P21389: Bug Torch

Phase 3: Preliminary Detailed Design Review

April 2021

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SYSTEM LEVEL DESIGN ACTION ITEMS

CLOSED:

Individual Three Week Plans
Diagram Updates
Risk Assessment Rating Updates (1-3-9)
Add a Team Vision Description

REMAIN OPEN:

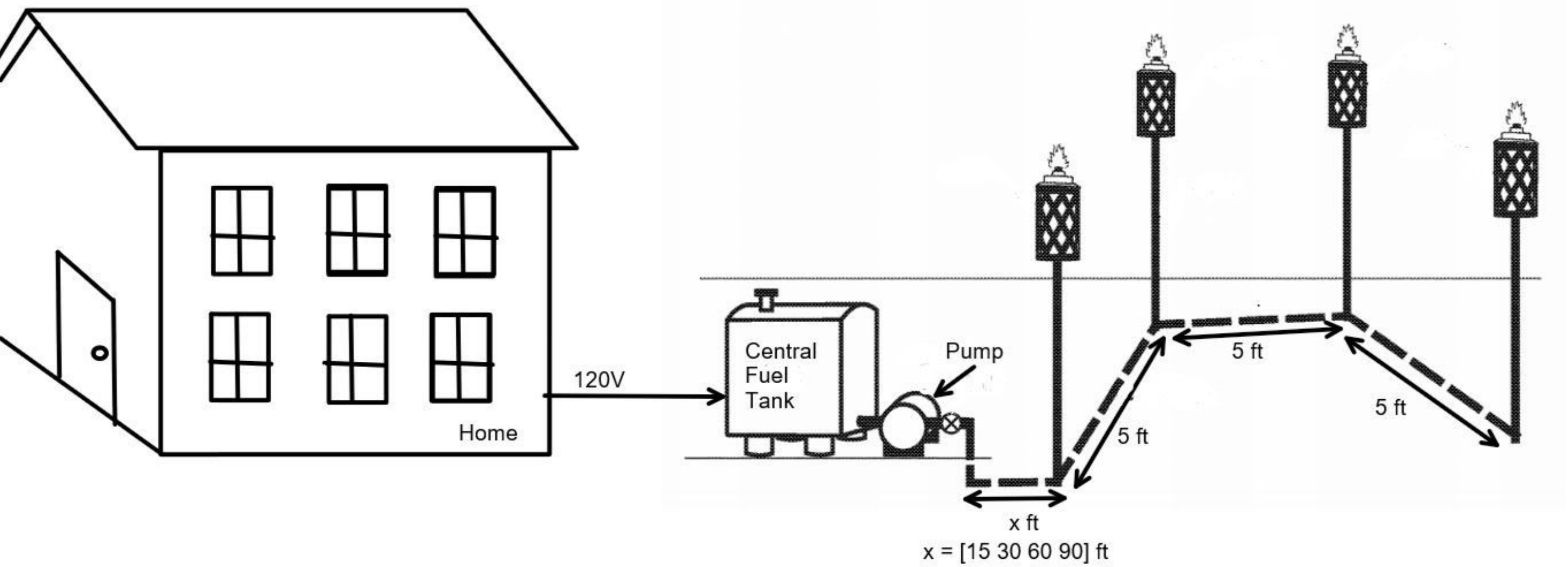
N/A

TEAM VISION FOR PRELIMINARY DETAILED DESIGN

Team Plan:

- Develop preliminary design documentation including CAD models and drawings
- Order parts for preliminary prototyping
- Maintain budgeting and risk assessment documentation
- Perform additional feasibility analysis

PRELIMINARY SYSTEM DESIGN



ENERGY

- 120V sourced from house for pump
- incorporate solar panels to eliminate wires on individual torches

PUMP TO TORCH

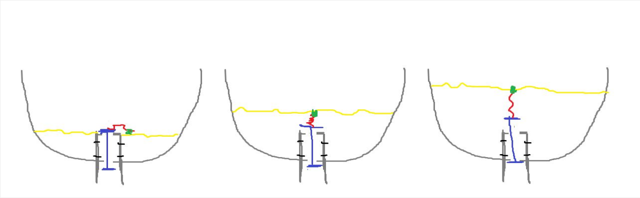
- variable distances meant to model different customizable set-ups
- understand how fluid transport is affected by linear distance

TORCH TO TORCH

- 5 ft distance
- based on typical 1ft effective range for citronella oil

MECHANICAL FEASIBILITY: PROTOTYPING, ANALYSIS & SIMULATION

A review of the pump we had decided upon concluded our candidate is not sufficiently powerful enough to allow smooth system function, so a new candidate will need to be chosen.



