Autonomous Ground Vehicle Design for Intelligent Ground Vehicle Competition

MEAC Presentation

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Overview

- Introduction
  - Team Dynamics
  - Intelligent Ground Vehicle Competition
- Competition Objectives
- Proposed Designs
  - Electrical Design Concepts
  - Mechanical Design Concepts
- Design Analysis
- Moving Forward
- Conclusion

Introduction - Team Dynamics

- Multidisciplinary Distance Teamwork
- FAMU-FSU College of Engineering
- FIT Team (Melbourne, FL)
  - 1 Computer Engineer
  - 1 Computer Science
  - 2 Mechanical Engineers
- Working on common goal of qualifying and competing in IGVC
- Biggest challenge is communication

AGV attempting to avoid an obstacle

Introduction- Intelligent Ground Vehicle Competition (IGVC)

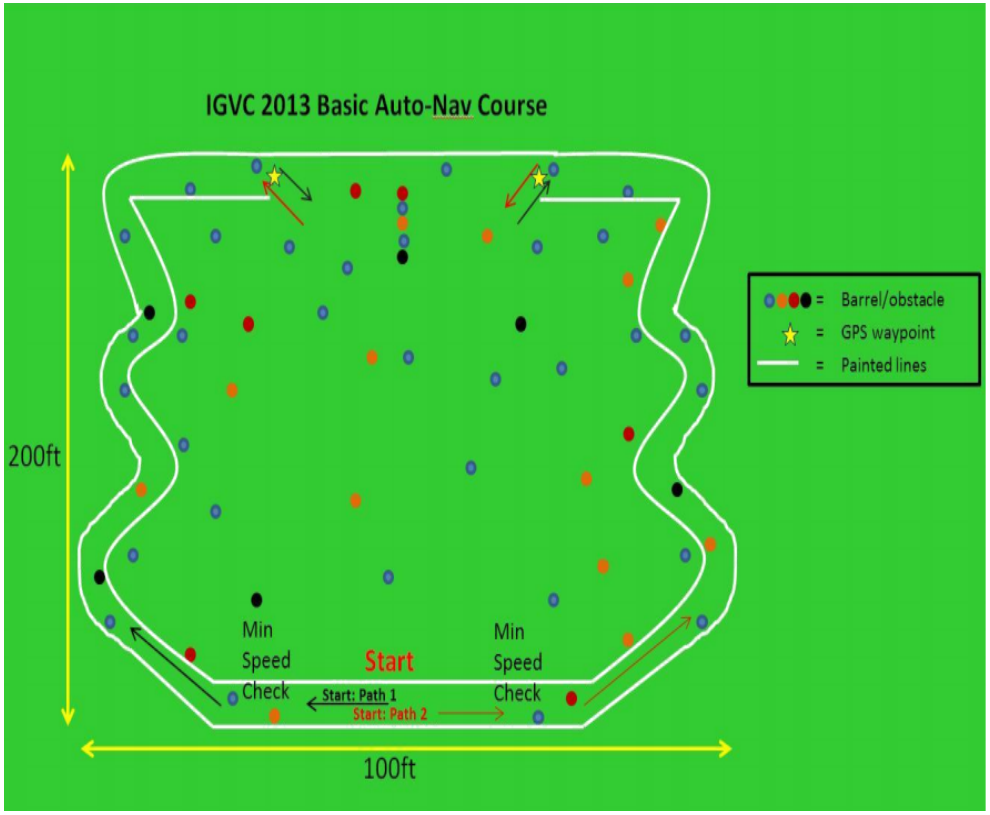
- **Annual design competition held in Rochester, Michigan established in**
- **Provides hands on experience**
- **Focuses on latest technological adv**
- **Team development**
- **Inside view of industrial design**
  - **Team members in remote locations**
  - **Communication**

An autonomous vehicle competing in the IGVC

Competition Objectives

The AGVs are required to navigate an outdoor obstacle course

- under 15 minutes
- Within speed restrictions
- Remain in lane
- Waypoint Identification
- Obstacles



