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

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

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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

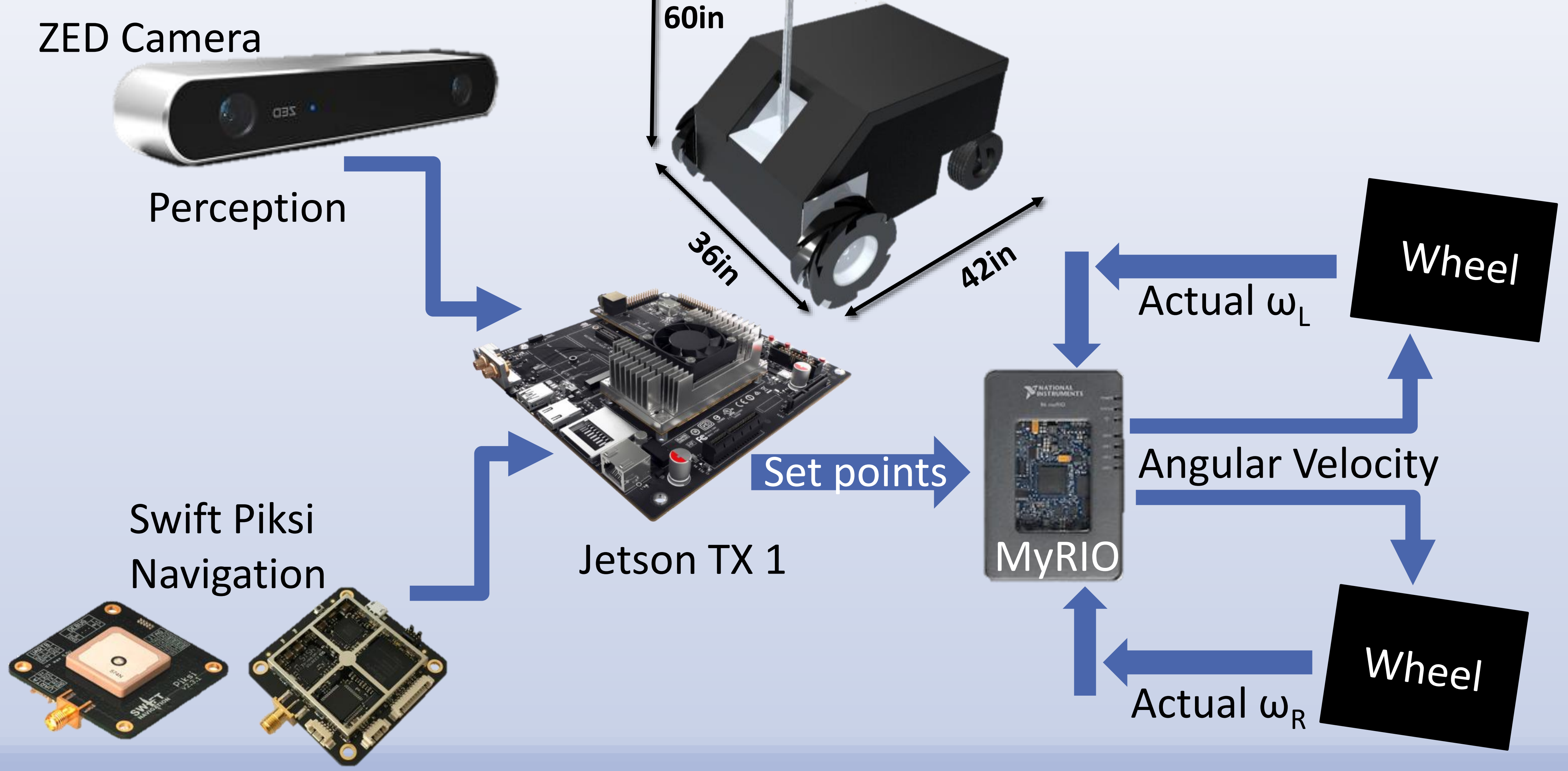
Project Statement

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

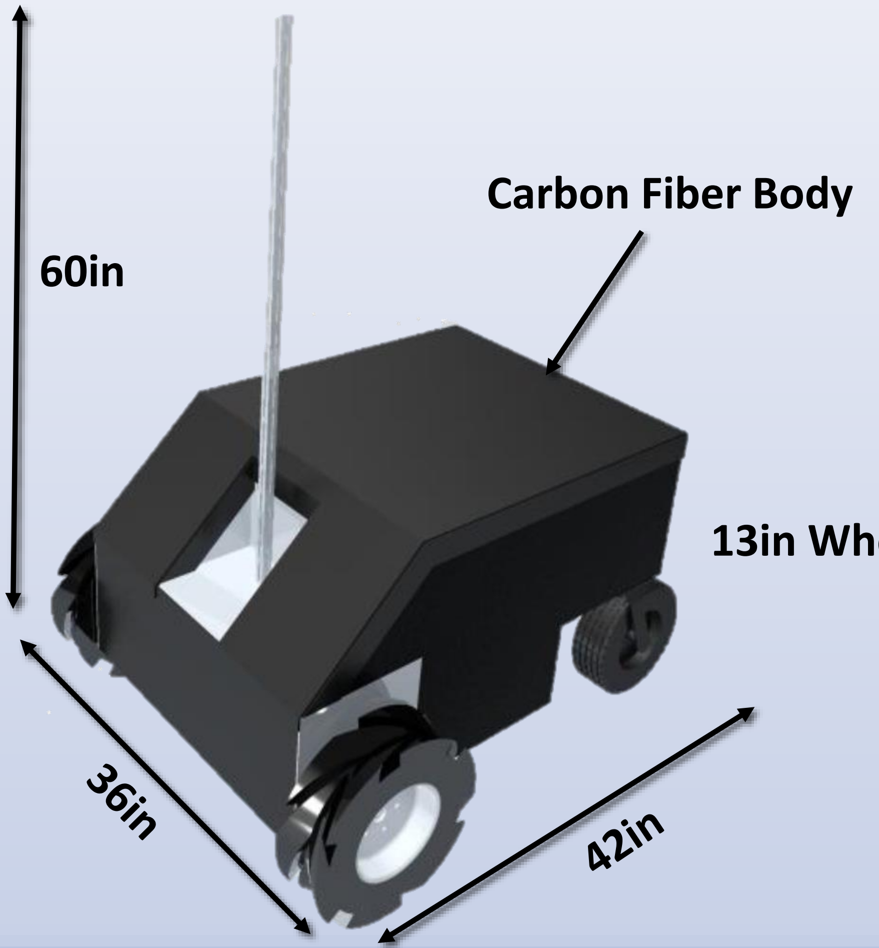
- **COE Goals:**
  - **Platform Design**
  - **Power Distribution**
  - **Hardware Integration**

