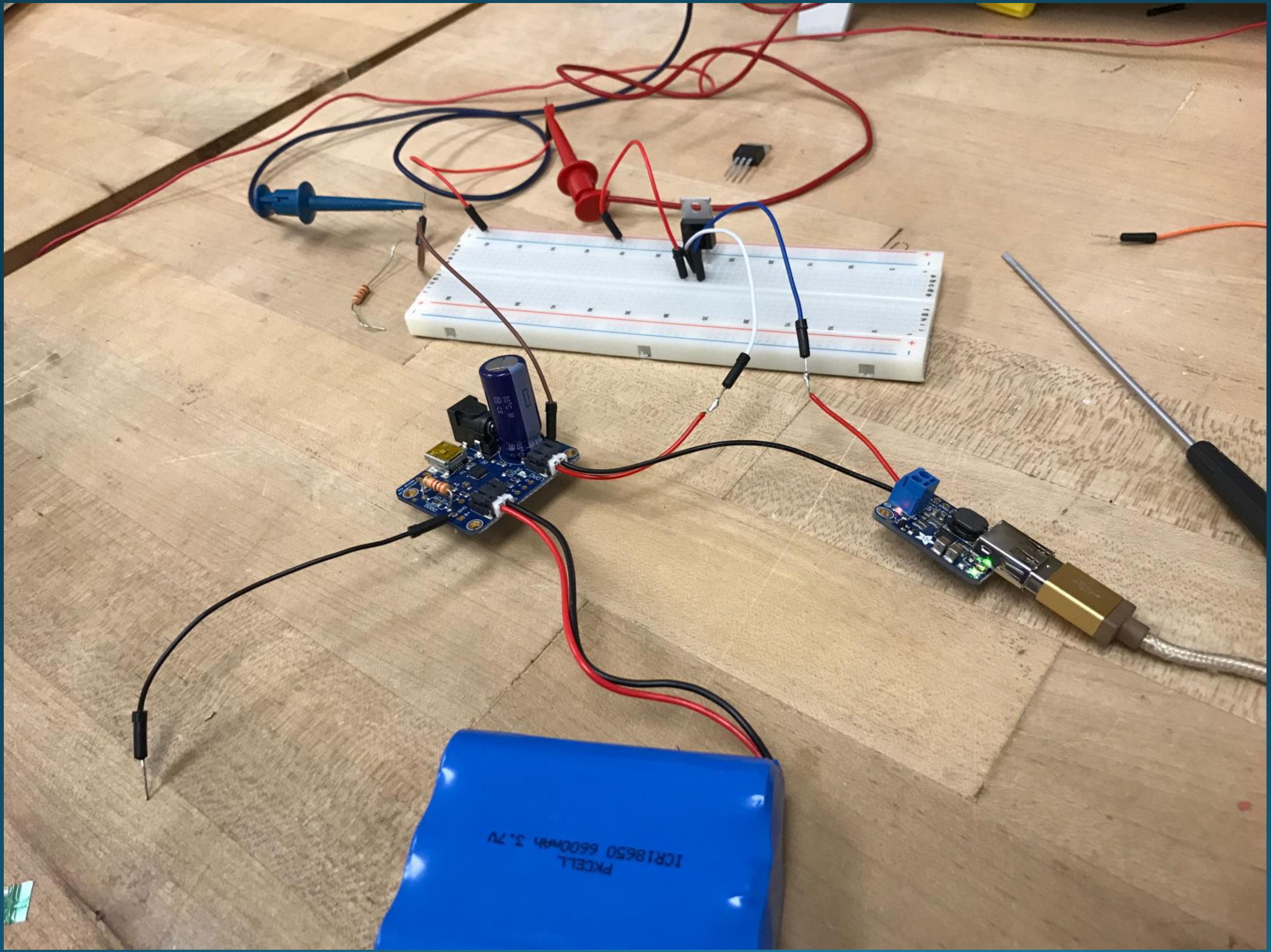
- General Power system: photovoltaic solar panel, charger, battery, DC/DC converter
- Parallel linkage of Solar panels
- 18650 Lithium Ion batteries
- Self powering system
- Temperature controlled
- SCADA system
- User interface for student login

