Team 11:
Design of an Autonomous Ground Vehicle
For Intelligent Ground Vehicle Competition

FLORIDA A&M UNIVERSITY – FLORIDA STATE UNIVERSITY – FLORIDA INSTITUTE OF TECHNOLOGY

FAMU-FSU College of Engineering(COE)

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Sponsored by:

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Motivation

To implement distributed engineering by collaborating with Florida Institute of Technology by dividing goals and working effectively

College of Engineering

Florida Institute of Technology

Distributed Engineering

Why:

- Geographically Separated Institutions
- Prepare for Industry jobs
- Multidiscipline Collaboration

How:

Communication

- Slackbot – Overall Team and Sub Team Messages
- Google Hangouts – Teleconferences
- Semester Visits

File Sharing

- GrabCAD – CAD File Sharing
- OneNote drive – Report and Note Sharing
- GitHub – Code Sharing

Intelligent Ground Vehicle Competition (IGVC)

June 2nd 2017 at Oakland University (Rochester, MI)

Multidisciplinary Competition with Real World Application

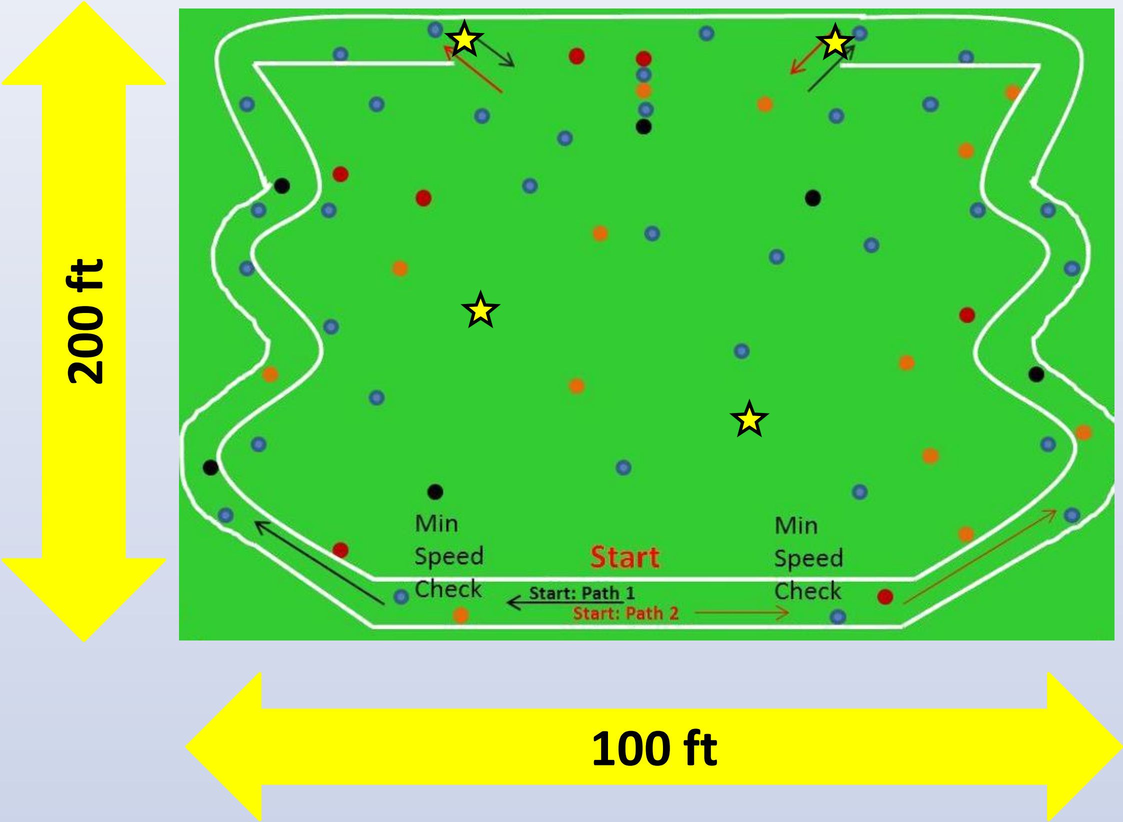
- Disciplines
  - Electrical Engineering
  - Computer Science and Engineering
  - Mechanical Engineering
- Applications
  - Self driving car
  - Warehouse robot
  - Manufacturing

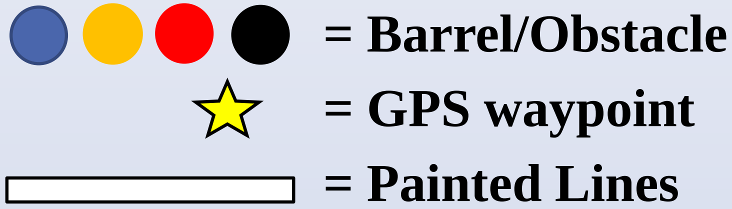
Three Challenges:

- Design
- Software Integration
- Auto-Nav Challenge

IGVC : Auto – Nav Challenge

Course





Scored on:

- **Time**
- **GPS Waypoints**

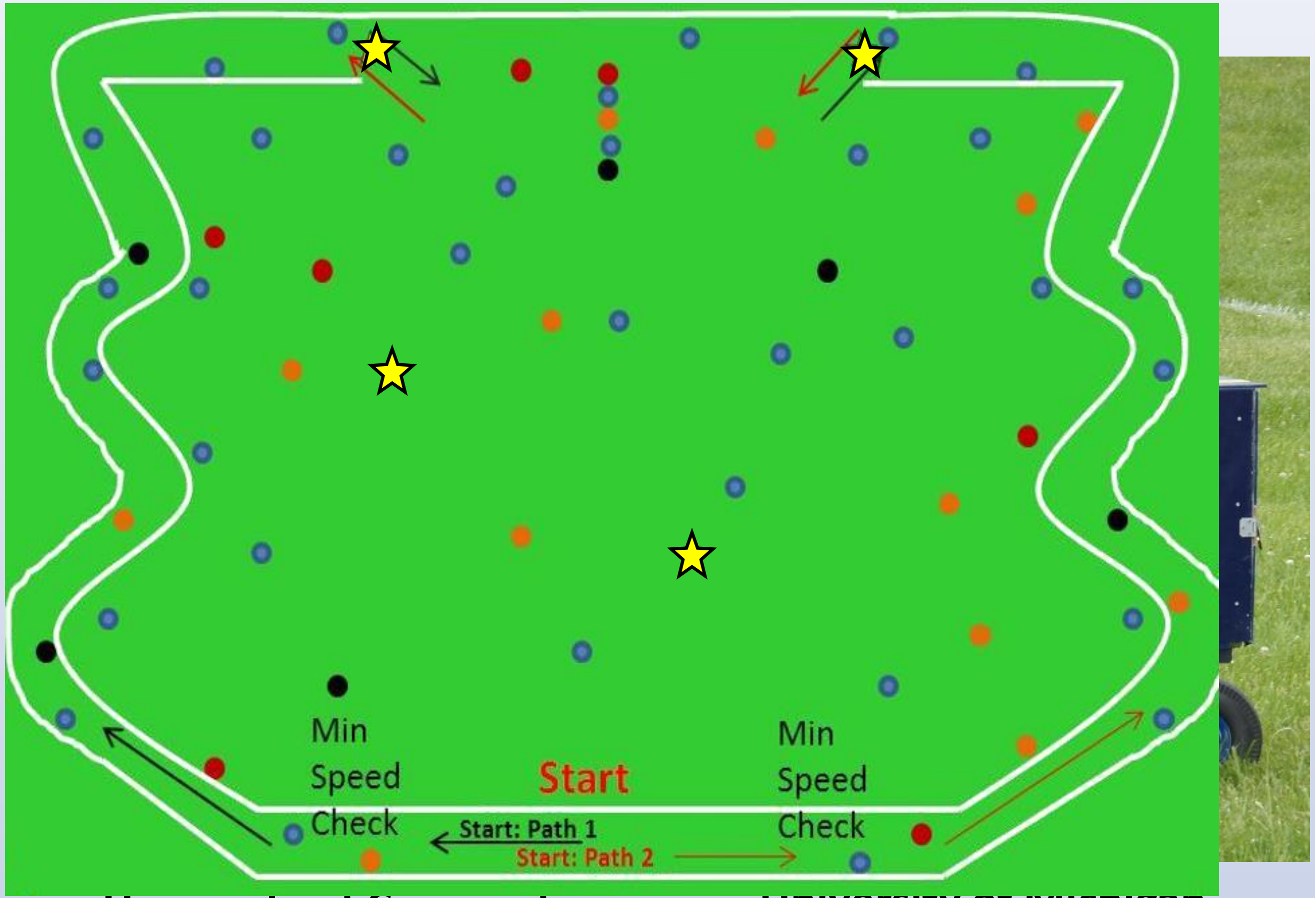
IGVC: Constraints

- 1 mph ≤ Speed ≤ 5mph
- GPS Waypoint-2 meter accuracy
- Safety
  - Wireless/Hard E-Stop
  - Emergency Light

