## **Robotic Claw**

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

### **Items under consideration**

The following items have been considered for use as a claw 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 | Item Name | Vendor | Description |
| ROB-11524 | Robotic Claw – MKII | Sparkfun | Parallel opening claw which features brass sleeves in joints to make them more rigid. The claw opens to about 2 inches and “depending on the servo motor used, it can pick up some relatively heavy objects.”**REF** |
| 276-2212 | Claw Kit | Vex Robotics | Claw made of heavy duty plastic, it is dexterous enough to grab a feather and strong enough to hold a 12 oz. soda can.**REF** |
| Custom | Custom | N/A | A magnetic block attached to a rod that provides Roadie the ability to change attachments depending upon what challenge it arrives at. |

Table 1: Claws under consideration for Roadie

## **Decision Matrix**

The decision matrix used to select a claw for Roadie is depicted in Table 2. The decision matrix weighs… The highlighted row is the claw selected for use on Roadie.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Factor | Maximum Holding Weight | Claw Opening | Versatility | Availability | Cost | Total |
| Weight | 0.1 | 0.3 | 0.4 | 0.1 | 0.2 |  |
| ROB-11524 | 5 | 1 | 2 | 1 | 5 | 3.1 |
| 276-2212 | 5 | 4 | 2 | 1 | 3 | 3.2 |
| Custom | 5 | 5 | 5 | 5 | 1 | 4.7 |

Table 2Decision matrix for claw

The weighted matrix, or the matrix computed by multiplying the score in each category by its weight is show in Table 3. The total score for each item in the decision matrix (Table 2) is calculated by summing the values for each row in the weighted value matrix.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Factor | Maximum Holding Weight | Claw Opening | Versatility | Availability | Cost |
| ROB-11524 | 0.4 | 0.9 | 0.8 | 0.1 | 1.0 |
| 276-2212 | 0.4 | 1.2 | 0.8 | 0.1 | 0.6 |
| Custom | 0.4 | 1.5 | 2.0 | 0.5 | 0.2 |

Table 3Weighted 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 4

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Factor | Maximum Holding Weight | Claw Opening | Versatility | Availability | Cost |
| ROB-11524 | Variable | Approx. 2 inches | Single purpose | In stock | $11.95 |
| 276-2212 | 12 oz soda can | 3.375 inches | Single purpose | In stock | $19.95 |
| Custom | Variable | Custom | Very versatile | Available | $40.00 |

Table 4 Quantitative and qualitative values of the claws under consideration that led to the decision matrix.

### **Justifications**

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

#### **Maximum holding weight**

The maximum holding weight of the claw is how much weight the claw can safely hold. For the ROB-11524, the manufacturer claims that the weight that the claw can hold depends solely on the servo or motor used to control the claw. For the 276-2212, the manufacturer claims that the heaviest the object that the arm can hold is a 12oz soda can, which weighs about 380g. A custom solution for Roadie would have a variable weight holding as it can be designed and modified to suit any issues that may appear. The Rubik’s cube used in competition has a weight of approximately 181.4g **REF**. Therefore, all of the arms will exceed the heaviest item Roadie may have to pick up, thus receiving a score of five across the board.

If the maximum holding weight is low, Roadie will not be able to pick up the items it needs to. It is for this reason that maximum holding weight was given a weight of 10% as the holding weight does have an effect on Roadie’s ability to complete the challenges.

#### **Claw opening**

In order for Roadie to be able to interact with the challenges, the claw must be able to open wide enough to support all the challenges. Since the ROB-11524 opens approximately 2 inches, this might not be wide enough given the Rubik’s cube to be used is approximately 2.2 inches wide **REF**. However, as the manufacturer does not give specifics, it may be possible that the ROB-11524. Bearing this in mind, the ROB-11524 was scored a one because it may not work. The 276-2212 was scored a four because it is not the widest opening claw in this comparison, though it does place a close second. For this reason, it has been given a score of four. The custom claw will be able to open and grip the items as AWTY deems fit. It is for this reason it was ranked the highest with a score of five.

Claw opening was given a weight of 30% because the claw must open wide enough to be able to interact with all of the challenges. If the claw is unable to do so, Roadie will not be able to perform its tasks.

#### **Versatility**

The versatility of the claw is how adaptable and readily changeable each claw is, as perceived by AWTY. In this particular instance, both ROB11524 and 276-2212 are simple claws that open and closed when attached to a servo motor. While this may work for all the challenges, AWTY feels that this is not adaptable enough, and may cause problems with the design as the system progresses. It is for this reason, that the “off the shelf” claws have been awarded a two. In their current state, they will require some modifications, however, they may suffice. It is also very likely that one “off the shelf” claw may not suffice. In this case, Roadie would require multiple claws to be able to complete challenges which is not desirable. The custom option received a score of five because AWTY is not locked into a single design or form factor. It is very customizable and modifiable as prototyping advances, making the custom route very attractive.

The weighting for versatility is set to 50% because Roadie will be completely dependent upon some form of claw to be able to implement each challenge. The claw chosen must be versatile enough to adapt to four very different, very distinct challenges. If the claw lacks this ability, not only will it compromise Roadie’s ability to complete the challenge, it also imposes more constraints on the design, as multiple claws may have to be employed to complete the challenges.