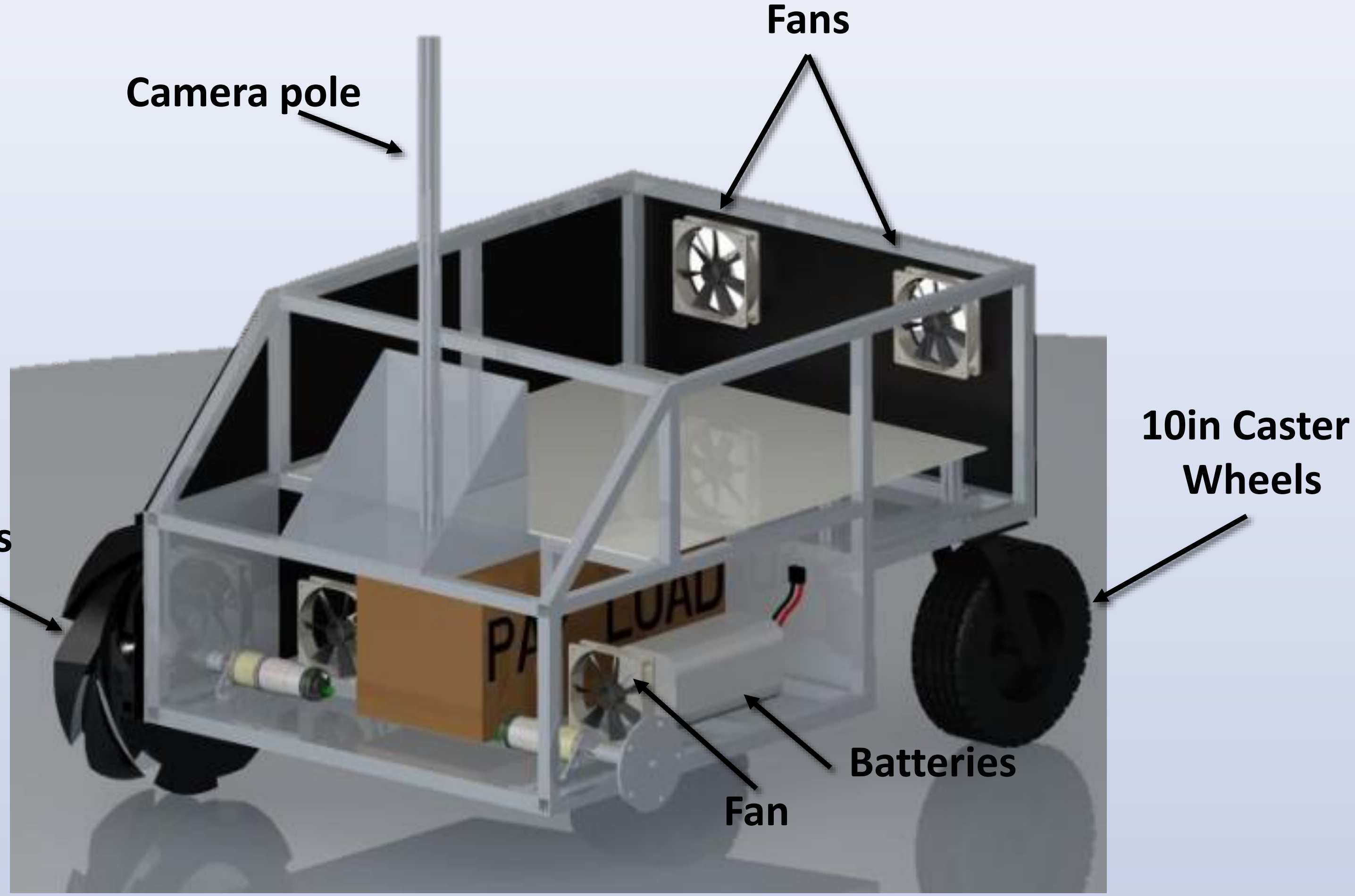
- **FIT Goals:**
  - **Perception**
  - **Object/Color Detection**
  - **Motion Planning**

