NORTHERN ARIZONA UNIVERSITY

School of Informatics, Computing, and Cyber Systems

Bugs Life

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Subject: Design Document #2

I agree with and approve of this design document.
February 17, 2023 Theodore Kennedy

NORTHERN ARIZONA UNIVERSITY
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Statement of Needs:

For the capstone project “Smart Lamps” the needs of the client are relatively simple. The lamp is used for collecting insects so that scientists can collect data and study what the insects are doing and what they are telling them about the area and its environment. We are trying to achieve longer lasting batteries without the hassle of replacing batteries every 4 hours. Working with their previous design, they would like the lamp to function around 30 hours from their current 4 hours. The lamp's will be deployed on river expeditions down the Colorado River in the Grand Canyon, which lasts 7-27 days. The lamp needs to operate for one hour each night. Additionally regardless of how this is achieved, the client has specified that the spectrum of light be maintained from their previous design to keep their data consistent. Lastly for the complete prototype, all components must fit into a 40 mil ammo can. The client also stated that the minimum amount of time they are looking for from the lamp is 15 hours. For the client around 20 hours of battery life would be the ideal amount needed for the trips and the 30 hours would be the best case scenario.

The ideal design should be easy for the user to operate because the device will be incorporated in a community science project and will be primarily deployed by commercial river guides. Community scientists receive between 10-20 minutes of training before collecting data in the field. Our design will be very simple to set up and easy to use. The design must also not overheat.

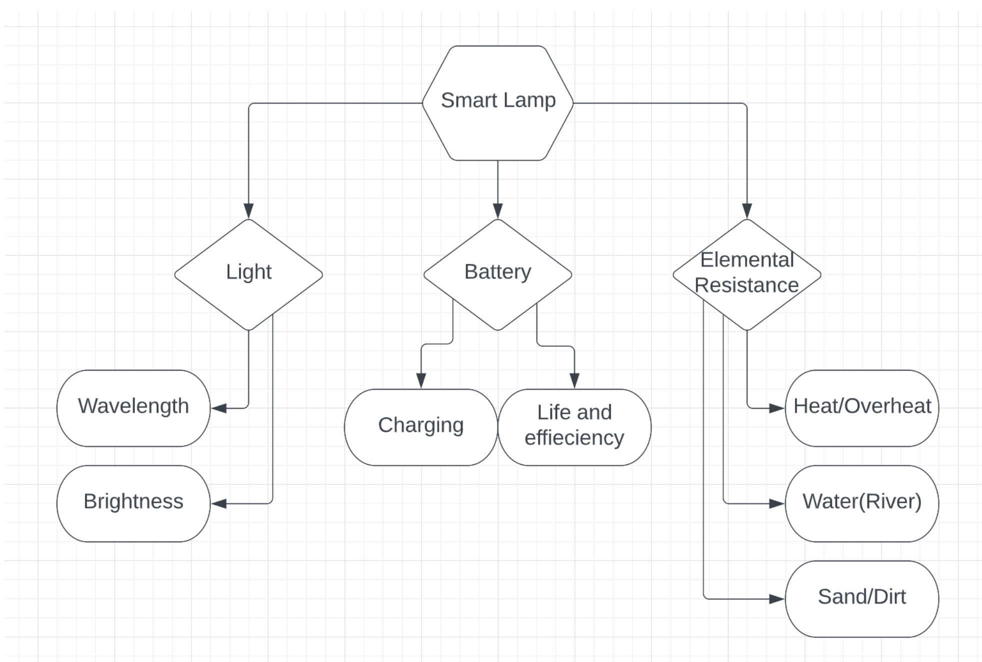
Statement of Objectives:

- 30 hours of battery life
- Weather resistant device
- Self charging device

We will bring our Engineering skills to create a device that will be weather resistant, charge by itself without replacing batteries frequently, and last the amount of time needed without replacing any batteries for the testing and data collection that is needed to be done.

Objective Tree:

Fig.1



Decision Matrices:

Battery decision matrix:

The decision matrix below in figure 2 shows the three different batteries we selected to use for our project. After using the decision matrix we chose to use the Lifepo4 6 volt battery as it was fairly cheap, had good amp hours, and was going to be easy to charge using a solar panel.

Fig.2

	A	B	C	D	E	F	G
1		**Cost** (weight:3)	**size** (weight:4)	**Ah (Amp Hours)** (weight:3)	**Charging** (weight:4)	**Score**	
2	Lifepo4	3	2	4	4	**45**	
3	18650 battery	4	3	1	4	43	
4	Lipo	2	2	5	2	37	
5							
6	comparisson scale:	1=equal	2=moderate	3=strong	4=very strong	5=extreme	
7							
8							
9							
10							
11							
12							
13							

Solar panel decision matrix:

The decision matrix below shows four different solar panels and the one that got the highest score is the ICP solar panel. This panel had a cheap cost, small size, and was the most durable when compared to the others. The 1000W solar panel score was very close to the ICP solar panel score and we will keep that in mind while we are building and testing this project because we may want to do a test with both as they are not very expensive.