#### **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 claws were obtained by giving the most expensive claw a score of one, and the least expensive claw a score of five. As there was only one other claw to consider, a score of 3 was awarded since it fit between most expensive and least expensive item. It should also be noted that the custom claw was allotted a budget of $40 since it will be doing the work of what may amount to four claws if the “off the shelf” route was chosen.

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 BLAH,** below, the requirement ID is followed by the requirement text and an explanation of how the custom claw will fulfill said requirement.

|  |  |  |
| --- | --- | --- |
| ID | Requirement Text | Fulfillment |
| 3.3.3 | The system shall play the Simon Carabiner. | The custom claw will have a specific attachment dedicated to being able to play the Simon Carabiner. |
| 3.3.3.1 | The system shall play the Simon Carabiner for 15 seconds. | The custom claw will allow for Roadie to correctly interact and play Simon for the entire duration of 15 seconds. |
| 3.3.3.2 | The system shall initiate the Simon Carabiner by pressing the start button. | By having an attachment made specifically for Simon, Roadie will be able to precisely hit the start button on Simon to activate the game. |
| 3.3.4 | The system shall twist one row of a Rubik’s Cube 180 degrees. | The custom claw will have a specific attachment dedicated to being able to the Rubik’s cube, allowing Roadie to twist one row of a Rubik’s cube 180 degrees. |
| 3.3.5 | The system shall draw “IEEE” on the pocket Etch-A-Sketch. | The custom claw will have a specific attachment to twist the knobs on the Etch-A-Sketch, allowing Roadie to correctly draw “IEEE”. |
| 3.3.5.1 | The system shall use [Font and Size TBD] for drawing “IEEE”. | With the implementation of a custom claw, Roadie will have the ability to very finely manipulate the knobs on the Etch-A-sketch, thus allowing for a wide range of fonts and sizes. |
| 3.3.6 | The system shall collect a single playing card [Exact deck TBD]. | The custom claw will have a specific attachment for the retrieval of playing cards, allowing Roadie to pick up exactly one card. |
| 3.3.6.1 | The system shall carry playing card across finish line. | The custom claw will enable Roadie to maintain a grip on the single card, regardless of the time taken from Roadie picking up the card to Roadie crossing the finish line. |
| 3.3.6.2 | The system shall keep the card in a usable condition. | The custom arm will enable Roadie to keep the card in a usable condition. |

Risk Analysis

The arm of Roadie represents the appendage in which Roadie will interact with all the challenges during competition. Therefore, a failure of the arm would result in total failure of the competition. As such, precautions must be made to ensure that the arm operates in a safe and optimal manner. An example of a catastrophic of the arm would be if the means for attachment retrieval failed or was damaged during competition. A failure of this magnitude would render that round of competition as a definitive loss, very likely harming Roadie’s overall performance during competition. An example of a minor failure would be if the arm became misaligned. While this would affect Roadie’s performance, Roadie would still be able to complete the challenges, albeit not optimally, and receive some points for that particular round. Table **BLANK** depicts the risks associated with the arm system.

|  |  |  |  |
| --- | --- | --- | --- |
| Risk | Prob. | Sev. | Mitigation of Risk |
| Attachment gets stuck on arm | 2 | 9 | If an attachment becomes stuck on the arm, this will cause Roadie to no longer be able to compete for that particular round. As the attachments will be held in place by an electromagnet, this is a very unlikely to occur. The reason being that once power is cut to the electromagnet, there will no longer be a magnetic field joining the attachment and arm. In order to mitigate this event Roadie will **WHAT** |
| Arm becomes misaligned relative to challenges | 3 | 3 | If the arm becomes misaligned during competition, this will hinder Roadie’s ability to complete each challenge. This would be attributed to Roadie thinking the arm is aligned in one place, when in fact it may be offset by a slight degree. In order to mitigate this, Roadie will have a form of track to make sure that the arm is always aligned in the proper spot. |
| Arm fails to extend or retract | 2 | 9 | If the arm fails to retract, Roadie would be unable to retrieve subsequent attachments for the arm. This would result in Roadie scoring less than optimally for the round. If Roadie is unable to extend the arm, Roadie would once again, be unable to retrieve the appropriate attachments. It is also possible that if the arm is extended in such a manner, Roadie will be unable to progress further, thus terminating the round. In the event that this scenario occurs, **WHATTTTTT** |
| Attachment falls off arm during competition | 1 | 9 | If the attachment were to fall off the arm during competition, this could pose several distinct problems for Roadie. The first of such problem would be subsequent round completion. If the part is damaged upon falling off, this would hinder Roadie’s ability to complete future course rounds. Additionally, if the part falls off in such a way that it impedes Roadie’s advancement during the round, Roadie would ultimately fail that round of competition. In order to mitigate these risks, all attachments to the arm will have some form of redundancy built in. This will help to assure that Roadie will reliably be able to maintain control of the arm attachments. |

<https://www.sparkfun.com/products/11524>

<http://www.vexrobotics.com/276-2212.html>