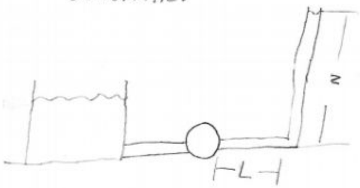
The images above is the first concept of a “floating plunger”; this design runs the risk of being closed prematurely by the flow of fuel into the tank

This design inverts the plunger; where down is the closed position. This is achieved by having a float attached to a cord that runs through the side of the stopper, and connects to the top of the plunger. When the float rises, it pulls the cord which forces the plunger downwards.

Given: Pipe diameter: $D = 3.175 \cdot 10^{-3}$ m
fluid flow rate $= 8.4 \cdot 10^{-6}$ L/s
$L = 12.19$ m
$\rho = 1000$ kg/m³
$z = 1.83$ m
$\mu = 1 \cdot 10^{-3}$ kg/m·s
$\nu = 1 \cdot 10^{-6}$ m²/s
$g = 9.81$ m/s²

Find: Required pump head (h_p)

Schematic:



Assumptions:
Incompressible fluids
Uniform, fully developed and steady flow
Pipe is a straight line with no joints or fittings
To function, hp must be greater than or equal to the total head losses of the system

$h_p = h_{L_{minor}} + h_{L_{major}} + z$ (with $h_{L_{minor}} = 0$)

$h_p = 4.185 \cdot 10^{-7}$ m $+ 1.83$ m

$h_p = 1.830000419$

$h_{major} = f \frac{L}{D} \frac{\bar{V}^2}{2g}$

$= .19 \frac{12.19}{3.175 \cdot 10^{-3}} \cdot \frac{(1.06 \cdot 10^{-4})^2}{2 \cdot 9.81}$

$h_{major} = 4.185 \cdot 10^{-7}$ m

$Re = \frac{\rho Q D}{\mu A}$

$= \frac{1000 (8.4 \cdot 10^{-7})(\ldots}{(1 \cdot 10^{-3})(\pi \cdot 1.58\ldots}$

$Re = 336.85$

Flow is Laminar

$f = \frac{64}{Re} = \frac{64}{336.85} = 0.1\ldots$

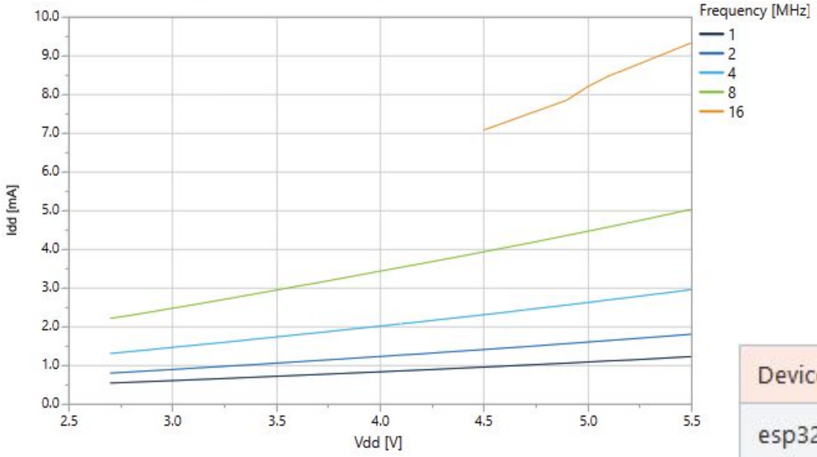
$\bar{V} = \frac{\dot{V}}{A} = \frac{4\dot{V}}{\pi D^2}$

$= \frac{4(8.4 \cdot 10^{-7})(\frac{1 m^3}{1000 L})}{\pi (3.175 \cdot 10^{-3})^2}$