Fig.3

	A	B	C	D	E	F	G
1		**Cost** (weight:3)	**Size** (weight:5)	**Watts** (weight:3)	**Durability** (weight:4)	**Score**	
2	ICP solar panel	4	4	3	4	**57**	
3	Thunderbolt 25W	2	2	4	3	40	
4	Sunnytech 3w	5	5	3	1	53	
5	1000w solar panel	3	3	5	4	55	
6							
7	comparisson scale:	1=equal	2=moderate	3=strong	4=very strong	5=extreme	
8							
9							
10							
11							
12							
13							

Buck convertor matrix:

The figure below shows the best option for the buck convertor we will be using. As the LM2596 is very close to the PlusRoc we ordered both just to do tests with both parts as they were cheap and then we can decide what will be the best fit for our application.

Fig.4

	A	B	C	D	E	F	G
1		**Cost** (weight:3)	**Size** (weight:5)	**Volt Range** (weight:3)	**Durability** (weight:4)	**Score**	
2	PlusRoc step down module	4	5	1	4	**56**	
3	DROK step down module	3	2	4	3	43	
4	LM2596 Buck convertor	5	3	4	3	54	
5							
6							
7	comparisson scale:	1=equal	2=moderate	3=strong	4=very strong	5=extreme	
8							
9	LM2596	DROK		PlusRoc			



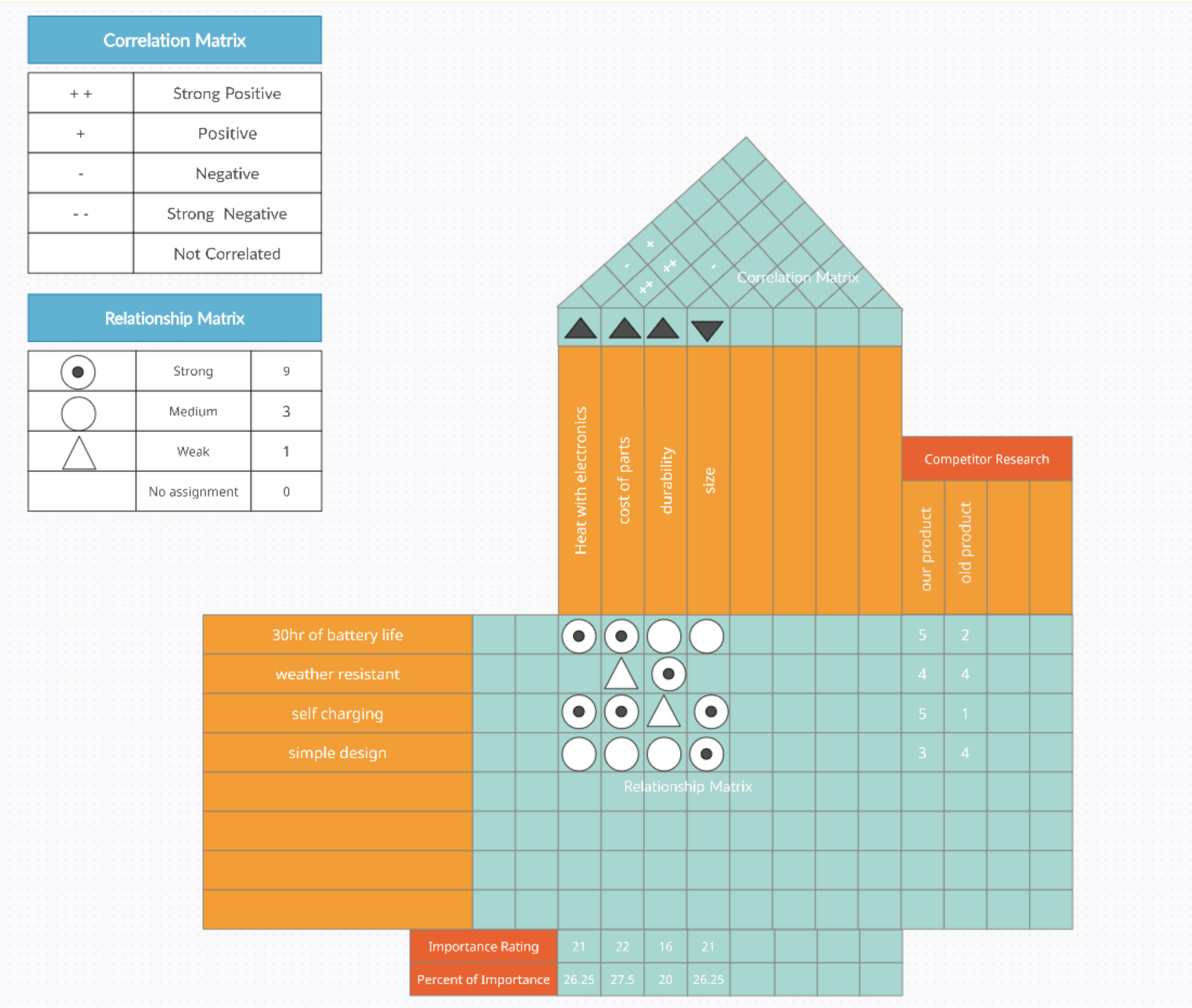
Charge controller matrix:

From figure 5 below we have a tie between the intelligent MPPT, and the Allto solar charger. We decided to buy the intelligent MPPT to do our first tests and later in the future we will end up buying the Allto solar charger to run tests and decide for ourselves what will be the best fit for the current project.

Fig.5

	A	B	C	D	E	F	G
1		**Cost** (weight:3)	**Size** (weight:5)	**Amps/Charging ports** (weight:3)	**Durability** (weight:4)	**Score**	
2	Renogy Rover	1	2	4	4	41	
3	**Intelligent MPPT**	3	3	5	4	**55**	
4	WERCHTAY MPPT	3	3	4	4	52	
5	**Allto solar**	3	4	2	5	**55**	
6							
7	comparisson scale:	1=equal	2=moderate	3=strong	4=very strong	5=extreme	
8							
9							
10							
11							
12							
13							

House of Quality:



- The build must be water resistant
- Sand resistant
- Heat resistant
- The internal parts need to produce low amounts of heat
- Weather resistant
- The light need to be heat resistant
- The wires need to be insulated
- Must be able to withstand harsh movements and bouncing around

Constraints:

- 30 hours of run time on the device
- 20 hours of run time is also acceptable on this device
- The black light used must be the same wavelength of light as the EIKO F4T5/BL black light
- The build must fit in a ammo can provided to us
- Lamp size should be 17 cm long
- We must use the EIKO F4T5/BL black light

General System Description:

The Smart Lamp project by USGS is fairly simple, and allows us to expand our thoughts and put all of our great ideas together to come up with a great functional product. As listed previously in this document are the requirements and constraints that are to be considered while designing the final project.

The goal of this project is to engineer a way to prolong battery life so that battery waste will be minimized, and the overall use of the design will be much more user friendly. The constraints given are that we have a minimum of 20 hours of run time, must use the same black light bulb so all data remain unaffected, the design must be scalable enough to fit into the ammo can given, and the final product needs to be durable to withstand any harsh elements that it will encounter.

For this project we are creating a design that will eliminate all battery waste by implementing solar for recharging the power source. Through solar charging we will eliminate the constant replacement of the double A batteries. This project design will be utilizing two 6 volt lipo batteries in series in order to create 12 volts for the 12 volt power regulator. The power regulator will connect the solar panel, the battery, and the light bulb. For our final design we are installing a digital thermometer and utilizing DC male and female connectors for connecting and unconnecting the solar panel and the light bulb easily. The threaded DC connector with the dustproof plug will help keep the parts and ammo can well sealed, and weatherproof. The outside of the ammo can will have a digital temperature gauge so that you will always be able to read the temperature inside the can to make sure that nothing is overheating while either charging or in use.

For the inside of the ammo can we will use double sided tape to secure all parts that will not need to be removed, and we will also use foam to secure the batteries so that they will not be able to get banged around inside the can while on these expeditions. The solar power regulator is a 12 volt charge regulator that will keep our batteries charged without overcharging them which would cause them to go bad. This charge regulator has two usb ports with a 2.4A max for any other charging that the user would need for instance charging a phone. This regulator also has two DCoutput ports installed in the device. This model regulator is fairly advanced and has a built in timer, and also has an internal temperature sensor. This model also allows us to set a voltage that we want to be charging the two 6 volt batteries that are connected in series.

Simplicity and user friendly is our goal with this project, and we want to make it as easy as possible to use for the river guides setting these out at night to collect their insect data. Incorporating a timer in this project is another option to be considered so that the river guides can flip a switch and have the entire system turn on and shut off on its own. By using two 6 volt batteries in series, a solar charge regulator, a solar panel, a timer, and an on/off switch this design will be simple and easy for everyone to use.

System Capabilities, Conditions, and Constraints:

The project we are creating will be going on long river trips that will endure harsh weather conditions, and will be getting tossed around in a river boat. With the conditions on the river our product needs to be waterproof, sand proof, and needs to be able to take a beating while getting tossed around in the boat. Our system will be able to take on harsh weather elements and still be able to serve its purpose at the end of the night when it's time to collect data.