Proposed Function Block Diagram

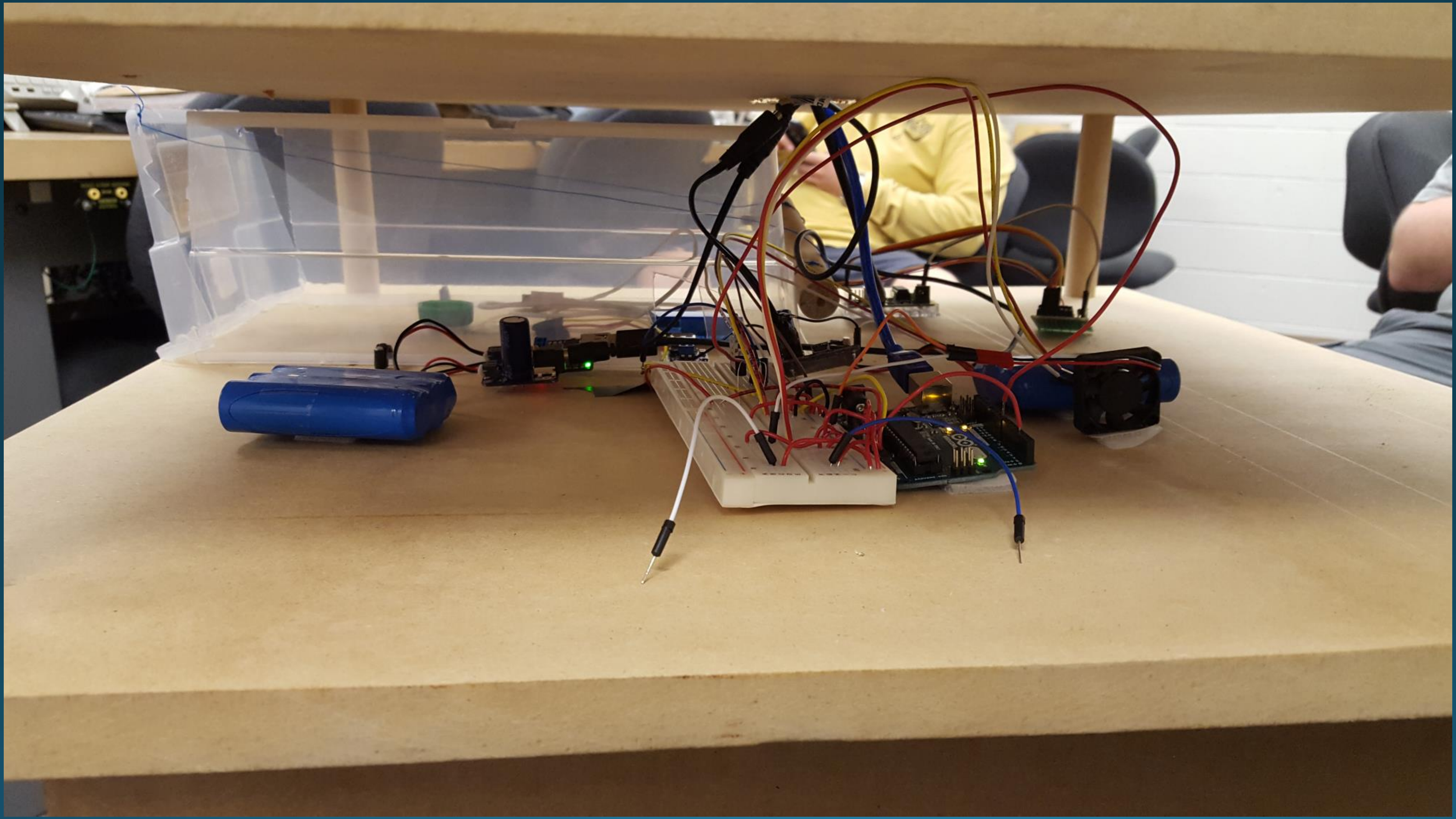
Demonstrated Implementation

Solar Panels and Power Diversion



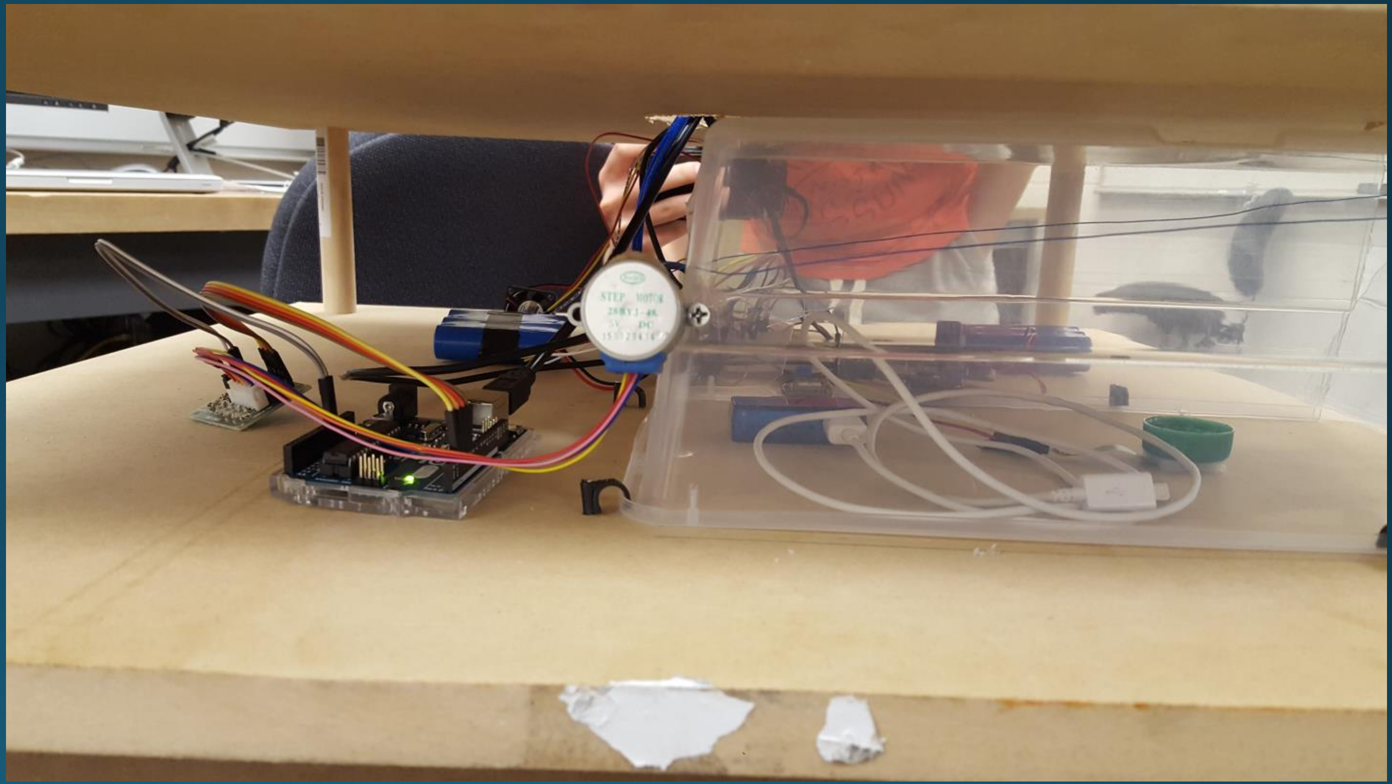

ICR18650 6600mAh 3.7V
PKCELL

Arduino 1



Arduino 2 to Raspberry Pi

- Stepper Motor
- Motor driver
- Plastic Container
- USB to B (serial communication)

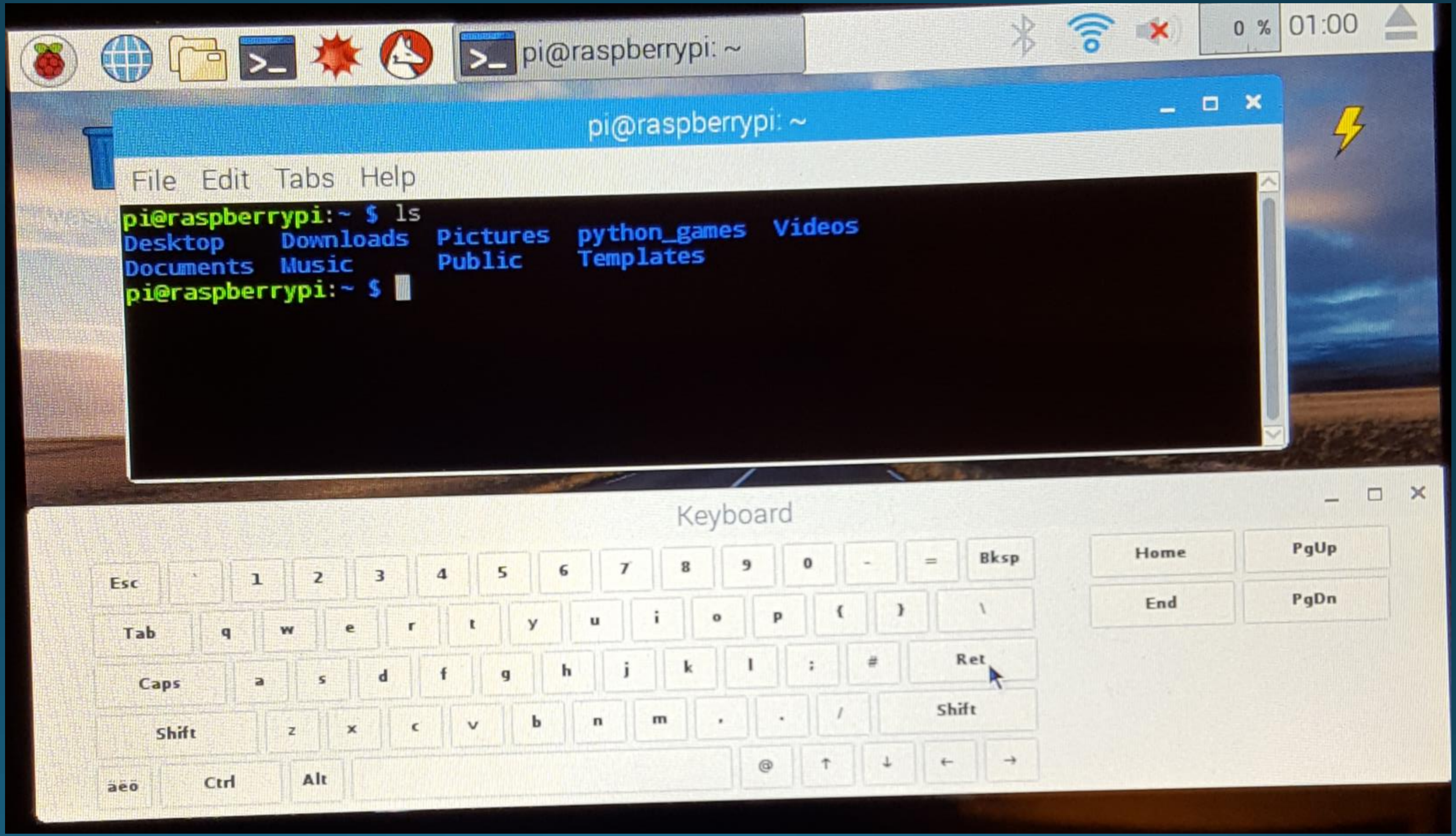


Raspberry Pi

- OS: Raspbian
- Touchscreen display
- Website interface

Raspberry Pi Raspbian (Debian)

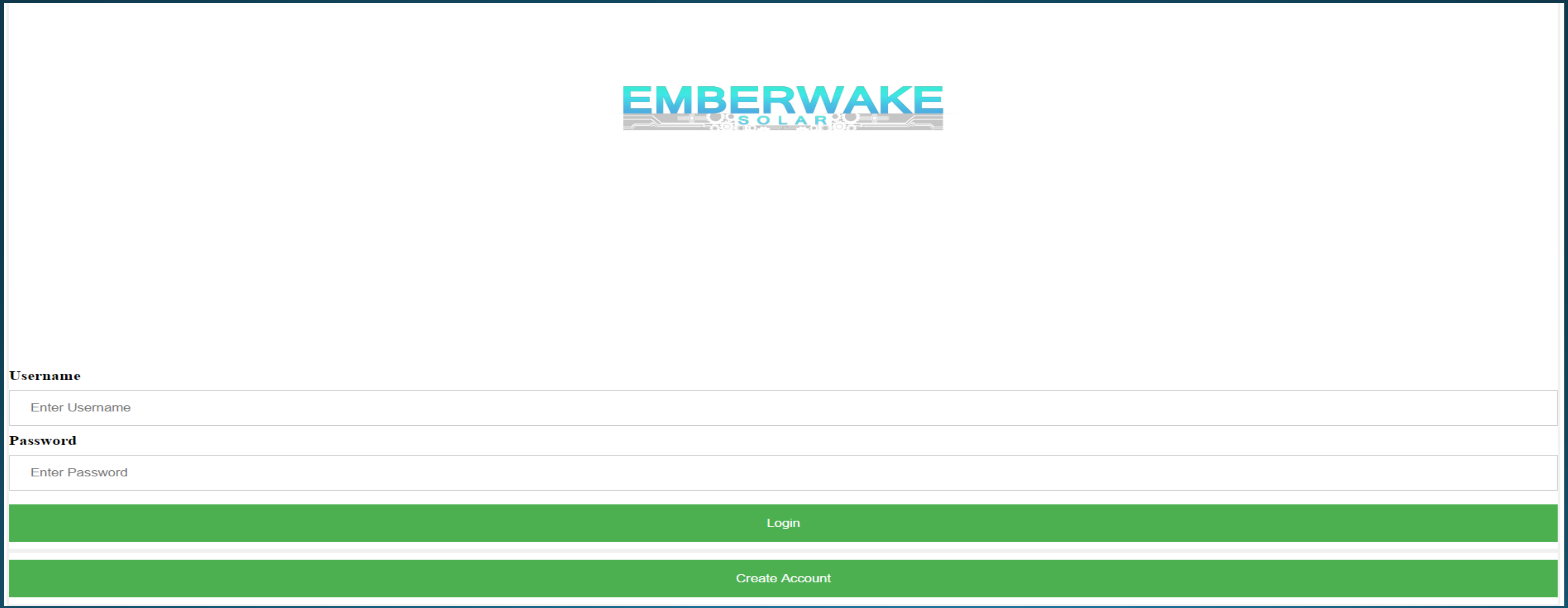
- Linux Based Terminal
- Socket Server in C
- Socket Client in PHP
- Used get-apt install to install dependencies such as LAMP