$\bar{V} = 1.06 \cdot 10^{-4}$ m/s

ELECTRICAL FEASIBILITY: PROTOTYPING, ANALYSIS, & SIMULATION

Figure 39-4. Active Supply Current vs. V_{DD} (f=[1, 16] MHz OSC20M) at T=25°C

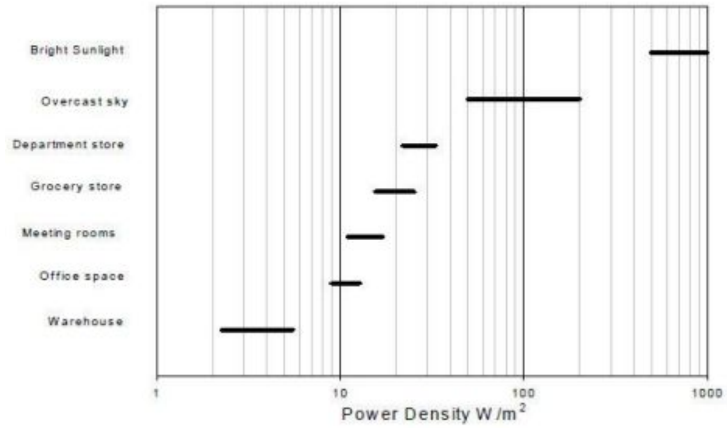


- By using the above chart and the power charts from each components respective datasheet it is concluded that the torches will run off of 3.3V and require ~62mAh to last 12h. By using a 1000mAh battery the system could last roughly five days without recharge. By using a small solar panel the battery can be easily recharged while in use and extend the electronic lifetime indefinitely.

Device	Symbol	Description	Min	Typ.	Max	Unit
esp32	V_{DDA}	Voltage applied to power supply pin.	1.8	3.3	3.6	V
NRF-DONGLE	V_{DD}	Normal voltage mode operating voltage.	1.7	3	3.6	V
Level Sensor	V_{DD}	Input Voltage	N/A	3.3	5	V

ELECTRICAL FEASIBILITY: PROTOTYPING, ANALYSIS & SIMULATION (cont.)

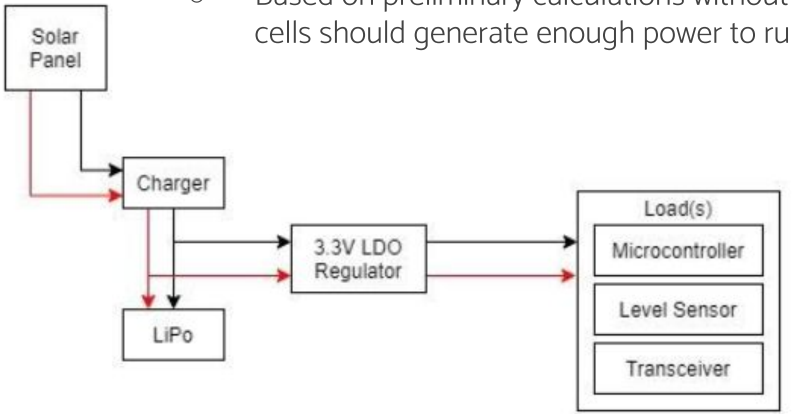
			Unit
Panel	Full Sun	132.3	mW
	Part Sun	13.23	mW
	Hours of Daylight	8	hr
	Power Generated per day	105.84	mW
	Power Needed by Subsystem	0.22	W
	Quanity of Panels Needed	2.078609221	Panels



Relative Light Power Densities

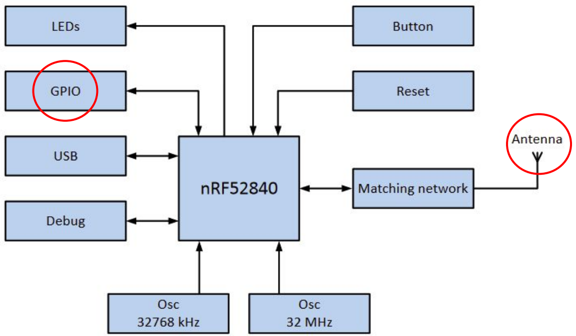
Electrical Considerations:

- Sensor Feasibility
  - Moving forward with capacitive and not ultrasonic sensor
- Power Feasibility
  - Based on preliminary calculations without out valve, solar cells should generate enough power to run system



Part	Qty per Torch	Voltage Output	Output Current	Datasheet
Solar Panel	3	5/10V	-	SM500K12L DATA SHEET 202007.pdf
Charger	1	3-4.2V	-	bq24074.pdf
LiPo Battery	1	3.7V	-	Li-Polymer_Battery_1200mAh_3.7V.pdf
LDO Regulator	1	3.3V	800mA	LD1117_VoltageReg.pdf
Capacitor (100nF &10uF)	1 each	-	-	TBD

DRAWING, SCHEMATIC, FLOWCHARTS, SIMULATION, ETC.



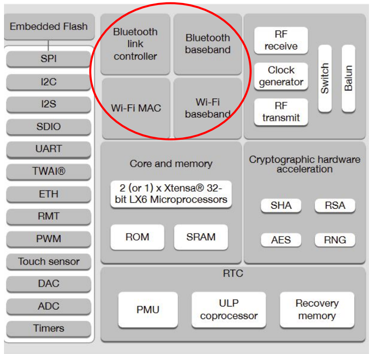
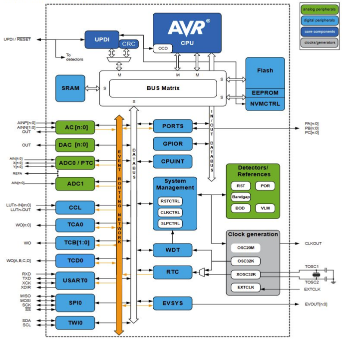
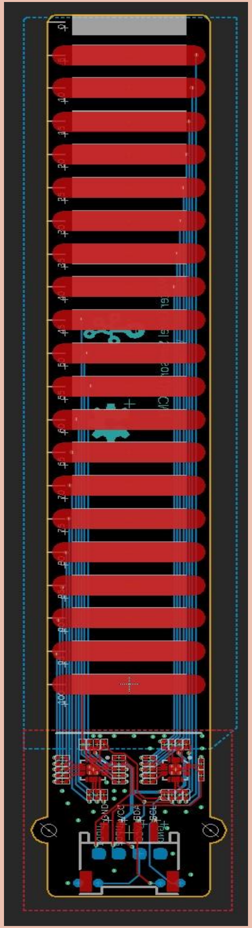


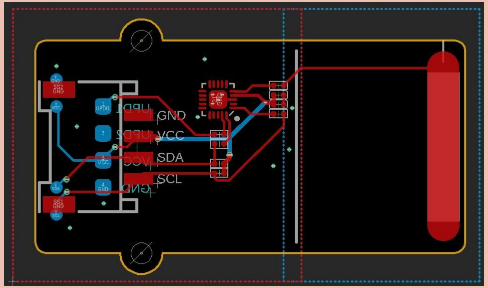
Figure 3-1. ATtiny1616/1617 Automotive Block Diagram



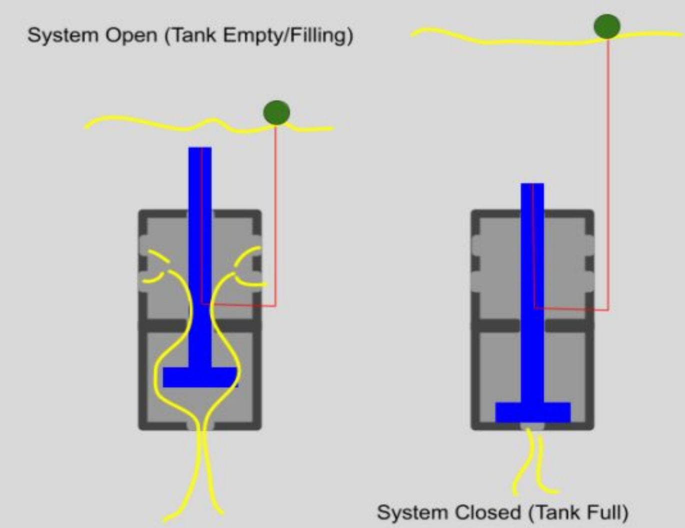
- Seen here are the flowcharts for the microcontrollers used in this system.

