Team C9: GrubTub

Design Presentation

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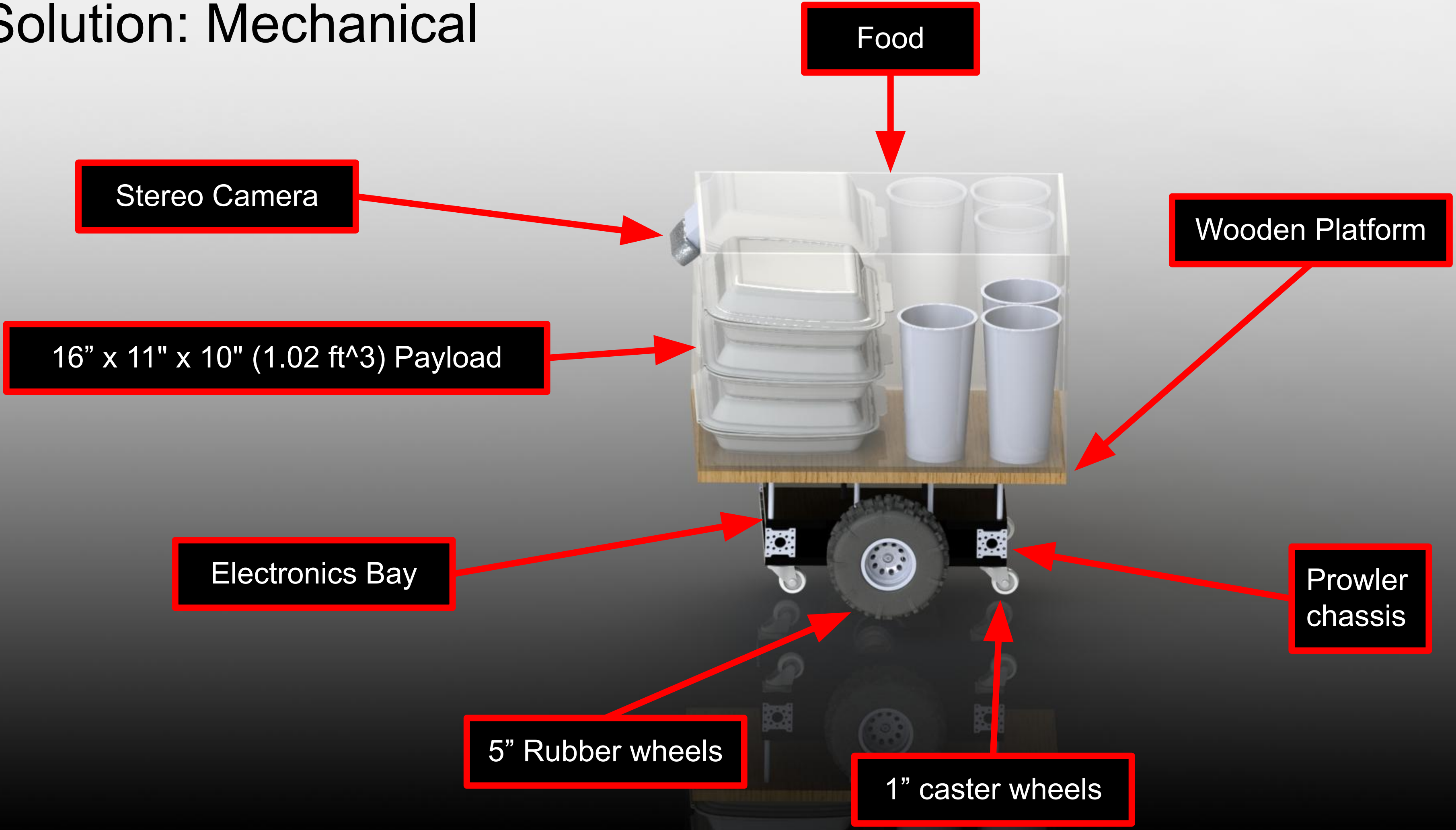
3/8/2021

Application Area

- On-campus food delivery
- Delivers food within campus roads
  - **No slopes**
- Must hold and transport multiple deliveries
- Must not collide with pedestrians
- Minimal human intervention
- Food delivery in a timely fashion
- Food must be intact during delivery