Project Recap



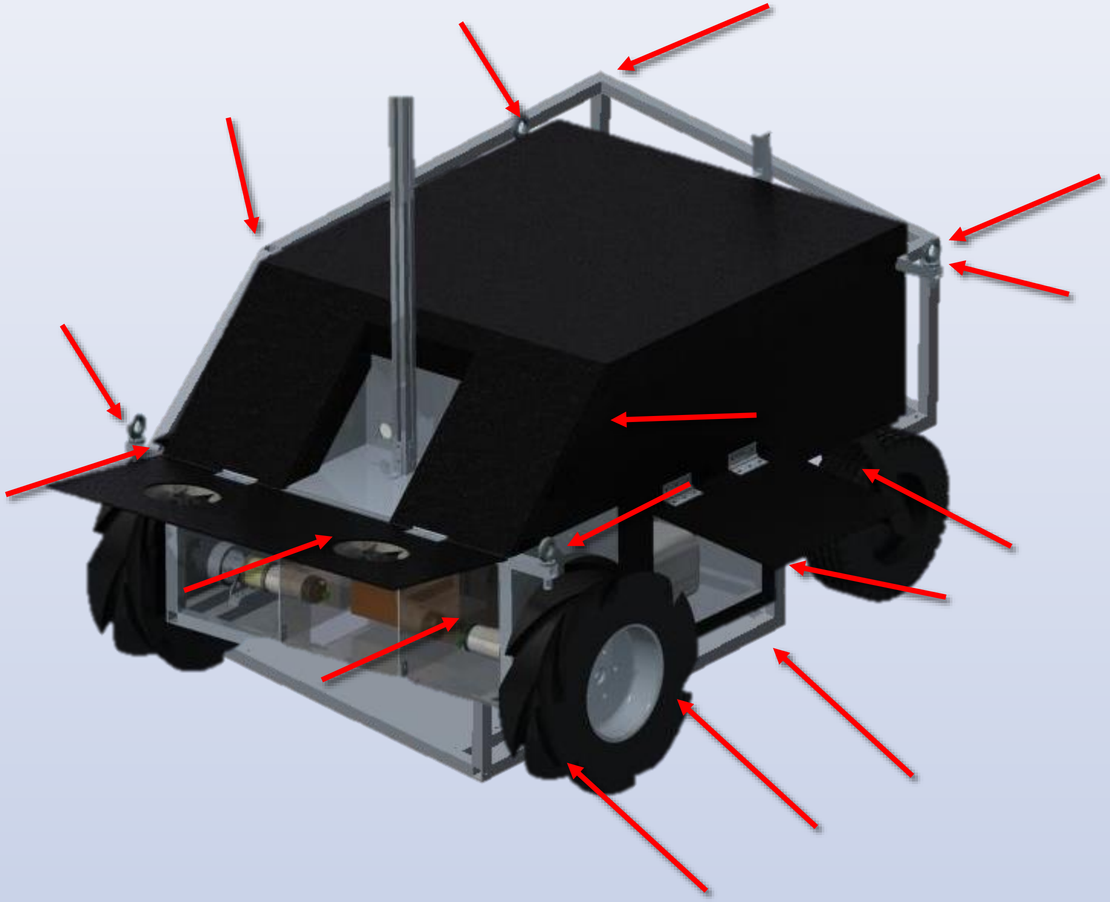
Original Selected Design





Design Improvements

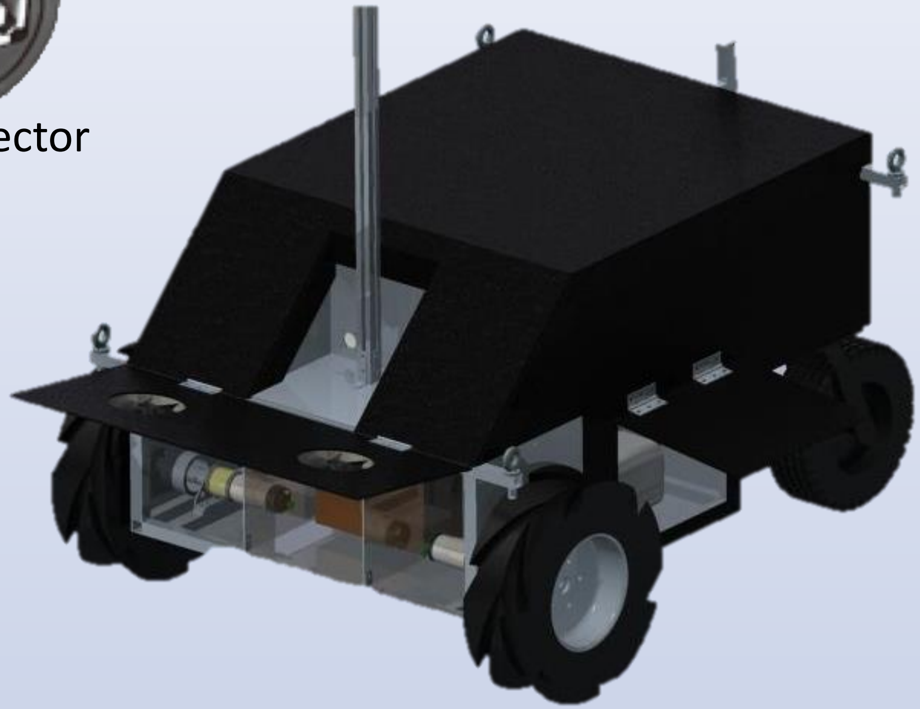
- Machine time reduction
  - Riveting baseplate
  - Welding Frame
  - Reduction of tapping holes in frame
- Weight Reduction by 15 lbs
  - Decrease thickness of baseplate
- Increase Structural Integrity
  - Stabilize camera pole with cables
  - Additional hollow aluminum tubes support
  - Output shaft support



Design Improvements Continued

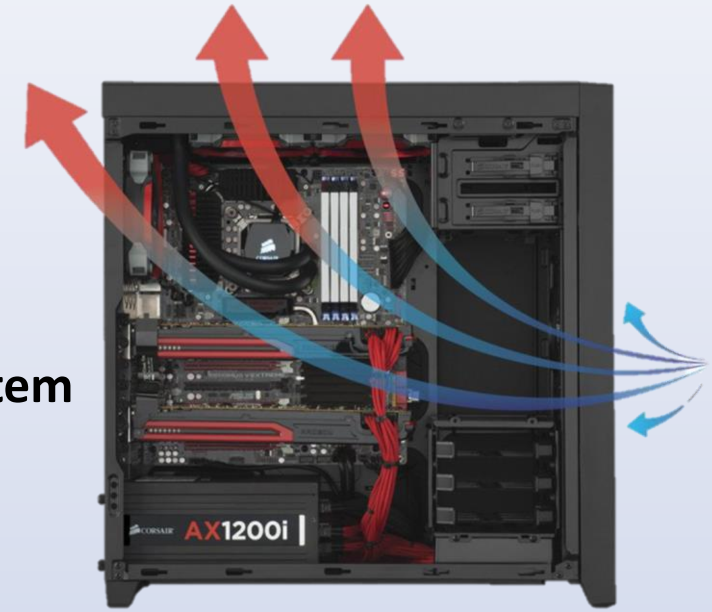
- **Waterproofing**
  - **Hydrophobic cloth**
  - **Quick connectors**
  - **Weatherproofing seals**
- **Component placement – One step removal**
  - **Electronics**
  - **Battery**
  - **Motor**
  - **Isolation of payload**

Quick Connector



Cooling

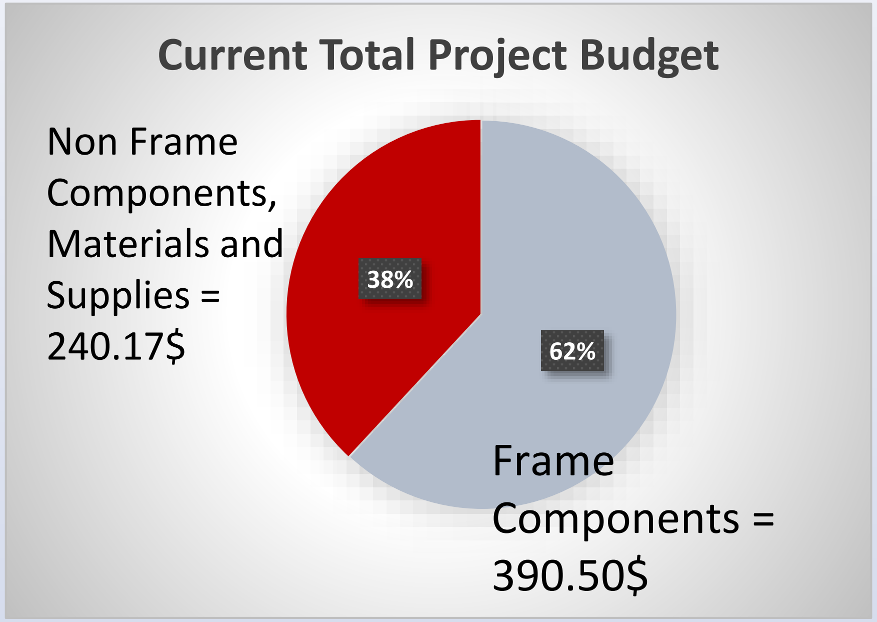
- Electronics
  - Will be cooling the electronics using 5V fans
    - 43.8 Cubic Feet Per minute
  - Water Cooled NZXT Kraken X61 280mm All-in-One Liquid Cooling System
    - GPU
    - CPU

