# Final Design Report Presentation

Team 14


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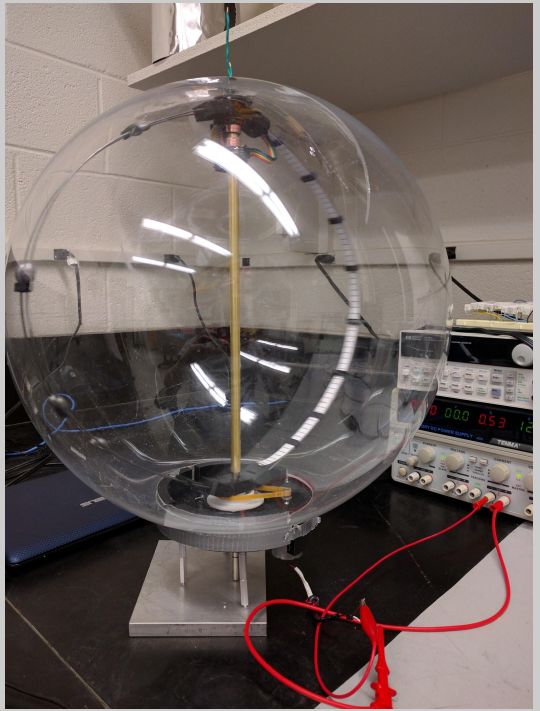
# Objective

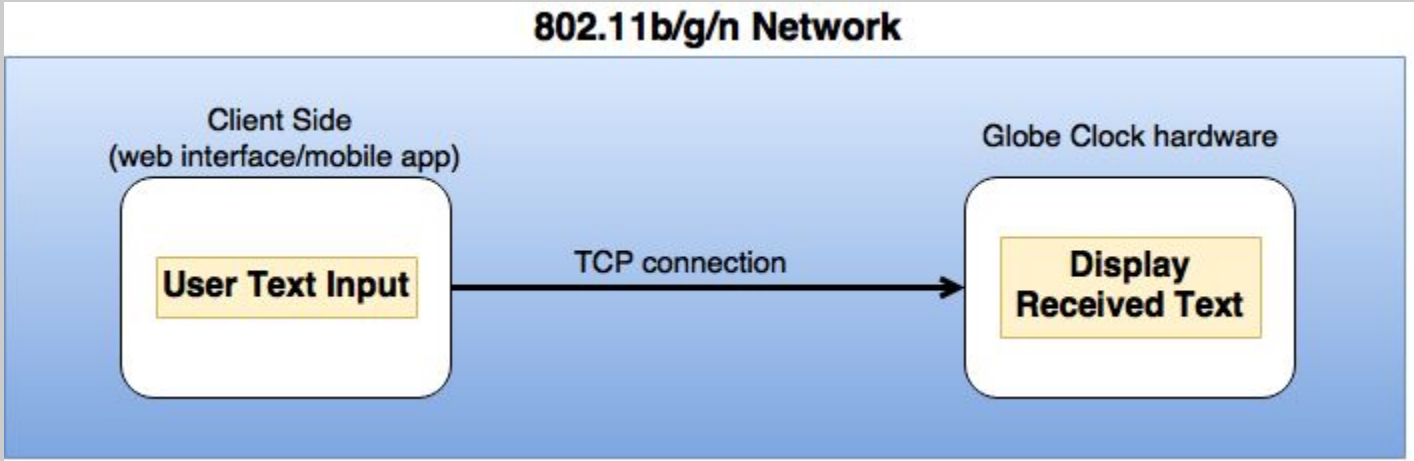
- Build, test and implement a POV (Persistence of Vision) display to be used for attention grabbing and effective advertising.
- Provide a time/welcome message to be displayed at the ECE commons.
- Provide a cost effective solution.
- Prioritize usability for the end customer.
  - Limited physical interaction
  - Easy content management
- Prioritize versatile placement for the end customer
  - Various mounting positions (wall, ceiling, et, al.)
  - Varying display diameters

# Overall System Interaction and Visual Aid



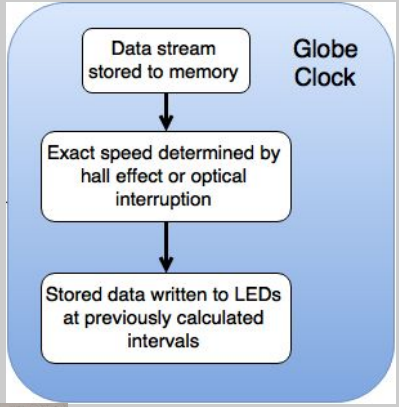
# Level 0 - Overall Design

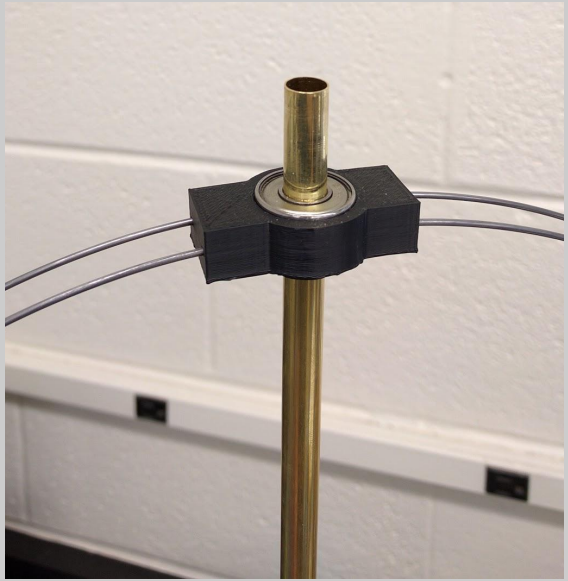
- Utilizing Wi-Fi functionality of Espressif ESP8266
- Now using TCP based file transfer for image data to display
  - Allows for simpler, more versatile end-user interfaces
  - Simpler to implement on globe hardware with precompiled Lua modules for tcp based communication
  - Using an interpreted language saves programming time of writing all 4MB of flash

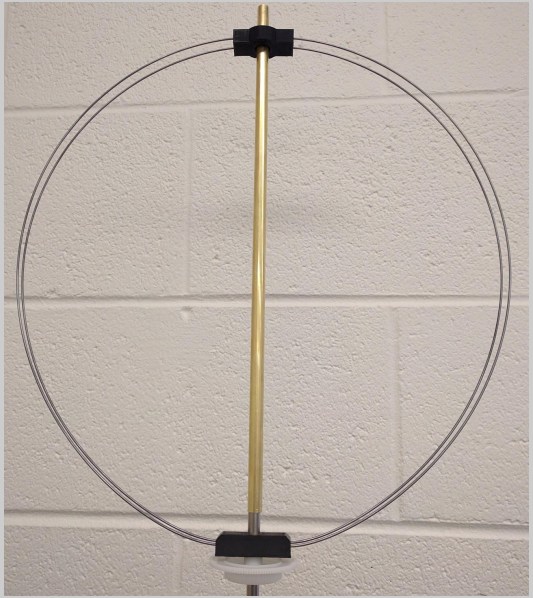


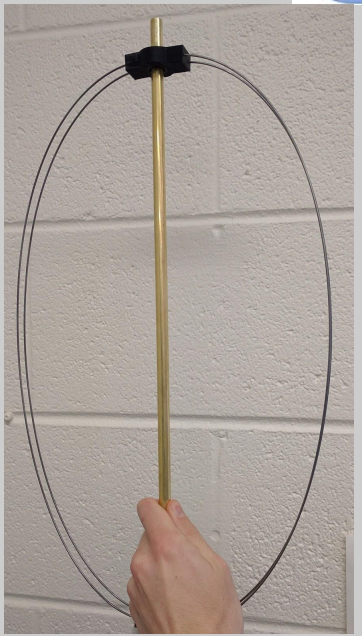
# Level 0 Hardware Design

- Spring steel based band system to allow insertion of LED ring into acrylic globe
- Concentric shafts can extend to allow bands to compress
- Ball bearing lets outer shaft stay stationary for mounting