MYSQL, PHP, Apache, PHP-MYSQL, Apache-PHP-MYSQL, MYSQL server

User Interface

- Login Page

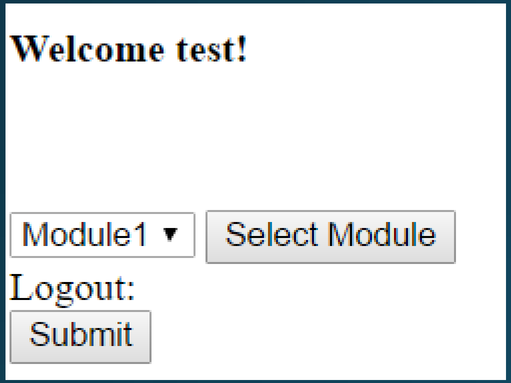


User Interface cont.

- Account Page

User Interface cont.

- Login Page



User Interface

- Login or Create an account
  - Uses hash cryptography to protect password
  - Login authentication to protect phone from theft
- Action Page
  - Select module and click button to trigger motor.
  - Controlling Arduino from Raspberry Pi through serial communication
  - Raspberry Pi sends a byte (ASCII hexadecimal number) which encodes which module was selected. This byte is sent from the PHP code to C code through a pipe, then from the C code to the Arduino though the serial port.

Part 4: Project Evaluation

- Goals and Objectives
- Critical Specifications
- Feasibility

Review of Goals and Objectives

- **SMART GOAL: Consider power system that can adequately charge all devices in the prototype**
- Criterion:
- Pass Threshold:
- Method:
- Measured Value:
- Result:

Review of Goals and Objectives

- **SMART GOAL: Successfully create security system to protect prototype.**
- Criterion: Using sensors and software to create a security system.
- Pass Threshold: Security system installed utilizing password encryption and locking mechanism.
- Method: Hash encryption for passwords entered into database, and small motor to create a locking mechanism.
- Measured Value: N/A
- Result: Passed

Review of Goals and Objectives

- **SMART GOAL: Provide means to improve our customers experience with our prototype**
- Criterion: Measure the amount of time it takes for a full charge.
- Pass Threshold: If it takes less than an hour to fully charge.
- Method: N/A
- Measured Value: N/A
- Result: Failed

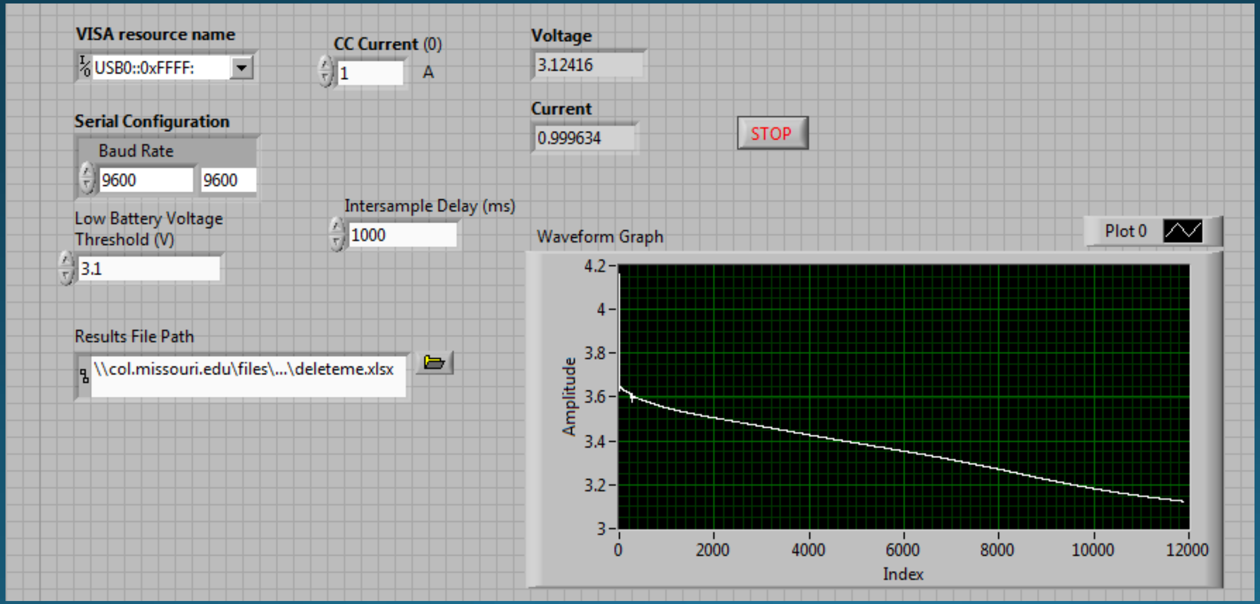
Review of Goals and Objectives

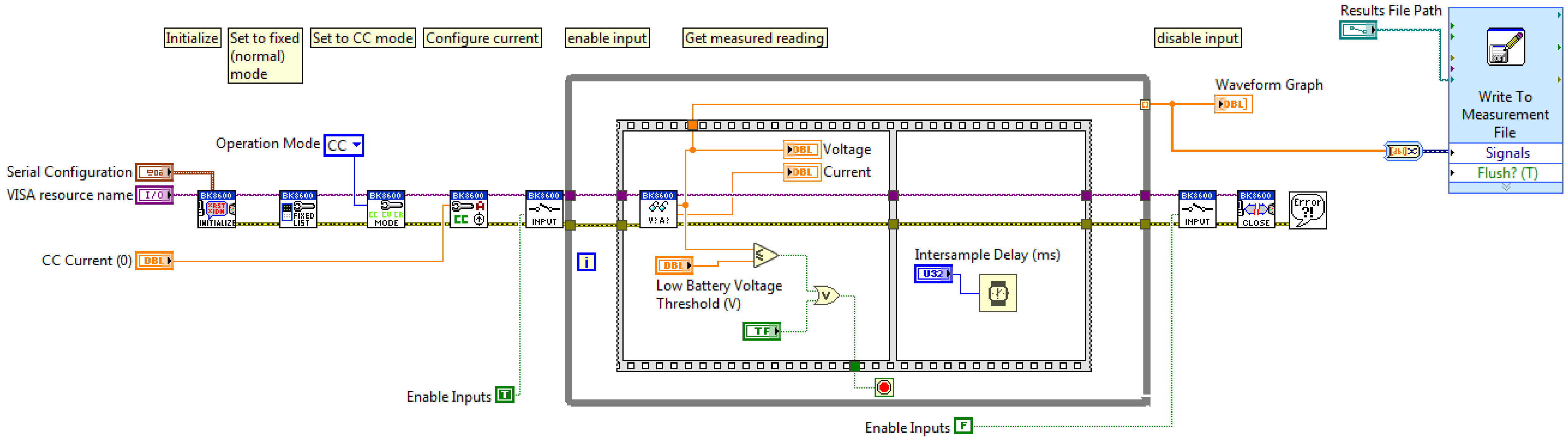
- **SMART GOAL:** Making sure the temperature of the battery is within safe area, and the force sensor is sensitive enough
- Criterion: Let the battery work for an amount of time and put phone above the force sensor
- Pass Threshold: If the fan starts work when the temperature of battery is over 30° and keep it not goes up. If the phone starts to be charged when it is put on the force sensor
- Method: N/A
- Measured Value: N/A
- Result: Temperature-controlled Fan failed. Force sensor success

