

Daynight Panel

Group 2

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Project Description

Blue light emitted by LEDs is becoming an increasingly common exposure to humans thanks to an increasing ownership of personal device technology. In 2015, the Pew Research Center studied that 68% of Americans owned smartphones (up from 35% in 2011), and 45% own tablet computers [1]. Over exposure to the illumination of blue light—especially in the evening—can be interruptive to the sensitive schedule of a circadian clock. Human circadian clocks are synchronized with solar time, thus continuous exposure to blue light after the sun has set can cause negative health effects.

Luminous flux—measured in lumens—is a common way for light manufacturers to advertise general brightness of a light as observed in all directions. This description of a visual impression that a light has can be helpful to determine how beneficial the light will be in illuminating a room. Since the quantitative measure of a light’s luminous flux is only related to the brightness or intensity of a light, many different colors of light may emit the same number of lumens. This would be the case even if the lights have different wavelength makeup. Varying wavelengths of light correspond to the light’s color in the visible spectrum, so it also becomes important to understand that light sources also possess colorimetric quantities [2].

Color temperature of a light—given in degrees in Kelvin (K)—will be our biggest focus in the scope of this project. Although all colors can be described with color temperatures, we are most interested in the color temperature description of white light, as to closely match daylight simulation. Bounding our attention to white light also abstracts information that might be confusing since lights of different colors may be quantified as having the same color temperature. Normalizing color temperatures to a white color will provide the best way to clearly understand and simulate daylight.

The circadian rhythm is kept on track and maintained by observing the color temperature of natural light. Therefore, exposure to blue light (naturally observed during the daytime) when the circadian rhythm is expecting orange light (naturally overused during or after sunset) can be disruptive. The production of melatonin is kept on schedule with circadian rhythms and can be disrupted by extension.

Natural light and its effects on the human circadian rhythm are important to understand for the scope of this project. As outside light enters a building, it provides a lower level of inside light. These two measurements of light are used to create a daylight factor, seen in architecture. A ratio is created between outside light to inside light and is used to create environment lighting requirements inside buildings to support the best human well-being [3]. The daylight factor in a building can be increased by placing windows to have a better “view” of the sky, by increasing the reflection of light of exterior surfaces outside of the window, or by choosing furniture inside of a room with lighter colors to increase the

illumination of the room. When simulating daylight, the first two approaches to adjust the daylight factor of a building will be abstracted from the user.

The Daynight Panel is a system that simulates outdoor lighting by using a grid of LEDs under a light diffuser. The LEDs provide a source of light by using exact and intentional measurements of color intensity and color temperature. The light diffuser will achieve a blur effect or frosted effect to hide the individual LEDs. These together are intended to create an illusion and simulate light. By pairing the device to an iPhone, data can be collected by utilizing location services, location-specific weather, and seasonal conditions. This information will be used to change color intensity and color temperature of the LEDs in Daynight Panel. The changes intend to follow the rhythm of daylight. As discussed above, providing a sense of outside daylight can “ground” a human’s circadian rhythm in instances where access to daylight is sparse, infrequent, or unavailable. The Daynight Panel will be optimized to provide the best “outside” experience. By removing this concern or burden on homeowners or architecture designers for office space, it creates opportunities for saving time and money in efforts to achieve this otherwise.

A daylight simulation system may also be used to benefit people that suffer from isolated work environments, closed off or walled-in classrooms or housing quarters, or even jet lag. Benefits of a system that simulate daylight reach beyond Earth; astronauts that spend time on the space station are often exposed to limited amount of light during the daytime. It is common for astronauts on the ISS to only receive 2 hours of sleep per night [4].

