**Budget Proposal for Roadie**

Sponsor

**Electrical, Computer, Software & Systems Engineering at Embry-Riddle Aeronautical University**

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**Are We There Yet?**

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|  |  |  |
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| Date | Reason for Change | Version |
| 1 October 2014 | Initial Draft | 0.1.0 |

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# **Introduction**

## **Purpose**

The purpose of this document is to provide the customers of Roadie with a preliminary budget as well as the selection process and justification for the items included in this budget. The justifications include analytical processes in the form of decision matrices and qualitative processes in the form of written justification. The quantitative and qualitative methods are backed by requirements traceability and risk analysis for the parts listed in this document.

## **Scope**

This document is intended to provide a monetary budget as well as justifications for each item. Core components, with a price of $20[**REF TO RUBRIC]** or higher are included in this document. The document contains the high-level design of Roadie as well as a description of the subsystems and functional description of Roadie. The sole purpose of the document is to provide the reader with an idea of the monetary costs involved in the creating of Roadie.

## **Team Information**

|  |  |
| --- | --- |
| Name | Role |
| Brian Powell | Team Leader |
| Michael Philotoff | Software Configuration Manager |
| Alex Senopoulos | Testing Leader |
| Brian Sterling | Development Leader |

# **Functional Decomposition of System**

Roadie is broken down into six main subsystems: (1) the Simon Carabiner subsystem, (2) the pocket Etch-A-Sketch subsystem, (3) the Rubik’s cube subsystem, (4) the playing card subsystem, (5) the line following subsystem and (6) the communications and coordination subsystem. The division of these subsystems is illustrated in **Fig. 1**.



**Fig 1**: Division of Roadie into six subsystems.

The communication and coordination subsystem relays information to each of the challenge subsystems (line following, Simon carabiner, pocket Etch-A-Sketch, Rubik’s cube and playing card). As each of the challenge subsystems completes it task, it relays data back to the communications and coordination subsystem. These subsystems are further divided by functionality to create the high-level architecture as described in Section 2.1.

## **High-Level Architecture of System**

The system architecture of Roadie is designed in a layered approach, depicted in **Fig 2** below, in order to better divide the work being done and to aid in the conceptualization of the system design.

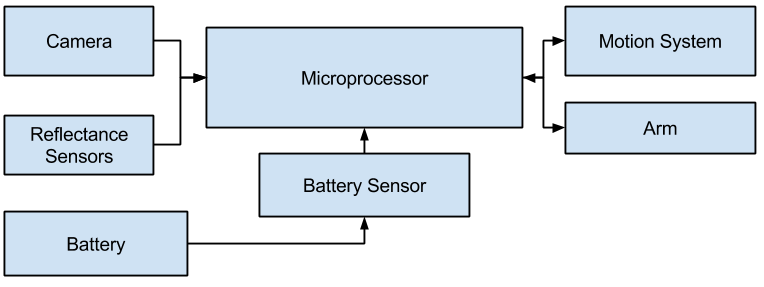


**Fig2**: High level description of the systems in Roadie.

The applications on the communications and coordination system in the form of feedback from the sensors (reflectance and camera) is translated by the middleware (software) to the physical communications means. From here, the arm subsystem and the movement subsystem are directed by the communications and coordination system in order to do complete the challenges. From there, middleware in the form of software is used to talk to the applications. In this instance, the application on the arm side represents the challenges (Simon Carabiner, pocket Etch-A-Sketch, Rubik’s cube, picking up a playing card), with the movement application being line following. As Roadie progresses along, it continues to send feedback from the movement system and the arm system to the communications and coordination system so that Roadie may understand what exactly is happening.

## **Decomposition of Communications and Coordination**

**Fig 3** below, better illustrates the communications that occur amongst the systems in Roadie.



**Fig 3**: Decomposition of communications and coordination system for Roadie.

As the figure shows, the camera, the reflectance sensors and the battery, (via the battery sensor), provide input to the communications and coordination system. From here, the communications system sends commands to both the arm and motion system so that they will be able to complete their individual tasks. As the arm and motion systems complete their tasks, they relay feedback back to the communications and coordination system for further guidance.

# **Budget Decision Matrices and Justifications**

This section contains the justification for the selection of the major components of Roadie. The driving force for the selection process are decision matrices. Decision matrices aid in the decision process by assigning a 1 through a 5, with 1 being least desirable, to characteristics applicable to each item. Each characteristic is given a weight, with higher weights being more important to each item. The total of the weight/score pair is calculated for each item. The item with the highest total score relative to its opponents is deemed the preferable option in its category.

## **Microcontroller**

The following tables and justifications are the basis for the decision making process of selecting a suitable microcontroller for Roadie.

### **Items under Consideration**

The following items have been considered for use as a camera on Roadie. Each item has a unique product ID as well as the vendor and a short description of the product, as depicted in **Table 1**

|  |  |  |
| --- | --- | --- |
| Item ID | Vendor | Description |
| UDOO Quad | UDOO | The UDOO Quad is a quad core 1 GHz microcontroller with 1 GB of Random Access Memory (RAM). There are many different types of ports provided on the board, including digital in and out pins, USB, SATA, CSI Camera, HDMI, and analog audio and mic ports. Additionally, the board comes with a Wi-Fi Module, which is great for debugging. [] |
| B00K7EEX2U | Amazon | The BeagleBone Black Rev C is a high power microcontroller with a 1 GHz CPU clock speed with 1 GB of RAM. Additionally, the BeagleBone Black Rev C comes with 4 GB on-board flash storage, 3D graphics, and digital in and out pins. [] |
| B006H0DWZW | Amazon | “The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.” [] |
| B009SQQF9C | Amazon | “The Raspberry Pi is a credit-card sized computer that plugs into your TV and a keyboard. It's a capable little PC which can be used for many of the things that your desktop PC does, like spreadsheets, word-processing, and games, as well as plays high-definition video.”[] |

**Table 1**: Microcontrollers under consideration for Roadie.

### **Decision Matrix**

Since the microcontroller is the brain of Roadie, it represents one of the most critical aspects of the system. The decision matrix used to select a microcontroller for Roadie is depicted in **Table 1**. Factors considered in the decision process of the microcontroller include processing power, RAM, cost, the community support for the microcontroller, the power consumption of the microcontroller, memory, size, Wi-Fi, and availability.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Factor | Processing Power | Memory | Cost | Community | Power Consumption | Ports | Wi-Fi | Availability | Total |
| Weight | 0.2 | 0.2 | 0.1 | 0.15 | 0.05 | 0.15 | 0.05 | 0.1 |  |
| UDOO Quad | 5 | 5 | 1 | 4 | 3 | 5 | 5 | 5 | 4.35 |
| B00K7EEX2U | 4 | 5 | 3 | 2 | 4 | 4 | 1 | 1 | 3.55 |
| B006H0DWZW | 2 | 1 | 5 | 5 | 2 | 2 | 1 | 1 | 2.4 |
| B009SQQF9C | 3 | 3 | 4 | 4 | 4 | 3 | 1 | 1 | 3.2 |

**Table 2**: Decision matrix for microcontroller.

### **Justifications**

The following section represents the reasoning behind each category and how their weights were determined.

