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
  - Hardware Integration
  - Localization

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

Intelligent Ground Vehicle Competition (IGVC)

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

Multidisciplinary Competition with application in real world

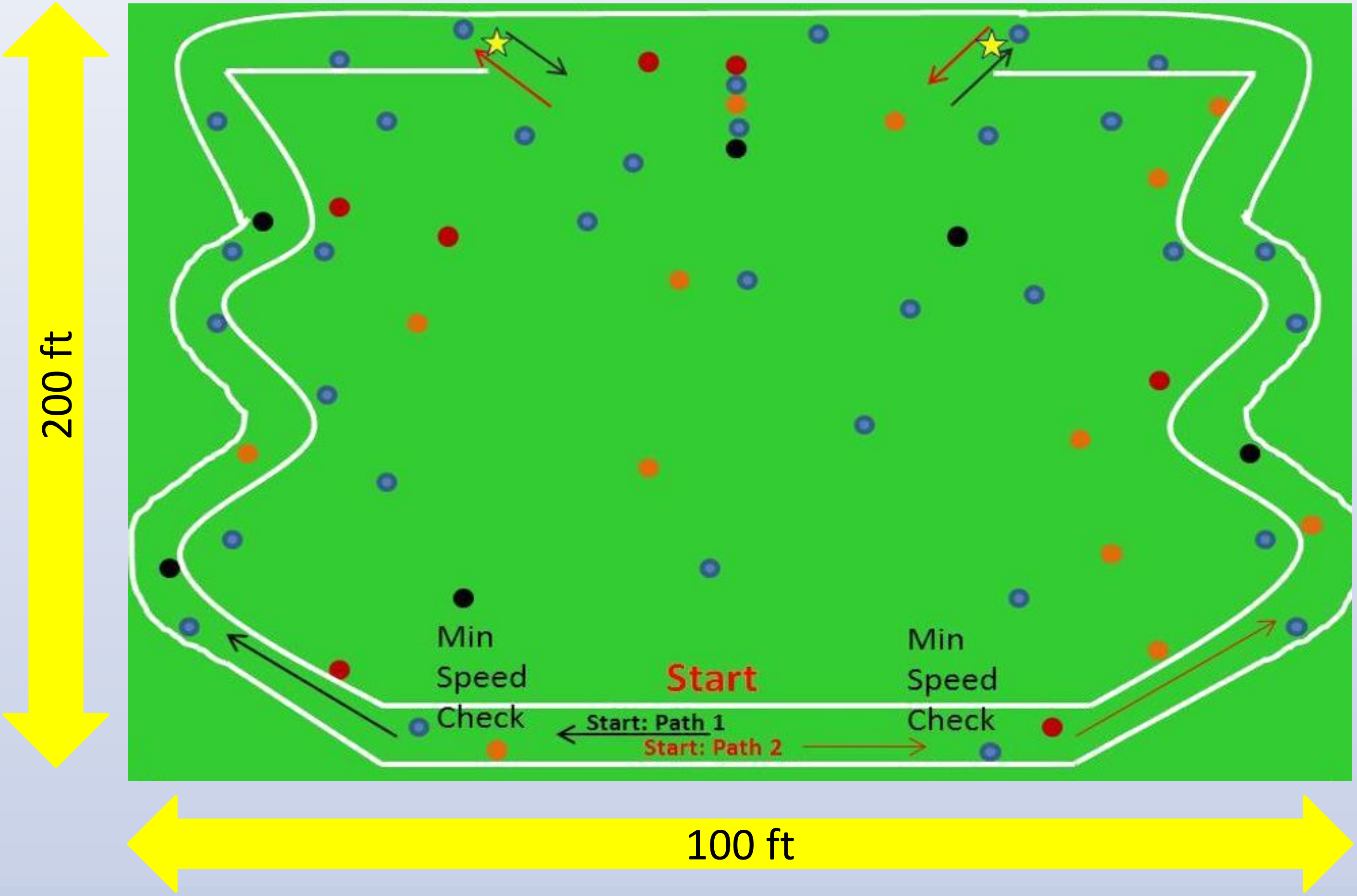
- Electrical Engineering
- Computer Science and Engineering
- Mechanical Engineering