Dimensions of the Vehicle:

- 3ft < Length < 7ft
- 2ft < Width < 4ft
- Max Height - 6ft

- Payload: 20lb - 18” x 8” x 8”
- Water Resistant



University of Cincinnati University of Michigan

Course

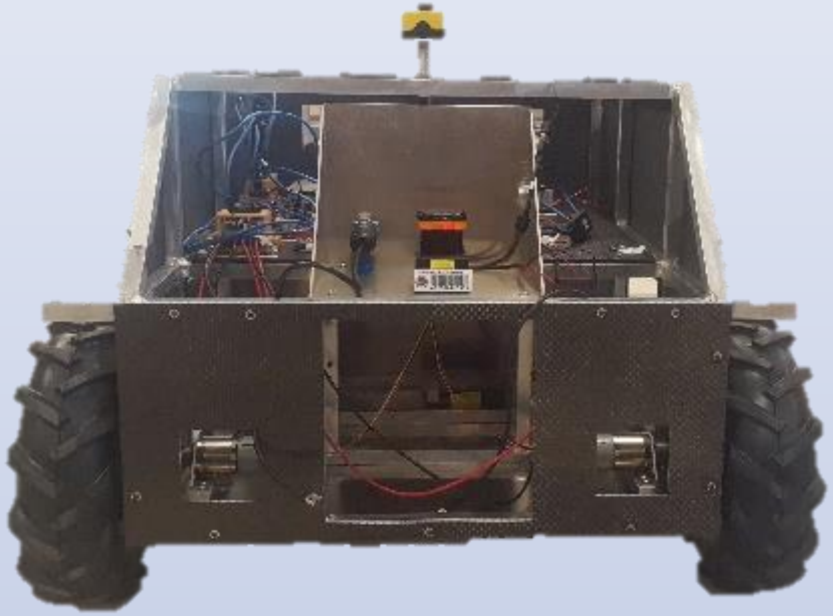
Project Statement

Goal: Design and develop an autonomous ground vehicle capable of competing in the Intelligent Ground Vehicle Competition in June 2017.

- COE Goals:
  - Platform Design
  - Hardware Integration
  - Localization

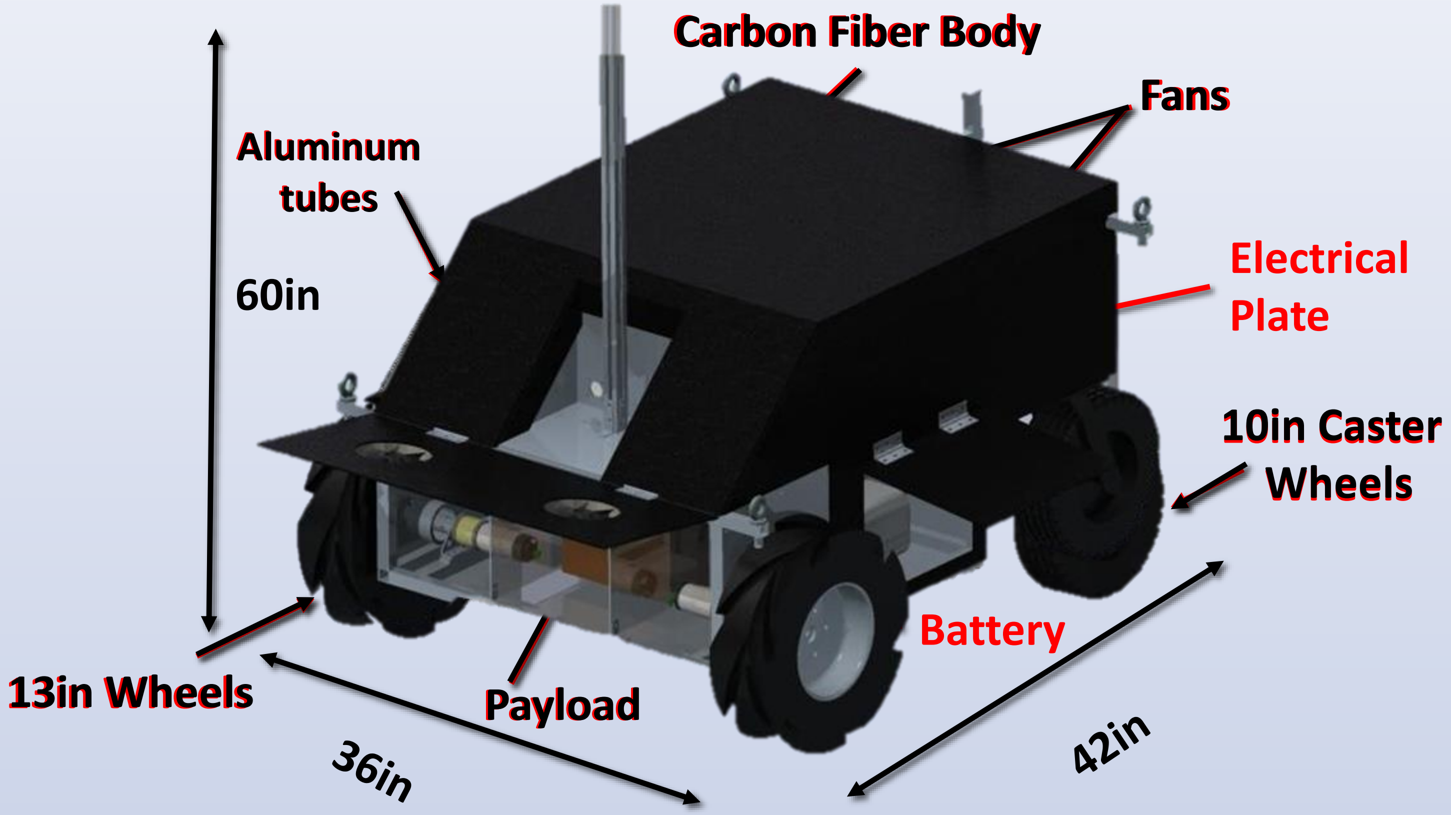
- FIT Goals:
  - Perception
  - Object Detection
  - Motion Planning