#### **Processing Power**

An integral component in Roadie’s ability to quickly decipher and react to events that happen during competition is the processing power of the microcontroller. Since some of the challenges have an underlying time constraint such as the Simon Carabiner, the microcontroller must have enough processing power to allow Roadie to react in time. **Table 3** represents the values for processing power such as the number of cores the microcontroller has, the clock speed of the microcontroller, and the RAM on the microcontroller.

|  |  |  |  |
| --- | --- | --- | --- |
| Factor | Clock Speed | Cores | RAM |
| UDOO Quad | 1 GHz | 4 | 1 GB |
| B00K7EEX2U | 1 GHz | 1 | 1 GB |
| B006H0DWZW | 258 MHz | 1 | 128 KB |
| B009SQQF9C | 700 MHz | 1 | 512 MB |

**Table 3**: Values for processing power for each microcontroller.

Processing Power was given a weight of 20% since the processing power of the microcontroller plays such a large role in Roadie’s challenge completion abilities.

#### **Memory**

Memory is the combination of RAM and any additional memory store that is available to the microcontroller. **Table 4** shows a breakdown of RAM, on board storage and any additional storage that may be available to each microcontroller.

|  |  |  |  |
| --- | --- | --- | --- |
| Factors | RAM | On board storage | Additional storage |
| UDOO Quad | 1 GB | 1 GB | Micro SD Card |
| B00K7EEX2U | 1 GB | 1 GB | Micro SD Card |
| B006H0DWZW | 128 KB | 258 KB | N/A |
| B009SQQF9C | 512 MB | 512 MB | N/A |

**Table 4**: Storage space and RAM available to each microcontroller.

Memory was given a weight of 20% because having a large amount of RAM will enable Roadie to run more robust code without causing a hindrance to the overall performance of the system. Furthermore, having a large amount of additional storage allows more flexibility in code structures.

#### **Cost**

The scores for the cost of the microcontroller were obtained by giving the most expensive microcontroller a score of one and the least expensive microcontroller a score of five. If the price of a microcontroller was within $10 of an item it was awarded the same score as the item it was nearest.

Cost was given a weight of 10% as the cost of items are a very import factor in any budget, but not the most important consideration for this item.

#### **Community**

The community score was based on how much community support is available for each microcontroller. Factors for this decision included how much example code is available as well as how much documentation exists within the community for each microcontroller.

The community was given a weight of 15% as it relates to how many code examples exist as well as how much assistance can be found when problems occur with integrating the microcontroller with all of Roadie’s systems.

#### **Power Consumption**

The power consumption score for each item was obtained from each microcontrollers lowest recommend voltage. Therefore, the higher the voltage need to run the microcontroller the lower the score it received.

Power consumption was given a weight of 5% as it directly relates to how fast Roadie will deplete its power source. However, as the power supply is a piece that is easily reconfigurable, power consumption was not one of the more important considerations for the microcontroller.

#### **Wi-Fi**

The Wi-Fi score for each item was obtained by awarding the microcontroller a five if the microcontroller has Wi-Fi, and a one if the microcontroller does not have Wi-Fi.

Wi-Fi was given a weight of 5% as Wi-Fi is not a requirement for Roadie, however it will be useful for debugging purposes.

#### **Availability**

The availability score for each item was obtained by scoring items on hand as a five, and items that need to be purchased as a one.

Availability was given a weight of 10% as it directly relates to the ability to prototype Roadie.

#### **Ports**

The ports score for each microcontroller was obtained by determining how many input and output ports each microcontroller has. The types of ports included in this decision are general purpose input pins, general purpose output pins, pulse width modulation (PWM) pins, HDMI, USB, Camera, SATA, and Ethernet ports.

Ports was given a weight of 15% as it directly relates to what hardware components can be used on Roadie.

### **Risk Analysis**

The risk analysis section includes information regarding risks related to the line following equipment and solutions to mitigate those risks. Take, for instance, the fact that the microcontroller plays an integral role on Roadie. Therefore, mitigating any and all risks relating to the microcontroller is of the utmost importance. Should the microcontroller become damaged in any way, this would represent an annoying, yet minor failure. It would require the disassembly of essentially the whole system in order to replace the microcontroller. Risks and the methods in which they will be mitigated can be seen in **Table 5** below.

The probability of each occurrence, denoted as **Prob.**, will give the likelihood on the scale of one to nine with one will be the lowest likelihood of occurrence. The severity of an occurrence, denoted as **Sev.,** will give the impact that the event will have on a scale of one to nine with one being lowest impact.

|  |  |  |  |
| --- | --- | --- | --- |
| Risk | Prob. | Serv. | Mitigation of Risk |
| CPU Overheating | 3 | 5 | If the CPU of the microcontroller was to overheat, this would pose a large problem to Roadie. This is especially true if this was to occur during competition. In order to mitigate this risk a supplemental heat dissipation system will be installed. This supplemental system, in conjunction with the heat sink already installed on the microcontroller will be robust enough to dissipate the heat generated by Roadie during operation. |
| Short Circuits | 2 | 9 | One of the concerns when working with electrical circuits are shorts. This problem becomes even more prevalent when working with high voltage systems in conjunction with components that do not react well to high voltage such as the microcontroller. To mitigate a short circuit running the microcontroller, a few design methods will be employed. One such method is using a non-conductive chassis. If the chassis does not conduct electricity, it will not allow the chassis to become charged, thus helping to lower the chances of short happening as a result of a wire touching the chassis. Another technique that will be employed is installing motor shields to prevent electrical feedback from the motors to the microcontroller. |
| Physical Damage | 4 | 6 | In order to mitigate physical damage to the microcontroller, a casing will be installed around the microcontroller to help adsorb any impact that may arise as a result of the microcontroller being hit dropped. |

**Table 5**: Risks that can be attributed to the microcontroller and their associated mitigations.

## **Power Source**

The section pertaining to the selection of the power source for the system will be divided into two parts: power source for the microcontroller and power source for the rest of the system.

### **Batteries for Microcontroller**

The following tables and justifications are the basis for the decision making process of selecting a suitable power supply for the microcontroller.

