M.S.RAMAIAH INSTITUTE OF TECHNOLOGY
BANGALORE, INDIA

MOKSHA

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1. Introduction

The robotics team of M.S. Ramaiah Institute of Technology is proud to present its Autonomous Ground Vehicle MOKSHA. MOKSHA was conceptualized early in the year 2009 with the intention of being able to move through obstacle courses without any hindrances and to compete at the IGVC. The autonomous vehicle is a complex system with the integration of software, electronic, electrical, and mechanical engineering streams. This report elaborates on the details, innovations, integration of systems, cost productivity and the team structure.

The word 'MOKSHA' is from the ancient language Sanskrit which means 'release or liberation'. Through this project we hope to achieve this 'liberation' from the normal cycle of engineering life in India.

2. System Design

2.1 Workflow Process

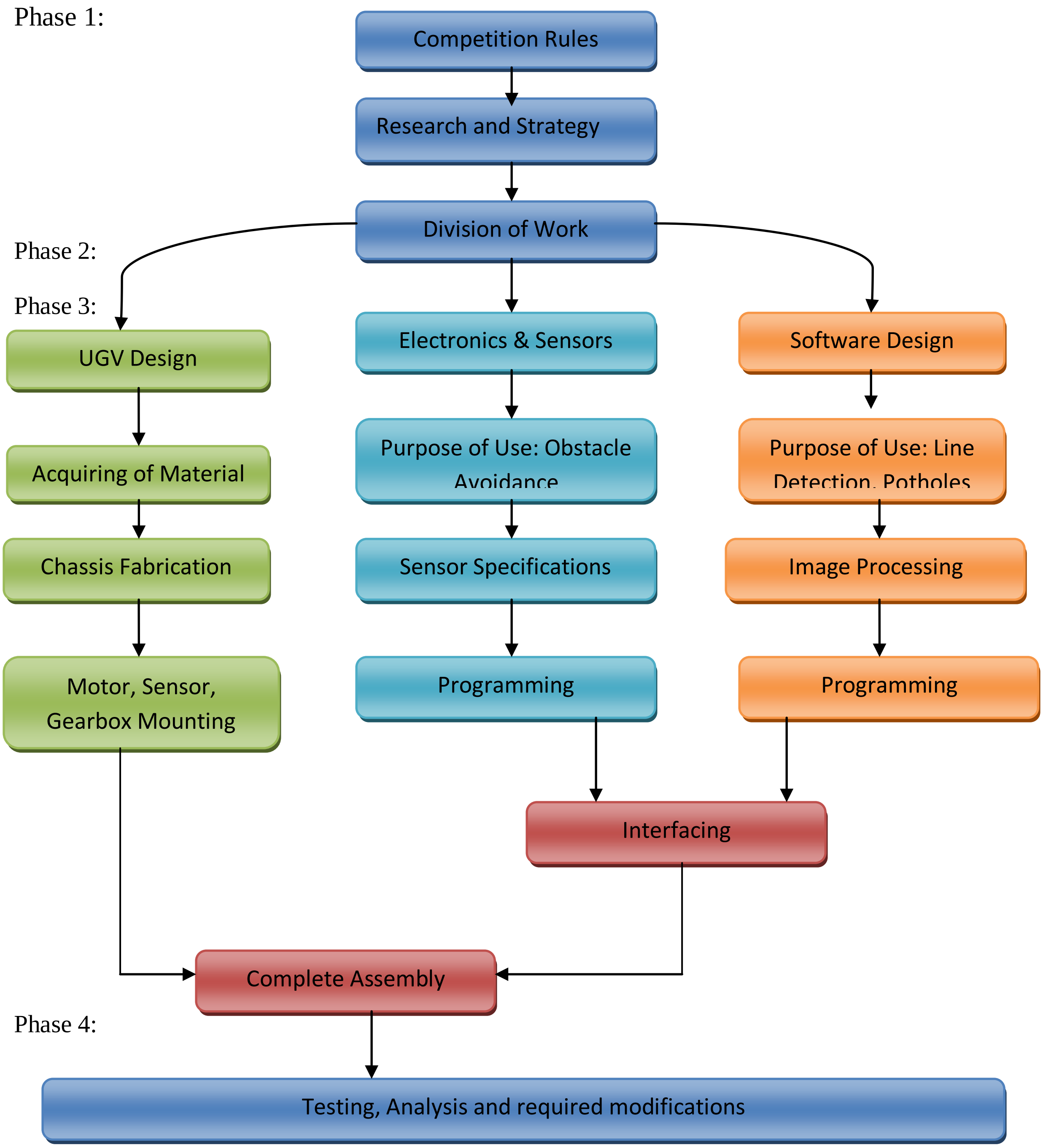
The workflow process describes briefly the overview of how this project has been brought to completion.

