Smart Medical Pill Dispenser
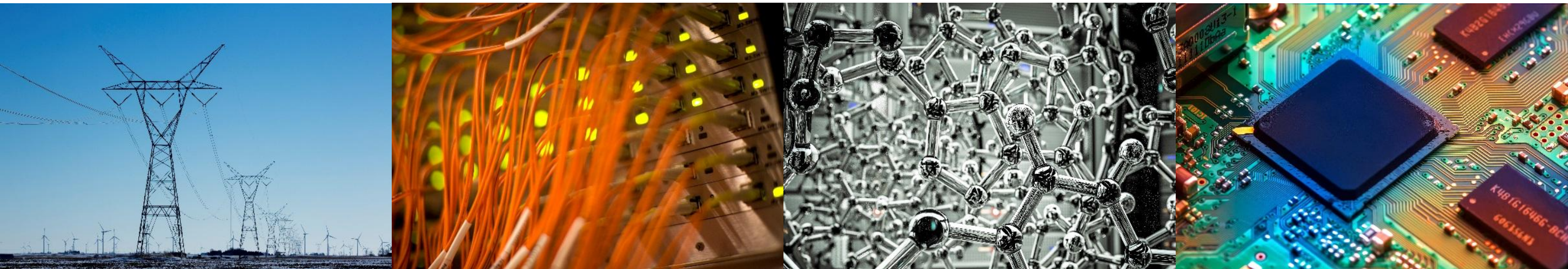
ECE 445: Team 40

Aditya Perswal, Aryan Gosaliya, Aryan Moon

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Electrical & Computer Engineering

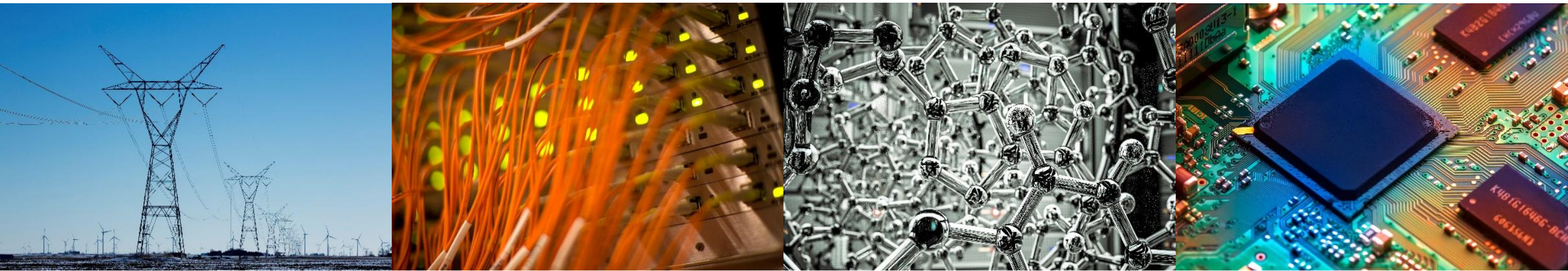GRAINGER COLLEGE OF ENGINEERING

01 Introduction

The Smart Medical Pill Dispenser

A single device to house all your medication

- Refill your medication on time
- Take your medication on time
- Dispense your medication accurately
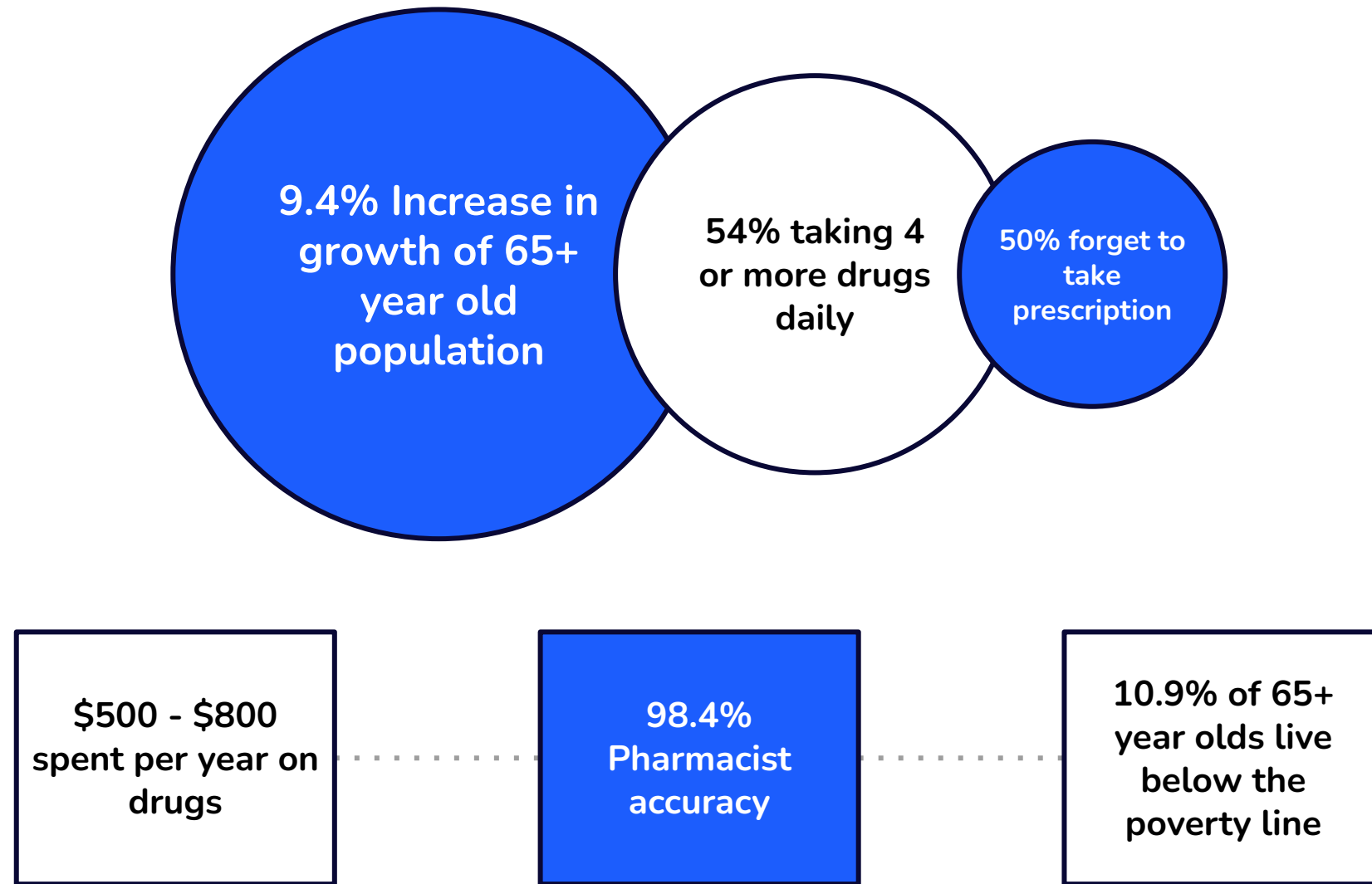- Interact with your medication seamlessly

02 Objective

Rising drug costs & elderly population

9.4% Increase in growth of 65+ year old population

54% taking 4 or more drugs daily

50% forget to take prescription

$500 - $800 spent per year on drugs

98.4% Pharmacist accuracy

10.9% of 65+ year olds live below the poverty line

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Making a Market Beating Dispenser