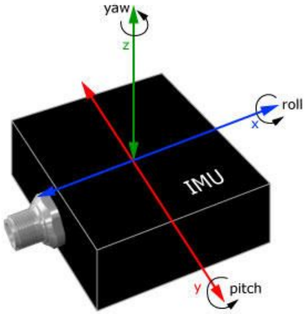
```
Wean Turtle              Doherty Main Entrance
0--89.62--1---38.74---2---53.97---3
|         |         /  |
32.29     31.68 49.62 34.7
|         |     /      |
4--91.91--5---39.59---6
Porter               Baker
```

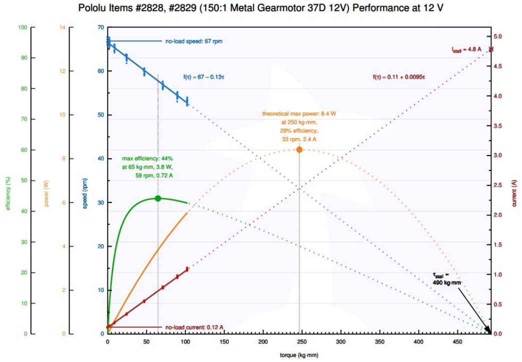
Solution: Mechanical

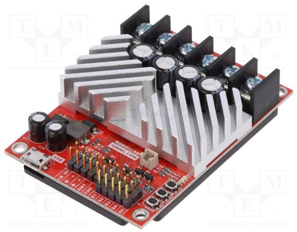


Solution: Hardware

- Jetson AGX Xavier
- Pololu 37D Gearmotors
  - Encoders included
  - Supplies enough torque
- RoboClaw Motor Driver
- Wi-Fi Module
- 2 x 5000mAh LiPo Batteries
- Sensors
  - Adafruit Ultimate GPS
  - BNO055 IMU (9-DOF)
  - Motor Encoders
  - Intel RealSense D415







BoE Calculations

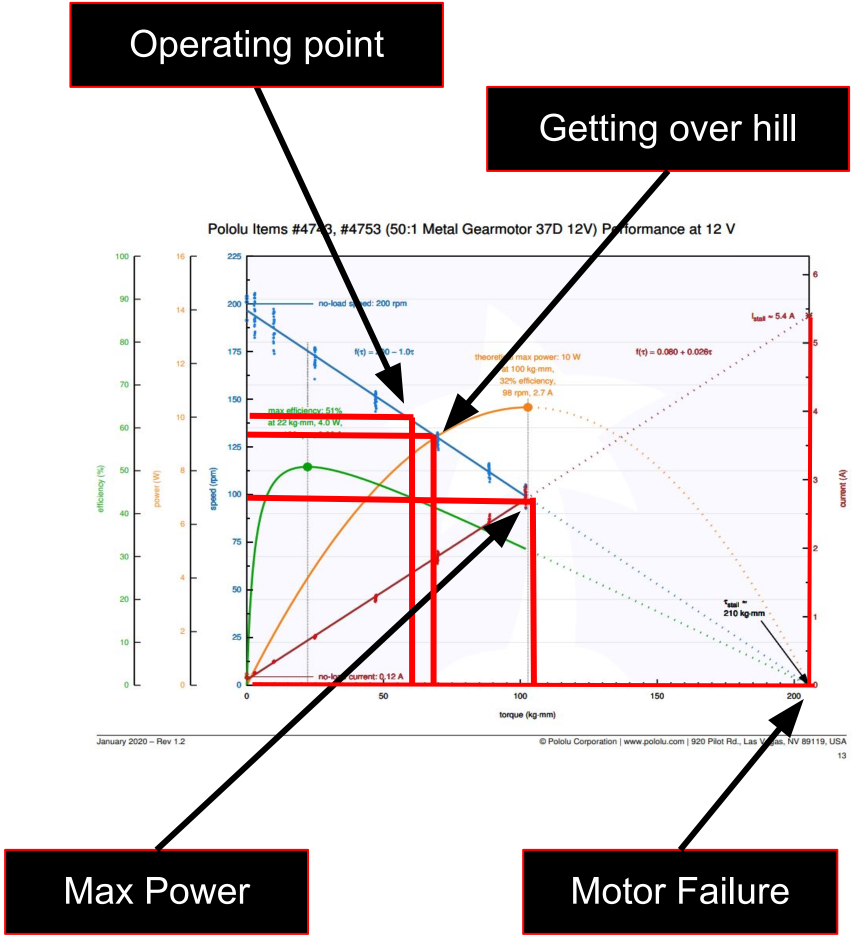
Assumptions

- M = 2kg + 3kg = 5kg
- R = 0.0685m,
- V = 1 m/s.
- K = tan(21) = 0.384 (21 degree incline for slack)