Fig.6

Photo credit: koji hirano

General Overview:

For the final project we are building, we are using all of the strategies that were listed above. Making testing matrices to test each part and decide which parts are going to work best for our final project and which ones we will need to change in order to create the most user friendly and efficient product. Our Gantt chart that we all created gives us dates and deadlines for when we need to have things ready and done by. This keeps us all on track and we are able to track our progress as the project goes on. This project is to remain simple and have the minimal amount of parts needed. The more parts that we put into this project the more likely parts will break and go bad. For longevity and reliability we are using few parts that will make it the most user friendly.

Behavioral Analyses:

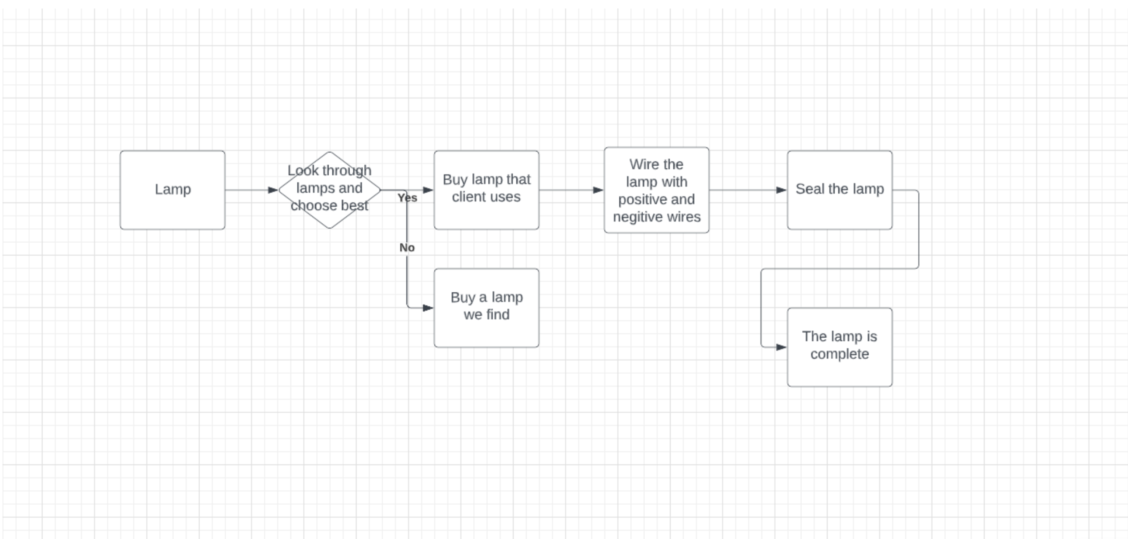
When determining the behavioral analysis of a system we must keep in mind the following criteria: Role dependant, Goal Oriented, What the System Does, and Based on Purpose/Usage. One of the most important aspects of this project is solar charging. The System should be able to charge via solar power in an efficient and practical manner. During expeditions the batteries should be fully charged beforehand. If more power is necessary, the charging process should be done where sunlight is viable for a couple hours during the day. Next the system should be able to run at maximum efficiency during data collection. This is very important for our client since any dimming of the light could result in lost data. Additionally, since there are multiple power electronics that will be within the ammo container, proper safety precautions will be included within the can and a temperature gauge to ensure that lamp users are not injured and that none of the components are damaged. Lastly, connection and disconnection of the bulb and solar panel should be handled with ease and without complication since river guides will be handling the equipment.

Functional Analyses:

Lamp

For this Flow chart we are looking at the light. As you can see the first step is looking at all the possible lights we can use for our project. We decided to go with the lamp our clients have been using for a long time to keep the bug trapping data the same by using the same lamp. The next step is to solder wires to the positive and negative terminals so the lamp will be hard wired and not battery powered. Finally we will seal the lamp and it is good to go!

Fig.7



Batteries

The next flow chart is for the batteries. We first need to decide what voltage type we need for our battery. The two choices for voltage are 6v and 12v, we decided to go with the 6v batteries because we can move them around in our smaller case.We wire two 6v batteries in series to get the 12v we need for our charge controller with the ability to fit the batteries better. With that the batteries are done.