#### **Items under Consideration**

The following items have been considered for use as a power supply for the microcontroller on Roadie. Each product has a unique product ID as well as the vendor and a short description of the product, as depicted in **Table 6** below.

|  |  |  |  |
| --- | --- | --- | --- |
| Item ID | Item Name | Vendor | Description |
| B0027GEY3Y | Venom 800mAh 7.4 LiPo [b1mp] | Amazon | 7.4 volt LiPo battery with a 800 mAh capacity and a 16 A discharge rate. |
| B00DDTKYME | Dynamite 7.4V 180mAh LiPo [b2mp] | Amazon | 7.4 volt LiPo battery with a 180 mAh capacity and a 16 A discharge rate. |
| B0073VCS0O | Eflite Blade 800mAh 7.4V LiPo [b3mp] | Amazon | 7.4 volt LiPo battery with a 800 mAh capacity and a 16 A discharge rate. |

**Table 6:** Power sources under consideration for Roadie.

#### **Decision Matrix**

The decision matrix used to select a battery for Roadie’s microcontroller is depicted in **Table 7**. Factors considered in the decision process of the battery include the power output, cost, safety, and battery life of each battery. The highlighted row is the battery selected to power the microcontroller for Roadie.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Factor | Power | Battery Life | Safety | Cost | Total |
| Weight | 0.40 | 0.25 | 0.20 | 0.15 |  |
| B0027GEY3Y | 4 | 5 | 3 | 5 | 4.2 |
| B00DDTKYME | 1 | 2 | 3 | 3 | 1.95 |
| B0073VCS0O | 4 | 5 | 3 | 1 | 3.6 |

**Table 7**: Decision matrix for microcontroller.

The weighted matrix, or the matrix computed by multiplying the score in each category by its weight is show in **Table #.**

**Justification table**

**CAPTION**

#### **Justifications**

The following section represents the reasoning behind each category and how their weights were determined.

##### **Power**

The scores for power of each battery was obtained by examining the voltage of the battery and how many milliamps per hour the battery provides. The battery must have sufficient voltage to power the microcontroller in addition to being below the maximum voltage the microcontroller can handle. Therefore the score of the voltage for each battery is proportional to how far the battery’s voltage is from the recommended voltage for the microcontroller. The milliamps per hour was used to determine if the batteries could provide enough amperage to the motors for them to run.

Power was given a weight of 40% as the power of the battery dictates how long Roadie can run without having to recharge the batteries.

##### **Battery Life**

The score for battery life of each battery was obtained by giving the battery with the lowest battery life a score of five, and the battery with the highest battery life a score of one. The other batteries were given a score proportional to how close their battery life was to the longest battery life. The estimated battery life for each battery is given by the **equation ()** at maximum load.

The battery life for each battery can be seen in **Table 8** below

|  |  |  |  |
| --- | --- | --- | --- |
| Factor | mAh | mA | Life (Hours) |
| B0027GEY3Y | 800 | 16000 | 0.035 |
| B00DDTKYME | 180 | 16000 | 0.00788 |
| B0073VCS0O | 800 | 16000 | 0.035 |

**Table 8**: Battery life for each battery under consideration for powering Roadie’s microcontroller.

Battery life was given a weight of 25% as the battery life is how long a battery will last on a single charge. This translates into how long Roadie will be able to operate.

##### **Safety**

The scores for safety of each battery was obtained by factoring in the inherent risks associated with each variant of battery as well as the impact each variant of battery will have on the environment. The risk for each battery rates to how the battery will react to mishaps. Examples of mishaps would be dropping, shorting out, or overheating the battery. The environmental impact of each battery is dependent upon the materials that the battery is composed of as most batteries contain some type of heavy metal that is harmful to both humans and the environment. [1mp]

Safety was given a weight of 20% as the safety of the team and the environment in which Roadie is worked on are both important aspects of the project.

##### **Cost**

The values for cost of the batteries were obtained by giving the most expensive battery a score of one, and the least expensive battery a score of five.

Cost was given a weight of 15% as the cost of items are a very items are a very important factor in any budget, but not the most important consideration for this item.

#### **Requirements Traceability**

The following requirements traceability refers to the System Requirements Specification for Roadie, revision 1.0.0, published September 18, 2014. As shown in **Table 9** below, the requirement ID is followed by the requirement text and an explanation of how the B0027GEY3Y will fulfill said requirement.

|  |  |  |
| --- | --- | --- |
| ID | Requirement Text | Fulfillment |
| 4.2.1 | The system shall operate for a minimum of [TBD] minutes when the power source starts with a full charge. | By choosing batteries that provide more amperage than what is required to run the microcontroller and motors, it will be possible to ensure that Roadie will be able to operate for at least [TBD] minutes. |

**Table 9**: The requirements that the selection of B0027GEY3Y will fulfill.

#### **Risk Analysis**

The risk analysis section includes information regarding risks related to the line following equipment and solutions to mitigate those risks. Take, for instance,

The probability of each occurrence, denoted as **Prob.**, will give the likelihood on the scale of one to nine with one will be the lowest likelihood of occurrence. The severity of an occurrence, denoted as **Sev.,** will give the impact that the event will have on a scale of one to nine with one being lowest impact.

Batteries

Lithium Polymer batteries (LiPo) are extremely energy dense for a chemical battery. However since LiPo batteries are energy dense it also means they are unstable under abuse. When a LiPo battery is damage in anyway the battery has a chance to ignite and catch on fire, this is known as thermal runaway. This could come from the battery being physically damage or if the battery is shorted out. But the chances of LiPo to have a thermal runaway is every small. [4mp]

Environment Impacts

All batteries contain some sort of heavy metal or toxic and hazardous chemicals. Each battery should be disposed of properly to reduce the environmental impact of batteries. LiPo batteries are one of the few battery types that environment friendly meaning as long as the proper procedure is used to discharge the battery it can throw away in the normal trash. [4mp]

### **Batteries for Motors**

The following tables and justifications are the basis for the decision making process of selecting a suitable power supply for the motors on Roadie.

#### **Items Under Consideration.**

The following items have been considered for use as a power supply for the motors on Roadie. Each product has a unique product ID as well as the vendor and a short description of the product, as depicted in **Table 10**

|  |  |  |  |
| --- | --- | --- | --- |
| Item ID | Item Name | Vendor | Description |
| B0027G9F9M | Venom 5000 mAh 14.8V LiPo [b4mp] | Amazon | 14.8 volt LiPo battery with a 5000 mAh capacity and a 125 A discharge rate. |
| B003CUB4QO | Venom 5000 mAh 14.8V Hard Case LiPo [b5mp] | Amazon | 14.8 volt LiPo hard case battery with a 5000 mAh capacity and a 175 A discharge rate. |
| B003CUJ1WI | Venom 3800 mAh 18.5V Hard Case LiPo [b6mp] | Amazon | 18.5 bolt LiPo hard case battery with a 3800 mAh capacity and a 133 A discharge rate. |

**Table 10**: Power supplies under consideration for the motors for Roadie.

#### **Decision Matrix**

The decision matrix used to select a battery for the motors on Roadie is depicted in **Table 11**. Factors considered in the decision process of the battery include the power output, cost, safety, and battery life of each battery. The highlighted row is the battery selected to power the microcontroller for Roadie.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Factor | Power | Battery Life | Safety | Cost | Total |
| Weight | .40 | .25 | .20 | .15 |  |
| B0027G9F9M | 5 | 5 | 3 | 5 | 4.6 |
| B003CUB4QO | 1 | 3 | 3 | 1 | 1.9 |
| B003CUJ1WI | 3 | 3 | 3 | 3 | 3 |

**Table 11**: Decision matrix for the battery for the motors for Roadie.

The weighted matrix, or the matrix computed by multiplying the score in each category by its weight is show in **Table #.**

**Justification table**

**CAPTION**

#### **Justifications**

The following section represents the reasoning behind each category and how their weights were determined.

