TCNJ
THE COLLEGE OF
NEW JERSEY

Parking Lot Availability System using a Campus-Wide Wireless Network

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ENGINEERS

Matthew Cook
Computer Engineer

Detection

Nikita Eisenhauer
Electrical Engineer

Power System

Stephanie Fournier
Electrical Engineer

Enclosure & Assembly

Warren Seto
Computer Engineer

Base Station & Server

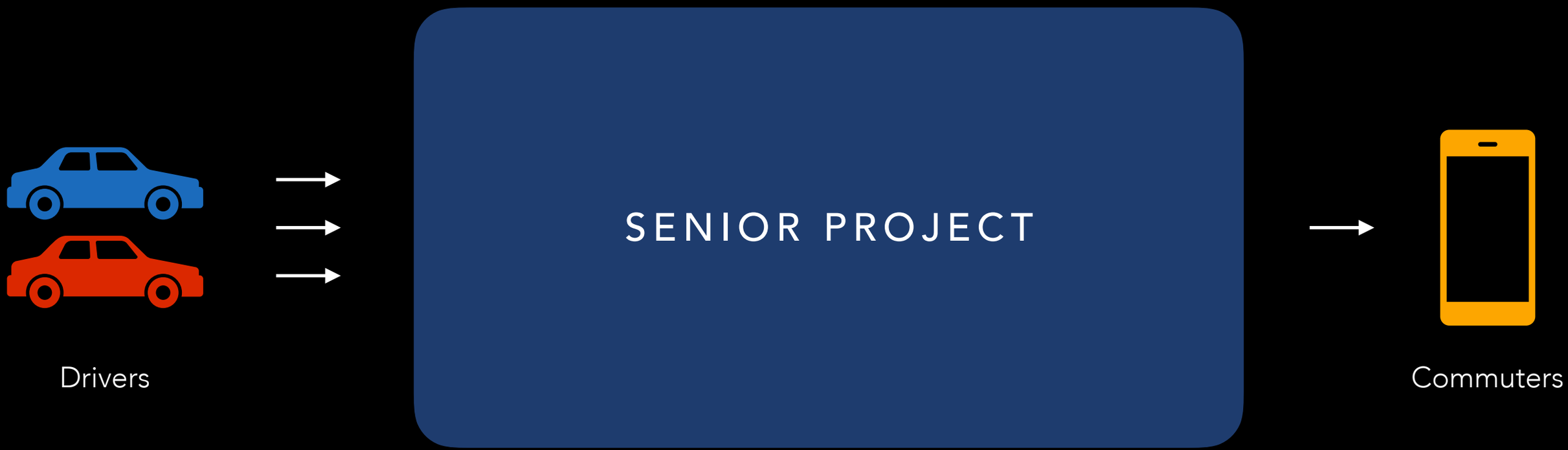
PROBLEM

PROBLEM

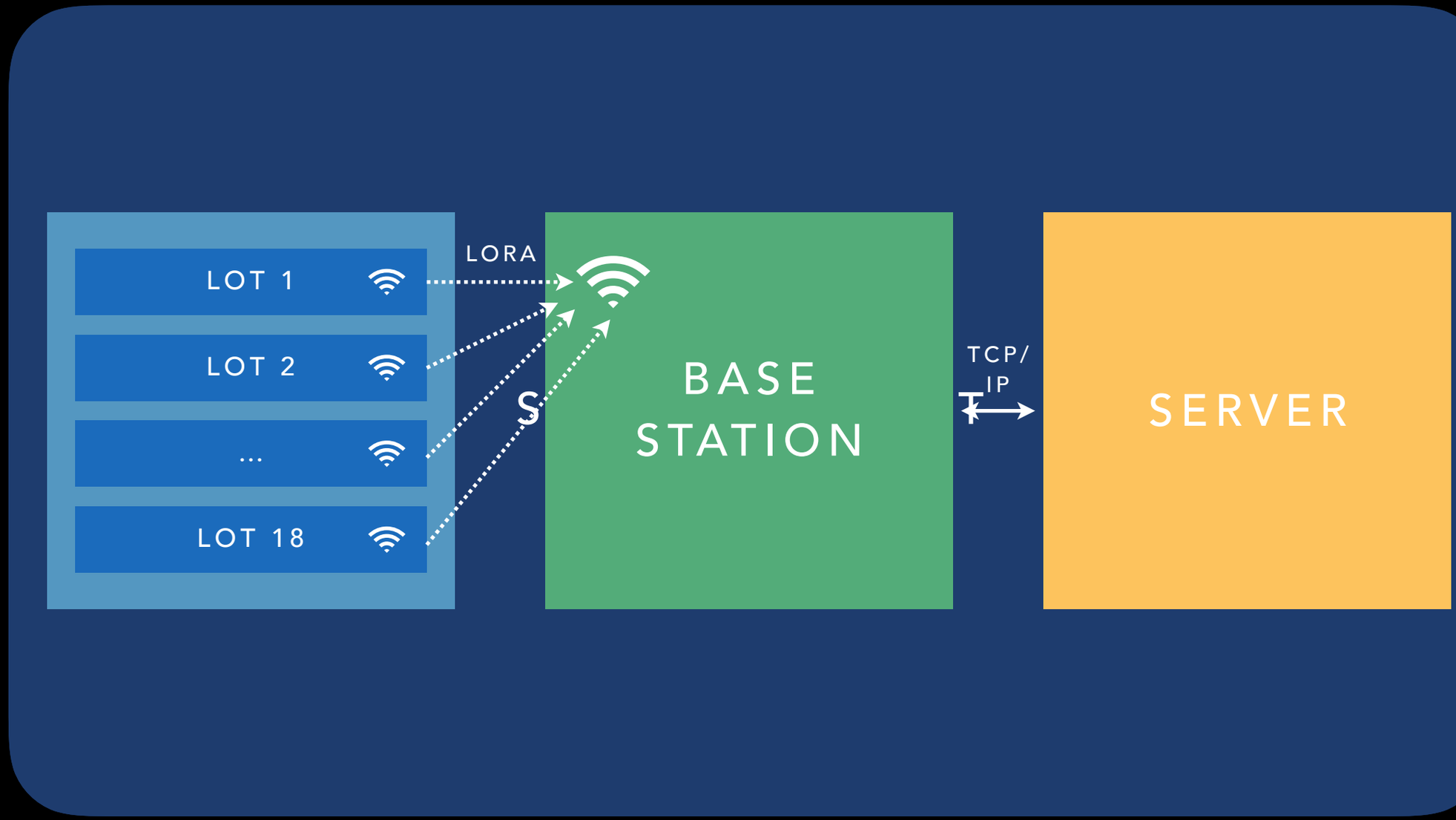
- Lack of coordination to accommodate growth
- Limited Lots, Limited Spots
- Currently, finding lots…
- Leads to Guessing
- Leads to Wandering
- Leads to Frustrated drivers
- … all before your first class

WHAT IF...

SENIOR PROJECT ARCHITECTURE



SENIOR PROJECT ARCHITECTURE



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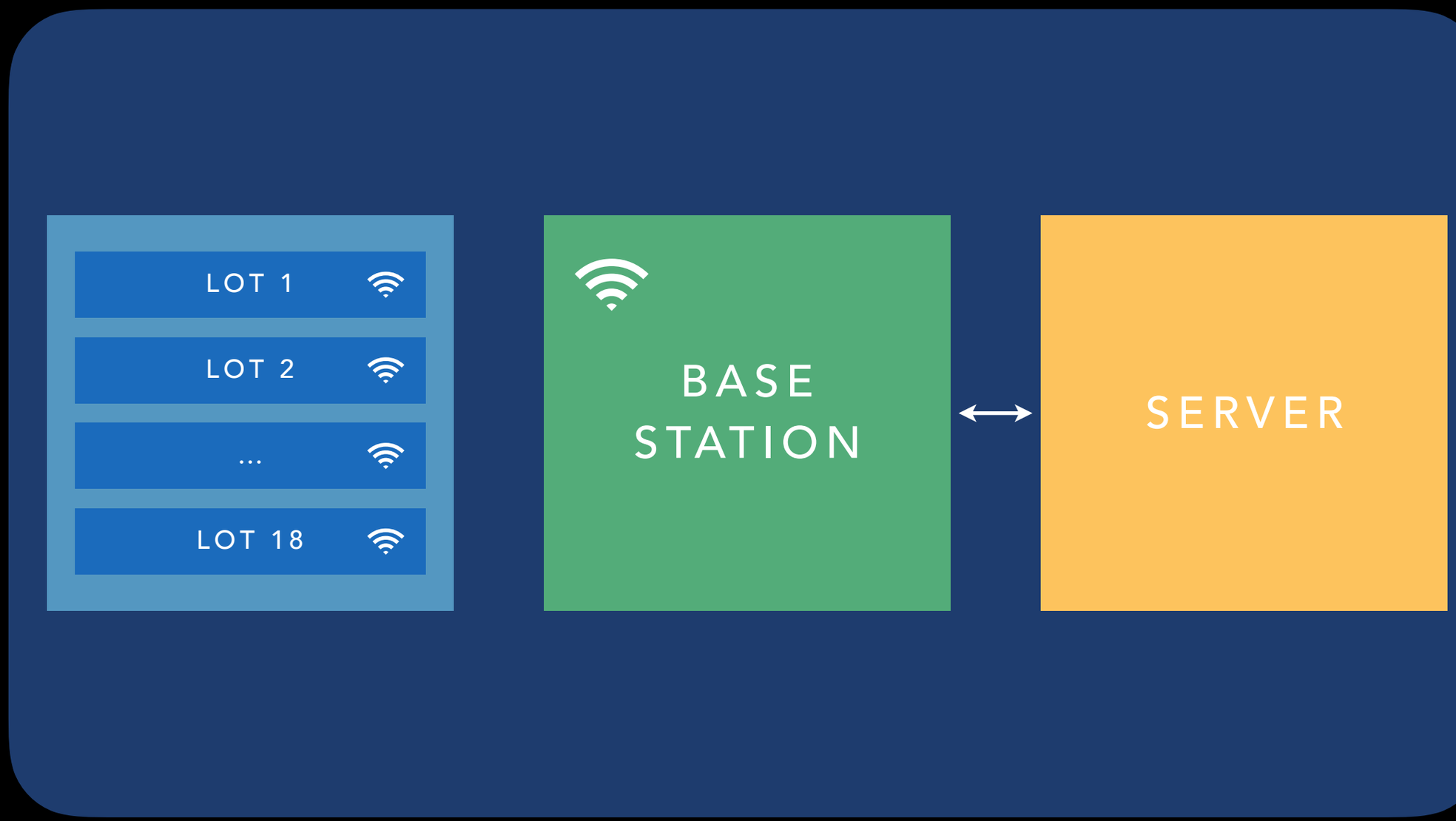
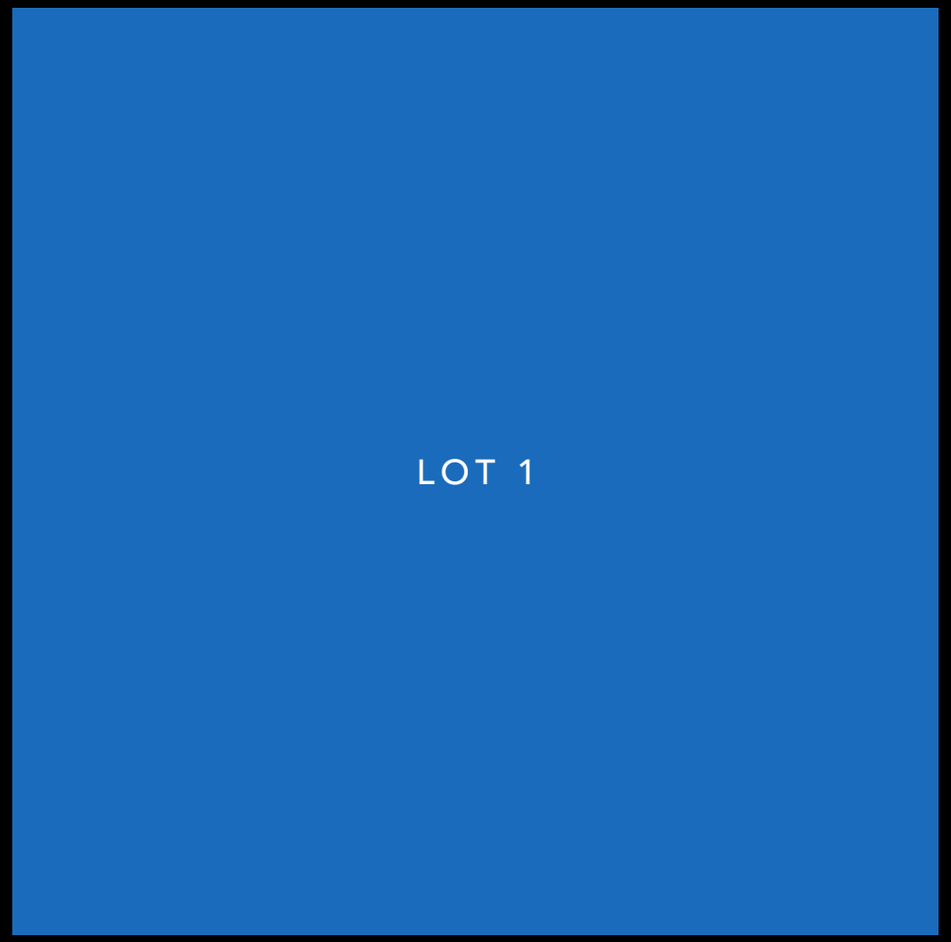
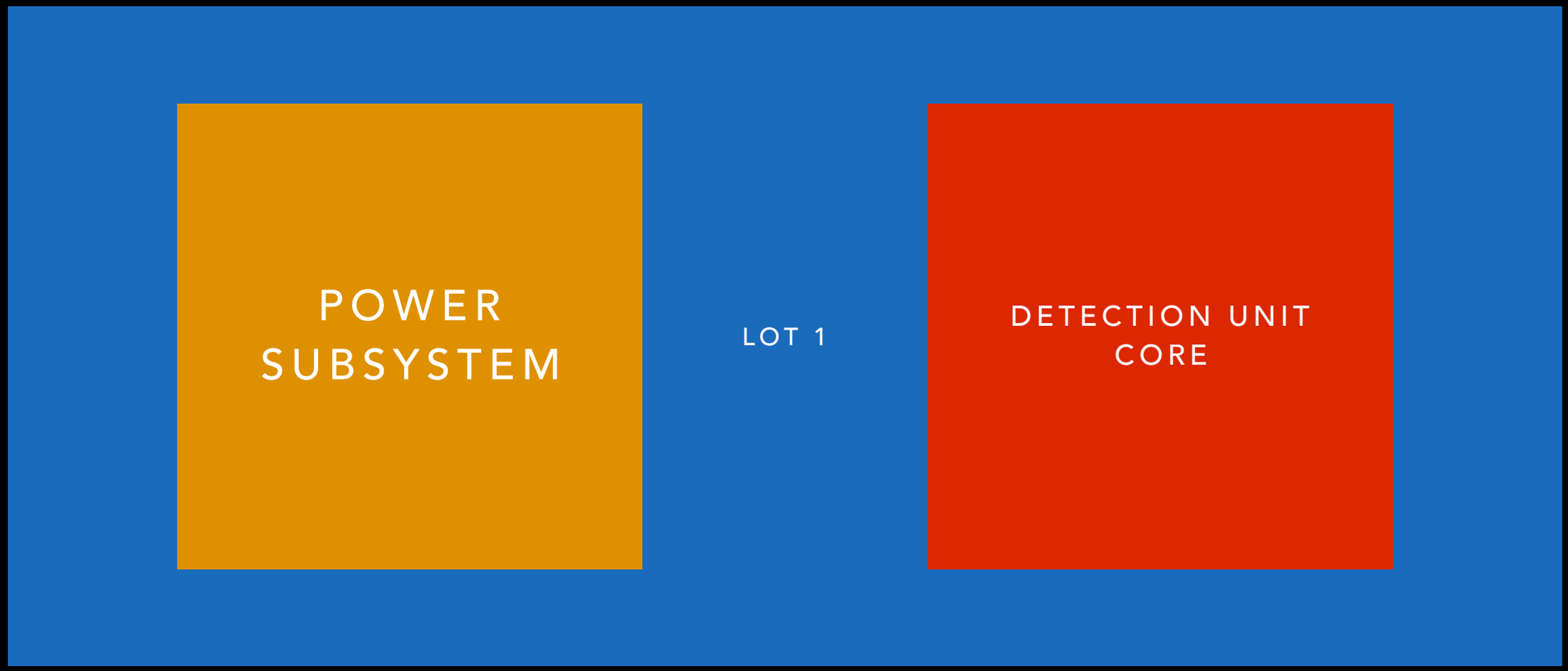


DETECTION UNIT REQUIREMENTS

- Self-powered
- Reliably detect vehicles entering and exiting the parking lot
- Withstand harsh weather conditions and elements