Phase 1: After initially going through the design rules a strategy was developed on how to face the challenges after researching on the requirements.

Phase 2: Once the requirements were specified the work was divided amongst the group members from different branches of engineering.

Phase 3: Each group followed their own procedure to come to a common position of integration of the vehicle.

Phase 4: Testing, analysis and required modifications.



2.2 Objective of Vehicle

While starting off the group defined a few objectives being:

1. Egg Shaped Design
2. Four Wheel drive: Differential Drive System
3. Sensors used for obstacle detection and Camera for Lane detection, potholes.
4. Maximum Speed of 5mph

5. Weight of 80kgs
6. Dimensions of 1.5m x 1m x 1.5m

2.3 System Overview

The Unmanned Vehicle is broken up into subsystems as sensor and actuator assemblies. The sensors used and the actuators used are detailed in the tables below:

Sensors	
Lane Detection, Pothole Detection	Camera GreyPoint Firefly MW
Obstacle Avoidance	Leuze ROD 4-20 LIDAR
Position Detection	Garmin HVS17 GPS

Actuators	
Propulsion	4Wheel Drive
Motor	Magmotor S28-400 Shown RPM: 4900
Gear Train	7:1 reduction box
Propulsion Drive	4 independent wheels Differential Drive

The acquisition, fusion and processing of the data from the camera, the LIDAR, and the Differential GPS is done on a laptop. On processing the data is sent serially from the laptop to the Arduino 1280 microcontroller which in turn will control the actuators through a motor driver AmpFlow 160A Motor Controller. This motor controller will drive the Magmotor S28-400s at its required voltage, power and the rpm will be controlled using PWM (Pulse Width Modulation).

2.4. Innovations Used

The entire vehicle built is an innovation on its own as it was built entirely from scratch by the students of M.S. Ramaiah Institute of Technology. Also the idea of an egg shaped vehicle is an innovation. The egg shape of the vehicle enhances the ability of the LIDAR being placed in the front and hence increases the ability to scan 180^0.

The use of Solar panels on the vehicle so that the size of the batteries is reduced. This introduces the use of Green Technology.

3. Mechanical Design

3.1 Design method

The first visualizations of the vehicle were put down on paper where we delineated the basic shape of the vehicle, the dimensions, the allotment of space for various components etc.

The unique egg shape chassis was conceptualized and designed in SOLID EDGE V.20. 3-D models of the various components were made.

3.2 Structure overview

3.2.1. Chassis:

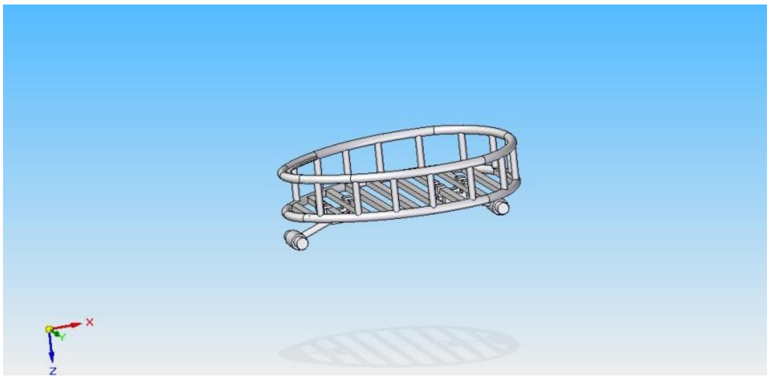
Drawing attention specifically to the unusual egg shape, the advantages are as follows:

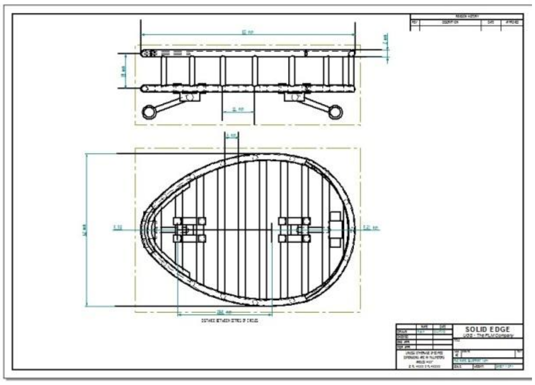
1. A tapering front provides us with a better turning radius.
2. An enhanced range of view for the sensor at head of the bot.
3. Edges pose a problem as they may tend to chip off in case of collision.
4. The payload has been positioned roughly with its COG coinciding with that of the egg shaped base for improved stability especially while climbing inclines.

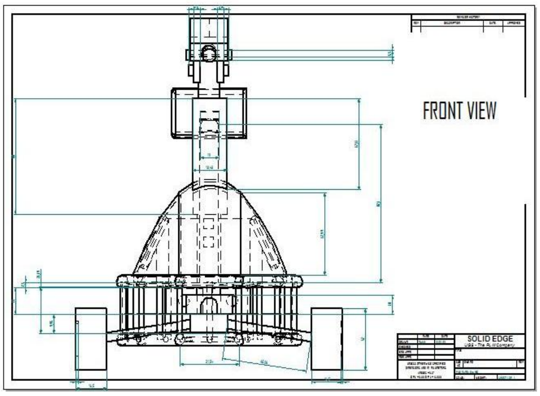
The dome frontal shield provides for some amount of protection for the circuitry within .Subsequently more plates may be added to cover the latter portion of the vehicle similarly during transport. The designs for the camera arm and that for the solar panel have been kept simple using a screw and slot to move the arm to a desired height and then fix it there.

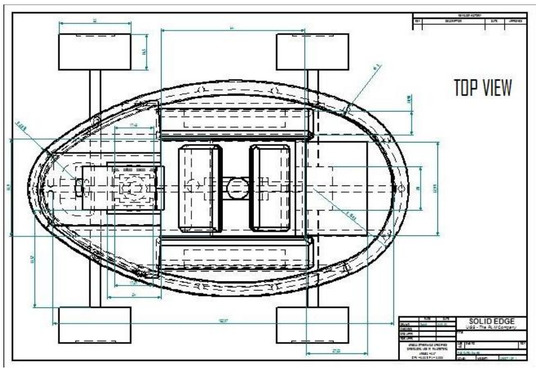
3.2.2. Body:

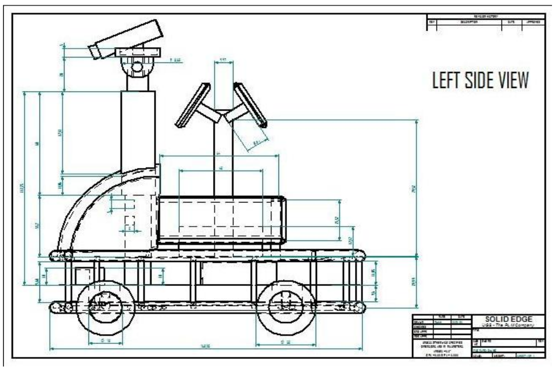
The whole body resembles a ROLE CAGE present in cars which makes it a robust design. Also, polypropylene board has been used as our base plate due excellent mechanical properties, weight factor and easy machining











3.3. Drive train

Our vehicle has a 4-wheel drive with a Differential Drive mechanism .We have incorporated 4 S28-400 MAGMOTORS each coupled with TWM3M GEARBOX for each wheel with a gear reduction of 7:1. The speeds of the motors are regulated with the use of motor controllers varying the voltage to get the required RPM.