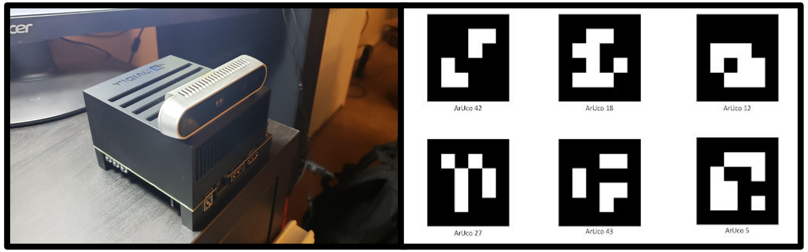
- 5.5 A stall current / motor
- 2.4 A x 2 = 4.8 A for two motors @ max power
- 3.38 A max draw from Xavier

Calculations:

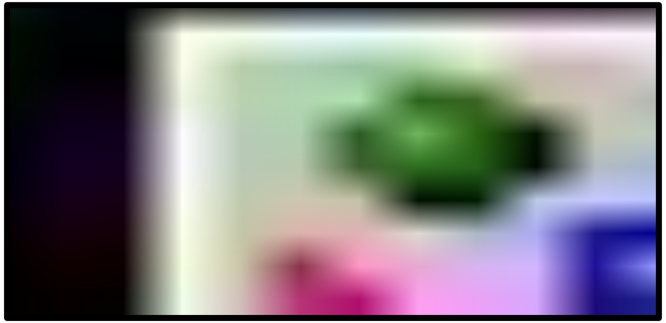
- With a **10 A*h battery** we can get 10 / (4.8A + 3.38A) = 1.2 hour
- Worst case @ 50% power efficiency = **36 min battery life (>30 min required)**
- Torque/motor = 0.5*Fr = 0.5*mgkr = **6.585 kg*cm**
- RPM = (60*v) / (π*2r) = **139.2 rpm**