Platform Design

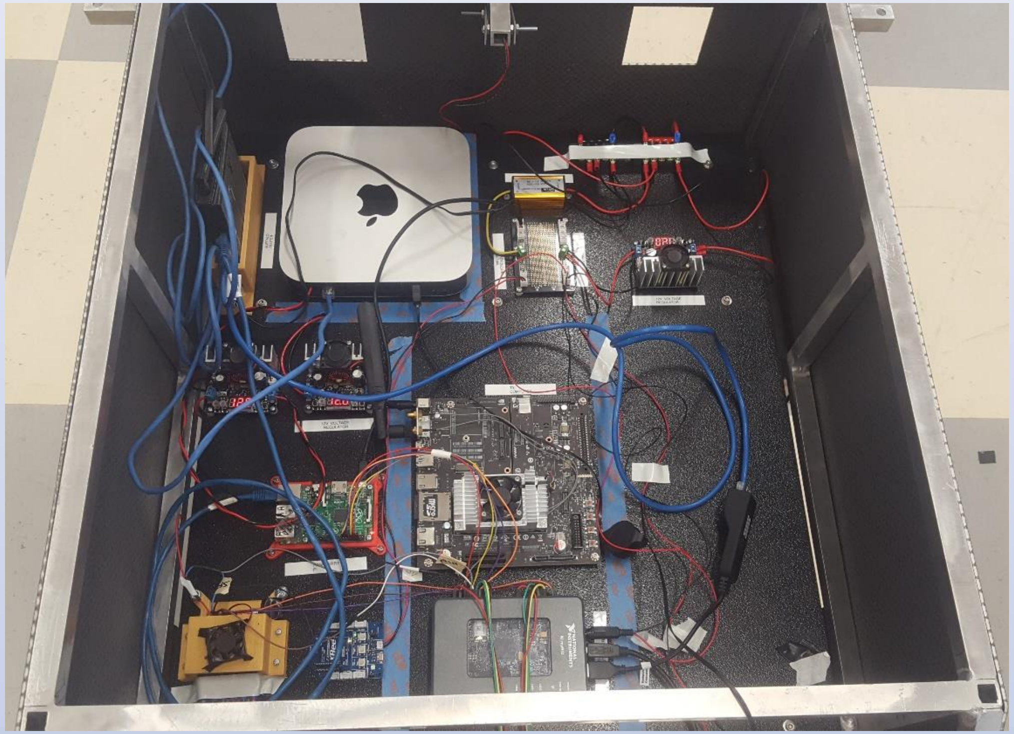


Vehicle Overview

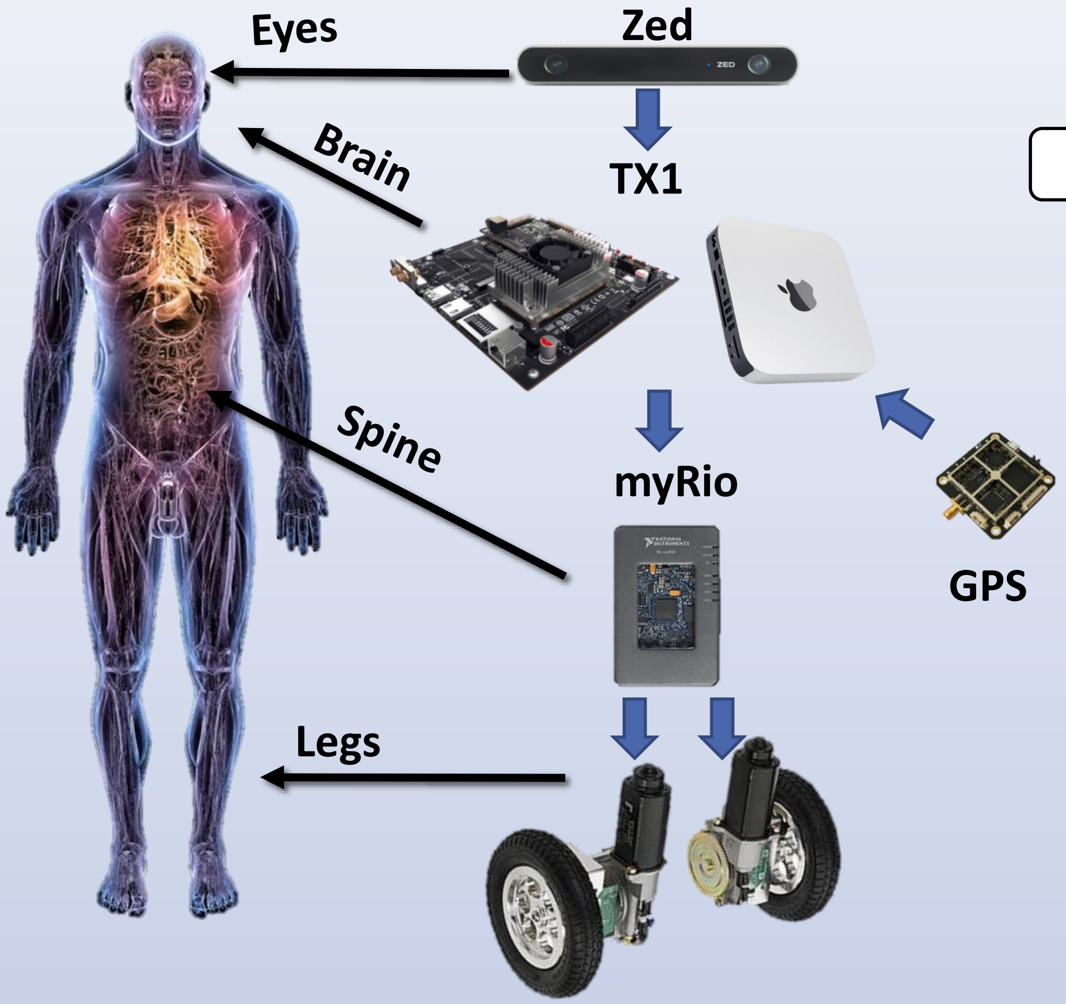
- Structural Design
  - Frame: Hollow Aluminum Tubes
  - Body: Carbon Fiber
- Vehicle Maneuverability
  - Differential Steered
- Weight Distribution
  - Payload
- Ease of Maintenance
  - Cooling
  - Accessibility