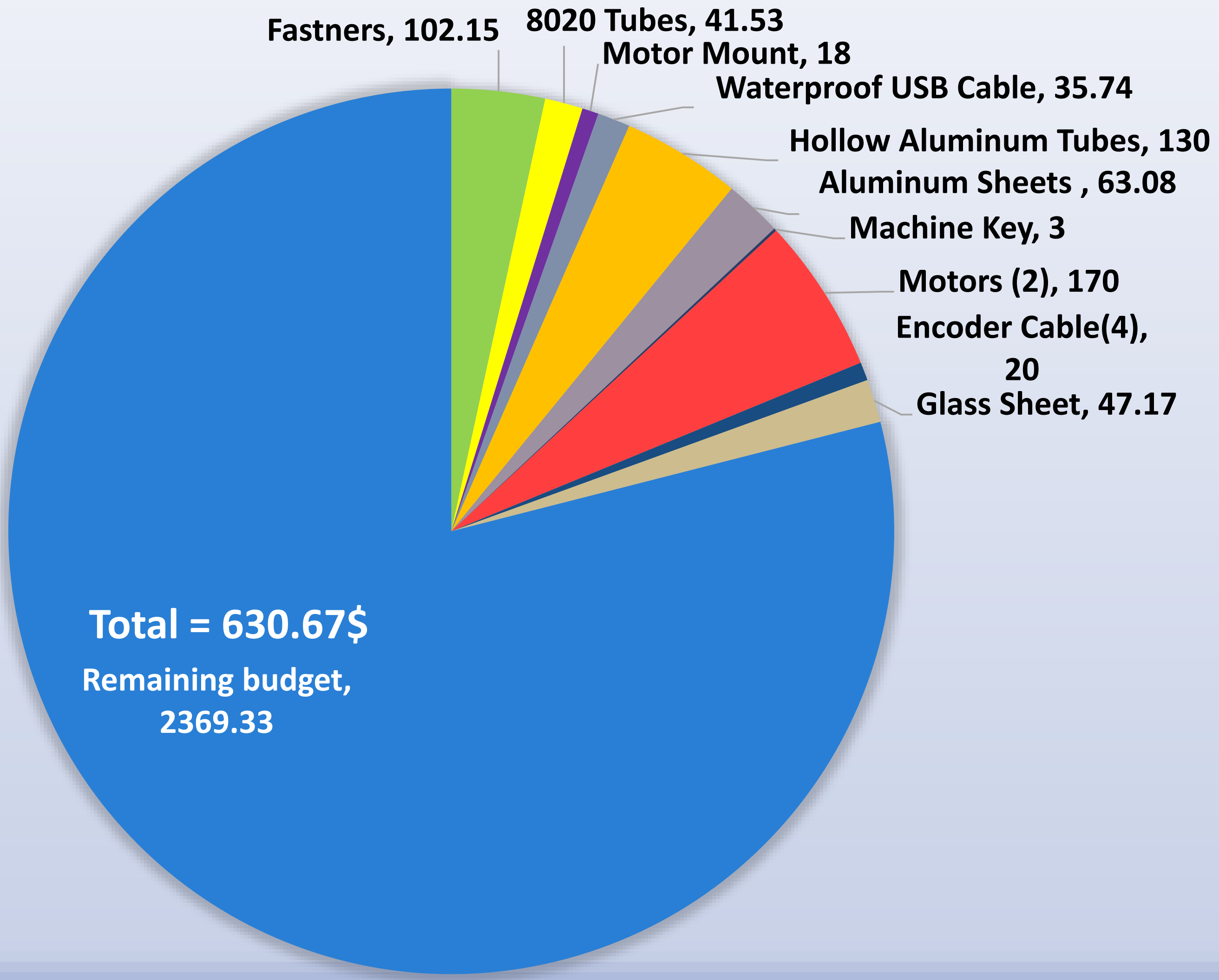


Wind flow with computer fans

Water cooled GPU cooling system

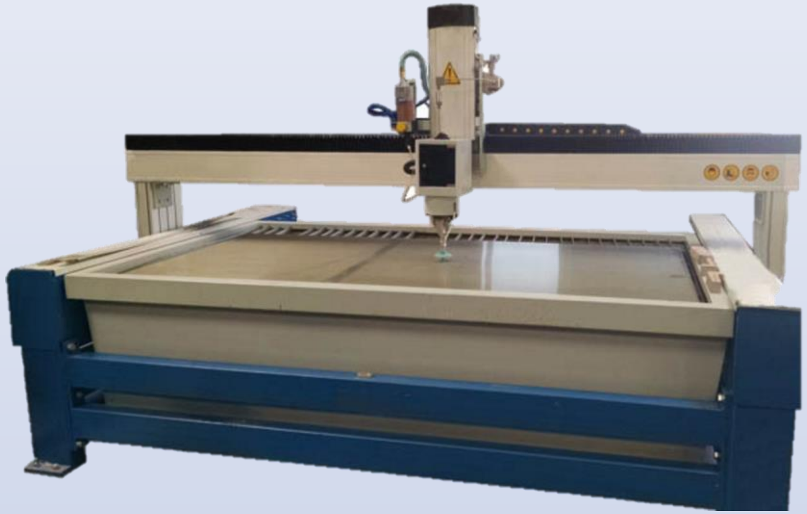
Budget Breakdown





Assembly

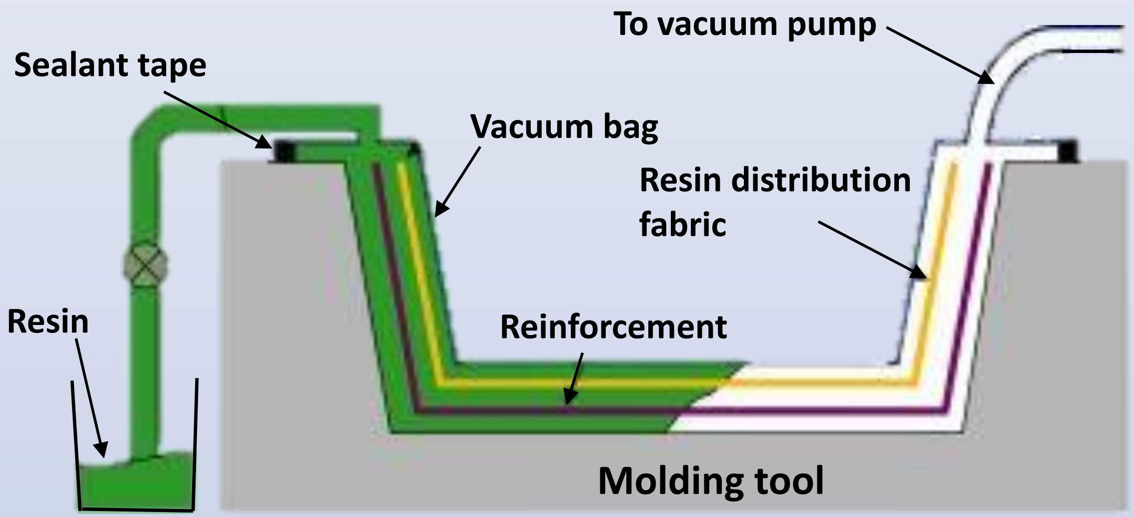
- **Important Factors: Accessibility/ Re-Assembly**
  - **Make necessary component changes**
  - **Swap Parts**
  - **Repairs**
  - **Any other task that would require the robot being dis-assembled in any way**
- **Fabrication processes include:**
  - **Welding**
  - **Milling**
  - **Water Jetting**
  - **Autoclave Composite Manufacturing**