Three Challenges: Design, Programming, Auto-Nav

Two Courses: Basic and Advanced

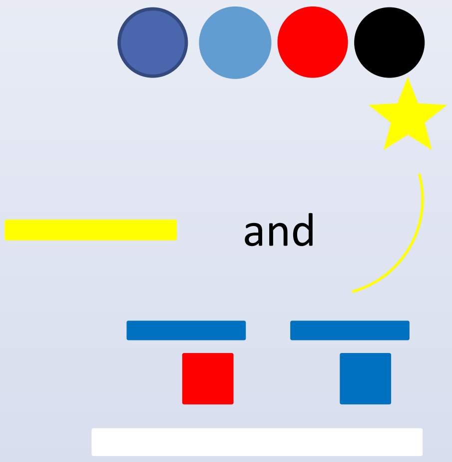
IGVC : Auto – Nav Challenge

The Basic Course



IGVC : Auto – Nav Challenge

The Advanced Course



= Barrel/Obstacle
= GPS waypoint
= Fencing
= Gates
= Flags
= Painted Lines

<u>Vehicle Must have</u>

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

IGVC: Constraints

Dimensions of the Vehicle:

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

- 1 mph ≤ Speed ≤ 5mph
- Payload: 20lb - 18” x 8” x 8”

University of Cincinnati

University of Michigan

Previous Years Prototype

Team 22 successfully built a prototype that could execute straight lines

Wooden made it easy to modify

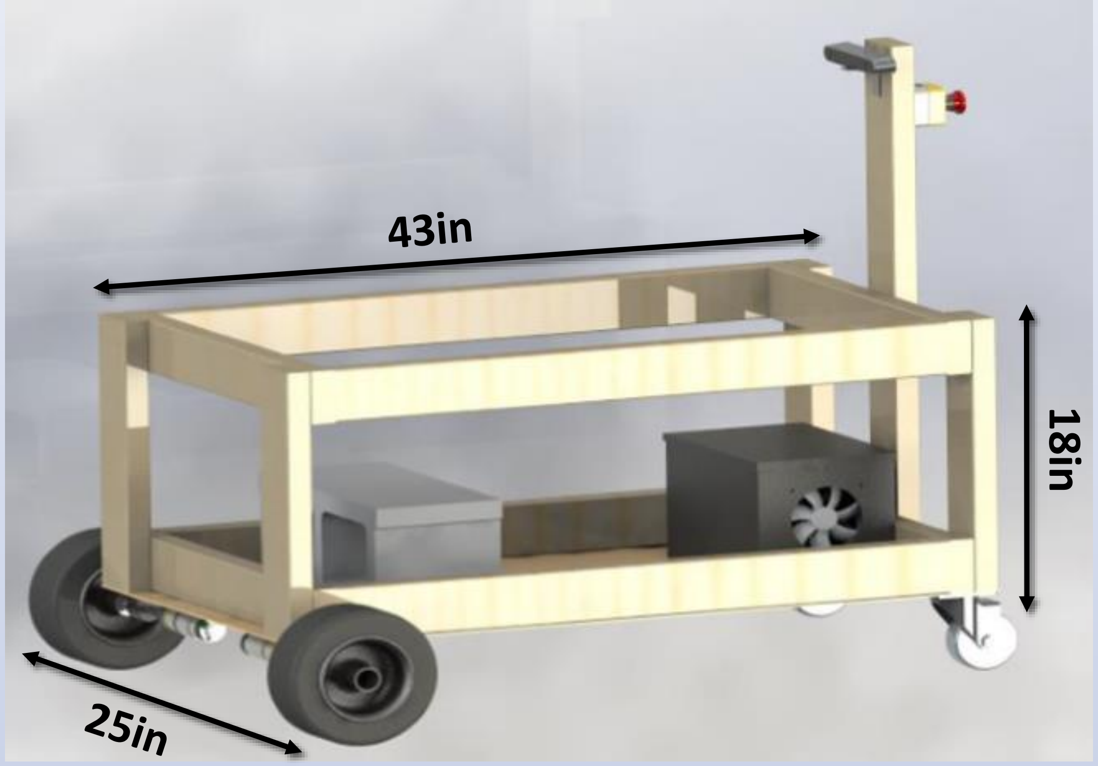
Differential steering

Two Fixed Wheels

Two Caster Wheels

Previous purchased hardware

- Zed
- TX1
- Rasberry Pi
- myRio
- Andy Mark Motors



Last years prototype

House of Quality

Row #	Weight / Importance	Column #	1	2	3	4	5	6	7	8	9	10	11	12
		Engineering Characteristics / Competition Requirements	Water Resistance	Structural Integrity	Affordability	Communication Protocols	Image Processing	Fabrication Time	Computation time	Energy Consumption	Power Distribution	Modular Design	Ventilation	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 Protoc