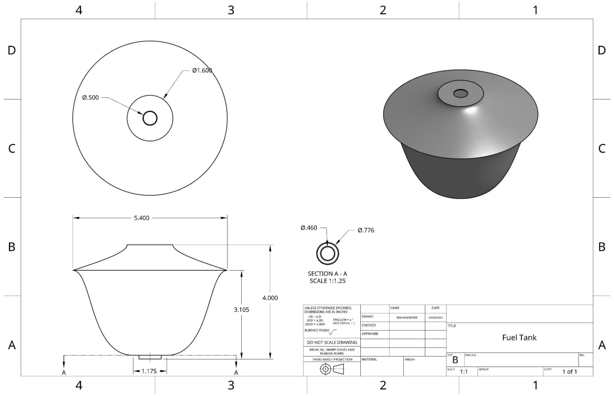
Electrical Diagrams

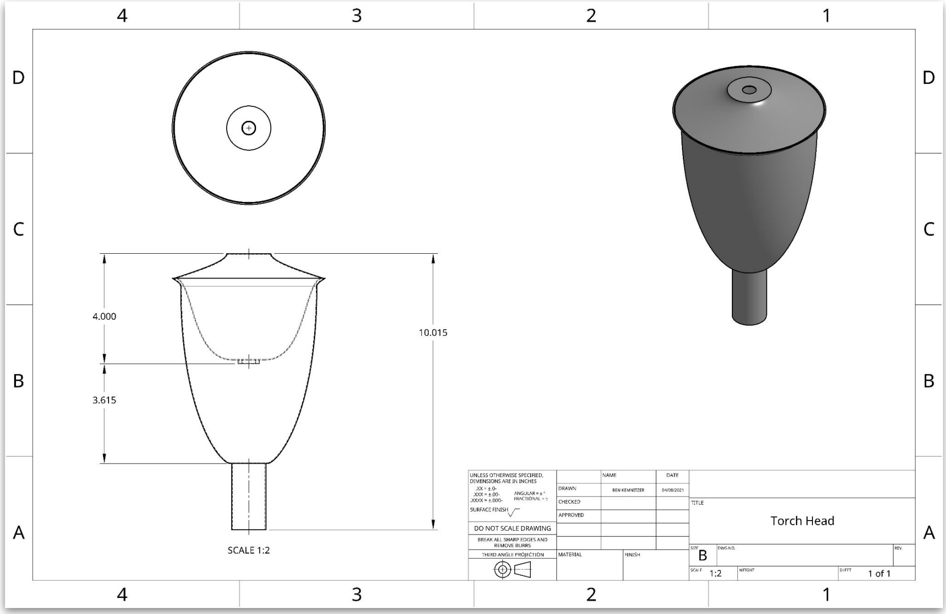


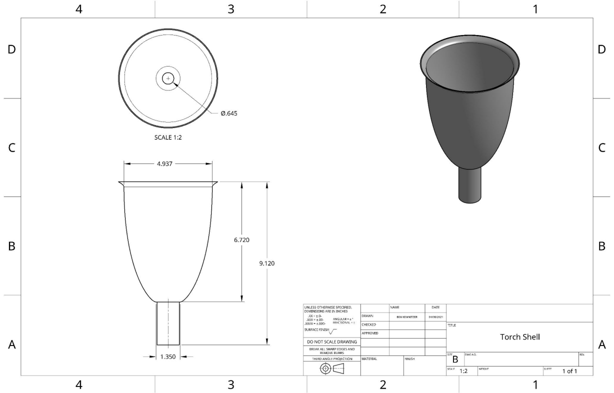


- Pictured here are the sensor from seed studio and the adjustments we made to fulfill the customer requirements.
- Adjustments seen are removal of unnecessary capacitive pads, resistors and IC's.
- To prevent board erosion the PCB can be coated in several varnish materials like nail polish for example.