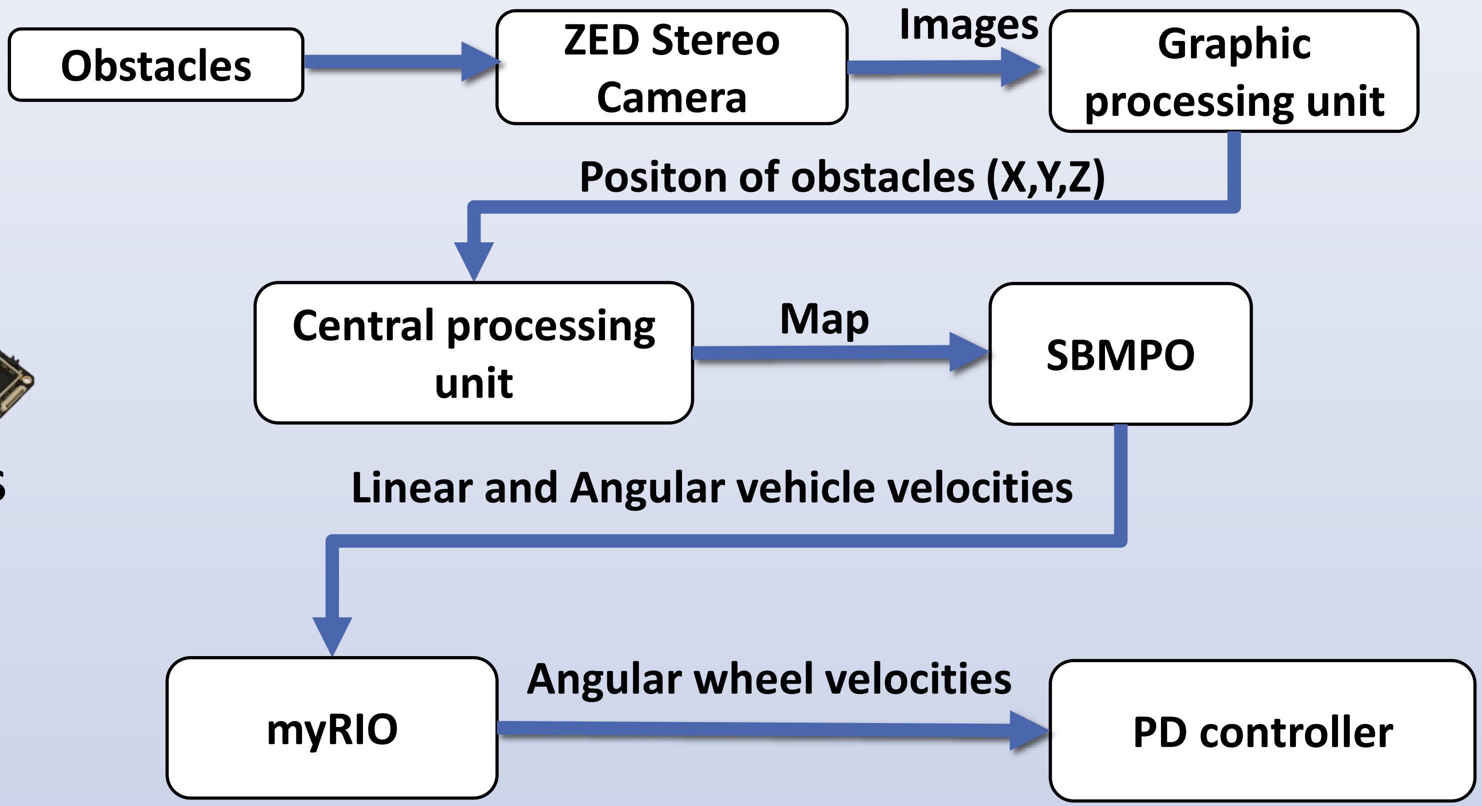


Hardware Integration



Autonomous System Operation

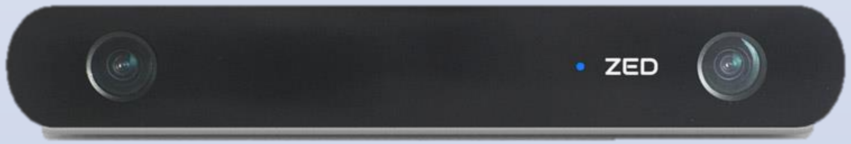




Perception (Eyes)

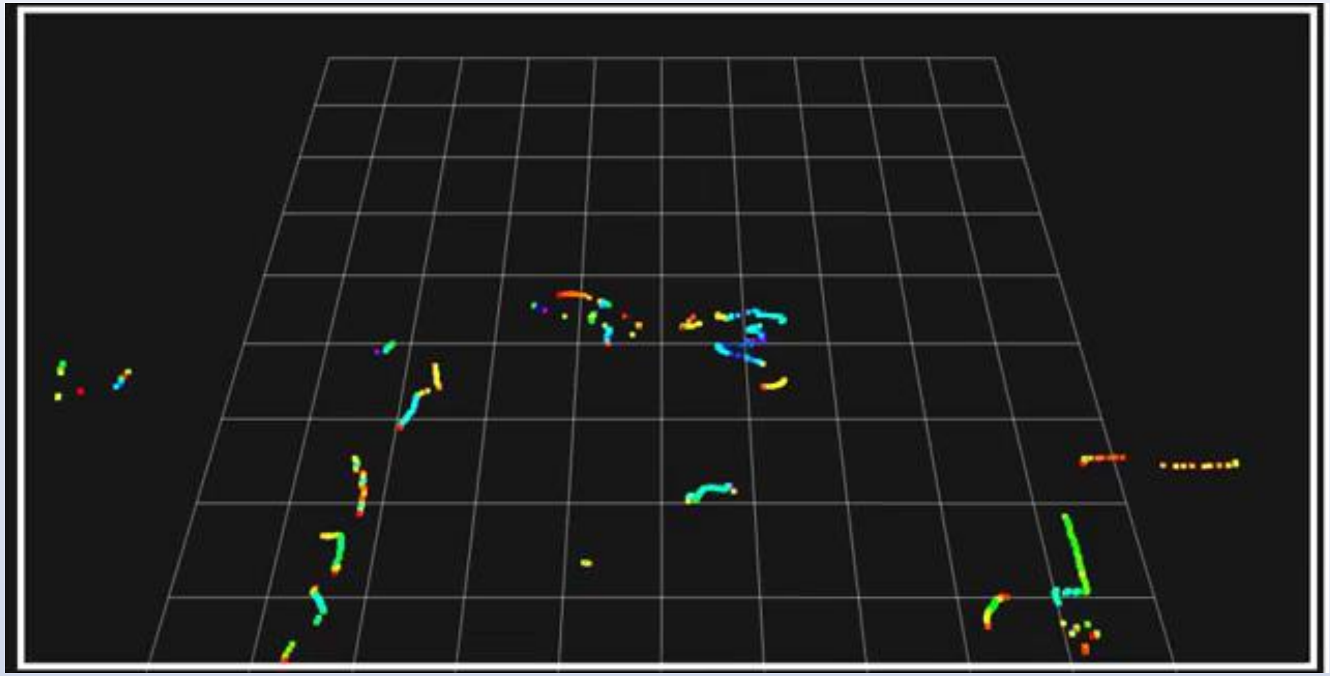
- LIDAR
  - Streaming Object Data
  - Visualize Obstacles
  - Fill Up Occupancy Grid
- Line Detection
  - Detecting Lines in Certain Conditions

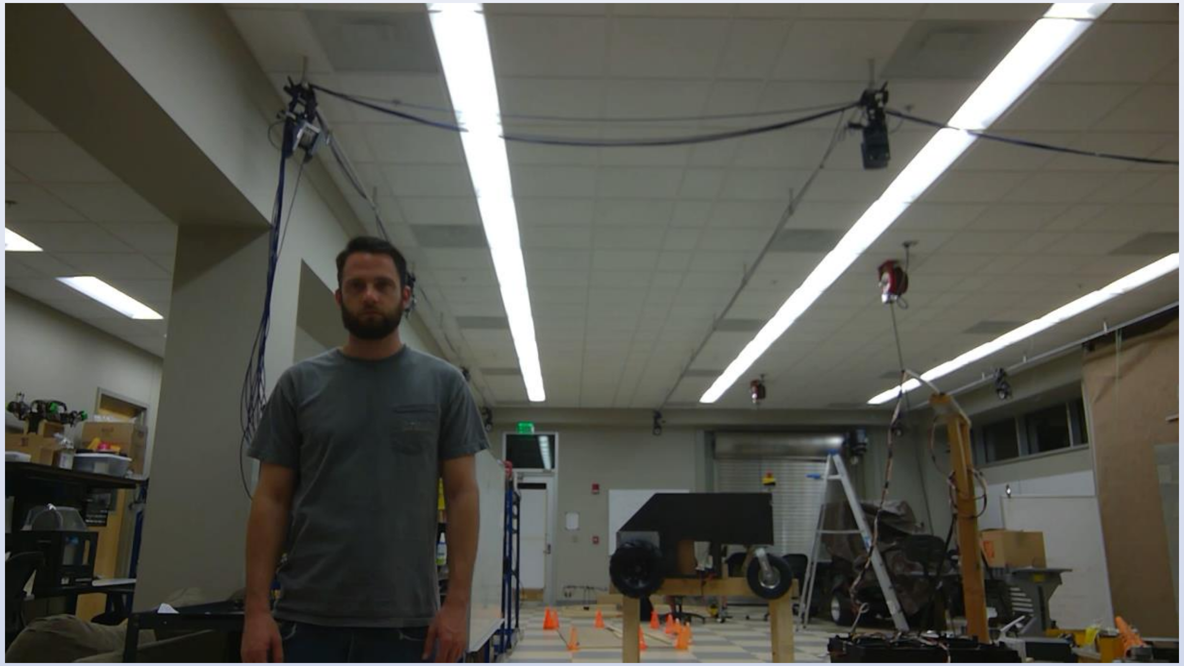
Hokoyu LIDAR



ZED Camera

Perception (Eyes)





Perception (Eyes)

Localization (Brain)

Piksi by SwiftNAV

- Centimeter Accuracy (With Base Station)
- 2-3 Meter Accuracy (Without Base Station)
- 10 Hz Update Rate

Quadrature Encoders to Output Shaft

- 700 Ticks per Revolution
- Gear Ratio-50:1

•Inertial Measurement Unit

- Orientation

Piksi by SwiftNAV

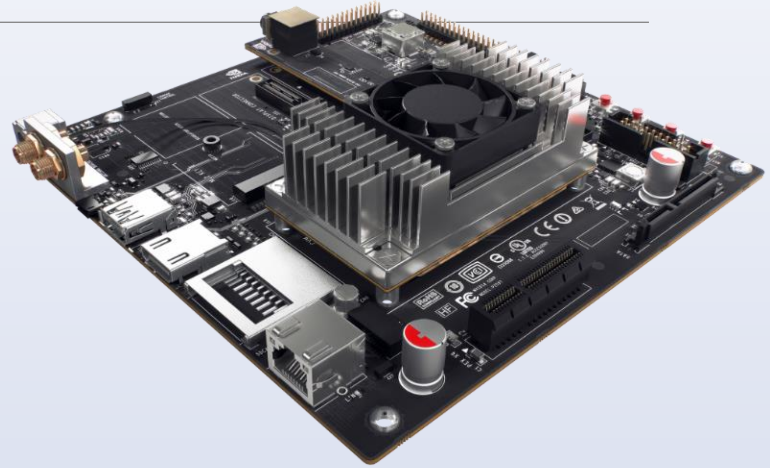
Example Encoder

IMU

Computer (Brain)

Nvidia Jetson TX1

- Powerful GPU
- Processing Raw Images from ZED.