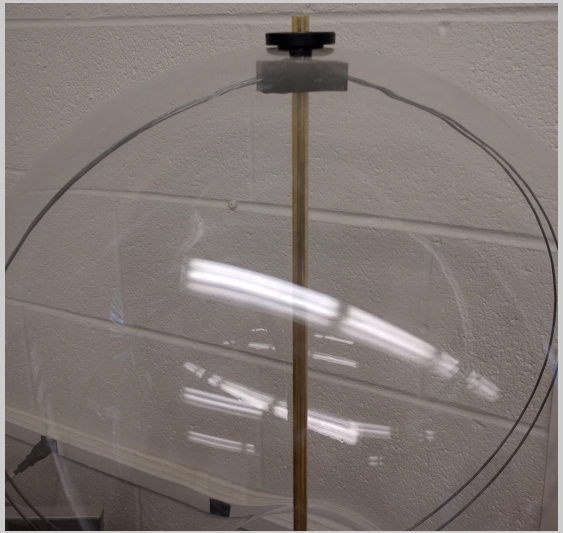





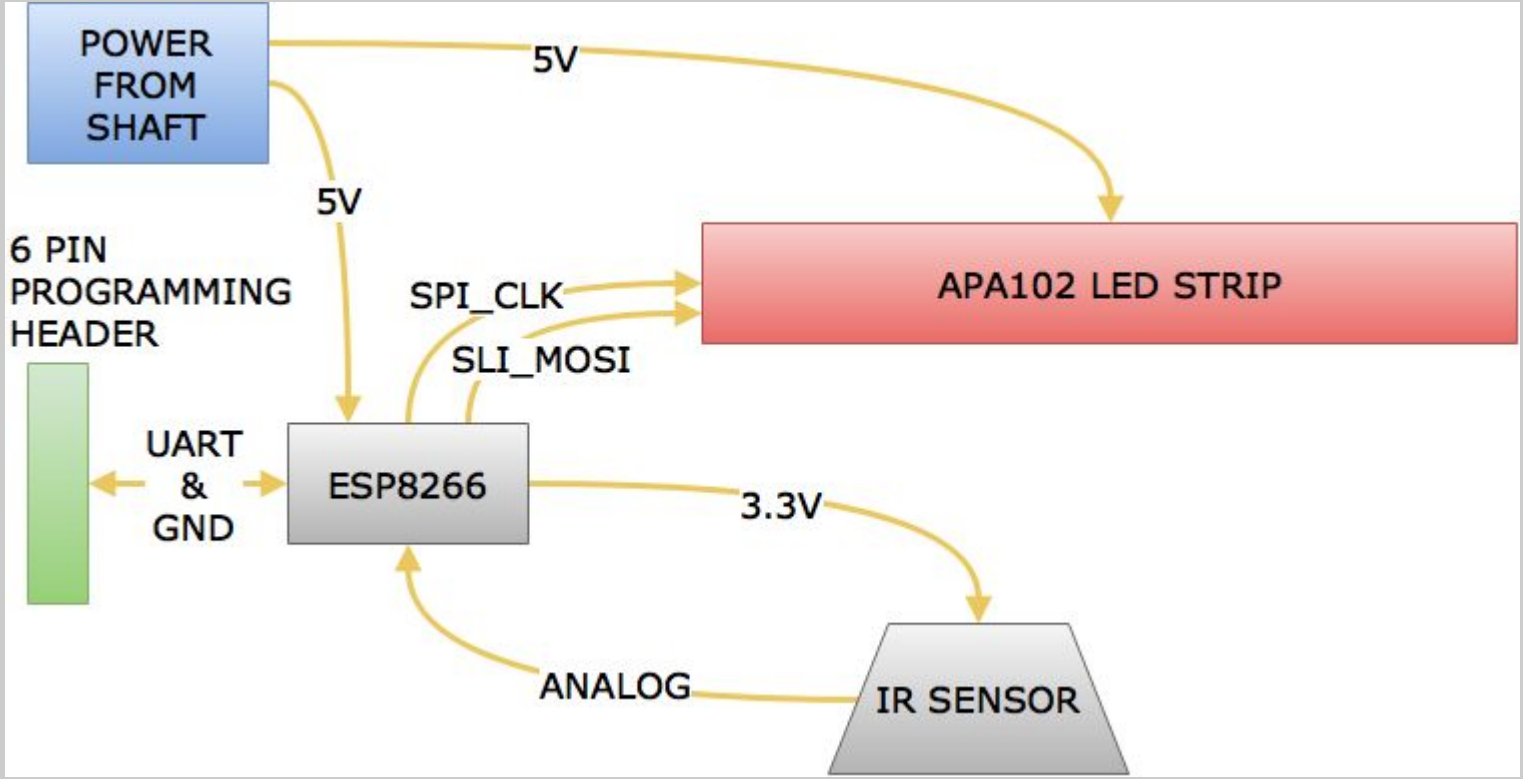


# Level 1 Hardware Design cont.

- Three 3-D printed parts affix steel rods to main shaft and center the stationary shaft to the acrylic sphere
- Machined drive system with steel shaft, gear, matching motor and drive belt.
    - Salvaged from printer, fits inside stationary brass tube to allow free rotation of lower half and expansion along the axis of rotation.

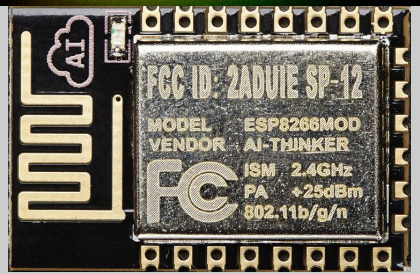


# Level 2 Hardware - Overall Design



# Level 3 Hardware Design - Control and Lights

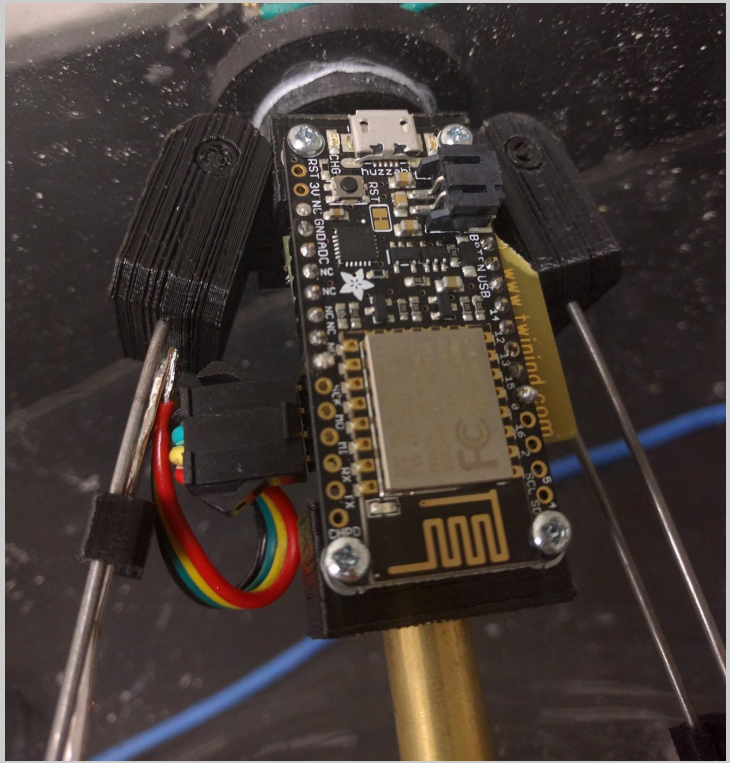
- APA102 Serial Peripheral Interface Red/Green/Blue LED strip weighed in at 38.28 grams - need that much weight on opposing bands for balance.
  - Standard SPI interface - can clock up to 19.2 kHz refresh rate
  - 0.5 meter @ 144 LEDs/meter gives 72 LEDs for our use
  - Max current draw is 4.32A but brightness is controllable
  - .5” strip width fits perfectly between steel bands of ring.
  -
- WiFi module footprint available from Adafruit, schematic is currently being drawn up in EAGLE to be printed and affixed to printed base rod anchor.

