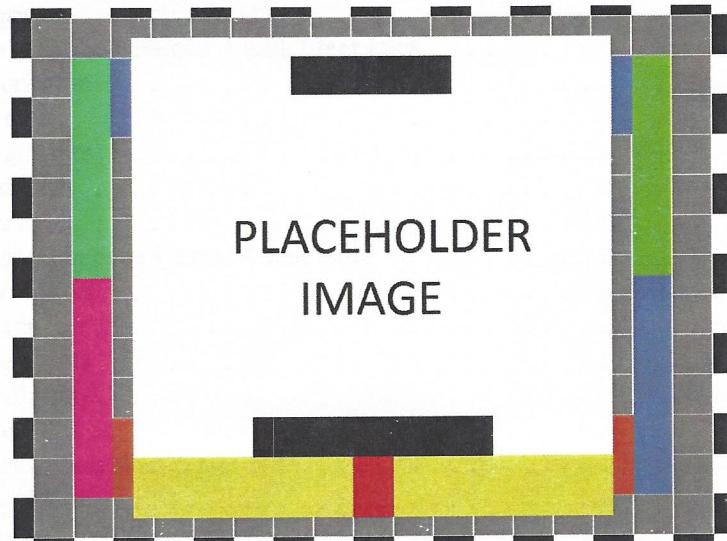


DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING  
THE UNIVERSITY OF TEXAS AT ARLINGTON

SYSTEM REQUIREMENTS SPECIFICATION  
CSE 4316: SENIOR DESIGN I  
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105

IGVC  
AUTOMAV

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## REVISION HISTORY

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## 1 PRODUCT CONCEPT

This section describes the purpose of AutoMav and its intended audience. Automav is autonomously controlled vehicle that can navigate itself from its current location to a point in GPS coordinates.

### 1.1 PURPOSE AND USE

The AutoMav is an intelligent ground vehicle that acquires data about its surroundings using sensory equipment and uses the data to navigate itself to a location given in GPS coordinates. To do this AutoMav must recognize specific obstacles and boundaries in its path and calculate an optimal route around them while maintaining above a specified average speed.

### 1.2 INTENDED AUDIENCE

The intended audience of AutoMav are those in areas of autonomous robot research and development. Automav is intended to display an implementation of current autonomous navigation technology.

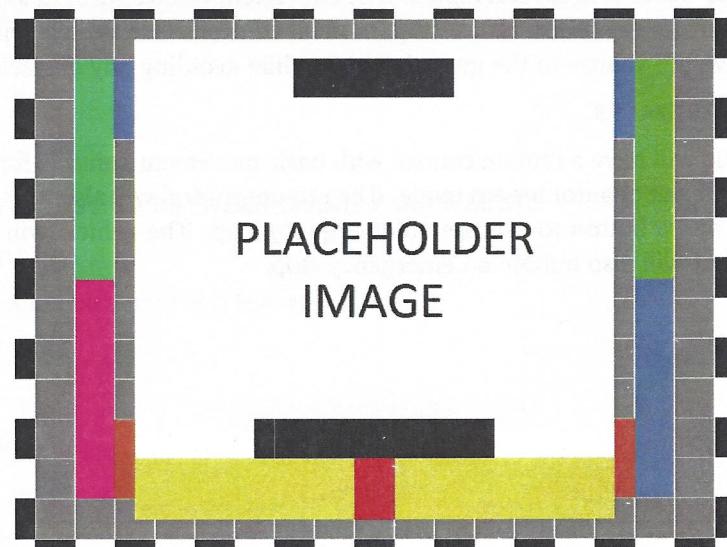


Figure 1: X conceptual drawing

## **2 PRODUCT DESCRIPTION**

This section describes the AutoMav vehicle's functionality. Specifically the vehicle's features, inputs and outputs, and the product interfaces.