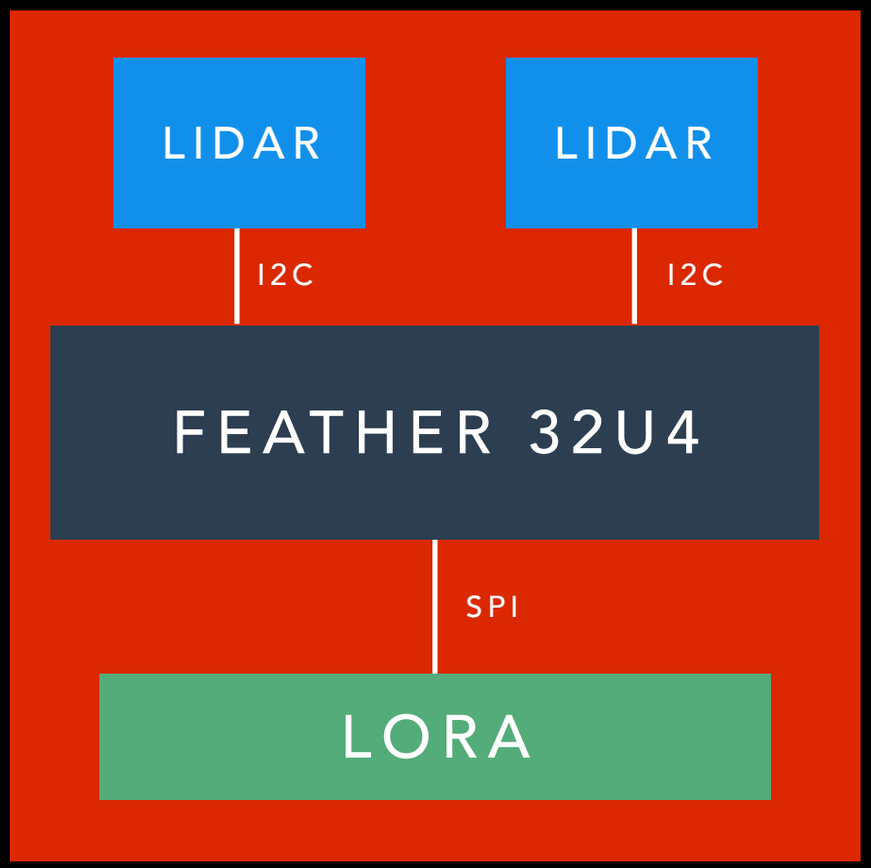


DETECTION UNIT BREAKDOWN

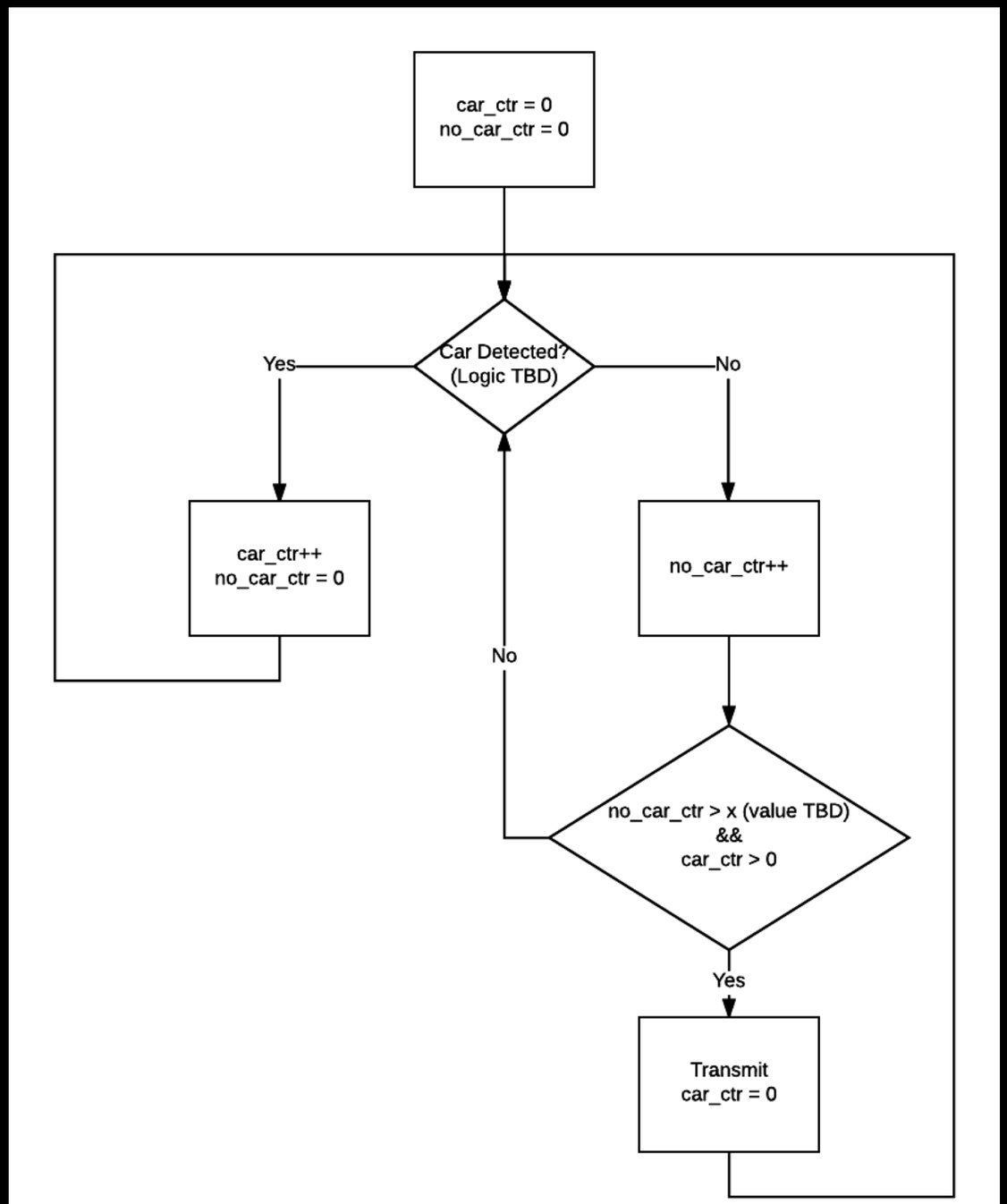


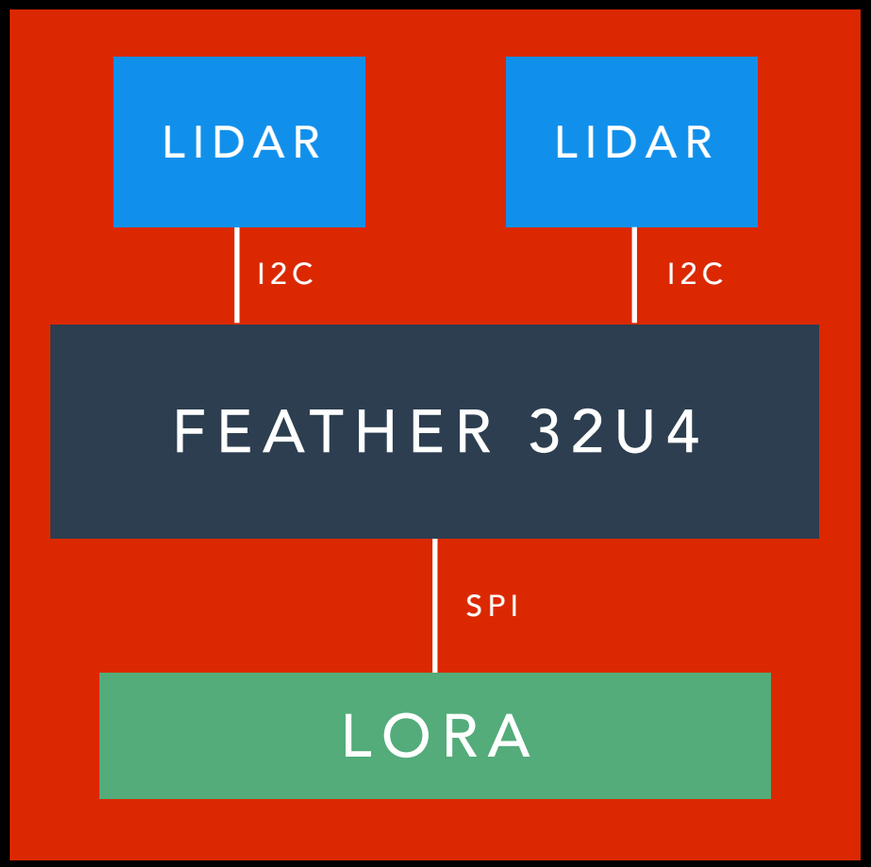
DETECTION UNIT CORE ARCHITECTURE

- Arduino Based Microcontroller
- 2 LIDAR Sensors
- Wireless LoRa to communicate with Base Station

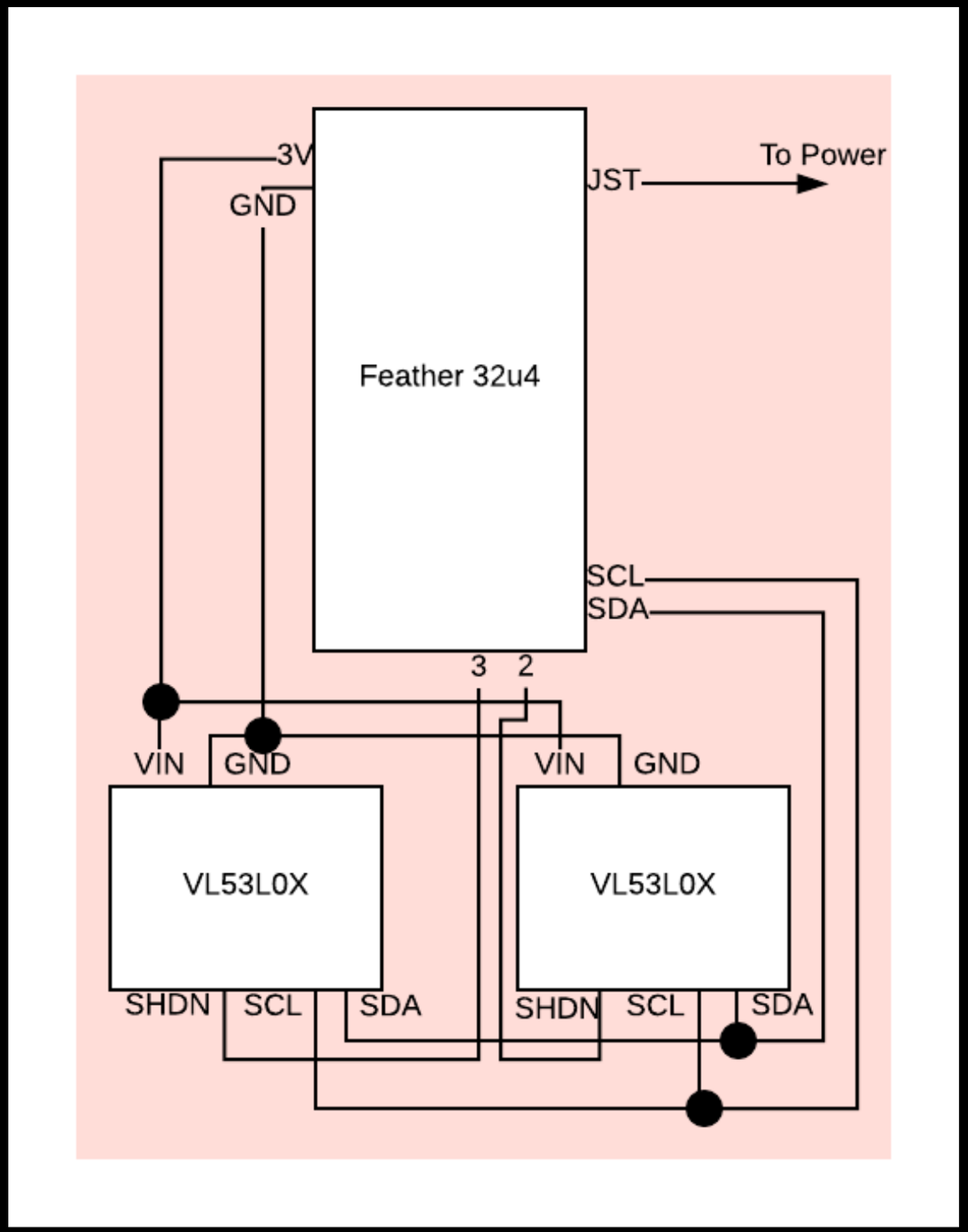


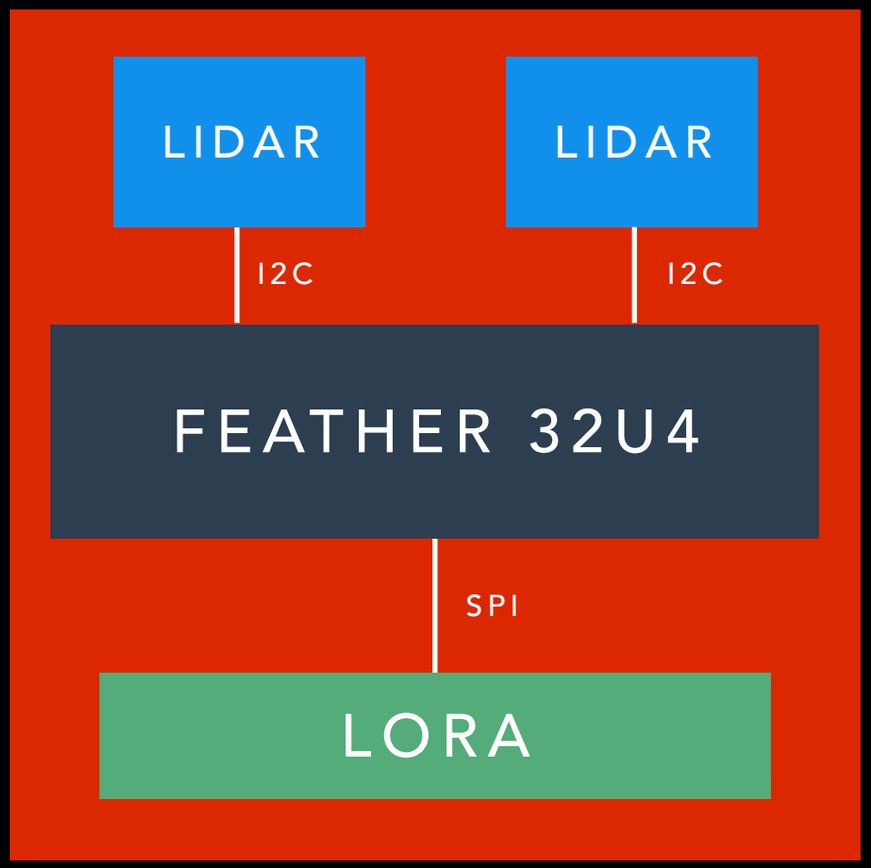
DETECTION UNIT CORE SOFTWARE ARCHITECTURE





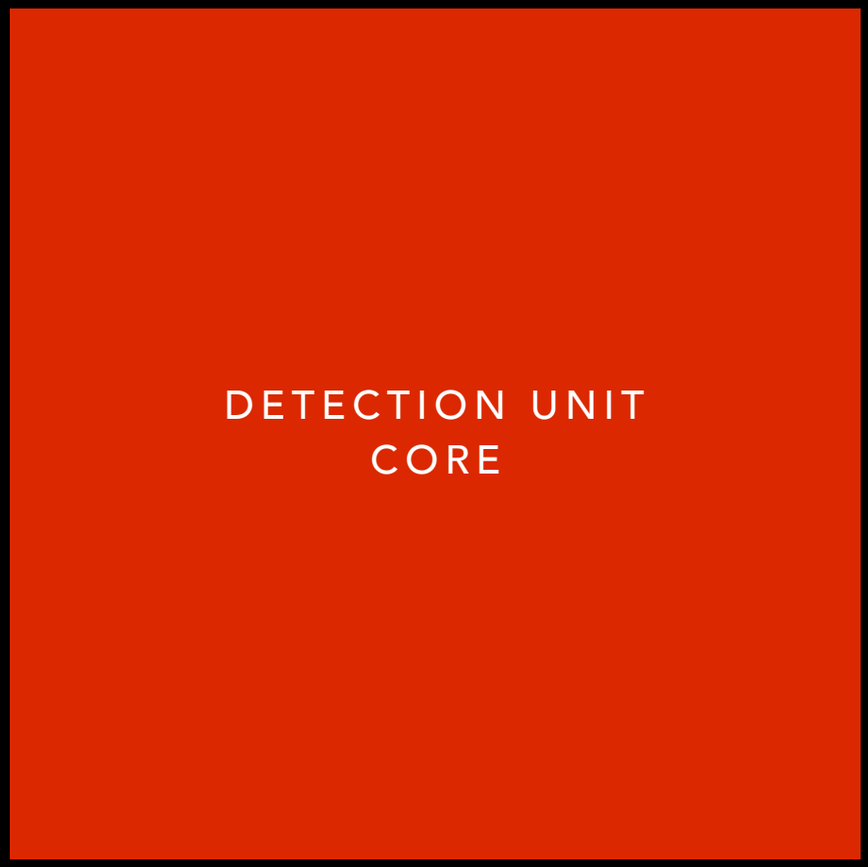
DETECTION UNIT CORE HARDWARE ARCHITECTURE



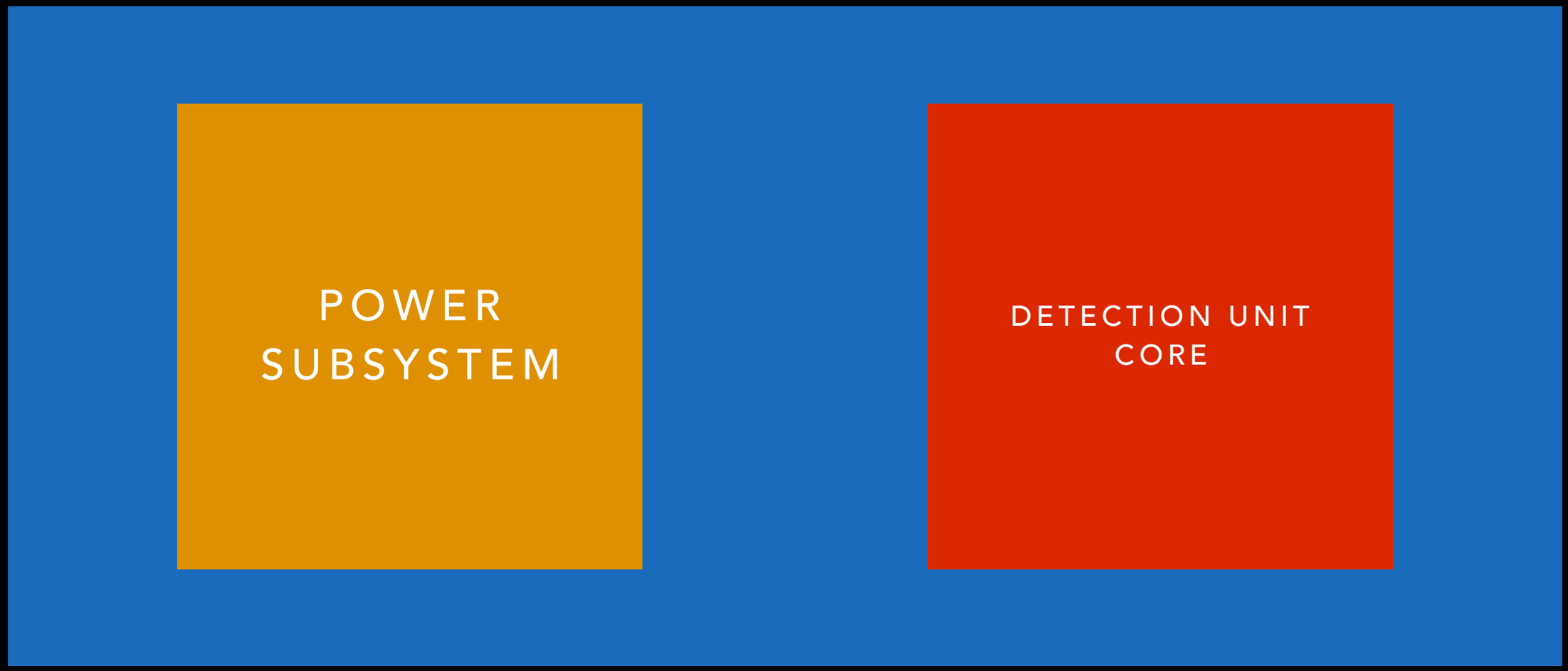


DETECTION UNIT CORE PROGRESS

- Completed Tasks
  - Measure data from one LiDar sensor
- Future Tasks
  - Measure data from both LiDar sensors
    - Familiarize with I2C Protocol
    - Create sensor shutdown circuitry