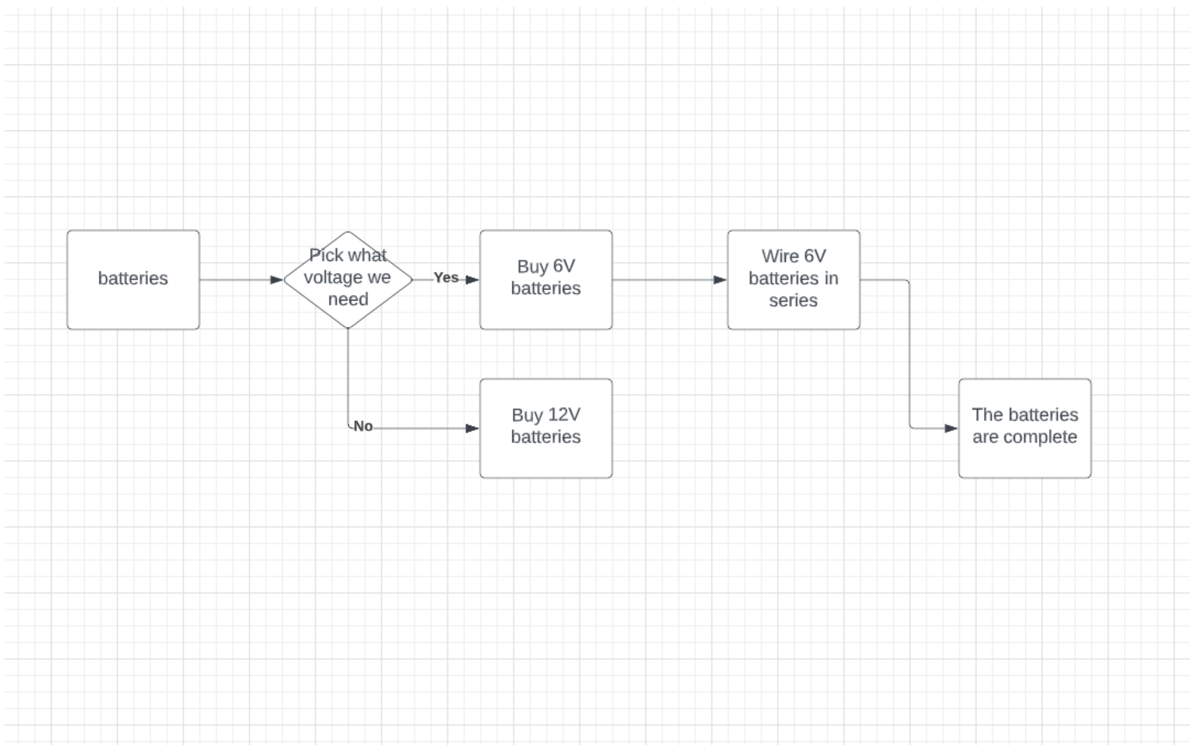
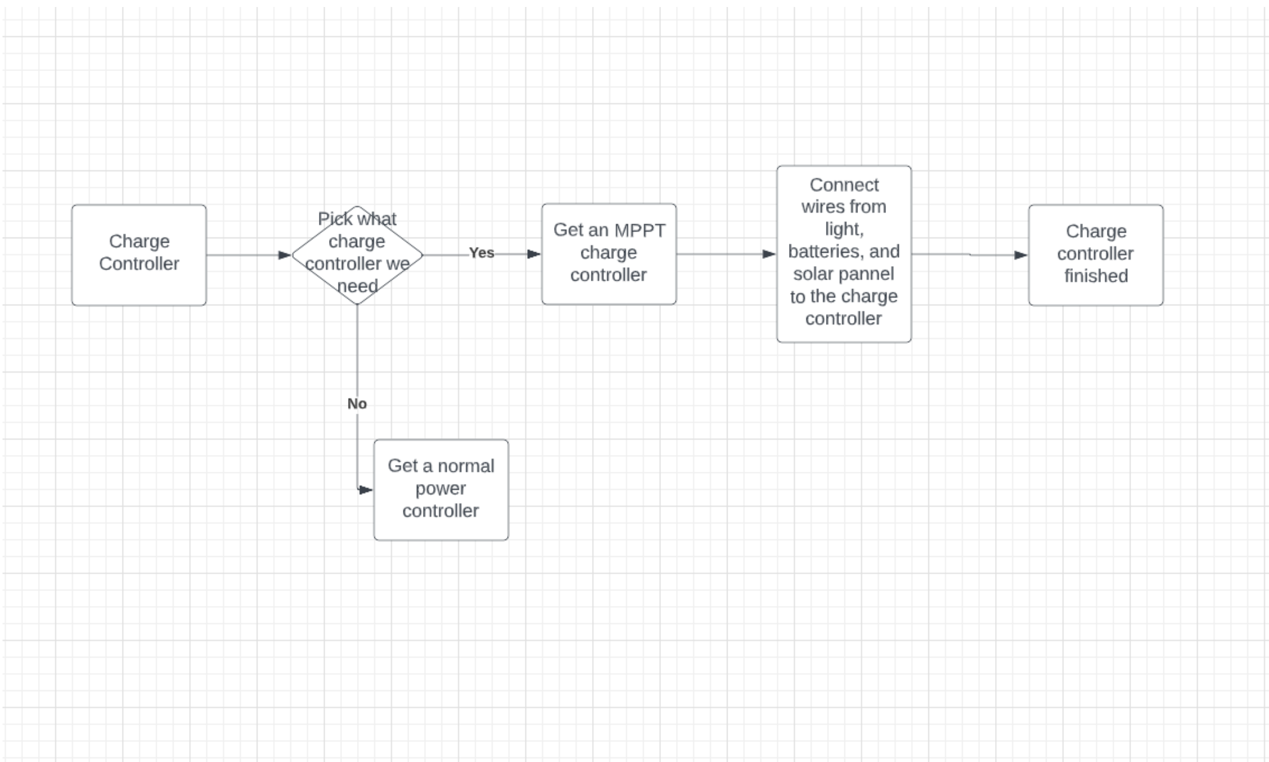


