NASA TSGC Design Challenge: Reconfigurable Lighting System

FINAL PRESENTATION TO IAB MEMBERS
13 December 2022

Team #6
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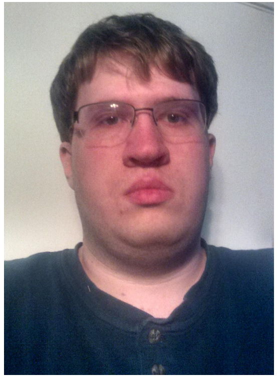
CULLEN COLLEGE of ENGINEERING

http://www.tsgc.utexas.edu/challenge/PDF/topics/Topic_TDC_78_S22.pdf

Team Members

- From top left, clockwise:
  - Hector Carrera **(Team Leader)**
  - Christopher McLoughlin
  - Christopher Andrew (Treasurer)
  - Jackson Clark



Background: Problem

- Current lights are bulky
- Not efficient
- Not flexible
- Fixed
- Complicated
- Not compatible with circadian rhythms

Figure 3. Current NASA qualified fluorescent General Luminaire Assembly (GLA) procured for human factors

Background: Problem (cont'd.)

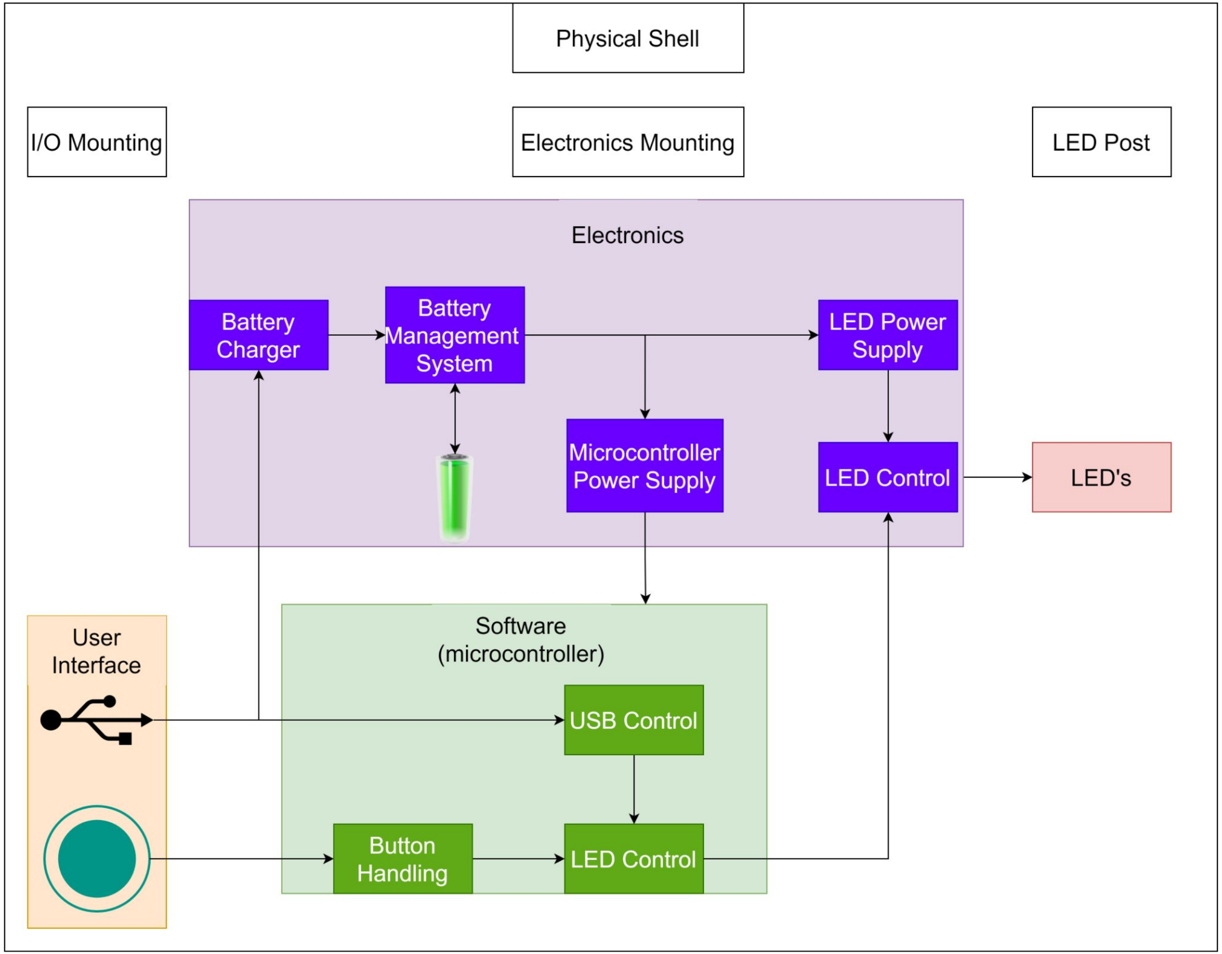
- Light is needed for workplace safety
- Space is hostile
- Space is isolated