3. Computation time

Morphological Chart

Design 1 Design 2 Design 3

Requirements	Functional Parameter	Concepts or Solutions that satisfy the function			
Maneuverability	Forms of steering	Differential Steer	Skid Steer	Ackerman Steer	
	Support	Tracks	Wheels		
Structural	Frame	8020	Hollow square	Hollow round	Aluminum plates
	Fasteners	8020 Fasteners	Nuts and Bolts	Welding	
	Body	Carbon fiber	Fiber glass	Aluminum	Plastic
Positioning	Location of Hardware	Bottom center	Middle of robot		
	Location of Payload	On top	Over Front Wheels	Bottom center	
	Location of Motors	Inside	Outside		
	Location of Batteries	Bottom Sides	Middle of Robot		

Decision Matrix

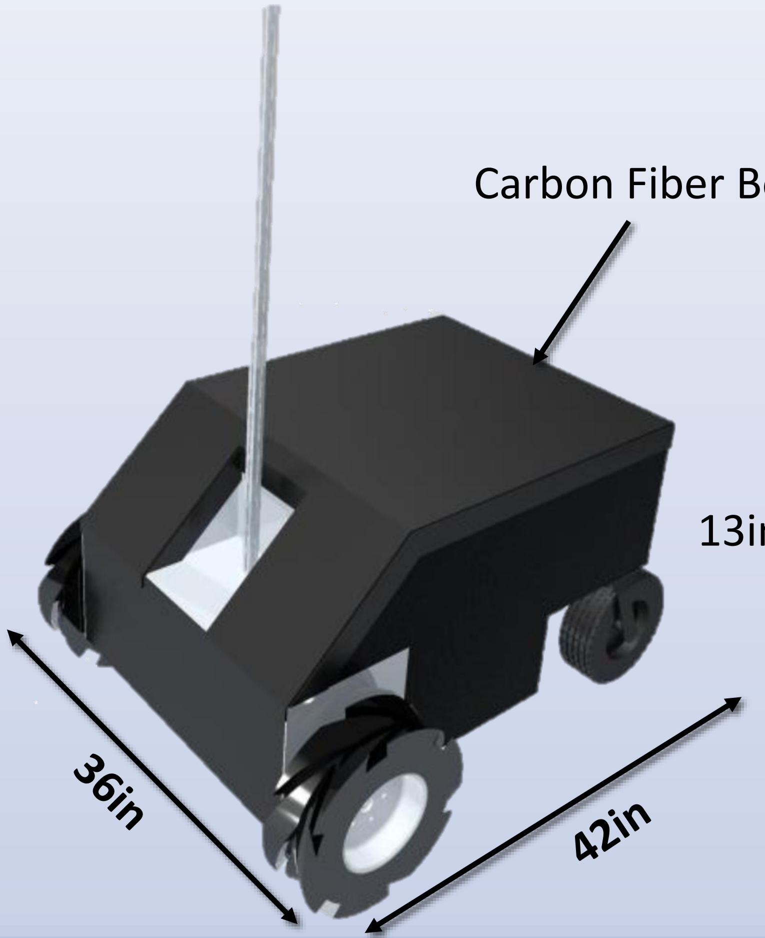
Concept weighting [1=better than datum, -1=worse than datum]				
Engineering Char.	**Datum**	**Design 1**	**Design 2**	**Design 3**
Water Resistant	0	1	1	1
Structural Integrity	0	-1	-1	0
Affordability	0	1	1	1
Fabrication Time	0	-1	-1	-1
Energy Consumption	0	-1	0	1
Modular Design	0	1	1	-1
Weight	0	0	0	1
Totals	0	0	1	2