Fig.8

Charge controller

For the charge controller we had two choices for our project. The two choices are an MPPT charge controller and a PWM charge controller. SInce we have a solar panel in our design we decided to go with the MPPT charge controller to get maximum power. The final step is to connect everything to the charge controller and we are done.

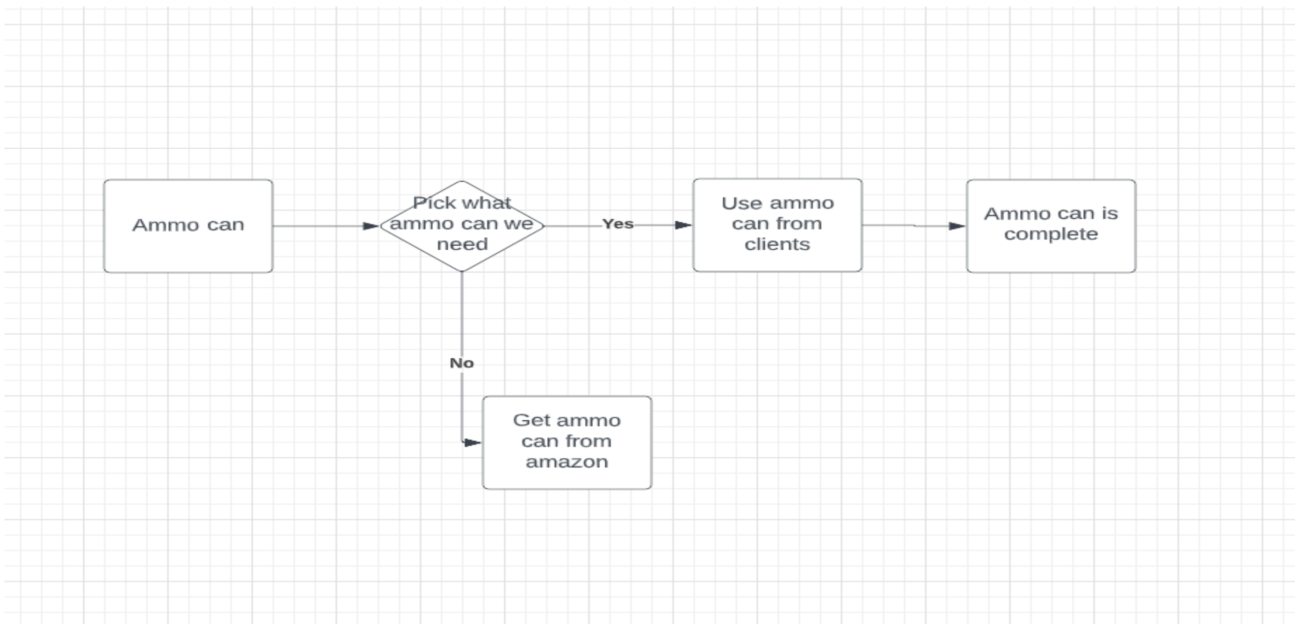
Fig.9



Ammo Can

Our final flow chart is for the ammo can. For this we decided to go with the ammo can provided to us by the client. Finally we need to put everything in the ammo can.

Fig.10



Implementation plan:

Testing Matrix

Table.1

Requirements	Prototype #	Parts for individual prototypes	Time required to put together	Cost	Status
30hrs of battery life	1	(2)6V single cell Lipo	1hr	$33.98	Need to assemble and test.
Fit inside given ammo can	2	Power regulator	1hr	$34.28	PWM regulator charged the batteries to 12.5v with sunlight.
keep the same light	3	Tactacam solar panel	1hr	$59.99	The solar panel we had produced a 13.1v charge to the regulator.
simple design w minimum parts					Keeping it simple with only 3 major parts.

