Mission to Mars

MCHE 201: Introduction to Mechanical Design

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Abstract

The Mission to Mars Contest is a competition that challenges students to design, construct, and program an autonomous robot to complete specific tasks. The tasks are ~~as follows:~~ transport astronauts to Mars, plant a flag on the Mars Landing Zone, avoid and/or collect asteroids, collect pre-launched fuel, and return to Earth. The design entry is limited to specifications on dimension, construction materials, and cost. The final design, the Ragin' Rover, is selected to compete in the contest because it is determined to earn the most points of the three leading potential designs discussed in this report. Key aspects of the final design that led to this conclusion are minimalistic framework, controlled forward-backward movements, and fixed shaft rotation. This design is constructed with structural components chosen for versatility and support for its dependent subsystems. Likewise, each alternative design has its own significant characteristics. The three designs are generated based on studies of various mechanical movements and examples of the manufacturing process; however, establishment of a relationship between mechanical properties and the Mission to Mars Contest is by virtue of problem-understanding tools. Selection of the final design derives from the results of the Third-Level Evaluation Matrix in which the designs are all compared. This evaluation defines how the final design is most qualified to meet the customer requirements and engineering characteristics considered. According to the judges of the competition, this design is ranked 5^{th} highest in presentation, ingenuity, and aesthetics. The Ragin' Rover prove~~s~~d to be most successful robot to complete the Mission to Mars, finishing in 1^{st} place overall.

Good

it already happened

1 Introduction

The Mission to Mars Contest is a competition that challenges students to accomplish a small-scaled trip to Mars. The competition tests students on skills involving preparation, design, ingenuity, and creativity. A premade track, shown in Figure 1, represents the “Solar System” and is used as the setting of the competition. The goal of the competition is to design, program, and construct an autonomous robot to complete tasks for the Mission to Mars. The contest includes a number of limitations on construction, which must be heavily prioritized during the design process [1].

The construction limitations on any design are as follows: the device must fit within a 1’ wide x 2’ long x 18” tall box; it must also fit on the 2’ x 2’ Start Zone on the track; use of only one Arduino controller, sensors and servomotors contained in three SparkFun Inventor’s Kits, and components from the provided team kit are permitted. The use of the small DC motors from the SIK kits are prohibited. The device must also not exceed the cost of $100, excluding the prices of those pieces previously listed.

The following are the tasks of the Mission to Mars: transport astronauts to Rotating Mars Base, plant a flag in the Mars Landing Zone, avoid and/or mine asteroids, collect pre-launched fuel, and return to Earth. Five Lego Mini Figures are analogous to astronauts, aluminum foil-wrapped table tennis balls are asteroids, and plastic toy blocks are pre-launched fuel. Point values are assigned for each task as a means of scoring the competition. Each astronaut who completely lands in the Mars Base is worth 10 points, and each astronaut who completely lands in the Mars Landing Zone is worth 5. A successfully planted flag in the Mars Landing Zone is valued at 10 points. Any asteroids in a team’s zone result in a deduction of 5 points each, but any asteroids collected into the Asteroid Processing Zone will earn 5 points. Each pre-launched fuel collected into the team’s zone is worth 10 points. The Mars Base, Mars Landing Zone, Earth, and the Asteroid Processing Zone are shown in Figure 1.

These challenges and how they play a role in the preparation for this contest will be discussed in the rest of the report. Section 2 will elaborate on the final design, and Section 3 will explain the problem-understanding process. Section 4 will provide a concept evaluation, and Section 5 will evaluate the final design’s performance. The report will be concluded in Section 6, and all tables and figures will follow. References are listed at the very end of the report in Section 7.

Good

2 Final Design

The final design, the Ragin’ Rover, is shown in Figure 2. The key aspects of the design are minimalistic framework, controlled forward-backward movements, and fixed shaft rotation. The design is aimed to complete the mission using the simplest operations possible. In addition, it is constructed using little material, allowing it to be flexible to change, low maintenance, lightweight, and cost-effective. This design can be divided into three basic subsystems that are visible in Figures 3 and 4: the wheel-DC motor subsystem, the depositing subsystem, and the mechanical arm subsystem. These characteristics fulfill the customer requirements and the engineering characteristics of a competitive robot.