  - **Vacuum Infusion Process**



Water Jet

Carbon Fiber Shell

- **Side Panels**
  - **Vacuum Infusion Process**
  - **Water-Jet cut into appropriate shapes**
  - **Secure Panels to hollow aluminum frame**



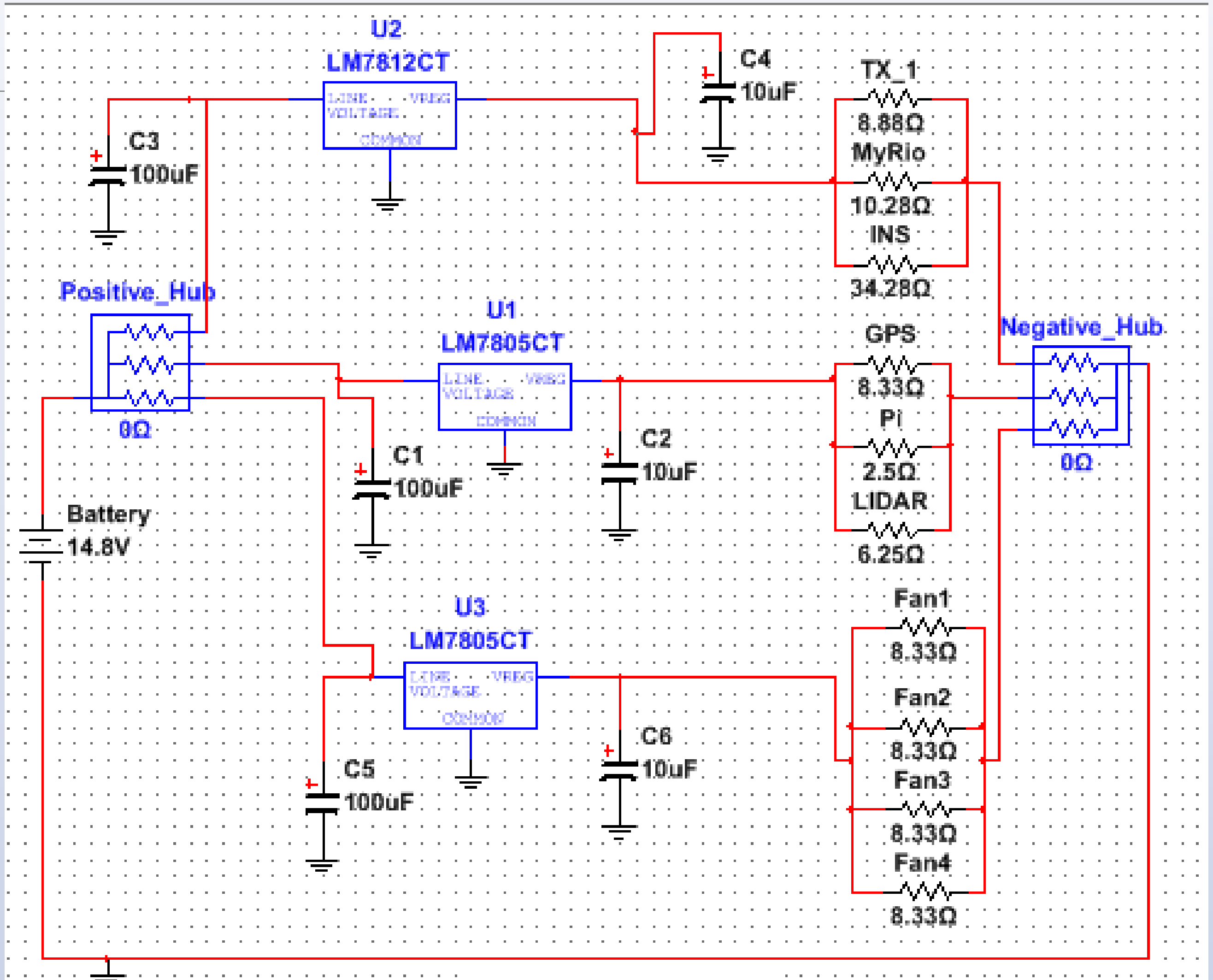
How the vacuum infusion process works

- **Top Lid**
  - **Inverse Mold**
  - **Autoclave Composite Manufacturing**

Example of a carbon fiber mold

Power Diagram

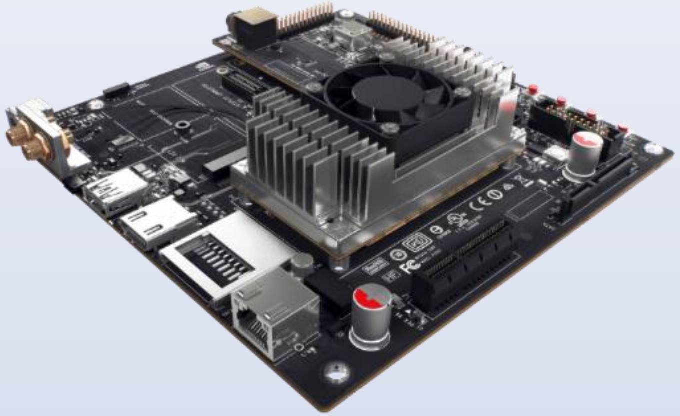
- Given a 14.8V battery
- TX1 (5-19.6)V
- myRIO (6-16.6) V
- GPS (5V)
- LIDAR (5V)
- Fans (5V)