Jetson TX 1

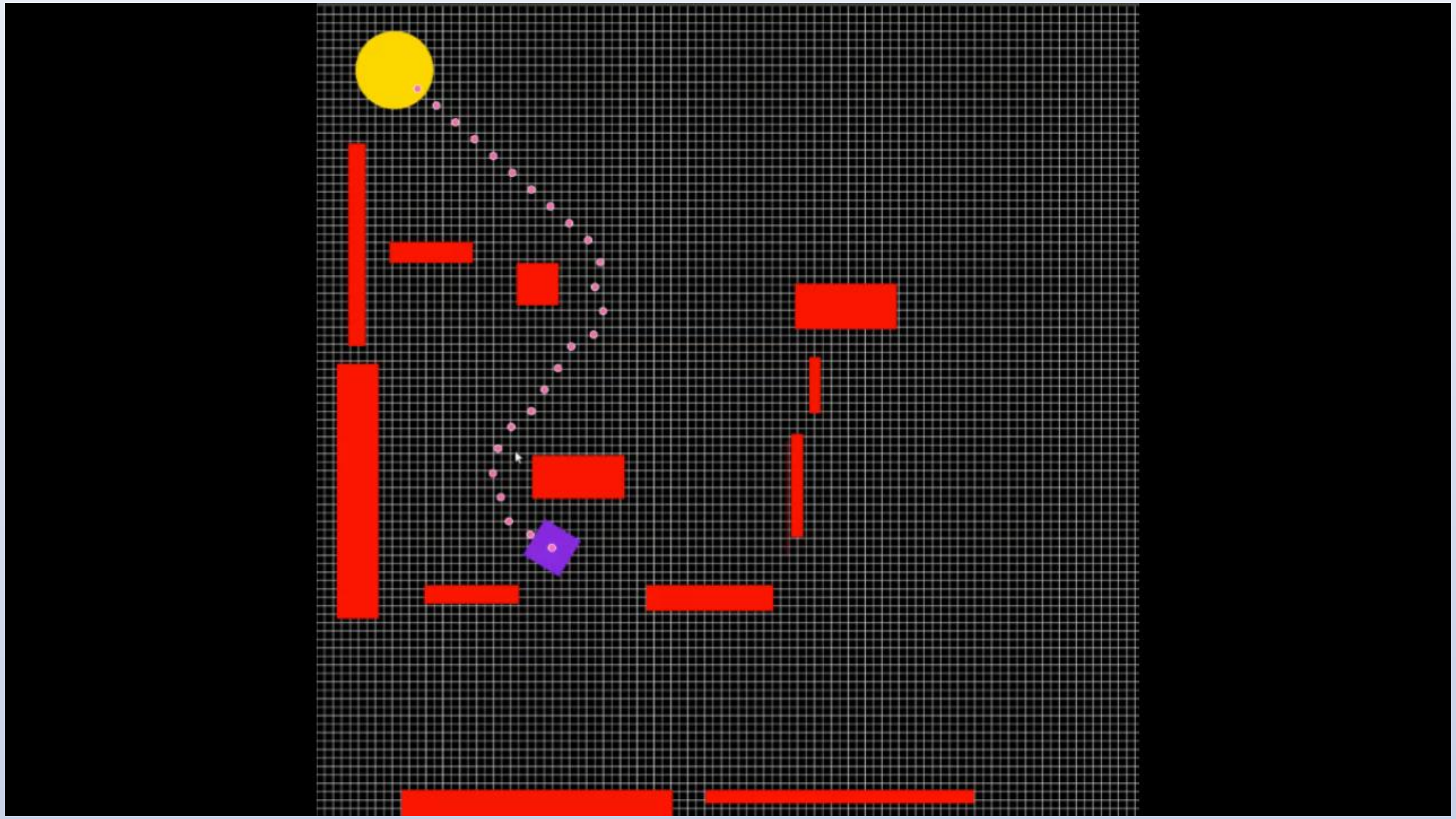
Mac Mini

- Used for CPU
- Processing Trajectories from Motion Planner (SBMPO)

Mac Mini

Computer (Brain)

Motion Planner Simulation



Motor Control (Legs)

- Receives Vehicle Command Velocities (Linear and Angular) from Motion Planner
- Programmed through MyRIO/LabVIEW
- Implemented PD Controller for Effective Velocity Control for Position
- Encoders Determine Error in Position and Velocity

MyRIO Microcontroller

Motor Control (Legs)

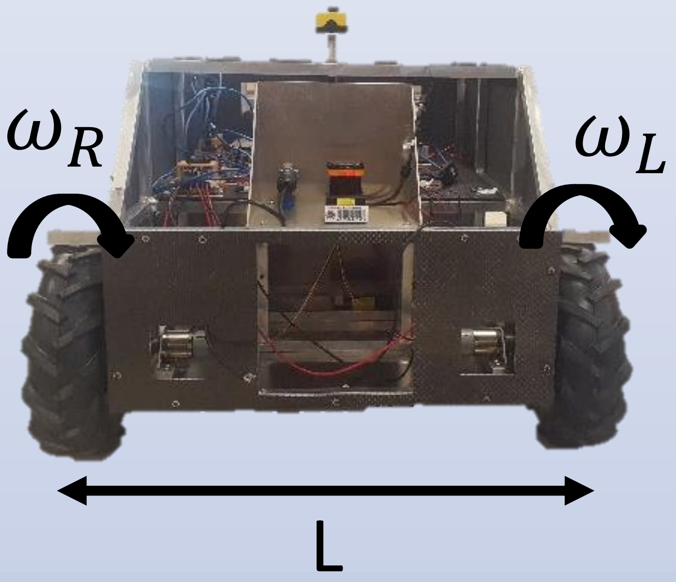
Kinematic Model

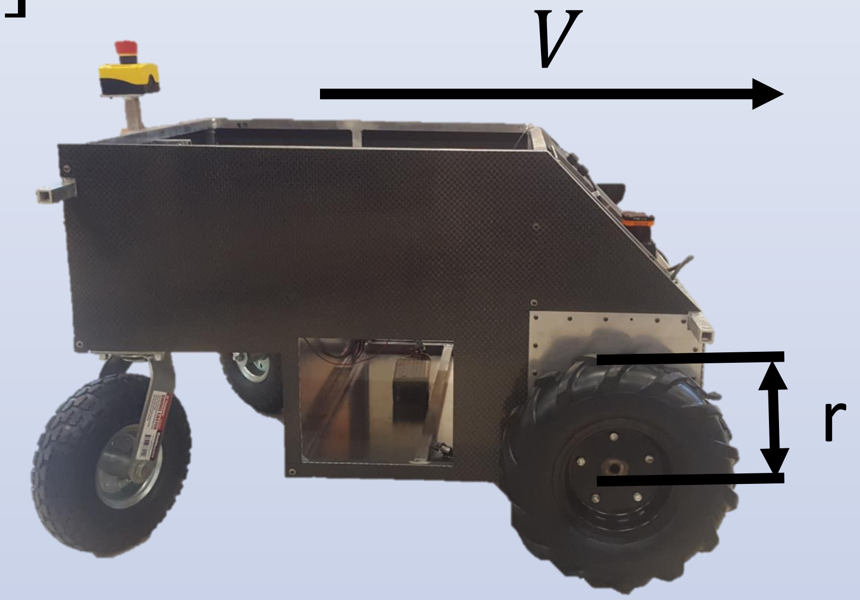
Inputs
- Linear Velocity of Vehicle
- Angular Velocity of Vehicle