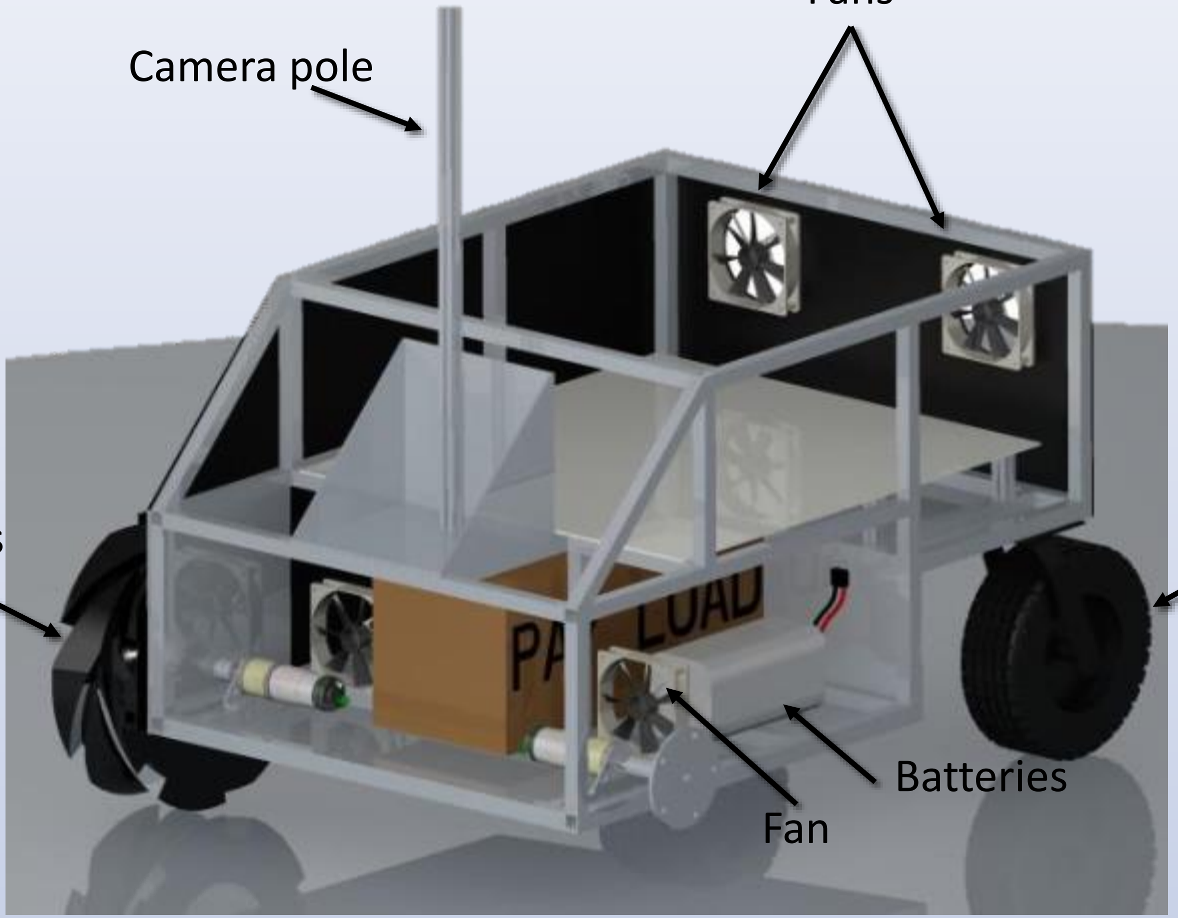
Design 3:

- Differential Steering
- Wheels
- Frame: Hollow Aluminum Tube
- Frame Welded together
- Carbon Fiber body
- Motors located inside

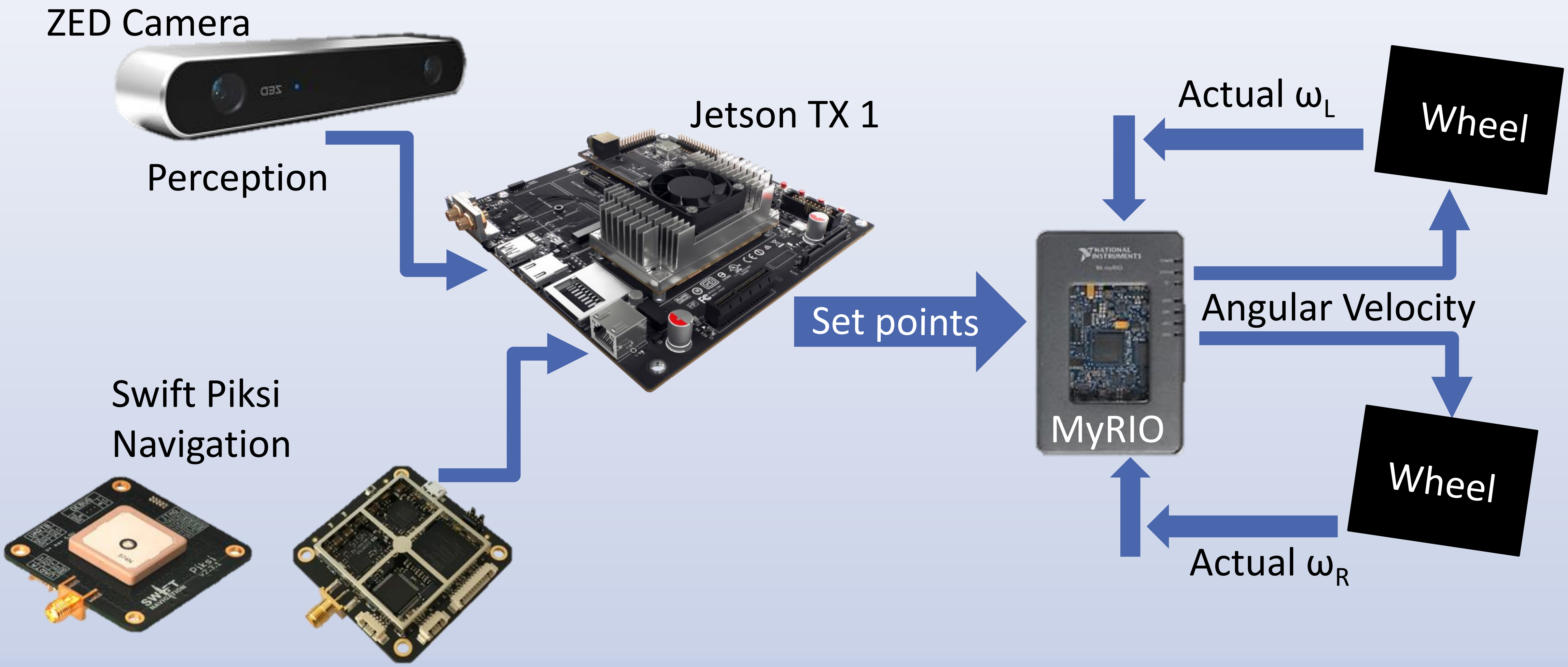
Last years Winner:
Lawrence Tech University