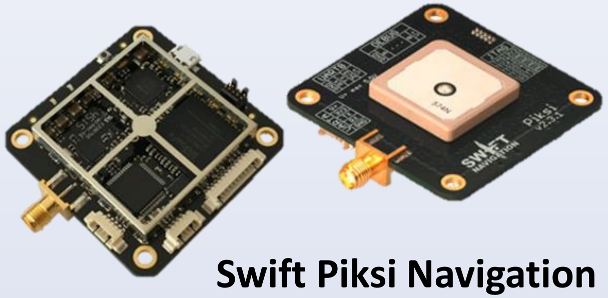
Power Diagram

Hardware Integration

ZED



TX1



Swift Piksi Navigation

Lidar

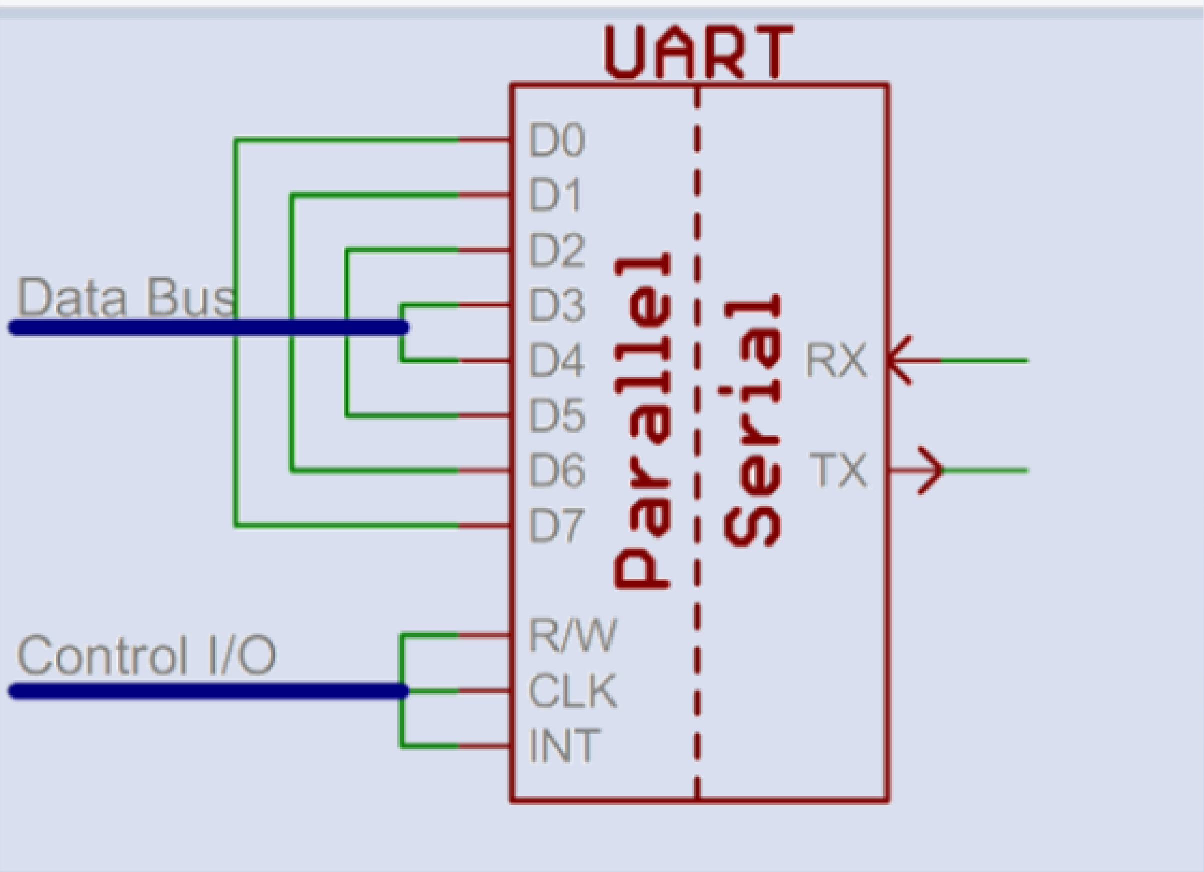
Router

Raspberry PI 2

MyRio

Universal Asynchronous Receiver/ Transmitter

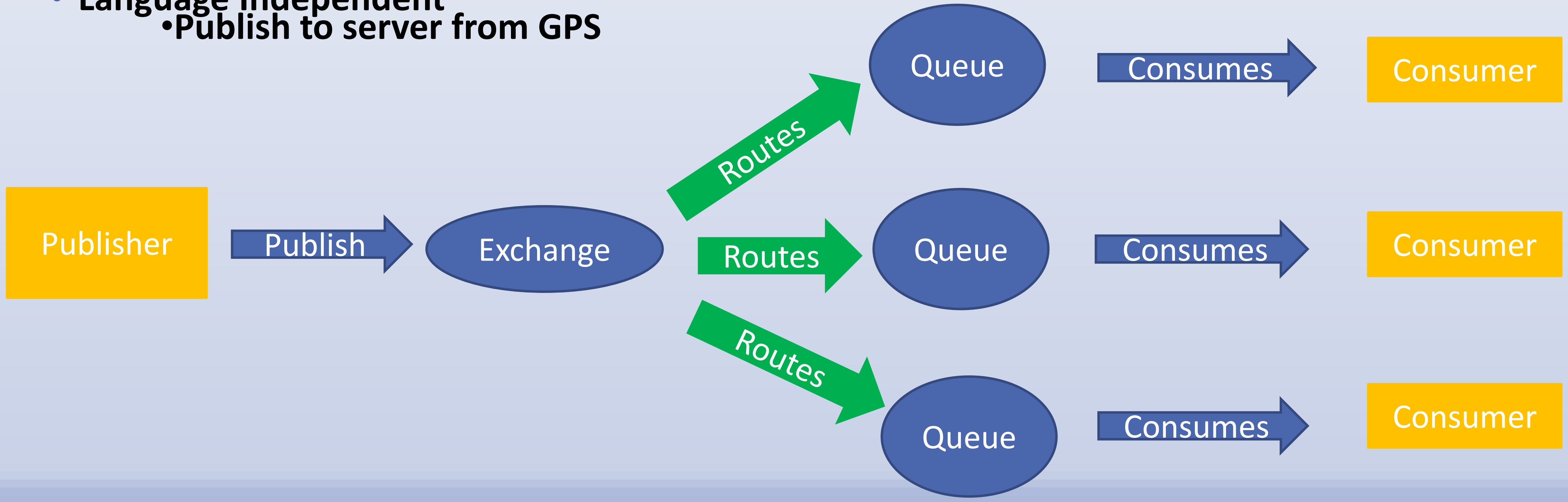
- Intermediary between parallel and serial interfaces
  - Transmit (TX) and Receive (RX) pins
  - Baud rate
- Pros
  - Multiple resources and sample code
  - Most of the hardware uses UART