Outputs
- Angular Velocity of Wheels

Kinematic Model for Differential Steering

$$\begin{bmatrix} \omega_R \\ \omega_L \end{bmatrix} = \begin{bmatrix} \frac{1}{r} & \frac{-L}{2r} \\ \frac{1}{r} & \frac{L}{2r} \end{bmatrix} * \begin{bmatrix} V \\ \omega \end{bmatrix}$$

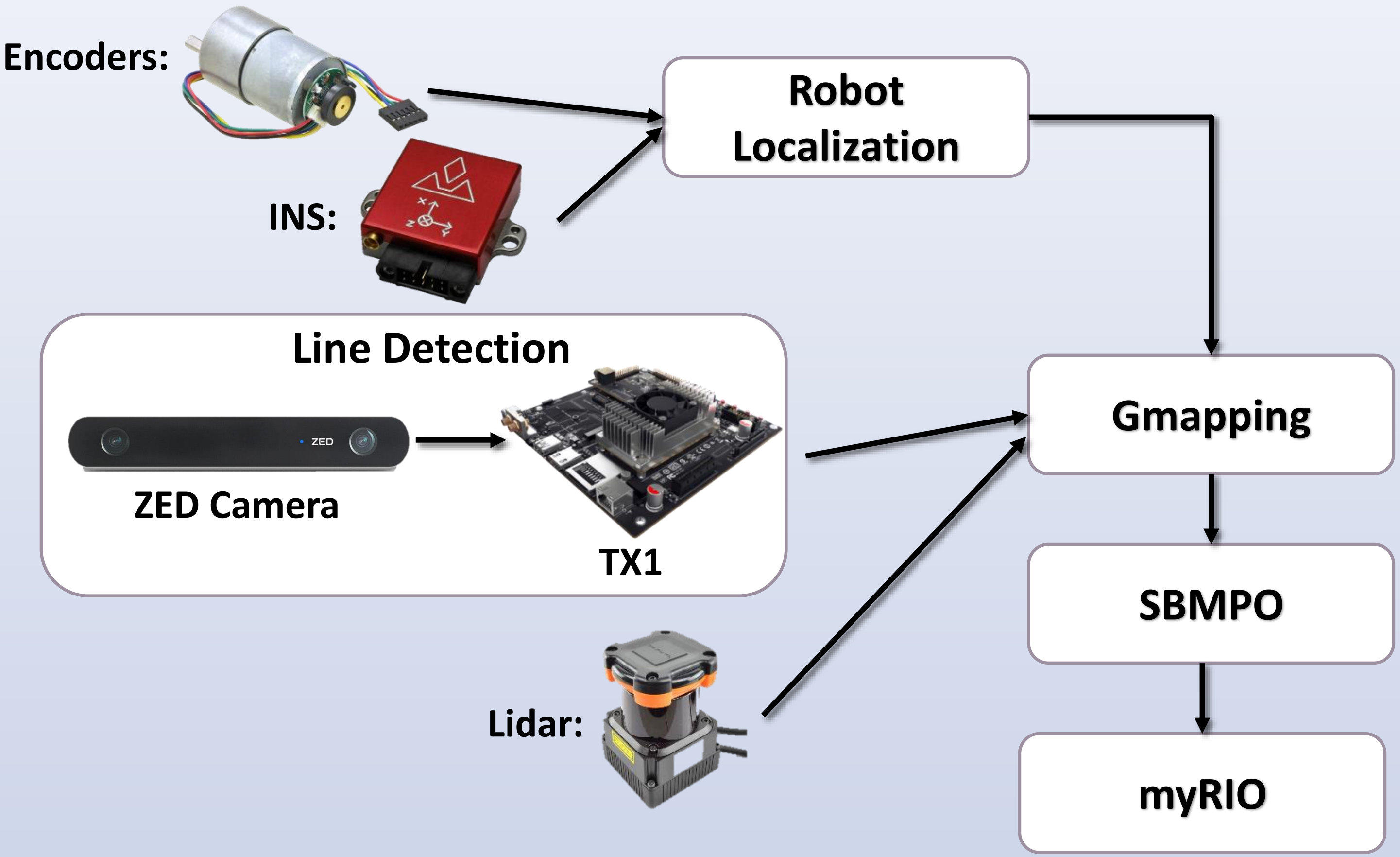


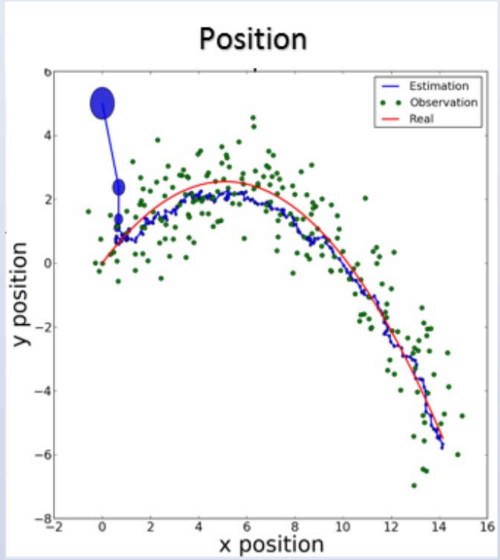


Motor Control (Legs)

Robot Operating System

Package Layout





Summary

Achievements

- **Fully Fabricated Robotic Platform**
- **Development of PD Controller**
- **Power Systems**
- **Integration of Electronics**
- **Water Resistant Design**
- **Manual Control of Platform**
- **Integration of Perception/Localization Sensors**
- **Ability to Send Trajectories from Motion Planner**

Future Work

- Motion Planner Integration
- Line Following Integration
- Finish Localization
- Competition