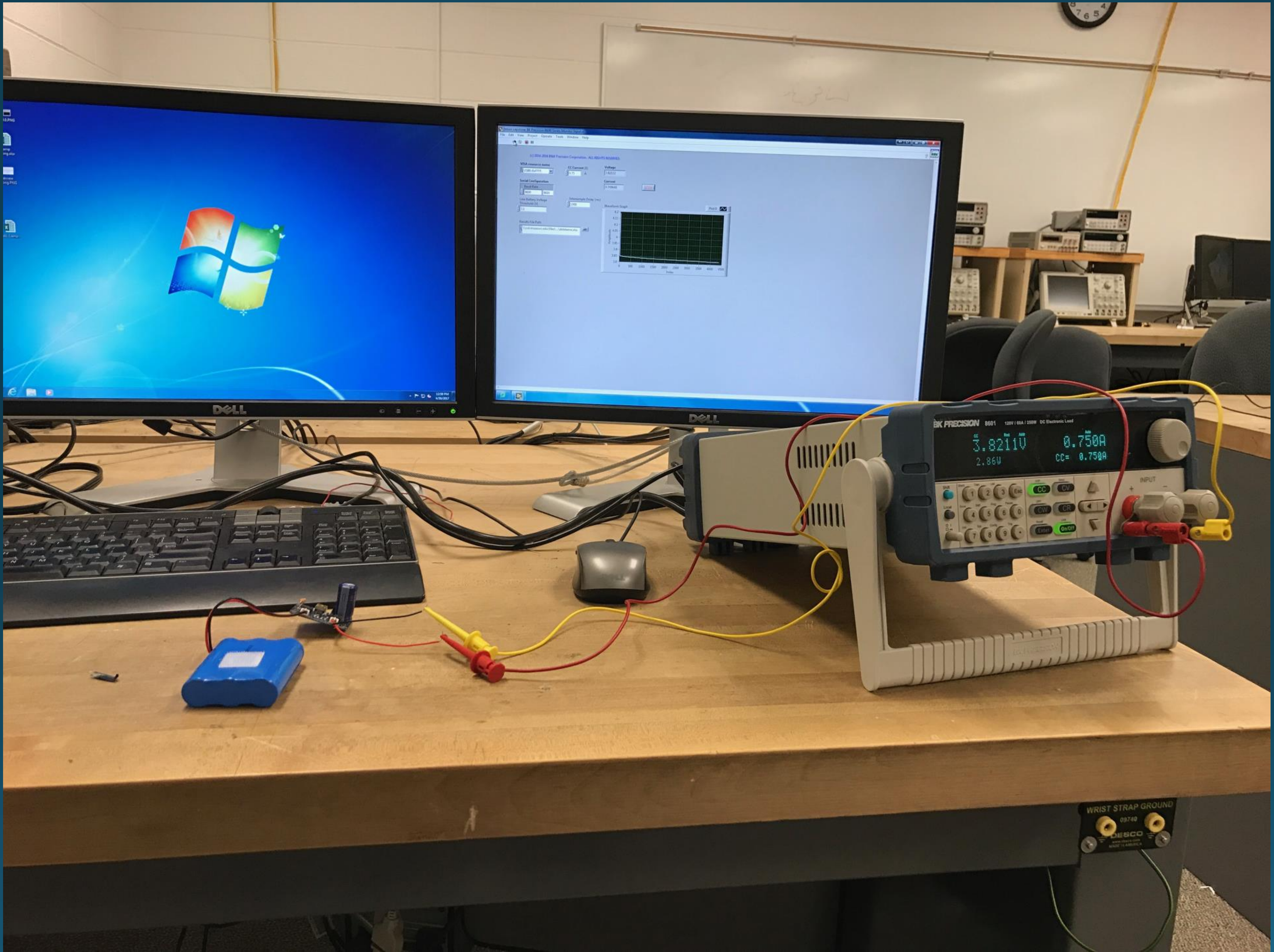
Review of Prototype Specifications

Feasibility of our Prototype

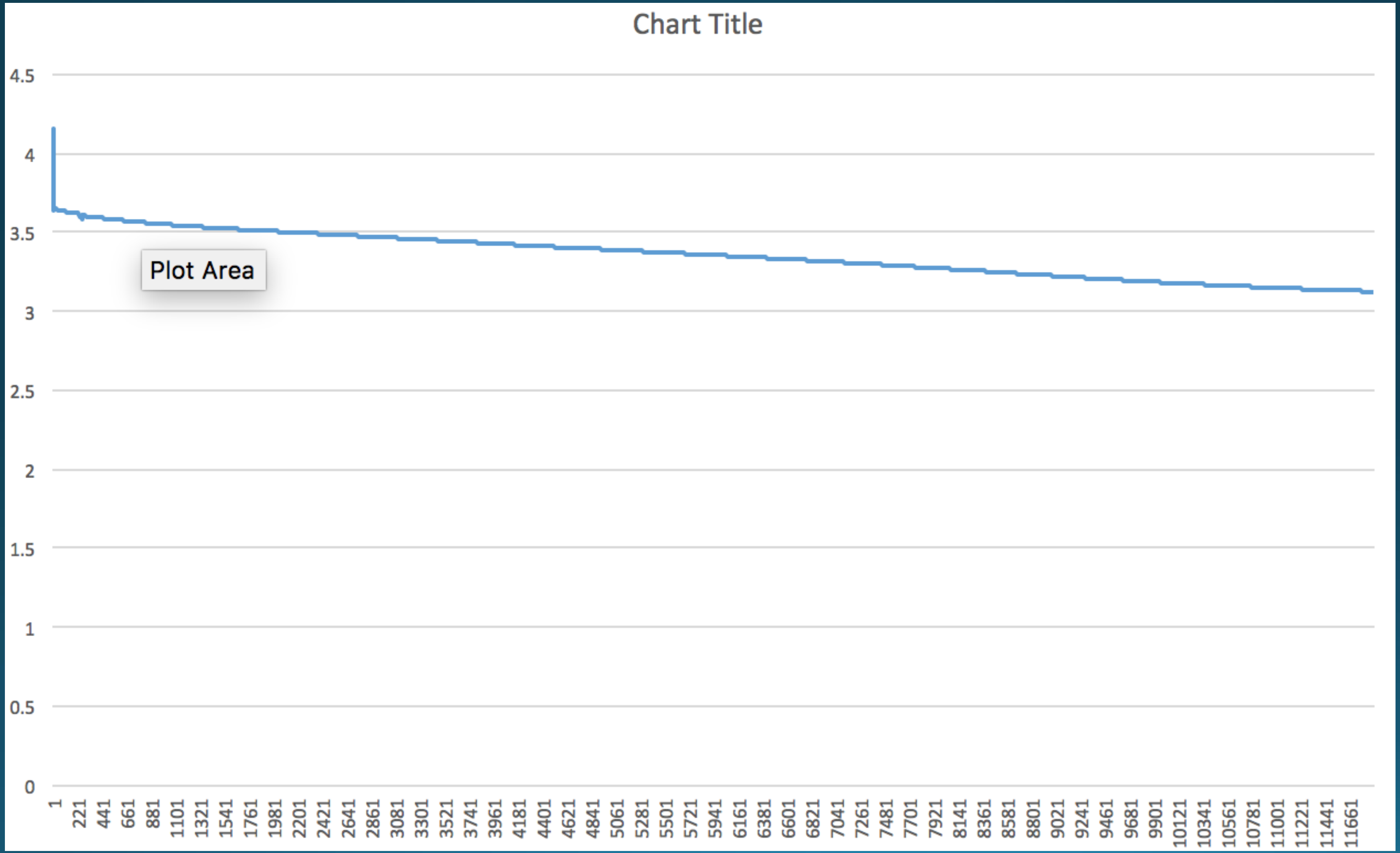
- How long do the batteries last?
- 6600mAh batteries tested at 750mA and 1A draw rate
- Using BK Precision 8601 DC Electronic Load
- LabVIEW