https://spinoff.nasa.gov/Spinoff2015/cg_6.html

Proposed Solution

- A portable lighting system that could be easily adapt to the user's needs.
- This device is able to adapt by allowing the user to control brightness, correlated color temperature, and customizable firmware.

Overview Diagram



Safety Design Requirements

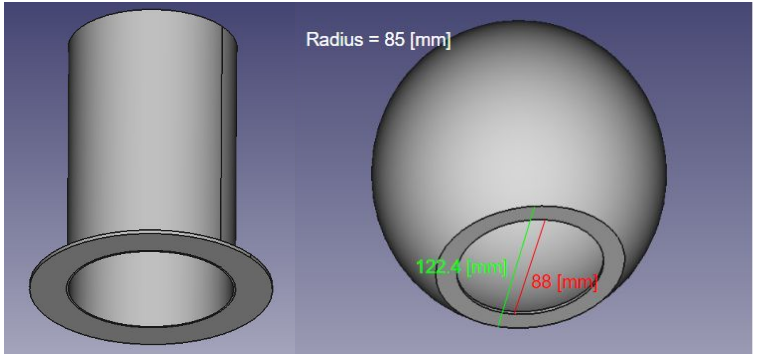
- There is limited research on using rechargeable lithium batteries in space. The need for rechargeable batteries is there and lithium batteries are a promising option. [1]
- PLA was chosen as the 3D printing material do to it being less flammable when compared to other options. [2]

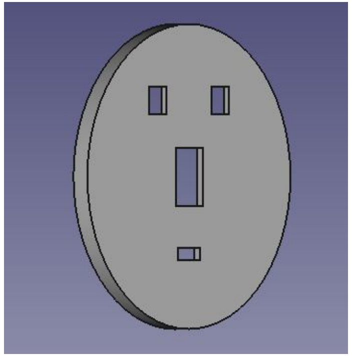
Safety Design Requirements

- Battery Management System utilized to ensure safe operation of the batteries. [3]
- The minimum amount of light needed for working environments is 93 [lx]. [4]

Deliverables

- The main deliverable is **the lighting system**
- 3D models for the lighting system
- Software to control the lighting system
- Electrical diagrams for the lighting system