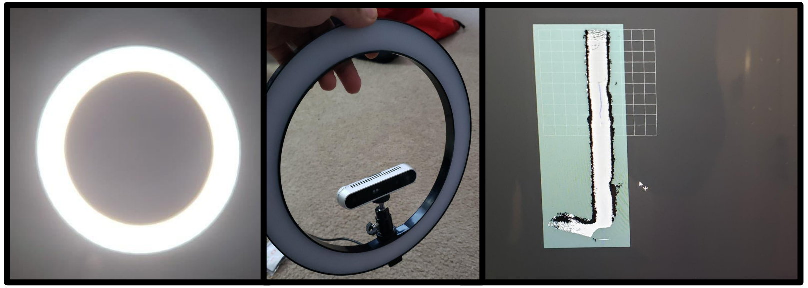
High-Risk Problems + Solutions



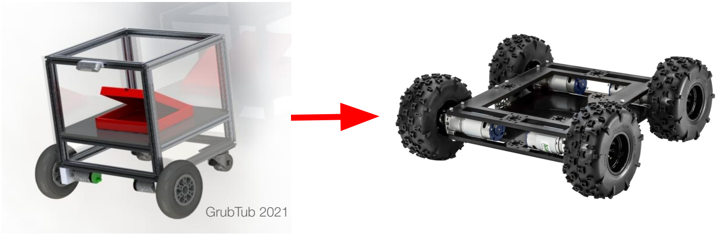
Running SLAM at 24 fps on Xavier



Path Planning/Waypoint following