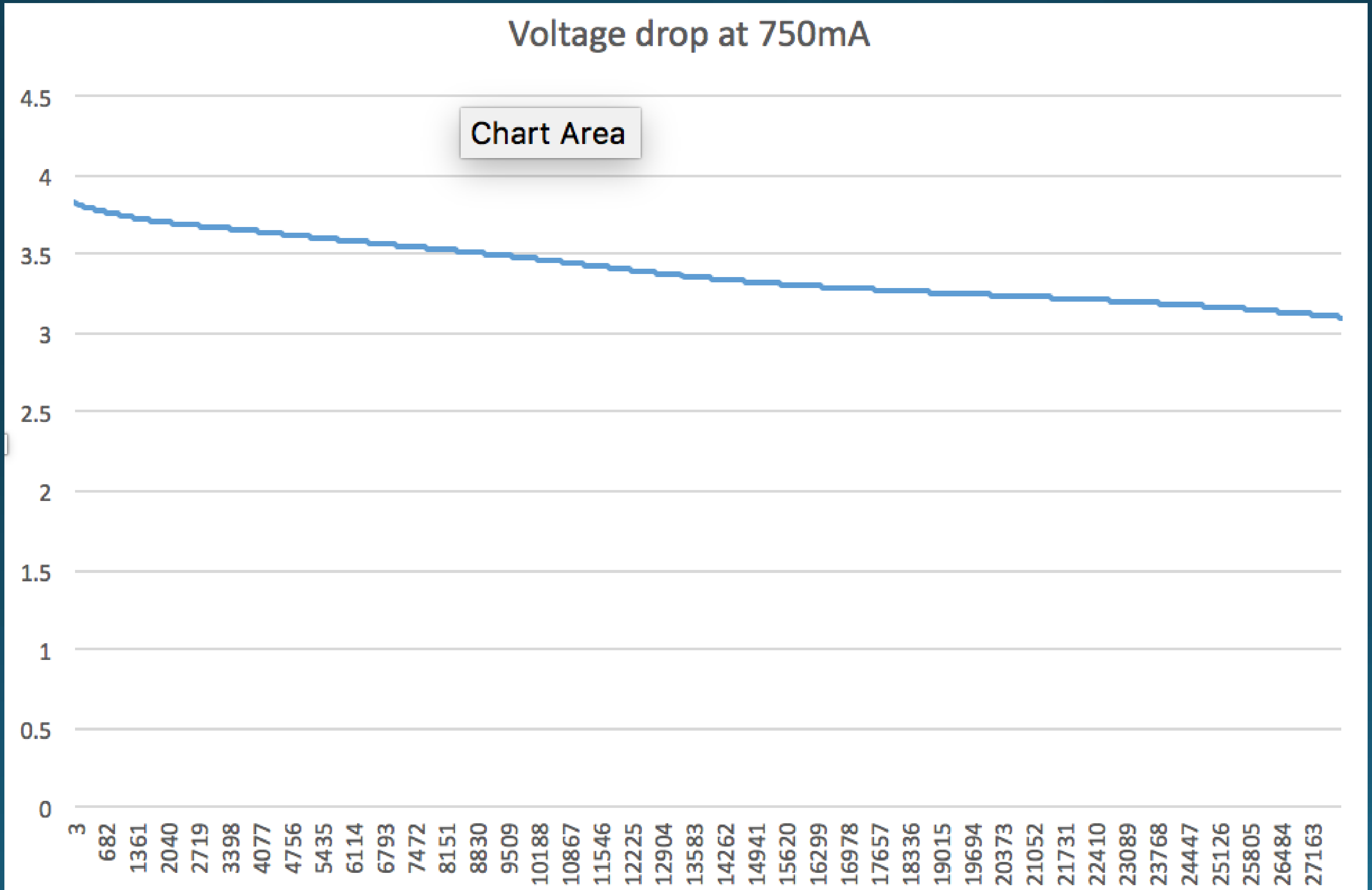

Initialize
Set to fixed (normal) mode
Set to CC mode
Configure current
enable input
Get measured reading
disable input
Results File Path
Write To Measurement File
Signals
Flush? (T)
Waveform Graph
Operation Mode
CC
Serial Configuration
VISA resource name
CC Current (0)
Voltage
Current
Low Battery Voltage Threshold (V)
Intersample Delay (ms)
Enable Inputs
Enable Inputs


DELL
DELL
BK PRECISION 8601 120V / 60A / 250W DC Electronic Load
3.8211V
0.750A
2.86W
CC= 0.750A
CC
CV
CW
CR
Esc
Enter
On/Off
INPUT
WRIST STRAP GROUND
DESCO

Mostly charged battery at 1000mA, 3.3 hrs starting @ 3.6V



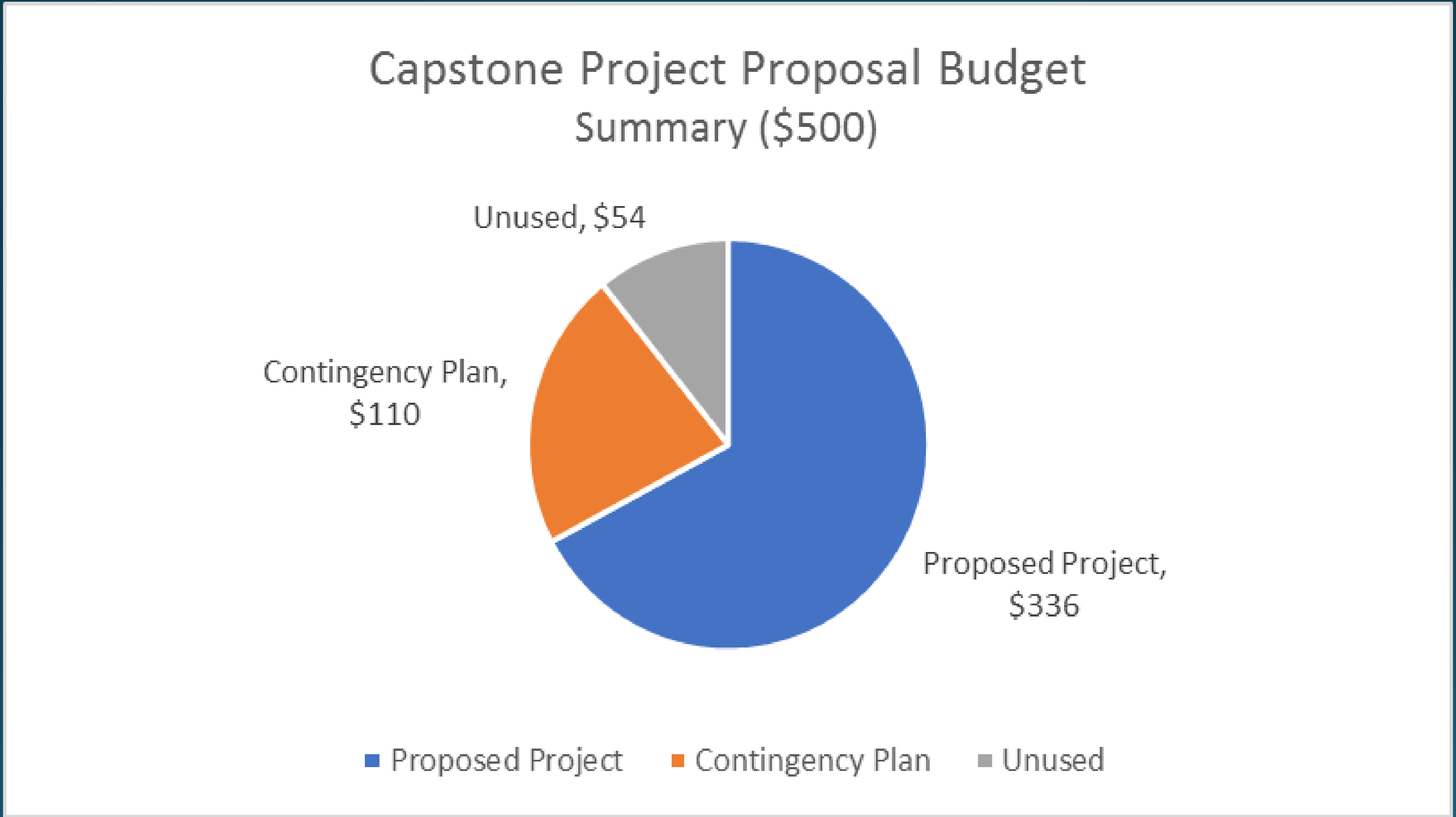
Fully Charged battery at 750mA, 7.7hrs starting @ 3.83 V