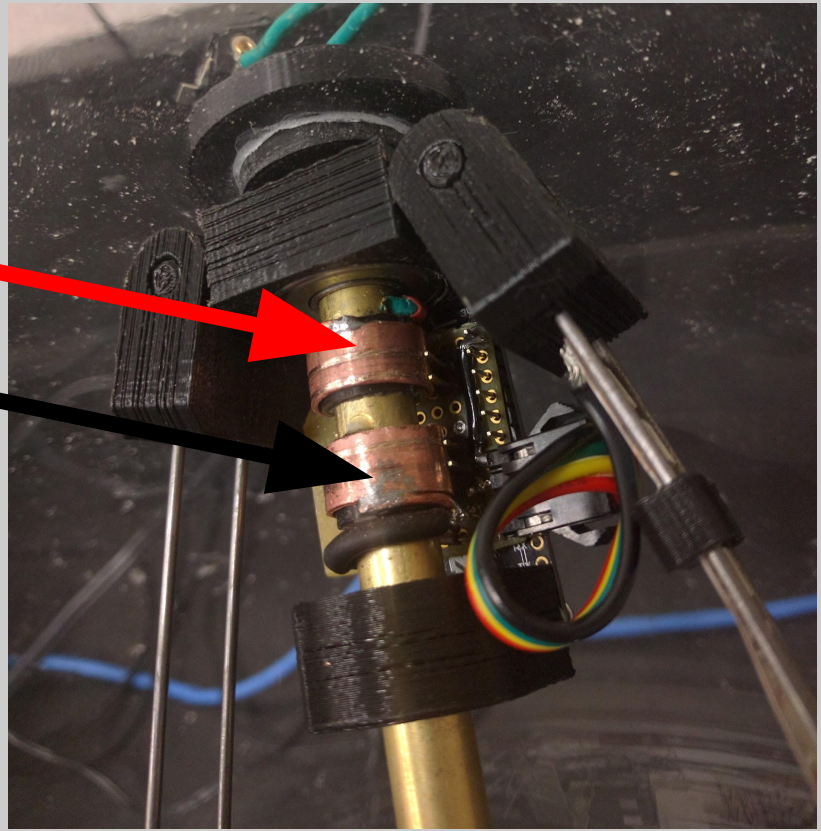


# Level 3 Hardware - Rotation Sensor

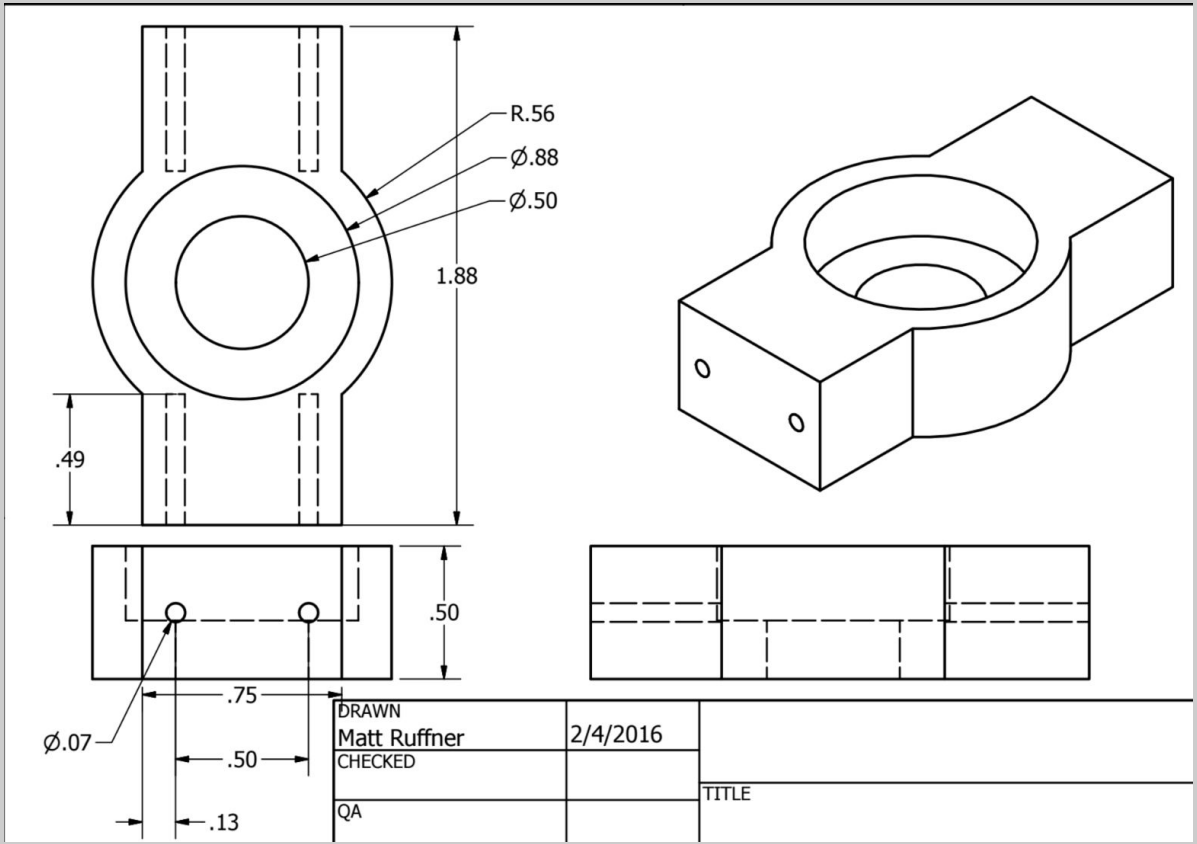
- Mount downward facing on PCB
- IR reflectance, higher analog output when next to whiter surface.
- Will trigger interrupt on ESP8266 whenever a lighter/darker surface color is passed over