DETECTION UNIT BREAKDOWN



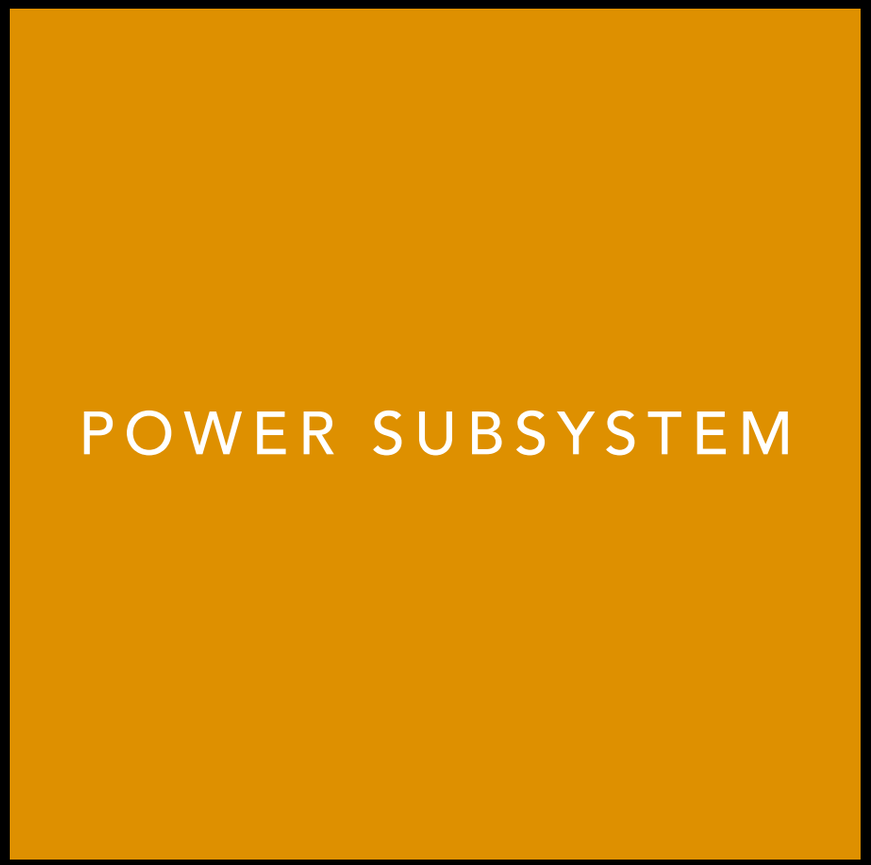
POWER
SUBSYSTEM

DETECTION UNIT POWER SUBSYSTEM CURRENT ANALYSIS

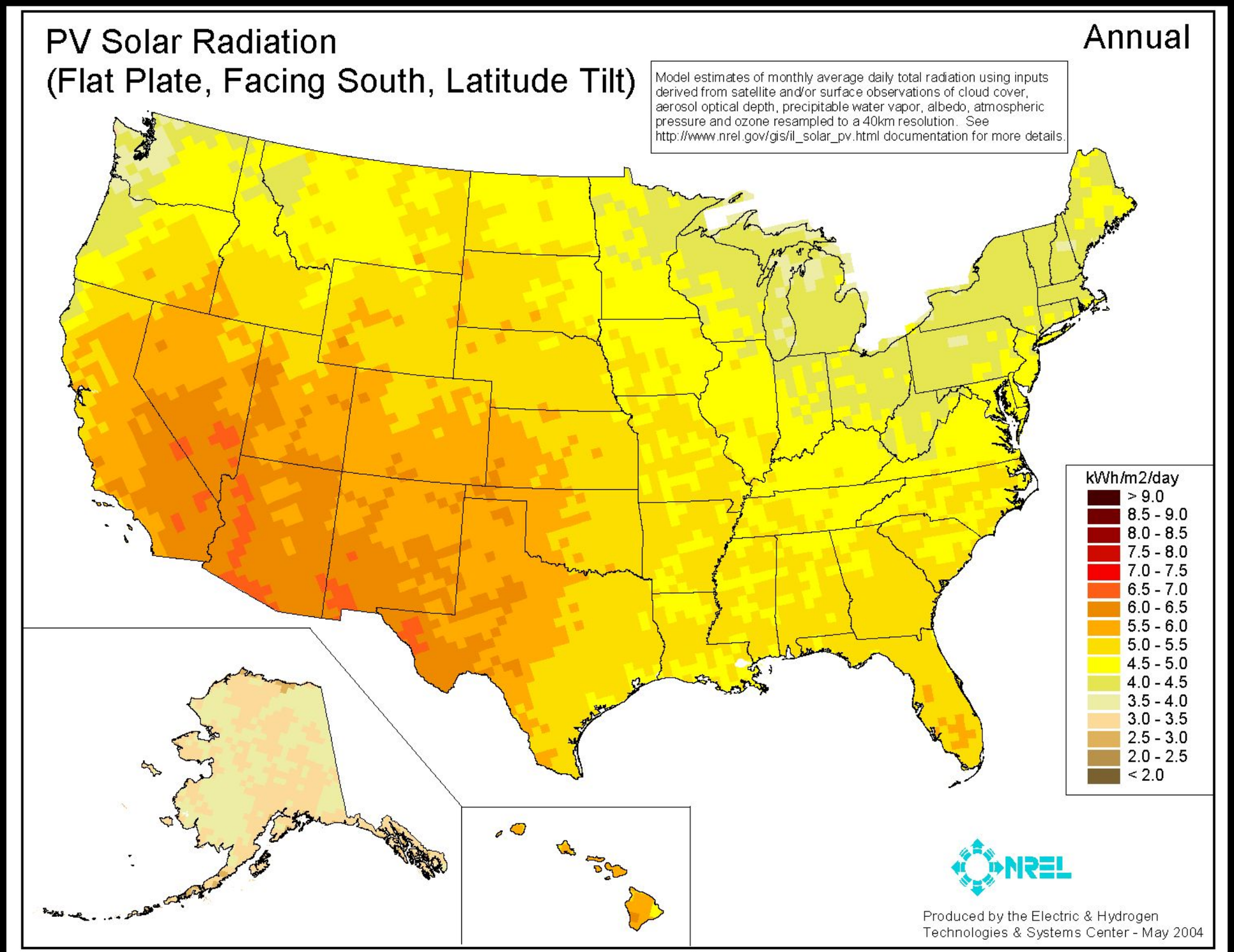
			Detection Unit Draw	
LoRa (x1)	IR Sensor 1	IR Sensor 2	**(V)**	**(A)**
Sleep	Standby	Standby	[3.3V]	314uA
Sleep	Standby/Peak	Standby/Peak	[3.3V]	40.307mA
Sleep	Peak	Peak	[3.3V]	80.3mA
Listening	Standby	Standby	[3.3V]	40.014mA
Listening	Standby/Peak	Standby/Peak	[3.3V]	80.007mA
Listening	Peak	Peak	[3.3V]	120mA
Peak	Standby	Standby	[3.3V]	120.014mA
Peak	Standby/Peak	Standby/Peak	[3.3V]	160.007mA
Peak	Peak	Peak	[3.3V]	200mA

DETECTION UNIT POWER SUBSYSTEM PARTS

- 5V parallel solar panels w/ Schottky blocking diodes and current sensing resistor
- DC / DC switching converter in step - up configuration
- 4.2 volt regulator w/ 1 amp current limiting in series configuration
- MOSFET battery sub-circuit switch controlled from LoRa module
- High frequency decoupling capacitors for ripple and spike rejection
- Current sensing cutoff at battery terminals



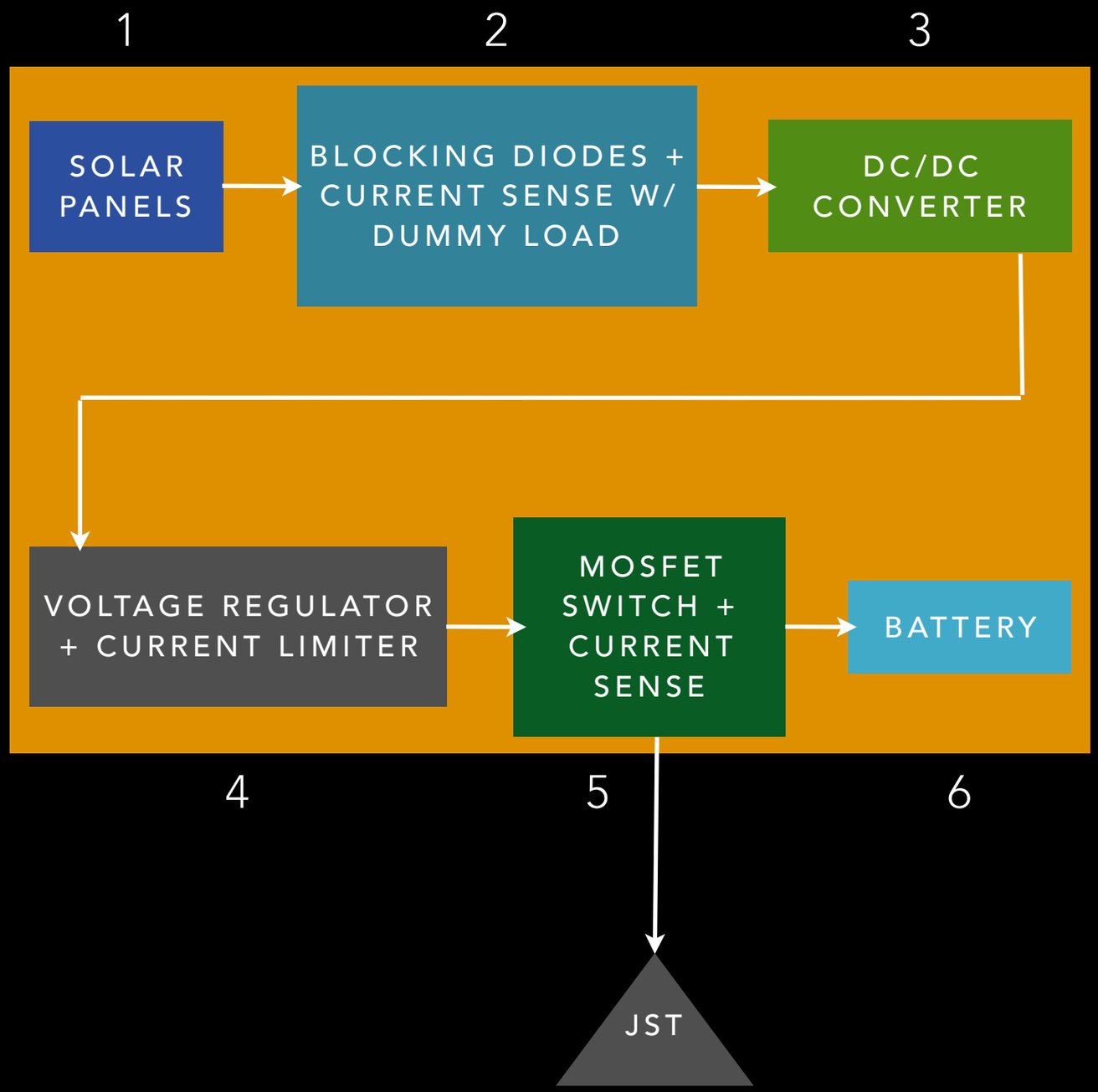
DETECTION UNIT POWER SUBSYSTEM GENERAL SOLAR MAP



DETECTION UNIT POWER SUBSYSTEM WIRELESS RANGE MAP

DETECTION UNIT POWER SUBSYSTEM ARCHITECTURE BREAKDOWN

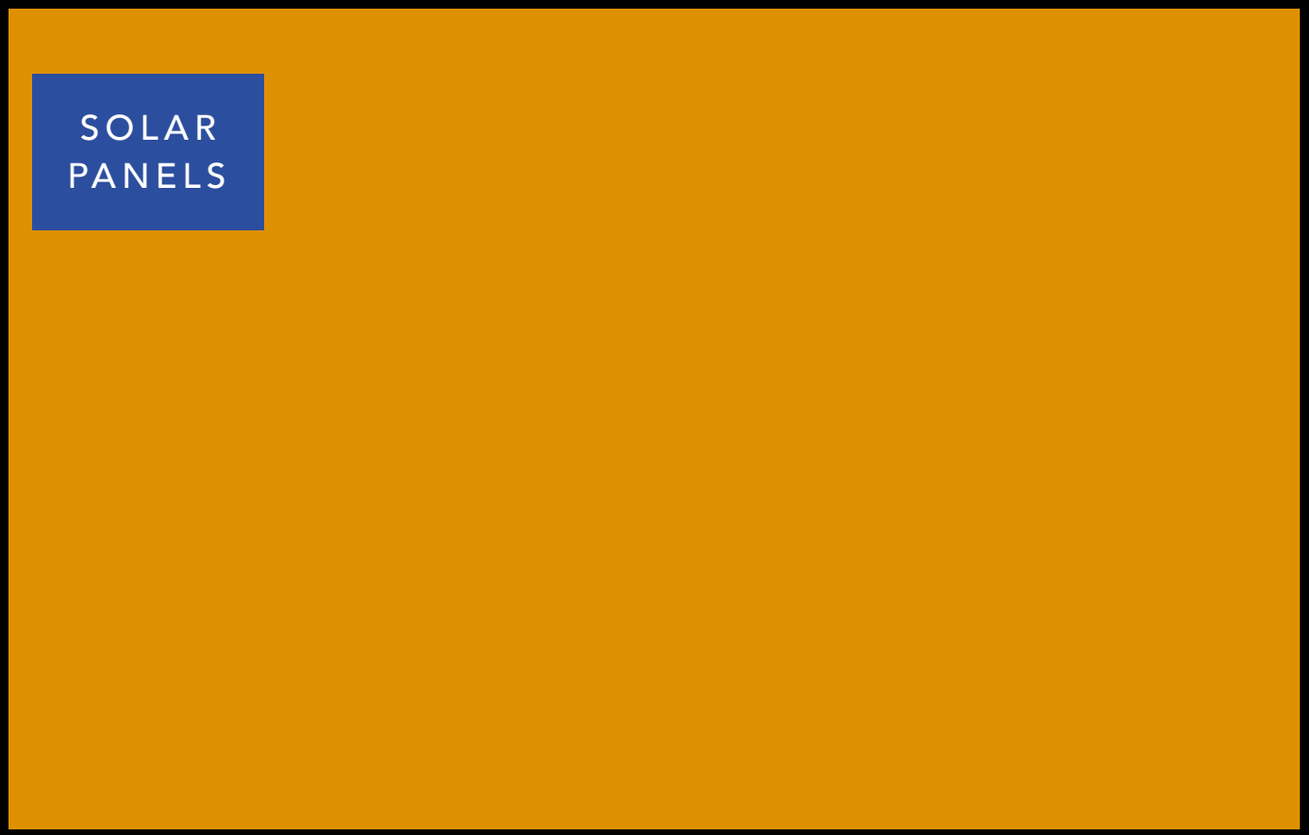
- **Block Sections**
  1. Solar
  2. Circuit Protection & Measurement
  3. Power Conditioning
  4. Power Regulation & Limiting
  5. Charging Control & Measurement
  6. Battery



DETECTION UNIT POWER SUBSYSTEM ARCHITECTURE BREAKDOWN

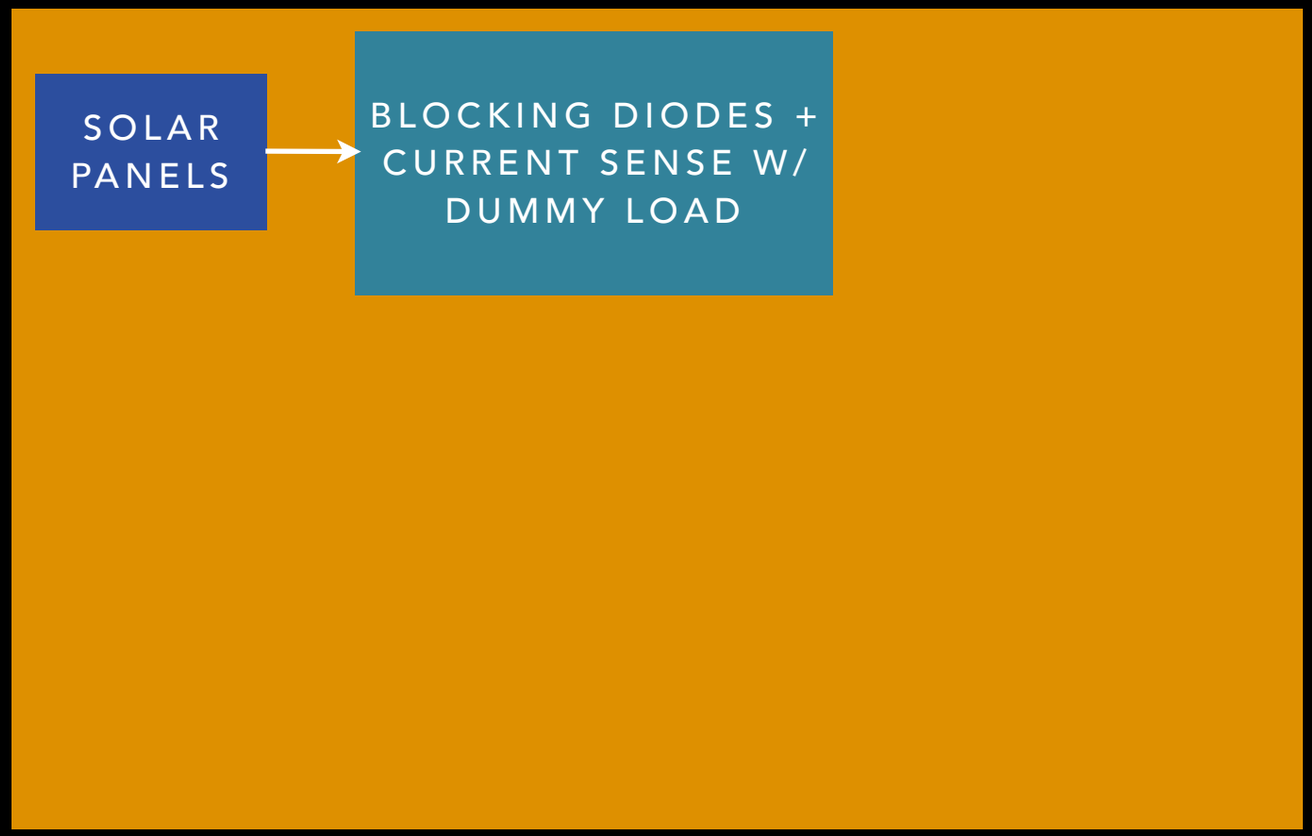
1. Solar Panel

- 5 V / 500 mA
- 2.5 W
- Bare bones, no blocking or over-current protection



DETECTION UNIT POWER SUBSYSTEM ARCHITECTURE BREAKDOWN

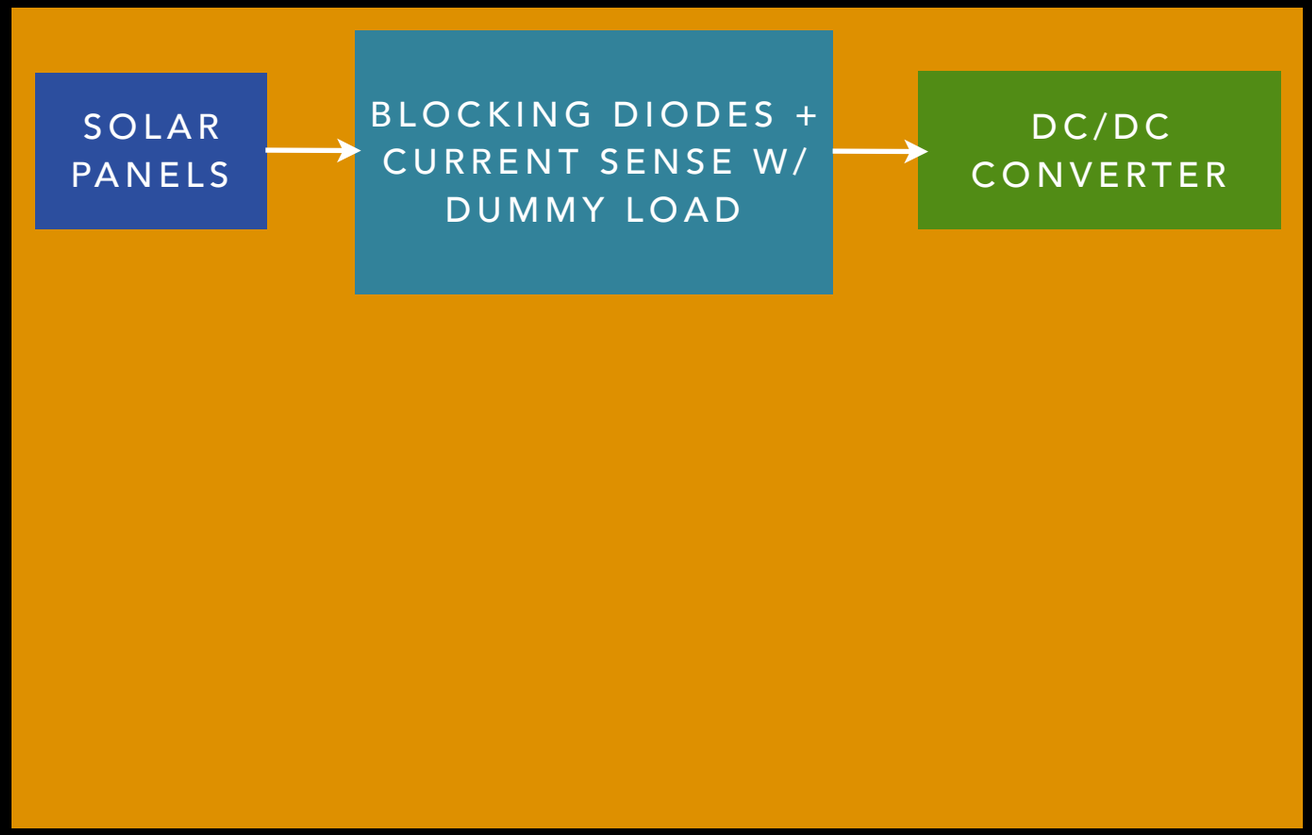
- **2. Circuit Protection & Measurement**
  - Schottky blocking diodes
    - Low forward voltage drop
    - Parallel panel feedback blocking
  - Low value current sense resistor w/ dummy load switching
    - Determine sunlight conditions and solar panel operation