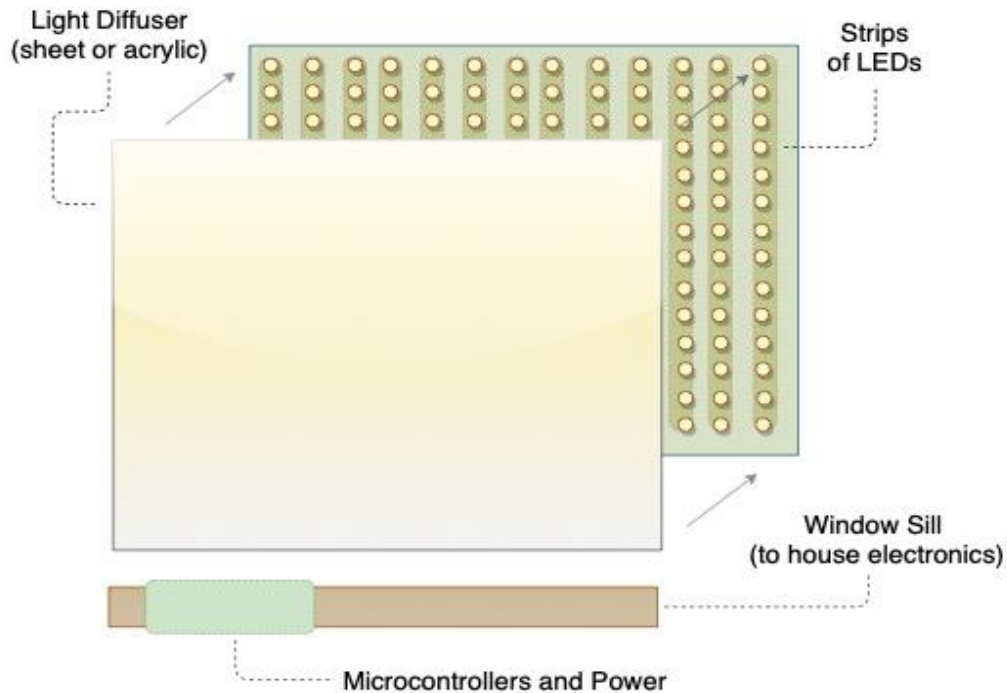


Figure 1. Rough Diagram for Daynight Panel

Requirements and Specifications

Table 1. Requirements Table

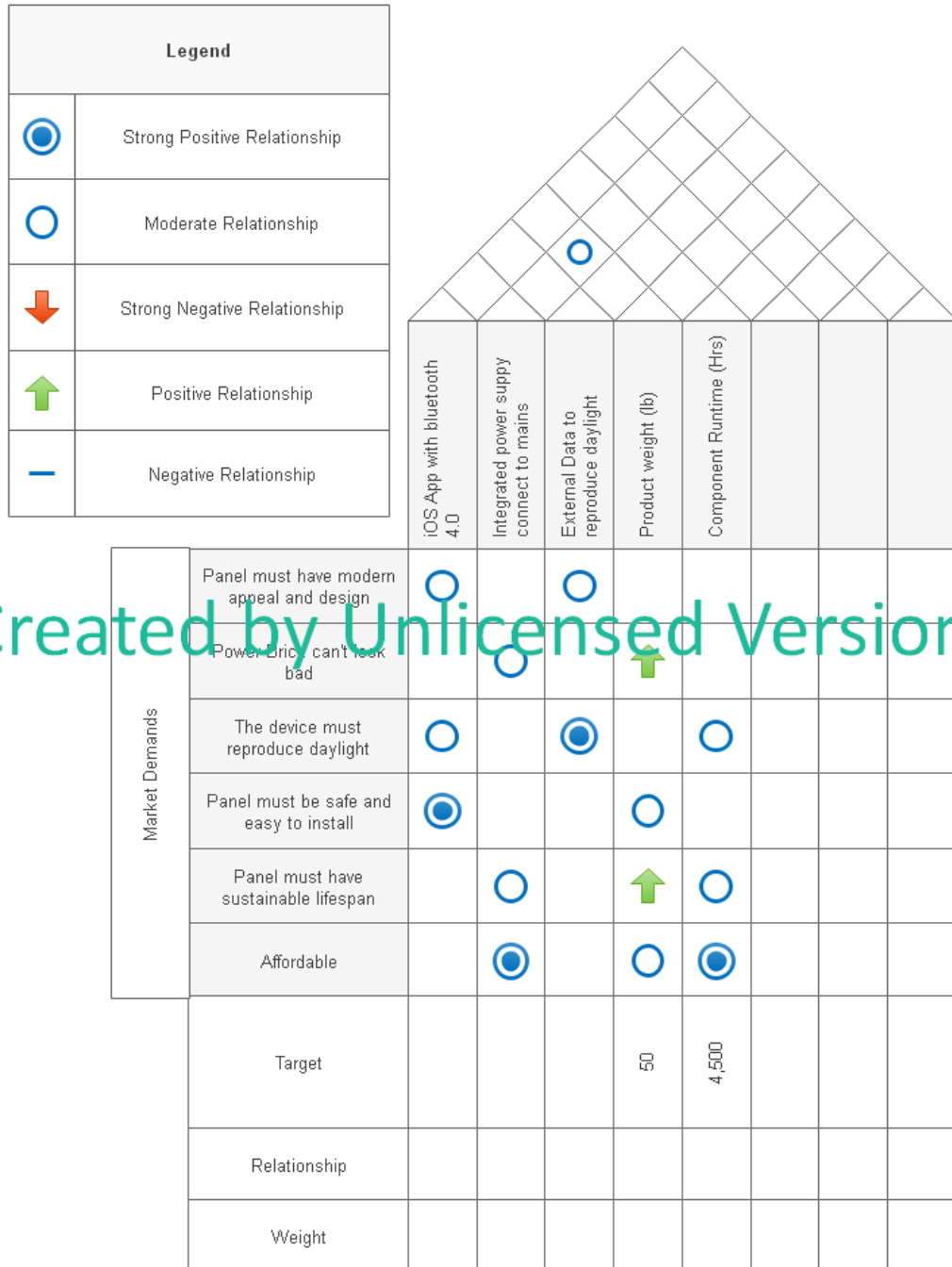
Marketing Requirements	Engineering Requirements	Justification
1, 3, 4, 6	1. Should have an iOS app that supports <i>Bluetooth 4.0</i> connectivity to a microcontroller.	All the latest “smart” devices aimed at user consumption in the home support various controls through smartphone support over Bluetooth 4.0
2, 5	2. Should have an integrated power supply to connect to the mains	For aesthetic reasons the power supply “brick” required for the AC/DC conversion must be integrated into the frame
1, 3	3. Should be able to use external data to reproduce the effect of daylight	For realistic daylight effect and user simplicity, the device must be able to use external data and/or sensors to produce a unique realistic experience
2, 4, 6	4. Should weigh under <i>50 lbs</i>	To ensure a non-intrusive installation process, keeping the panel under 50 lbs would make sure that no more than two people are required to install
5, 6	5. Weakest component must have at least 4,500 run hours	This will ensure the panel can stay powered for up to 12 hours of daylight use.

