



Semi-Autonomous Growing Environment

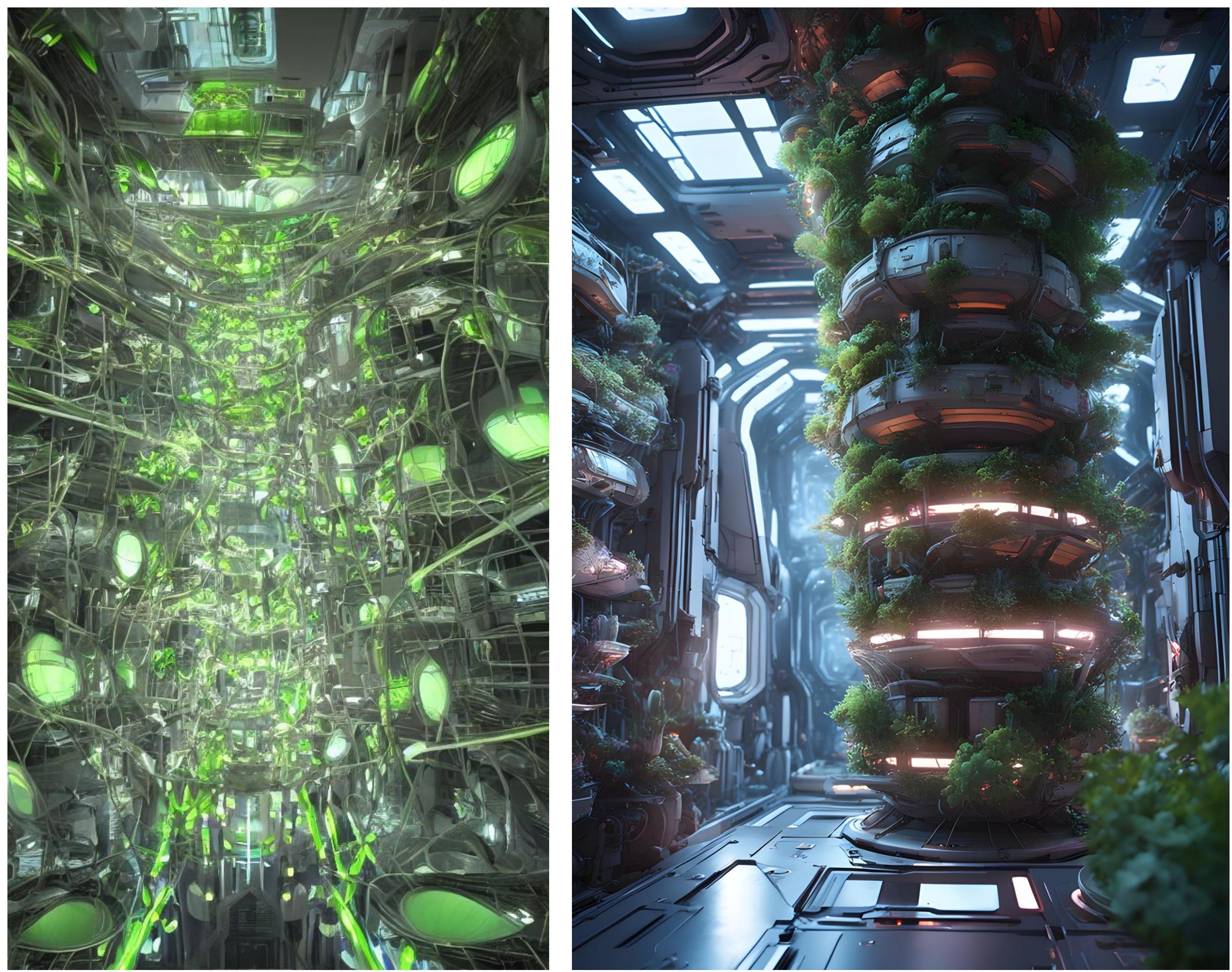
The SAGE System

Taylor Inman, Electronics, EECE 2024, inmant@wwu.edu



MAKE WAVES.