DETECTION UNIT POWER SUBSYSTEM ARCHITECTURE BREAKDOWN

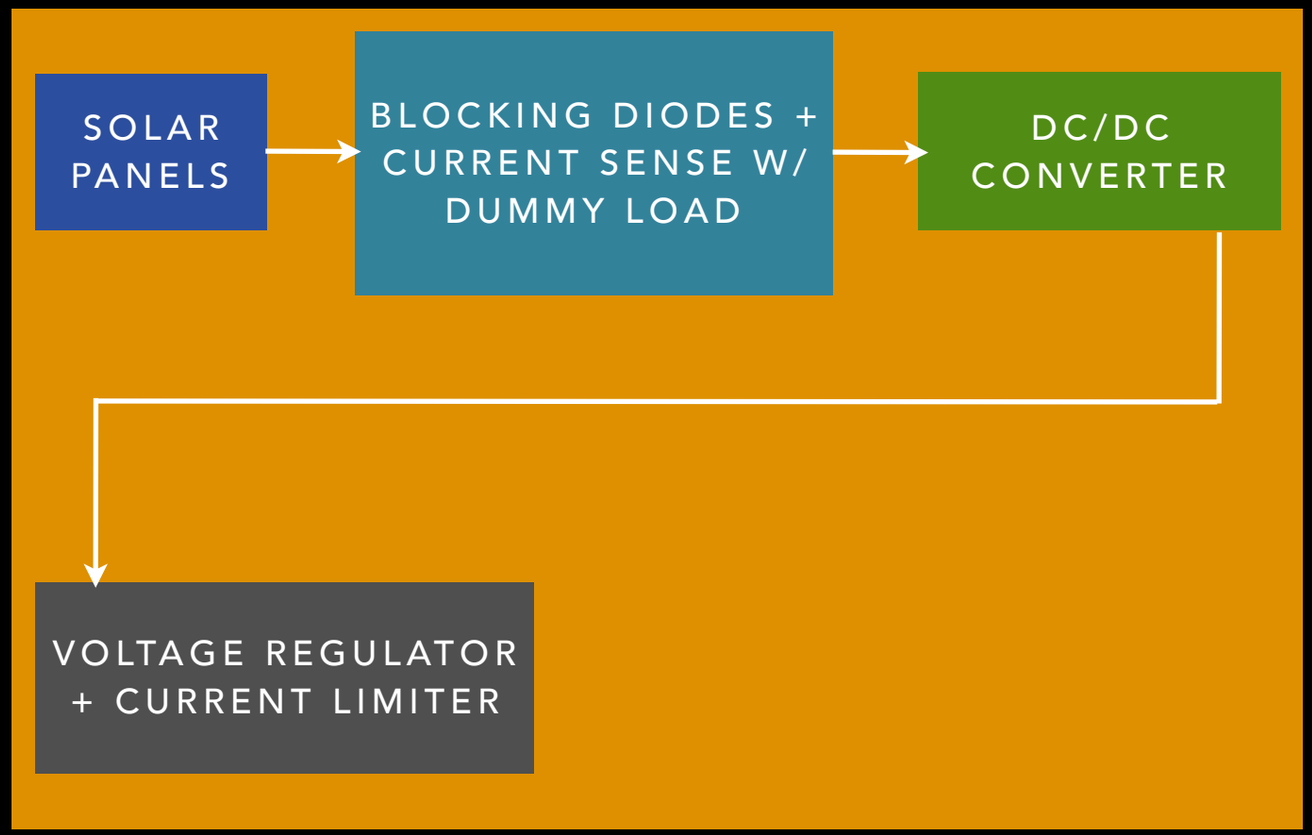
3. Power Conditioning

- DC/DC switching converter
- Step up voltage
- High efficiency / low power loss



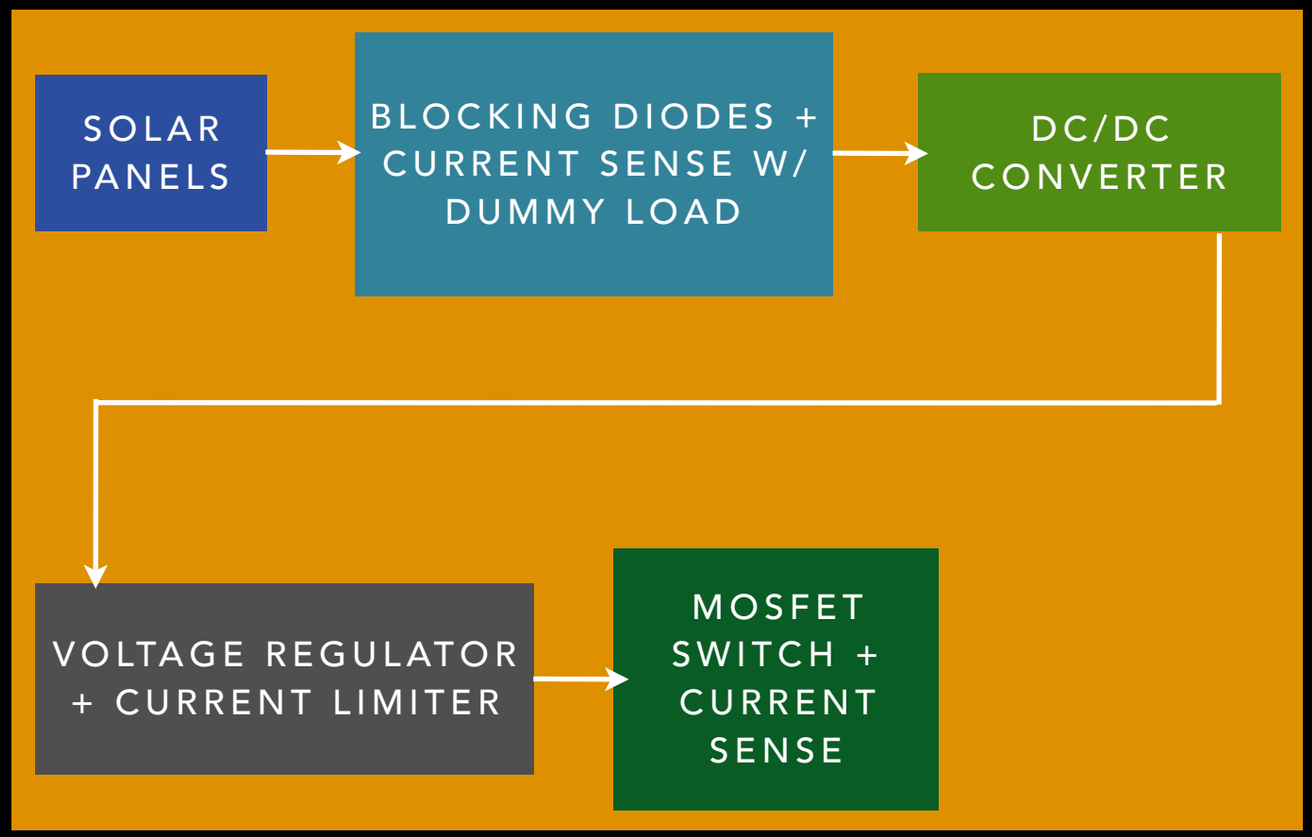
DETECTION UNIT POWER SUBSYSTEM ARCHITECTURE BREAKDOWN

- **4. Power Regulation & Limiting**
  - LM317 linear regulator
    - Variable output voltage
    - Current limiting capabilities



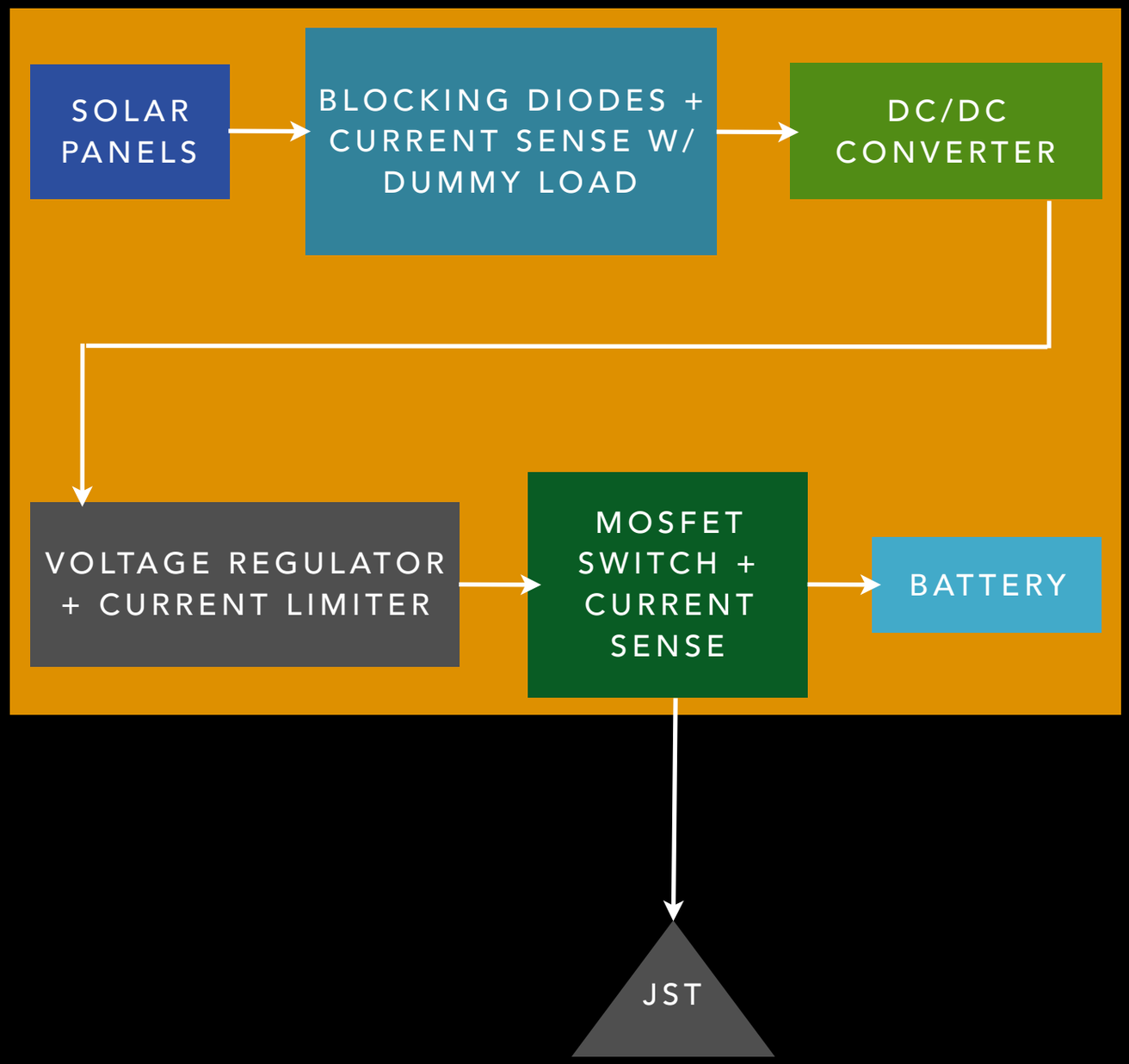
DETECTION UNIT POWER SUBSYSTEM ARCHITECTURE BREAKDOWN

- **5. Charging Control & Measurement**
  - MOSFET switch
    - Control charging / discharging durations of battery
  - Low value current sense resistor
    - Determine battery capacity

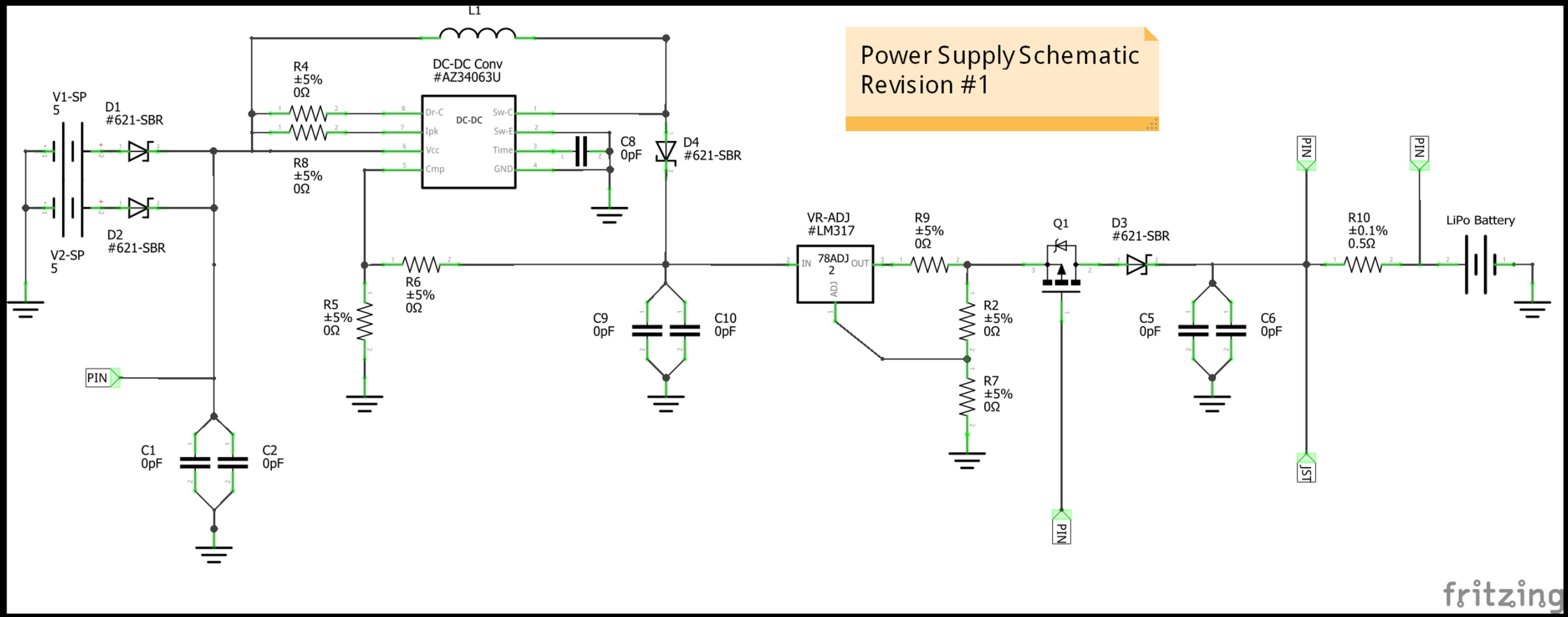


DETECTION UNIT POWER SUBSYSTEM ARCHITECTURE BREAKDOWN

- **6. Battery**
  - 4.2 / 3.7 V
  - 4000 mAh
  - Battery cutoff circuitry



DETECTION UNIT POWER SUBSYSTEM SCHEMATIC



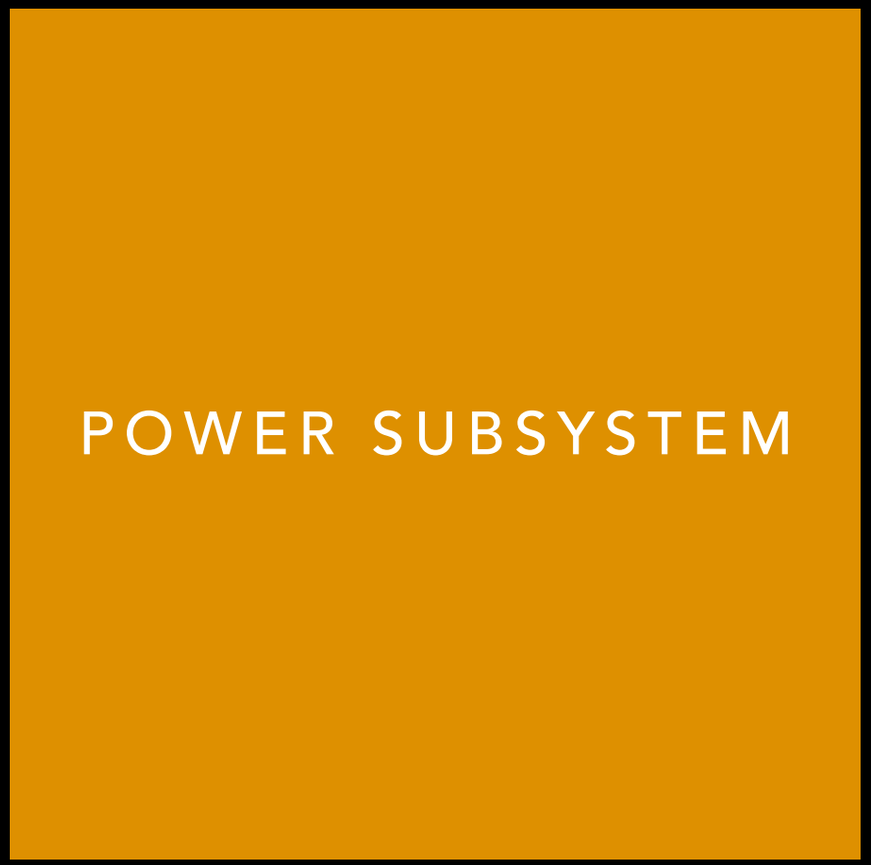
DETECTION UNIT POWER SUBSYSTEM PROGRESS

Completed

- Solar and battery system background research
- Circuit current draws and demands
- Initial necessary constituent components
- Initial schematic design

In Progress

- Final component selection
- Battery performance and weekly traffic prediction
- Schematic revision
- Circuit simulation (individual components and total circuit)
- Solar panel Voc and Isc testing, plus shade performance and load testing