Market Requirements

1. The panel must have a modern appeal and design
2. The power brick cannot detract from the aesthetic appeal of the device
3. The device must be able to use sensors or data to reproduce the daylight
4. The panel must be easy and safe to install
5. The panel should have a sustainable lifespan
6. The panel should be affordable

Trade-off table (HOQ)

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Figure 2: House of Quality (Made on trial version)

The house of quality table shows the relationships between various market requirements and engineering solutions. These aspects can have weak, moderate, or strong relationships. These relationships can then be directly or inversely related.

Block Diagrams

Hardware Block Diagram

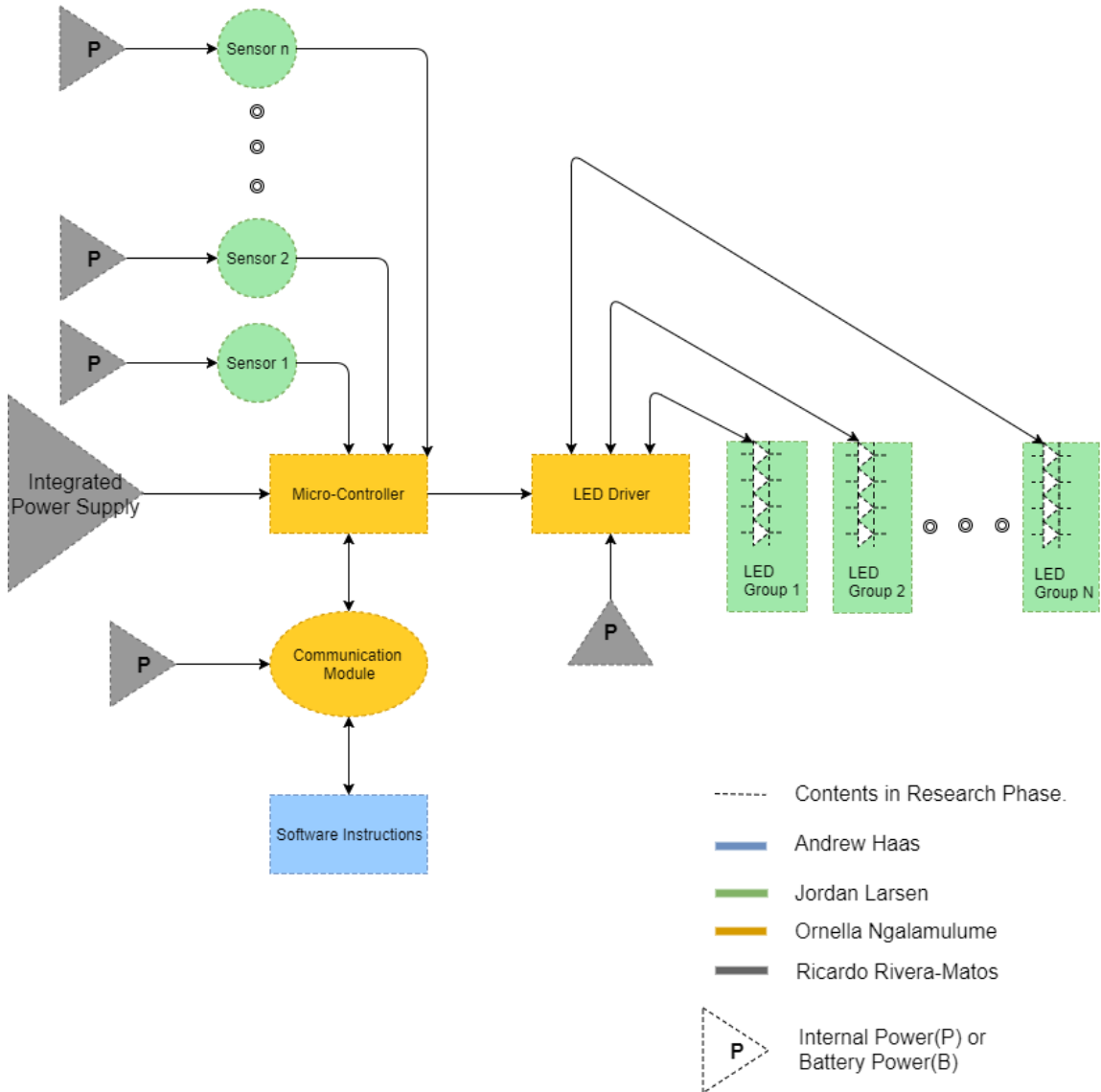


Figure 3. Hardware Block Diagram

The Daylight Panel will be a system composed of a central controller powered by an integrated power supply and possibly additional batteries. The controller will receive software instructions and sensor data to decide how to tune the LED's to mimic current daylight conditions. The tuning will be done by the LED driver which will receive instructions from the controller and change the color or intensity of the appropriate group of LEDs.