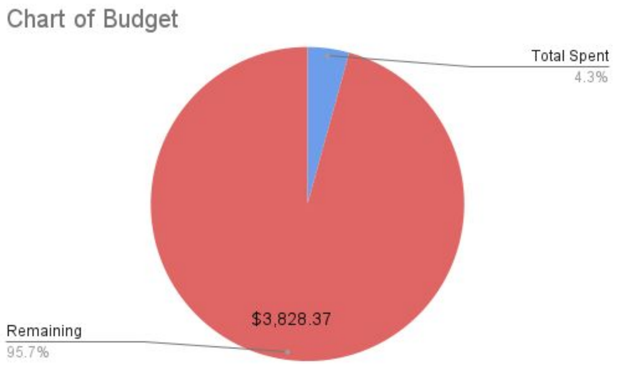
Mechanical Diagrams

BILL OF MATERIALS

https://wiki.rit.edu/pages/viewpage.action?pageId=249960301

Team #:	P21389	**Team Name:**	BugTorch		
Date:	3/18/2021	**Document Owner:**	Ben Kemnitzer	Budget	$4,000.00
Revision #:	1			Total Spent	$171.63
				Remaining	$3,828.37

Subsytem	Part #	Name	Qty.	Unit Cost	Total Cost	Vendor	Website
Electronics	PIM531	Prototype Board	11	$1.00	$11.00	Digikey/Mouser	https://www.mouser.com/ProductDetail/Nordic-Semic
Electronics	NRF52840-DONGLE	Main MCU	8	$10.00	$80.00	Digikey/Mouser	https://www.mouser.com/ProductDetail/Pimoroni/PIM
Electronics	ZW-MF-10	Jumper Wire MF	1	$4.40	$4.40	Mouser	https://www.mouser.com/ProductDetail/854-ZW-MF-1
Electronics	ZW-MM-10	Jumper Wire MM	1	$4.40	$4.40	Mouser	https://www.mouser.com/ProductDetail/854-ZW-MM-
Electronics	SM500K12L	IXOLARTM High Efficiency Solar Panels	6	$5.71	$34.26	Digikey	https://www.digikey.com/en/products/detail/anysolar-l
Electronics	BQ24074	Adafruit Universal USB / DC / Solar Lithium Ion/Polymer charger - bq24074	2	$9.95	$19.90	Adafruit	https://www.adafruit.com/product/4755#description
Electronics	LD1117V33	3.3V Voltage Regulator	3	$0.59	$1.77	Digikey	https://www.digikey.com/en/products/detail/stmicroele
Electronics	LP-503562 3.7V 1200mAh with PCM	LiPo Batter 1200mAh	1	$9.95	$9.95	Adafruit	https://www.adafruit.com/product/258
Electronics	LIPO 552530 350mAh 3.7V	LiPo Batter 350mAh	1	$5.95	$5.95	Adafruit	https://www.adafruit.com/product/4237



TEST PLANS

In order to get sufficient testing during MSD, the initial test setup will consist of only one torch. This will allow the team to test major components of the system such as:

- Fuel level reading and reporting
- Pumping fuel from the reservoir to the torch
- Valve that closes when tank is full