### **2.1 FEATURES & FUNCTIONS**

The AutoMav vehicle is an autonomous system that contains several subsystems that allow it to collect data about its surrounding area, process the data and use it to navigate itself to a given location. The vehicle uses data from images obtained by cameras mounted around the vehicle. Other data is also gathered from a lidar laser mounted to its front. The data is then processed using computer vision techniques to classify obstacles and recognize lanes that determine the vehicles valid path to the goal location. The navigation involves path finding to navigate itself around observed obstacles.

### **2.2 EXTERNAL INPUTS & OUTPUTS**

The AutoMav vehicle will take in several inputs: a GPS location, video data of its surroundings, lidar data and interface inputs from the user (start, e-stop, manual control). The vehicle will output a movement action that will move the vehicle to the given location while avoiding any obstacles in its path.

### **2.3 PRODUCT INTERFACES**

The AutoMav vehicle will have a remote control with basic movement controls for the user to manually steer the vehicle while out of autonomous mode. The remote control will also feature a button to engage autonomous mode and a button to execute an emergency stop. The vehicle will also feature a button at the center rear that will also initiate an emergency stop.

### **3 CUSTOMER REQUIREMENTS**

This section describes the properties and functionality of AutoMav as specified by the customer (IGVC Rules).

#### **3.1 THE VEHICLE MUST MAINTAIN CONTACT WITH THE GROUND**

##### **3.1.1 DESCRIPTION**

The vehicle will remain in contact with the ground at all times during operation.

##### **3.1.2 SOURCE**

IGVC Rules

##### **3.1.3 CONSTRAINTS**

N/A

##### **3.1.4 STANDARDS**

N/A

##### **3.1.5 PRIORITY**

Critical

#### **3.2 THE VEHICLE MUST BE BETWEEN 3 AND 7 FEET LONG**

##### **3.2.1 DESCRIPTION**

The vehicle length must be between 3 feet and 7 feet.

##### **3.2.2 SOURCE**

IGVC Rules

##### **3.2.3 CONSTRAINTS**

N/A

##### **3.2.4 STANDARDS**

N/A

##### **3.2.5 PRIORITY**

Critical

#### **3.3 VEHICLE MUST BE BETWEEN 2 AND 4 FEET WIDE**

##### **3.3.1 DESCRIPTION**

The vehicle width must be between 2 feet and 4 feet

##### **3.3.2 SOURCE**

IGVC Rules

##### **3.3.3 CONSTRAINTS**

N/A

##### **3.3.4 STANDARDS**

N/A

### **3.3.5 PRIORITY**

Critical

## **3.4 VEHICLE MUST BE LESS THAN 6 FEET TALL**

### **3.4.1 DESCRIPTION**

The vehicle height must not exceed 6 feet, excluding the antenna for wireless emergency stop functionality.

### **3.4.2 SOURCE**

IGVC

### **3.4.3 CONSTRAINTS**

N/A

### **3.4.4 STANDARDS**

N/A

### **3.4.5 PRIORITY**

Critical

## **3.5 THE VEHICLE MUST MAINTAIN A AVERAGE SPEED**

### **3.5.1 DESCRIPTION**

During the competition, the vehicle must maintain an average speed above 1 mph throughout its time on the course.

### **3.5.2 SOURCE**

IGVC Rules

### **3.5.3 CONSTRAINTS**

N/A

### **3.5.4 STANDARDS**

N/A

### **3.5.5 PRIORITY**

Critical

## **3.6 THE VEHICLE MUST MAINTAIN A MINIMUM SPEED**

### **3.6.1 DESCRIPTION**

During the competition, there will be a section at the beginning of the course that requires the vehicle to travel at a minimum of 1 mph. This section will be about 44ft long.

### **3.6.2 SOURCE**

IGVC Rules

### **3.6.3 CONSTRAINTS**

N/A

### **3.6.4 STANDARDS**

N/A

### **3.6.5 PRIORITY**

Critical

## **3.7 THE VEHICLE MUST NOT EXCEED A MAXIMUM SPEED**

### **3.7.1 DESCRIPTION**

The vehicle must not exceed a maximum speed of 5 mph.