Concept Art (AI Generated)



Methods and Materials

To establish a base system to expand upon, four sensors were chosen for simplicity and efficacy, shown in the table below. These four elements, in addition to soil quality itself, are most important to establishing a baseline growing environment. Once this was met, additional factors can be added in.

Manufacturing and assembly was **not** prioritized due to project and time constraints, but the interior chamber is as “sealed” as it can be using various means. As the mechanical aspect was not a requirement for the project, sacrifices were made to ensure the electrical functionality and requirements were met.

Hardware

Microcontroller: K32L2B3A1
48Mhz Arm Cortex-M0+

Sensors: Soil Moisture, Soil Temp, Air Temp, Relative Humidity.

Lights: (2) Samsung Horticulture LED Gen2

Irrigation: On/Off Drip-Line w/ Tank & LED Indicator

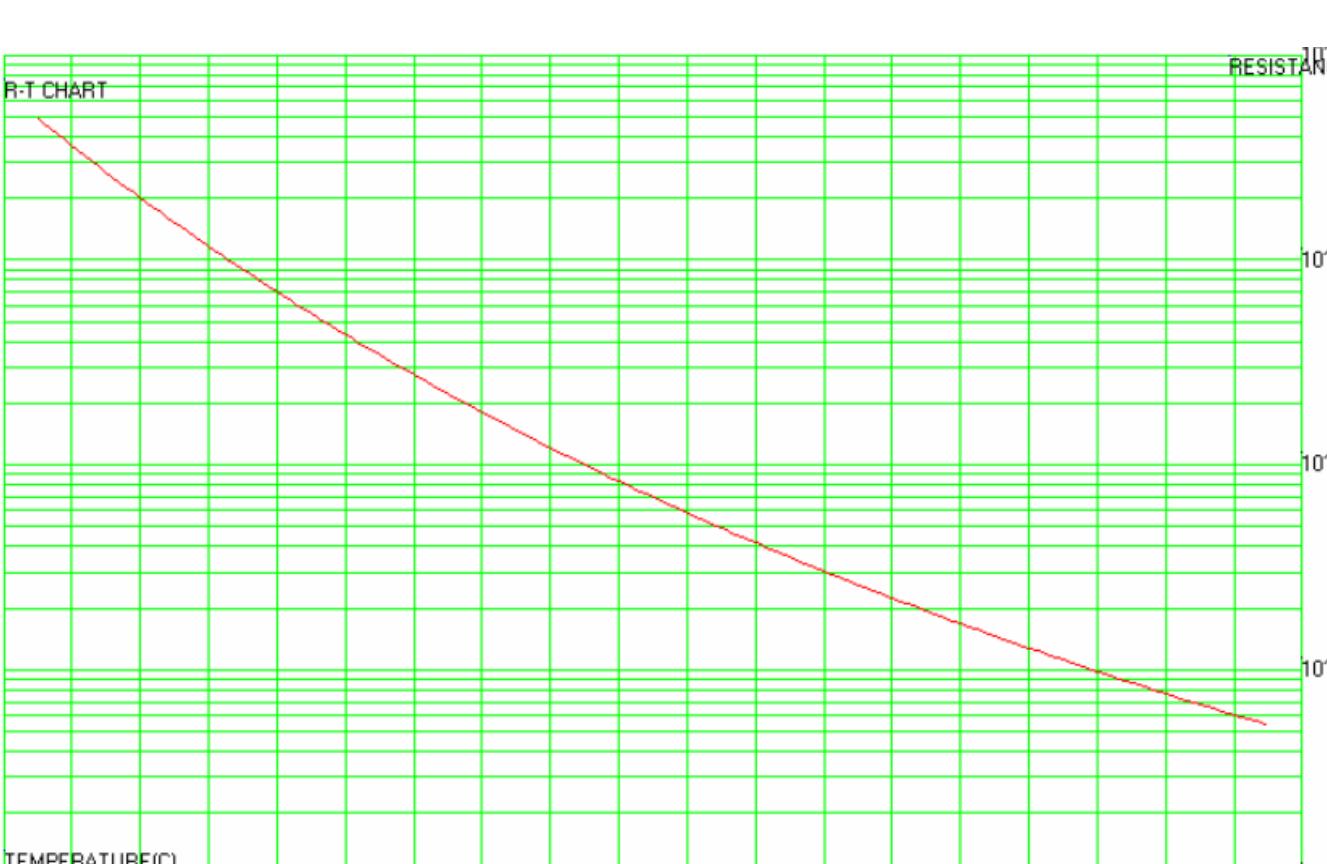
Software

Programming IDE: MCUXpresso for C/C++

Operating System: FreeRTOS

Debugger: J-Link Segger w/ MCUXpresso

Power Supplies:



Epoxy PVC Thermistor Properties

Creation & Assembly

Total 3D Printing Time: ~630 Hours

of Pieces: ~88 Structural, 32 Floor, 16 Ceiling