Layout of 2013 IGVC basic course

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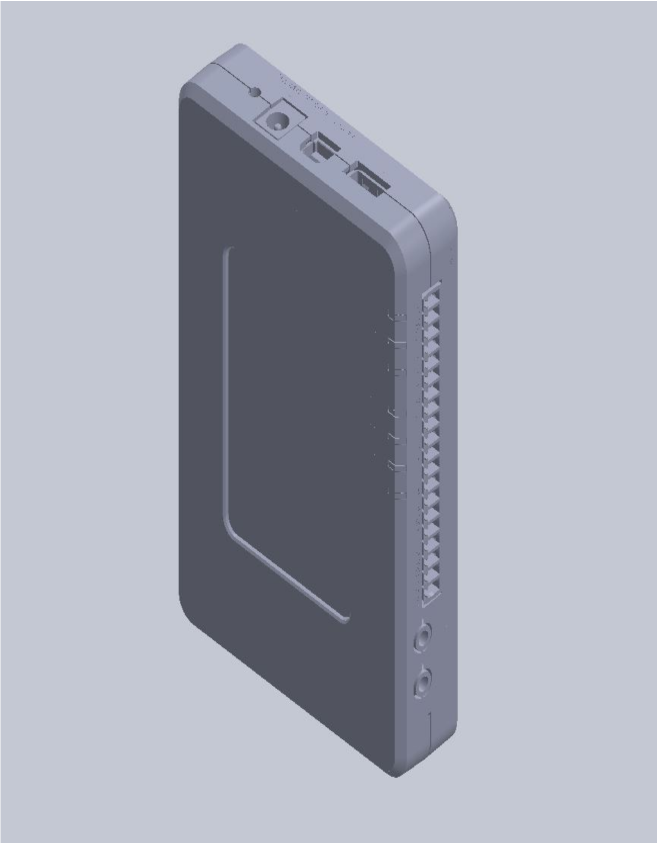
IGVC Design Constraints

- **Dimension:**
  - **Length: 3~7 ft**
  - **Width: 2~4 ft**
  - **Height max: 6 ft**
- **On board Battery Power**
- **1 ~ 5 mph Speed.**
- **On Board and Wireless Emergency Push Stop**
- **Safety light**
- **Payload: 20lb (18" x 8" x 8")**

Electrical Design Concepts–Processors

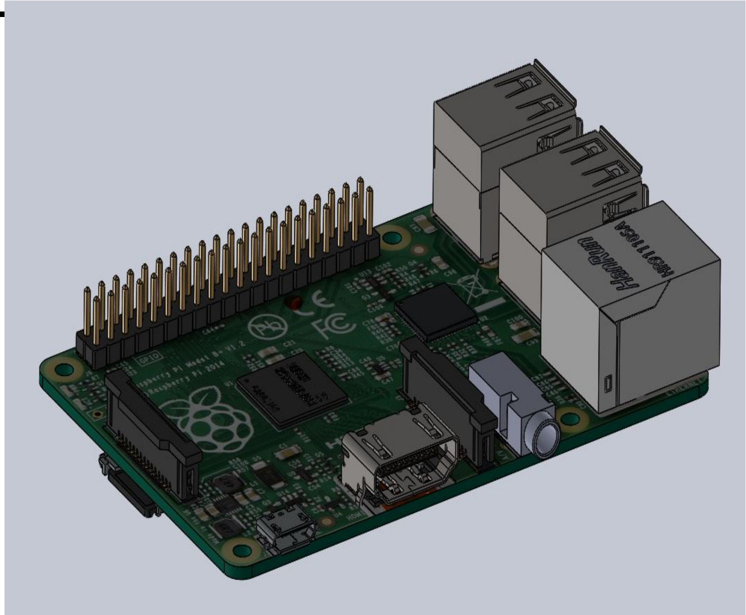
- MyRio 1900

- Portable reconfigurable I/O device
- Xillinx Zynq 7 Series FPGA
  - Dual-core Cortex A9 Processor (667 MHz)
- 34- pin headers
- Integrated WIFI (150 m)
- 3 axis accelerometer
- 40 I/O pins
- 193 g (6.8 oz)
- 256 MB memory, 512 MB DDR3
- 14 W power consumption,
  6-16 V operation voltage