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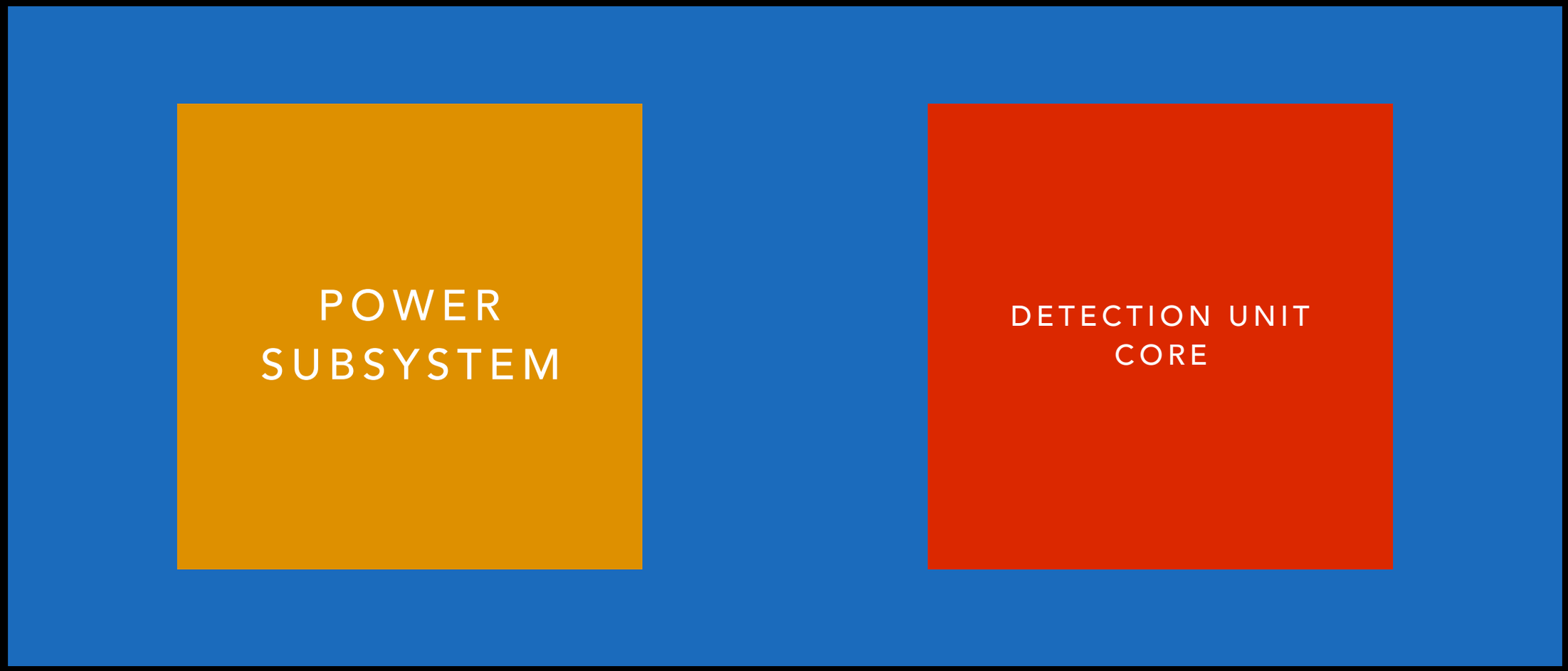
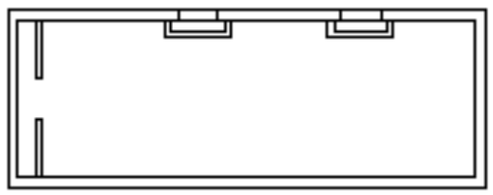
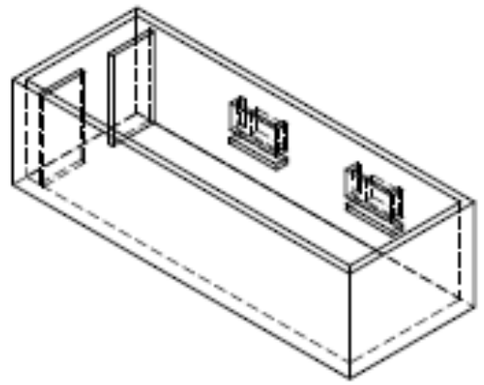


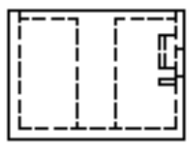
DETECTION UNIT ENCLOSURE DESIGN

- Object of enclosure is to ensure security to parts and to keep them in place.
- Must conserve space to conserve material.
- For detection unit, sensors are mounted on the wall of the enclosure with an opening.

DETECTION UNIT ENCLOSURE DRAWING

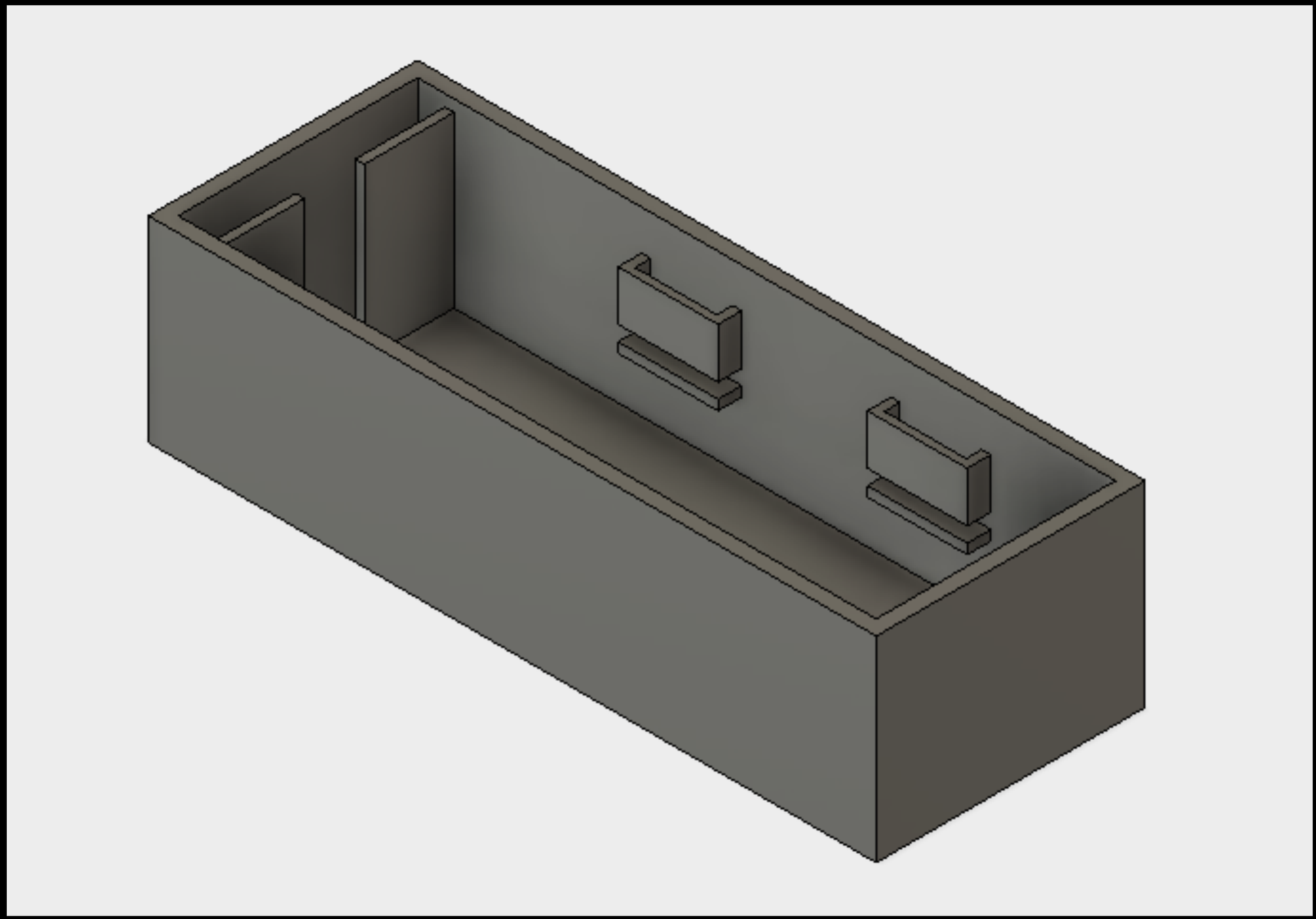




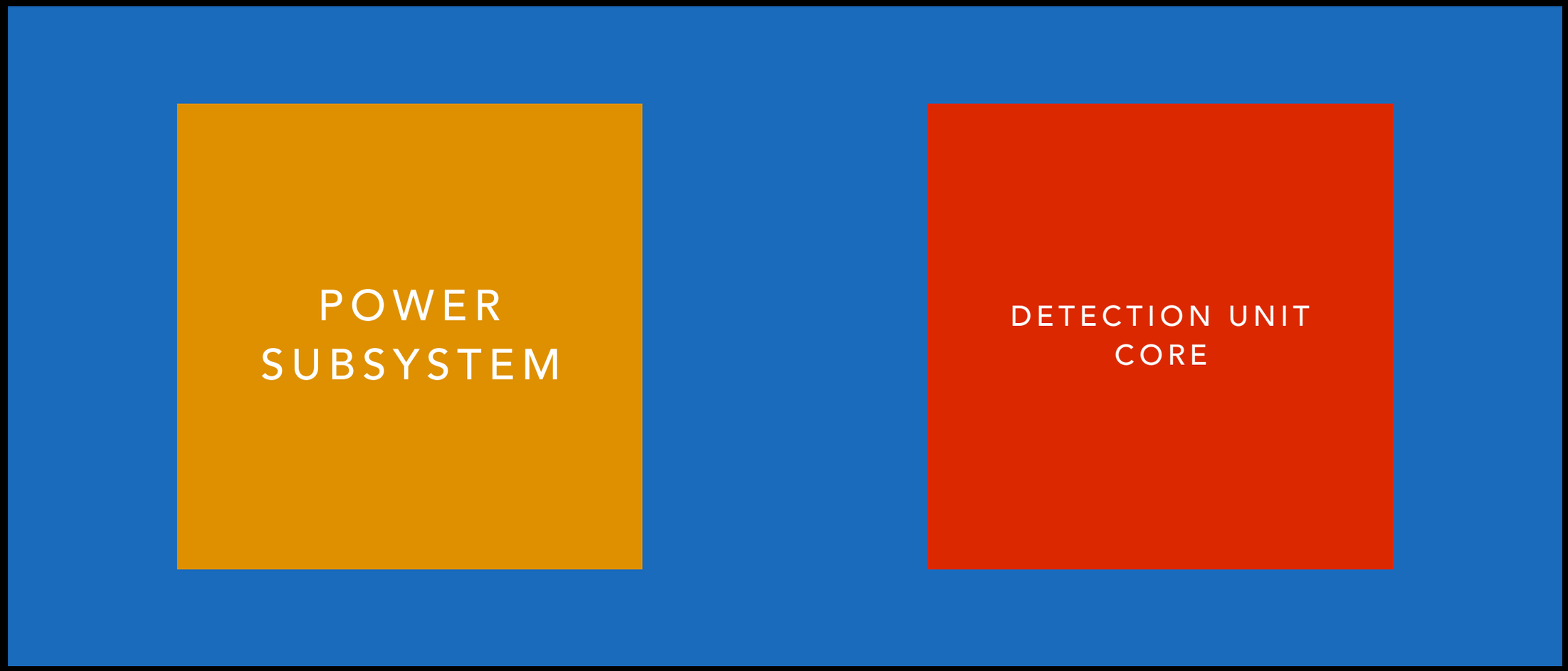


	PROJECT: Senior Project			
	TITLE: N1 P1 v5			
APPROVED	SIZE: B	CODE	DWG NO	REV
CHECKED				
DRAWN: Stephanie Fournier/1/20	SCALE: 1:2	WEIGHT	SHEET: 1/1	

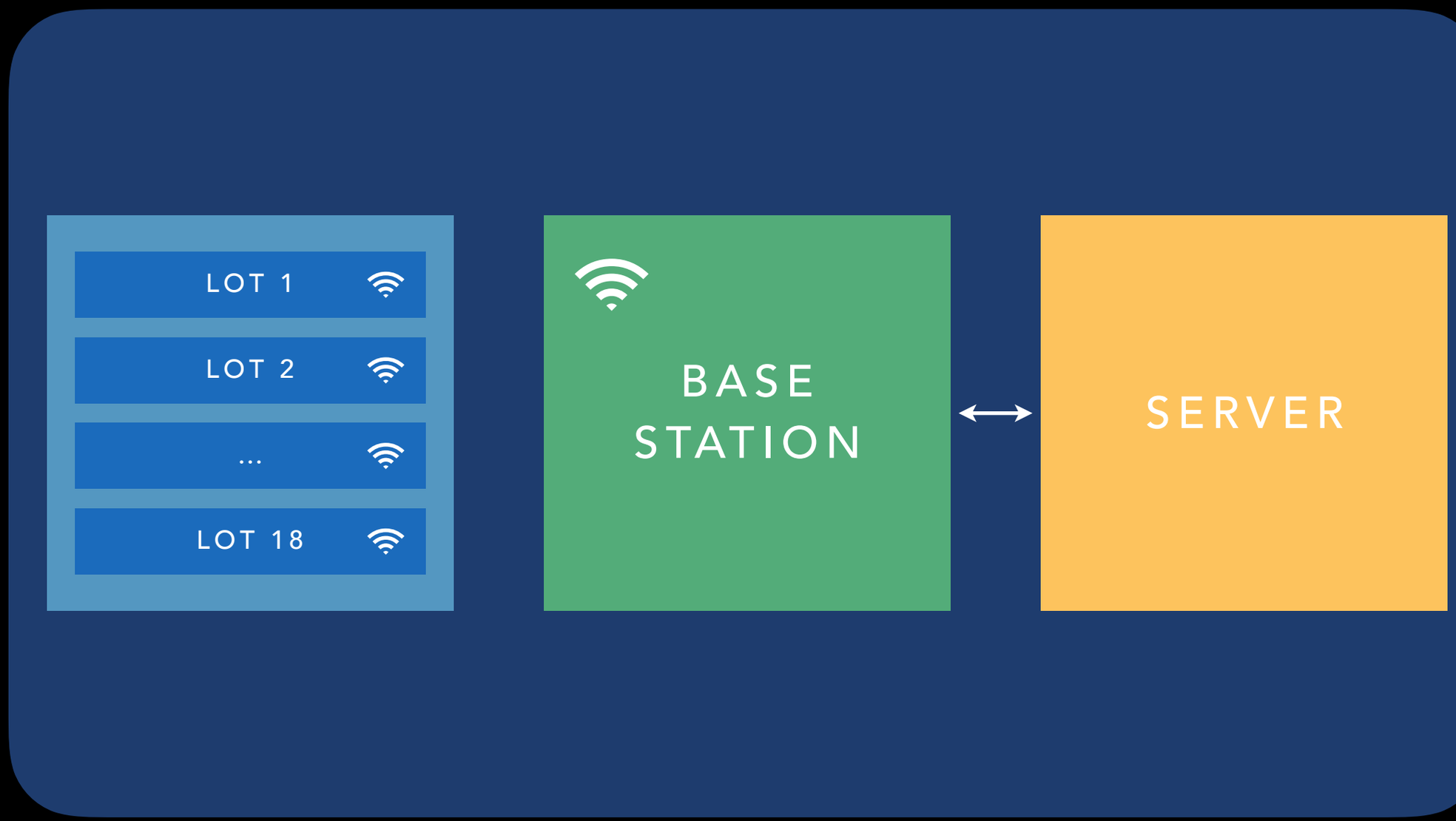
DETECTION UNIT ENCLOSURE RENDER



DETECTION UNIT BREAKDOWN

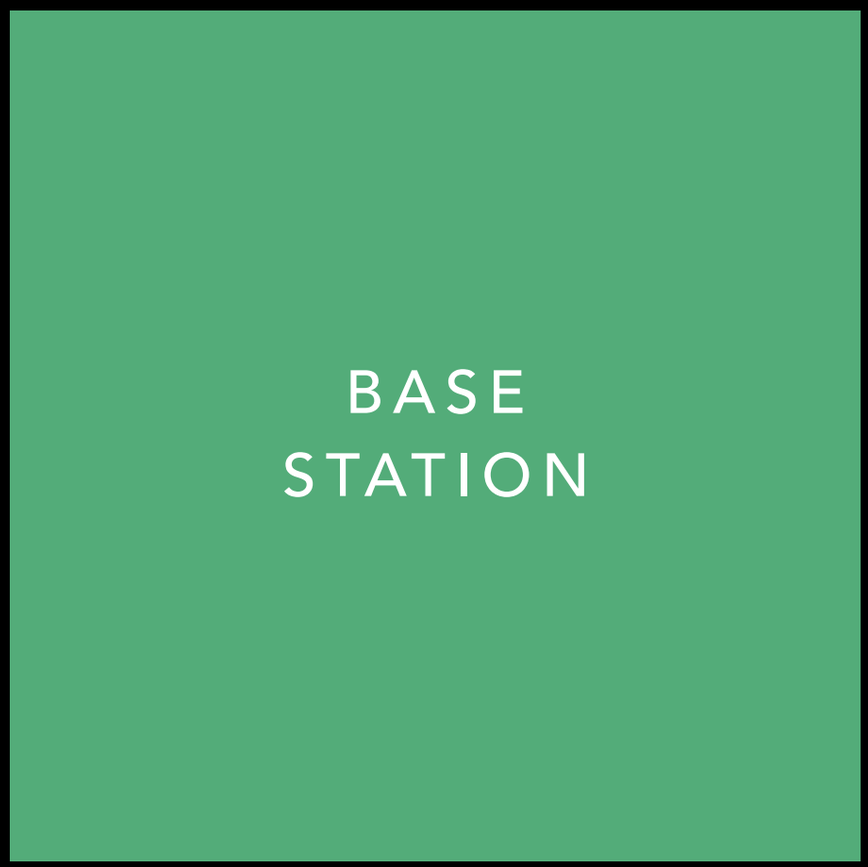


SENIOR PROJECT ARCHITECTURE

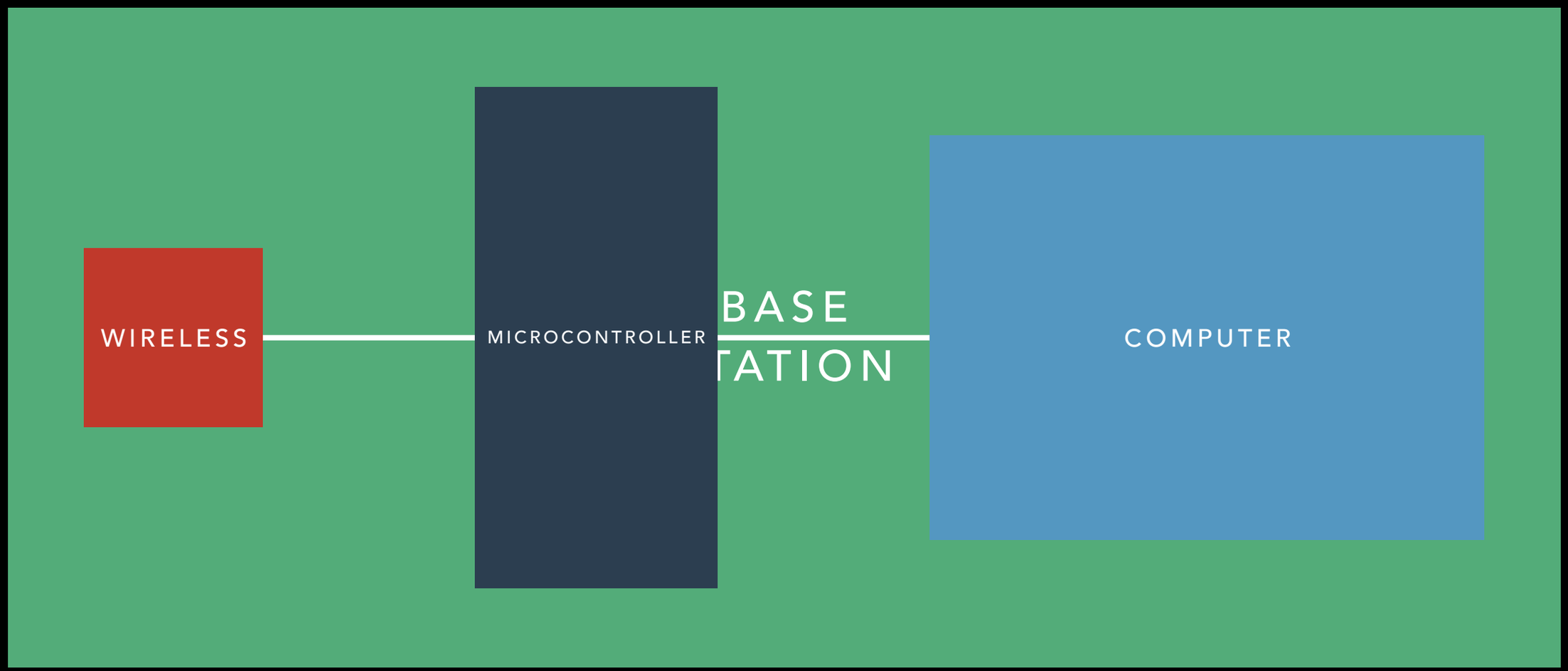


BASE STATION REQUIREMENTS

- Accept incoming payloads from multiple detection units
- Reliable connection to AWS
- Can be updated with new software