what does this mean? prototyping of what? I think you may mean something else

The physical structure of the robot is constructed from 0.5"-thick framing lumber, and the foundation rests on two rubber support wheels that are 2" tall. The height of the robot comes from the neck-like structure that stems straight up and out from the base. The functionality of this component brings the astronauts and the flag directly to the location necessary to drop them into the Mars Landing Zone. This minimizes any need to lift the astronaut and the flag a distance from the base of the track. A single large wooden wheel is centered at the back of the robot to serve as the main driving factor. ~~The~~ A DC motor ~~provided in the MCHE 201 Kit~~ is attached directly to the center of the wheel to enable the mobility of the device. The wheel-DC motor subsystem is attached to the framework via a thin sheet of plywood. This plywood also serves as the ideal place to attach the Arduino Redboard and Motor Shield for prototyping. The main purpose of a design geared toward simplicity is that it conserves time, which is very crucial in this competition.

Good

The wheel-DC motor subsystem is a vital part of the design because of its function to drive the robot. The rotating shaft of the DC motor is inserted directly into the center of the cross sectional area of the wheel. The two are sealed together with removable adhesive. Power provided to the DC motor causes rotation of the shaft, which therefore, causes rotation of the wheel to move the device forward and backward. The wooden wheel, alone, lacks traction on the smooth surface of the track of the "Solar System," so a thin strip of sand paper is secured along its circumference to resolve this issue. This subsystem is ~~found to be~~ the most direct way to add a driving component to the robot, allowing it to travel both to Mars and back to Earth.

refer to names as those in Figures

The depositing subsystem is located at the end of the protruding neck piece. It is easily identified by the plastic cup. This subsystem is the most simplistic of the four subsystems and consists of only a plastic cup and a servomotor from the SparkFun Kit. The rotating shaft on the servomotor is inserted through a punctured hole in the side of the cup. A servo horn is then layered on top to seal the wall of the cup in between. The purpose of the cup is to house the astronauts and the flag. The servo rotates the cup to deposit its components into the desired location. The benefit of using a servomotor for this subsystem instead of a DC motor is that the degree of rotation on the servo can be adjusted within the program written to run the robot.

The mechanical arm subsystem also takes advantage of shaft rotation behavior. It is located at the front base of the device. Servomotors, thin arms carved from sheets of wood, and two sheets of plastic make up this subsystem. Each servo is attached to the base, one on the upper right-hand corner and one on the upper left-hand corner, with the shaft pointing upward. The shaft of each servo is inserted into the wooden asteroid/fuel-collecting arm at one end, and the plastic sheet is suspended from the other end. The servos are programmed to rotate away from the device to open up these arms and close them when the device is within parameters of the asteroids and pre-launched fuel. The device can then drive in reverse to drag the collected asteroids into the Asteroid Processing Zone and the pre-launched fuel into the Team Zone while the plastic sheet keeps them contained. These three subsystems function in a sequence of steps to complete the mission.

3 Problem Understanding

A key factor in any design process is to completely understand the problem at hand. Utilizing any number of design tools that aid in both recognizing potential issues and coming up with an effective design also helps to understand the problem. The House of Quality, ~~as~~ seen in Table 1, is one of these tools that can organize as well as relate key characteristics and requirements of any given design together. Some important customer requirements are as follows: carry astronauts to base, operate autonomously, and can be confined in a volume of 1' x 2' x 18". These requirements are deemed important because they most effectively satisfy the important goals of the customers. The customers for this project include the source of the rule book and ~~even~~ the design team, itself. Furthermore, any given design that satisfies the most customer requirements can be determined to be the one most suited for the problem at hand. The time it takes to return to Earth is an important engineering characteristic represented by its high relative importance. This means that it would be wise to spend more time and resources on this aspect of the design than some of the others that scored a lower relative importance. The correlation matrix helps in weighing characteristics to one another. For instance, if the weight is to reach a specific target value, minimizing the number of parts could help achieve this.

use same units

a bit too general.

A development of a Specification Sheet, as seen in Table 2, plays a key role in the design process by extracting numerical values from the engineering characteristics as well as important customer requirements that can be quantified. For the Mission to Mars Specification Sheet, total height is not to be greater than 18". This specific specification qualifies as a demand and must be met in order for any final design to be deemed successful. Wants are specifications that one particular customer would like to have – such as weighing less than ten pounds - but do not necessarily have to be met in order for a design to be successful. It is also very important that the Specification Sheet becomes a "living" document, meaning that it is constantly updated as soon as new information is presented that allows for certain specifications to become improved or maybe removed all together. It is also important that the person responsible for any changes place his or her name next to the change in order for others to contact them about the modification. If used effectively, the Specification Sheet serves as a very useful tool in quantifying any given design and ruling out early potential designs that may not meet certain criteria.