Electrical Design Concepts – Processors

- Raspberry PI 2 – Model B



- 40 GPIO pin header
- Broadcom BCM2835 processor (900 MHz)
  - Quad-core ARM Cortex A7 CPU
- 100 mps Ethernet port
- CSI camera connector
- High efficiency power supply
- 1 GB RAM
- 5 V operation voltage
- 45 g (1.6 oz)

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Electrical Design Concepts – Sensory

- LIDAR-LITE V2

- 40m range
- 905nm single stripe laser transmitter
- 3 degree FOV with 14mm optics receiver
- 5 V operation voltage
- +/- 0.025m accuracy
- 0.02 sec acquistion time
- PWM interface
- 1-500 Hz rep rate

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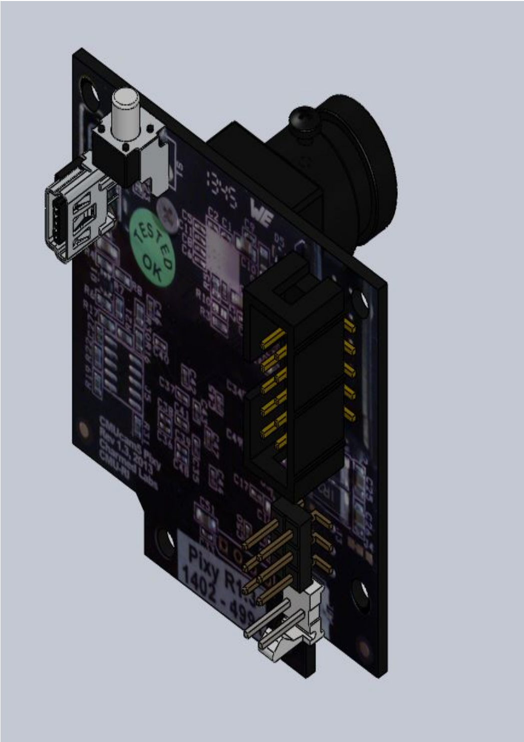
Electrical Design Concepts – Perception

- **Pixy Cam**
- **Teachable camera**
- **Uses hue and saturation**
- **50 frames per sec**
  - **640 X 400 – 20 ms**
- **Multiplatform compatible**
- **up to 7 different color signatures**
- **Detects 100 plus object at a time**
- **75 degrees horizontal , 47 degree vertical FOV (Filed of View)**
- **Standard M12 lens**
- **27g weight**
- **140 mA power consumption**
- **5 V operation voltage**

- **Omnivision OV9715 image sensor**
  - **1/4 ", 1280 x 800**
- **NXP LPC4330 Processor**
  - **Dual- Core (204 MHz)**



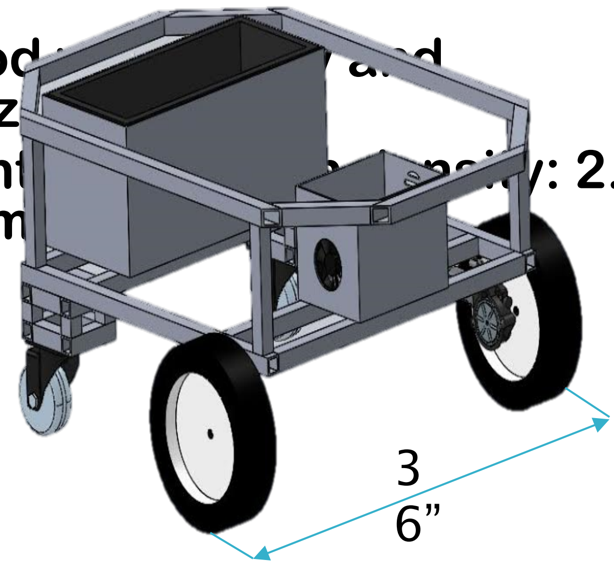
Mechanical Design Concept– Frame Design

- **Vehicle Frame**
- **DC gear motor**
- **Wheel**
  - **Driving wheel (10” diameter, 5” thickness)**
  - **Caster wheel (4” diameter, 2” thickness)**
- **Payload (Weigh 20”)**
- **Electronics Housing**