##### **Power**

The scores for power of each battery was obtained by examining the voltage of the battery and how many milliamps per hour the battery provides. The battery must have sufficient voltage to power the motors in addition to being below the maximum voltage the motors can handle. Therefore the score of the voltage for each battery is proportional to how far the battery’s voltage is from the recommended voltage for the motors. The milliamps per hour was used to determine if the batteries could provide enough amperage to the motors for them to run.

Power was given a weight of 40% as the power of the battery dictates how long Roadie can run without having to recharge the batteries.

##### **Battery Life**

The score for battery life of each battery was obtained by giving the battery with the lowest battery life a score of five, and the battery with the highest battery life a score of one. The other batteries were given a score proportional to how close their battery life was to the longest battery life. The estimated battery life for each battery is given by the **equation ()** at maximum load.

The battery life for each battery under consideration for the motors can be seen in **Table 12**below

|  |  |  |  |
| --- | --- | --- | --- |
| Factor | mAh | mA | Life (hours) |
| B0027G9F9M | 5000 | 125000 | 0.028 |
| B003CUB4QO | 5000 | 175000 | 0.02 |
| B003CUJ1WI | 3800 | 133000 | 0.02 |

**Table 12**: Battery life for each of the batteries under consideration for powering Roadie's motors.

Battery life was given a weight of 25% as the battery life is how long a battery will last on a single charge. This translates into how long Roadie will be able to operate.

##### **Safety**

The scores for safety of each battery was obtained by factoring in the inherent risks associated with each variant of battery as well as the impact each variant of battery will have on the environment. The risk for each battery rates to how the battery will react to mishaps. Examples of mishaps would be dropping, shorting out, or overheating the battery. The environmental impact of each battery is dependent upon the materials that the battery is composed of as most batteries contain some type of heavy metal that is harmful to both humans and the environment. [1mp]

Safety was given a weight of 20% as the safety of the team and the environment in which Roadie is worked on are both important aspects of the project.

##### **Cost**

The values for cost of the batteries were obtained by giving the most expensive battery a score of one, and the least expensive battery a score of five.

Cost was given a weight of 15% as the cost of items are a very items are a very important factor in any budget, but not the most important consideration for this item.

#### **Requirements Traceability**

The following requirements traceability refers to the System Requirements Specification for Roadie, revision 1.0.0, published September 18, 2014. As shown in **Table 13** below, the requirement ID is followed by the requirement text and an explanation of how the B0027G9F9M will fulfill said requirement.

|  |  |  |
| --- | --- | --- |
| ID | Requirement Text | Fulfillment |
| 4.2.1 | The system shall operate for a minimum of [TBD] minutes when the power source starts with a full charge. | By choosing batteries that provide more amperage than what is required to run the microcontroller and motors, it will be possible to ensure that Roadie will be able to operate for at least [TBD] minutes. |

**Table 13**: The requirements that the selection of B0027G9F9M will fulfill.

#### **Risk Analysis**

The risk analysis section includes information regarding risks related to the line following equipment and solutions to mitigate those risks. Take, for instance,

The probability of each occurrence, denoted as **Prob.**, will give the likelihood on the scale of one to nine with one will be the lowest likelihood of occurrence. The severity of an occurrence, denoted as **Sev.,** will give the impact that the event will have on a scale of one to nine with one being lowest impact.

Batteries

Lithium Polymer batteries (LiPo) are extremely energy dense for a chemical battery. However since LiPo batteries are energy dense it also means they are unstable under abuse. When a LiPo battery is damage in anyway the battery has a chance to ignite and catch on fire, this is known as thermal runaway. This could come from the battery being physically damage or if the battery is shorted out. But the chances of LiPo to have a thermal runaway is every small. [4mp]

Environment Impacts

All batteries contain some sort of heavy metal or toxic and hazardous chemicals. Each battery should be disposed of properly to reduce the environmental impact of batteries. LiPo batteries are one of the few battery types that environment friendly meaning as long as the proper procedure is used to discharge the battery it can throw away in the normal trash. [4mp]

## **Camera**

The following tables and justifications are the basis for the decision making process of selecting a suitable camera for Roadie.

### **Items under Consideration**

The following items have been considered for use as a camera on Roadie. Each item has a unique product ID as well as the vendor and a short description of the product, as depicted in **Table 14** below

|  |  |  |  |
| --- | --- | --- | --- |
| Item ID | Item Name | Vendor | Description |
| B00IUYUA80 | Pixy (CMUcam5) | Amazon | Pixy is an image sensor paired with a dedicated processor. Pixy is able to process images from the image sensor and send condensed image and location data to the microcontroller at a frame rate of 50Hz. [1] |
| B008GWPC1Q | Fosmon USB 6 LED Webcam | Amazon | 1.3 Megapixel webcam with six LEDs to illuminate objects. |
| B00K11RI6W | TeckNet C015 Webcam | Amazon | 5.0 Megapixel webcam with built in microphone. |

**Table 14**: Cameras under consideration for Roadie

### **Decision Matrix**

The decision matrix used to select a camera for Roadie is depicted in **Table 15**. Factors considered in the decision process of the camera include the resolution of the camera, if lights are installed on the camera, perceived ease of use, availability of the camera as well as the cost of the camera. The highlighted row is the camera selected for use on Roadie.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Factor | Resolution | Lighting | Ease of Use | Availability | Cost | Total |
| Weight | 0.3 | 0.2 | 0.3 | 0.1 | 0.2 |  |
| B00IUYUA80 | 2 | 1 | 5 | 1 | 1 | 2.6 |
| B008GWPC1Q | 2 | 5 | 2 | 1 | 5 | 3.3 |
| B00K11RI6W | 4 | 1 | 2 | 1 | 4 | 2.9 |

**Table 15**: Decision matrix for camera

The weighted matrix, or the matrix computed by multiplying the score in each category by its weight is show in **Table 16**. The total score for each item in the decision matrix (**Table 15**) is calculated by summing the values for each row in the weighted value matrix.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Factor | Resolution | Lighting | Ease of Use | Availability | Cost |
| B00IUYUA80 | 0.6 | 0.2 | 1.5 | 0.1 | 0.2 |
| B008GWPC1Q | 0.6 | 1.0 | 0.6 | 0.1 | 1.0 |
| B00K11RI6W | 1.2 | 0.2 | 0.6 | 0.1 | 0.8 |

**Table 16**: Weighted value matrix. It is comprised of the score for each category multiplied by the weight for the category.

The weightings for the decision matrix were created by using the data in Table 17

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Factor | Resolution | Lighting | Ease of Use | Availability | Cost |
| B00IUYUA80 | 1.0 Megapixel | No | Plug and play | In stock | $69.00 |
| B008GWPC1Q | 1.3 Megapixel | No | In-depth configuration required | In stock | $8 |
| B00K11RI6W | 5.0 Megapixel | Yes | In-depth configuration required | In stock | $10 |

**Table 17**: Quantitative and qualitative values of the cameras under consideration that led to the decision matrix.

### **Justifications**

The following section represents the reasoning behind each category and how their weights were determined.