Work 4 hours without power
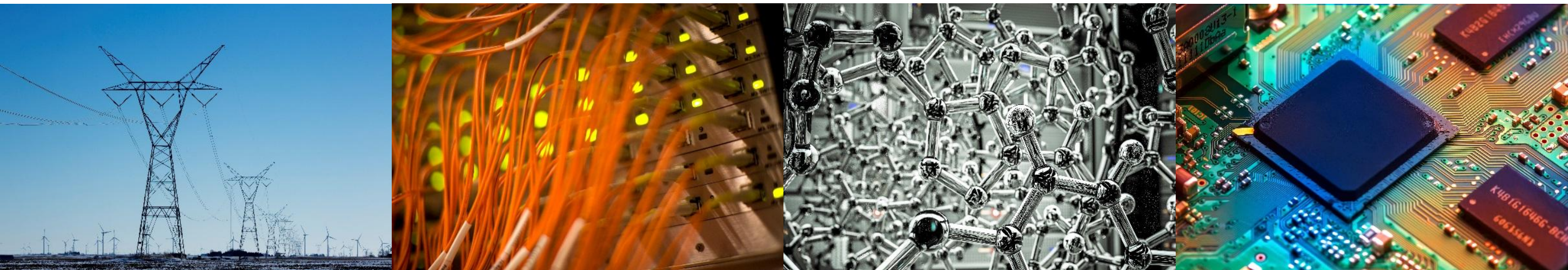
Work without WiFi

Work at a cost of $250 & $5/month

High Level Requirements

98.4% Pill Dispensing Accuracy

The SMPD alerts the user within 5 seconds

Refill alerts are sent out when left with 10%
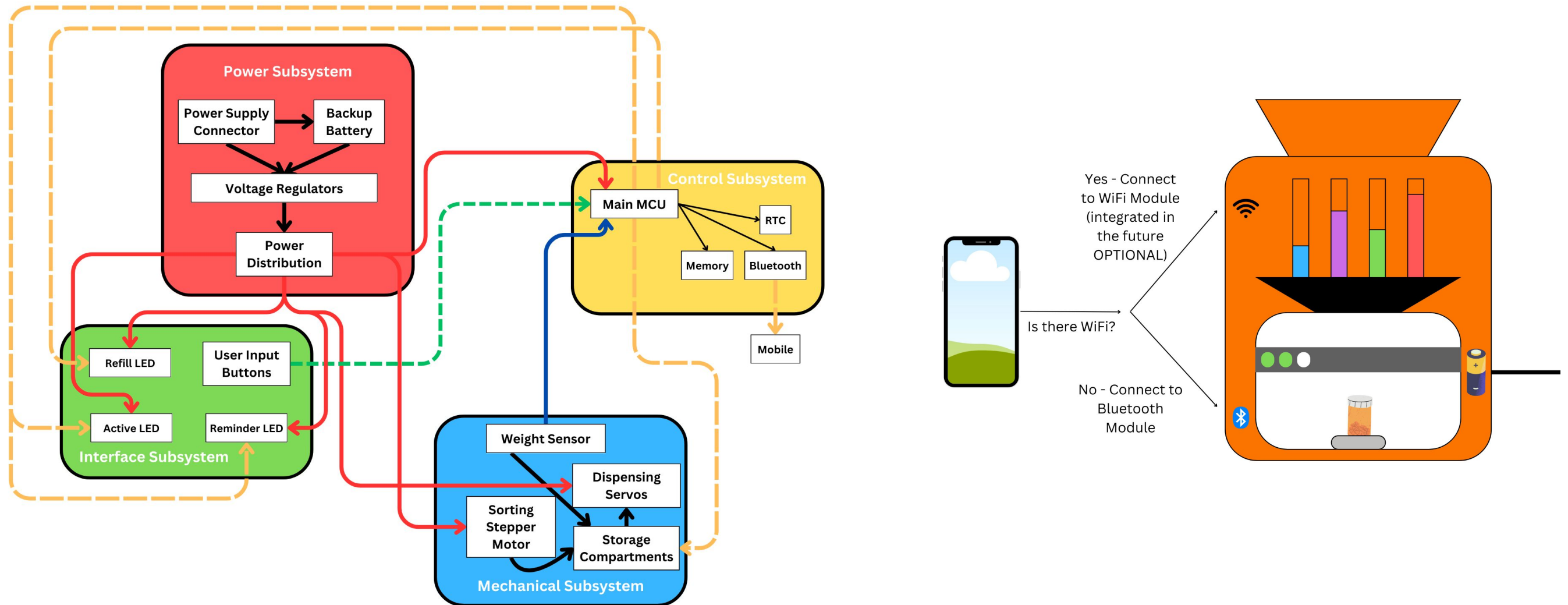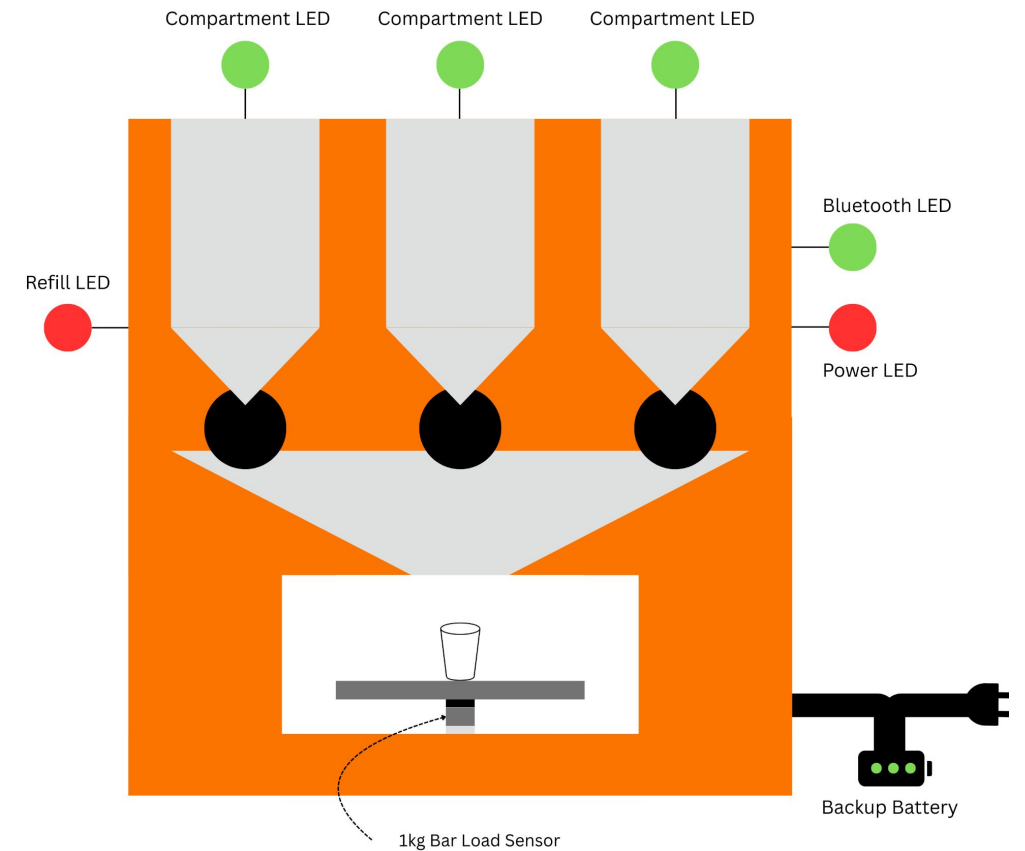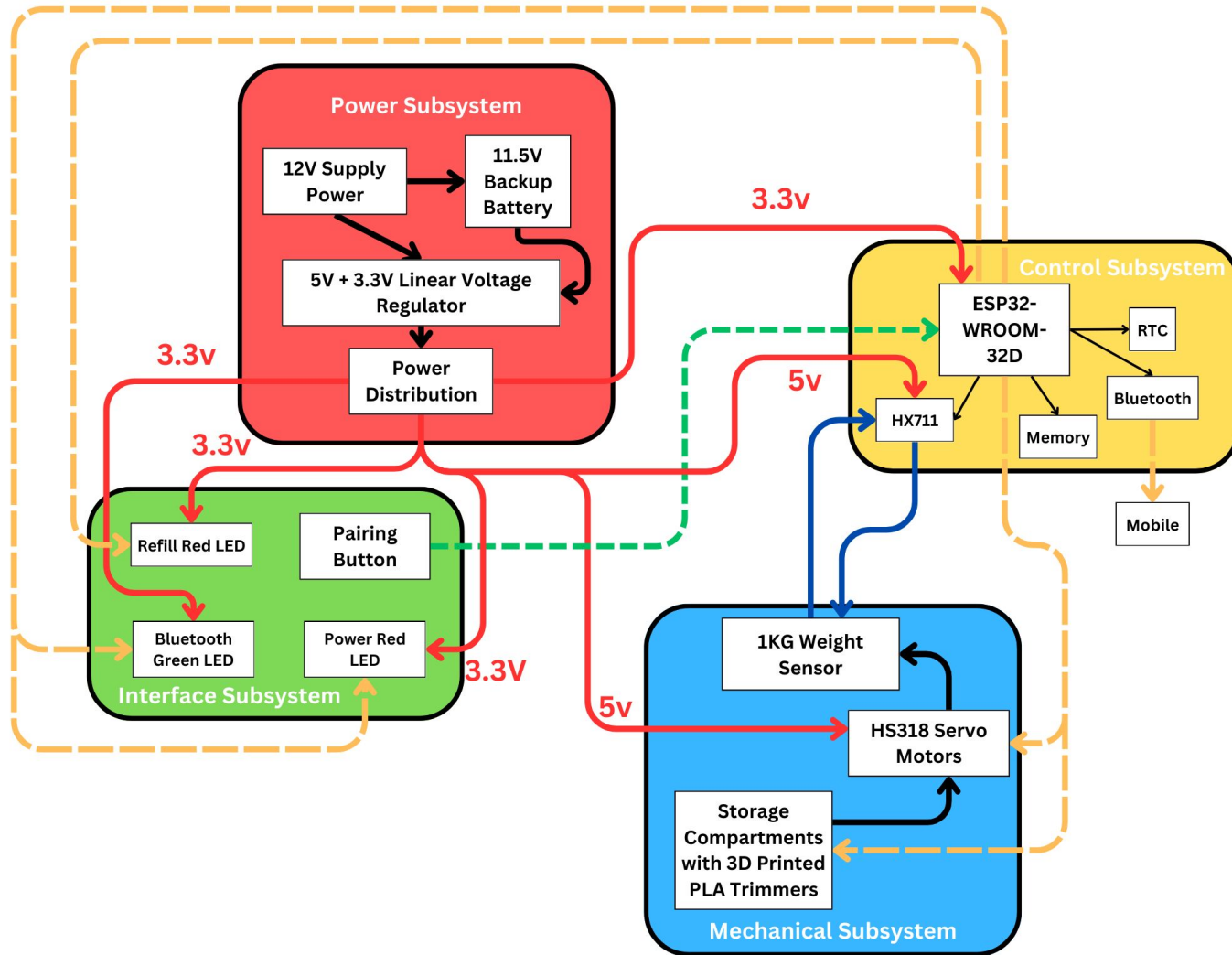
03 Brief Overview