### **3.7.2 SOURCE**

IGVC Rules

### **3.7.3 CONSTRAINTS**

The speed restriction must be enforced by speed restriction hardware.

### **3.7.4 STANDARDS**

N/A

### **3.7.5 PRIORITY**

Critical

## **3.8 THE VEHICLE MUST HAVE A MECHANICAL EMERGENCY STOP BUTTON**

### **3.8.1 DESCRIPTION**

The vehicle must feature a button that stops the vehicle. The button must trigger a quick and complete stop.

### **3.8.2 SOURCE**

IGVC Rules

### **3.8.3 CONSTRAINTS**

The button must be red and a minimum of one inch in diameter. It must be located at the center rear of the vehicle, at least two feet from the ground and less than four feet from the ground.

### **3.8.4 STANDARDS**

N/A

### **3.8.5 PRIORITY**

Critical

## **3.9 THE VEHICLE MUST HAVE A WIRELESS EMERGENCY STOP**

### **3.9.1 DESCRIPTION**

The vehicle must feature a control that stops the vehicle with a minimum effective range of 100 feet.

### **3.9.2 SOURCE**

IGVC Rules

### **3.9.3 CONSTRAINTS**

The emergency stop feature must be hardware based. The vehicle must trigger a quick and complete stop. The wireless emergency stop control will be held by the Judges during the competition.

### **3.9.4 STANDARDS**

N/A

### **3.9.5 PRIORITY**

Critical

## **3.10 THE VEHICLE MUST HAVE A SAFETY LIGHT**

### **3.10.1 DESCRIPTION**

The vehicle must have an indicator light that is solid when the vehicle is powered on. The light must begin flashing when the vehicle is put in autonomous mode. The light must return to solid when the vehicle exits autonomous mode.

### **3.10.2 SOURCE**

IGVC Rules

### **3.10.3 CONSTRAINTS**

The indicator must be easily viewed.

### **3.10.4 STANDARDS**

N/A

### **3.10.5 PRIORITY**

Critical

## **3.11 THE VEHICLE MUST CARRY A PAYLOAD**

### **3.11.1 DESCRIPTION**

The vehicle must be able to carry a payload weighing 20 lbs, and measuring 18 inches long, 8 inches wide, 8 inches high.

### **3.11.2 SOURCE**

IGVC Rules

### **3.11.3 CONSTRAINTS**

The payload must be securely mounted to the vehicle

### **3.11.4 STANDARDS**

N/A

### **3.11.5 PRIORITY**

Critical

## **3.12 THE VEHICLE MUST DEMONSTRATE LANE FOLLOWING**

### **3.12.1 DESCRIPTION**

The vehicle must detect and follow the lanes of the course during autonomous navigation.

### **3.12.2 SOURCE**

IGVC Rules

### **3.12.3 CONSTRAINTS**

N/A

### **3.12.4 STANDARDS**

N/A

### **3.12.5 PRIORITY**

Critical

## **3.13 THE VEHICLE MUST DEMONSTRATE OBSTACLE AVOIDANCE**

### **3.13.1 DESCRIPTION**

The vehicle must detect and avoid obstacles during autonomous navigation.

### **3.13.2 SOURCE**

IGVC Rules

### **3.13.3 CONSTRAINTS**

N/A

### **3.13.4 STANDARDS**

N/A

### **3.13.5 PRIORITY**

Critical

## **3.14 THE VEHICLE MUST UTILIZE WAYPOINT NAVIGATION**

### **3.14.1 DESCRIPTION**

The vehicle must be able to navigate to a 2 meter waypoint in GPS coordinates, navigating around an obstacle.

### **3.14.2 SOURCE**

IGVC Rules

### **3.14.3 CONSTRAINTS**

N/A

### **3.14.4 STANDARDS**

N/A

### **3.14.5 PRIORITY**

Critical

## **3.15 THE VEHICLE MUST COMPLETE THE COURSE IN UNDER 10 MINUTES**

### **3.15.1 DESCRIPTION**

The vehicle must reach the end of the course within 10 minutes of the start of the run.