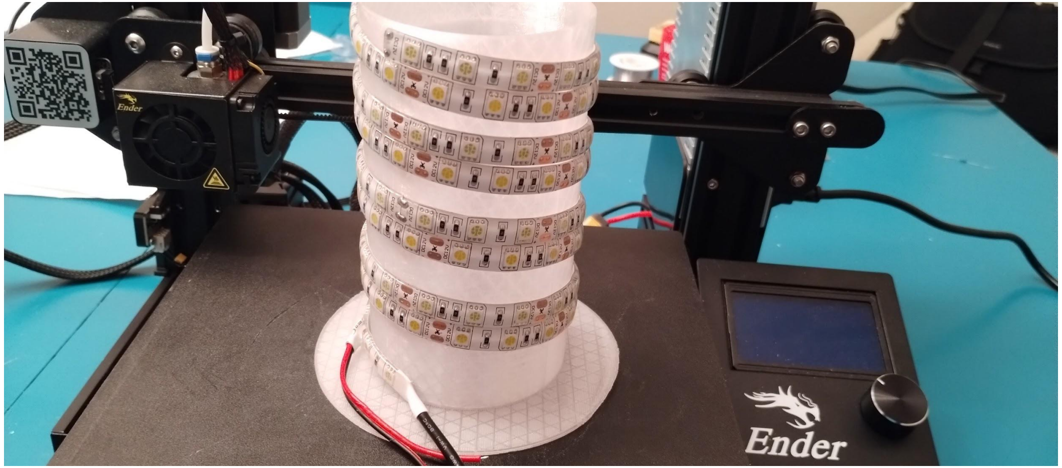


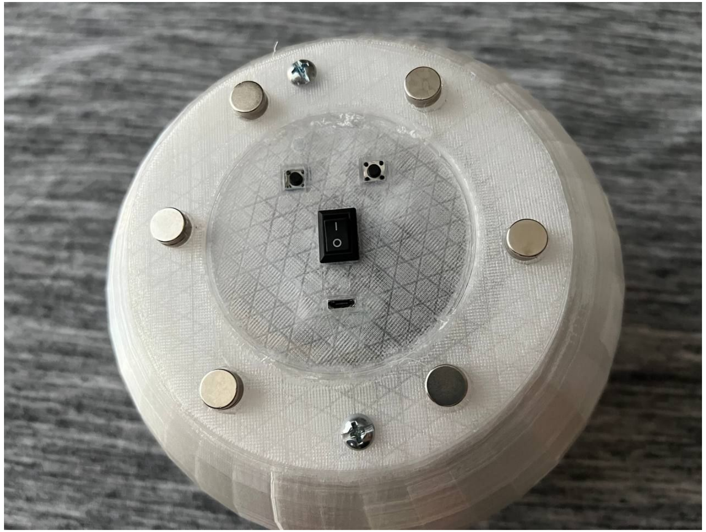


Specifications

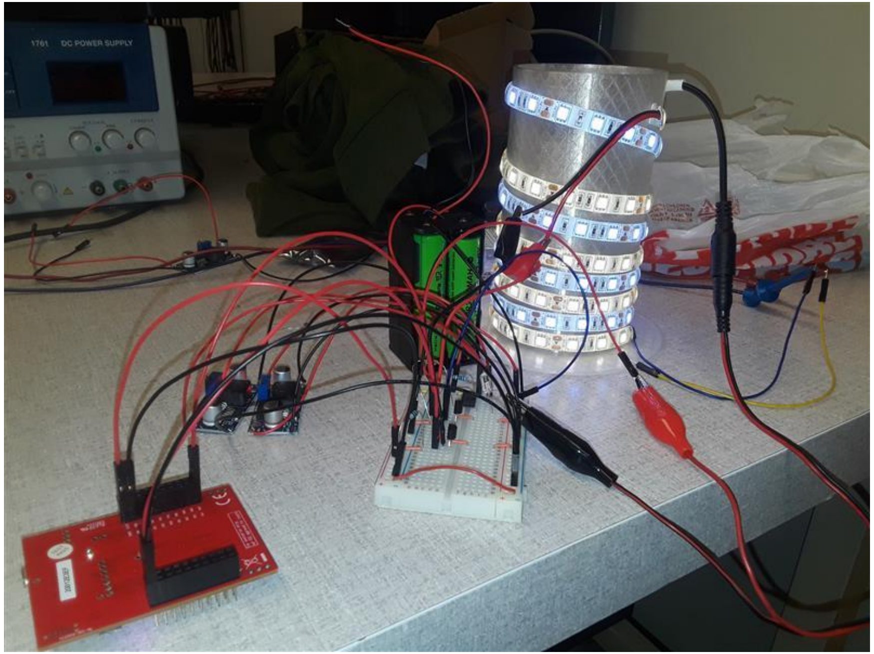
	Minimum Viable	Reached
Brightness	100-1000 [lux]	100-1700 [lux]
Color Temperature Control	Color temperature control	2400-6500 [K]
Brightness Control	Robust brightness control	Robust brightness control with multiple step-up ranges
Battery Life	5 [Hours]	9 [Hours]
3D Printing	3D printed shell, diffuses LED light	3D printed shell, diffuses LED light
USB	USB charging	USB charging and robust control
Mounting	Magnets	Strong magnets