Original Block Diagram and Design

Power Subsystem
- Power Supply Connector
- Backup Battery
- Voltage Regulators
- Power Distribution

Control Subsystem
- Main MCU
- RTC
- Memory
- Bluetooth
- Mobile

Interface Subsystem
- Refill LED
- User Input Buttons
- Active LED
- Reminder LED

Mechanical Subsystem
- Weight Sensor
- Dispensing Servos
- Sorting Stepper Motor
- Storage Compartments

Is there WiFi?

Yes - Connect to WiFi Module (integrated in the future OPTIONAL)

No - Connect to Bluetooth Module

Final Block Diagram and Design

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04 Project Build

Power Subsystem from 12V to 5V to 3.3V
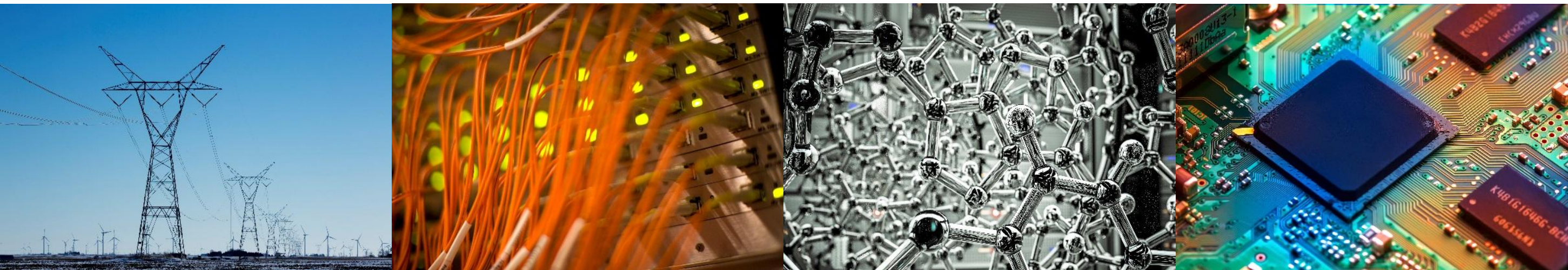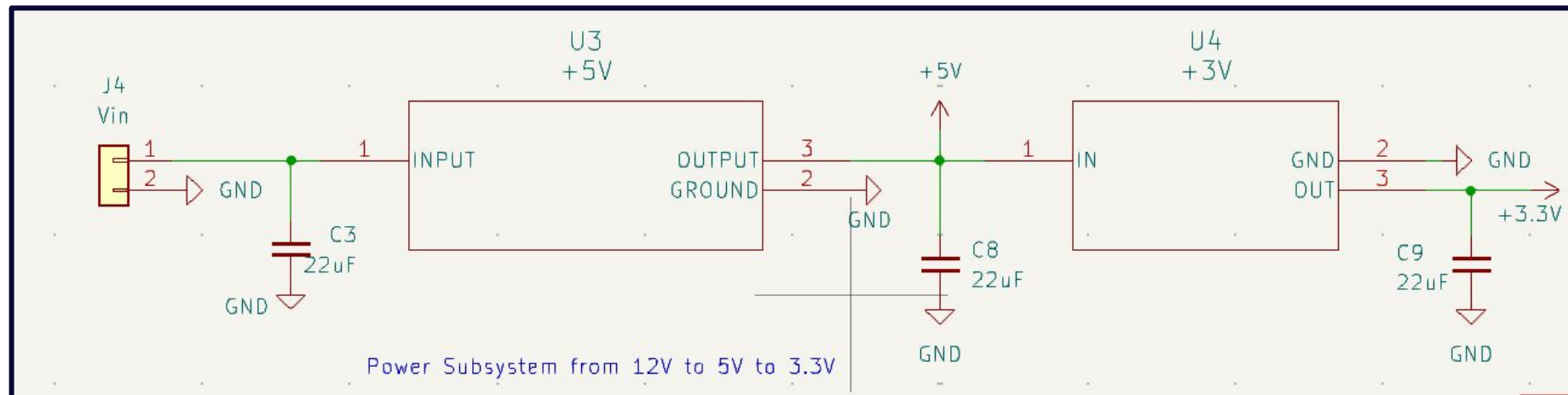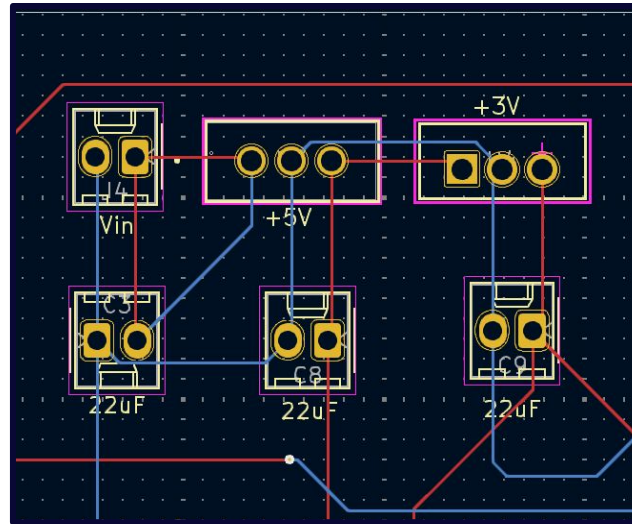
Power Subsystem