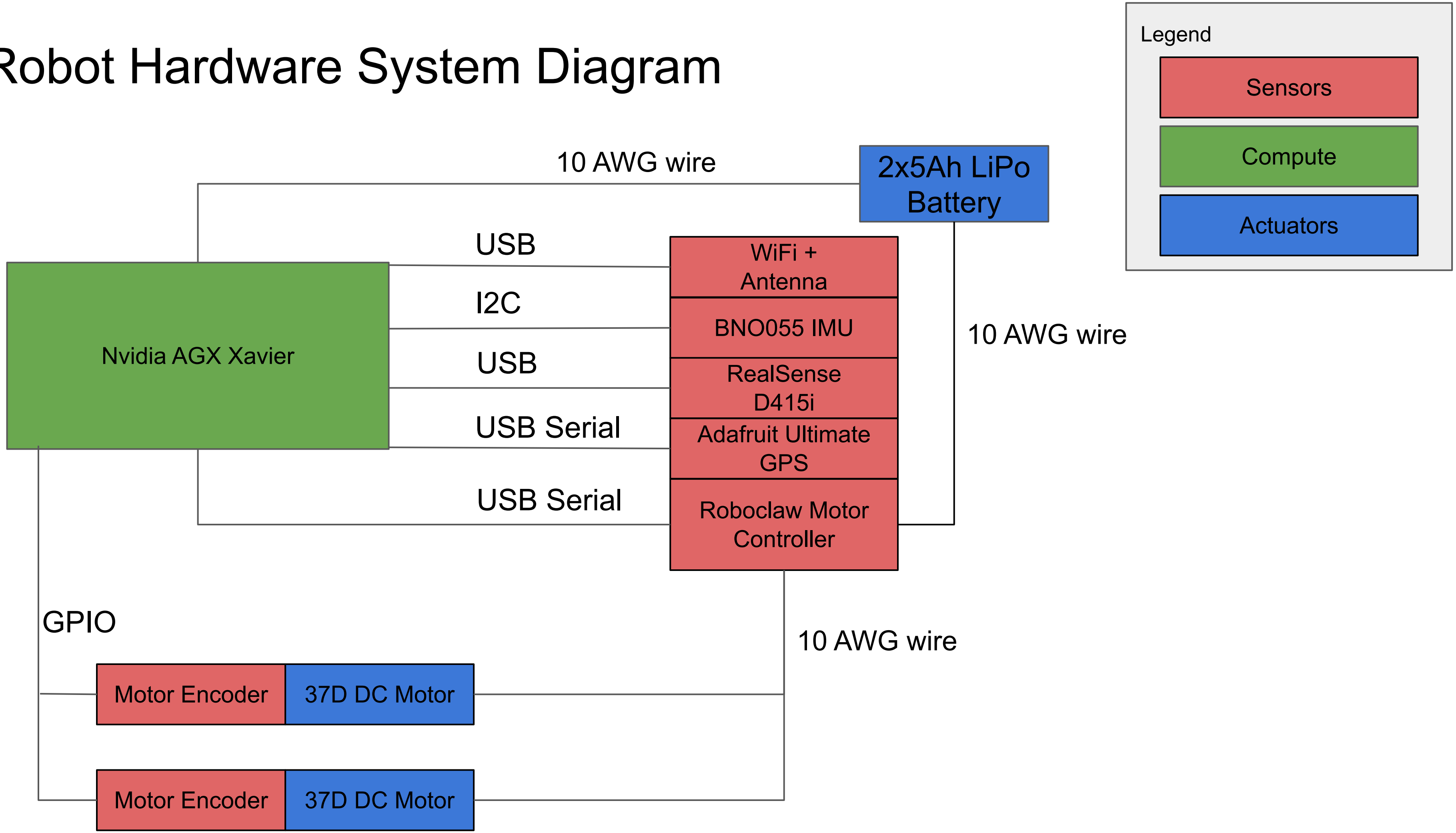


Running SLAM with bad lighting conditions

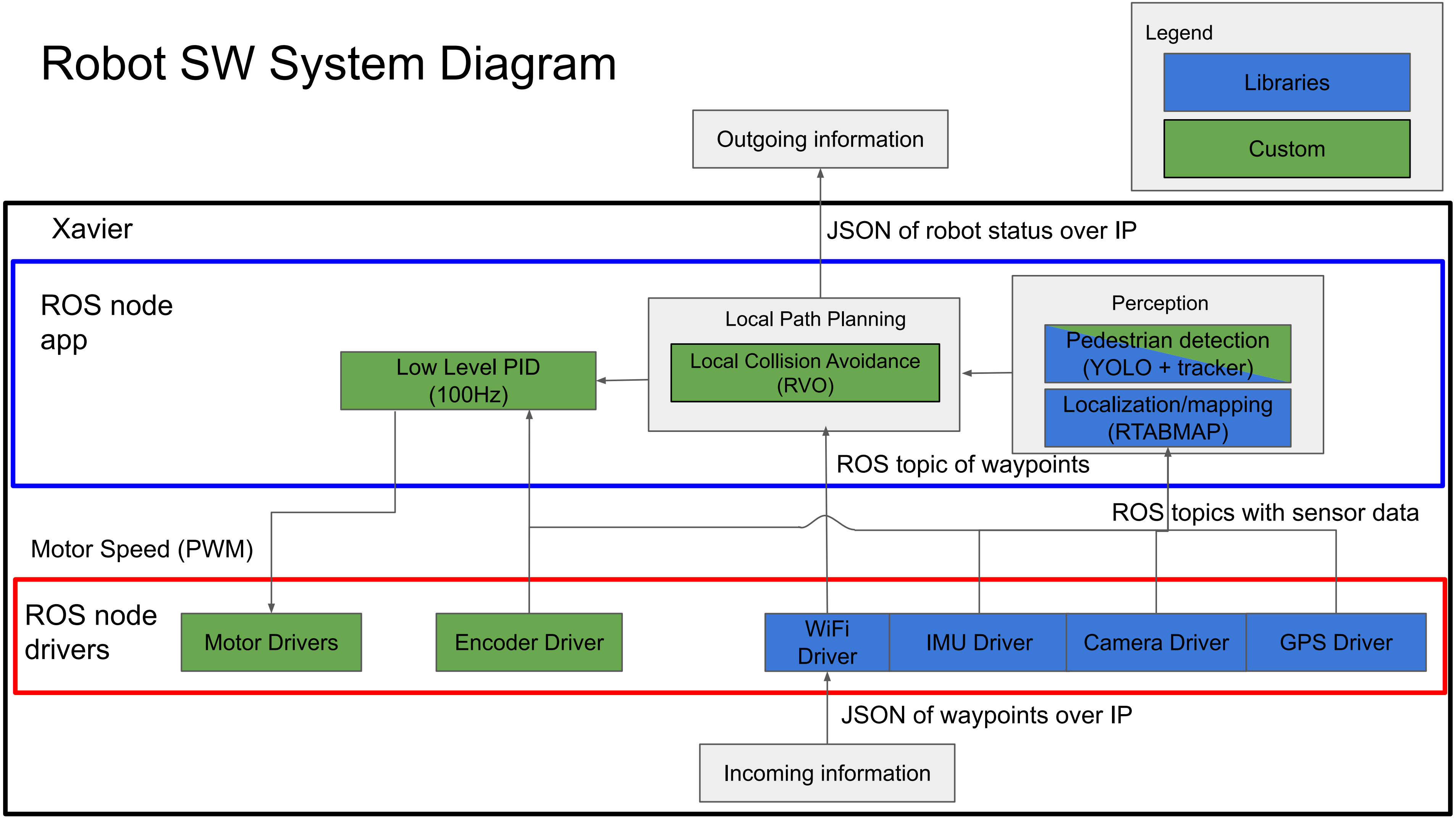


Creating and assembling the chassis