Software Block Diagram

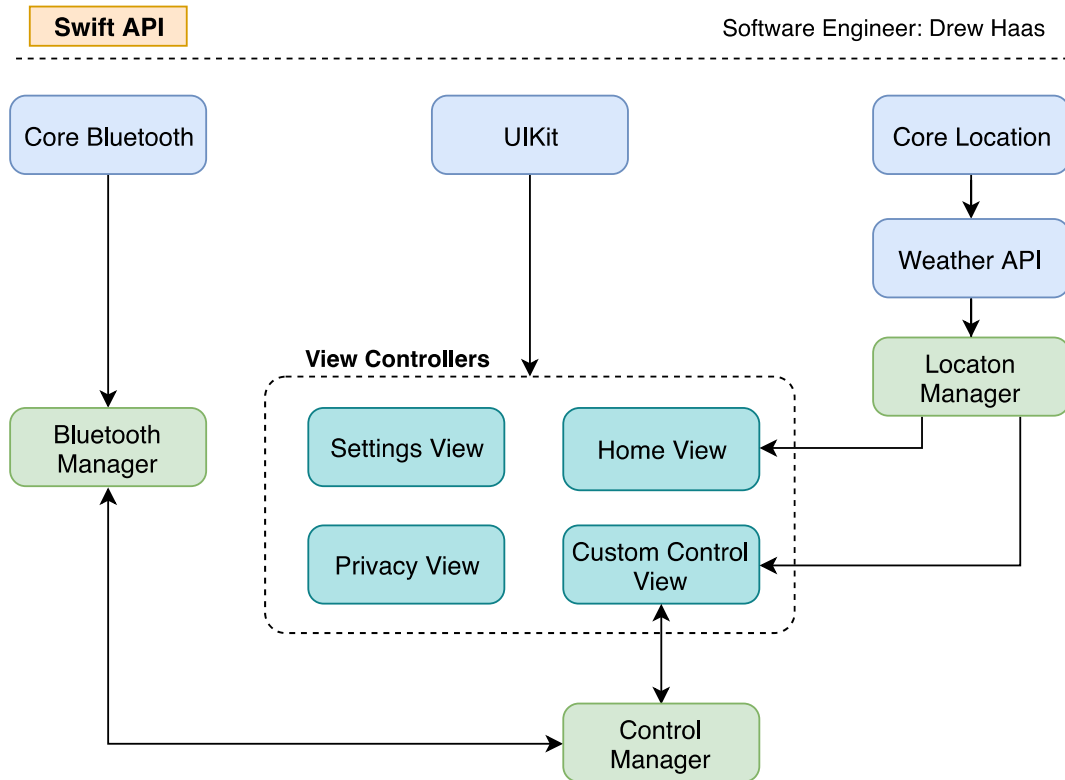


Figure 4. Software Block Diagram

All software will be designed and implemented using the Swift API provided by Apple, Inc. Core Bluetooth is a framework that provides classes and functions to create a seamless experience between a software application on iOS and hardware equipped to support Bluetooth 4.0 low energy technology. UIKit is a framework that supplies classes, functions, media, objects, and more to assist building a UI. UIKit-designed UIs are easy to use and quick to understand. This will be beneficial in creating an app that has a modern appeal and can neatly display all relevant information and controls. Core Location is a framework that provides information about the geographical location of a device by using all available on-device hardware such as Wi-Fi, GPS, Bluetooth, magnetometer, barometer, and cellular hardware.

View Controllers represent separate pages or views in the app. Laid out below is an outline of what views would be most beneficial for an app of this design. Managers are software classes that utilize information provided from APIs to interface with the view controllers. Manager classes should be the only classes editing data, and view controller classes should be the only classes editing the UI.

Budget and Financing

Table 2. Preliminary Project Budget

Hardware	Item	Item Price	Qty.	Total	Description
	LED Driver	\$ 6.41	2	\$ 12.82	TLC59582RTQR
	PCB Board	\$ 40.00	2	\$ 80.00	Estimate
	Wire Estimate	\$ 15.00	1	\$ 15.00	
	LED Light	\$ 11.19	15	\$ 167.85	Option B for Light
	Misc Electronic Est	\$ 45.00	1	\$ 45.00	
	Microcontroller	\$ 100.00	1	\$ 100.00	
				\$ 320.67	
Software	Item	Item Price	Qty.	Total	Description
	Swift License	\$ 99.00	1	\$ 99.00	
				\$ 99.00	
Misc Costs	Item	Item Price	Qty.	Total	Description
	Shipping Estimate	\$ 48.10	1	\$ 48.10	15% of hardware subtotal
	30 % Contingency	\$ 125.90	1	\$ 125.90	Early, so high contingency
				\$ 174.00	
				\$ 593.67	Final Estimate

Hardware costs are coming from the most expensive of several items that were found. These expensive items were used initially so that the budget can start there and work its way down. The items themselves were chosen based off expected base components needed to implement the system. The LED Driver controls the LEDs themselves. The PCB pricing was a very rough estimate. LED lights prices are based off components that produce approximate range of light seen in day conditions. The swift license is the cost to use the swift software for creating the app that controls the system.

The shipping estimate is 15% of the current hardware budget. This percentage is a high end of how much shipping can cost relative to the cost of the shipped materials. The 30% contingency is 30% of the subtotal of Hardware and Software. This percentage was a high-end contingency based off prior project experience. Due to how early on this budget was created, a high percentage was chosen.

Project Milestones

The timelines below show the basic project milestones with dates approximated based on the team's past experiences. These dates and milestones are subject to change as the project's scope becomes further defined.