Requirement & Verification

Power

Current Load (10 trials)	Voltage Read (5V | 3.3V)
100 mA	5.05 | 3.305
350 mA	5.05 | 3.305
510 mA	5.01 | 3.3
910 mA	4.98 | 3.28

Subsystem supplies 5V and 3.3V within +/- 6% under 100 mA load

Current Load (10 trials)	Transition Time
100 mA	Instant
350 mA	Instant
510 mA	Instant
910 mA	Instant

Transition from external to battery power takes 5 seconds

Current Load (3 trials)	Backup Battery Time
100 mA	6+ Hours
350 mA	6+ Hours
510 mA	~ 6 Hours
910 mA	~ 3 Hours

The backup battery provides 4 hours of continuous power

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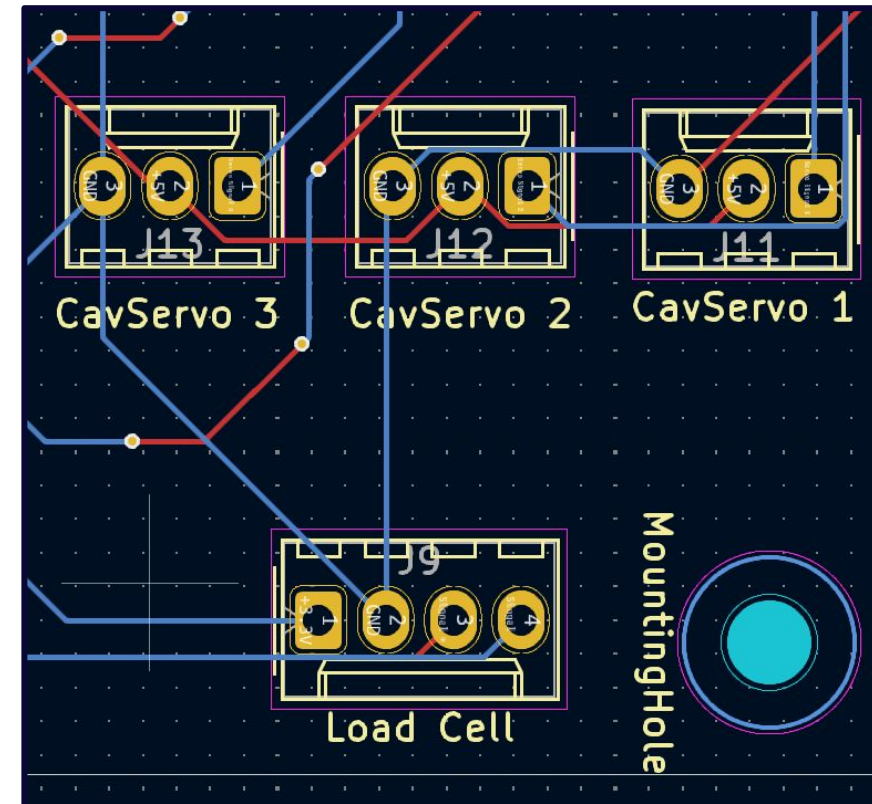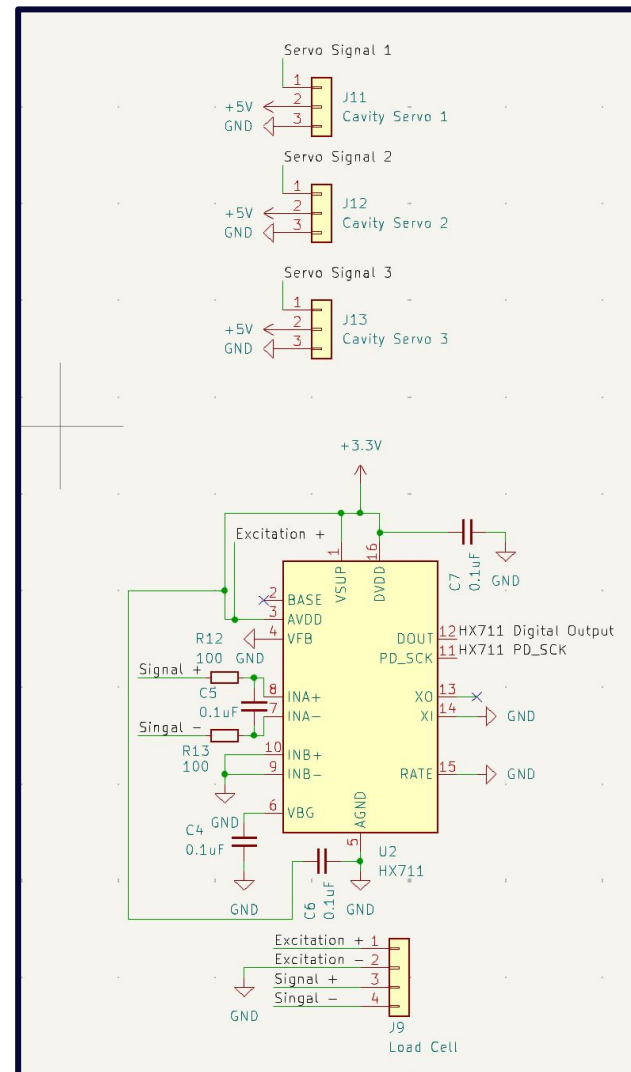
Mechanical Subsystem

Requirement & Verification

Mechanical

Comp Combos (10 Trials)	Accuracy
1 | 2 | 3	98.89%
1 | 2	98%
1 | 3	97%
2 | 3	100%
Total	98.47%

Dispense pills within 98.4% accuracy

Actual Weight (10 Trials)	Measured Weight
25 g	25.3 g
50 g	49.8 g
100 g	100.2 g
150 g	150.1 g
Total	0.2 g diff.

The load sensor weighs pills within 0.5g of actual weight

Target angle (10 Trials)	Measured angle
45.0	45.8
90.0	91.6
135.0	137.1
180.0	179.2
Total	1.39%