Design 3


Carbon Fiber Body
36in
42in


Camera pole
Fans
10in Caster Wheels
13in Wheels
Batteries
Fan

Overall Schematic



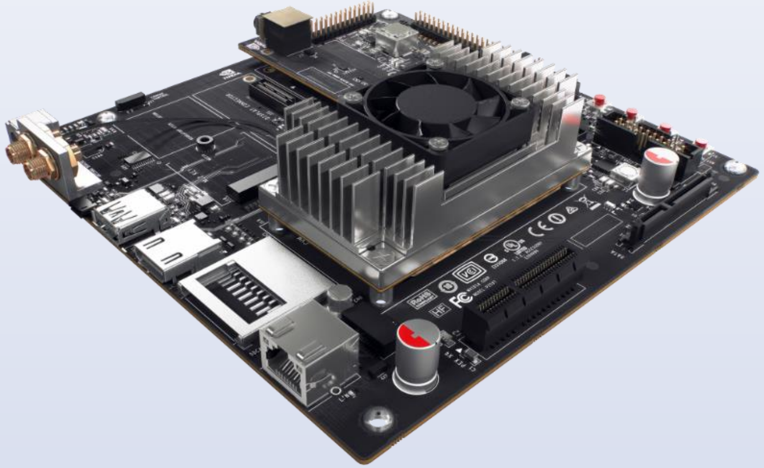
Hardware: Computer

NVidia Jetson TX1

- 4K video encode and decode capabilities
- Camera interface capable of 1400 MPix/s
- Capable of embedded deep learning, computer vision, graphics, and GPU computing.

Raspberry Pi 2 (Model: B+)

- Accessible GPIO
- Communication with MyRIO



Jetson TX 1

Raspberry PI b+

Hardware: Navigation

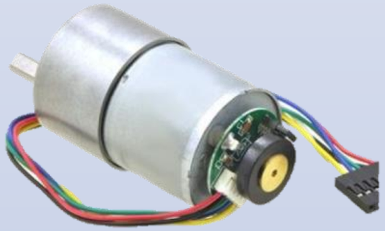
Piksi by SwiftNAV
- 2-3 Meter Accuracy (Without Base Station)
- Centimeter Accuracy (With Base Station)
- 10 Hz Update Rate

IMU: Crossbow NAV440
- 6 DOF

Quadrature Encoders to Output Shaft
- 700 ticks per revolution
- Gear Ratio-50:1

Piksi by SwiftNAV

NAV440 by Crossbow



Example Encoder

Hardware: Object Detection/Collision Avoidance

FIT –

ZED™ 2K Stereo Camera
- Depth Sensing
- Positional Tracking
- 3D Mapping
- Object detection
- Point Cloud Library (PCL)

COE –

2D Lidar
- Increase Working Depth of Robot
- Preliminary Identification of Objects

ZED 2K Stereo Camera

2D Lidar

PD Control for Position

- Receives Vehicle Command Velocities (Linear and Angular)
- Programmed through MyRIO/LabVIEW
- Encoders Determine Error in Position and Velocity
  - Inaccuracy due to wheel slippage