Shell and Mounting

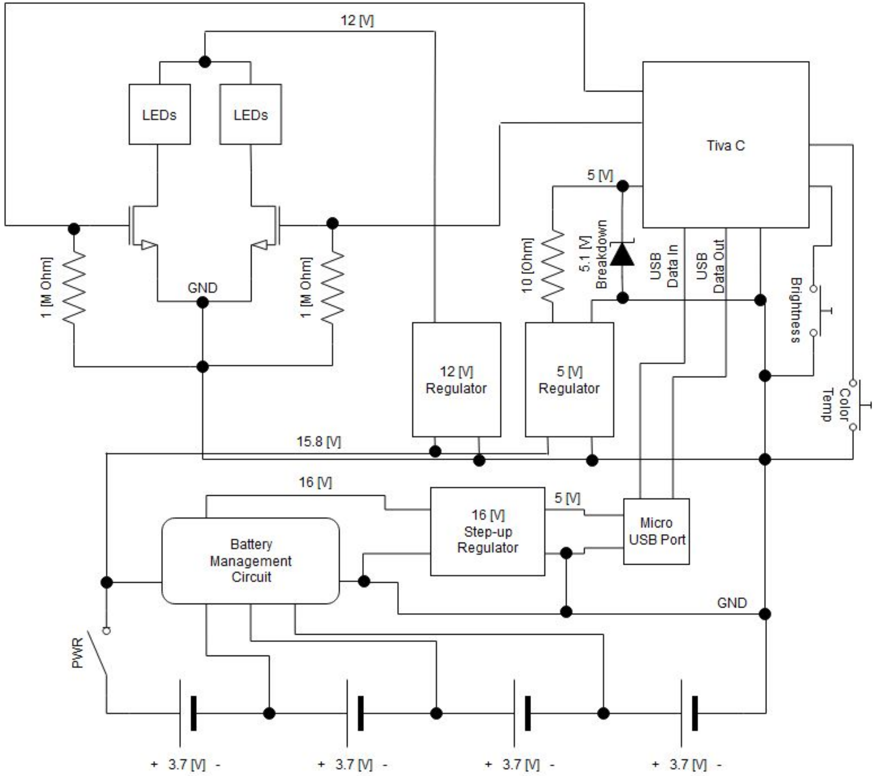