Servo motors position their angles within 2%
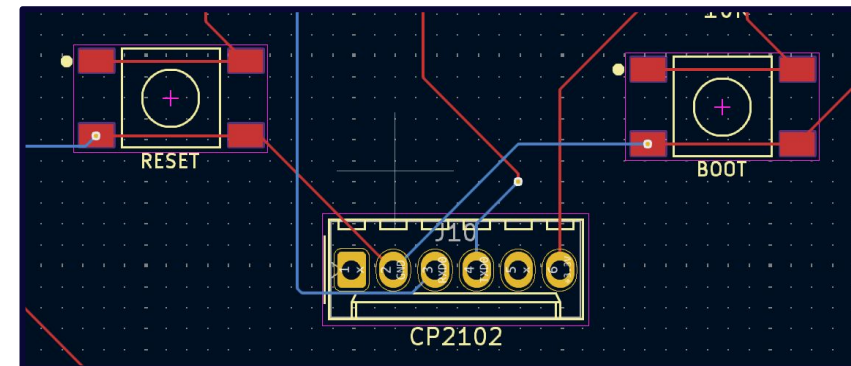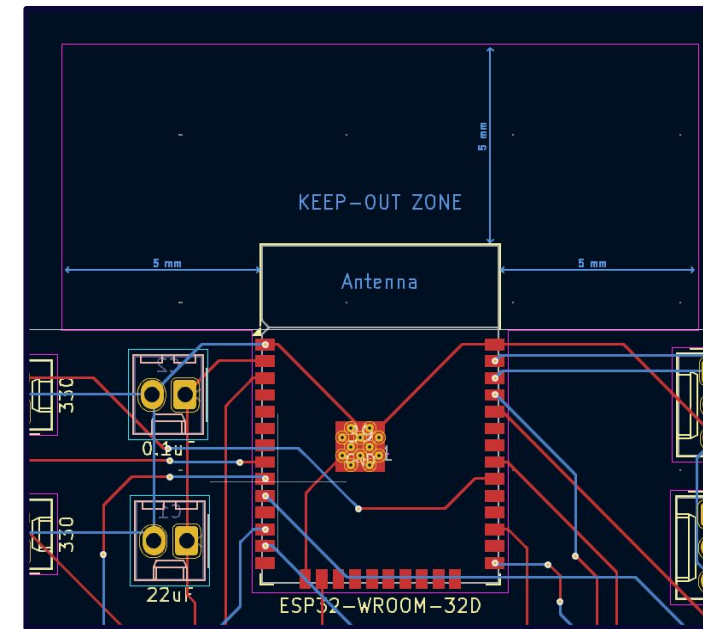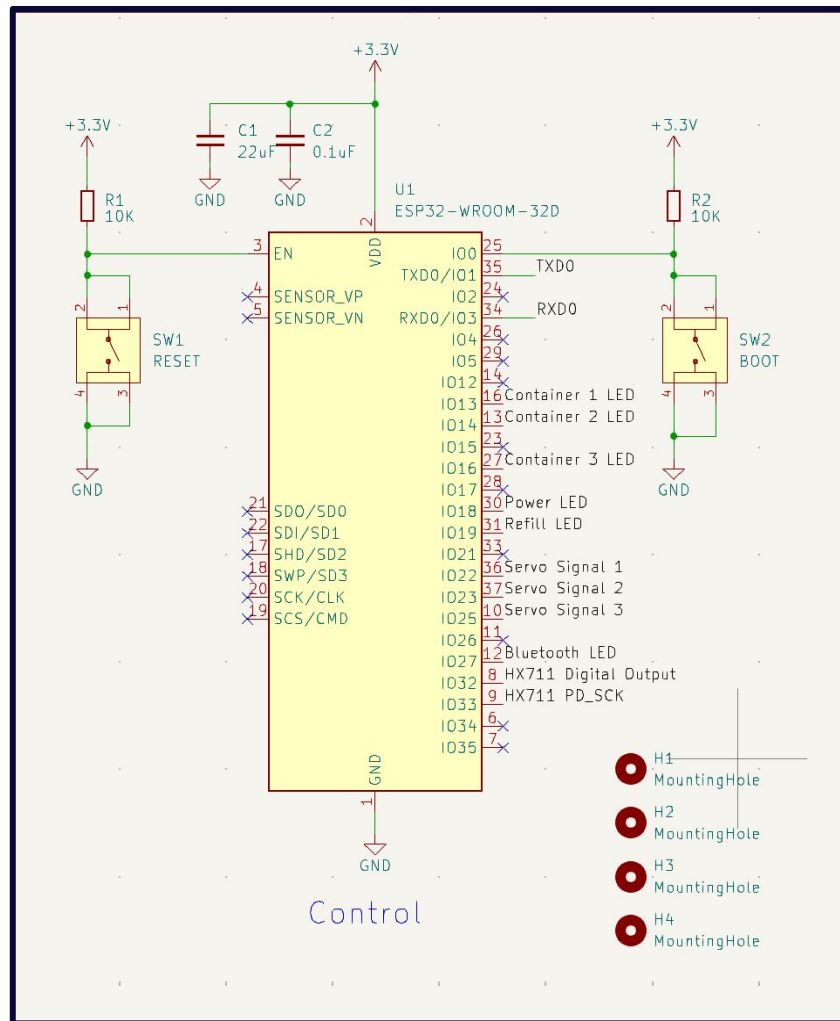
Control Subsystem

Requirement & Verification

Control

Time (5 Days)	Time to Dispense
9:00 AM	1.92 Seconds
1:00 PM	1.54 Seconds
5:00 PM	1.29 Seconds
10:00 PM	2.17 Seconds

Initiates dispensing event within 5 seconds of pressing "dispense"

Time (5 Days)	Accuracy
9:00 AM	Instant
1:00 PM	Instant
5:00 PM	Instant
10:00 PM	Instant

ESP32's RTC maintains time accuracy within +/- 1 minute / month

Events (10 Trials Each)	Command Execution
Fill	100%
Schedule	100%
Dispense	100%
Refill	100%

100% command execution between control and other subsystems
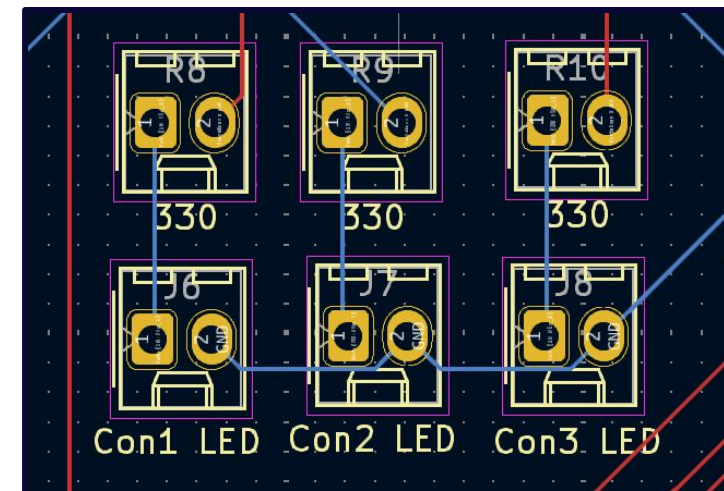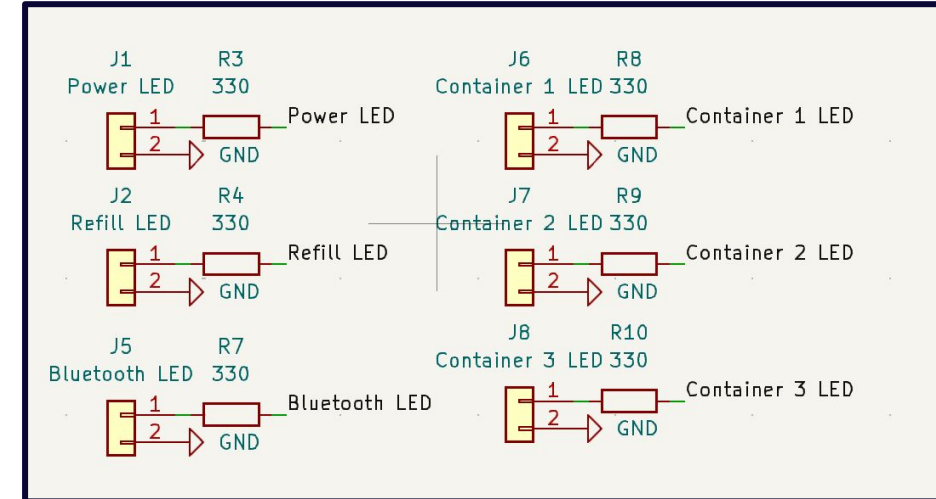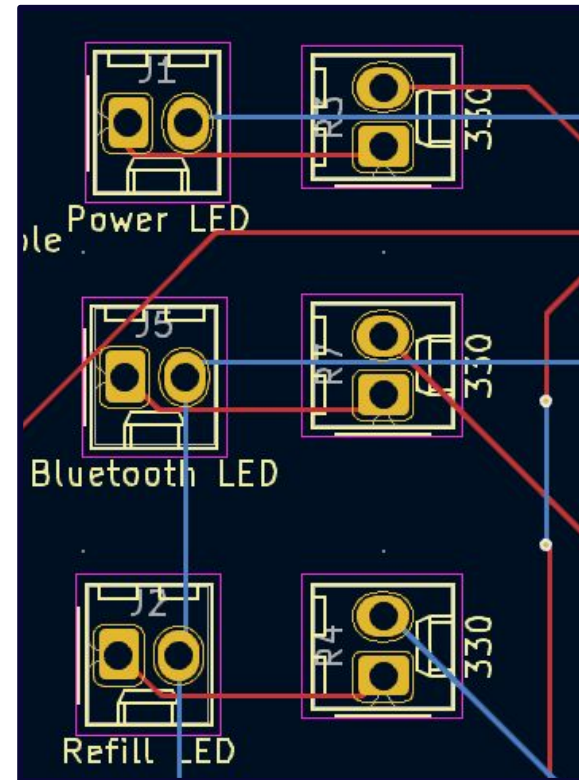
Interface Subsystem