# The Power of Revolution

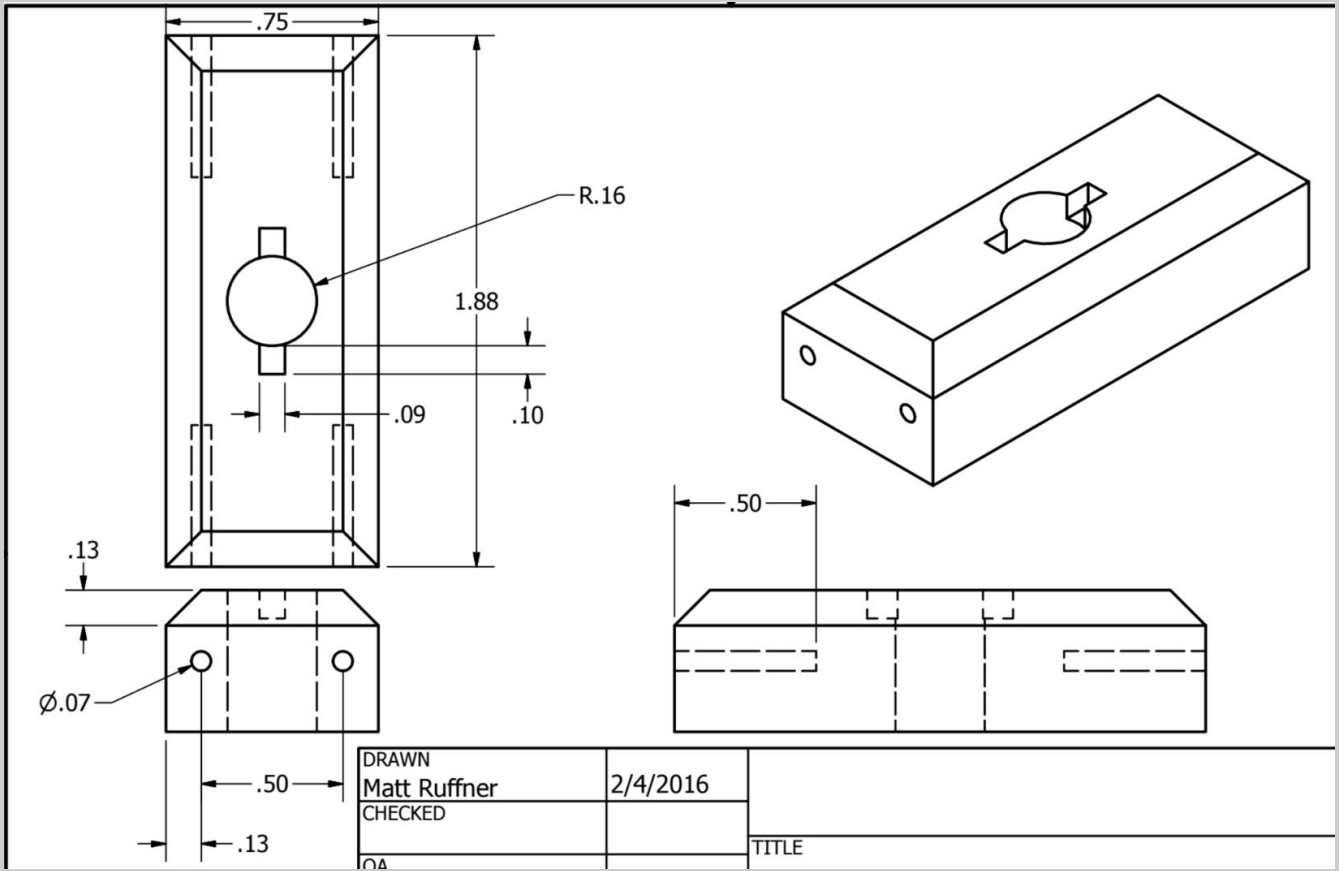




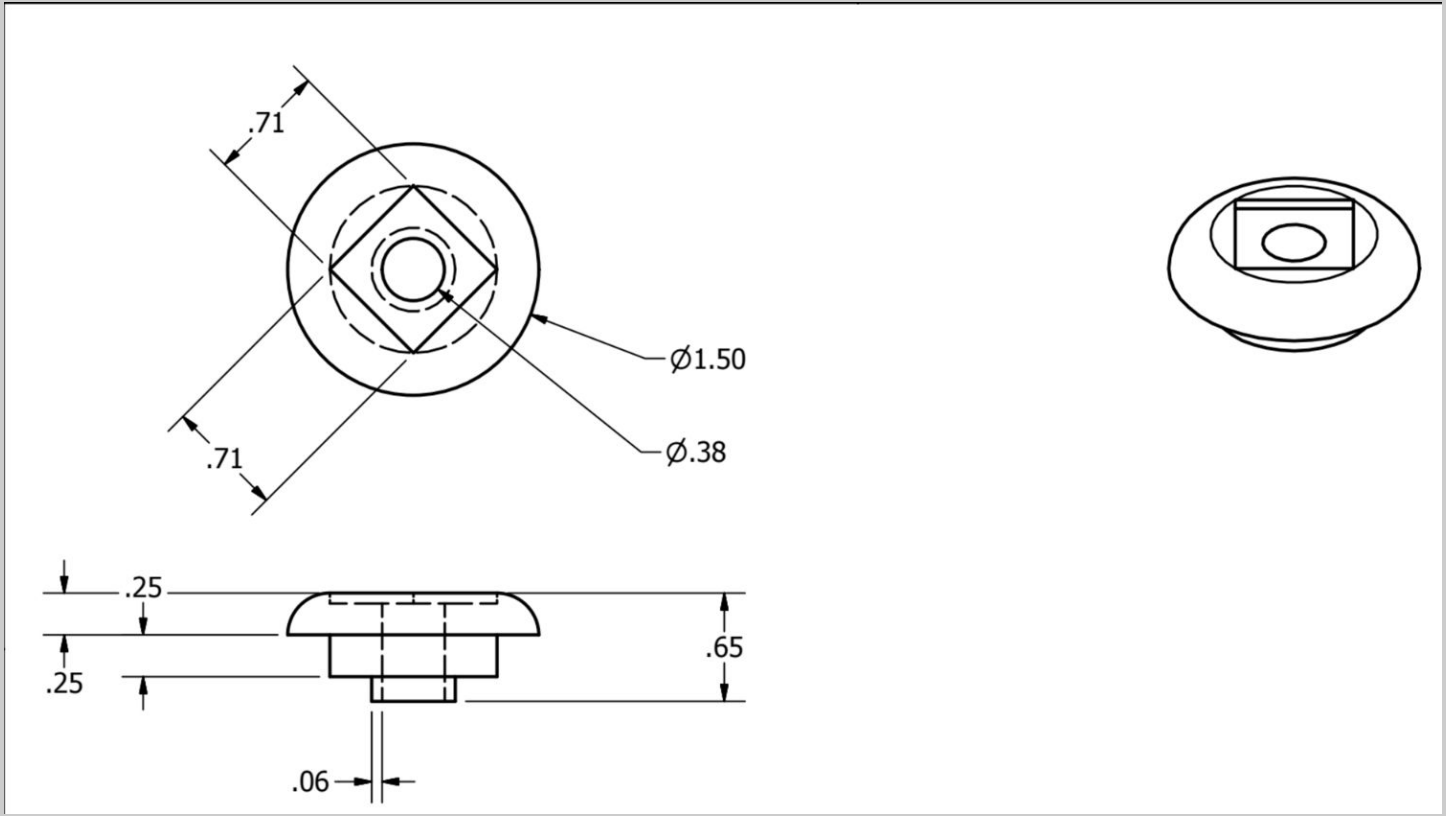
# Final Revision of printed parts - top shaft anchor



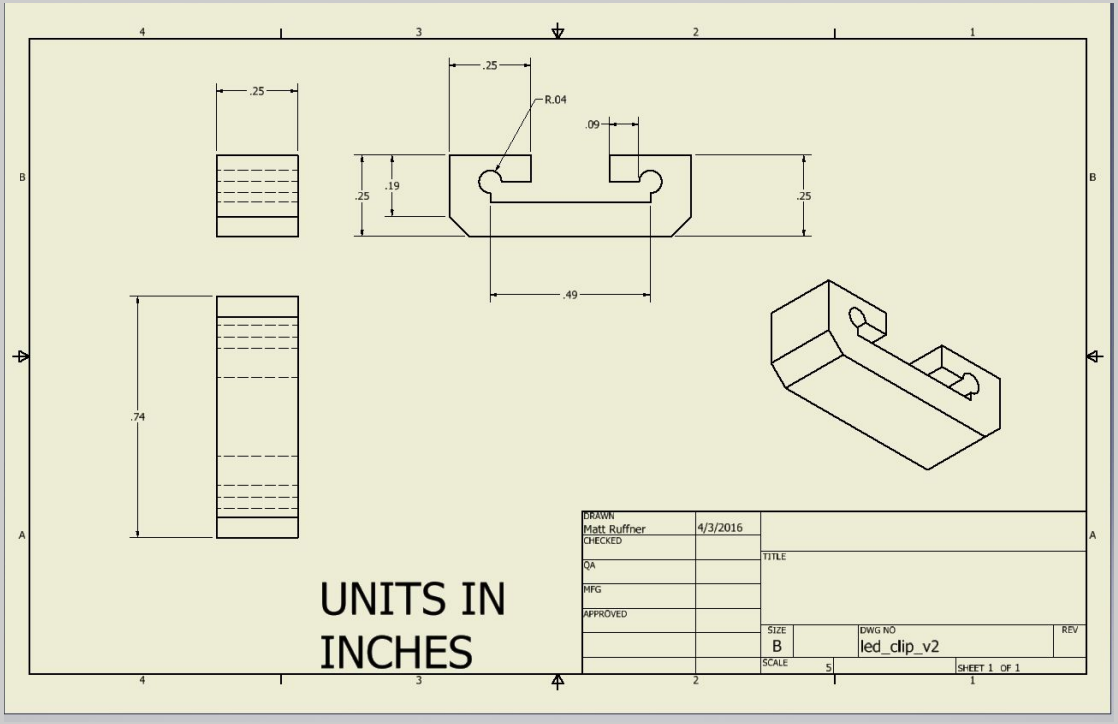
# Bottom shaft anchor



# Stationary shaft mount - fits in acrylic sphere



# LED Clip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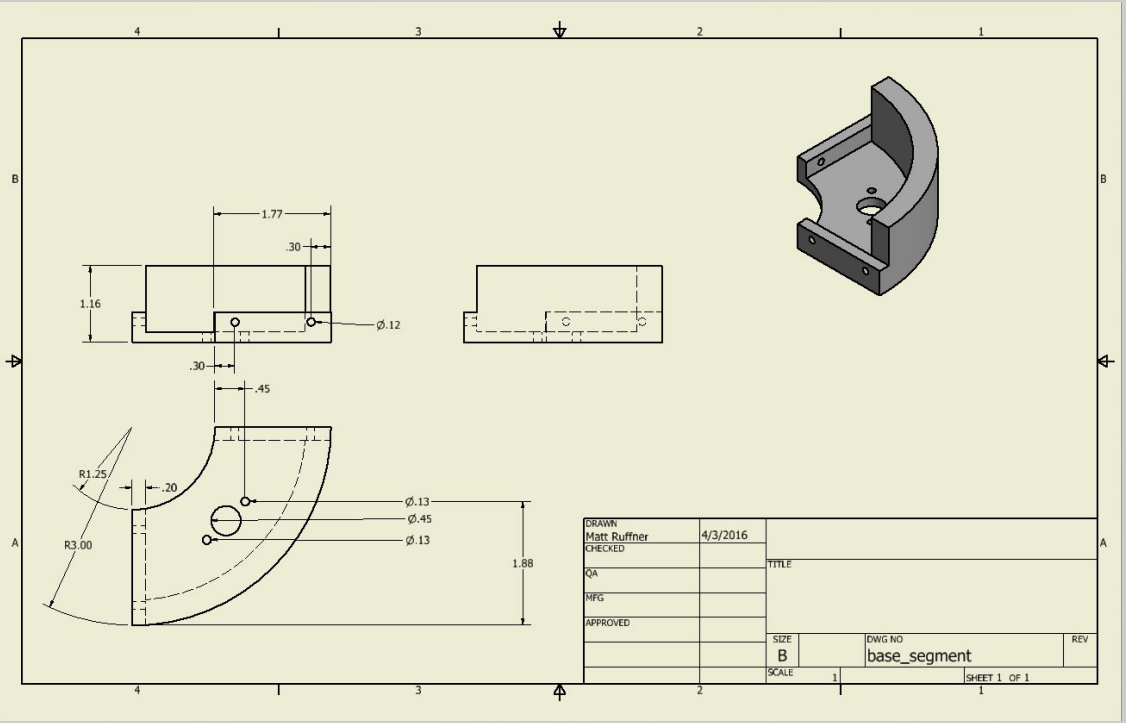
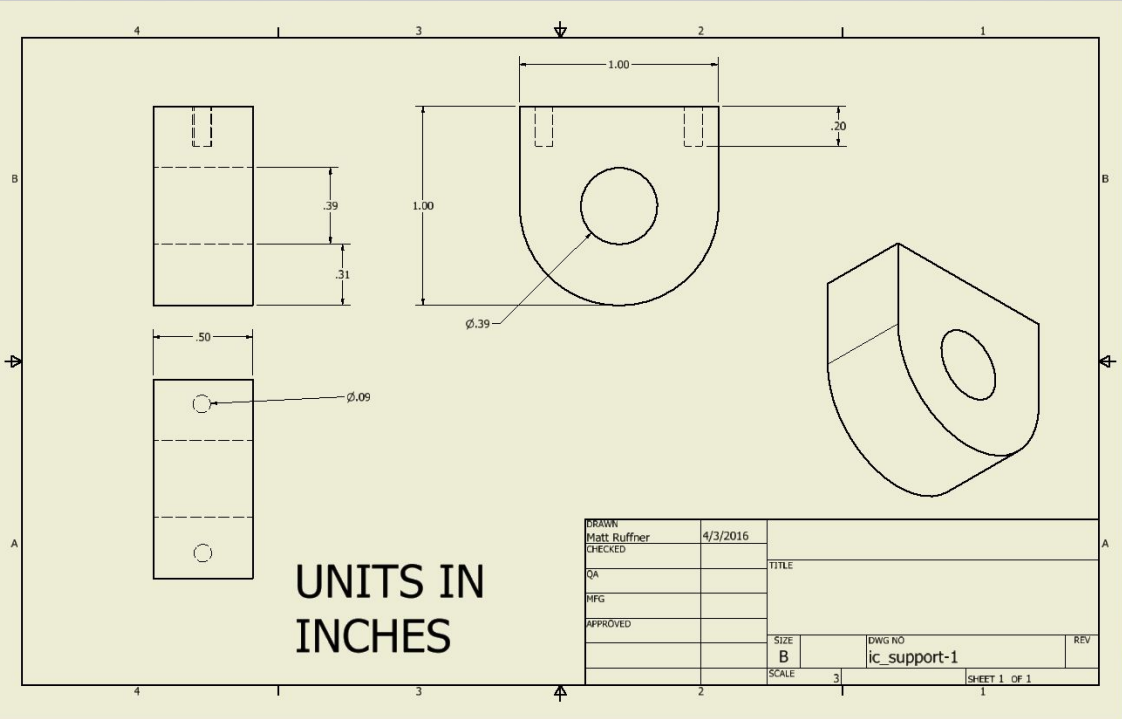
# Base Segment