3.4. Mountings:

The various mountings for the camera, solar panels, and GPS have been made using Mild Steel Square sections and "L" channels. The height of the arms for the camera and the solar panels are varied with a simple slot and screw mechanism. To optimize the usage of space the GPS unit has been mounted on the solar panel stand. The battery unit has been housed in a box made of the same PP sheet used to make the flooring sheet; the payload box is of the same material. The laptop has been incorporated above the payload box with suitable ventilation provided.

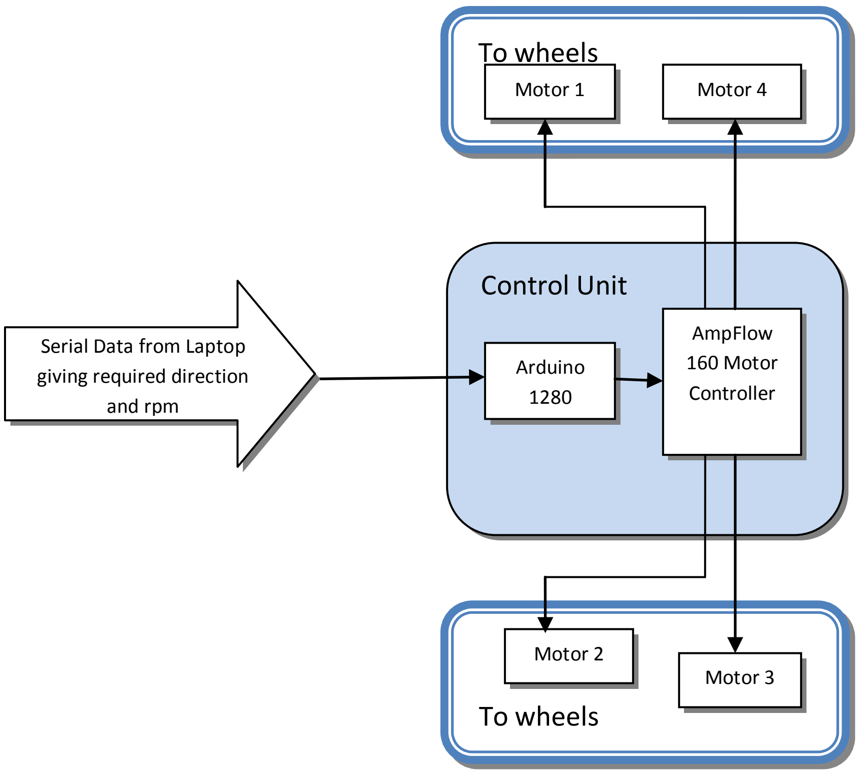
3.5. Mechanical datasheet

Material Used	AL-6063(HE9)
Length	4.5 ft
Width	3 ft
Height	4 ft
Wheels	4
Motors	4- S28-400 MAGMOTORS 1. Body Diameter 77mm 2. Body Length 170mm 3. Shaft diameter 12.7mm 4. 24V (can be run higher) 5. 4.5 horsepower 6. 3720 oz in Torque 7. Max current 390 Amps 8. 83% Efficiency 9. 4900 rpm 10. Weight 3.2Kg 11. Neodymium magnets

Gearbox	4- TWM3M 1. **Weight:4.5 pounds** 2. **Rpm:840** 3. **Max. Torque:878** 4. **Output shaft:0.75 inch**

4. Control Systems:

The control of the Unmanned Ground Vehicle is done through the microcontrollers used on board the system. The motor controller acts as an interface between the computer and the drive train. Using accurate Pulse Width Modified (PWM) data inputs to the motor controller the motors can be driven. Initially the output goes as serial data to the Arduino 1280 microcontroller which in turn gives the PWM data to the motor controller. The motor controller is the AmpFlow 160A which has dual channels with 160A each. This data is given to the encoders within the motor controller. The data communication is through RS232 to the laptop on board. The speed of the motors can be controlled by changing the rpm required.