#### **Resolution**

The resolution for a camera is directly related to how clear and image will be. Since the camera will be the primary way in which Roadie will be able to identify challenges, having the best resolution possible is very important. Therefore, items with a resolution low relative to the average resolution in the group (2.3 Megapixels) were ranked low and items with a resolution high relative to the average resolution in the group were ranked high.

Resolution was given a weight of 20% because if the resolution of the camera is low, it will result in a fuzzy or grainy image which may compromise Roadie’s ability to correctly identify the challenge.

#### **Lighting**

In order for the object to be reliably identified, lighting conditions must remain relatively constant. One way to assure lighting remaining constant is to purchase a web cam with lights on it. It is for this reason that a camera without lights was scored at one, where as a camera with lights on it was scored at five.

Lighting was given a weight of 20% because the ambient light in the room is something to be considered when identifying objects. If the lighting changes, the ability of Roadie to identify the challenges might as well.

#### **Ease of Use**

Ease of use is how AWTY perceived the difficulty in implementing each camera. A device that is plug and play with little to no set up was ranked a five, whereas a camera that has a learning curve with a great degree of difficulty would be ranked as a one. From our selections, two of the cameras, B008GWPC1Q and B00K11RI6W received a score of two as they will be difficult to implement, but their implementation will be guided by examples found on the internet. B00IUYUA80 was ranked a five because it includes software to natively recognize up to seven objects as well as software to recognize rotation angle and distance of an object.

The weighting for ease of use is set to 30% because Roadie will be completely dependent upon some form of camera to be able to correctly identify any challenge it arrives at. If the camera is not behaving as expected due to a difficult or poorly understood implementation, the whole system will fail.

#### **Availability**

The availability score for each item was obtained by scoring items on hand as a five, and items that need to be purchased as a one.

Availability was given a weight of 10% as it directly relates to the ability to prototype Roadie.

#### **Cost**

The values for cost for the cameras were obtained by giving the most expensive camera a score of one, and the least expensive camera a score of five. As there was only one other camera to consider, and its price was $2 more than the cheapest camera, a score of 4 was awarded since the price was so close.

Cost was given a weight of 20% as the cost of items are a very important factor in any budget, but not the most important consideration for this item.

### **Requirements Traceability**

The following requirements traceability refers to the System Requirements Specification for Roadie, revision 1.0.0, published September 18, 2014. As shown in Table 18,below, the requirement ID is followed by the requirement text and an explanation of how the B008GWPC1Q will fulfill said requirement.

|  |  |  |
| --- | --- | --- |
| ID | Requirement Text | Fulfillment |
| 3.1.7 | The system shall wait for red [RGB value TBD] LED in starting area to turn off before exiting the starting area. | With the selection of B008GWPC1Q, Roadie will be able to reliably identify the red LED in all lighting conditions. Additionally, B008GWPC1Q provides a fine enough resolution to correctly identify the red LED. |
| 3.2.3 | The system shall identify the challenge zone and stop movement upon arrival. | With the selection of B008GWPC1Q, Roadie will be able to reliably identify all challenge zones in all lighting conditions. Additionally, B008GWPC1Q provides a fine enough resolution to correctly identify all challenge zones. |
| 3.3.1 | The system shall correctly identify the challenge upon arrival. | With the selection of B008GWPC1Q, Roadie will be able to reliably identify the challenge it has arrived at in lighting conditions. Additionally, B008GWPC1Q provides a fine enough resolution to correctly identify the challenge zone it has arrived at. |
| 3.3.1.1 | The system shall correctly identify the Simon Carabiner depicted in Fig. 8. | With the selection of B008GWPC1Q, Roadie will be able to reliably identify the Simon Carabiner in all lighting conditions. Additionally, B008GWPC1Q provides a fine enough resolution to correctly identify the Simon Carabiner. |
| 3.3.1.2 | The system shall correctly identify the Rubik’s Cube depicted in Fig. 9 | With the selection of B008GWPC1Q, Roadie will be able to reliably identify the Rubik’s cube in all lighting conditions. Additionally, B008GWPC1Q provides a fine enough resolution to correctly identify the Rubik’s cube. |
| 3.3.1.3 | The system shall correctly identify the pocket Etch-A-Sketch depicted in Fig. 10. | With the selection of B008GWPC1Q, Roadie will be able to reliably identify the pocket Etch-A-Sketch in all lighting conditions. Additionally, B008GWPC1Q provides a fine enough resolution to correctly identify the pocket Etch-A-Sketch. |
| 3.3.1.4 | The system shall correctly identify the playing cards depicted in Fig. [TBD]. | With the selection of B008GWPC1Q, Roadie will be able to reliably identify the playing cards in all lighting conditions. Additionally, B008GWPC1Q provides a fine enough resolution to correctly identify the playing cards. |
| 3.3.3.3 | The system shall correctly sense color blue [exact RGB values TBD] when illuminated on the Simon Carabiner. | With the selection of B008GWPC1Q, Roadie will be able to reliably identify the blue LED on Simon in all lighting conditions. Additionally, B008GWPC1Q provides a fine enough resolution to correctly identify the blue LED on Simon. |
| 3.3.3.4 | The system shall correctly sense color red [exact RGB values TBD] when illuminated on the Simon Carabiner. | With the selection of B008GWPC1Q, Roadie will be able to reliably identify the red LED on Simon in all lighting conditions. Additionally, B008GWPC1Q provides a fine enough resolution to correctly identify the red LED on Simon. |
| 3.3.3.5 | The system shall correctly sense color yellow [exact RGB values TBD] when illuminated on the Simon Carabiner. | With the selection of B008GWPC1Q, Roadie will be able to reliably identify the yellow LED on Simon in all lighting conditions. Additionally, B008GWPC1Q provides a fine enough resolution to correctly identify the yellow LED on Simon. |
| 3.3.3.6 | The system shall correctly sense color green [exact RGB values TBD] when illuminated on the Simon Carabiner. | With the selection of B008GWPC1Q, Roadie will be able to reliably identify the green LED on Simon in all lighting conditions. Additionally, B008GWPC1Q provides a fine enough resolution to correctly identify the green LED on Simon. |

**Table 18**: Requirements traceability for camera.

### **Risk Analysis**

The risk analysis section includes information regarding risks related to the line following equipment and solutions to mitigate those risks. Take, for instance,

The probability of each occurrence, denoted as **Prob.**, will give the likelihood on the scale of one to nine with one will be the lowest likelihood of occurrence. The severity of an occurrence, denoted as **Sev.,** will give the impact that the event will have on a scale of one to nine with one being lowest impact.

|  |  |  |  |
| --- | --- | --- | --- |
| Risk | Prob. | Sev. | Mitigation of Risk |
| Complete loss of camera system | 2 | 9 | In the even that Roadie loses the camera system, its ability to complete the remaining challenges will be compromised. Since Roadie is completely dependent upon its camera to be able to identify the challenges, a loss of the camera would cause Roadie to fail that round of competition. In order to mitigate the occurrence of such an event, extensive stress testing and **BLRH** will be done to ensure that the camera performs flawlessly. |
| Misidentifcation |  |  |  |

## **Chassis**

The following tables and justifications are the basis for the decision making process of selecting a suitable chassis for Roadie.