# IC Support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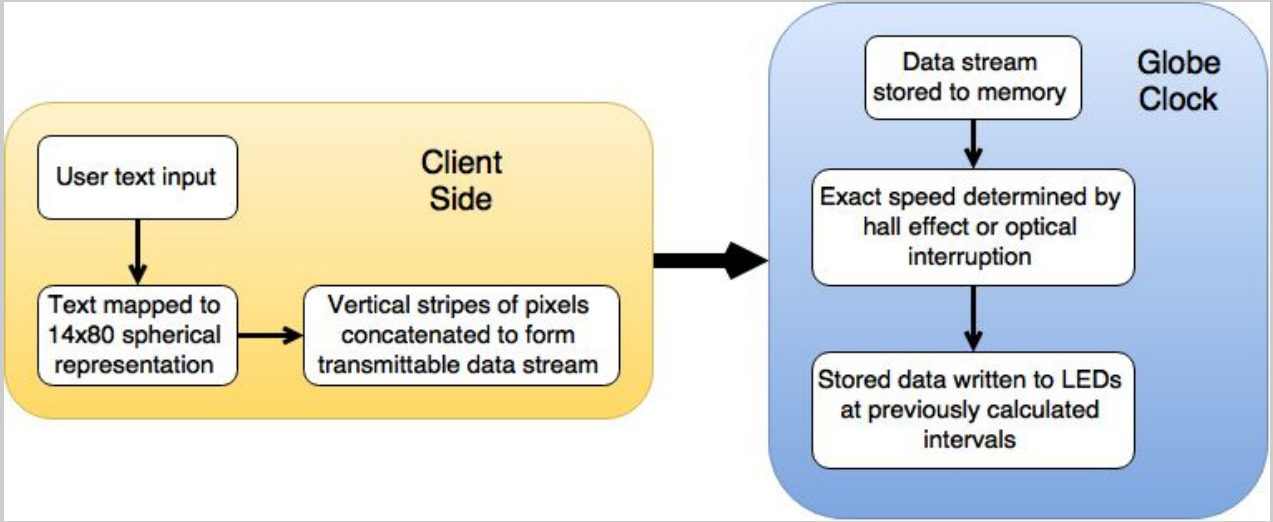
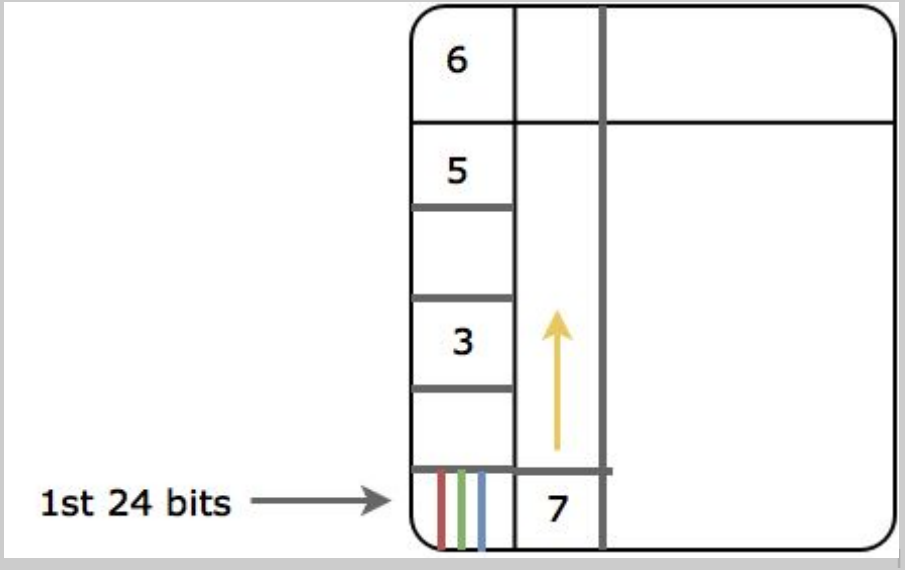
# Level 0 Overall Software Design

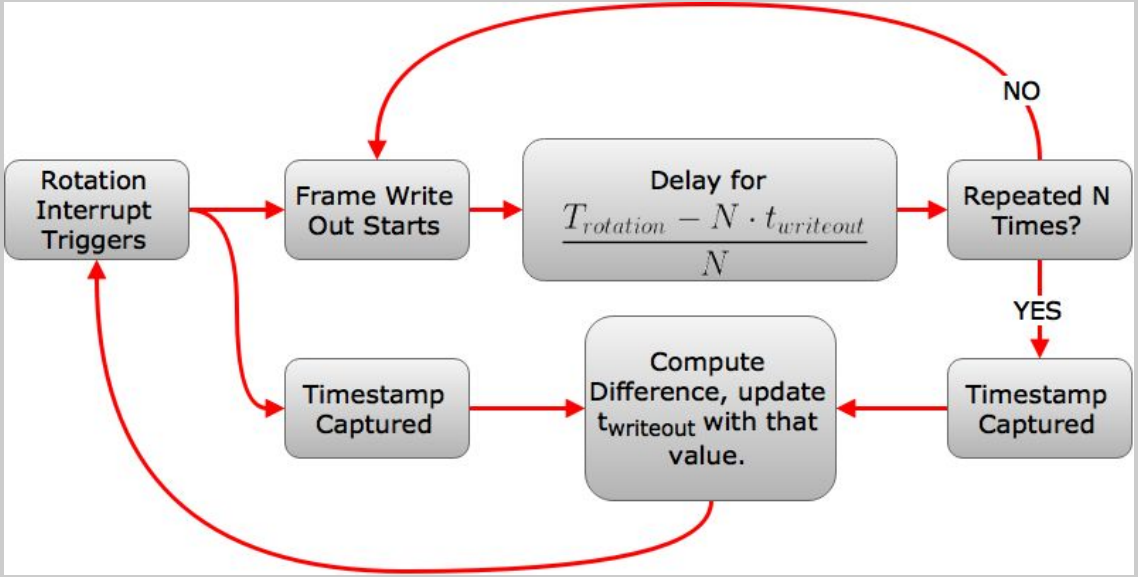


# Level 1 Software Design - Image data schema

- Take final image, concatenate red, green and blue color channels, 1 byte binary representations of each.
- Transfer file to Globe over TCP



# Level 2
# Globe Side Software




- With ESP8266 clocked at 160Mhz the Wi-Fi stacks' overhead is negligible.
- Running custom NodeMCU Firmware (Lua based),
  - cross compiled against Espressif's ESP8266 SDK. (ESP8266 also supports a port of MicroPython)
  - Need custom build to include module for simplifying SPI communication to the APA102 strip.
  - Also lets us cut out unnecessary modules to save flash space.
- Main event loop will be checking for rotation interrupt or a TCP transfer start from client side.
- NodeMCU supports 1 level file system, easily save/load transferred file.