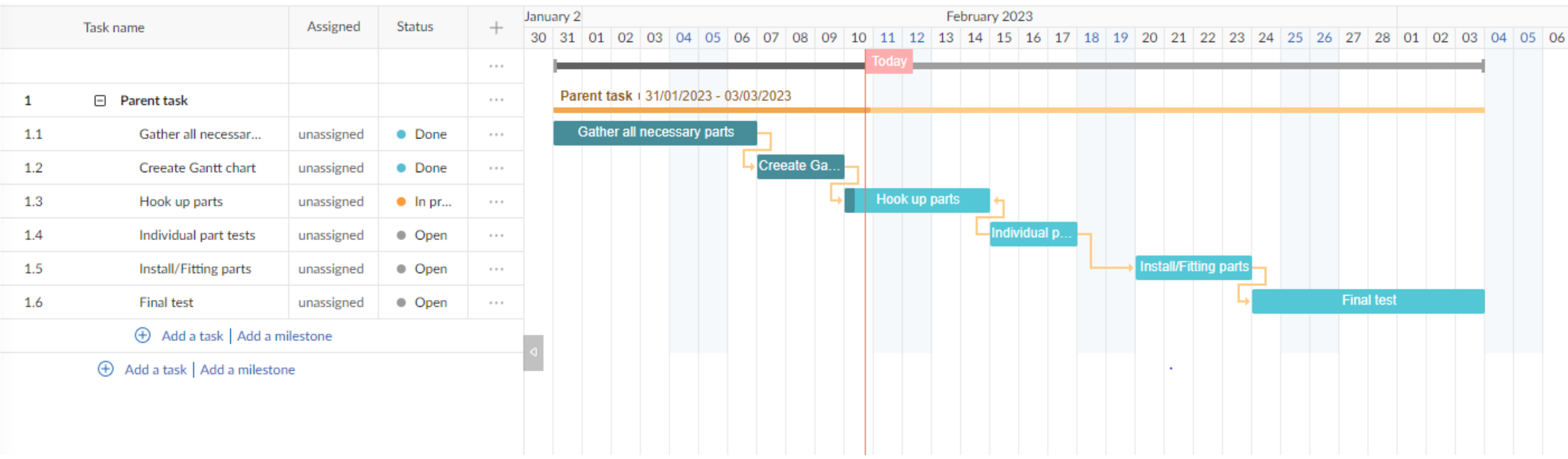
Testing parts from decision matrices:

Table.2

Parts	Cost	Time required to put together	Status	Start date	End date (Personal deadline)
Lifepo4 (battery)	$35.99	1hr	part received	2/13/23	Hook up and run tests by 2/24/23
ICP (solar panel)	$25.99	1hr	part received	2/13/23	Run separate tests by 2/24/23
Charge controller	$34.99	2hr	part received	2/13/23	2/24/23
Buck converter	$11.99	1hr	part received	2/13/23	2/24/23 (Have 2 parts to test)