References

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- Gupta, Nikhil. *Dynamic Modeling and Motion Planning for Robotic Skid-Steered Vehicles*. Diss. Florida State U, 2014. Tallahassee: FSU Digital Library, 2014. *Diginole*. Web. 4 Sept. 2016.
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- "Serial Peripheral Interface (SPI)." *Learn at SparkFun Electronics*. N.p., n.d. Web. 14 Nov. 2016. <https://learn.sparkfun.com/tutorials/serial-peripheral-interface-spi>.
- "Serial Communication." *Learn at SparkFun Electronics*. N.p., n.d. Web. 14 Nov. 2016. <https://learn.sparkfun.com/tutorials/serial-communication/uarts>.
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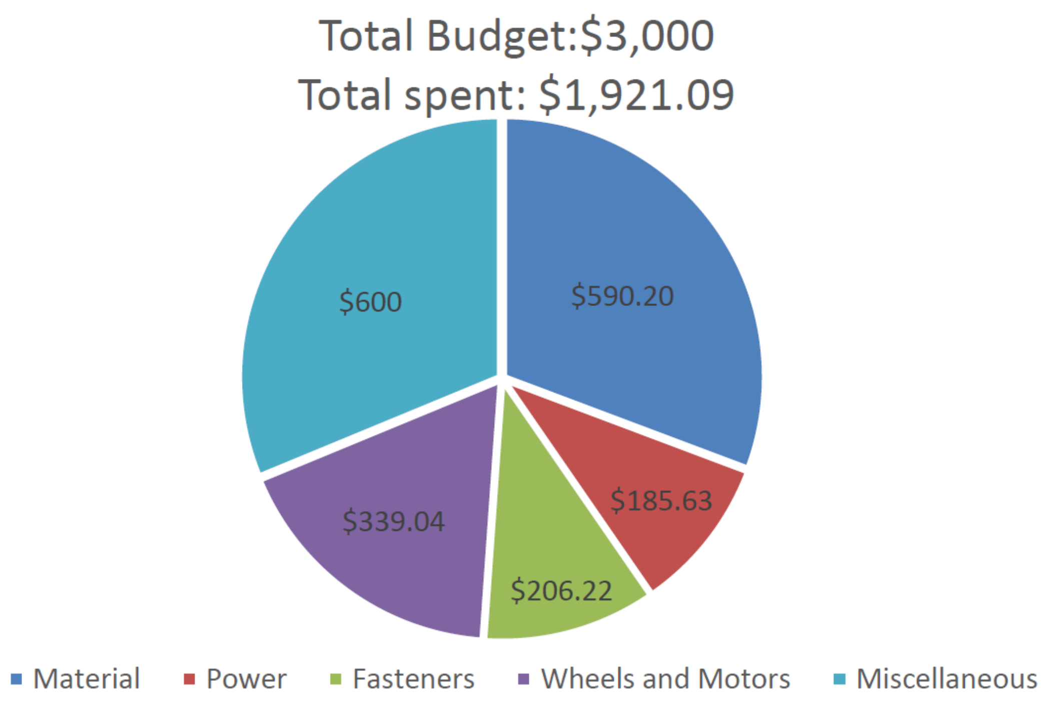
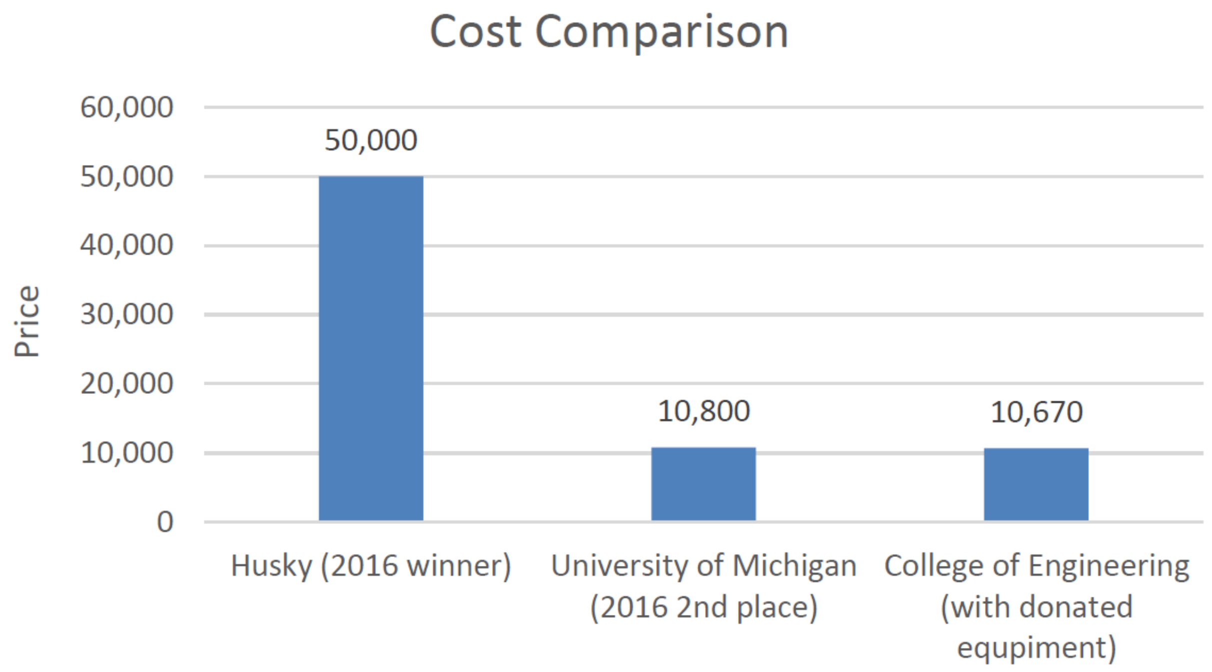
Questions?

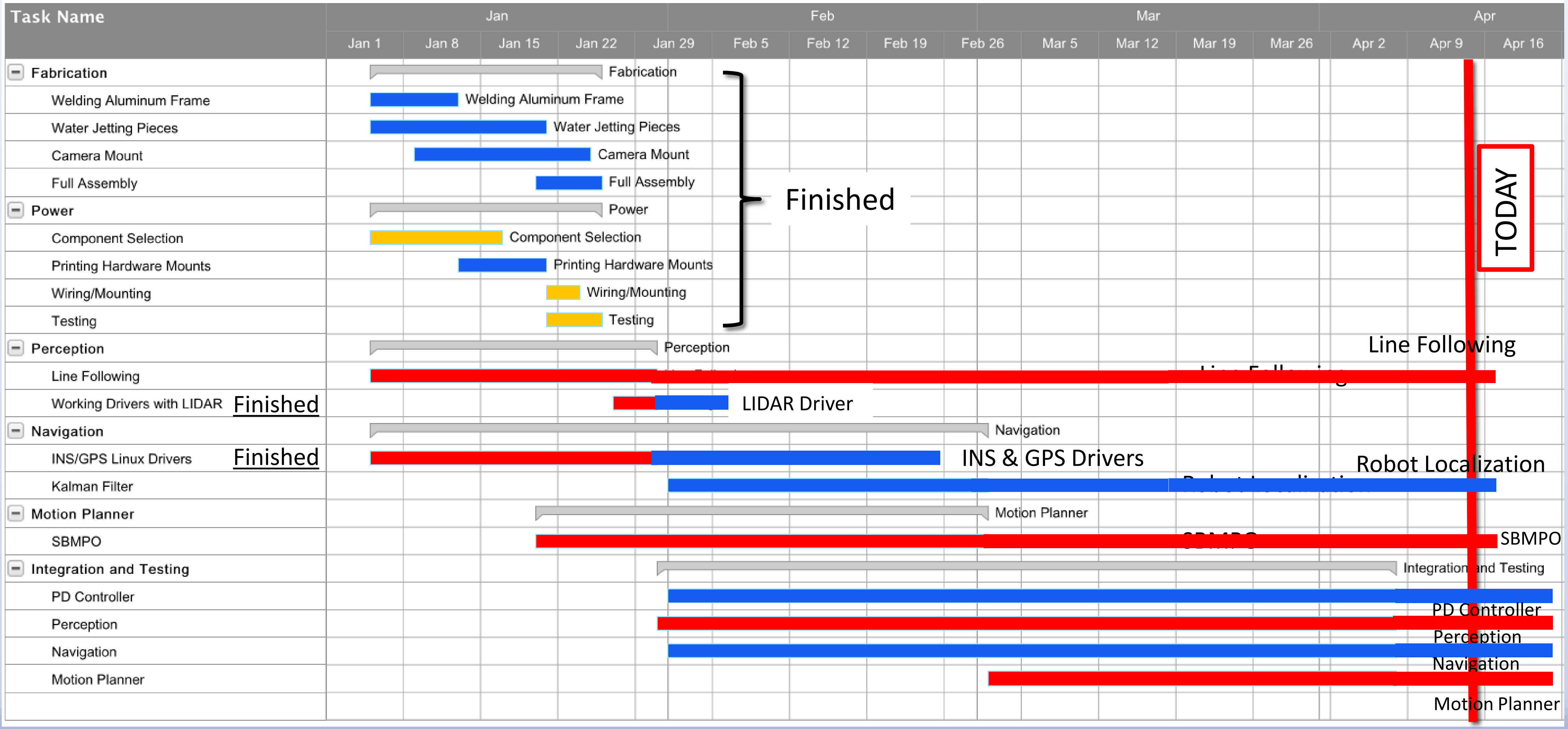
Budget


Total Budget:$3,000
Total spent: $1,921.09
$600
$590.20
$185.63
$206.22
$339.04
Material
Power
Fasteners
Wheels and Motors
Miscellaneous


Cost Comparison
Price
60,000
50,000
40,000
30,000
20,000
10,000
0
50,000
10,800
10,670
Husky (2016 winner)
University of Michigan (2016 2nd place)
College of Engineering (with donated equipment)