BASE STATION REQUIREMENTS ARCHITECTURE



WIRELESS

COMPARISON

	WIFI	BLUETOOTH	ZIGBEE	CELLULAR	LORA
CURRENT DRAW TX/RX (MILLIAMPS)	172/70	11/12.5	33/28	344/227	100/16
LINE OF SIGHT RANGE (METERS)	100	100	120	CELLULAR NETWORK COVERAGE	2000
COST (USD $)	25	20	23	40	20

All values are derived from products sold by Adafruit Inc. as of October 2017

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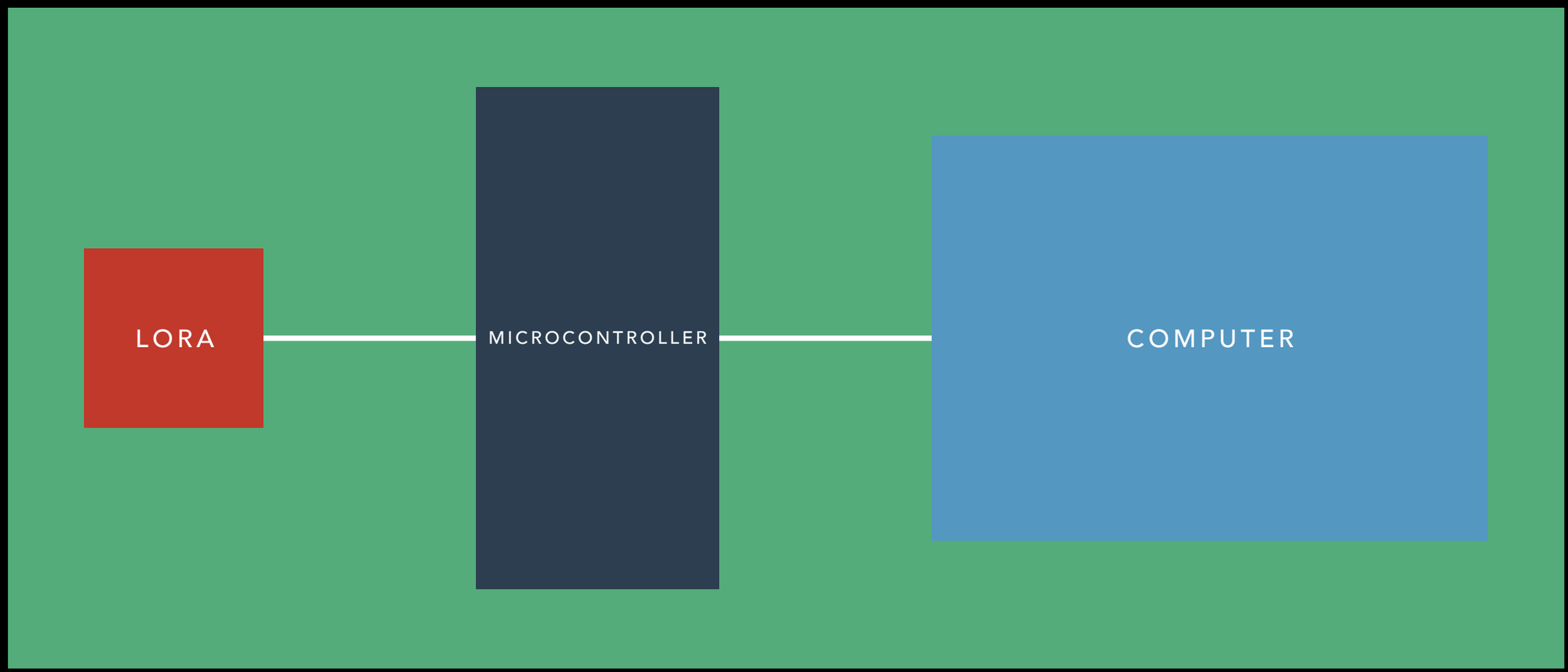

MICROCONTROLLER

COMPARISON

	ARDUINO UNO	ARDUINO MKR WAN	PARTICLE PHOTON	CYPRESS PSOC	ADAFRUIT FEATHER
CLOCK SPEED (MHZ) & (BIT)	16 (8-BIT)	32 (32-BIT)	120 (32-BIT)	48 (32-BIT)	48 (32-BIT)
FLASH MEMORY (KB)	32	256	1024	256	256
RAM (KB)	2	32	128	1024	32
COST (USD $)	25	35	20	45	35
ONBOARD RADIO OPTIONS	-	LORA	WIFI / CELLULAR	WIFI / BLUETOOTH	WIFI / BLUETOOTH / LORA

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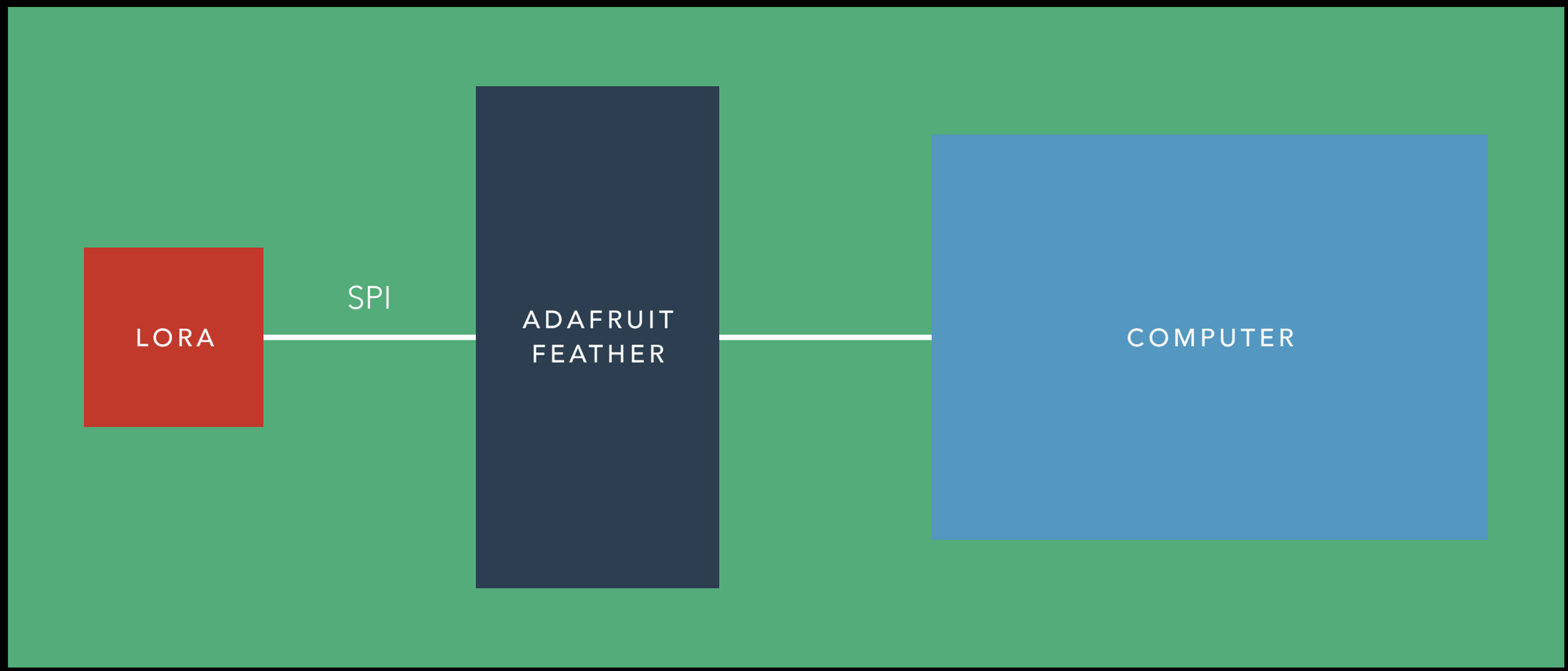

COMPUTER

COMPARISON

	DELL GX520	ADAFRUIT FEATHER M0	BEAGLEBONE BLACK	C.H.I.P	RASPBERRY PI 3
CLOCK SPEED (GHZ)	2.8 (DUAL CORE)	48 (SINGLE CORE)	1 (SINGLE CORE)	1 (SINGLE CORE)	1.2 (QUAD CORE)
DISK (GB)	400	0.000256	4	4	4
RAM (GB)	1	0.000032	0.5	0.5	1
WEIGHT (GRAMS)	8700	3.08	40.82	1.81	136
COST (USD $)	100	40	55	10	35
BUILT IN CONNECTIVITY	ETHERNET	ETHERNET	WIFI + BLUETOOTH	WIFI + BLUETOOTH	ETHERNET + WIFI + BLUETOOTH

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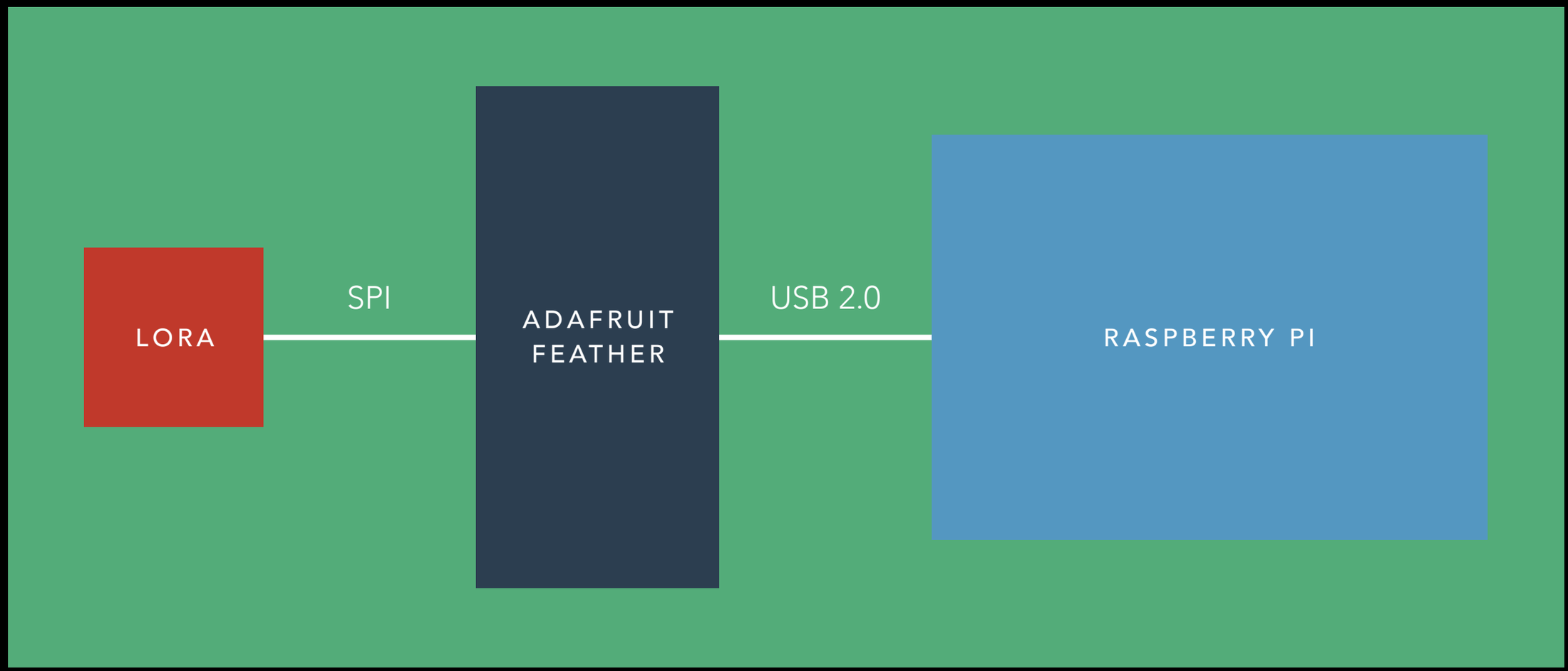
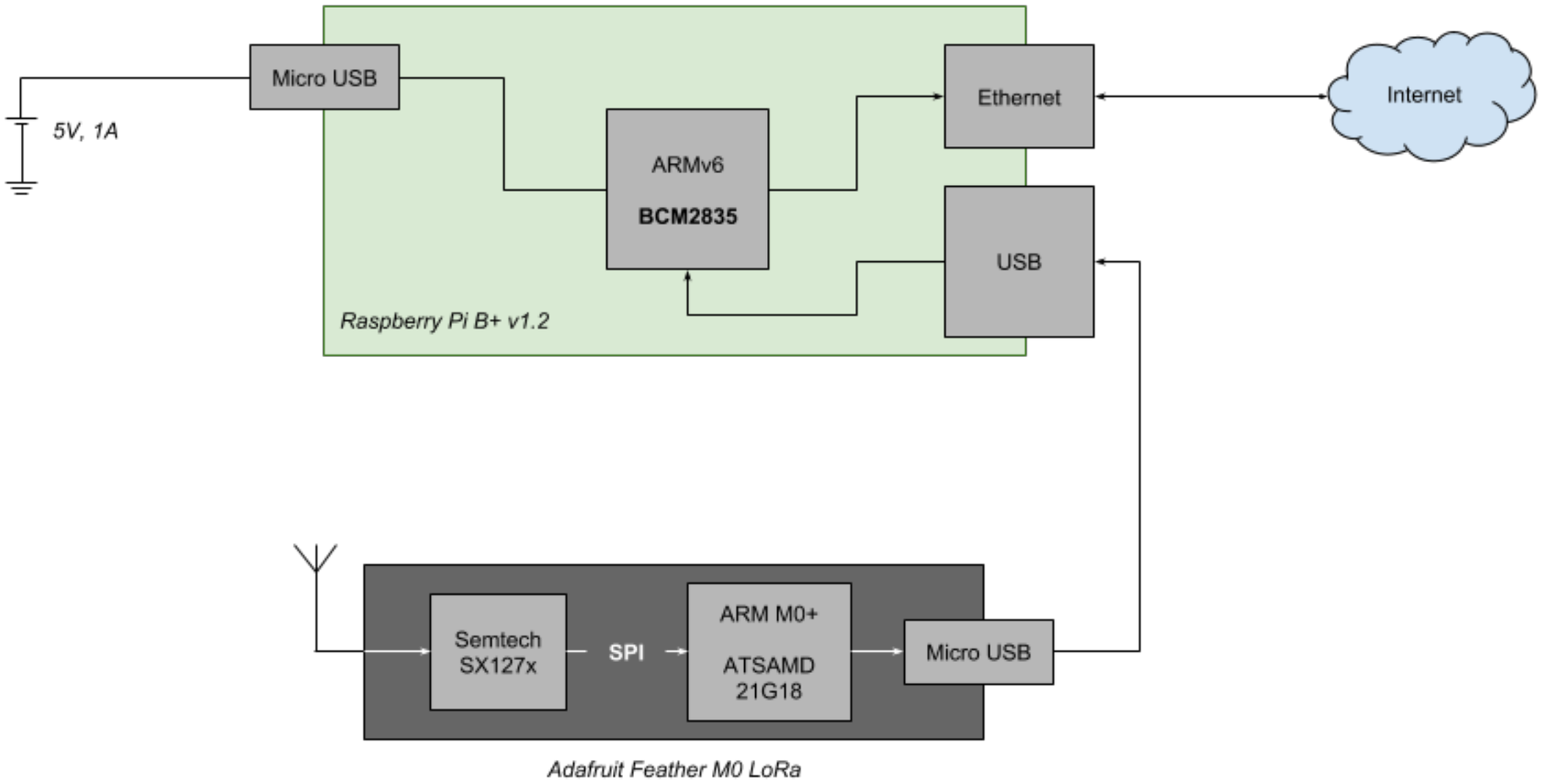
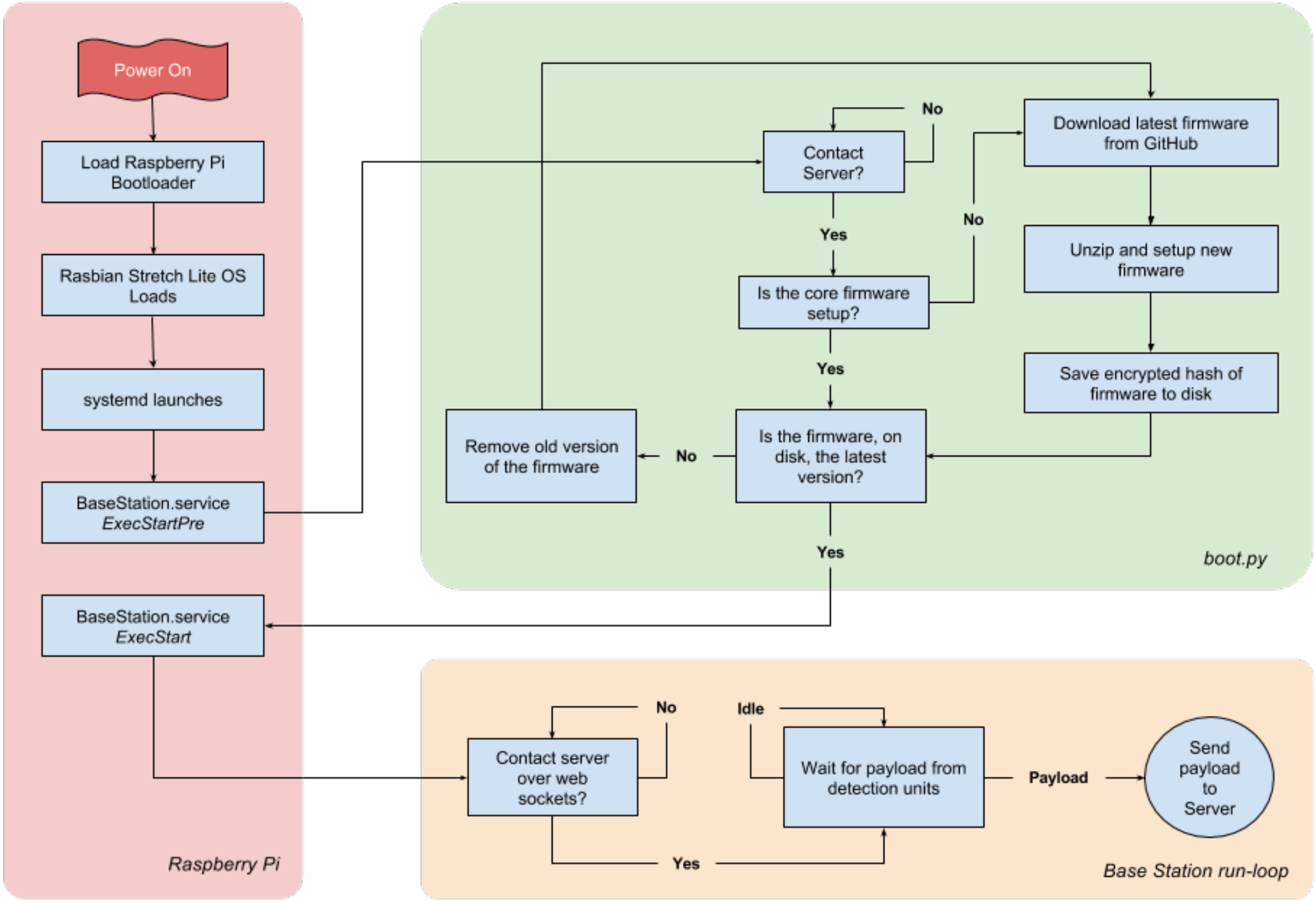