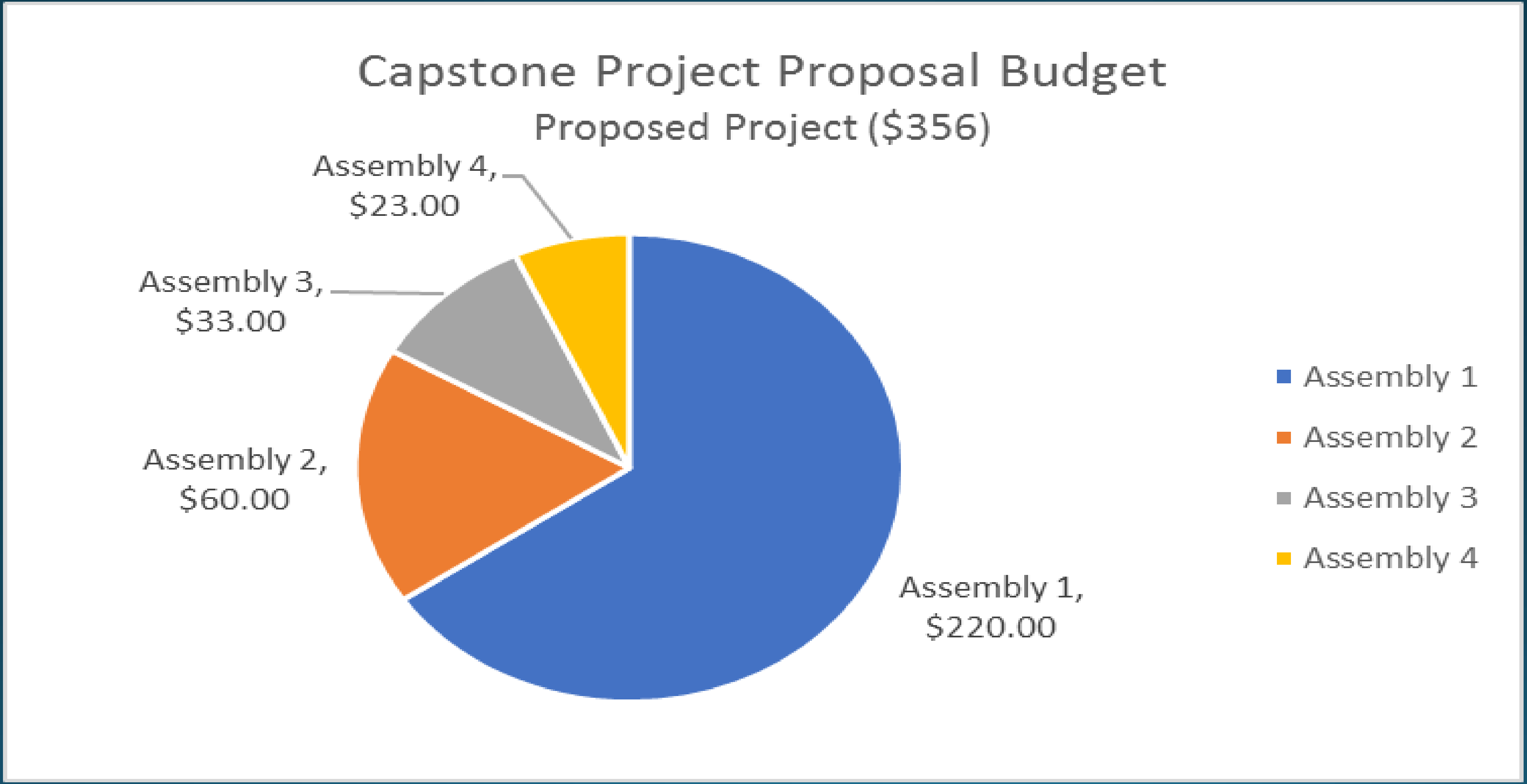
Part 5: Financials

- Proposed Costs
- Actual Costs
- Estimated Production Levels
- Estimated Production Cost per Unit
- Suggested Retail Price