RabbitMQ Server

- **Communications Server**
  - **Can Publish and Subscribe messages to server**
  - **Robust messages for communication between robot**
  - **Language independent**

- **PD Controller**
  - **GPS**
    - **Longitude, Latitude, and Attitude in JSON**
    - **Publish to server from GPS**



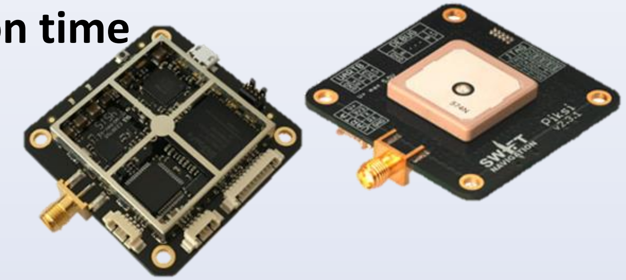
Hardware Integration

- Goal is to achieve a reliable form of data transfer that does not sacrifice computation time
  - Have to consider what ports are available

ZED

- USB

TX1
- USB 3.0
- Ethernet
- UART
- SPI
- USB 2.0 Micro AB



Swift Piksi Navigation
- UART
- USB

Lidar
- Micro USB
- UART

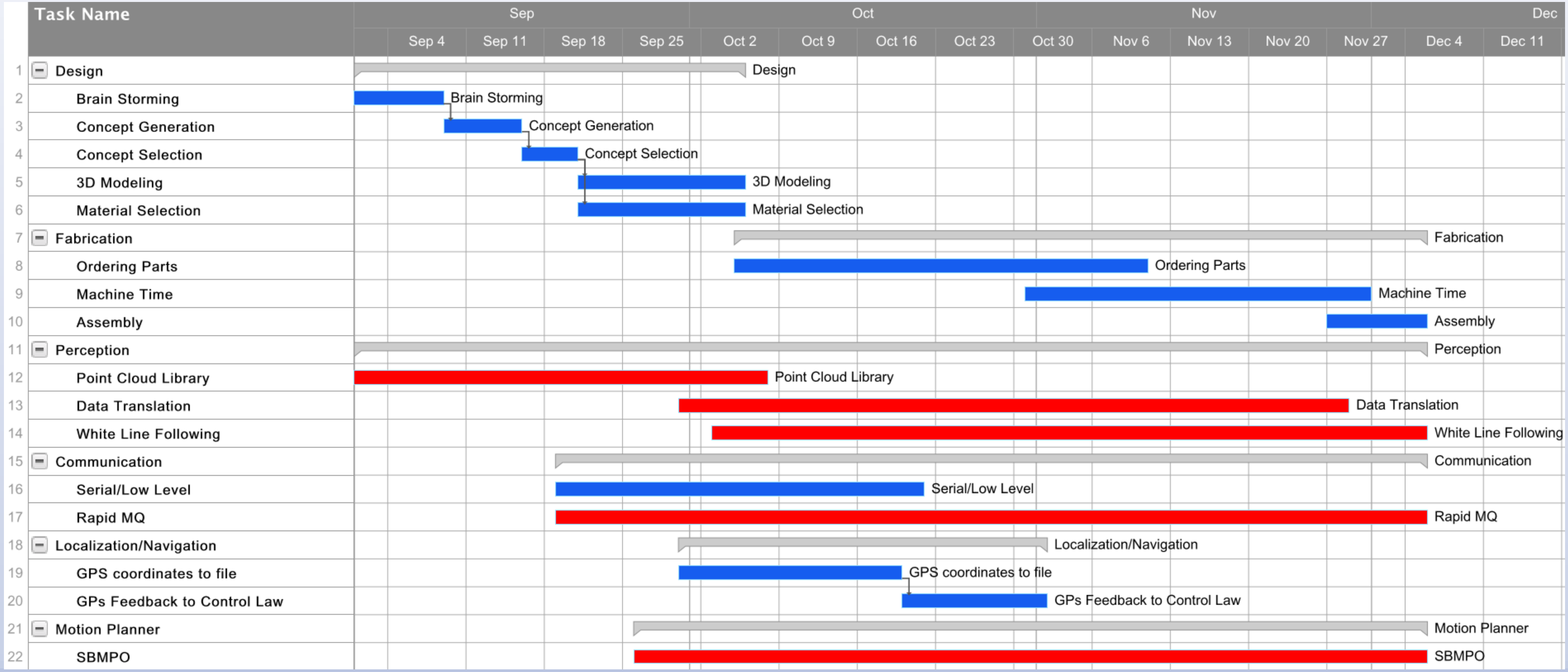
Router
- Ethernet

Raspberry PI 2
- SPI (Master only)
- Ethernet
- UART

MyRio
- Drive Sharing
- SPI
- TCP
- UART
- SPI (Master Only)

Gantt Chart for Fall Semester 2016

COE –
FIT –



Future Work

- Integrate Motion Planner: SBMPO
- Visit FIT
  - Have a mock course set up
- Setup
  - Zed - Camera
  - GPS integration with the controller
  - INS integration
  - Electronics
- Interoperability Protocol