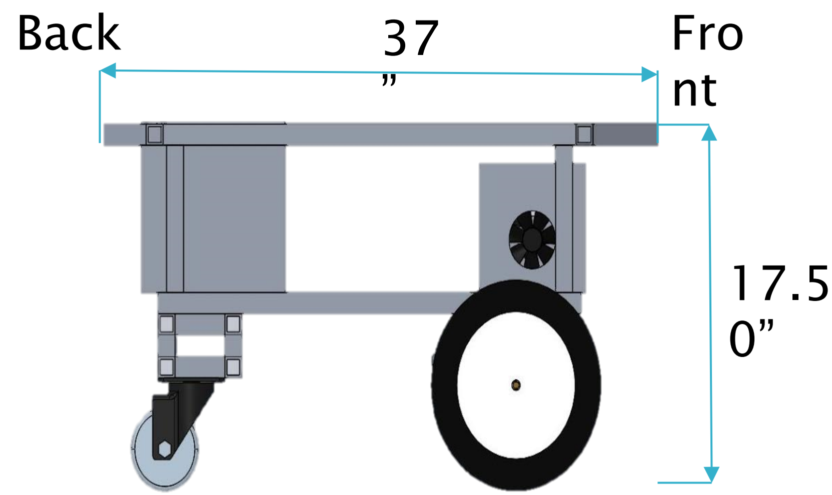
Frame material: Aluminum 6061

- **Medium High strength**
- **Good workability**

- **Good ... braz**
- **Light ... : 2.7 g/cm**



Isotropic view of the frame design



Side view of the frame design

Mechanical Design Concept-**Drive System**

Differential Steering:

- Two independently driven wheels
- Take turns at different wheel speed or direction
  - Easy to design and implement
  - Easy turning
  - Light weight
  - Inexpensive

Components:

- Wheel, Shaft
- DC gear motor
- Encoder

- **Motor driver**

Vehicle direction with respect to wheel rotation

MOTION	LEFT WHEEL	RIGHT WHEEL
Right Turn	Counter Clockwise	Counter Clockwise
Left Turn	Clockwise	Clockwise
Forward	Counter Clockwise	Clockwise
Backward	Clockwise	Counter Clockwise

Example of differential steering

Mechanical Design Concept-Motor Selection

- DC gear motor
- Controlled by motor driver
- Actuates the wheel.
- Enables continual shaft rotation.
- Easy to control
- Inexpensive

Torque needed: 6.023ft.lbf
Required current:8.63 Amp.

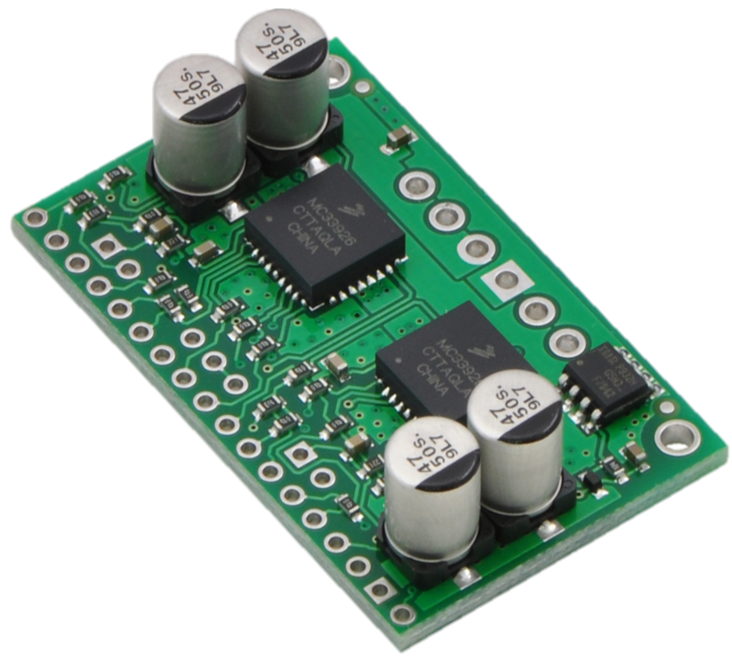
Specifications:

- Voltage: 12Volts
- Torque constant: 134ozf.in/A (o. 698ft.lbf/A)
- Angular-velocity constant:10.1 rpm/V
- No-load current: 3A
- Peak Power and efficiency: 0.0887hp and 45%

AME 210-series 12V 88in-lb LH gearmotor-shaft

Mechanical Design Concept– Motor driver

- **Motor driver:**
  - **Controls the motor**
  - **Interface between microprocessors and motors**
  - **Supplies relatively higher voltages and current to the motor .**
- **Specification:**
  - **Current: 3 ~ 5 Amperes.**
  - **Voltage: 5 ~ 28 volts.**
  - **Frequency: 20kHz.**
- **Advantage:**
  - **Eliminates audible switching sounds during speed control.**
  - **Reduced external connections.**
  - **Features current feedback**
  - **Over and voltage protection**



Dual MC33926 motor driver carrier.

Mechanical Design Concept- Encoder

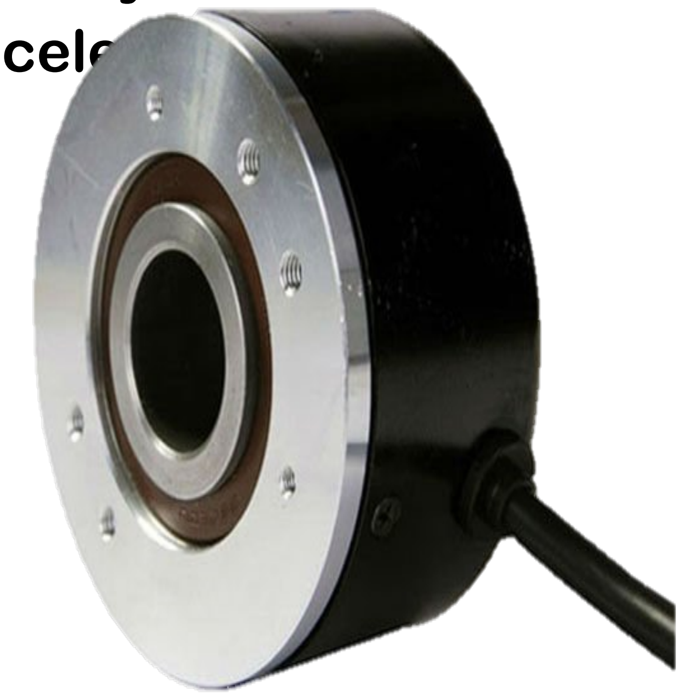
Measures wheel rotation and Uses

- Optical sensor(s)
- Moving mechanical component
- Special reflector

To Provide electrical pulses to
the motor driver and microcontroller.

Enables the AV to determine:

- Displacement
- Velocity
- Accele



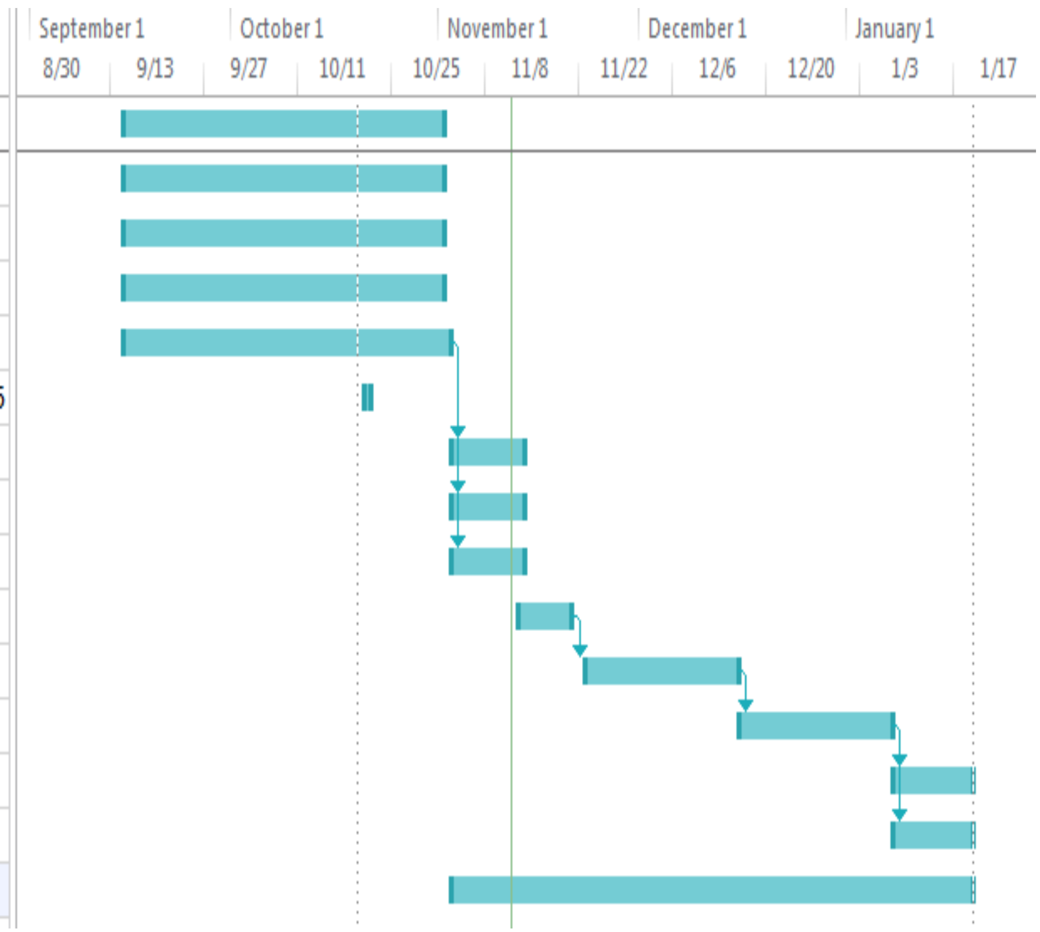
Hollow shaft encoder

Challenges

- Starting from scratch
- FAMU/FSU-FIT Collaboration
  - Distance teamwork
  - Meshing Computer/Electrical and Mechanical Engineers
  - Coming to sound decisions
- Familiarizing with unexplored technologies
- Availability of Products
- Time Constraints

Gantt Chart

Task Name	Duration	Start	Finish
Frame Design	35 days	Tue 9/15/15	Sun 11/1/15
Motor Specifications	35 days	Tue 9/15/15	Sun 11/1/15
Sensor Specification	35 days	Tue 9/15/15	Sun 11/1/15
Processor Specifications	35 days	Tue 9/15/15	Sun 11/1/15
Market Research	35 days	Tue 9/15/15	Mon 11/2/15
Frame Material Selection	1 day	Wed 10/21/15	Wed 10/21/15
Motor Selection	9 days	Tue 11/3/15	Fri 11/13/15
Sensor Selection	9 days	Tue 11/3/15	Fri 11/13/15
Processor Selection	9 days	Tue 11/3/15	Fri 11/13/15
Finalize Design Plan	6 days	Fri 11/13/15	Fri 11/20/15
Order Materials	17 days	Mon 11/23/15	Tue 12/15/15
Frame Machining	17 days	Wed 12/16/15	Thu 1/7/16
Sensor Mounting	8 days	Fri 1/8/16	Tue 1/19/16
Motor Mounting	8 days	Fri 1/8/16	Tue 1/19/16
Coding Prototype	56 days	Tue 11/3/15	Tue 1/19/16