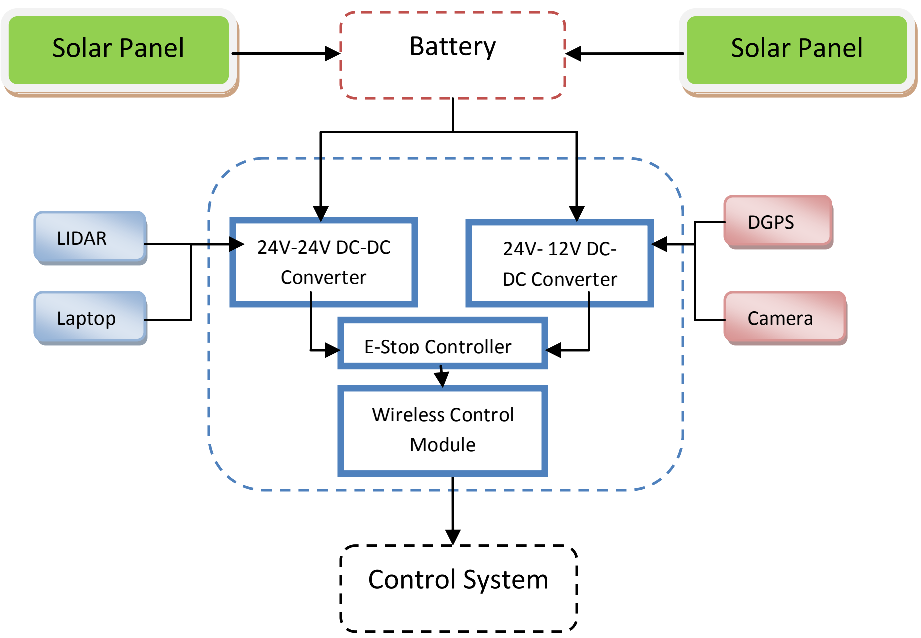


5. Electronic & Electrical Systems

5.1 System Process

The power system of the vehicle is made in such a way so as to be fully functional and to be as efficient as possible without any fluctuations. A certain amount of power needs to be supplied to each of the electronic components used to be able to function as a whole. We are hence using a single battery to supply the power and by reducing the voltage using 24V-24V DC-DC converters and 24V-12V DC-DC converters. It is extremely important that this much amount of power be supplied to each of the components otherwise there is a high risk of short circuiting or over heating of the systems. To be able to make the sizes of the battery lesser so that the Ah rating of the battery is reduced we are using Solar Panels. This is also a way to bring about efficiency in the use of Green Energy to be environmentally friendly.

The electronic system has a LIDAR, a camera, a Differential GPS, a wireless E-stop module, Arduino 1280 microcontroller, and a motor driver. All these need to be supplied the amount of power so as to be able to perform their functions simultaneously. This in turn will be interfaced with the laptop on board and will run the entire vehicle. The overall system configuration is shown below:



5.2 Components Utilized

The main components utilized here controlled by the battery are

1. LIDAR
2. Laptop
3. DGPS (Differential GPS)
4. Camera
5. Motors

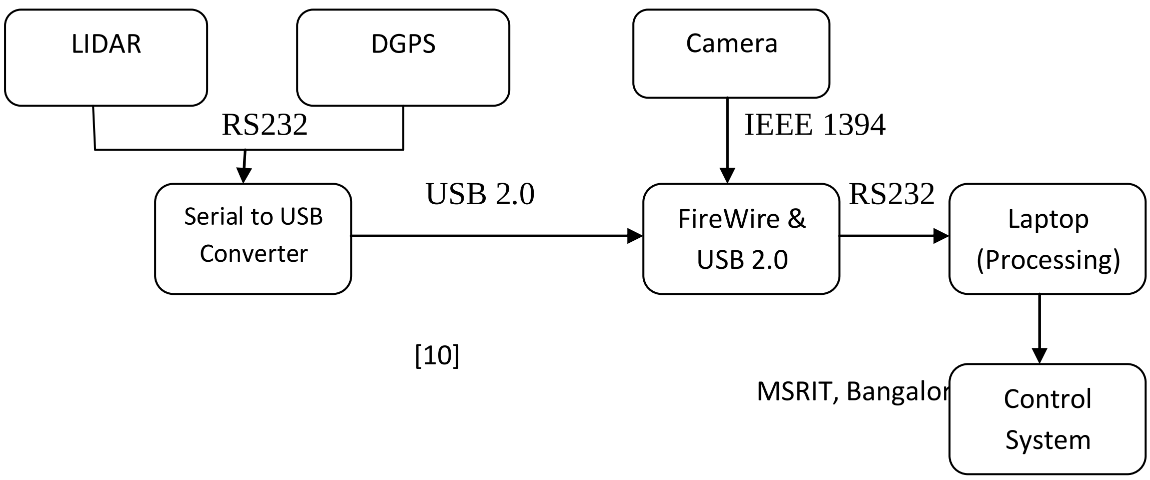
These components require different power ratings and different voltages. To provide this we use a 24 V Lead Acid battery. We also use a 24V-24V DC-DC converter and a 12V-12V DC-DC Converter to be able to run the system. The E-stop takes the required amount of power and it works as and when supposed to. The motors take up the maximum power as they run at 51 Amp each and there are 4 in number. This effect though is reduced by the use of the motor controller in the control system. The Laptop also requires 24V hence it also is connected to the 24V-24V DC-DC Converter. The battery will in turn be charged by the on board solar panels.