This part is too general. Talk about the important specs, not the spec sheet itself.

A Function Tree is used to identify each individual function required to complete the main goal. As seen in Figure 5, the main task of completing the Mission to Mars is divided into four smaller sub-tasks which are then broken down until only simple functions remain. For example, one of the four larger tasks is to mine or remove asteroids from a team's designated zone. In order for asteroids to be mined, they must be brought back to the Asteroid Processing Zone. This task can be further simplified into elementary functions, such as pick up asteroids, and stop with asteroids over designated area. The very process of breaking this main objective into these smaller tasks allows for a better understanding of the problem as a whole. Solving these more specific functions may shed some light on smaller problems and design challenges associated with the mission; this can improve smaller subsystems of the end design, which will make the total design more effective at completing the Mars Mission and satisfying its customers.

4 Concept Evaluation

how were these designs chosen?

The two alternate designs are the Pulley Alternate Design and the Pencil Alternate Design. These two designs are similar to the final design in that they maintain an almost identical simplistic framework, as it is established to be the most effective structure for this mission. They also run with the same controlled forward-backward movements. The Pulley Alternate Design incorporates mechanical work in conjunction with electricity, which is its most notable characteristic. It consists of three subsystems: the wheel-DC motor subsystem, the pulley subsystem, and the sweeping subsystem. The Pencil Alternate Design is also reliant on mechanical behavior. Its three subsystems are as follows: the axle-DC motor subsystem, the depositing subsystem, and the drop-drag subsystem.

redundant with next two paragraphs

refer to names as those in Figures

The Pulley Alternate Design, shown in Figures 6 and 7, drives forward and backward using the same mechanism as the chosen final design; the DC motor is inserted directly into a large wheel to drive the entire network. The pulley subsystem is run using a stepper motor in which the rotation of the shaft reels in a string on a spool. The spool is attached to a gear and the bucket used to deposit the astronauts and the flag into the Mars Landing Zone. The sweeping subsystem consists of two servomotors and two arms. One arm is located on the left side of the base. It begins in an upward position and drops down when the device is timed to collect the asteroids. The other arm, the asteroid-collecting arm, is located on the right side of the base and rotates inward to essentially sweep the asteroids in. The duo then encloses the asteroids to easily drag them backward toward the Asteroid Processing Zone.

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The Pencil Alternate Design, shown in Figures 8 and 9, drives forward and backward by utilizing the axle-DC motor subsystem. The DC motor rotates a gear attached to its shaft. The gear from the motor meets with a gear attached to the axle to enable rotation to move the entire system. The depositing subsystem relies on the device coming in contact with the Mars Landing Zone. The force from impact pushes the pencil to deposit the astronauts and the flag into the base. The drop-drag subsystem is used to collect asteroids. It contains a servomotor on the left and right sides of the base and asteroid-collecting arms that extend from the servos. The other ends of the arms are connected to each other with a sheet of plastic attached from the end of one arm to the end of the other. When the device is prepared to collect asteroids, both servos simultaneously rotate all components of the subsystem downward as a single unit. The sheet of plastic will gather the asteroids to be dragged toward the Asteroid Processing Zone.

The Third-Level Evaluation Matrix, shown in Table 3, provides a means of comparison for the three considered designs. The matrix lists customer requirements and gauges how well each design satisfies them. Across the top of the matrix are the Ragin' Rover, the Pulley Alternate Design, and the Pencil Alternate Design, respectively. This evaluation process is used to support the selection of the design that is best to compete in the competition. For example, consider the requirement of a quick preparation time for the mission. This requirement is given nine points for importance because of the competition setup time limit. The final design and the Pencil Alternate Design are given a higher point-value for fulfilling this requirement than the Pulley Alternate Design. This exhibits why the pulley subsystem is not the best method to deposit the astronauts and the flag; it noticeably takes more time to setup the string and spool, which can lead to failure to accomplish the mission or even a disqualification. Another example is the requirement of