Gantt Chart for Spring Semester 2017

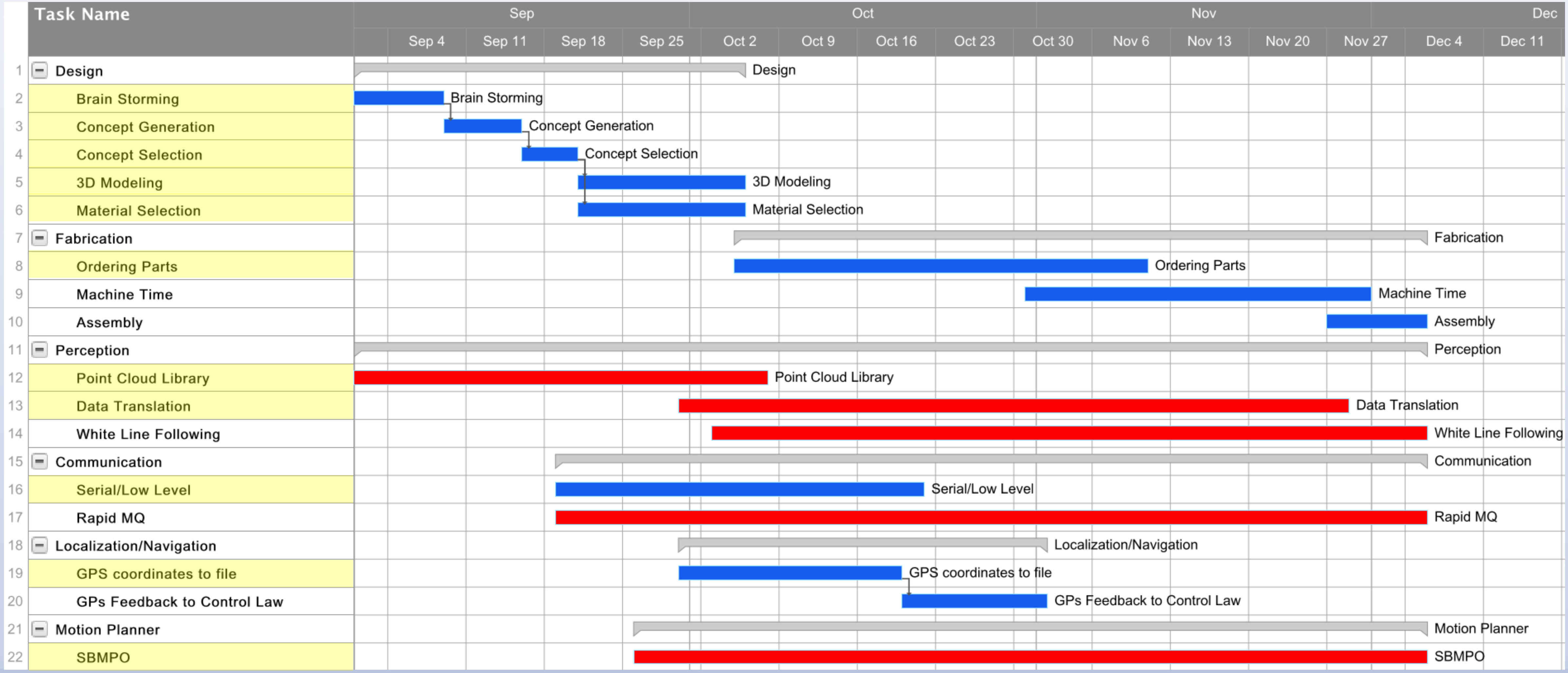
FIT –
BOTH –



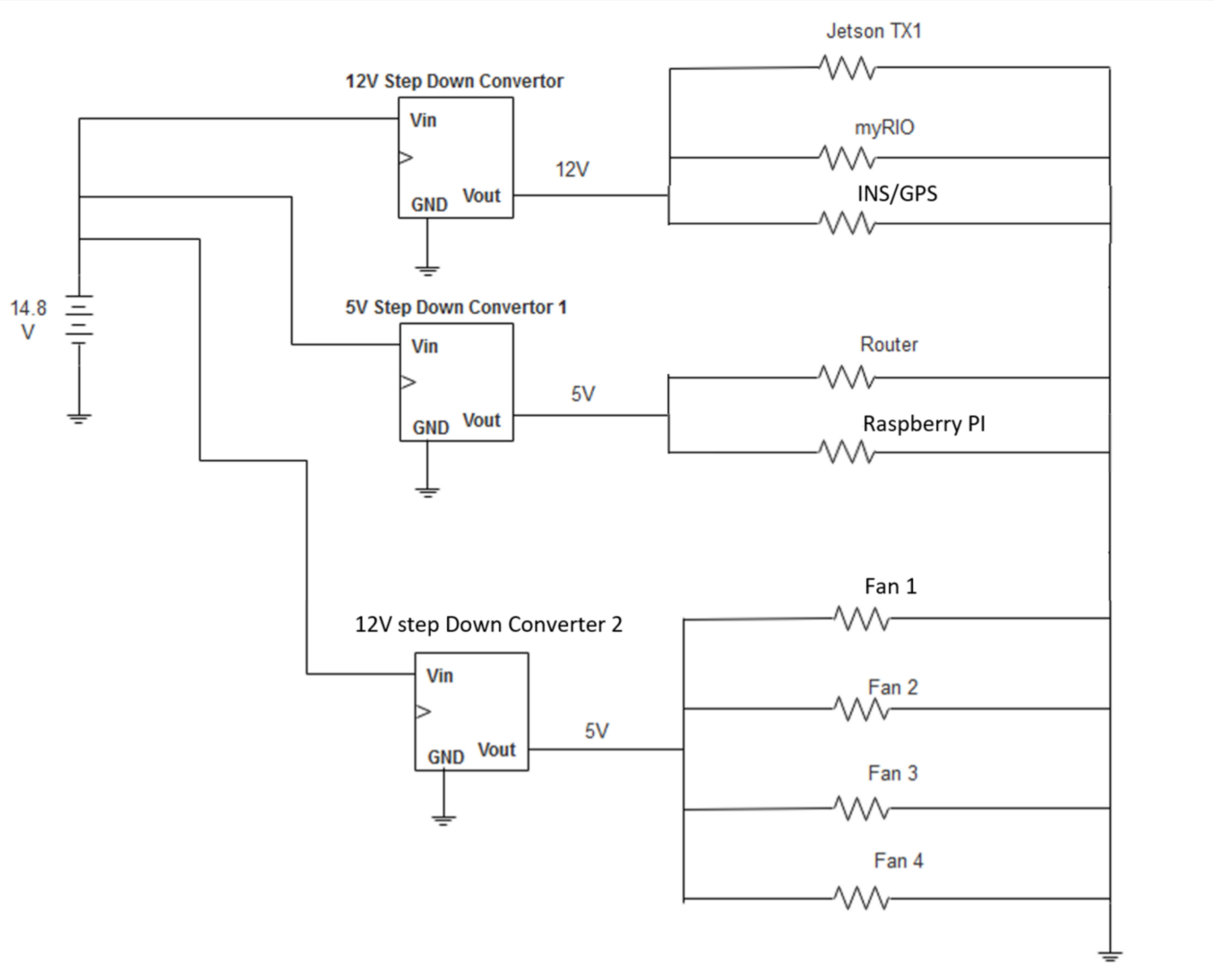
Gantt Chart for Fall Semester 2016

COE –

FIT –



Power Diagram



Problems and Solutions

Problems	Solutions
Programming • Dependencies	• Reallocation to FIT
Design • Water Jet Out of Order • Waterproofing • ONSHAPE Limitations	• Allocated Resources to Other Jobs • Waterproof Connectors/Carbon Fiber Shell • Switched to Pro-E/GrabCAD
Hardware • Drivers • Communication	• FIT Compiling Drivers • Raspberry PI
Perception • Identifying White Painted Lines • Multitasking with One Camera	• Research Line Identification • Added LIDAR