Internals

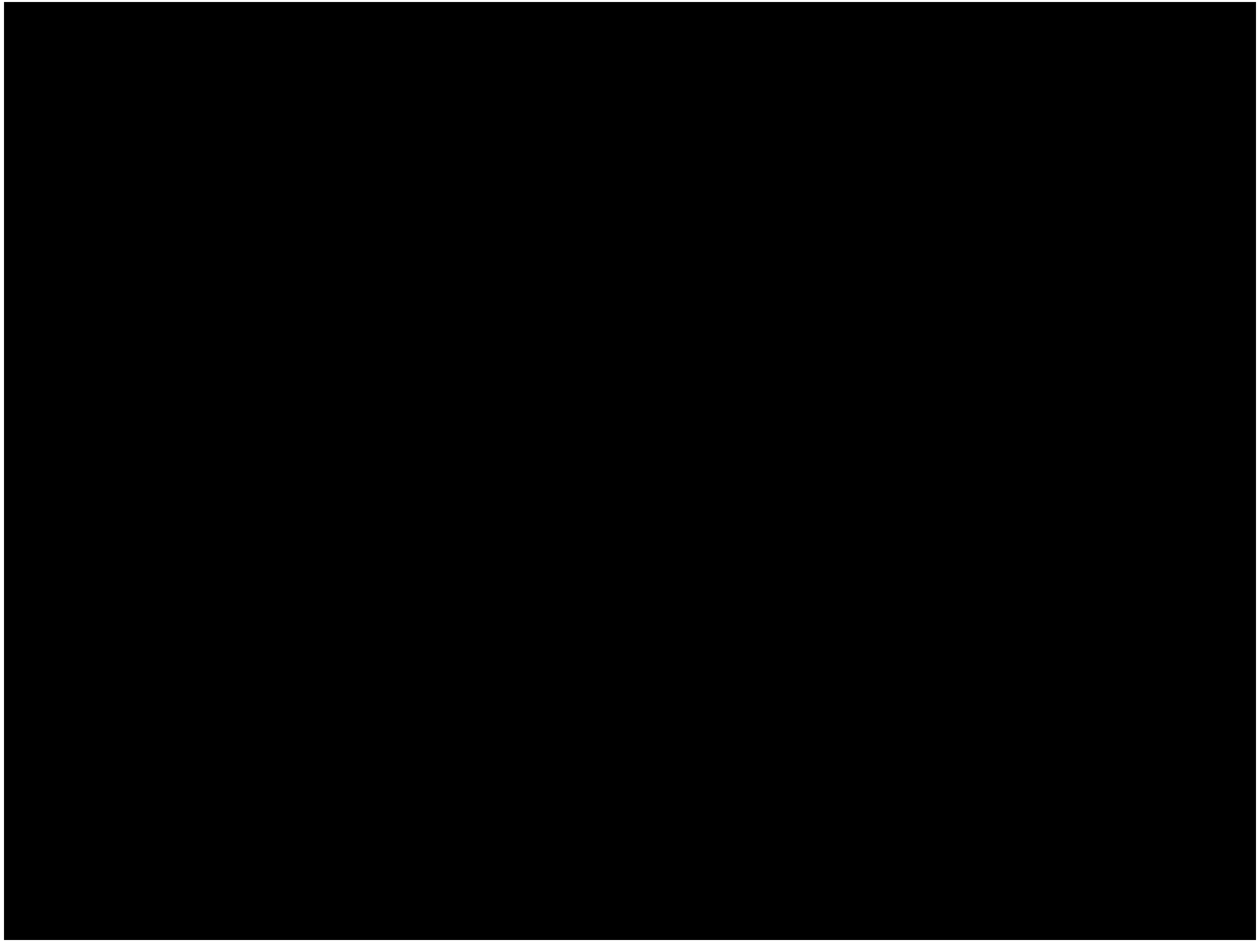