Approximate Weight: 16kg; ~35lbs + Electronics

5V & 3.3V AC/DC for MCU & peripherals, 72V AC/DC LED Driver.

Item	Unit	Rating		
		min	typ	max
Luminous Flux (Φ_v)	lm	8150	8960	-
Luminous Efficacy	lm/W	-	178	-
Color Rendering Index (Ra)	-	80	-	-
Operating Current (I _o)	mA	-	1200	1600
Operating Voltage (V _i)	Vdc	39.5	42.0	45.0
Power Consumption	W	47.4	50.4	54.0
PPF	umol/s	149.866	-	-
PPE	umol/J	2.975	-	-



Testing Photo of 1 LED Module

Project Abstract

Food security has become a concern for many people and collectives; As dense population centers continue to grow, and as natural resources become increasingly strained, alternative and progressive solutions for food production must be researched and established.

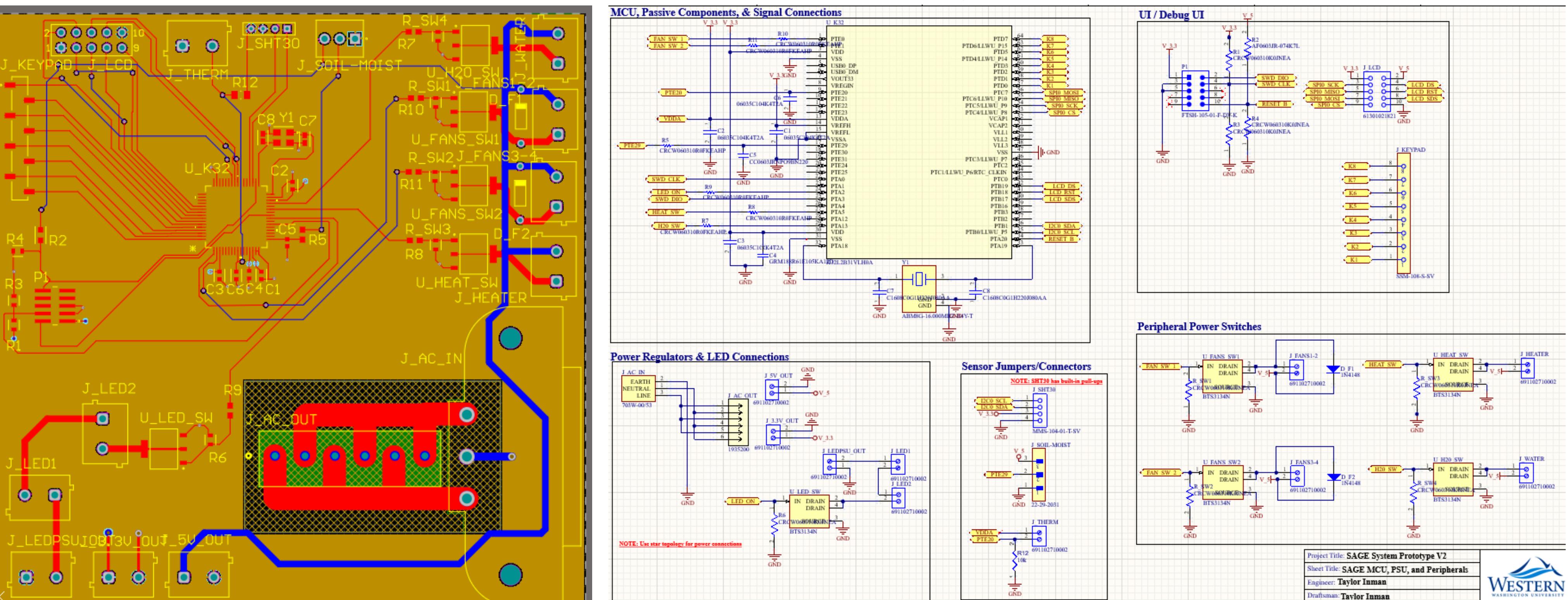
This project sought to leverage the rapid prototyping capabilities of Additive Manufacturing and CAD alongside the electrical design & verification process of the Capstone courses to produce a proof-of-concept device that allows the user to control and regulate the internal characteristics of a “sealed” chamber, housing a plant or inoculated substrate, to produce vegetables & other edible or medicinal flora or fungi without the need of an outdoor garden or greenhouse setup.