### **Items under Consideration**

The following items have been considered for use as a chassis on Roadie. Each item has a unique product ID as well as the vendor and a short description of the product, as depicted in **Table 19**

|  |  |  |  |
| --- | --- | --- | --- |
| Item ID | Item Name | Vendor | Description |
| ROB-12866 | Magician Chassis | Sparkfun | Acrylic chassis with two gearmotors, two 65mm wheels and a rear caster. Pre-drilled mounting holes. An AA battery holder with barrel plug termination is included. |
| KIT660 | Build Your First Robot Chassis Kit | Budgetrobotics.com | Dual level chassis with wheel well cutouts for drive wheels. Includes mounts for two servos. |
| DG012 | DG012-Tank | Hobbyking | Square chassis made out of aluminum. It come with two 48:1 geared motors, an AA battery holder and pre-drilled mounting points. |
| Custom | Custom Chassis | N/A | Constructed to resemble a cargo container crane. Room for four drive motors. Attachment point for arm mounted high on chassis. |

**Table 19**: Chassis under consideration for Roadie

### **Decision Matrix**

The decision matrix used to select a chassis for Roadie is depicted in **Table 20**. Factors considered in the decision process of the chassis include the surface area of the chassis, the perceived adaptability of the chassis, availability of the chassis and the cost of the chassis. The highlighted row is the camera selected for use on Roadie.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Factor | Surface Area | Adaptability | Availability | Cost | Total |
| Weight | 0.3 | 0.4 | 0.1 | 0.2 |  |
| ROB-12866 | 2 | 1 | 1 | 5 | 2.1 |
| KIT660 | 5 | 2 | 1 | 4 | 3.2 |
| DG012 | 3 | 1 | 1 | 1 | 1.6 |
| Custom | 5 | 5 | 5 | 3 | 4.6 |

**Table 20**: Decision matrix for chassis

The weighted matrix, or the matrix computed by multiplying the score in each category by its weight is show in **Table 21**. The total score for each item in the decision matrix (**Table 20**) is calculated by summing the values for each row in the weighted value matrix.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Factor | Surface Area | Adaptability | Availability | Cost |
| ROB-12866 | 0.6 | 0.4 | 0.1 | 1 |
| KIT660 | 1.5 | 0.8 | 0.1 | 0.8 |
| DG012 | 0.9 | 0.4 | 0.1 | 0.2 |
| Custom | 1.5 | 2 | 0.5 | 0.4 |

**Table 21**: Weighted value matrix. It is comprised of the score for each category multiplied by the weight for the category.

The weightings for the decision matrix were created by using the data in **Table 22**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Factor | Surface Area | Adaptability | Availability | Cost |
| ROB-12866 | 110 x 174 mm | Not very | In stock | $14.95 |
| KIT660 | 177.8 x 127 mm per deck (2 decks) | Moderately | In stock | $16.95 |
| DG012 | 157 x 149mm | Not very | In stock | $44.96 |
| Custom | Variable | Very | Available | $25.00 |

**Table 22** Quantitative and qualitative values of the chassis under consideration that led to the decision matrix.

### **Justifications**

The following section represents the reasoning behind each category and how their weights were determined.

#### **Surface Area**

The surface area of the chassis is how much surface will be available to mount components to Roadie. Since there will be many circuit boards, wires, and other sorts of devices, having an abundance of surface area will be to our advantage. Chassis with the highest surface area, KIT660, received a score of five. The custom chassis received a score of five because its surface area will be greater than or equal to that of KIT660. DG012 had a surface area approximately half of KIT660, therefore its score is half of KIT600’s score rounded up. ROB-12866’s surface area was close to that of DG012, earning it a two, one less point than DG012.

Surface area was given a weight of 30% because the more surface area Roadie has, the more space will be available for mounting of critical systems. Mounting systems to a chassis with little surface area will prove difficult as space would become a premium with larger items.

#### **Adaptability**

Adaptability of the chassis pertains to how well the chassis will be able to cope with our design changes. Currently, Roadie is still in the prototyping process. As such, we are not sure how well our system design will function. This means that the chassis of Roadie will need to be able to easily change as our design changes. Chassis that provide the ability to move components around without major modifications received a score of five and a chassis that would essentially require the building or purchase of another received a score of one. Both the ROB-12866 and the DG012 scored ones because they are designed to work with certain motors and wheels. Therefore, these chassis are not very adaptable. The KIT660 scored a two because while it does not come with any servos or motors, the wheel well cutouts limit the wheels that can be used. The custom chassis is very adaptable since it can be easily modified as the system design changes.

Adaptability was given a weight of 40% since the adaptability of the chassis directly correlates to the ability to rapid prototype. A chassis that is designed with particular wheels and motors in mind is not as adaptable to change as a chassis that is built independent of wheels and motors.

#### **Availability**

The availability score for each item was obtained by scoring items on hand as a five, and items that need to be purchased as a one.

Availability was given a weight of 10% as it directly relates to the ability to prototype Roadie.

#### **Cost**

The score for cost was obtained by ranking the lowest cost item, ROB-12866 as a 5 and the most expensive item, the DG012 as a one. Since the KIT660 was within $2 of the cost of ROB-12866, it received a score of 4. The custom option was budgeted at $25 as it is the average price of the other chassis in the group. This was awarded a 3 as it was about $8 more than the KIT660, and still significantly cheaper than the DG012. Since it was close to the lower priced chassis options, a score of 3 was awarded.

Cost was given a weight of 20% as the cost of items are a very important factor in any budget, but not the most important consideration for this item.

|  |  |  |
| --- | --- | --- |
| ID | Requirement Text | Fulfillment |
| 3.3.2 | The system shall align with the challenge before attempting to complete the challenge. | By implementing a custom design for the chassis, the time required to align with the challenge will decrease, thus shortening the overall time that Roadie is on the course. |
| 3.3.3.7 | The system shall not obstruct the Simon Carabiner during play. | By designing a custom chassis, it will be possible to ensure that Roadie will not obstruct the Simon Carabiner. |
| 3.3.4.1 | The system shall not obstruct the Rubik’s Cube during play. | By designing a custom chassis, it will be possible to ensure that Roadie will not obstruct the Rubik’s cube. |
| 3.3.5.2 | The system shall not obstruct the pocket Etch-A-Sketch during play. | By designing a custom chassis, it will be possible to ensure that Roadie will not obstruct the Etch-A-Sketch. |
| 4.1.1 | The system size shall be no greater than 1ft. x 1ft. x 1ft. within the starting area and the finishing area. | With a custom chassis design, it will be possible to ensure that Roadie fits into the mandated dimensions while still having enough surface area to mount all the required components. |
| 4.3.1 | The system shall have an easily accessible power switch. | With a custom design, Roadie will not be limited to where the power switch is mounted on an “off the shelf” chassis. |
| 4.3.3 | The system shall maintain contact with the competition area’s surface at all times. | Implementation of a custom chassis will ensure that Roadie will always maintain contact with the course. |

### **Requirements Traceability**

The following requirements traceability refers to the System Requirements Specification for Roadie, revision 1.0.0, published September 18, 2014. As shown in **Table 23**,below, the requirement ID is followed by the requirement text and an explanation of how the custom chassis will fulfill said requirement.