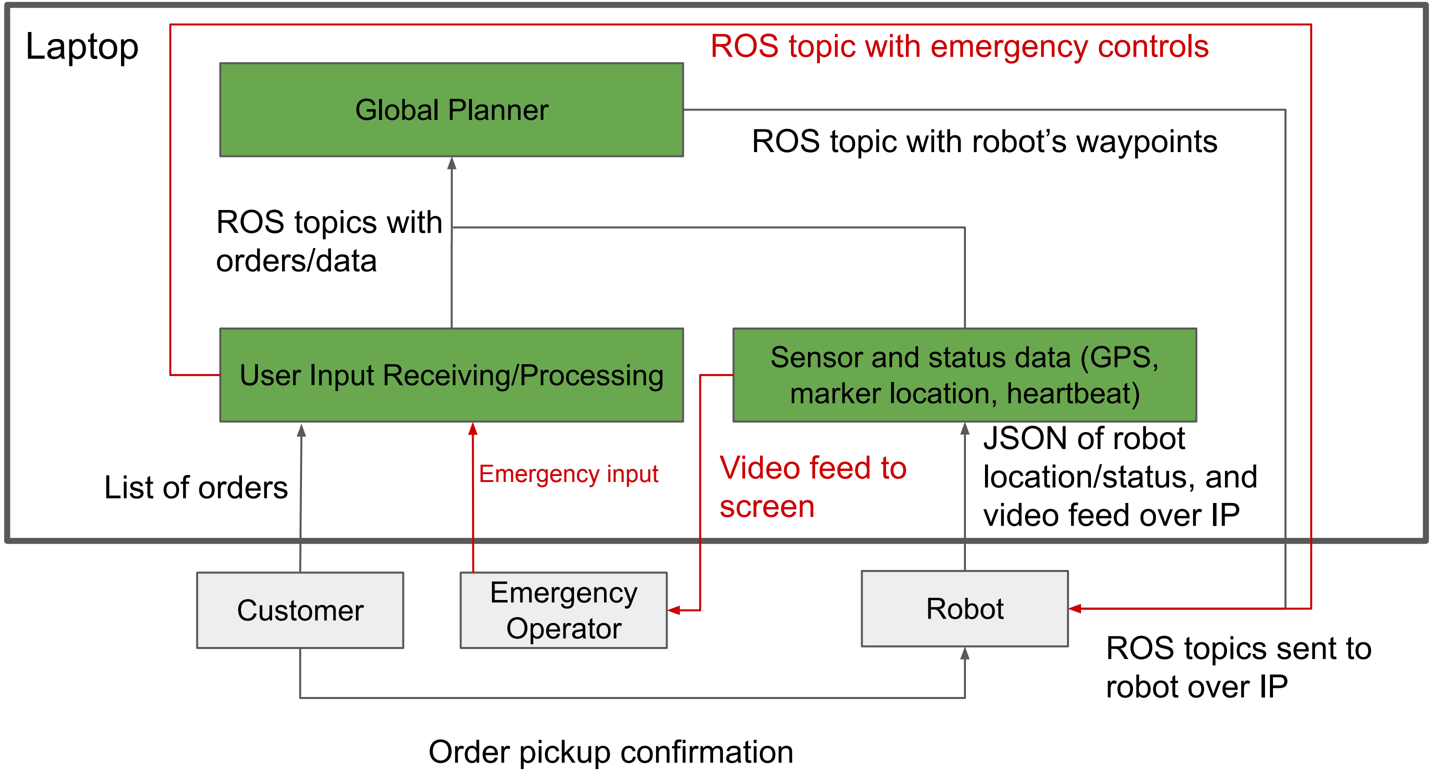
Robot Hardware System Diagram

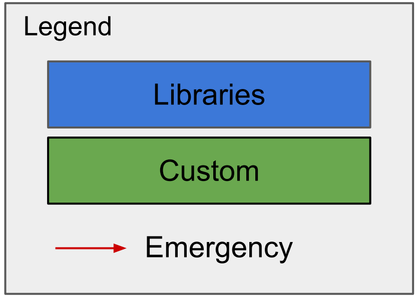


Robot SW System Diagram



System (Overall + Ground Station)