5.3 E-Stop

The e-stop is of 2 types: Mechanical and Wireless. The mechanical e-stop is done using a red button of 1 inch diameter. It is placed on the vehicle and once pressed the vehicle will then be stopped immediately. The wireless e-stop is such that once a signal is passed or given then it transmits a relay to the circuit and stops operation of the vehicle. The range of the wireless e-stop is 50m. On pressing this the vehicle must stop the power supply to every part of the vehicle.

6. Software Design

6.1 Architecture:



The Architecture of the Software is such that it can be used in the best possible method, that is, it provides for high level of flexibility and the system is divided into the parts of processing. The parts are used to control the various components being used on the vehicle. These are Sensors, Control Structure or loop, and finally the control of the Control Systems which has the microcontrollers for the control of the actuators. The sensors are connected to the laptop by the RS232 port that is it is serially connected to the laptop. The Camera is also connected to the Laptop by the IEEE 1394 port, that is, by FireWire through the USB 2.0 port. The laptop does the processing and passes the data to the Control System which will in turn move the actuators according to the data sent by the Laptop to the microcontroller again serially.

6.2 Control Structure :

6.2.1 Algorithm of Image Processing:

The image processing part of the software acquires data through the IEEE1394 port (FireWire port) and this data is acquired in the OpenCV library of Visual C++. The main advantage of using OpenCV is that the speed of processing and data transfer rate is much larger than that of MATLAB or any other tool used. Using this library we have used the Blob detection algorithm to detect and navigate the path of the track. The main steps of the algorithm are as follows:

1. Acquire data from camera, and capture frames of the image.
2. Convert the captured image into grayscale.
3. Once converted to grayscale, according to the threshold input, pixels with similar intensity are collected.
4. These are then gathered into a group.

5. The center of mass of each group is calculated from which the center of the track is found.
6. The vehicle will then be directed by the serial data sent to the Arduino 1280 microcontroller to the motor controller causing the vehicle to move in the desired direction.

This algorithm will also take care of pothole detection and the break of lines in the track. It will be able to function in such a way to detect these as blobs as a pothole of 2inches depth will have the same intensity pixels. When this is detected as a blob and the track on the other side is also detected as a blob, it will take the center of gravity according to the algorithm defined above and direct the vehicle away from the pothole.

6.2.2 Sensor Data:

The sensors used are the Leuze ROD 4-20 LIDAR scanner and the differential GPS being used. The LIDAR gives data serially through RS232 to the laptop and this will then be incorporated into the code.

The main use of taking the serial data from the LIDAR to the main program is to be able to incorporate interrupt programming and data fusion. The LIDAR has a range of 180^0 with scanning rate of 25 scans/sec and a resolution of upto 50mm. It also has the range of upto 50m, but for our usage we have set the range of only 10m. The data from the LIDAR will be taken as distance and angle. Depending on the Sensor data we configure the vehicle to move in a particular direction by data fusion.

6.3 Differential Global Positioning System:

We have used the GARMIN 17HVS GPS as our co-ordinate receiving system. This receiver is WAAS-capable and gives an extremely high level of accuracy. It is simple in function and simply returns NMEA data through a serial port.