**Table 23**: Requirements traceability for chassis.

### **Risk Analysis**

The risk analysis section includes information regarding risks related to the line following equipment and solutions to mitigate those risks. Take, for instance, the fact that the chassis is the component that supports all of the other components of the systems. Therefore, it is imperative that Roadie is operated in a manner as to not cause harm or damage to the chassis. Should the chassis be completely damaged, this would represent a catastrophic failure as it would require many man hours to reassemble the chassis and resolve any issues rising from such an event. An example of an even that would be an inconvenience, yet Roadie would still be operable would be if one of the towers supporting the arms became misaligned. This would be a temporary hindrance to the system as it would last for one competition round. Further examples of risks and their mitigations can be found in **Table 24**.

The probability of each occurrence, denoted as **Prob.**, will give the likelihood on the scale of one to nine with one will be the lowest likelihood of occurrence. The severity of an occurrence, denoted as **Sev.,** will give the impact that the event will have on a scale of one to nine with one being lowest impact.

|  |  |  |  |
| --- | --- | --- | --- |
| Risk | Prob. | Sev. | Mitigation of Risk |
| Loss of Chassis | 1 | 9 | In the event that Roadie was to fail in such an extreme event that the chassis is not salvageable, this could potentially result in the project not being delivered on time. An example of such an occurrence would be in the power source was improperly handled, thus causing the chassis to ignite or melt in some spectacular fashion. Another such instance would be if the vehicle ran into some obstacle at ludicrous speed, causing the chassis to be rendered useless. In order to mitigate these events, safeguards will be implemented to ensure that Roadie always maintains a safe operating speed. Additionally, all power sources will be properly handled and maintained to ensure that the chassis does not catch fire. |
| Misaligned arm tower | 2 | 4 | In the event that one of the chassis towers supporting the arm were to become misaligned, this would cause a slight hindrance to Roadie. Roadie would still be able to attempt the challenges, however, the attempts may not be optimal. In order to mitigate this, the arms will be redundantly reinforced as well as designed with the ability to support a load at least 1.5 times that of the theoretical load the arm would have to support. |

**Table 24**: Risks that can be attributed to the chassis and their associated mitigations.

## **Line Following**

The following information composes the justifications that were made to make a decision on the line following equipment for Roadie.

### **Items under Consideration**

The following items have been considered for use as line following equipment on Roadie. Each item has a unique product ID as well as the vendor and a short description of the product, as depicted in **Table 25** below

|  |  |  |  |
| --- | --- | --- | --- |
| Item ID | Name | Vendor | Description |
| ROB-09454 | QRE1113 (Digital) | SparkFun | This product utilizes a capacitor in order to rapidly determine exposure of light by using the time of discharge. [1] |
| GL5516 | Optoresister GL5516 | Amazon | An inexpensive method of detecting light. |

**Table 25**: Line following equipment under consideration for Roadie.

### **Decision Matrix**

The decision matrix used to select line following equipment for Roadie is depicted in **Table 26**. Factors considered in the decision process of the line following equipment include community and peer support for the sensor, the perceived ease of implementation of the sensor, availability of the sensor and the cost of the sensor. The highlighted row is the sensor selected for use on Roadie.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Factor | Community | Ease | Availability | Cost | Total |
| Weight | 0.3 | 0.4 | 0.2 | 0.1 | 1 |
| ROB-09454 | 4 | 5 | 5 | 1 | 4.3 |
| GL5516 | 2 | 4 | 5 | 5 | 3.7 |

**Table 26**: Decision matrix for line following equipment.

The weighted matrix, or the matrix computed by multiplying the score in each category by its weight is show in **Table 27.** The total score for each item in the decision matrix (**Table 26**) is calculated by summing the values for each row in the weighted value matrix.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Factor | Community | Ease | Availability | Cost |
| ROB-09454 | 1.2 | 2.0 | 1.0 | 0.1 |
| GL5516 | 0.6 | 1.6 | 1.0 | 0.5 |

**Table 27**: Weighted value matrix. It is comprised of the score for each category multiplied by the weight for the category.

The weightings for the decision matrix were created by using the data in **Table 28** below

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Factor | Cost per unit | Ease | Availability | Community |
| ROB-09454 | $2.95 | Compatible with Udoo | In stock | Online help easily found. Great support for Arduino IDE. |
| GL5516 | $0.249 | Compatible with Udoo | In stock | Various online tutorials can be found. |

**Table 28**: Quantitative and qualitative values of the line following sensors under consideration that led to the decision matrix.

### **Justifications**

The following sections represents the reasoning behind each category and how their weights were determined.

#### **Community**

The community is weighted fairly heavily since it is meant to regard how easy it is to find information and tutorials about the item. A large amount of information was found about the QRE1113 model specifically. Some information was found about generic photoresistors, but not nearly as much as the QRE1113.

#### **Ease**

The ease category related to the ease of integration with the microprocessor. There are many tutorials available for the integration of the QRE1113 with Arduino IDE, and some are available for generic photoresistors as well which include the GL5516.

#### **Availability**

The availability relates to how easy the item can be bought and replaced if the need arises. Both items are inexpensive and easy to find on the internet. There are no foreseeable issues in finding sources of the items.

#### **Cost**

Both options were very cheap compared to the rest of the system’s components, with the photoresistors being $4.98 per 20, and the QRE1113 being $2.95 each. Within the decision matrix, the scale was based so that 1 was the most expensive on the scale and 5 was the least expensive. Even so, the price of both factors is fairly low.

#### **Summary**

The main concern in selecting an item for line following was ease of implementation and the community. With a large amount of information available for the QRE1113, it seems to be the best option for Roadie as it will be the most efficient sensor to use for implementation of the line following system.