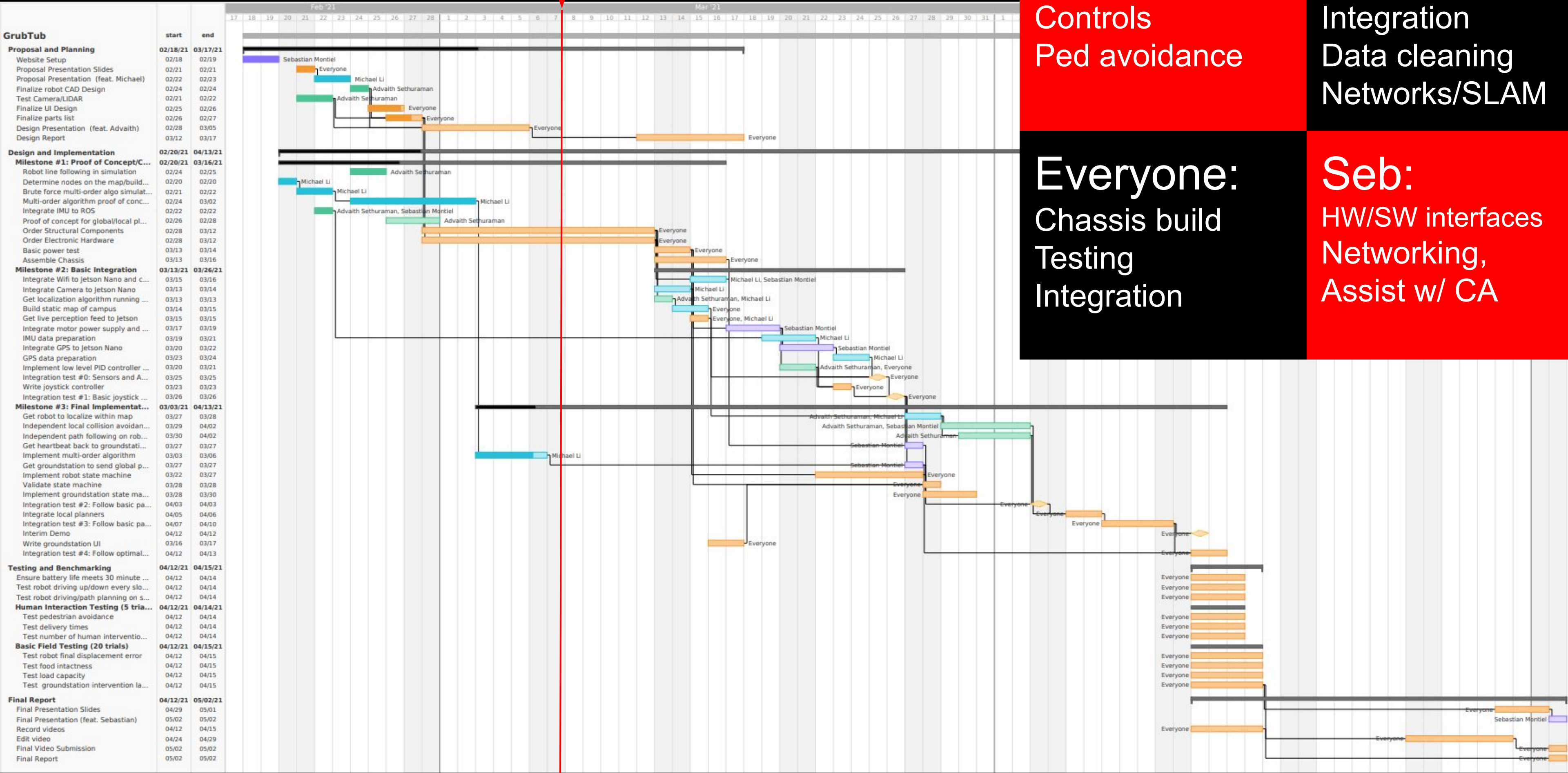
Testing, Verification, and Metrics

Requirement	Testing Method	Metrics
Robot must deliver food on campus roads **No slopes**	Test robot driving only on sidewalk areas	> 65% of time (s) on sidewalk than the grass (assuming robot goes half as fast on grass)
At least 30 minutes of battery life	Run robot until out of battery	Battery lasts > 30 mins
Robot must arrive close to the drop-off point	Test robot and measure delivery error	Within 1m 68% of the time (Gaussian) Within 3m 100% of the time $\|\|door - road\|\|_2$
Robot must transport multiple deliveries at once	Attempting to deliver increasingly heavy orders weighed beforehand	Must hold and transport 2kg food at 1 ft^3
Food must be intact during delivery	Test the number of times food is damaged from delivery in “Field Testing” runs	Food must be intact 100% of the time.

Testing, Verification, and Metrics

Requirement	Testing Method	Metrics
Robot must not collide with pedestrians or other objects	Have pedestrians walk near the robot while it is in transit.	Minimum distance >= .25 m at all times
Minimal human intervention	Give robot orders to random locations and empirically record the number of interventions/distance	Interventions/distance <= 1 intervention/50 meters
Robot must deliver food in a timely fashion	Give robot many random orders at once with varying payload weights and track the delivery time for each order	Each delivery time must be less than HRTT (human round trip time) measured in seconds
Robot must connect to ground station for emergency interventions and tracking	Robot does full tour of campus, using RosPing to quantify latency	Tail latency < 750ms, need time for robot to report emergency position and control takeover

Schedule



Advaith:
SLAM
Controls
Ped avoidance

Michael:
Multiorder algo
Integration
Data cleaning
Networks/SLAM

Everyone:
Chassis build
Testing
Integration

Seb:
HW/SW interfaces
Networking,
Assist w/ CA