Good

planting the flag on the Mars Landing Zone. Because this is one of five tasks of the competition, it is given 10 points for importance. The Ragin' Rover is valued to be the most capable of the three designs to complete this task. This is because the pulley subsystem on the Pulley Alternate Design and the depositing subsystem on the Pencil Alternate Design are more likely to lose an equilibrium state from the influence of the flag. The reliance on mechanical behavior makes the two devices much harder to maintain balance while they are mobile. The final design, on the other hand, is directly attached to the servo and can easily maintain its state with less influence from the components of the cup. Another major customer requirement is that the device runs the same every time, also 10 points in importance. Consistency during the contest stabilizes the chances of winning. The final design is ~~said to be~~ the most effective in meeting this requirement due to the fact that it is more electronic than the other two design options. These three examples show how the final design is capable of earning the most points during the competition; it satisfies the most important customer requirements, according to the Third-Level Evaluation Matrix. In addition, these requirements are that of various customers. These examples display how the Ragin' Rover is capable of following the rules of the competition, competing in the mission, and also fulfilling the most important desires of the design team. This comparison process among the various designs and customer requirements is repeated to effectively gauge the potential success of each design, which led to the selection of the design expected to earn the most points, the Ragin' Rover.

what does this mean?

be more concise here.

5 Design Performance Evaluation

The Judging Session was an important part of the final competition process. The judges graded the design team and the robot based on presentation, ingenuity, and aesthetics. The scoring was determined based on a series of questions and observations. The Ragin' Rover placed 5th out of 24 teams in the Judging Session with a total score of 4.2 points out of 5.0. Of the three judging criteria, the Ragin' Rover was deemed strongest in presentation but weakest in aesthetics. The lower score in aesthetics was expected because it was not a top customer requirement against those involving functionality; this was shown in the House of Quality. Sacrificing the aesthetics of the robot for better performance was a design-process decision based on level of utmost importance and the weight of the scores of the competition; performance was worth 8 points while judging was only worth 5 points. The time devoted to functionality was paramount, which ultimately led to the design's great success during the actual competition. Investing more time in the aesthetics could improve this score, but excelling in ingenuity and presentation helped to rank the Ragin' Rover among some of the most impressive robots in the competition.

yes

Good

The Mission to Mars Contest was broken down into the following rounds: the Preliminary Round, the Qualifying Round, and the Final Round. Each round had its own variant of the contest rules and scoring. During the Preliminary Round, each team competed individually. The points available during this round were that of transporting astronauts to Mars as well as collecting and/or mining asteroids. This round provided valuable information on the robot's performance, gauging how well it was capable of completing basic tasks with minimal influence from its surroundings. The Ragin' Rover finished 4th out of 24 teams by transporting astronauts to the Mars Landing Zone and collecting and mining zero asteroids. The round proved a need for

Just talk about the final contest.

improvement in the mechanical arm subsystem that was assumed to successfully collect the asteroids.

The Qualifying Round was run with the full contest rules and scoring. The Ragin' Rover finished 5th out of 7 interpolated scores. It was assumed to be capable of completing all tasks of the competition, fully prepared for the Final Round; therefore, it was also predicted to receive a positive amount of points. The Ragin' Rover was successful at completing the mission; however, it was unsuccessful at earning a positive amount of points. This was due to user error and failure to recognize a rule of the competition—the device must shut down at the end of the thirty-second competition. Upon completing the mission, the Ragin' Rover was programmed to reset after a thirty-second delay. In retrospect, it was apparent that the delay was not long enough to abide by the rule stated above. This incorrect assumption resulted in a disqualification, earning a negative amount of points. A slight adjustment to the program resolved the issue, and the Ragin' Rover performed as initially predicted for the second match of the round.

The Final Round proved that the final design was successful at completing the mission. Its most notable trait was its consistency per match, which was a key characteristic that was heavily focused on during the design process. It transported all astronauts, planted the flag, collected asteroids, collected a single pre-launched fuel, and safely returned to Earth; all subsystems performed as engineered. Such performance kept the Ragin' Rover within the winner's bracket throughout the entire competition. This satisfied the assumption that consistency was among the top most important customer requirements. The final design was also assumed to perform as planned with little influence from the behavior of adjacent competitors. Although this was correct during most of the competition, it failed to do so against one competitor who collided with the Ragin' Rover. The contact loosened a component of the mechanical arm subsystem, which caused the design to fail at collecting a pre-launched fuel. As a matter of fact, the robot gave these points to said competitor. Despite the contact with the competitor, its ability to earn points from completing other tasks allowed it to remain within the winner's bracket. Its minimalistic design made it low maintenance, as expected, and the loosened component was easily fixable. The Ragin' Rover finished in 1st place overall in the Final Round, ~~which proved that it was the most optimal design to complete the Mission to Mars.~~ not necessarily