### **3.15.2 SOURCE**

IGVC Rules

### **3.15.3 CONSTRAINTS**

N/A

### **3.15.4 STANDARDS**

N/A

### **3.15.5 PRIORITY**

Critical

## **3.16 ALL COMPUTATION, SENSING AND MOVEMENT CONTROL MUST OCCUR ON BOARD THE VEHICLE**

### **3.16.1 DESCRIPTION**

Any and all computation, sensing and motor control must be done through the vehicle's onboard systems.

### **3.16.2 SOURCE**

IGVC Rules

### **3.16.3 CONSTRAINTS**

The vehicle cannot utilize any outside remote control to complete the course.

### **3.16.4 STANDARDS**

N/A

### **3.16.5 PRIORITY**

Critical

## **3.17 THE VEHICLE POWER MUST BE GENERATED ON BOARD**

### **3.17.1 DESCRIPTION**

Power for the vehicle's systems must be generated by an on board power source.

### **3.17.2 SOURCE**

IGVC Rules

### **3.17.3 CONSTRAINTS**

Fuel storage and operation of combustion engines will not be permitted in the team maintenance area.

### **3.17.4 STANDARDS**

N/A

### **3.17.5 PRIORITY**

Critical

## **3.18 THE VEHICLE MUST BE WATER RESISTANT**

### **3.18.1 DESCRIPTION**

The vehicle must be able to operate in light rain conditions.

### **3.18.2 SOURCE**

IGVC Rules

### **3.18.3 CONSTRAINTS**

N/A

### **3.18.4 STANDARDS**

N/A

### **3.18.5 PRIORITY**

High

## **3.19 AUTONOMOUS NAVIGATION WILL INITIATE WITH A ONE TOUCH MOTION**

### **3.19.1 DESCRIPTION**

The competition judge must be able to initiate a run of the autonomous navigation via a single button operation.

### **3.19.2 SOURCE**

IGVC Rules

### **3.19.3 CONSTRAINTS**

N/A

### **3.19.4 STANDARDS**

N/A

### **3.19.5 PRIORITY**

Critical

## **3.20 THE VEHICLE SHALL NOT USE TACTILE SENSORS**

### **3.20.1 DESCRIPTION**

Tactile sensors will not be utilized for obstacle detection.

### **3.20.2 SOURCE**

IGVC Rules

### **3.20.3 CONSTRAINTS**

N/A

### **3.20.4 STANDARDS**

N/a

### **3.20.5 PRIORITY**

Critical

## **3.21 A WRITTEN REPORT WILL ACCOMPANY THE VEHICLE DELIVERY**

### **3.21.1 DESCRIPTION**

The vehicle will be delivered with a written report detailing the vehicle's design. The report will be a maximum of 15 pages in length.

### **3.21.2 SOURCE**

IGVC Rules

### **3.21.3 CONSTRAINTS**

N/A

### **3.21.4 STANDARDS**

N/A

### **3.21.5 PRIORITY**

Critical

## **3.22 THE VEHICLE SHALL MEET THE REQUIREMENTS FOR THE INTEROPERABILITY PROFILES CHALLENGE**

### **3.22.1 DESCRIPTION**

The vehicle design will be expanded to facilitate interoperability with other vehicles.

### **3.22.2 SOURCE**

IGVC Rules

### **3.22.3 CONSTRAINTS**

N/A

### **3.22.4 STANDARDS**

N/A

### **3.22.5 PRIORITY**

Future

## **4 PACKAGING REQUIREMENTS**

This section describes elements of the prototype's packaging at the end of development.

### **4.1 SOFTWARE**

#### **4.1.1 DESCRIPTION**

The vehicle will utilize ROS (Robot Operating System) that serves as the base software that facilitates all computer vision, path finding and navigation features. The software will be pre-configured such that the customer will only provide the desired GPS way points to enable autonomous navigation.