Requirement & Verification

Interface

Time (5 Days)	Results
9:00 AM	1.41 seconds
1:00 PM	2.35 seconds
5:00 PM	1.74 seconds
10:00 PM	2.02 seconds

Interface alerts user within 5 seconds of scheduled time

Trials	Results
1	43 ms
2	27 ms
3	32 ms
4	29 ms

Bluetooth button registers press reliably with debounce time of 50 ms

Conditions	Results
Night	5 meters
Daylight	5 meters
Unlit Room	5 meters
Lit Room	5 meters

LEDs clearly lit and useable under varying lighting conditions

05 Successes & Challenges
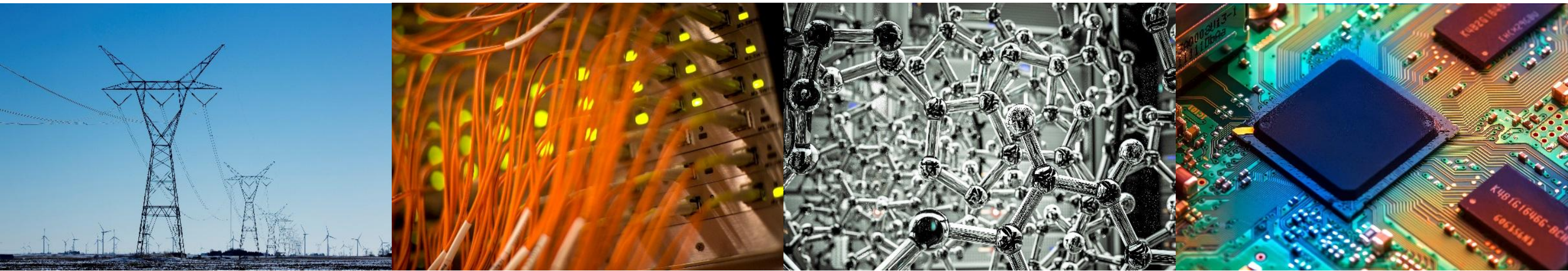
Successes

Interface Subsystem	Programming the ESP32	Keeping Fixed Costs Low
3 Weeks Development Time	95% Adherence to Server Commands	$250 + $5/month
1 Week Development Time	100% Adherence to Server Commands	$190 Fixed Cost

Challenges

PCB's Power Subsystem

Our power subsystem repeatedly burnt out our voltage regulators. We tried multiple solutions:

1. Power only PCB
2. Heat sink
3. Supplying 5V and 3.3V directly
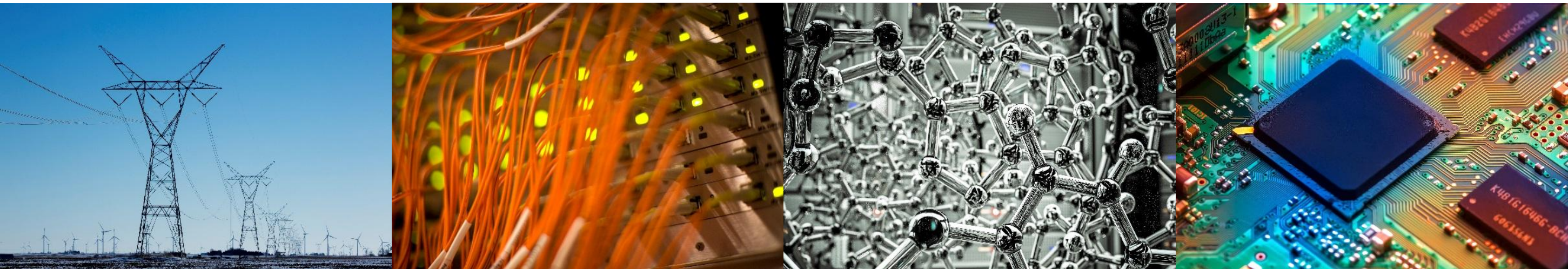4. Changing trace widths

Dispensing Accuracy

Dispensing accuracy required multiple changes to our dispenser. The following all were redesigns to increase accuracy.

1. Thinner and Long Oval Pills
2. 3D Printed compartment trimmers
3. Adjusted Servo Motor Angles
4. 3.3V Vibration Motors

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06 Conclusion

Learnings and Redesign Choices
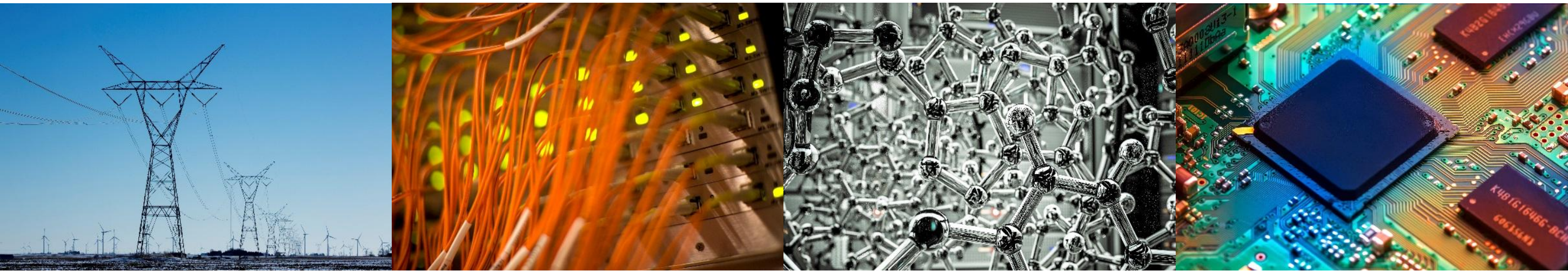
Trace widths need to be carefully calculated	Mechanical design should be given far more thought	Value subsystems based on user needs	Placement of capacitors on PCB matters
↓	↓	↓	↓
Calculate trace widths using online calculators and part specs earlier	Spend more time with machine shop finding a suitable design	Buy a larger battery but less powerful microcontroller chip	Set test points on the PCB & order with Conn. pins first for fast testing