# Globe Software Continued

```
s:listen(1234, function(c)
   c:on("receive", function(c, l)
      if( string.sub(l, 1, 4) == "data") then
        if(saved) then saved=not saved end

        if (not saved) then
            print("saving new globe image")
            file.open("image", "w")
            file.write(string.sub(l,5,-1))
        end
      elseif (l and not saved) then
            print("adding to file")
            file.write(l)
      end

   end)
```

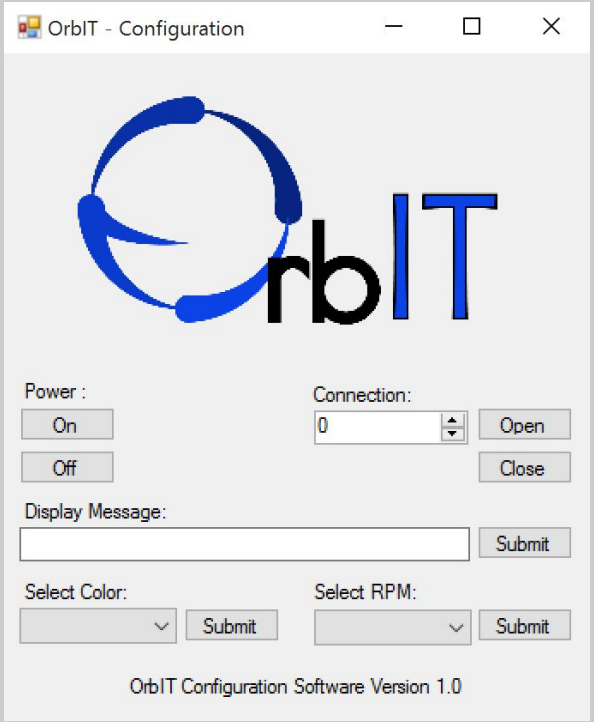
- Main image receiving code
  - Sets up TCP server on port 1234 and listens for incoming connections.
  - If first 4 bytes are ‘data’ then save the rest of the stream to the local file named ‘image’.

```
wifi.setmode(wifi.STATION)
wifi.sta.config("ukyedu", "")

dofile("apa102.lua")

dofile("ledserver.lua")

apa102.init()
```

- *init.lua* - the code to run at system startup
  - Connect to ukyedu WiFi, load LED driver, create server.

# Level 3 Client Side Software Design

Client application takes input text, maps output image with vertical resolution of 72, initiates TCP transfer with Globe.



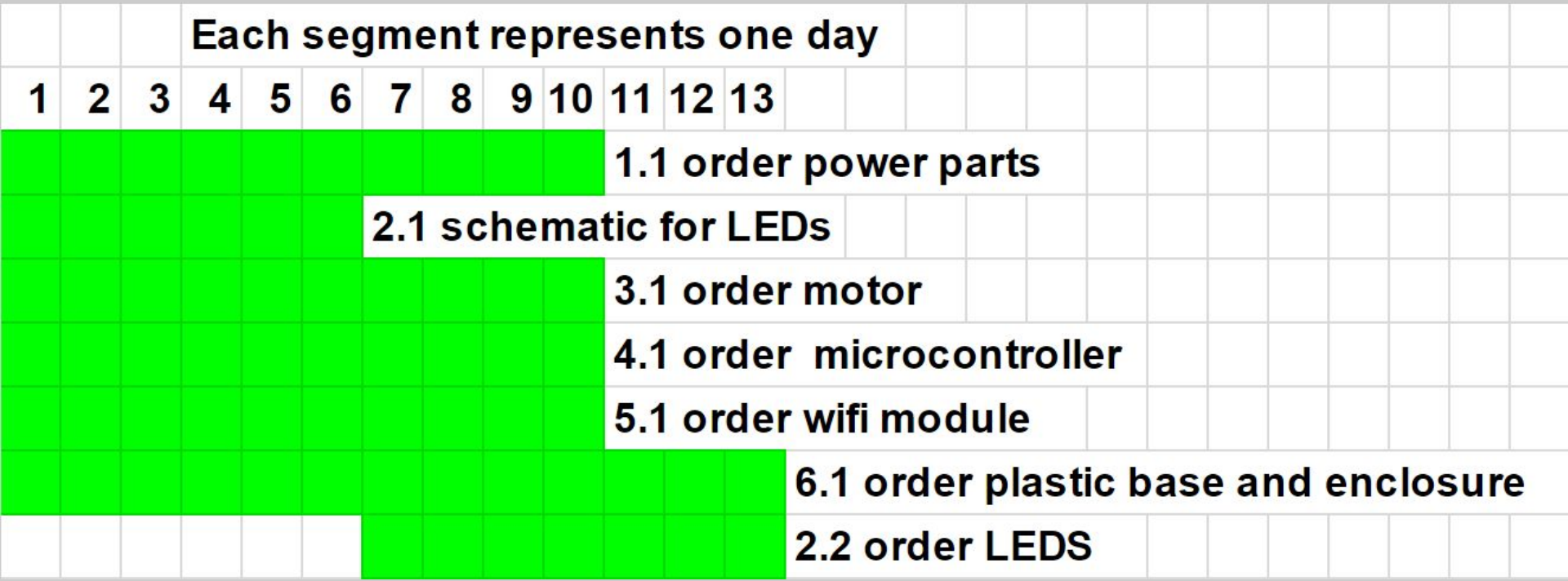
# Final Cost

| Part | Description | Supplier | Quantity | Cost |
|---|---|---|---|---|
| ESP8266 | WiFi Stack/Processor | Adafruit | 1 | $10.95 |
| Clear Globe | 16 inch Clear Acrylic Globe | Amazon | 1 | $41.51 |
| Brass Tube, Type K | 20”length<br>⅜” width | Hobby King | 1 | $3.96 |
| 24 V Power Supply | DC 24V @2A regulated power supply | Amazon | 1 | $9.99 |
| Universal 5V 1.2A AC Power Supply | 5v power supply | amazon | 1 | $25.00 |
| MAKERBOT REPLICATOR 2 BLACK PLA FILAMENT | BLACK PLA FILAMENT 1.75mm | Quickship | 1 | $16.72 |
| Individually Addressable LED RGB Strip | .5 meter, 144 LEDs/meter | Adafruit | 1 | $19.95 |
| | | Total | | $144.80 |

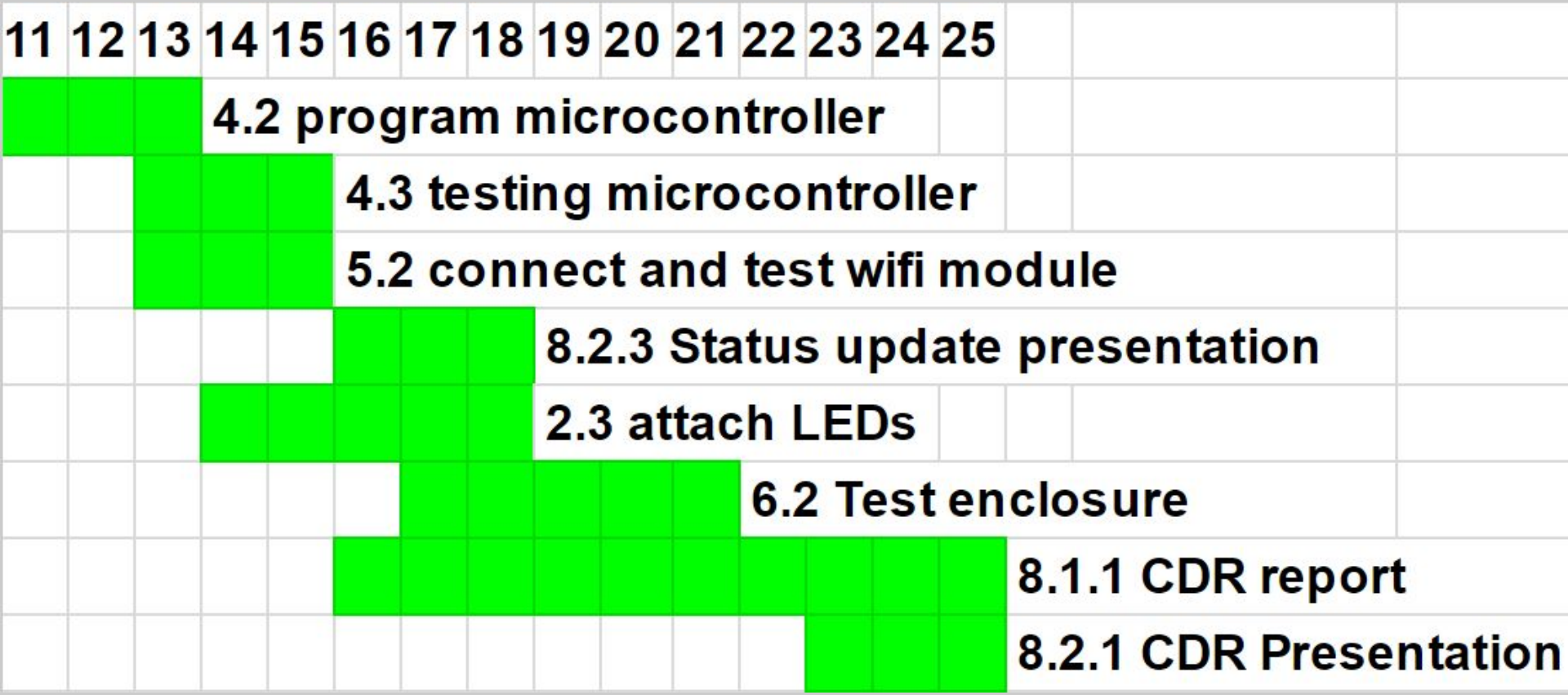
# Team Member Contributions

| Section | Primary | Secondaries |
|---|---|---|
| Power | Jessie | Hao, David |
| LEDs | Matt | David, Hao, Bill |
| Microcontroller/Wifi Module | Matt | Ben, Hao |
| Base and Enclosure | Bill | Hao, Matt, David |
| Computer Interface | Ben | Matt, Hao |
| EE 490 Tasks | All | All |