MyRIO Microcontroller

Kinematic Model

Inputs

- Linear Velocity of Vehicle
- Angular Velocity of Vehicle

Outputs

- Angular Velocity of Wheels

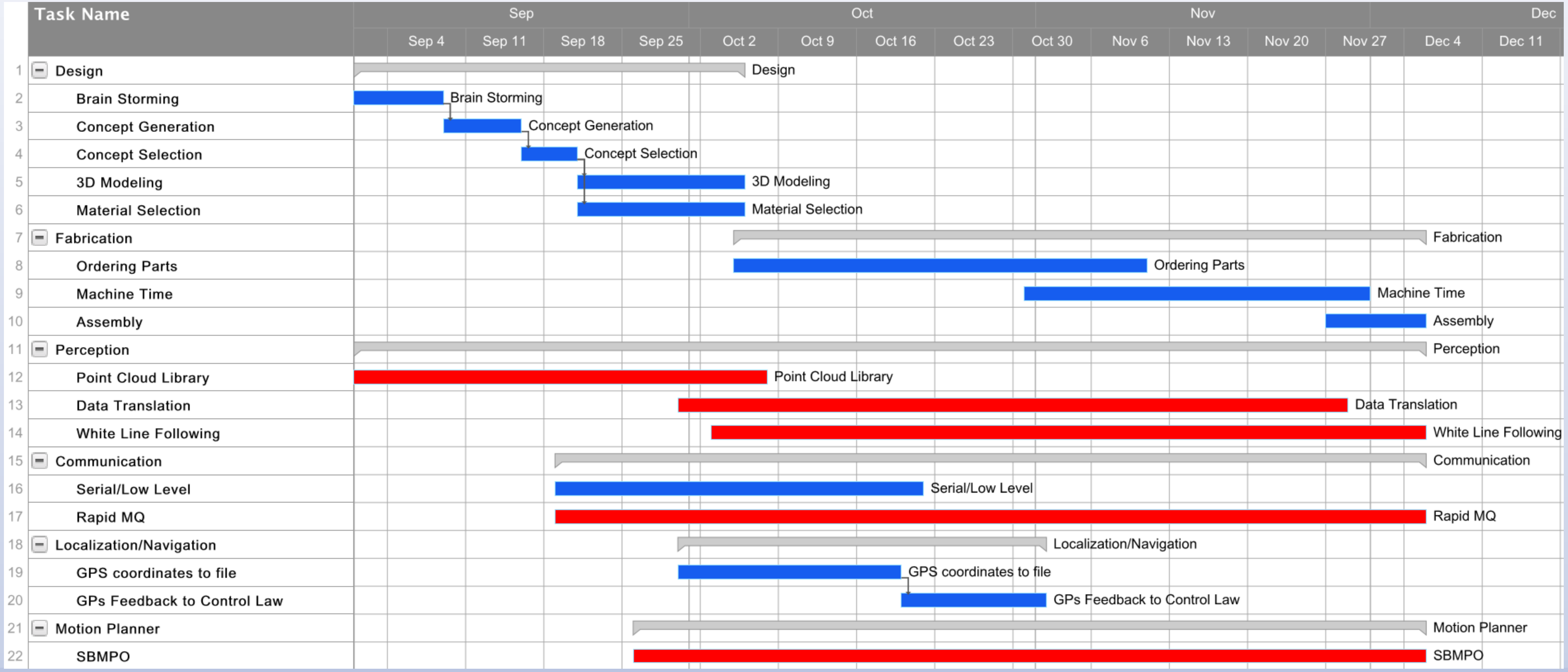
Kinematic Model for
differential steering

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

$\omega_R = Right\ Wheel\ Angular\ Velocity$
$\omega_L = Left\ Wheel\ Angular\ Velocity$
$L = Length\ from\ Wheel\ to\ Wheel$
$r = radius\ of\ wheel$
$V = Linear\ Velocity\ of\ vehicle$
$\omega = Angular\ Velocity\ of\ vehicle$

Gantt Chart for Fall Semester 2016

COE –
FIT –



Future Work

Design

- Order/Create Parts
- Assembly and Waterproofing

Power

- Electronics Schematic

Communication

- GPS/IMU to PD Control
- Serial Communication

Intelligence

- SBMPO
- Obstacle Avoidance

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

Questions?