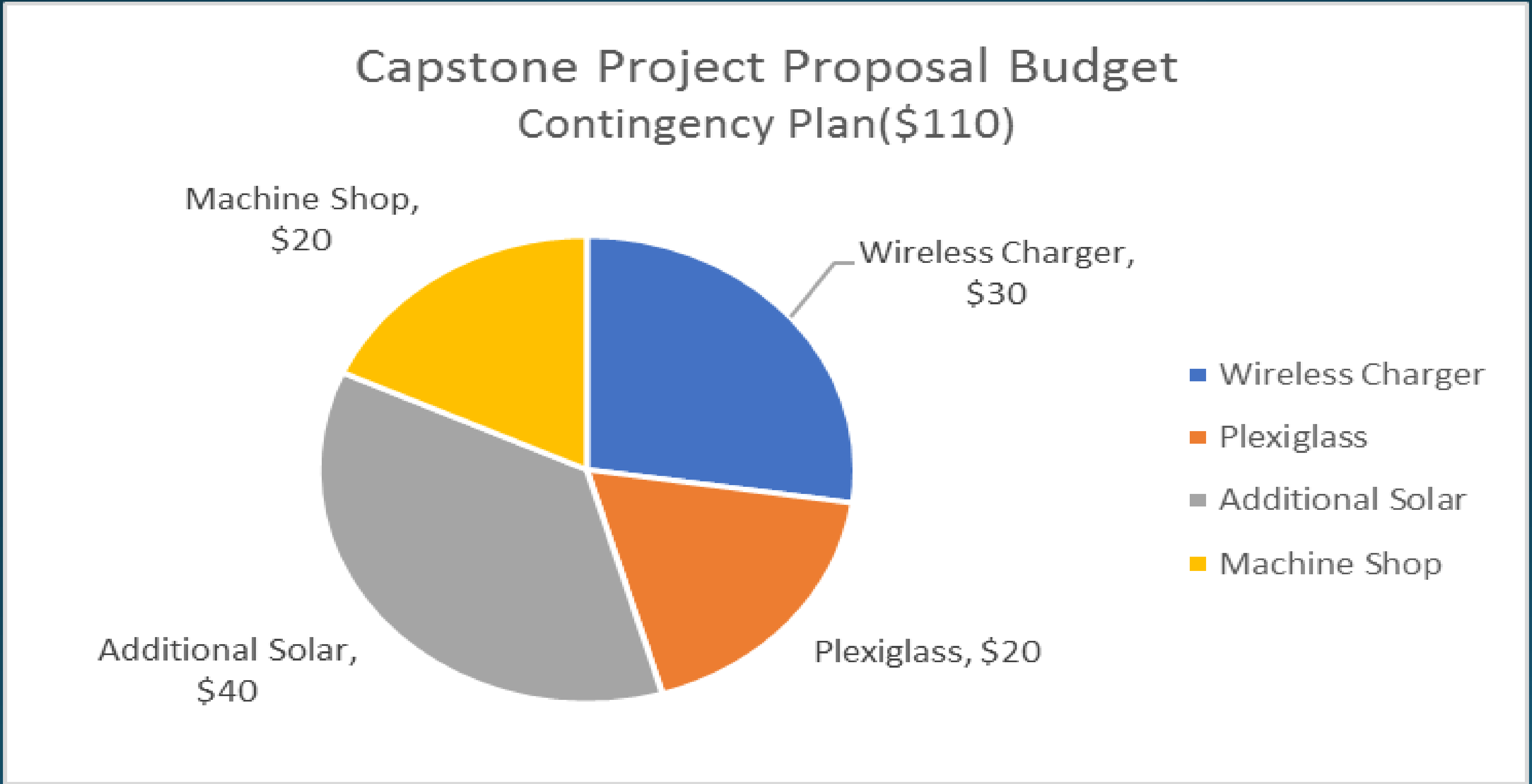
Proposed Costs



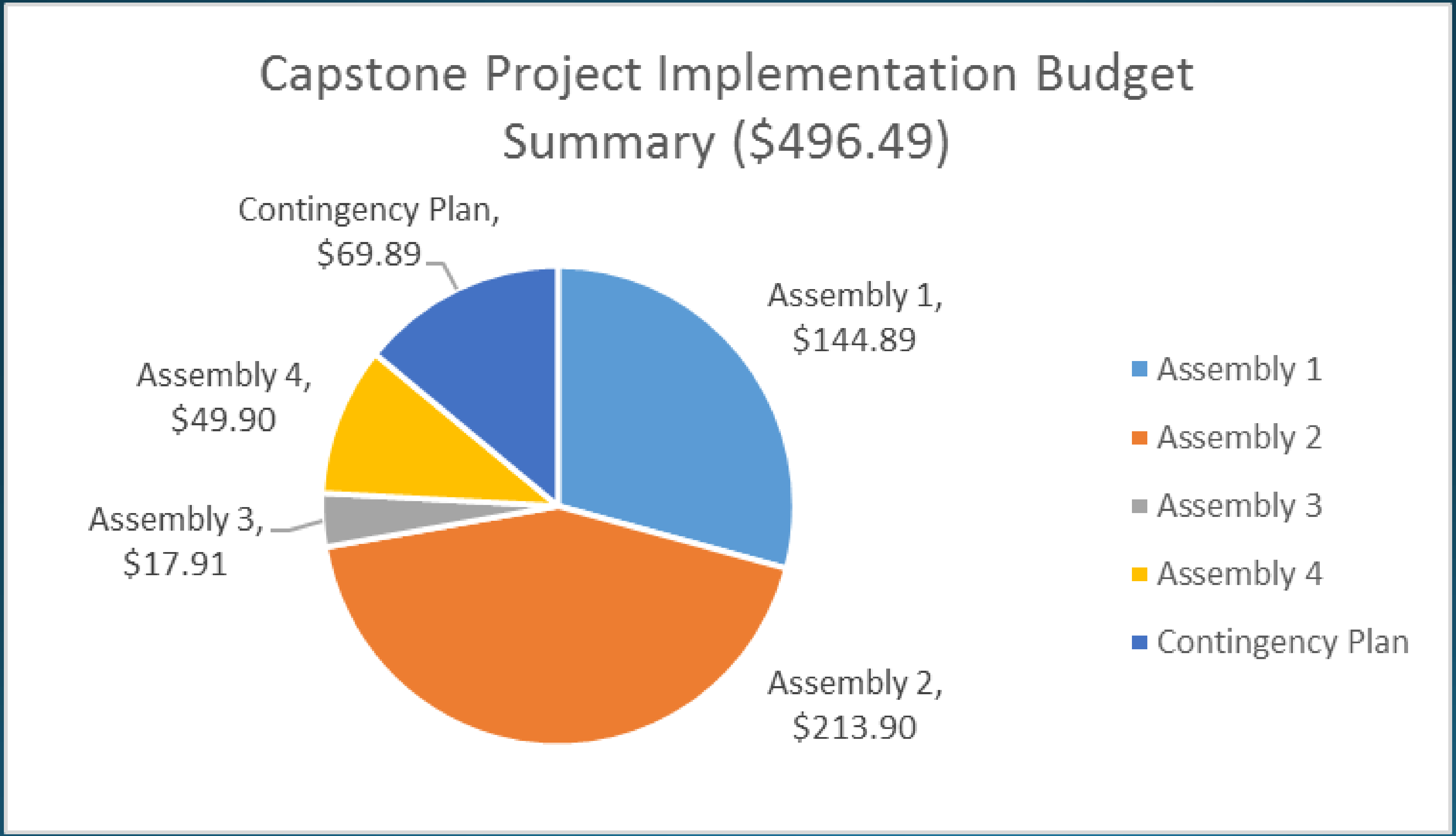
Proposed Assembly Costs



Contingency Plan



Actual Costs



Initial Development Costs

Projected Labor Estimations	
Salary	$58,000
Hourly Wage	$29/hour
Phase 1 Costs	$4180
Phase 2 Costs	$870
Total Cost	$5500

Actual Labor Calculation	
Salary	$58,000
Hourly wage	$29/hour
Phase 1 Costs	$5,220
Phase 2 Costs	$870
Total Cost	$6,090

Estimated Production Levels

Number of Workers	1
Time for Completion	4 Hours
Worker Wage	$20
Labor Cost	80$
Average Workday	8 Hours
Units Per Day	2 Units

Estimated Production Cost / Unit

Production Cost	
Labor	$80
Parts	$670
Total	$750

Suggested Retail Price

- Method 1
  - Location Purchases Device
  - Free usage

Cost of Production	$750.00
Shipment & Delivery Fee	$24.99
2 Year Warranty (Optional)	$85.99
Total Production Cost	$860.98
Profit Margin	$2139.01
Total Purchase Cost	$2999.99

Suggested Retail Price

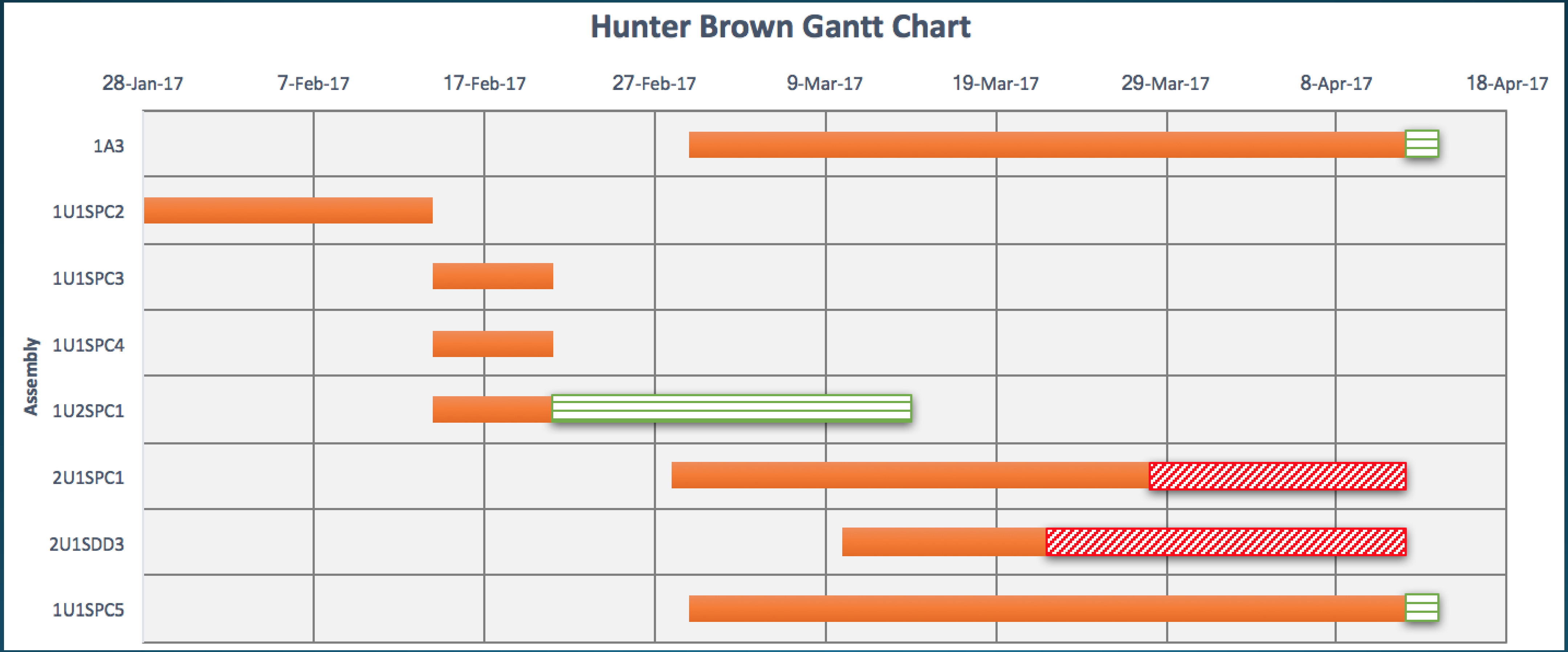
- Method 2
  - Device provided free of charge
  - Hourly rate to charge devices

Cost of Production	$750.00
Shipment & Delivery Fee	$24.99
Total Production Cost	$774.99
Hourly rate	$1.50
Endless Session	$10.00
Estimated Payback Time	550 Hours

