3.5.2 Weight/Size

The weight and size of the system determines how well it fits onto the Thumper chassis and whether or not it impedes the balance and desired movements of the Thumper. Smaller and lighter is preferred.

3.5.3 Memory

Memory determines how much data the system can store while running the developed algorithms and camera system. Higher memory is preferred.

3.5.4 Cost

Cost is the deciding factor if all other merit criteria are balanced between the design alternates. Lower cost is preferred.

4 Design Alternatives

4.1 SLAM System Alternatives

Three SLAM Systems were analyzed to determine the optimal system to implement to successfully do SLAM in an unknown environment. Each system – ZED and Jetson TX1, GMapping, and eDVS – was analyzed according to its advantages and disadvantages. All the systems would be implemented on a Thumper chassis with a 75:1 gear box and a Pixhawk Autopilot with a 3DR UBlox GPS + Compass Module which can be seen in Appendix A.

4.1.1 System 1 – ZED and Jetson TX1

System 1 uses the ZED Stereo Camera by Stereo Labs and Jetson TX1 Developer Kit GPU by NVIDIA, shown in Figures 1 and 2 respectively, to solve the SLAM problem. The ZED Stereo Camera is the first device in the industry to offer real-time depth sensing, positional tracking, and 3D mapping capabilities. It will be controlled by the Jetson TX1 which is a powerful graphical processing unit (GPU) with 4GB of RAM, a quad-core ARM Cortex Processor, and Linux OS that can easily control the ZED, Pixhawk, and Thumper. These devices are compatible and work together by installing the ZED SDK on the Jetson TX1. This system will also utilize ROS which is a software framework used on embedded robotics platforms. The SLAM technology that has been designed and integrated into the ZED Stereo Camera is available for use through the ZED SDK and ROS nodes. A node is simply a process that involves computation.

Since this is a relatively new system, there is little documentation of these two devices being used together to perform SLAM and the cost is on the upper end of our budget at $1,098 for just these two devices. However, the ZED Stereo Camera is capable of producing 3D maps, can be used in all environments, and is very accurate.

Figure 1: ZED Stereo Camera by Stereo Labs

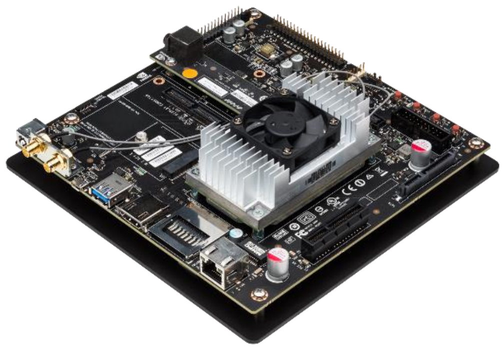

Figure 2: Jetson TX1 Developer Kit by Nvida

4.1.2 System 2 – GMapping

System 2 uses an Arduino Uno, Raspberry Pi 3-Model B, Adafruit Motor Shield, Laser Range Finder Sensor LRG/LIDAR, HMC5883L Compass, and Mouse Sensor PAW3504 to implement an ROS node called slam_gmapping. All of the components listed above can be found in Appendix B. The slam_gmapping node provides the packaging to do laser-based SLAM. The Raspberry Pi would be the main controller of the system and the component that processed the data from the other components to perform SLAM. The Adafruit Motor Shield would be attached to the Arduino Uno and together they would control the motors of the Thumper and pass all the data from the sensors to the Raspberry Pi. Using the components listed above along with the GMapping package, the system can create 2D occupancy grid maps of an area. An example map can be seen in Figure 3.

With so many components involved, there is a greater chance that issues will arise in trying to interface all of them. Also, the system would not always be reliable in outdoor environments because strong sunlight can cause the data from the laser rangefinder to become inaccurate.

Figure 3: Example Map Created by GMapping

4.1.3 System 3 – eDVS

System 3 uses an event-based embedded dynamic vision sensor and contact switches to autonomously explore and visually localize and map an unknown indoor environment in real time. An event would occur when there is a change in brightness at the individual pixel the sensor is reading. As the robot navigates an area, it would track the path it is taking and location estimates would be provided for events. However, information about obstacles cannot be derived from the visual input because the event-based vision sensor is pointed upwards as it uses features on the ceiling for self-localization. To detect obstacles, when the contact switches are triggered, the system would record the location of the collisions. By combining the self-localization provided by the event-based vision sensor and the data from the contact switches, a 2D map of the ceiling could be generated with indications of collision positions. A sample map generated by this system can be seen in Figure 4. The robot could then use this map to plan collision-free paths with that environment.

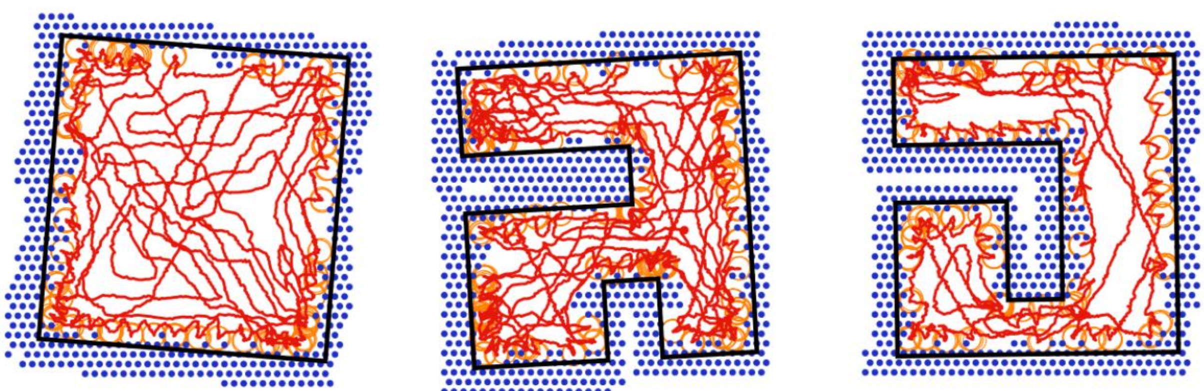

Figure 4: Sample Maps Generated by eDVS

4.2 Mount Design Alternatives

Three different camera mount designs were analyzed to determine the appropriate way to attach the ZED Stereo Camera to the Thumper. The first is a direct mount, attaching the ZED Stereo Camera to the Thumper using a simple strap. Design 2, shown in Figure 5, is a mount set on top of a five-inch length of tubing with a separate motor to drive its rotation independently from the Thumper. This design will use a nylon strap to secure the ZED to the platform. Design 3, shown in Figure 6, is similar to Design 2; the tubing is 11 inches long and utilizes a cage to hold the camera in place.

In addition to the three different designs, the merit criteria were used to evaluate materials for the arm as well. Aluminum, PVC, Steel, and Carbon composite were all assigned merit scores for cost and density.

Figure 5: Mount Design 2

Figure 6: Mount Design 3

5 Evaluation of Design Alternatives

5.1 Feasibility of Mount Designs

To compare the three designed mount alternatives against the feasibility criteria set forth in the section above, a matrix was created. The project team considered all options and assigned each method of manufacturing a rating of pass or fail with respect to the project scope.

Table 1: Feasibility Analysis for Three Mount Designs

	Mount Feasibility Criteria		
	Technical	**Payload**	**Operational**
Design 1	Pass	Pass	Fail
Design 2	Pass	Pass	Pass
Design 3	Pass	Pass	Pass