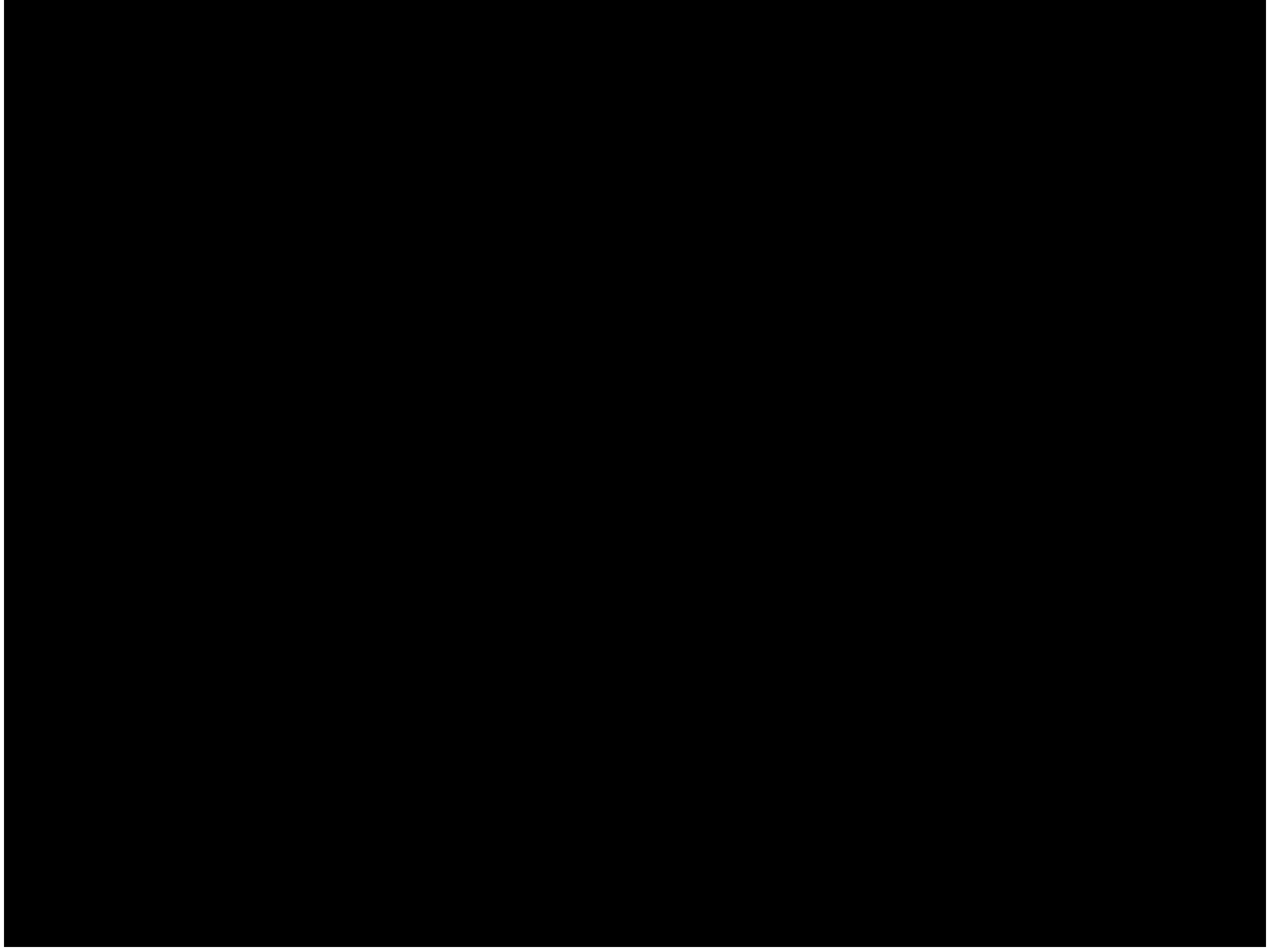
Discrete internals, without battery charging