#### **4.1.2 SOURCE**

AutoMav Team

#### **4.1.3 CONSTRAINTS**

N/A

#### **4.1.4 STANDARDS**

N/A

#### **4.1.5 PRIORITY**

High.

## **4.2 WHEELCHAIR BASE**

### **4.2.1 DESCRIPTION**

The vehicle's base will be an electric wheelchair that has been customized to be controlled by the ROS unit.

#### **4.2.2 SOURCE**

AutoMav Team

#### **4.2.3 CONSTRAINTS**

The wheelchair base must be able to support the full weight of the robot frame, components and payload while being able to maintain an average speed of 1 mph during operation.

#### **4.2.4 STANDARDS**

N/A

#### **4.2.5 PRIORITY**

High.

## **4.3 FRAME**

### **4.3.1 DESCRIPTION**

The vehicle frame will support two compartments, a lower compartment for the payload and an upper compartment for the on board computational equipment.

#### **4.3.2 SOURCE**

AutoMav Team

#### **4.3.3 CONSTRAINTS**

The frame system must be mountable to the existing mounting holes on the wheelchair base.

#### **4.3.4 STANDARDS**

N/A

#### **4.3.5 PRIORITY**

High.

### **4.4 HARWARE MOUNTS**

#### **4.4.1 DESCRIPTION**

The vehicle will feature several sensors such as cameras, GPS and Lidar. To reduce data noise due to vibrations, the cameras will be attached using a gimble mount. The Lidar system will be mounted to the front of the vehicle based to capture data about approaching obstacles. The GPS will be mounted in a way that promotes the strongest signal. Any other cameras will be mounted such that they provide data that is consistent with other cameras on the vehicle.

#### **4.4.2 SOURCE**

AutoMav Team

#### **4.4.3 CONSTRAINTS**

All electronics must fit within the designed electronics compartment.

#### **4.4.4 STANDARDS**

N/A

#### **4.4.5 PRIORITY**

High.

### **4.5 PAYLOAD COMPARTMENT**

#### **4.5.1 DESCRIPTION**

The payload compartment will be designed to securely transport the payload, ensuring that unexpected weight shifting does not occur during operation. The compartment will also be designed so that when the payload is present, the new weight does not affect the normal operation of the vehicle.

#### **4.5.2 SOURCE**

AutoMav Team

#### **4.5.3 CONSTRAINTS**

Must be able to carry and securely mount an 18"x8"x8" payload.

#### **4.5.4 STANDARDS**

N/A

#### **4.5.5 PRIORITY**

High.

### **4.6 AESTHETICS**

#### **4.6.1 DESCRIPTION**

The vehicle will be aesthetically pleasing, incorporating the school colors of orange, blue and white as well as any sponsorship logos on its surface.

## 4.6.2 SOURCE

AutoMav Team

### 4.6.3 CONSTRAINTS

N/A

#### **4.6.4 STANDARDS**

N/A

#### 4.6.5 PRIORITY

Medium to Low.

## **5 PERFORMANCE REQUIREMENTS**

This section includes requirements that detail specific aspects of the performance of the vehicle.

### **5.1 AVERAGE SPEED**

#### **5.1.1 DESCRIPTION**

The average speed shall be above 1 mph, any vehicle slower than the average speed will be disqualified.

#### **5.1.2 SOURCE**

IGVC Rules

#### **5.1.3 CONSTRAINTS**

There are sections of the course in which the speed can not fall below 1 mph.

#### **5.1.4 STANDARDS**

N/A

#### **5.1.5 PRIORITY**

Critical

### **5.2 MAXIMUM SPEED**

#### **5.2.1 DESCRIPTION**

The maximum speed of the vehicle shall not exceed 5 mph. The vehicle shall be hardware governed not to exceed this maximum speed. No changes to maximum speed control hardware shall be allowed after the vehicle passes qualification.

#### **5.2.2 SOURCE**

IGVC Rules

#### **5.2.3 CONSTRAINTS**

The speed must be hardware limited

#### **5.2.4 STANDARDS**

N/A

#### **5.2.5 PRIORITY**

Critical

### **5.3 MINIMUM SPEED**

#### **5.3.1 DESCRIPTION**

The vehicle shall consistently travel above 1 mph in the designated zones of the course.