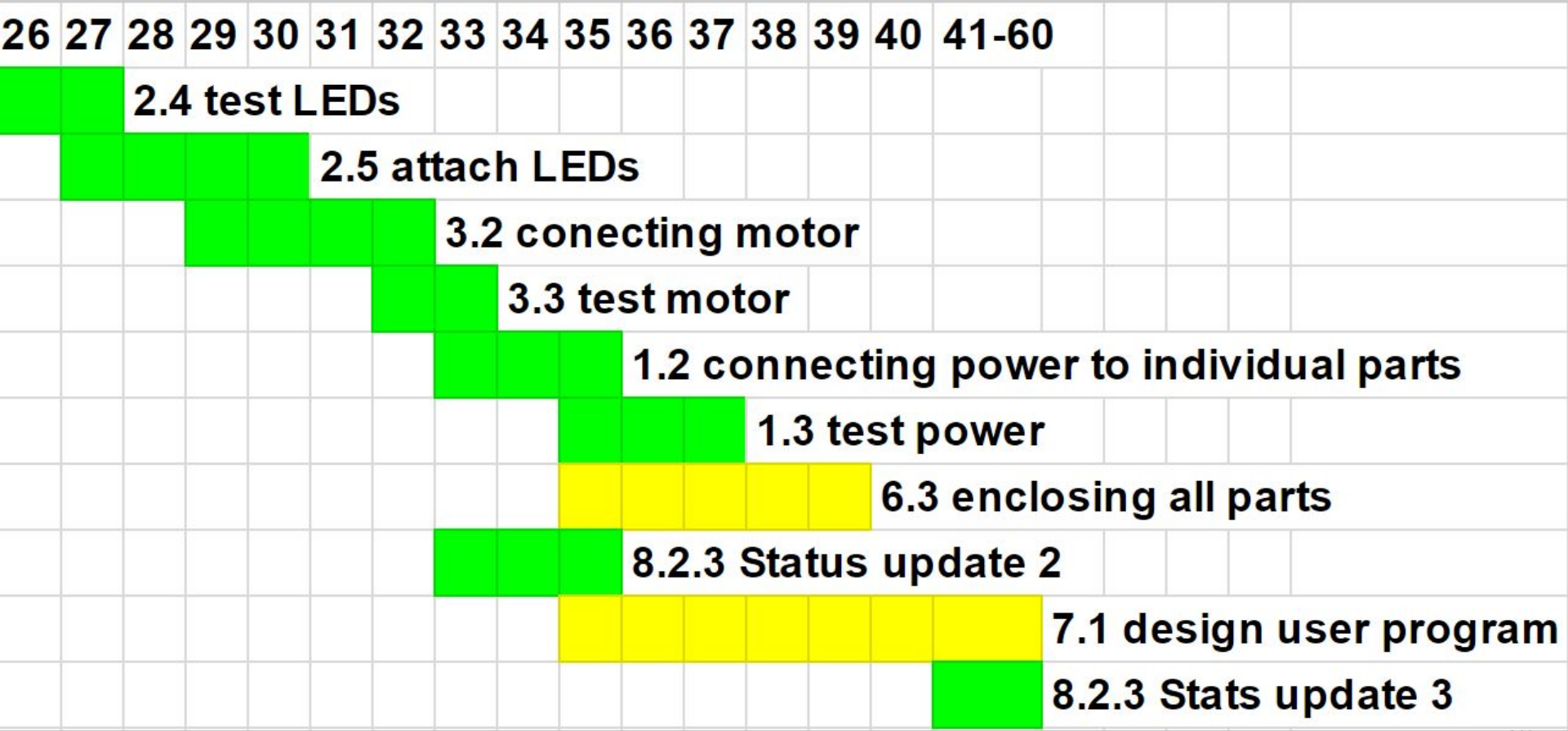
# Gantt Chart segment 1, days 1-13



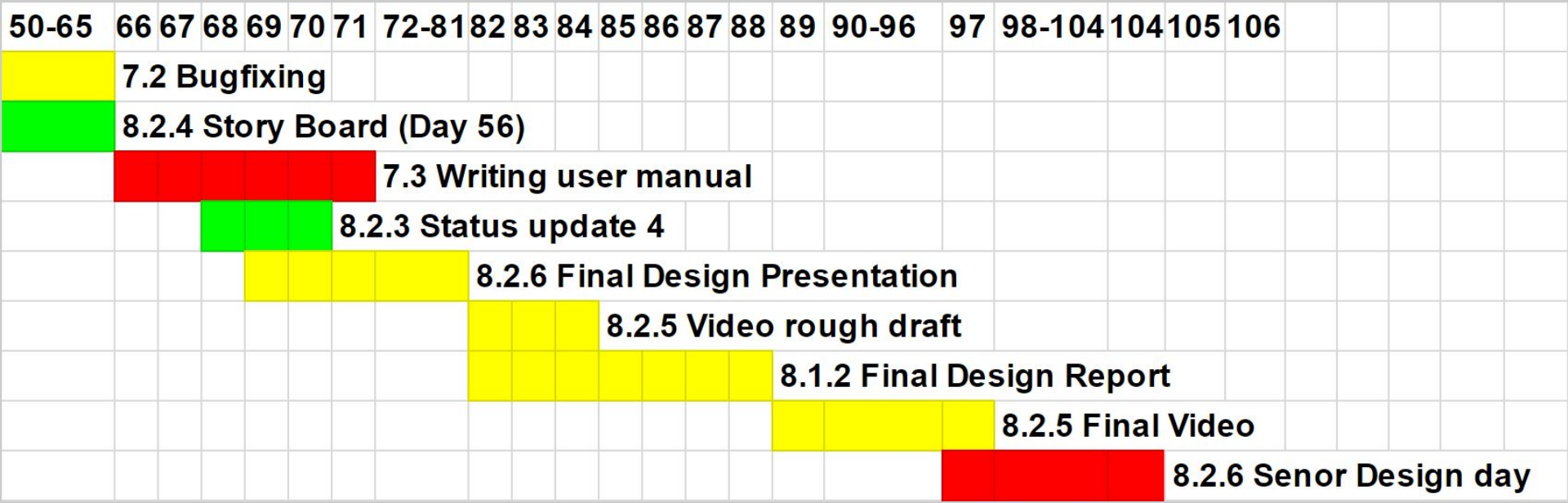
# Gantt Chart segment 2, days 11-25



# Gantt Chart segment 3, days 26-60



# Gantt Chart segment 4, days 50-106



# Marketing Requirements

1. The device *shall* be able to display a 32 letter message (16 characters by 2 lines) around the circumference of the globe (3360 bytes). This is the *standard configuration.* **IN PROGRESS**
2. The device *shall* be priced competitively (currently less than $500). **COMPLETE**
3. The device *shall* not be affected by people touching it or surrounding areas. **COMPLETE**
4. The device *shall* be reprogrammable without physical interaction with the device. **COMPLETE**
5. The device *shall* be easily mountable. **IN PROGRESS**
6. The device *shall* be powered from the socket from which it is mounted. **IN PROGRESS**
7. The device *shall* be more energy efficient than the competition. **COMPLETE**
8. The device *should* be able to store 1 *standard configuration* of text. **COMPLETE**
9. The device *should* be able to be mounted on the ceiling with clearance for bystanders. **IN PROGRESS**
10. The device *should* be able to display 1 image. **IN PROGRESS**
11. The device *should* be able to display content clearly. **IN PROGRESS**
12. The device *should* be able to operate outside in the elements. **IN PROGRESS**

# Engineering Requirements

| Table 1: The device shall be able to connect to 802.11 b/g networks. (Marketing Requirement 4) | | | | |
|---|---|---|---|---|
| | Engineering Requirement | Justification | Testing | Status |
| 1.1 | The device *shall* be able to store 1 standard configuration of uploaded text. | The displayed text will be an advertisement or other relevant information for the viewer. | Look at the globe clock and see if it displays text correctly. | Complete |
| 1.2 | The device *shall* be able to open a TCP or UDP connection. | This allows for data transfer from a computer to the display so that text and images can be changed. | Transfer known data over TCP connection; dump over serial from micro controller and verify similarity. | Complete |
| 1.3 | The device *should* be able to broadcast its own 802.11b/g network with a preset SSID. | This gives the globe clock the ability to receive data from a computer. | Check and see if a 802.11b connected device shows the globe clock's broadcast. | Complete |
| 1.4 | The device *should* be able to connect to 2.4 GHz 802.11n networks. | This connects the globe clock to the computer. | Successfully connect the globe clock to various other 24 GHz 802.11n enabled devices. | Complete |
| 1.5 | The device *should* be able to store 1 uploaded image. | This will allow the owner to display an advertisement or other relevant information as an image. | Upload an image and look at the globe clock to see if it displays correctly. | Complete |