07 Looking to The Future

Upgrades we plan to implement

Additional Compartments

Changing Cavity Sizes

Longer Lasting Battery

Auto Filling Funnel
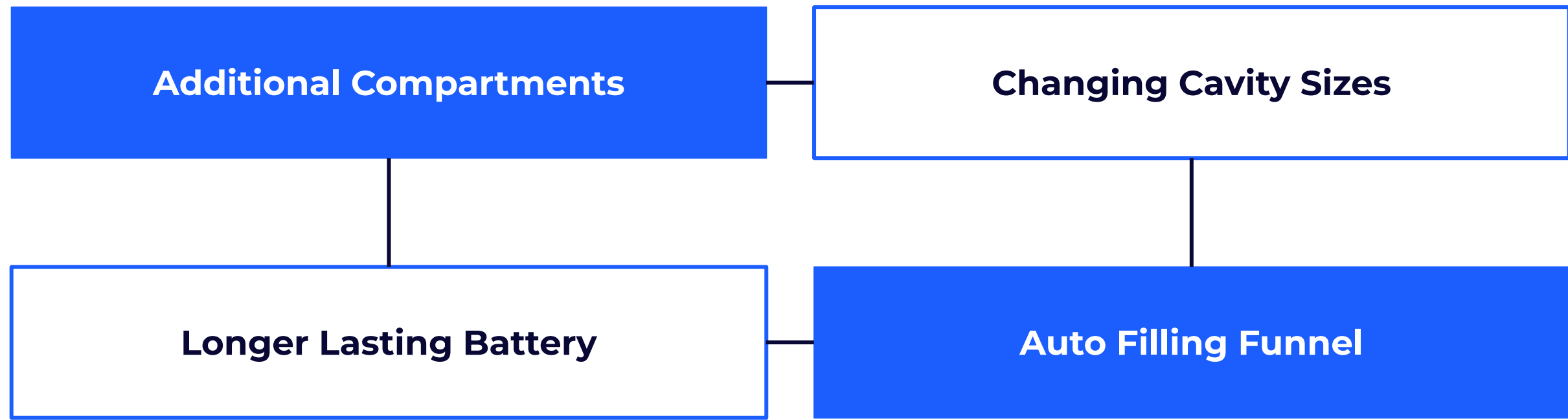
Ethical Consideration: Currently logs can be read by anyone that pairs with the device, giving access to unauthorized users to changing a user's medication schedules or monitor their prescriptions

Working with core demographics for testing

Senior Living Associations

- 30,600 communities in USA
- 5.86% CAGR until 2030
- 90% of residents take medication

Personal Homes

- 57.8 Million 65+ year olds in USA
- Hero's Dispenser costs $540/year
- 88.6% of elderly take medication

Hospitals

- 26% of hospitals have a pharmacy
- 18% of patients are 65+ year olds
- 34% of prescriptions given to elderly

Private Practices

- Pediatrician group's 7.6% CAGR
- At home nurse's 8.4% CAGR (2031)

Demonstrated User Interest

Dear Aditya, Aryan, and Aryan,

I am writing on behalf of WithAarya NGO, an organization founded in 2016 that focuses on healthcare, nutrition, and support for underprivileged patients and their caregivers in Mumbai, India.

Our mission is to create "waves of kindness that encompass the underprivileged and make them feel safe and cared for," particularly in healthcare settings.

I recently learned about your Smart Medical Pill Dispenser project through our partnership network with educational institutions. Your innovation has captured our attention as it directly aligns with our mission to support caregivers and patients managing complex medication regimens.

Our organization currently provides support to caregivers of patients with various illnesses, many of whom struggle with the management of multiple medications. Through our various initiatives, we have been serving these communities since a very long time, one of our key initiatives is "Dava Daan" where we provide medicines and we've observed firsthand the challenges they face:

* Many caregivers struggle to maintain medication schedules while balancing hospital visits
* Approximately 65% of our beneficiaries report medication non-adherence due to confusion or forgetfulness
* The cost of existing medication management systems is prohibitive for most of the families we serve
* Long hospital stays often mean caregivers must manage medications with limited resources

Your affordable solution with its automated reminders, accurate dispensing, and backup power system addresses these challenges perfectly.

The price point of $150-200 makes it significantly more accessible than commercial alternatives, which is crucial for our community.

We would be very interested in:
1. Learning more about your device through a virtual demonstration
2. Exploring a potential pilot program with 15-20 of our caregiving beneficiaries
3. Discussing adaptations that might be needed for implementation in the Indian context
4. Collaborating on potential funding opportunities to support distribution to our communities

Could we schedule a video call in the next two weeks to discuss this potential collaboration? We believe your project has tremendous potential to support our mission of creating "waves of kindness that encompass the underprivileged and make them feel safe and cared for."

Best regards,
Forem Lapsiwala
Chief Operations Officer
9833879040

Interest in the Smart Medical Pill Dispenser ∑ Inbox ×

deepa soman <somandeepa34@gmail.com>
7:50 PM (1 hour ago)
to me, Deepa, deepa

Dear Aryan Moon,
I hope this message finds you well.
Following our recent conversation, I wanted to express my strong interest in the Smart Medical Pill Dispenser. I am thoroughly impressed with the device's design and functionality. It offers a streamlined and secure approach to medication management, ensuring that pills are properly organized and easily accessible — a feature that would greatly benefit many clinical environments.
I have worked in acute care hospital settings and I believe this device could be a valuable addition to their practices, and I would be glad to recommend it to them for consideration.
Thank you again for sharing this innovation with me. I look forward to staying in touch and supporting efforts to bring it into the appropriate medical settings.
Best regards,
Deepa Soman BSN , RN-BC
Utilization Review Rn
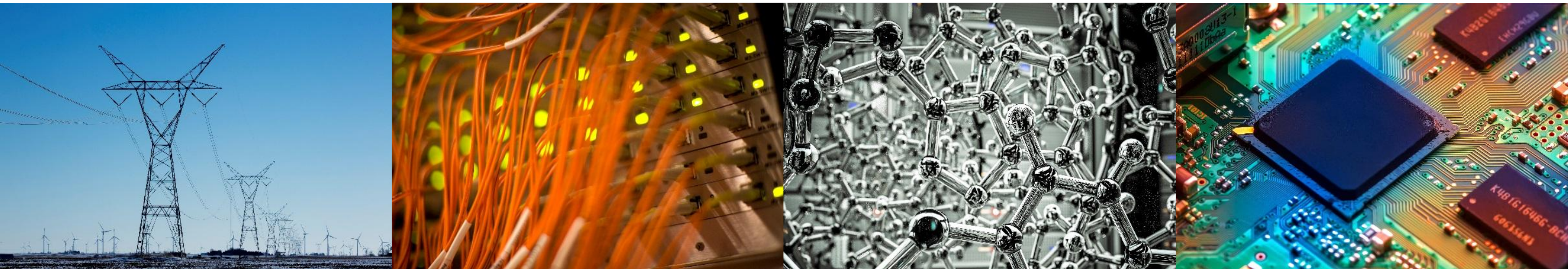Overlook medical Center
99 Beauvoir Ave
Summit
Nj - 07901
Ph-908 -522- 2000

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Thank You!