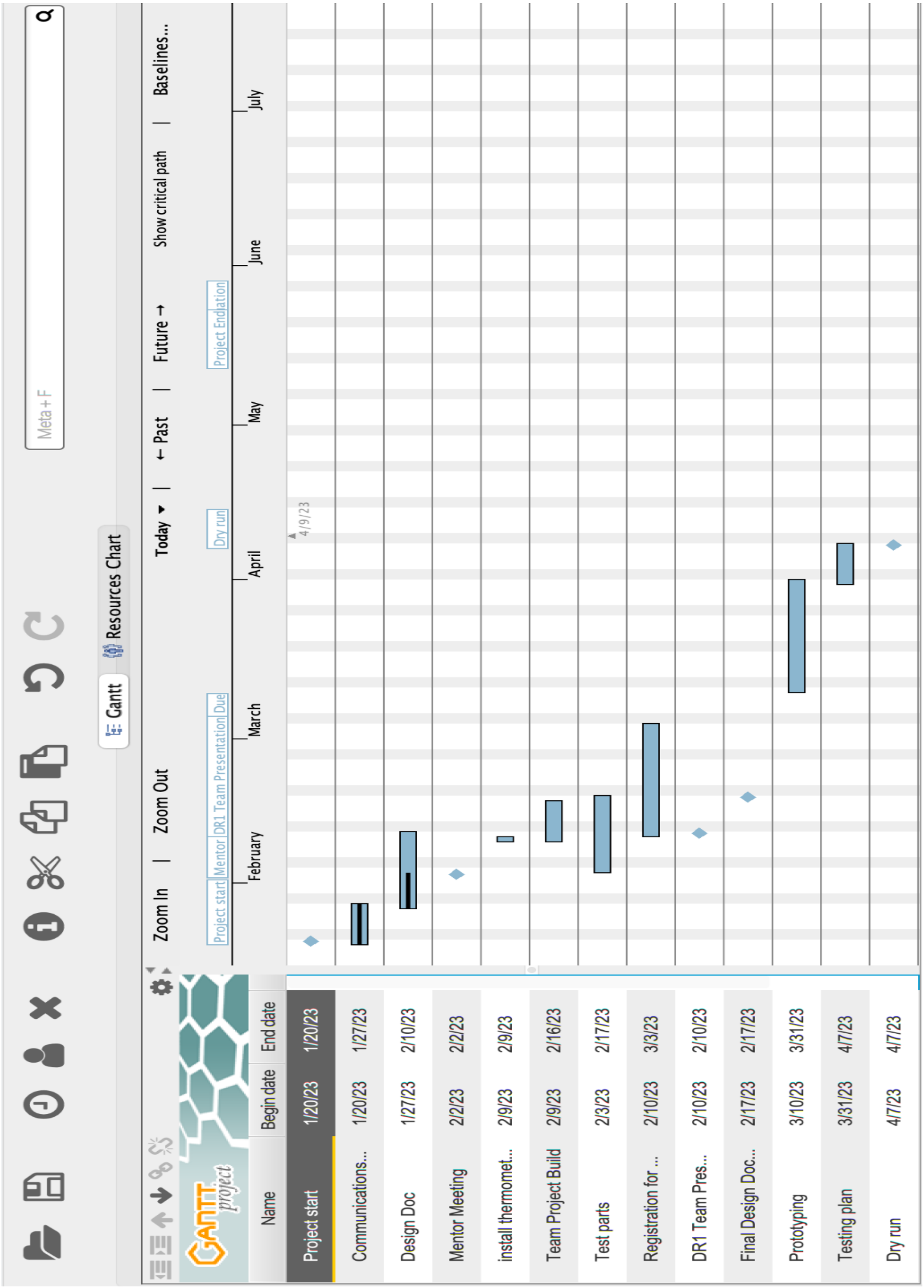
Work Breakdown Structure for the System:

Fig.11



Gantt Chart:

Fig.12



Financial Analyses:

Our product is made specifically for trapping bugs in the grand canyon. However, it could be used in other places around the world as well that has access to sunlight for part of the day. First we will begin with the cost of each part we are using in the design of the bug trapper.

First we will start with the two 6V with 6AH batteries, these cost 36 dollars without tax from amazon. We will then continue onto the charge controller, we are using a Maximum Power point tracking charge controller that cost us 20 dollars off of Amazon. The next part we need is the actual black light lamp, the lamp is 13 dollars on amazon as well. Next up we got two wire spools red and black, they were 12 gauge and are each 25 feet in length which is 17 dollars. This was also purchased on amazon. Next up we have the wired timer(JVR 12v) this time costs 14 dollars on Amazon. Next we have the buck converter from amazon. This converter costs 10 dollars. We also got our solar panel off amazon for 30 dollars. Our ammo can was provided to us by our client.

Now for our revenue, in theory we would only be getting paid by our client who had us improvise their design. However, for the sake of this project we are going to pretend we are putting this on the market. First off this is a very niche product and not many are searching for it. Our market is companies or customers who are looking to attract and collect flying insects. The USGS our client is doing research on the bugs in the grand canyon. Our product would sell to other people looking to do research on the type of bugs in an area.

Our device costs around 90 dollars to make with parts alone. Our break even point would be around 110 dollars because of tax and shipping. If we sold these devices around 200 each, we could get a possible return of investment of 90 dollars. That sounds great but we haven't added in the cost of labor for each device. I am estimating the cost of labor for just one device would be around 40 dollars a unit. This brings down our return on investment to 50 dollars per unit. If we sell an estimated 100 units per year we are looking at a total profit of 5,000 for the year.

Now 5,000 is not a large amount of money for a year. The main reason the product is not producing a large amount of money is the fact that our clientele is very limited. One option we can do to make a better return on investment is to increase the price of our product. Another way to increase our return on investment is to use cheaper materials or purchase our materials in bulk to lower the cost. Both methods above are possible solutions to giving us a greater return on investment.

Conclusion:

In conclusion, we now have a functioning bug trapping product. This product has a 12V battery that can be recharged with a solar panel when it gets drained. Our product will go on many different adventures during its use. The main trip it will be taken on is the grand canyon expeditions. Our product will be placed all over the floor of the grand canyon to gather the different types of bugs down there. It's great to see that our hard work will end up doing something in the real world. Especially that it helps researchers at USGS with trapping their bugs for research. The different types of bugs are very interesting down in the grand canyon and we look forward to seeing all the new bugs they catch with our device we built!