#### **5.3.2 SOURCE**

IGVC Rules

#### **5.3.3 CONSTRAINTS**

N/A

#### **5.3.4 STANDARDS**

N/A

### **5.3.5 PRIORITY**

Critical

## **5.4 LANE FOLLOWING**

### **5.4.1 DESCRIPTION**

The vehicle shall detect and follow lanes.

### **5.4.2 SOURCE**

IGVC Rules

### **5.4.3 CONSTRAINTS**

There shall be a minimum of five feet clearance, minimum passage width, between the line and the obstacles.

### **5.4.4 STANDARDS**

N/A

### **5.4.5 PRIORITY**

Critical

## **5.5 OBSTACLE AVOIDANCE**

### **5.5.1 DESCRIPTION**

The vehicle shall detect and avoid obstacles present on the course.

### **5.5.2 SOURCE**

IGVC Rules

### **5.5.3 CONSTRAINTS**

Competitors should expect natural or artificial inclines (ramps) with gradients not to exceed 15 percent and randomly placed obstacles along the course. The course will become more difficult to navigate autonomously as vehicle progresses.

### **5.5.4 STANDARDS**

N/A

### **5.5.5 PRIORITY**

Critical

## **5.6 GPS NAVIGATION**

### **5.6.1 DESCRIPTION**

Vehicle shall prove it can find a path to a single two meter navigation way point by navigating around an obstacle. Two way point pairs for the course will be provided prior to competition. One way point pair will be the entrance and exit of the course in "No-Manâs Land". There will be two additional way points in "No-Manâs Land".

### **5.6.2 SOURCE**

IGVC Rules

<b>5.6.3 CONSTRAINTS</b>	N/A
<b>5.6.4 STANDARDS</b>	N/A
<b>5.6.5 PRIORITY</b>	Critical
<b>5.7 WIRELESS DRIVE</b>	
<b>5.7.1 DESCRIPTION</b>	The device shall be able to be driven remotely using an RF based transmitter receiver combination. This will allow for easy transportation and navigation of the vehicle when not on the actual competition course.
<b>5.7.2 SOURCE</b>	Team Discussion
<b>5.7.3 CONSTRAINTS</b>	Must be able to be used without the need for ROS or any software components.
<b>5.7.4 STANDARDS</b>	N/A
<b>5.7.5 PRIORITY</b>	Medium

## **6 SAFETY REQUIREMENTS**

This section includes safety requirements for the AutoMav vehicle.

### **6.1 SYSTEM WIRING**

#### **6.1.1 DESCRIPTION**

Any wires used by the system must be properly packaged and grounded in accordance with existing safety standards to prevent risk of electrocution.

#### **6.1.2 SOURCE**

IGVC Guidelines

#### **6.1.3 CONSTRAINTS**

N/A

#### **6.1.4 STANDARDS**

UL-1740

#### **6.1.5 PRIORITY**

Critical

### **6.2 SHARP OBJECTS**

#### **6.2.1 DESCRIPTION**

There must be no sharp objects protruding from the system, should any be found they should be handled appropriately and removed or padded to prevent harm to any individual.

#### **6.2.2 SOURCE**

IGVC Guidelines

#### **6.2.3 CONSTRAINTS**

N/A

#### **6.2.4 STANDARDS**

UL-1740

#### **6.2.5 PRIORITY**

High

### **6.3 EMERGENCY STOP**

#### **6.3.1 DESCRIPTION**

The system shall have two emergency stops: one on-board button that should be bright red and easily visible and the other should be remote and able to turn off the system from a distance

#### **6.3.2 SOURCE**

IGVC Guidelines

### **6.3.3 CONSTRAINTS**

N/A

### **6.3.4 STANDARDS**

UL-1740

### **6.3.5 PRIORITY**

High

## **6.4 SAFETY LIGHTS**

### **6.4.1 DESCRIPTION**

The system shall have LED light that indicates the system is in autonomous mode. It shall be easily visible on the system.