Semester 1 Milestones

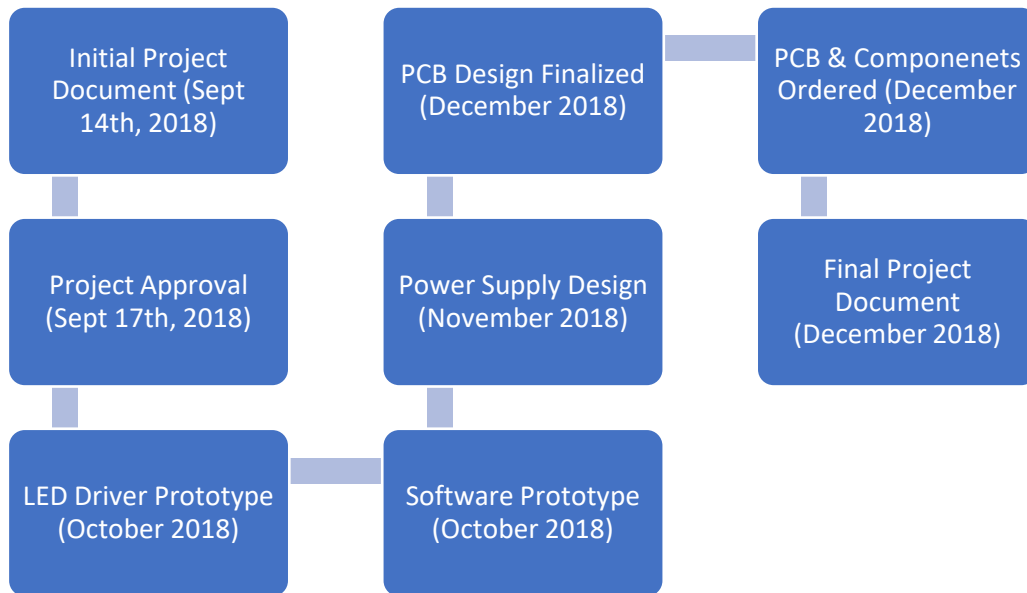


Figure 5. Semester 1 Timeline

Semester 2 Milestones

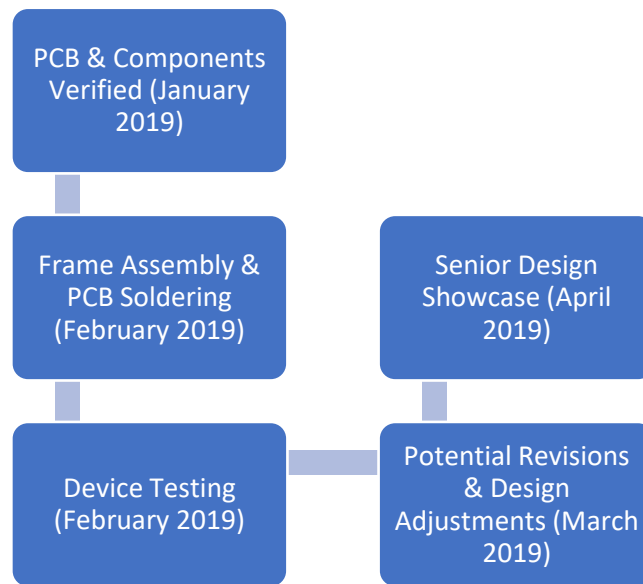


Figure 6. Semester 2 Timeline

References

- [1] M. Anderson, "Technology Device Ownership: 2015," Pew Research Center, 29 October 2015. [Online]. Available: <http://www.pewinternet.org/2015/10/29/technology-device-ownership-2015/>. [Accessed 10 September 2018].
- [2] P. R. Boyce, Human Factors in Lighting, CRC Press, 2014.
- [3] Advanced Buildings, "Daylight Factor," Advanced Buildings, [Online]. Available: <http://patternguide.advancedbuildings.net/using-this-guide/analysis-methods/daylight-factor>. [Accessed 10 September 2018].
- [4] NASA, "Wide Awake in Outer Space," NASA, 4 September 2001. [Online]. Available: https://science.nasa.gov/science-news/science-at-nasa/2001/ast04sep_1/. [Accessed 10 September 2018].