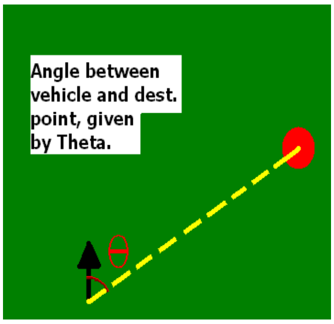
6.3.1 Extraction of Data:

As already mentioned, the receiver returns NMEA data which then has to be extracted appropriately. In our case, we extract the strings that are labeled by “$GPRMC”. From these specific strings, we extract the data required, that is, North-South co-ordinates, East-West co-ordinates, and possibly velocity. We have done this using C in the Visual Studio environment.

$GPRMC,123519,A,4807.038,N,01131.000,E,022.4,084.4,230394,003.1,W*6A

6.3.2. Determination of Relative Angle:

Now that the present co-ordinates have been obtained, we manually input the destination co-ordinates into a sub-controlling program, which then continuously calculates the relative angle between the destination point and the present direction of the vehicle. It decides, first, which point is closest to its present location, selects that point, and then makes its angle calculations. This data is returned continuously to the main controlling program, where decisions are made. Once the point has been reached, the next nearest uncovered point is selected, till the sixth waypoint has been reached.



6.4 Waypoint Navigation:

The data input from the GPS software and that from the obstacle detection sensor is interfaced in the main controlling program. Here, decisions are made regarding the direction in which the vehicle ultimately moves, after evaluation of the direction to the next destination point and obstacles in the vehicle's path to that point. This is a continuous process.

7. Predicted Results:

As a team having made the efforts that we have, we have set a few results and targets for our vehicle to meet:

1. To be able to qualify through the initial round.
2. To be able to make the mechanical and wireless E-Stop work in such a fashion as to stop the vehicle motion when used.
3. To be able to maintain the speed of 5mph throughout the course and to be able to navigate through the potholes and the
4. To be able to come out on top in the navigation and the design challenges.

8. Team Structure:

Name	Area Of work	Year of Course	Hours Input
Vineet Sahu (Team Leader)	Software & Electronic Systems	3rd year Electronics & Communication Engineering	600
Shekar N.H.	Software & Electronic Systems	3rd Year Electronics & Communication Engineering	600
Praveen Pitchai	Software & Electronic Systems	3rd Year Electronics & Communications	600

		Engineering	
Rohan Pradip Shah	Software	3rd Year Electronics & Communication Engineering	600
Mohit Sain Mathur	Mechanical Systems	2nd Year Mechanical Engineering	350
Nakul Shetty	Mechanical Systems	2nd Year Mechanical Engineering	350
Nikhil Acharya	Mechanical Systems	2nd Year Mechanical Engineering	350

9. Budget:

Components	Actual Cost	Team Cost
Leuze ROD 4-20 LIDAR	**$4609**	**$888**
Garmin HVS17 GPS	**$264**	**$297**
Fabrication	**$560**	**$560**
Batteries	**$1000**	**$1000**
Solar Panel	**$150**	**$150**
Motors and Motor Driver	**$2031**	**$3050**
Gearbox	**$1700**	**$2476**
E-stop	**$200**	**$200**
Arduino Microcontroller Board	**$90**	**$90**
Laptop	**$900**	**$0**
Total	**$11504**	**$8711**

10. Acknowledgement:

TEAM MOKSHA would like to acknowledge and commemorate all of its team members, our guide C.G.Raghavendra, our Head of Department Dr.S.Sethu Selvi, the E&C Department staff, the Mechanical Engineering staff, the Alumni Assocaiation of M.S. Ramaiah Institute of Technology, the Chief Executive, and the Principal of the Institution for all of their support, help and immense encouragement. We would like to make a special mention of our sponsors as without them this project would not be at the stage it is:

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2. M. S. Ramaiah Institute of Technology
3. Leuze Electronics
4. CNS Comnet Solutions
5. SGC Services Pvt. Ltd.

Finally we would like to thank all of our families and friends for supporting us throughout the endeavor.