BASE STATION HARDWARE ARCHITECTURE



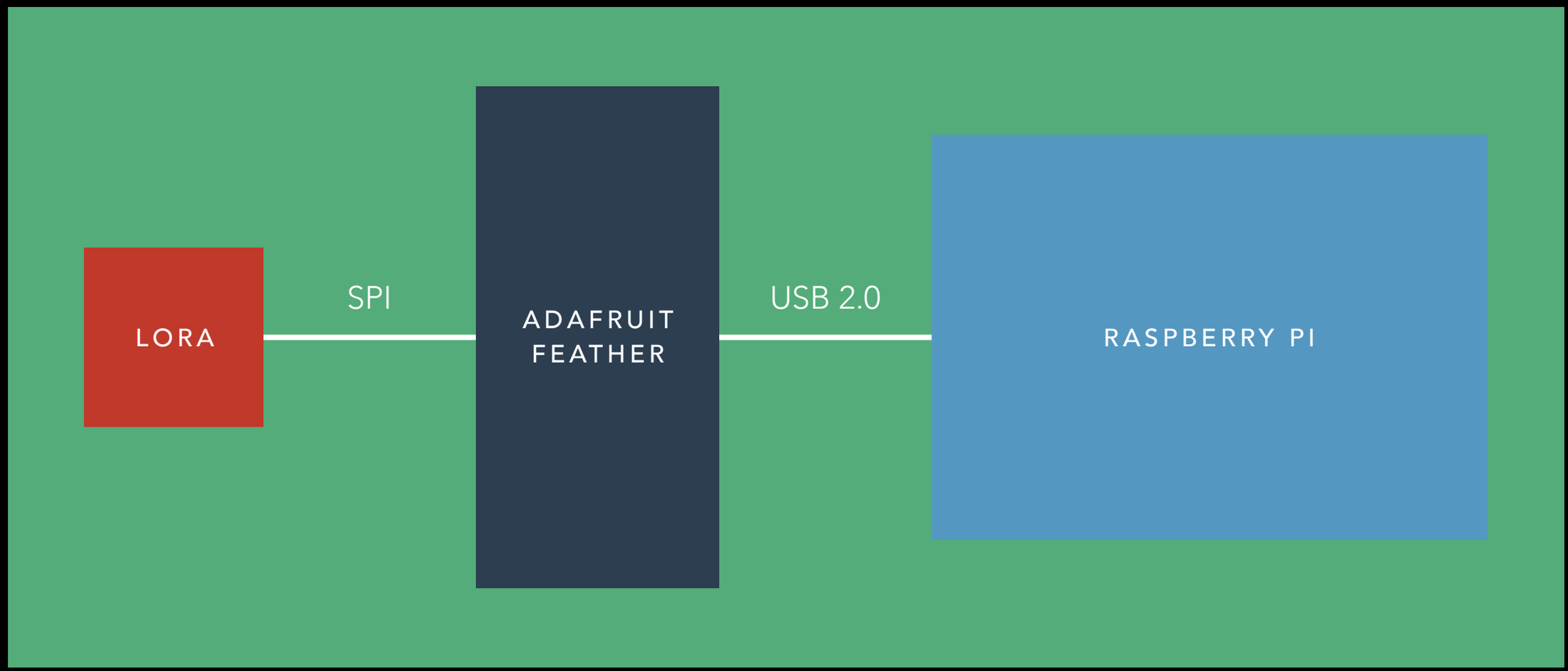
BASE STATION SOFTWARE ARCHITECTURE



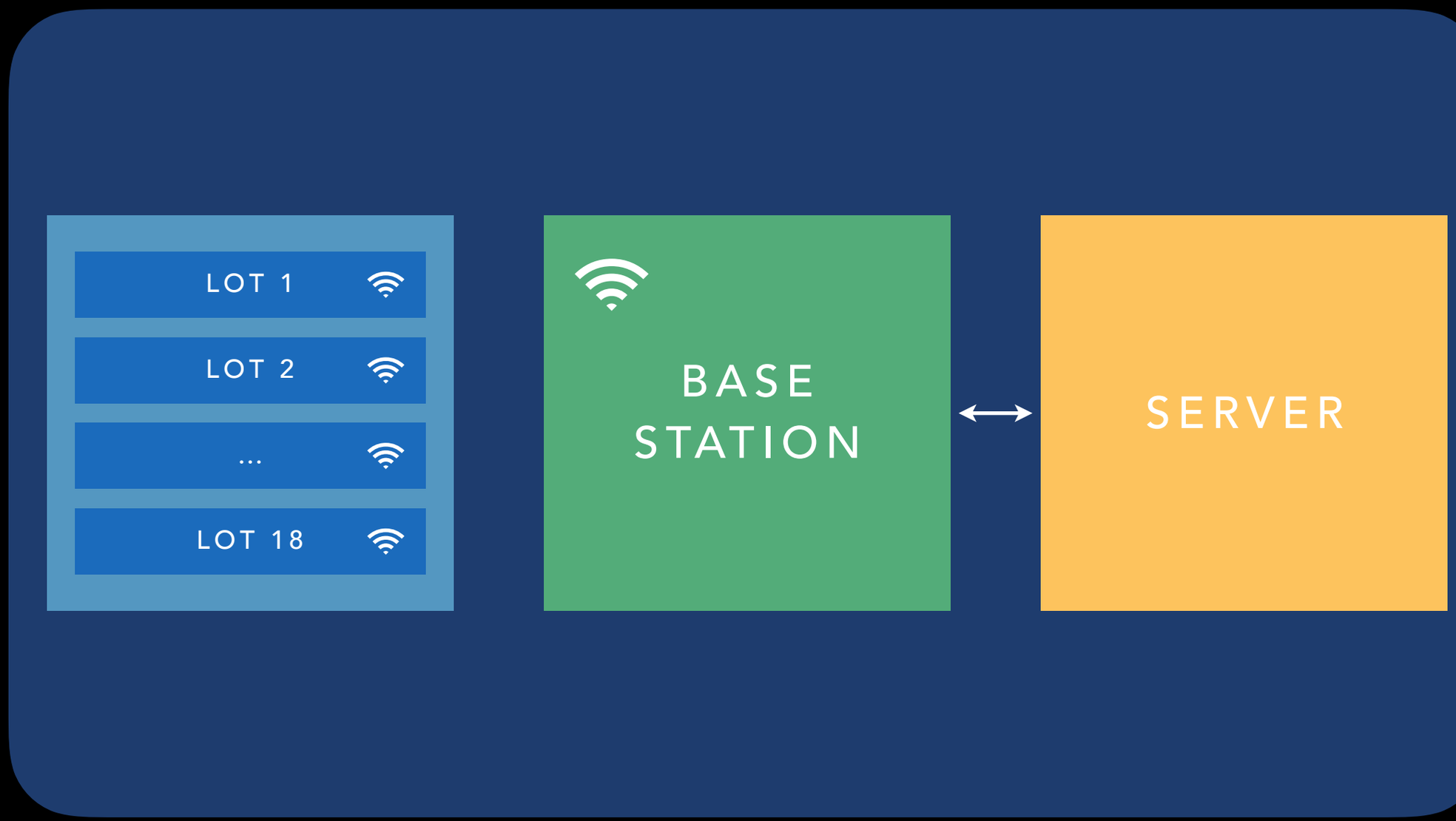
UPCOMING BASE STATION DEVELOPMENT TASKS

1	SPEED UP BASE STATION BOOT UP
2	STABILIZE V1.0 FIRMWARE FOR RASPBERRY PI
3	REFACTOR V1.0 FIRMWARE FOR ARDUINO WIRELESS RECEIVER
4	IMPLEMENT PROTOCOL FOR BASE STATION TO DETECTION UNIT COMMUNICATION

BASE STATION REQUIREMENTS ARCHITECTURE

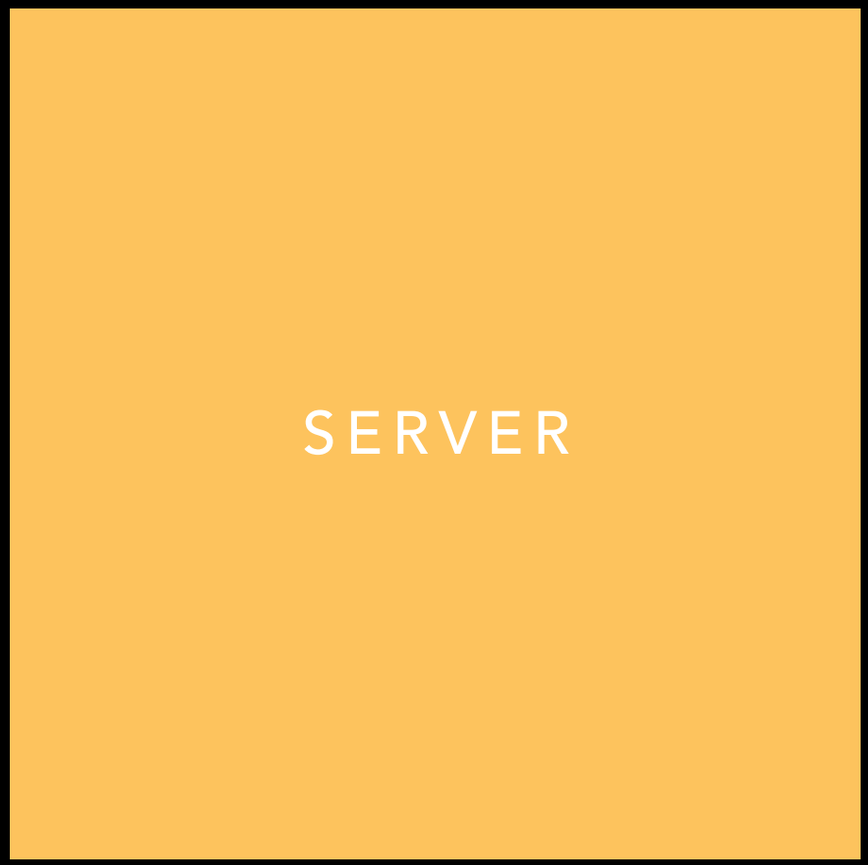


SENIOR PROJECT ARCHITECTURE

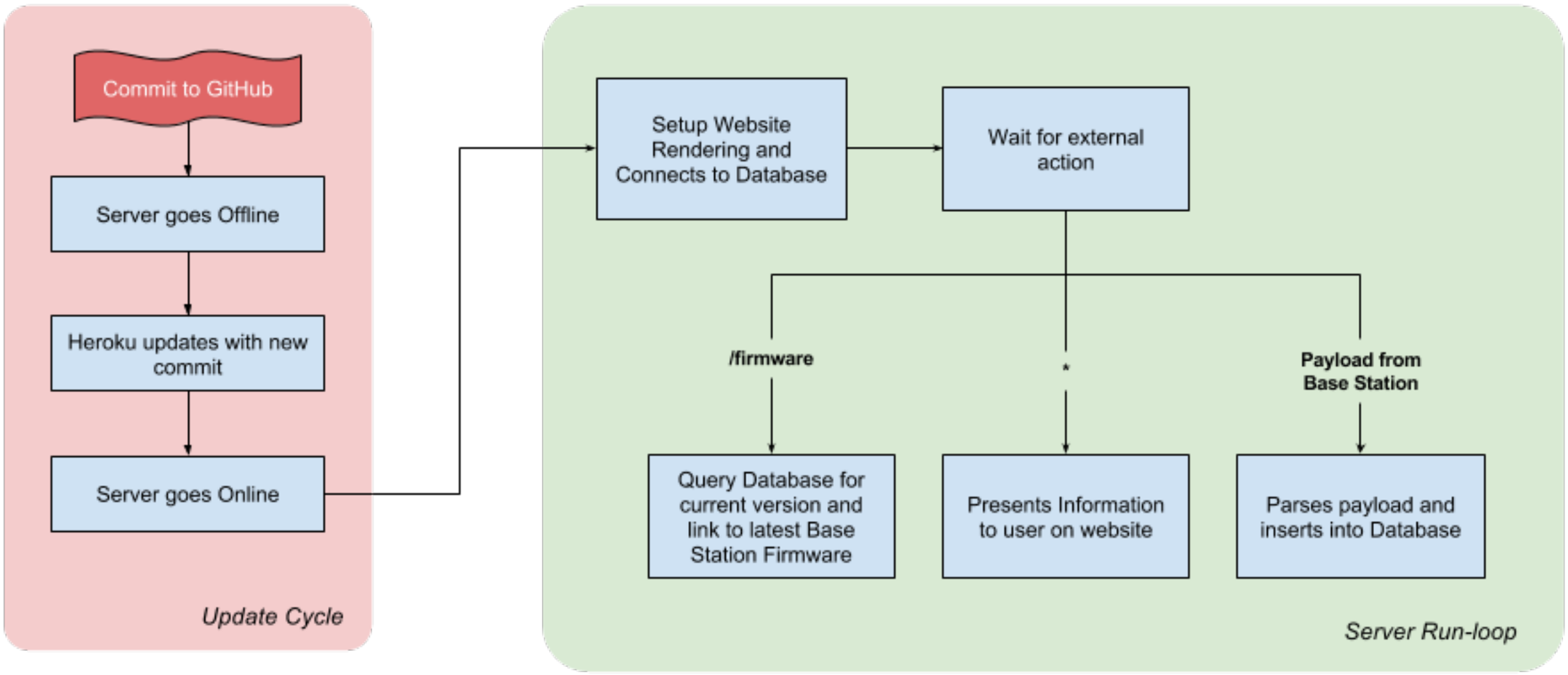


SERVER REQUIREMENTS

- Accept incoming payloads from Base Stations
- Reliable connection to Base Stations
- Can be updated with new software
- Provide a user interface for the occupancy of each lot
- Ability to store the status of each lot



SERVER SOFTWARE ARCHITECTURE



SERVER IS LIVE!

https://tcnj-traffic.herokuapp.com

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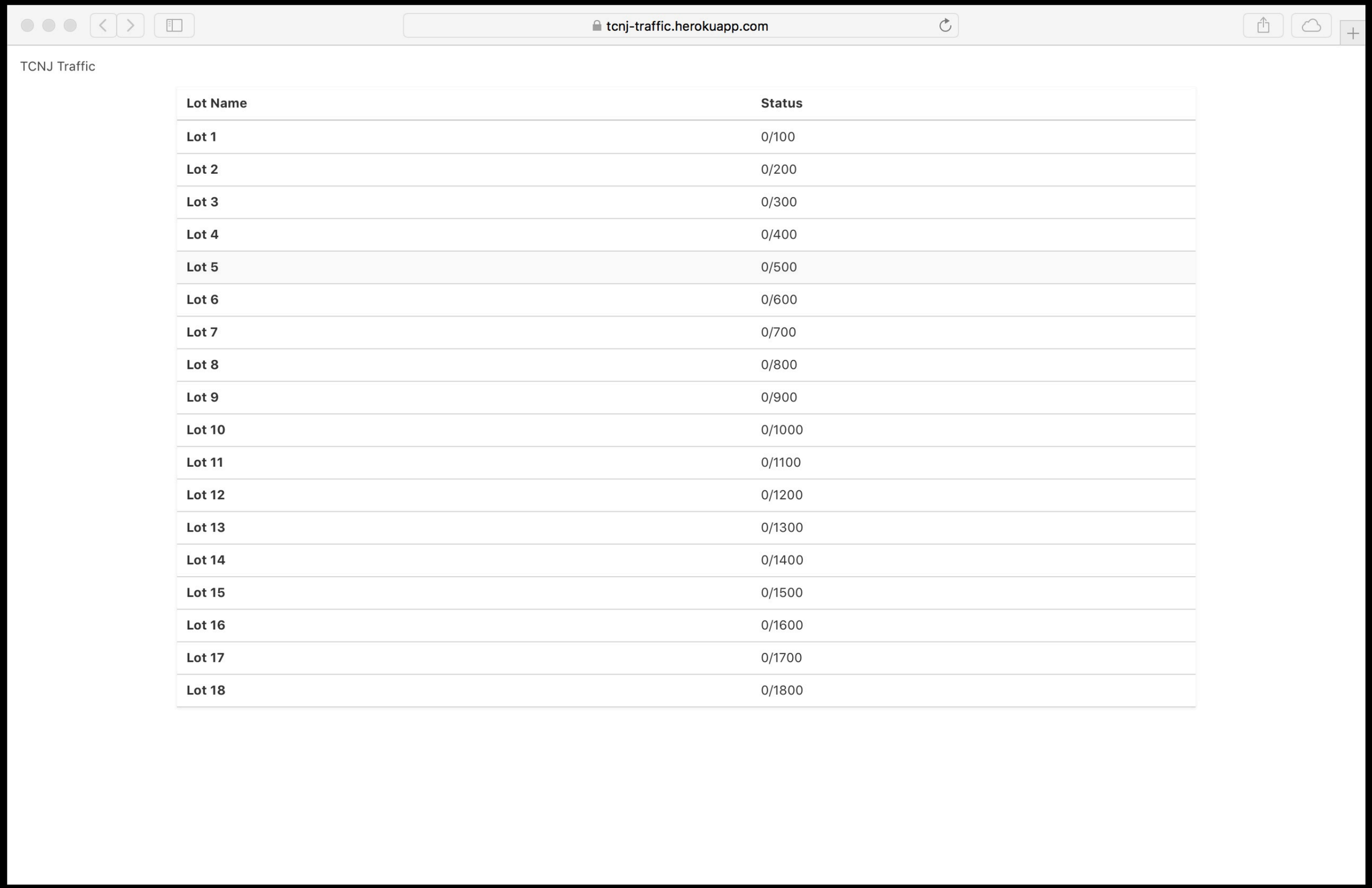
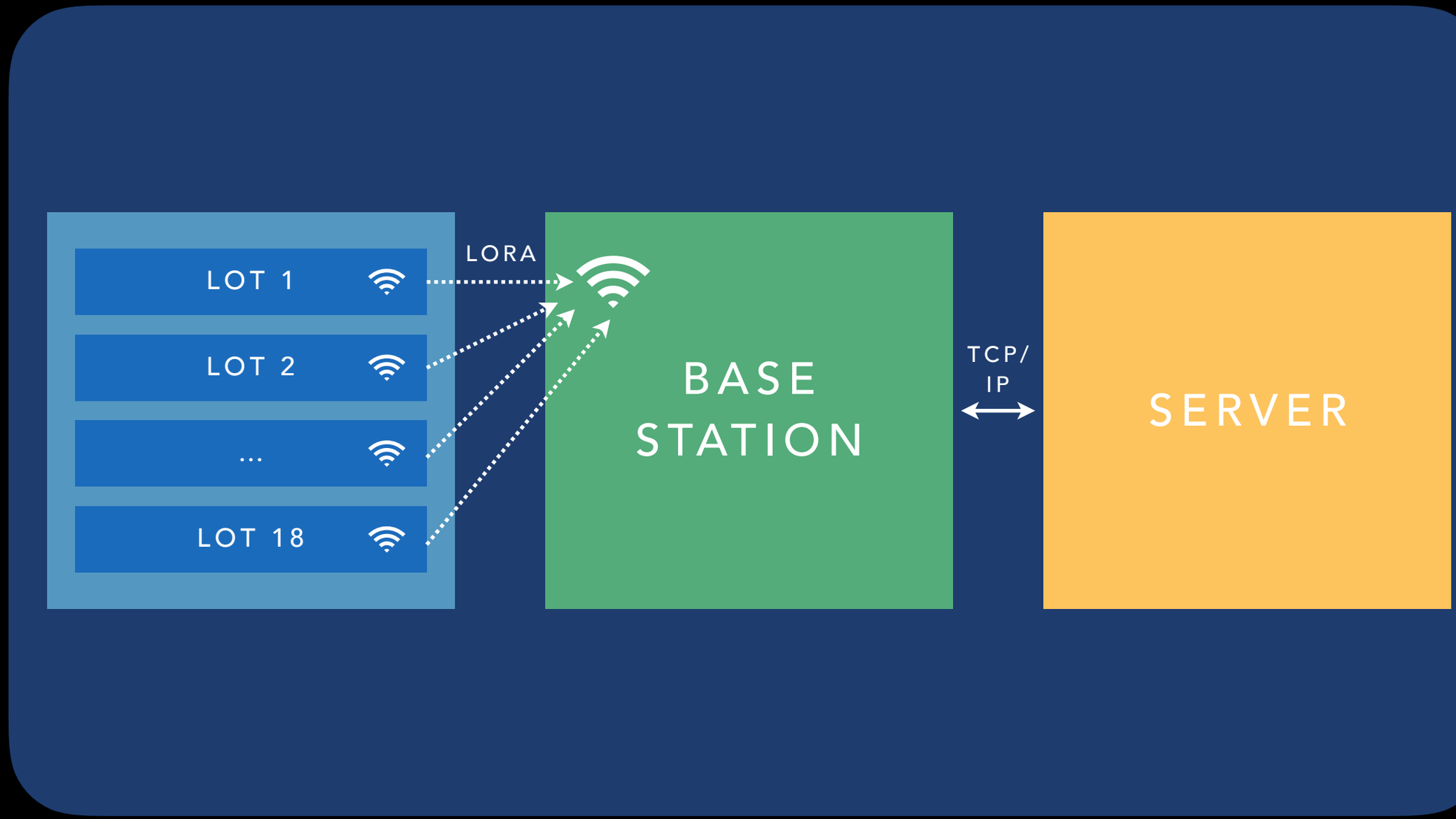