Final Diagram

Demo



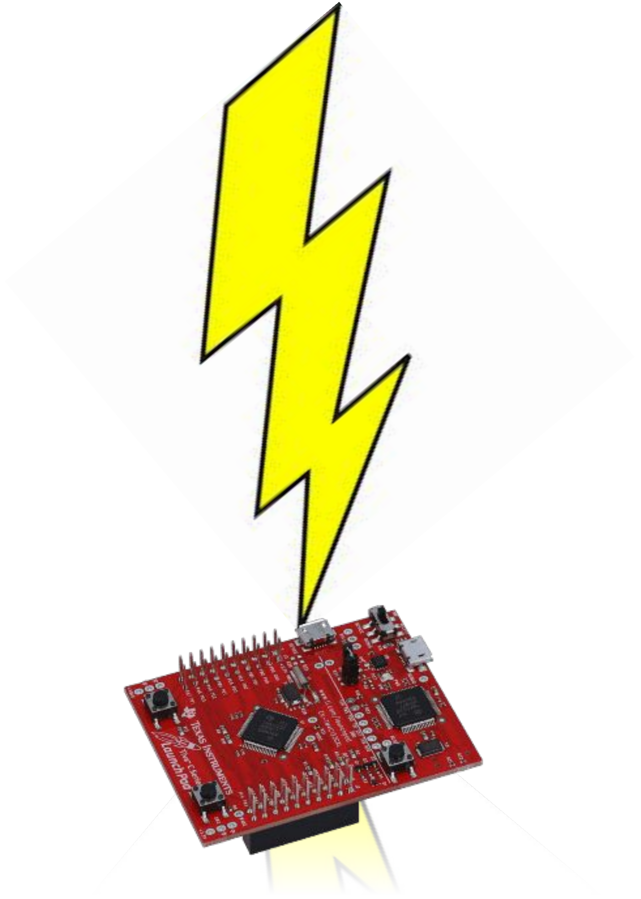


Accomplishments

- We exceeded initial specifications!
  - Battery life
  - Brightness range
  - Features and lighting
- Minimalist design
- Efficient circuitry

Setbacks

- LED post redesigned to hold components inside the post
- Buck converter on startup can supply too much voltage resulting in damage to the microcontroller
- Boost converter for battery charging could draw more current than a USB port was rated to supply



Going Further

- Bluetooth control of one or more units
- Change USB 2.0 interfaces to USB-C to allow faster charging
- All in one PCB design
- 24 [Hr] color temperature/brightness profile
- Move away to a different 3D printing process to produce a clearer sphere

Lessons Learned

- The engineering design process
  - Organizing and delegating tasks
- Handling setbacks
- 3D printing
- Voltage spike protection circuitry
- USB communication was more complicated than expected

Summary

- We **developed** a robust, minimalist, functional and reconfigurable lighting solution for crew in outer space.
- We **completed** the project under budget and ahead of schedule, and fulfilled all tasks with regards to the project.
- We **learned** a lot from setbacks, challenges and learned about intricacies of engineering design and the importance of a schedule.

Acknowledgements

We would like to thank our mentor **Dr. David Mayerich** and **Dr. Pei** - our project manager - for helping us throughout this project!

Q&A

References

[1] W. Walker, S. Yayathi, J. Shaw, H. Ardebili, Eds., “Thermo-electrochemical evaluation of lithium-ion batteries for space applications,” in *Journal of Power Sources*, Dec 2015. [Online]. Available: https://www.sciencedirect.com/science/article/abs/pii/S0378775315302081

[2] C. Réti, M. Casetta, S. Duquesne, S. Bourbigot, R. Delobel, Eds., “Flammability properties of intumescent PLA including starch and lignin,” in *Polymers for Advanced Technologies*, Jun 2008. [Online]. Available: https://onlinelibrary.wiley.com/doi/abs/10.1002/pat.1130

[3] “Battery Management Systems Ensure Safety and Reliability.” aved.com. https://aved.com/battery-management-systems-ensure-safety-and-reliability/ (accessed Dec 12, 2022).

[4] Iman Dianat, Ali Sedghi, Javad Bagherzade, Mohammad Asghari Jafarabadi, Alex W. Stedmon, Eds., “Objective and subjective assessments of lighting in a hospital setting: implications for health, safety and performance,” in *Ergonomics*, Jul 2013. [Online]. Available: https://www.tandfonline.com/doi/abs/10.1080/00140139.2013.820845

Template

- Bullets