### **Requirements Traceability**

The following requirements traceability refers to the System Requirements Specification for Roadie, revision 1.0.0, published September 18, 2014. As shown in **Table 29**,below, the requirement ID is followed by the requirement text and an explanation of how the B008GWPC1Q will fulfill said requirement.

|  |  |  |
| --- | --- | --- |
| ID | Requirement Text | Fulfilment |
| 3.2.2 | The system shall progress forward along the blue guidance tape until reaching a challenge area or reaching the finish line. | The QRE1113 will allow Roadie to sense the tape, providing the ability to recognize the challenge areas as well as the finish line. |
| 3.2.3 | The system shall identify the challenge zone and stop movement upon arrival. | The QRE1113 will allow Roadie to sense challenge areas allowing the system to stop its movement. |
| 3.3.1 | The system shall correctly identify the challenge zone upon arrival. | The QRE1113 will be able to sense when the tape splits in order to identify challenge areas. |
| 4.3.2 | The system shall be completely autonomous after being powered on. | The QRE1113 gives Roadie the ability to navigate independent of human interaction. |

**Table 29**: Requirements traceability for line following sensors.

### **Risk Analysis**

The risk analysis section includes information regarding risks related to the line following equipment and solutions to mitigate those risks. Take, for instance, a damaged sensor. Should a sensor become damaged, this could hinder Roadie’s ability to correctly track the line. In order to help mitigate this risk, redundant sensors will be installed on Roadie. Additional risks and their associated mitigations can be seen in **Table 30**

The probability of each occurrence, denoted as **Prob.**, will give the likelihood on the scale of one to nine with one will be the lowest likelihood of occurrence. The severity of an occurrence, denoted as **Sev.,** will give the impact that the event will have on a scale of one to nine with one being lowest impact.

|  |  |  |  |
| --- | --- | --- | --- |
| Risk | Prob | Sev | Mitigation |
| Sensing distance changes | 1 | 8 | Ensure that proper measures are taken during construction of each prototype to keep the sensor in the same spot. As long as the sensor is secured tightly and properly to the system, there should be no surprises on competition day. The sensor's optimal distance is 3mm. [1] |
| Improper reading | 2 | 8 | Have redundancy of sensors. There will be five sensors attached to the system so that readings on each sensor can be compared to obtain the most accurate readings. |
| Damaged sensor | 1 | 4 | In the event that a sensor is damaged, one can be easily attached in its place. Having one or two backup sensors in case one fails will mitigate this risk. |

**Table 30**: Risks that can be attributed to the line following sensors and their associated mitigations.

# **Glossary**

The glossary contains definitions of words and phrases used throughout this document.

|  |  |  |
| --- | --- | --- |
| Entry | Definition | Aliases |
| Align | The system will position itself so the appendages can properly reach the challenges. |  |
| Autonomous | Undertaken or carried on without outside control [2]. |  |
| Bad state | Any state that is not the line following state or the challenge state. |  |
| Challenge State | The state in which Roadie is completing one of the four challenges. |  |
| Challenge Zone | The 1ft. x 1ft. areas where each of the challenges will be played along the course. |  |
| Competition Area | The competition area is the plywood board where the competition is being held on. The system must maintain contact with the board at all times. |  |
| Course Round | A span of five minutes during which the system is expected to complete the 4 challenges [1]. |  |
| Pocket Etch-A-Sketch | The pocket Etch-A-Sketch is a popular children’s toy with two knobs to move the cursor up and down as well as left and right. For the competition, the specific version of the pocket Etch-A-Sketch being used is SKU:FD79DD3F from Toys R Us online [7], and can be seen in **Fig. 10.** |  |
| Finish Line | The finish line is the ending point of the competition. It is the point where the Scotch Blue Painter’s Tape comes to the final “T” shape on the course [1]. It is marked as FINISH in **Fig. 7**. |  |
| Good state | Either the line following state or the challenge state. |  |
| Institute of Electrical and Electronics Engineers | “IEEE is the world's largest professional association dedicated to advancing technological innovation and excellence for the benefit of humanity” [4]. That being said, IEEE is not only composed of electronic and electrical engineers as the name might suggest. Other types of members include computer scientists, software developers and even some doctors. | IEEE |
| Line Following State | The state in which Roadie is following the Scotch Blue Painter’s tape located on the competition area. |  |
| Obstruct | SoutheastCon rules state that the system cannot obstruct any obstacle [1]. |  |
| Playing Card | Information on the specific playing cards is still pending, thus, [TBD]. |  |
| Random Access Memory |  | RAM |
| Rubik’s Cube | The Rubik’s Cube is a puzzle game that achieved popularity in the 1980’s. For the competition, the specific version of the Rubik’s Cube being used is SKU:DAD09D9E from Toys R Us online [6], and can be seen in **Fig. 9.** |  |
| Scotch Blue Painter’s Tape | Scotch Blue is a brand of painter’s tape produced by the company 3M. For the competition, the specific model of painters tape being used is SKU: 958999 from Home Depot [8], and can be seen in **Fig. 11.** | Guidance Tape |
| Simon Carabiner | The Simon Carabiner is another version of the game, Simon, which is an electronic version of the children’s game “Simon Says”. For the competition, the specific version of Simon being used is SKU:226CE810 from Toys R Us online [5], and can be seen in **Fig. 8.** |  |
| SoutheastCon | SoutheastCon is the annual IEEE Region 3 Technical, Professional, and Student Conference. The conference includes technical sessions, tutorials, and exhibits. Additionally, various challenges and competitions are held for students to demonstrate their technical knowledge and understanding.“IEEE Region 3 encompasses the southeastern United States and includes the states of Alabama, Florida, Georgia, areas of Indiana, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia and the country of Jamaica” [3]. |  |
| Starting Area | A one foot by one foot area on the competition area marked by Scotch Blue Painter’s tape [1]. |  |
| Usable Condition | SoutheastCon rules state that the playing card must be left in a usable condition [1]. |  |

# **Acronyms and Abbreviations**

|  |  |
| --- | --- |
| Acronym | Meaning |
| AWTY | Are We There Yet |
| ECSSE | Electrical, Computer, Software & Systems Engineering |
| ERAU | Embry-Riddle Aeronautical University |
| IEEE | Institute of Electrical and Electronics Engineers |
| RAM | Random Access Memory |

# **Appendix A**

This appendix includes a diagram of the competition course as well as pictures of the individual challenges the system must complete. Also included is a picture of the tape that will designate the line the system must follow.

## **Competition Course**

The course, as shown in **Fig. 6** below, shows the rough outline of the track the system will follow, as well as what a challenge station would look like.

**Figure4** Competition course for SoutheastCon[1].

## **Simon Carabiner**

The Simon Carabiner, as seen in **Fig. 7** is the specific Simon game that the system will play.



**Figure5:** The exact Simon Carabiner to be used during competition [5].

## **Rubik’s Cube**

The Rubik’s Cube, as seen in **Fig. 8** is the specific Rubik’s Cube that the system will play.



**Figure6:** The exact Rubik's Cube to be used during competition [6].

## **Pocket Etch-A-Sketch**

The pocket Etch-A-Sketch as shown in **Fig. 9** is the specific pocket Etch-A-Sketch the system will play.



**Figure7:** The exact pocket Etch-A-Sketch to be used during competition [7].

## **Playing Cards**

[TBD] The playing cards will be updated with an appropriate picture once there is a specific set listed in the competition rules.

## **Scotch Blue Painter’s Tape**

The Scotch Blue Painter’s Tape as show in **Fig. 10** is the exact painter’s tape that will be used to designate the line the system must follow.



**Figure8:** The exact painter’s tape to be used on the course [8].

# **References**

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