UPCOMING SERVER DEVELOPMENT TASKS

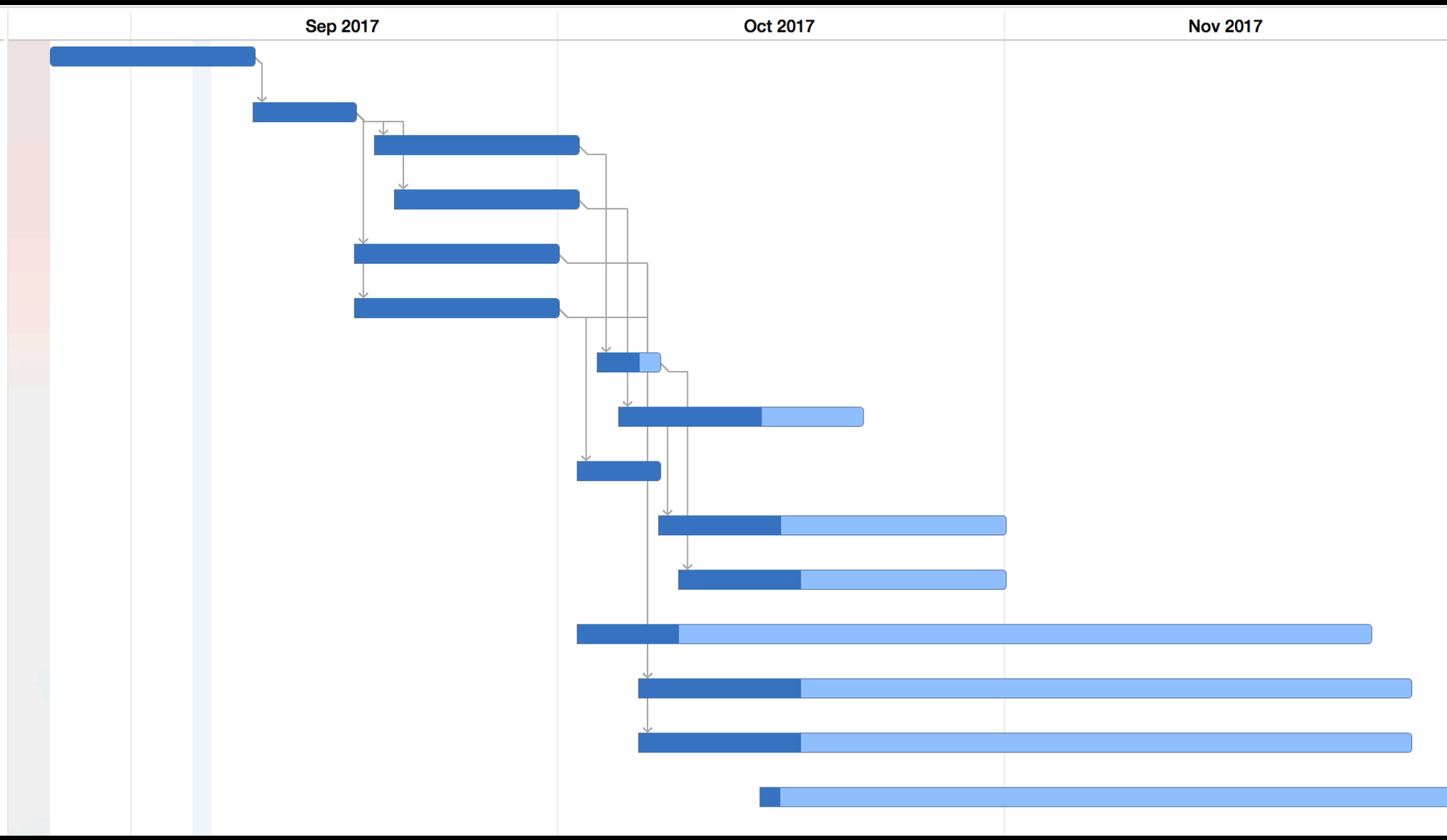
1	ADD STYLESHEETS TO FRONTEND OCCUPANCY SITE
2	ADD ADMINISTRATIVE ACCESS
3	ADD ABILITY TO VIEW AND MANAGE DETECTION UNITS
4	ADD ABILITY TO VIEW AND MANAGE CONNECTED BASE STATIONS

SENIOR PROJECT ARCHITECTURE



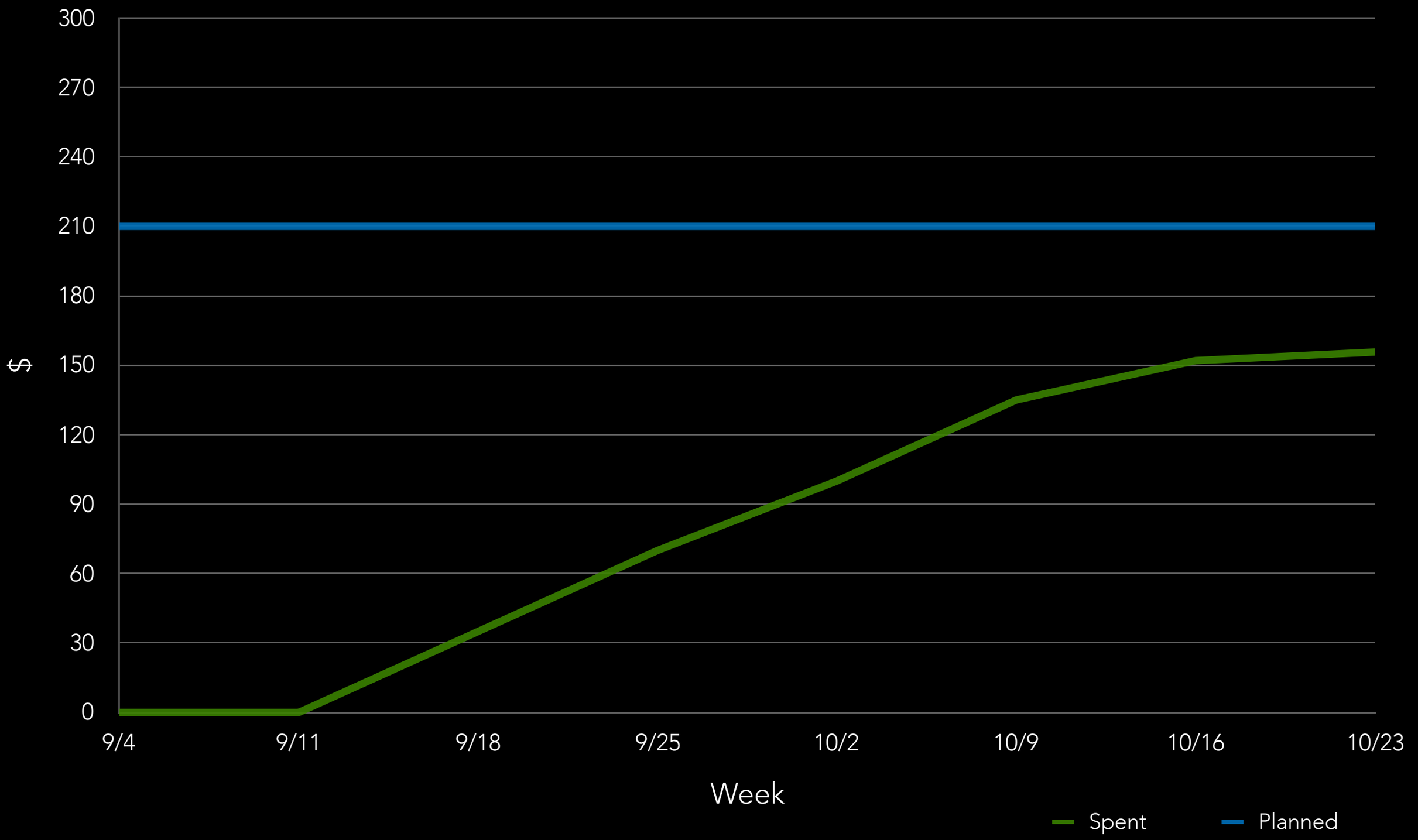
SCHEDULE

	Title	Effort
1)	Preliminary Research & Design	2w
2)	Schedule Tasks	1w
3)	Investigate Sensors for Detection Unit Detection	2w
4)	Investigate Hardware for Detection Unit Power System	1w 4d
5)	Investigate Hardware for Base Station	2w
6)	Investigate Software for Base Station & Cloud Server	2w
7)	Architectural Design for Detection Unit Detection	3d
8)	Architectural Design for Detection Power System	2w 2d
9)	Architectural Design for Base Station & Cloud Server	4d
10)	Order Parts for Detection Unit Detection	3w 2d
11)	Order Parts for Detection Unit Power System	3w 1d
12)	Detection Software Development	7w 4d
13)	Base Station Software Development	7w 3d
14)	Cloud Server Software Development	7w 3d
15)	Detection Unit Assembly	6w 4d



PROJECTED TIME BUDGET

PROJECTED COST BUDGET



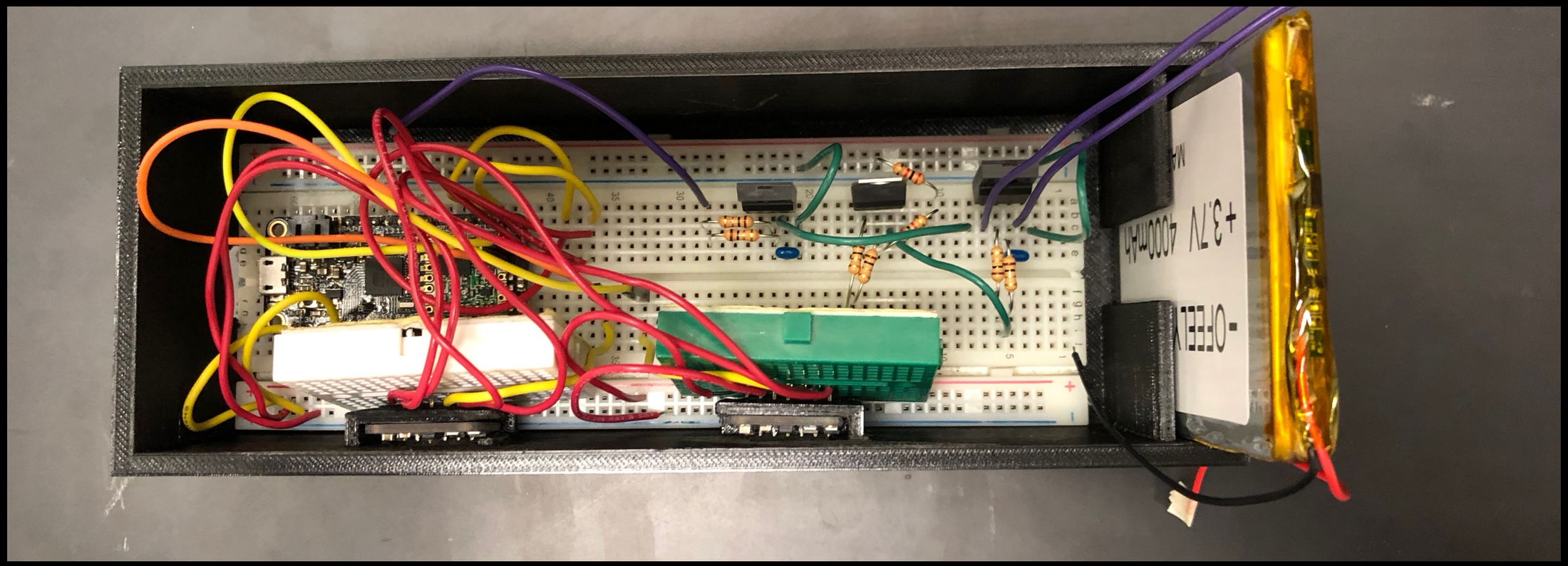
PROJECTED COST BUDGET

ITEM	QUANTITY	COST PER QUANTITY	TOTAL COST
ADAFRUIT FEATHER	2	$35	$70
RASPBERRY PI	1	$32	$35
LIDAR SENSORS	2	$15	$30
LIPO BATTERY	1	$17	$17
SCHOTTKY DIODES	2	$1.35	$2.70
LINEAR VOLTAGE REG	1	$0.53	$0.53
(DC/DC CONVERTER)	1	$0.47	$0.47
BUDGET			$400.00
GRAND TOTAL			$155.70
REMAINING FUNDS			$244.30

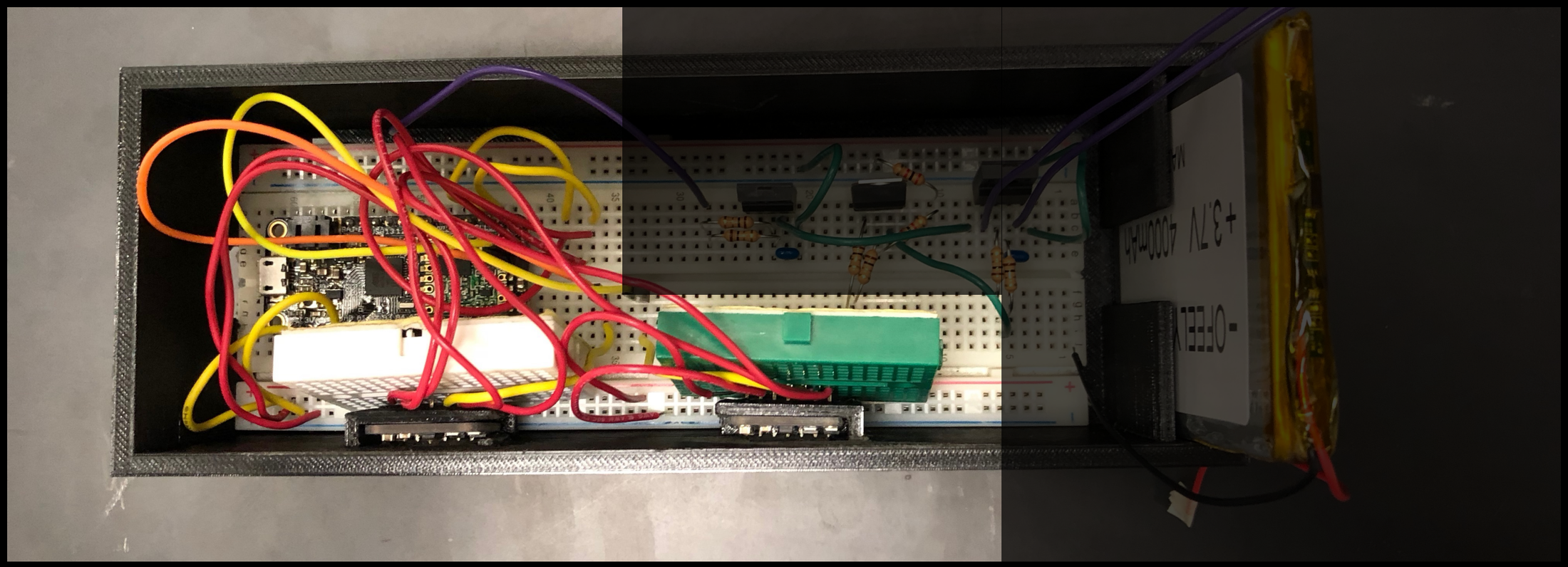
DETECTION UNIT

PROTOTYPE

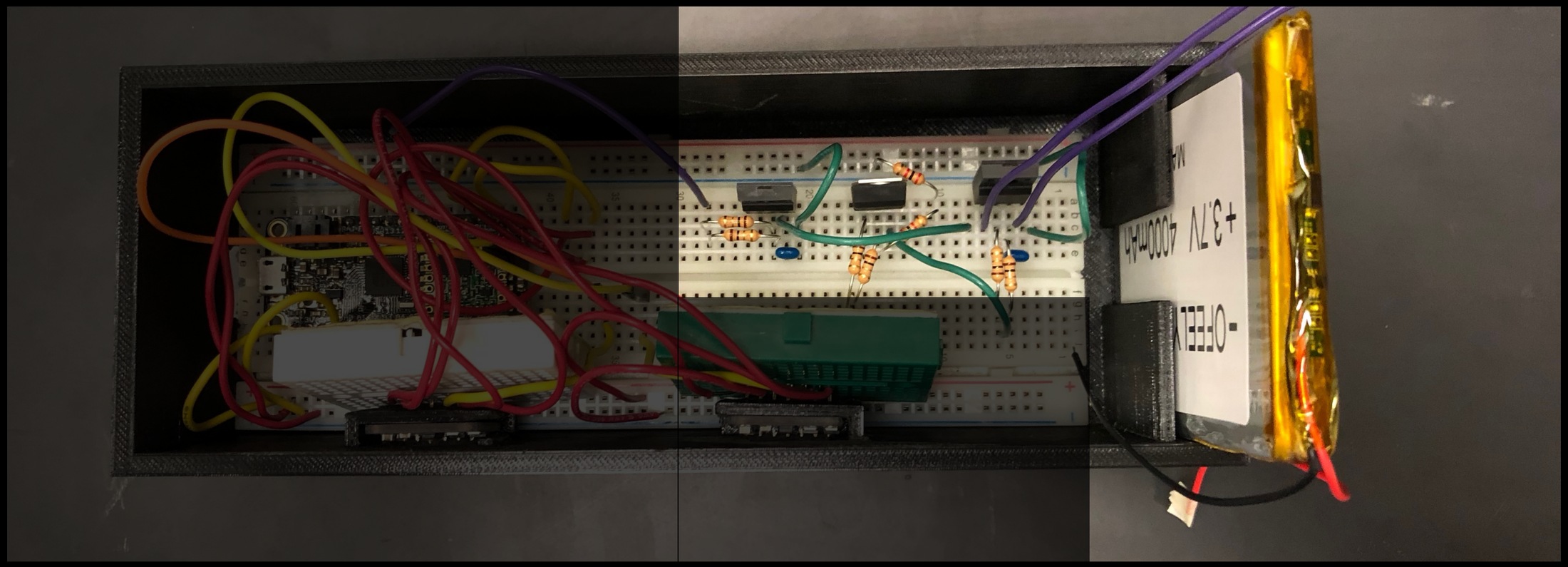
DETECTION UNIT PROTOTYPE



DETECTION UNIT CORE PROTOTYPE



POWER SUBSYSTEM PROTOTYPE



TCNJ
THE COLLEGE OF
NEW JERSEY

Parking Lot Availability System using a Campus-Wide Wireless Network

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