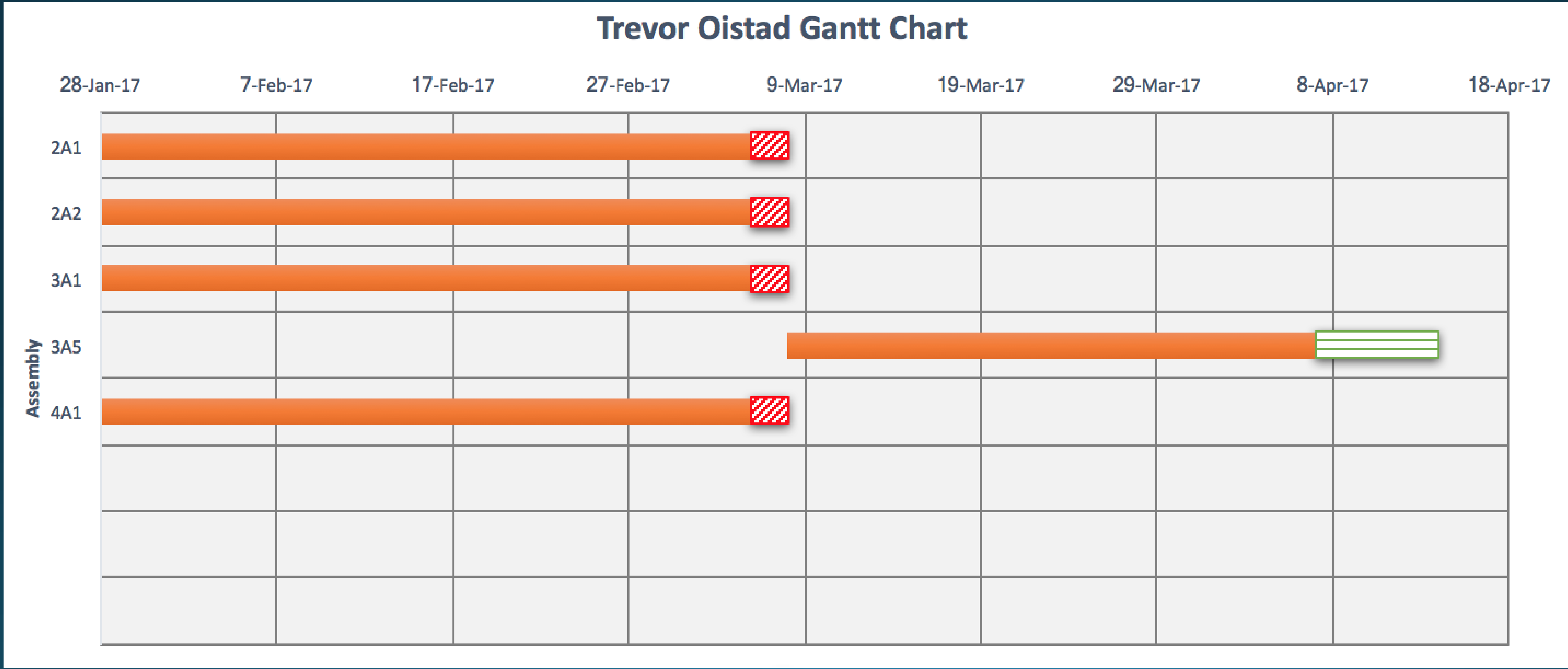
Part 6: Prototype Timeline

- Estimated Timeline
- Actual Timeline

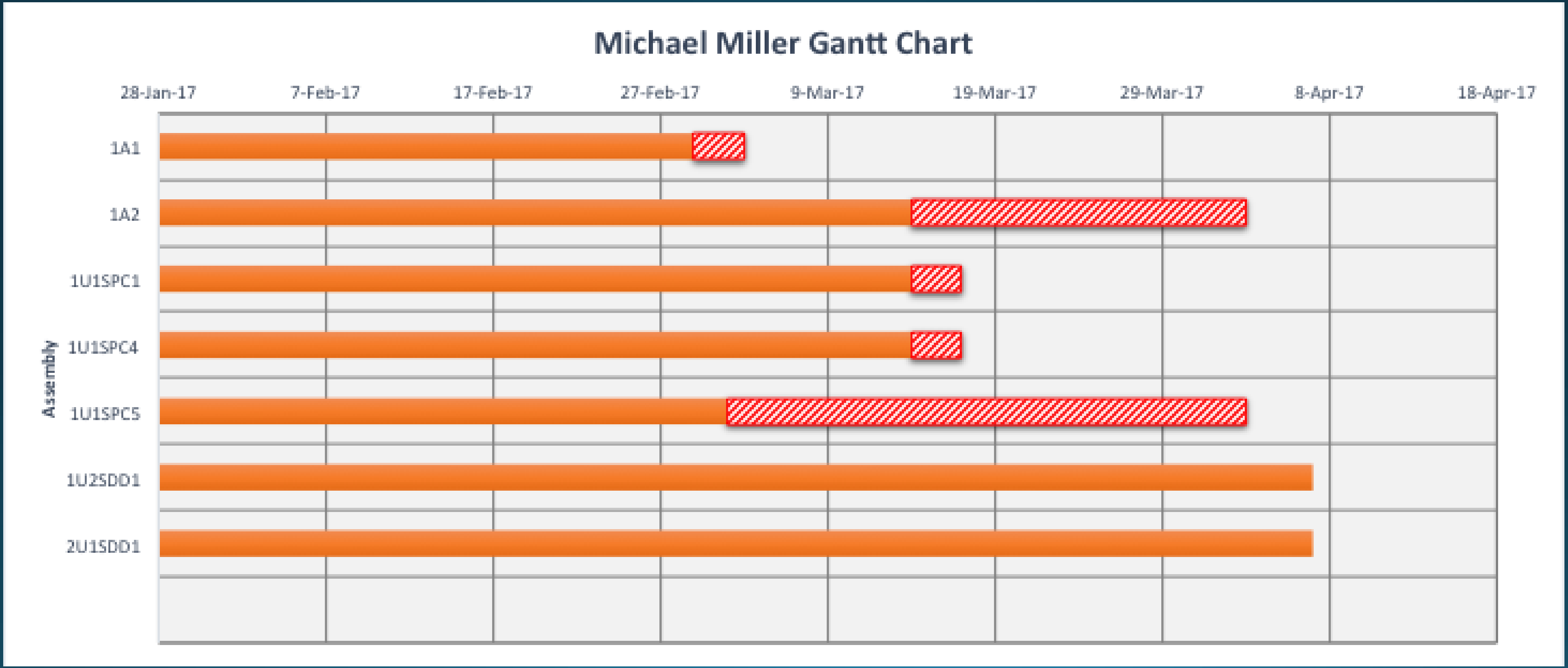
Timeline - Hunter



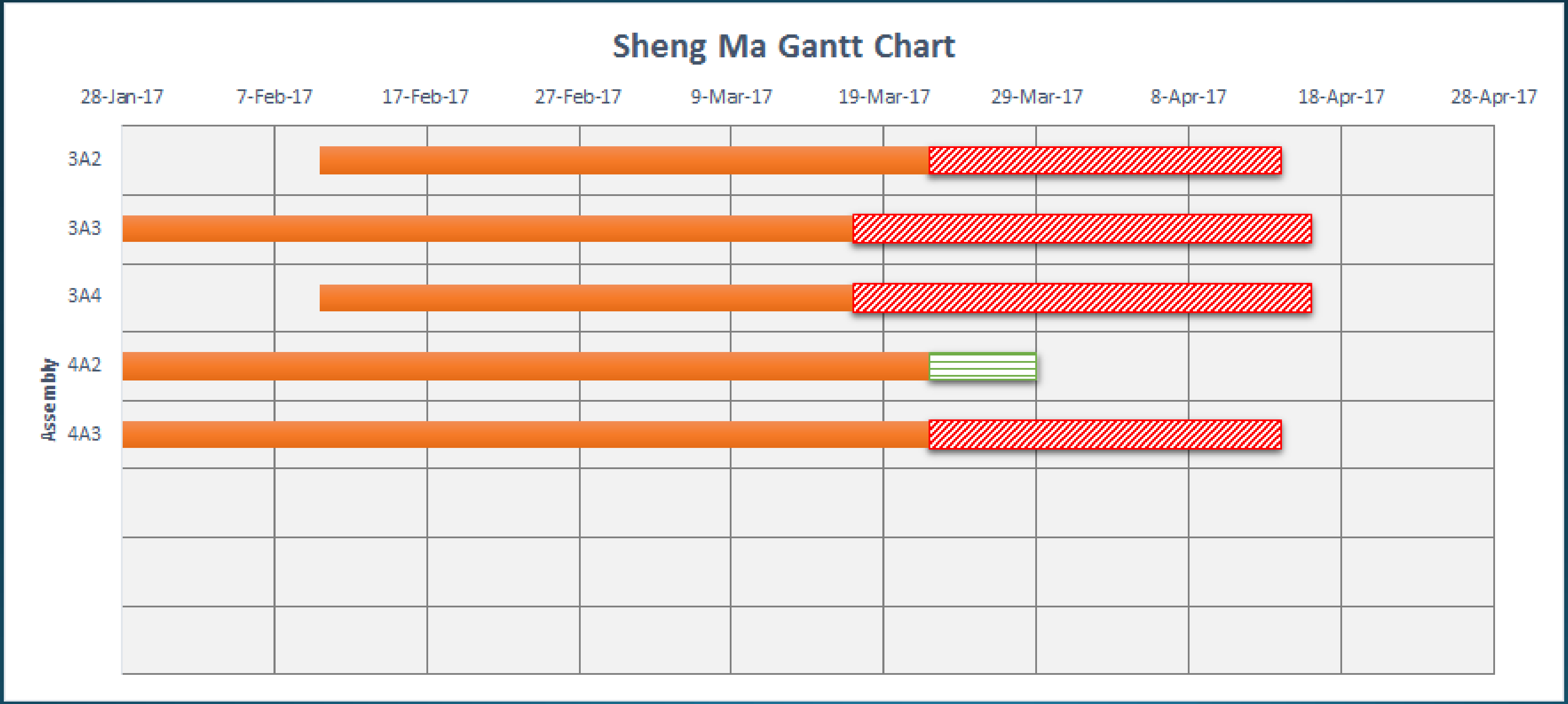
Timeline - Trevor



Timeline - Michael



Timeline - Sheng



Part 7: Summary and Conclusions

- What did we accomplish?
- What did we learned?
- How was this beneficial?

Questions?