### **6.4.2 SOURCE**

IGVC Guidelines

### **6.4.3 CONSTRAINTS**

N/A

### **6.4.4 STANDARDS**

N/A

### **6.4.5 PRIORITY**

Medium

## **6.5 FRAGILE MATERIALS**

### **6.5.1 DESCRIPTION**

The system shall not be made using fragile materials. For example, the main support frames of the system should not be made of glass or any other fragile material

### **6.5.2 SOURCE**

IGVC Guidelines

### **6.5.3 CONSTRAINTS**

N/A

### **6.5.4 STANDARDS**

List of applicable standards

### **6.5.5 PRIORITY**

High

## **6.6 BATTERY HANDLING AND DISPOSAL**

### **6.6.1 DESCRIPTION**

Caution should be used connecting the system battery as there is risk for electrocution. Once the system battery is no longer of use it should be disposed in accordance with local waste management policy to protect the environment from the harmful chemicals found with them.

### **6.6.2 SOURCE**

AutoMav Team

### **6.6.3 CONSTRAINTS**

N/A

### **6.6.4 STANDARDS**

UL-1740

### **6.6.5 PRIORITY**

Medium

## **7 MAINTENANCE & SUPPORT REQUIREMENTS**

This section includes requirements involving the maintenance and support of the vehicle after the end of development.

### **7.1 HARDWARE DESIGN DOCUMENTATION**

#### **7.1.1 DESCRIPTION**

The provided system documentation shall include diagrams of hardware components, as well as overall mechanical design in order for future teams to fully and easily understand the existing hardware system.

#### **7.1.2 SOURCE**

AutoMav Team

#### **7.1.3 CONSTRAINTS**

N/A

#### **7.1.4 STANDARDS**

N/A

#### **7.1.5 PRIORITY**

High

### **7.2 SOFTWARE DESIGN DOCUMENTATION**

#### **7.2.1 DESCRIPTION**

The provided system documentation shall provide documents detailing the architecture of the overall software system, as well as the individual subsystems.

#### **7.2.2 SOURCE**

AutoMav Team

#### **7.2.3 CONSTRAINTS**

N/A

#### **7.2.4 STANDARDS**

IEEE 26514

#### **7.2.5 PRIORITY**

High

### **7.3 SENSOR CALIBRATION**

#### **7.3.1 DESCRIPTION**

Calibration of sensors and cameras shall be performed on use of the system to insure that accurate and proper data is being acquired.

#### **7.3.2 SOURCE**

AutoMav Team

#### **7.3.3 CONSTRAINTS**

N/A

#### **7.3.4 STANDARDS**

N/A

#### **7.3.5 PRIORITY**

Medium

### **7.4 COMPONENT SPECIFICATIONS**

#### **7.4.1 DESCRIPTION**

The provided system documentation shall include component lists, that specifies the exact components used, and the specifications of the components.

#### **7.4.2 SOURCE**

AutoMav Team

#### **7.4.3 CONSTRAINTS**

N/A

#### **7.4.4 STANDARDS**

ISO 7573:2008

#### **7.4.5 PRIORITY**

Medium

## 8 OTHER REQUIREMENTS

This section includes any requirements not covered in any previous sections.

## **9 FUTURE ITEMS**

This section includes features that will not be implemented in the initial prototype. These features could be implemented with further development time and resources.

### **9.1 THE VEHICLE SHALL MEET THE REQUIREMENTS FOR THE INTEROPERABILITY PROFILES CHALLENGE**

#### **9.1.1 DESCRIPTION**

The vehicle design will be expanded to facilitate interoperability with other vehicles.

#### **9.1.2 SOURCE**

IGVC Rules

#### **9.1.3 CONSTRAINTS**

N/A

#### **9.1.4 STANDARDS**

N/A

#### **9.1.5 PRIORITY**

Future

## REFERENCES