A special thanks to Professor Zhao, Jiankun Yang, Sainath Barbhai, and the rest of the ECE 445 Team
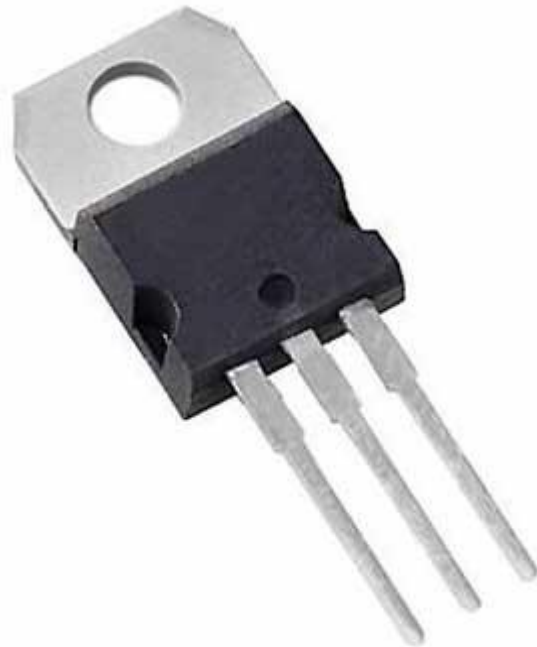
08 Appendix

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Electrical & Computer Engineering

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5.0V Linear Regulator
LM7805ACT

3.3V Linear Regulator LP2950CZ

TalentCell Rechargeable 12V DC
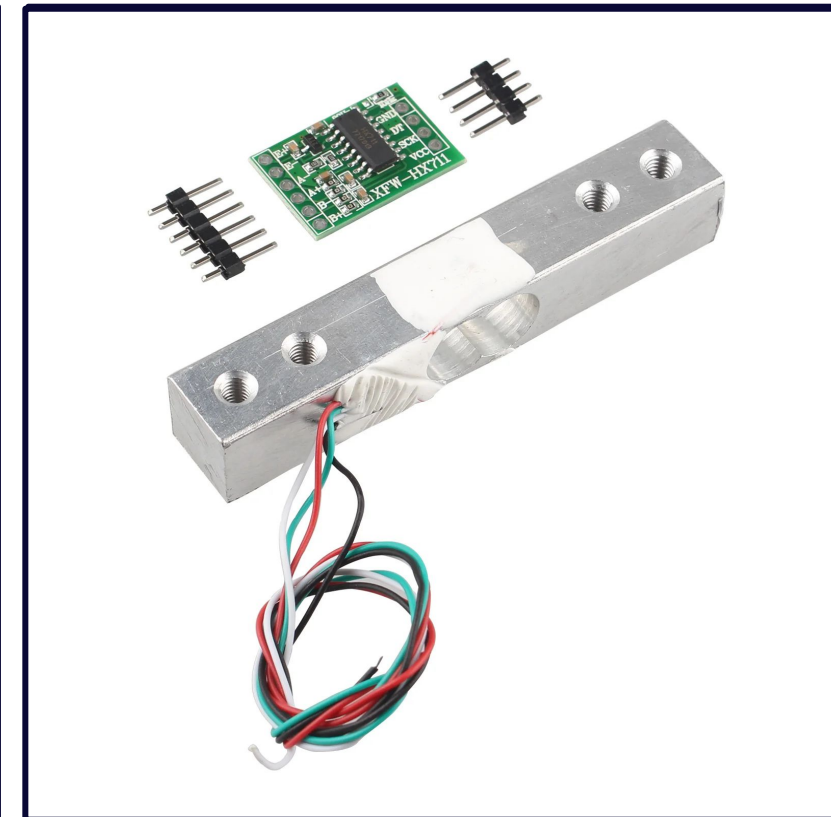Output Lithium ion Battery Pack

Power Subsystem
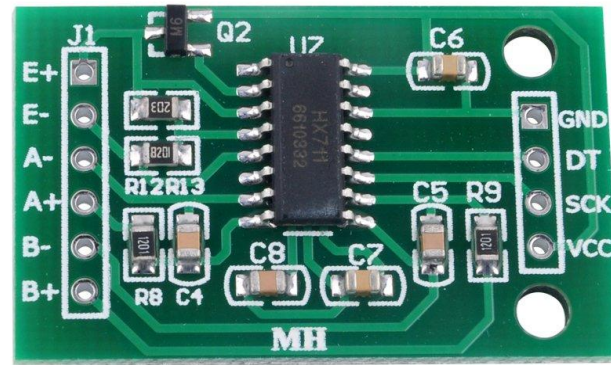
Servo Motor HS-318

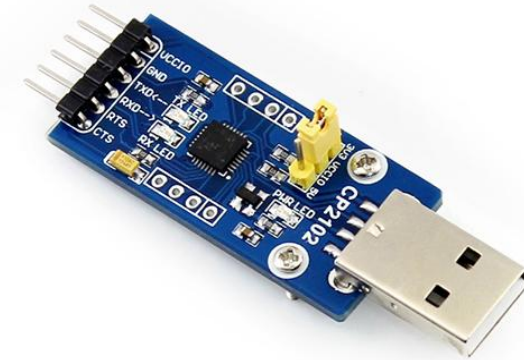3D Print PLA Filament

1kg Load Sensor
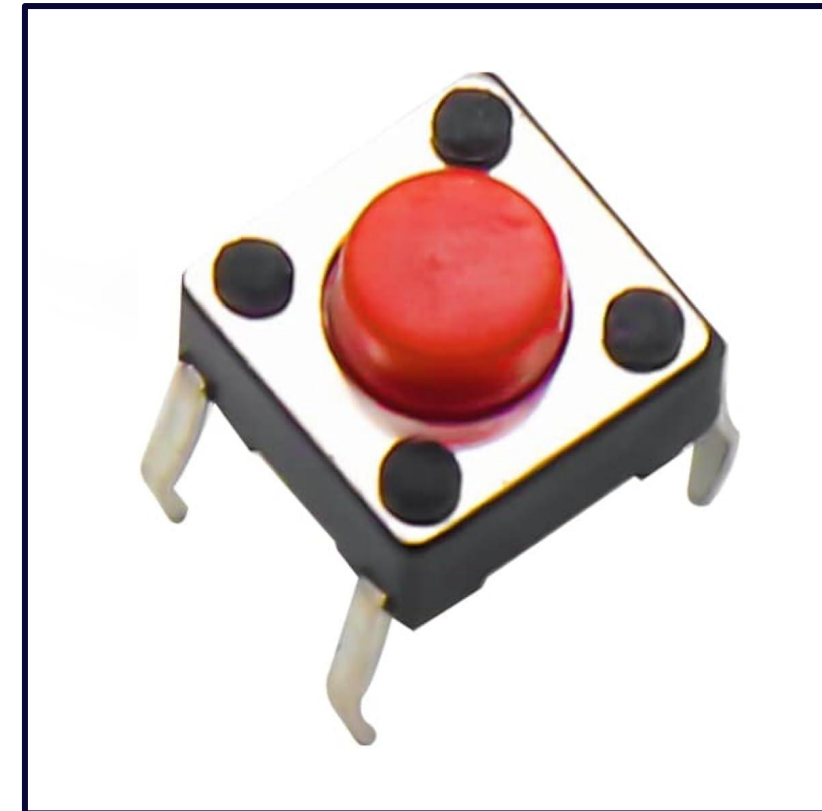
Mechanical Subsystem

ESP32-WROOM-32D

HX711

CP2102

Control Subsystem

Red LED

Green LED

Push Button

Interface Subsystem

Successes

Interface Subsystem

Setting up LEDs, coding the Electron app, converting it to a functional Android APK, and have an intuitive UI/UX was far easier to build than anticipated.

Programming the ESP32

It took us quite a bit of time to understand how to code with Arduino IDE. However, we were able to pick it up and build a bluetooth server that followed commands with 100% adherence to the Electron app.

Keeping Fixed Costs Low

We were initially expecting the cost of our design to reach around $250 and need $5/month for server upkeep. However, after designing the whole device we realized parts costs came to be around $190 and we didn't need a server at all since everything ran locally. This helped us make the product far more affordable for the user.

Upgrades we plan to implement

Additional Compartments

Currently we only support 3 medications in our design, however, there is a lot of space that is largely not used. This space can be instead used to house more medication.

Changing Cavity Sizes

Our pill dispenser requires each pill to be given it's own compartment, however, it would be better for us to have any pill go into any compartment

Longer Lasting Battery

Power outages can easily last 24 hours and a larger battery with a cooling system to ensure it doesn't melt pills would help.

Auto Filling Funnel

Right now we tell the user which compartment to fill using LEDs, but with one input funnel, the user experience would require fewer steps.

Ethical Consideration: Currently logs can be read by anyone that pairs with the device, giving access to unauthorized users to changing a user's medication schedules or monitor their prescriptions

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