While the immediate demographic for this project is those in apartments, office spaces, dormitories, retirement homes, or dense urban areas, a consequence of the design & manufacturing process is that this concept is almost immediately scalable to industrial, agricultural, and extraterrestrial purposes – such as vegetable production shuttles for interplanetary colonization efforts.

Results & Conclusions

The system functions as intended with few, but some glitches. Particularly, the user interface is not as polished as would be ideal, in terms of both size and function. The most significant glitch involves a value error in the keypad module, resulting in the third column not registering and requiring reprogramming at random. This will definitely be fixed in future iterations.

The microcontroller handles all user input & output as well as the switching on and off of all peripherals. Additionally, it will save the user configuration upon power loss thanks to onboard FLASH memory. Overall, the initial proof of concept can be considered a success, with much polishing to be done for versions 2 & onward.



References

- Carolyn E. Moore, Kathleen E. Davis & Wanyi Wang (2021) Low Food Security Present on College Campuses despite High Nutrition Literacy, Journal of Hunger & Environmental Nutrition, 16:5, 611-627, DOI: 10.1080/19320248.2020.1790460
Household Food Security in the United States in 2021. (n.d.). <https://www.ers.usda.gov/publications/pub-details/?pubid=104655>
Kalaizoglou, P., van Ieperen, W., Harbinson, J., & van der Meer, M. (2019, February 28). Effects of continuous or end-of-day far-red light on tomato plant growth, morphology, light absorption, and fruit production. Frontiers. <https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2019.00322/full>

Future Development

- Redesign PCB for additional sensors: O₂, CO₂ gas; Nitrogen, Phosphorus, Potassium (NPK) Nutrient PPM; Soil/Water PH.
- Acquire larger 3D Printer and redesign CAD files to reduce build time & increase strength.
- Research & acquire higher-durability filament for manufacturing; Tungsten PETG is one potential candidate, but significantly more expensive.
- Research patenting system design and begin market research for product viability and potential customers.

Acknowledgements

Professors Todd Morton & John Lund for their assistance, coaching, and patience during this righteous 1-year marathon, as well as the rest of the EECE faculty for their support & understanding along the way.

The Student Technology Center & all its wonderful student employees for access to the 3D printers and various prototyping tools needed for this project's completion.

My parents, brother, and roommate, for their never-ending patience and support while I buried myself to the ears in extra work for a cool final project.