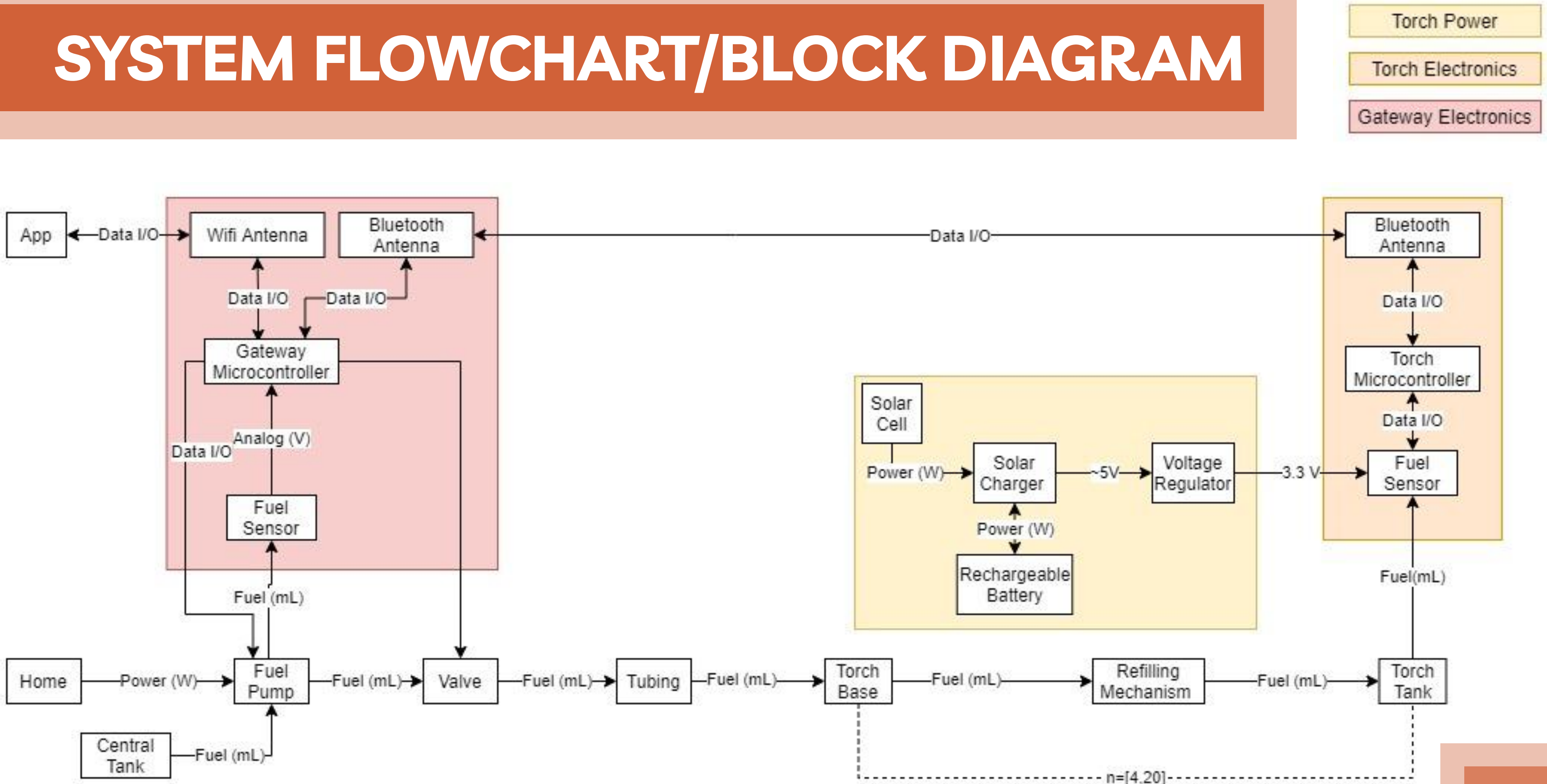
Once these system operate under conditions satisfactory to our requirements, the team will expand the BugTorch System to include up to four torches in series, in order to evaluate how the system operates with multiple outputs.

To best define the system conditions under the average/recommended layout, testing and calculations will follow these standards:

- The distance from the reservoir and pump to the first torch in the system will be separated by 15-90 feet of tubing
- The distance from one torch to the next in the system will be separated by 5 feet of tubing

To comply with RIT In order to comply with RIT Safety Guidelines, the team plans to do all current testing with water or s similar liquid in place of the citronella oil. We understand the risks of running tests with flammable liquids; water is a much safer and cost-effective alternate.

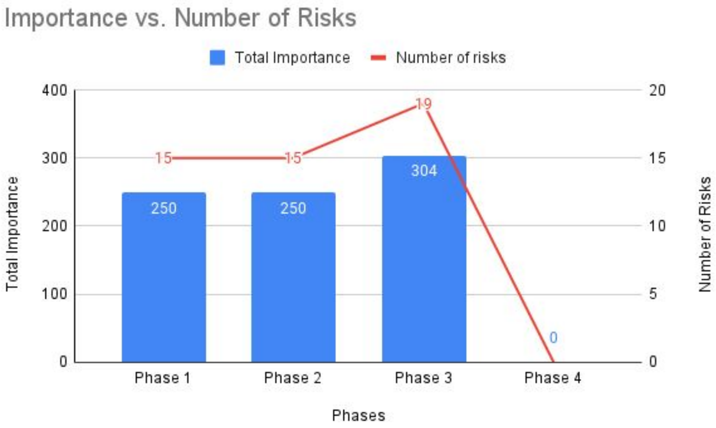
SYSTEM FLOWCHART/BLOCK DIAGRAM



RISK ASSESSMENT

Team #:	P21389	Team Name:	BugTorch
Date:	2/8/2021 8:41	Document Owner:	Owen Straub
Revision #:	1		