# Engineering Requirements Continued...

| Table 2: The device shall spin at a minimum of 900 RPM to achieve at least 15 fps. (Marketing Requirement 1) | | | | |
|---|---|---|---|---|
| | Engineering Requirement | Justification | Testing | Status |
| 2.1 | The pixels *shall* be able to turn on and off within 8.33 ms to achieve 15 fps (to meet test display specifications). | These values are necessary for the transitions and movement to appear fluid to the human eye. | Monitor LED data lines with a logic analyzer. | Complete |
| 2.2 | The resolution per character *shall* be greater than 5x7 pixels. | This ensures that letters don't appear grainy to the viewer. | Measure the number of pixels across characters and verify that it is greater than 5x7 pixels. | In Progress |
| 2.3 | The pixel spacing must be close enough such that 14 LEDs fit within the 45° section in the middle of the globe. | The pixel density needs to be high enough so that an image can be displayed clearly on the globe clock. | Count the number of pixels around the clock, divide by four and check to see if this number is 14 or greater. | Complete |

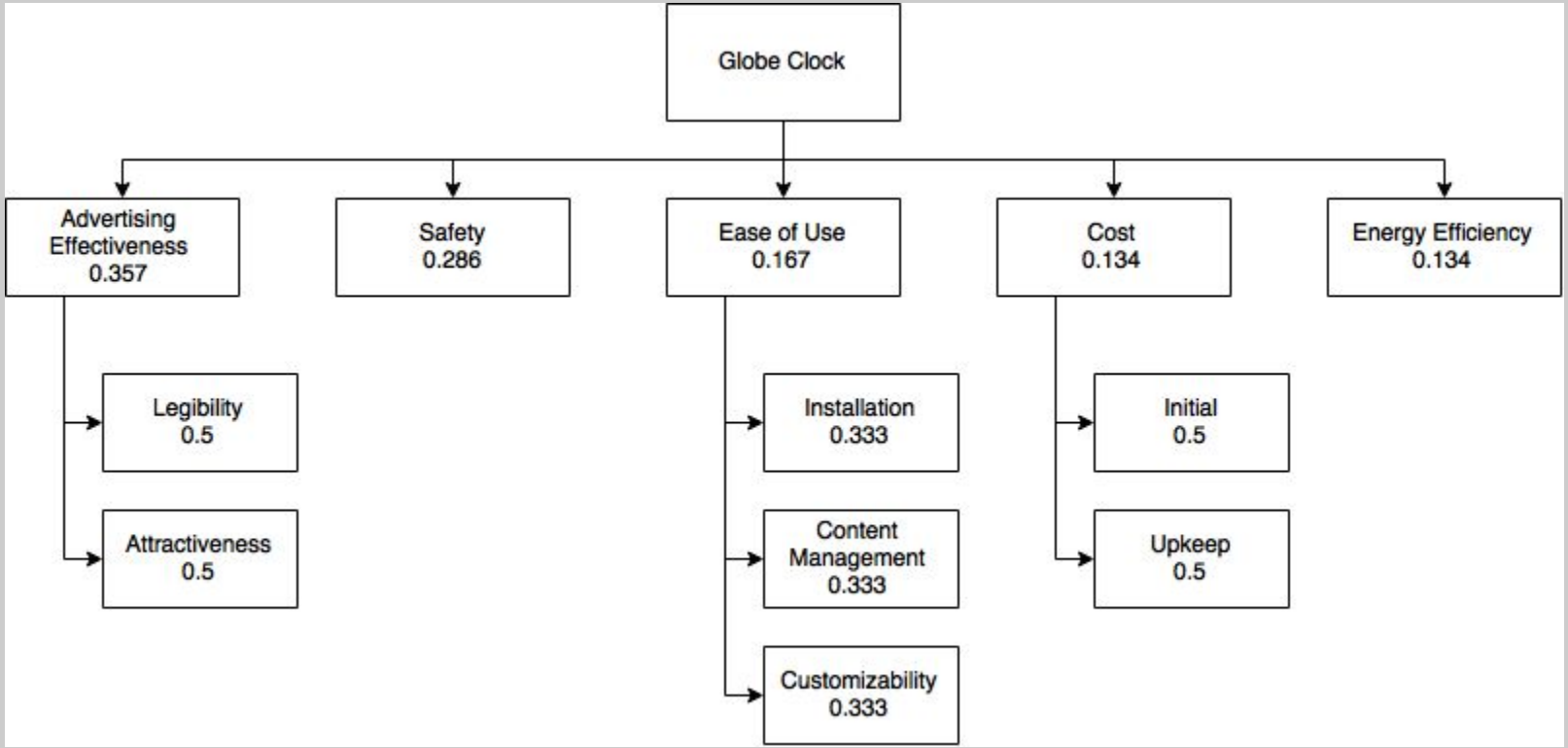
# Engineering Requirements Continued...

| Table 3: The globe clock should display a distinguishable image. (Marketing Requirement 7) | | | | |
|---|---|---|---|---|
| | Engineering Requirement | Justification | Testing | Status |
| 3.1 | The pixels *should* be able to turn on and off within 521 us to achieve 24 fps. | This will make the image appear clear to the viewer while the globe clock is spinning. | Monitor LED line with a logic analyzer. | Complete |
| 3.2 | Distortion along the edges of image *should* be minimized. | The image should be displayed clearly on the surface of the sphere. | Display different images on the globe clock to ensure that they are clear. | Complete |
| 3.3 | The images *should* be at least 14x80. | This ensures that the image doesn't appear grainy to the user. | Count the number of pixels displayed on the display portion of the globe clock. | Complete |

# Engineering Requirements Continued...

| Table 4: Other Engineering Requirements | | | | |
|---|---|---|---|---|
| | Engineering Requirement | Justification | Testing | Status |
| 4.1 | The device *shall* be able to replicate at least 256 colors using RGB LEDS. | To have greater color reproduction than the competition. | Check LED spec sheet to verify PWM output is more than 7/bits of color. | Complete |
| 4.2 | The device *should* consume less than 45W of power when displaying text. | To be more efficient than the competition. | Calculate and measure current consumed by circuitry and motor. | Complete |
| 4.3 | Moving parts pertaining to the creation of the POV image *shall* be enclosed by a physical barrier with minimal visual degradation. | To protect bystanders, consumers and the circuitry. | Subject the enclosed globe to jostling forces. | Complete |

# Objective Tree



# Impacts

| Impact | Description |
| --- | --- |
| Economic | The globe clock is economically viable, because it allows the buyer to earn consistent ad revenue without spending much on capital or other recurring costs. The globe clock is built on energy efficient technologies such as LED lights so it will consume around 45 Watts of power which is less than a typical incandescent light bulb. Additionally, the globe clock will be sold for $600 which is a low startup cost compared to alternative means of advertising such as billboards or radio ads. The start up cost will be recouped quickly by the profits made from advertising thus making the globe clock economically viable. |
| Social | In order to meet the social need the globe clock will be attractive, effective and impressionable. We should make the information displayed with rotating ring of LEDs become the great bright spot compared to the traditional print ads while benefiting the users by creating an advertising form that both attracts attention and stimulates customer response. In addition, it should be widespread use in society by designing its ease of installation and use. |

# Impacts Continued...

| Impact | Description |
| --- | --- |
| Safety | The globe clock will be widely used in storefronts and businesses, so the safety of customers is very important. The globe should account for traditional safety hazards such as fire or water, and should be physically enclosed so that people cannot stick their hands in moving parts. |
| Manufacturability | Despite the flashing lights and mesmerizing nature of the globe clock, the underpinnings are built simply. The components are straightforward to assemble which will increase the scalability of mass manufacturing. Additionally, much of the underpinnings of the globe clock is software, which is exceptionally easy to mass produce, and furthers scalability. |

# Impacts Continued...

| Impact | Description |
| --- | --- |
| Environmental | The globe clock is built to be environmentally sustainable as it encompasses technologies to keep energy consumption minimal. This not only keeps the operating costs of the globe clock down but also reduces the carbon footprint by not causing the power plants to burn as much fuel. The globe clock consumes only 45 watts of power which is substantially less than other advertising mediums such as billboards or television. Additionally, despite the advances of modern technology, many ads are still in print whether it be in the form of fliers, mail, or newspapers. If companies advertised on the globe clock instead of in print, less paper could be used and trees could be saved. Thus, advertising with the globe clock would be much more environmentally friendly than alternative advertising platforms. |

# Questions?