Good

6 Conclusions

The goal of the Mission to Mars Contest is to design, program, and construct an autonomous robot to complete specific tasks. The tasks are as follows: transport astronauts to Mars, plant a flag on the Mars Landing Zone, avoid and/or collect asteroids, collect pre-launched fuel, and return to Earth. Specifications on dimension, construction materials, and cost are the main challenges of the competition. The final design entry, the Ragin' Rover is identified by its minimalistic framework, its controlled forward-backward movements, and its application of fixed shaft rotation. Alternative designs, the Pulley Alternate Design and the Pencil Alternate Design, have their own significant characteristics, but were not as sufficient to compete in the competition. The Ragin' Rover is evaluated to earn the most points out of the three leading potential designs by satisfying the most important customer requirements and engineering characteristics. Concepts for these designs stem from the use of problem-understanding tools,

Good

and the selection process is based on the Third-Level Evaluation Matrix. The evaluation provides a comparison among the three designs, highlighting which customer requirements each design satisfies the most. This evaluation defines how the final design is most qualified to meet the customer requirements and engineering characteristics considered. According to the judges of the competition, it is ranked 5th highest in presentation, ingenuity, and aesthetics. The Ragin' Rover proves to be most successful robot to complete the Mission to Mars, finishing in 1st place overall.

Why so blurry?