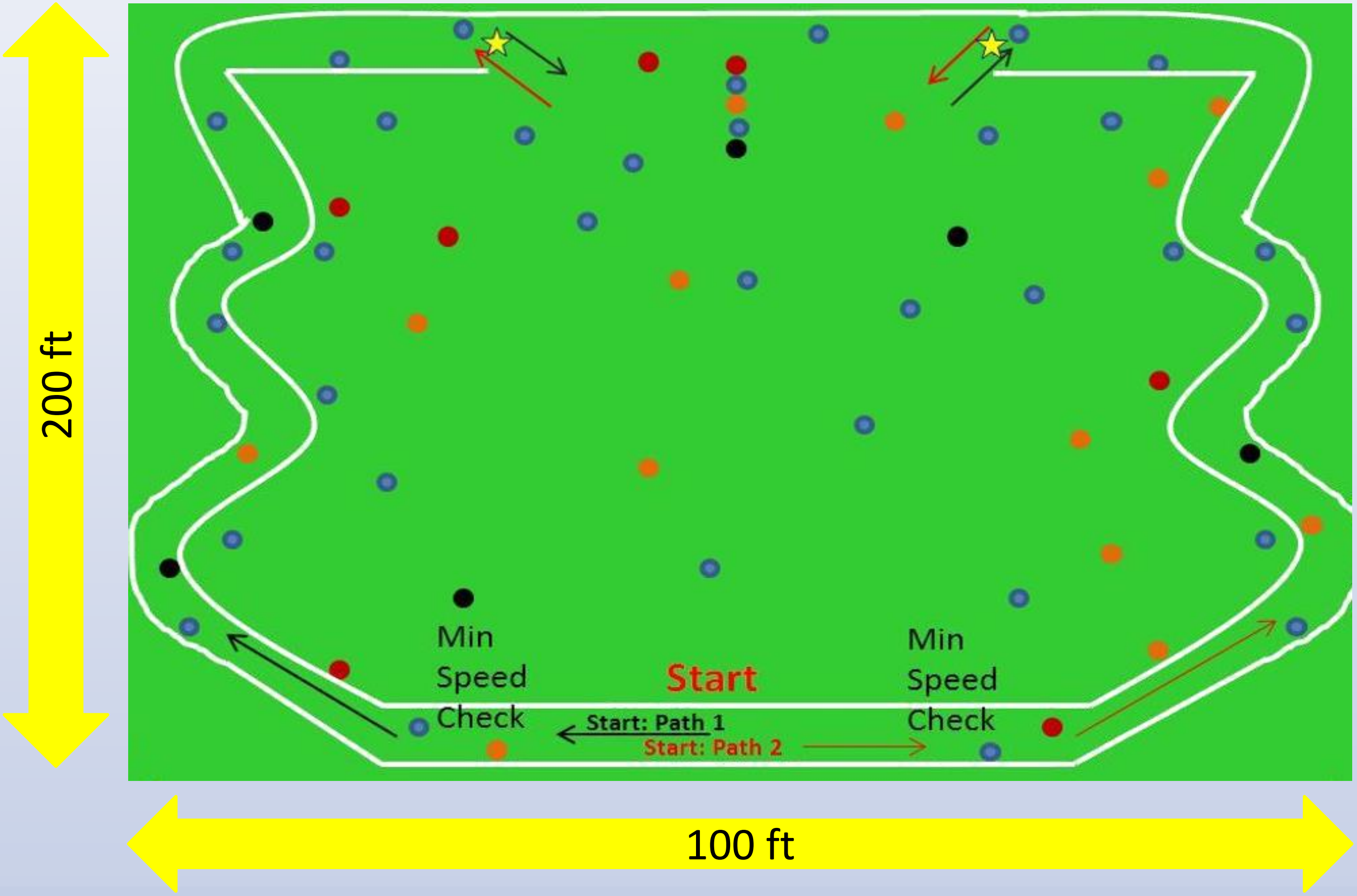
References

- Dudek. "Differential Kinematics and Statics." *Advanced Textbooks in Control and Signal Processing Robotics* (2010): 105-60. *Computational Principles of Mobile Robotics*. Web. 05 Oct. 2016.
- 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.
- http://www.nvidia.com/object/jetson-tx1-module.html
- https://www.swiftnav.com/piksi.html
- "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>.
- "I2C." *Learn at SparkFun Electronics*. N.p., n.d. Web. 14 Nov. 2016. <https://learn.sparkfun.com/tutorials/i2c>.

Questions?

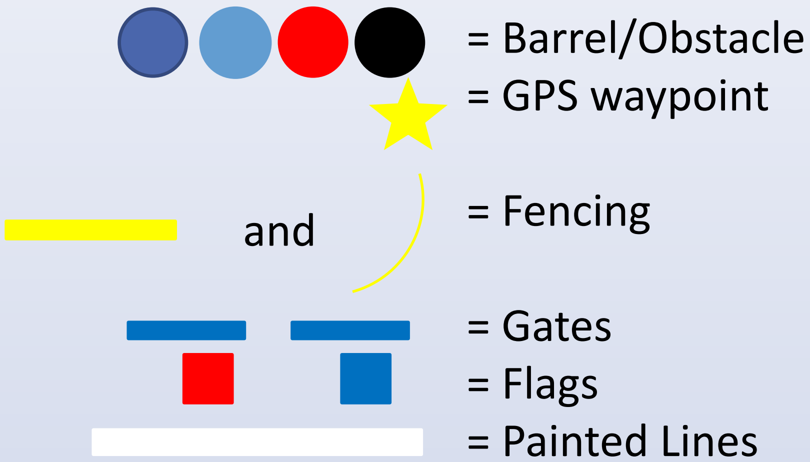
IGVC : Auto – Nav Challenge

The Basic Course



IGVC : Auto – Nav Challenge

The Advanced Course



<u>Vehicle Must have</u>

- Object Detection/Collision Avoidance
- Color/Line Detection
- GPS Waypoint Navigation

Power Source

Batteries

- Thunder Power 7700-4SM70
  - 7700mAh 4-Cell/4S 14.8V Magna Series 70C LIPo split w/ interconnect
  - Quantity: 2
  - Specifications:
    - Max Charge: 12C
    - Max Charge Current 92.4A
    - Max Continuous Discharge: 70C
    - Max Continuous Current 539A
    - Max Burst: 140C
    - Max Burst Current 1078A
    - Weight: 780g
    - Price $300

Thunder Power 7700-4SM70

House of Quality

Row #	Weight / Importance	Column # / Engineering Characteristics / Competition Requirements	1 Water Resistance	2 Structural Integrity	3 Affordability	4 Communication Protocols	5 Image Processing	6 Fabrication Time	7 Computation time	8 Energy Consumption	9 Power Distribution	10 Modular Design	11 Ventilation	12 Weight
1	4.0	Durability	2	10	6			5				5		7
2	5.0	Size of Robot		5	4			7		2				10
3	4.0	Localization	1			8			6		4	8	2	
4	5.0	Reliability	10	4	1	5	8						10	
5	2.0	IOP Challenge				10	8		6					
6	3.0	Speed			7		4		10					10
7	3.0	Accessibility		6	2			4				10		
8	5.0	Safety	5								7		4	
9	5.0	Motion Planning	1		5	8	10		8	2		6	2	
10	2.0	Innovative Design	4	3	4			2			2	4	1	6
		Score	92	109	109	117	118	71	106	20	51	92	88	120
		Rank	7.0	4.0	5.0	3.0	2.0	10.0	6.0	12.0	11.0	8.0	9.0	1.0

Most Important Characteristics:

COE -

1. **Weight**
2. **Structural Integrity**
3. **Affordability**

FIT -

1. **Image Processing**
2. **Communication Protocols**
3. **Computation time**