Future Plans Outline

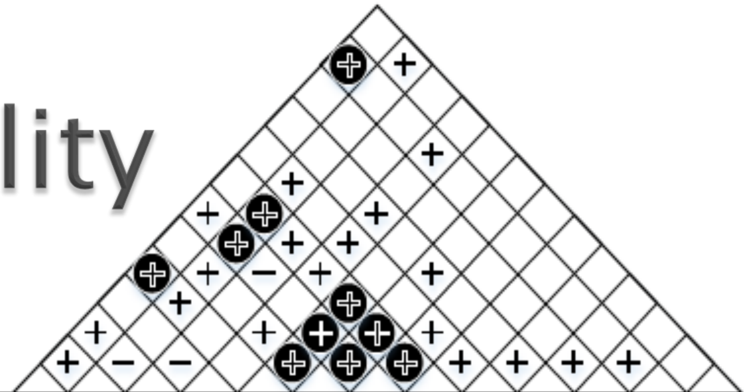
- **Prototype Perfection**
- **Finalize Frame Design with FIT**
- **Purchasing Parts**
- **Construction of Robot**
  - **Frame**
  - **Obstacle detection**
  - **Obstacle avoidance**
  - **GPS navigation**

Reference

1. http://www.igvc.org/objective.html
2. http://www.igvc.org/2016IGVCRules.pdf
3. http://www.robotmarketplace.com/products/AME-210-1012.html
4. https://www.pololu.com/product/1213
5. https://www.sparkfun.com/products/13680

questions?

House of Quality



Strong Positive	⊕
Positive	+
Negative	−
Strong Negative	⊖

Engineering Characteristics / Design Requirements	Design Requirement Weight	Cost	Sensors	Power	Motor	Image Analysis	Programming	Microcontrollers	Interfacing	Mobility	Differential Drive	Speed Control	Weight	Body Styling
Vehicle Speed	5	1	1	3	5	1	3	5	3	5	5	5	3	1
Size	1	3	1	1	1	1	1	1	1	3	3	3	5	5
Lane Following	5	5	5	3	1	5	3	5	3	3	1	1	1	3
Obstacle Avoidance	5	1	5	1	5	5	3	5	3	5	3	3	1	1
Waypoint Navigation	3	3	3	1	1	1	3	5	3	1	1	1	1	1
Mechanical E-Stop	5	1	1	1	1	1	3	3	3	1	1	3	1	5
Wireless E-Stop	5	1	5	1	1	1	3	3	3	1	1	3	1	1
Absolute Importance		57	95	49	69	69	85	121	85	81	61	81	43	63
Relative Importance		6	11	6	8	8	10	12	10	9	7	9	5	7
Rankings		6	2	7	5	5	3	1	3	4	6	4	8	6

Strong - 5
Medium – 3
Weak - 1

Decision Matrices

Steering	Base	Control	Feasability	Speed	Total
Differential Steering	0	7	7	7	21
Skid Steering	0	7	5	5	17
Tank Tread	0	5	3	3	11
Steering Fans	0	3	3	5	11
Ackerman Steering	0	5	0	5	10

Body Structure	Base	Manufacturability	Weight	Availability	Total
Tubing Frame	0	7	5	7	19
Sheet Material	0	7	5	5	17
3D Printed	0	5	5	3	13
Hovercraft	0	3	7	5	15

Materials	Base	Machinability	Density	Availability	Total
4130 Steel	0	7	3	5	15
Aluminum 6061	0	7	5	7	19
ABS Plastic	0	5	7	5	17
Wood	0	5	7	5	17

Decision Matrices

Processor	Base	Power Consumption	Processor Speed	Memory	Total
NI MyRio 1900	0	5	5	5	15
Raspberry PI 2	0	5	7	7	19
Arduino	0	5	3	3	11
MSP430	0	5	3	3	11

Sensor	Base	Accuracy	Range	Speed	Total
Infrared	0	5	0	5	10
Ultrasonic	0	3	5	7	15
Radar	0	3	5	5	13
Lidar	0	7	7	7	21

Vision	Base	Resolution	Intigration	Accuracy	Total
Pixi Cam	0	7	7	5	19
USB Camcorder	0	5	3	5	13

Power	Base	Capacity	Voltage	Weight	Total
Lead Acid	0	7	5	5	17
Lithium Ion	0	7	7	7	21
Nickel-Metal Hybrids	0	7	5	5	17
Lithium Polymer	0	7	5	3	15