ID	Environmental/Social	Risk Item	Effect	Cause	Likelihood	Severity	Importance	Action to Minimize Risk	Owner
	What type of risk is this?	*Describe the risk briefly*	*What is the effect on any or all of the project deliverables if the cause actually happens?*	*What are the possible cause(s) of this risk?*	*L*	*S*	*L*S*	*What action(s) will you take (and by when) to prevent, reduce the impact of, and/or transfer the risk of this occurring?*	*Who is responsible for following through on mitigation?*
1	Environmental	Torch Oil Spills/leaks	Saftey standard violations	Bad seals/ lack of gaskets	3	3	9	accept	Ben
2	Safety	Fire/burn hazards	team members harmed	Carelessness or Incompetence	1	1	1	Prevent	Jason
3	Safety	electrocution hazard	team members harmed	Carelessness or Incompetence	3	1	3	Prevent	Owen
4	Resource-related	dev kit costs	Could quickly expend budget	Frivolous spending	1	3	3	Reduce	Yoon
5	Social	Market for the product	Product might not sell	Ugly/expensive torches	9	9	81	transfer	Bryn
6	Safety	Covid	Project progress could slow down	Covid spreads	3	3	9	Take safety precautions	All team members
7	Environmental/Social	Loud pump noises	Can be annoying/distracting	Faulty pump	3	1	3	Possible sound muffling box	Jason
8	Technical	Keep sensors away from oil	Possible failure of parts	Not designing around this issue	1	3	3	Being careful with design	Ben
9	Resources	Internet connectivity	Limit productivity	Energy provider and possibly weather	1	3	3	Accept the risk because it is beyond our control	all team members
10	Social	Team not all being in-person	Limit productivity	Covid and transportation	3	3	9	Communciate with team to prevent impact	Bryn
11	Safety/ Technical	Weather Hazards	Part failures and broken system	Weather (i.e. snow, rain, lightening, earthquakes)	9	9	81	Test for weather impact in a secure enviroment	Bryn
13	Technical	Limited knowledge of app development and fluids	May prevent team from reaching project deliverables	Lack of knowledge/education on topic	9	3	27	Discuss with experts and ask for advice when encountering issues to prevent risks	All team members
14	Technical	Make overall price of torch low	Could make system too expensive	Needing to buy more expensive materials	1	9	9	Taking consideration of parts cost	Yoon
15	Resource	Reliance on custom-built components	Delays, failure to finish prototype	Delays or cancellation of mid-long lead time parts	3	3	9	Order custom parts with significant lead time	Yoon
16	Technical	Sensor PCB can't withstand oil errosion	Sensor will decay and malfunction	Natural relationship between oil and silicon	3	9	27	Find a form of protective coating that minimizes erosion	Owen
17	Resource	Solar power does not meet power requirements	Could fry controllers or make system fallible	Unexpected power draw or clouds/etc...	1	9	9	Look into power alternatives or using a wired system	Bryn
18	Resource	Delay in ordered parts	Delay in prototyping or testing components	Parts out of stock or shipping delay	3	3	9	Making sure to be quick with ordering and checking quantity	Yoon
19	Technical	Mechanical parts not being compatible with other parts	Needing to find another part to fit our solution	Not having enough information about torch	3	3	9	Making sure torch measurements are finished and checked with other parts	Ben/Jason



PLAN FOR NEXT PHASE

- Prototype solar power and individual torch electronic subsystems if possible
- Focus on electronics and fluid dynamics with respect to the central fuel tank
- Finalize an alternative testing fluid or start to file paperwork to use citronella oil to test
- Look into designing a solar power system which includes a solenoid valve in the assembly for risk management purposes
- Determine a new pump candidate
- Iterate upon drawings and feasibility calculations

Questions?