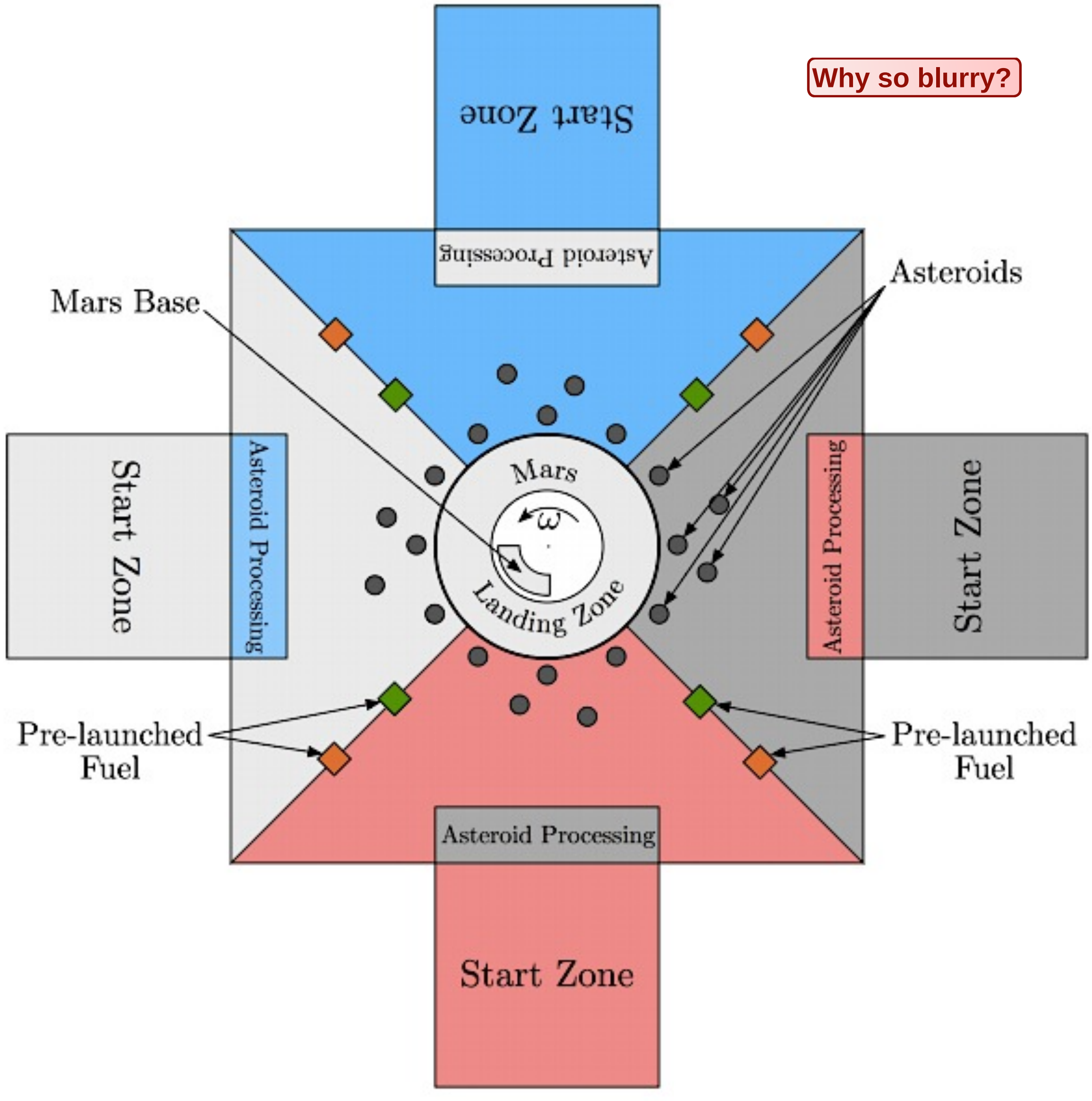


Figure 1: Mission to Mars Track [1]

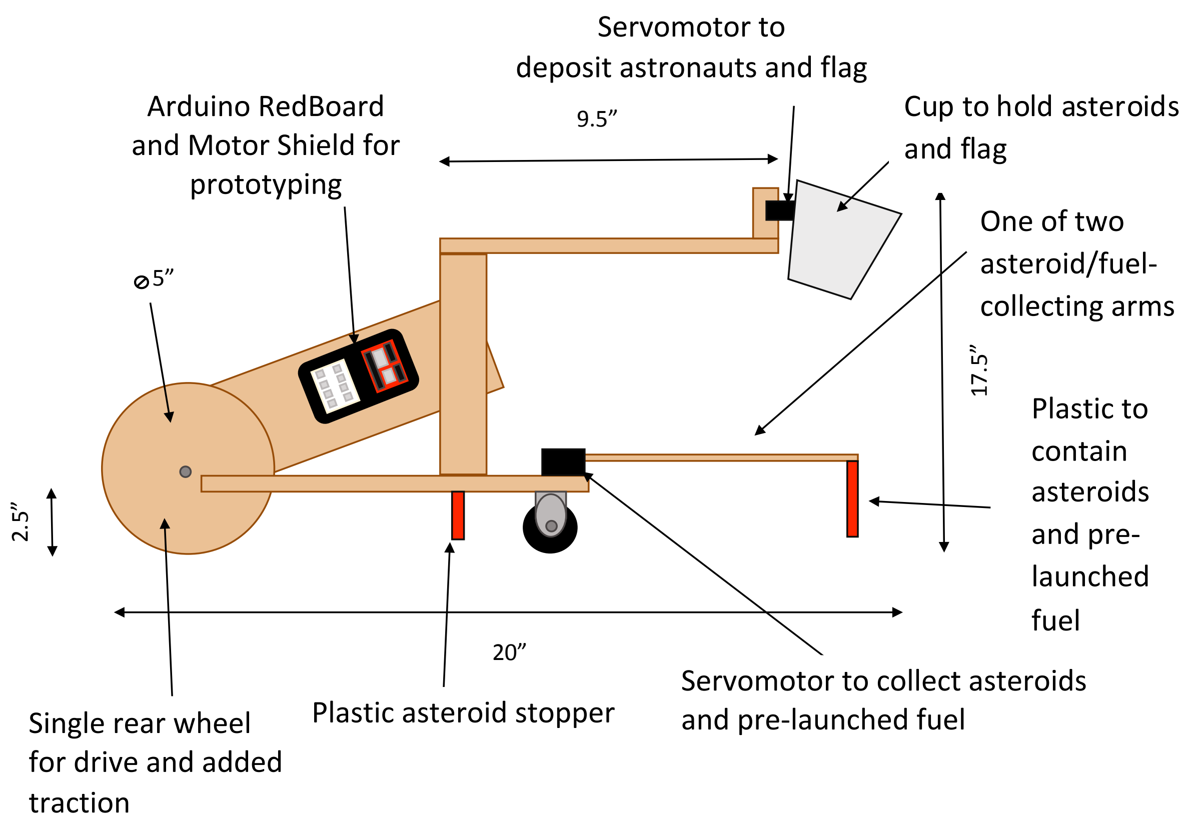


Figure 2: Final Design Side View

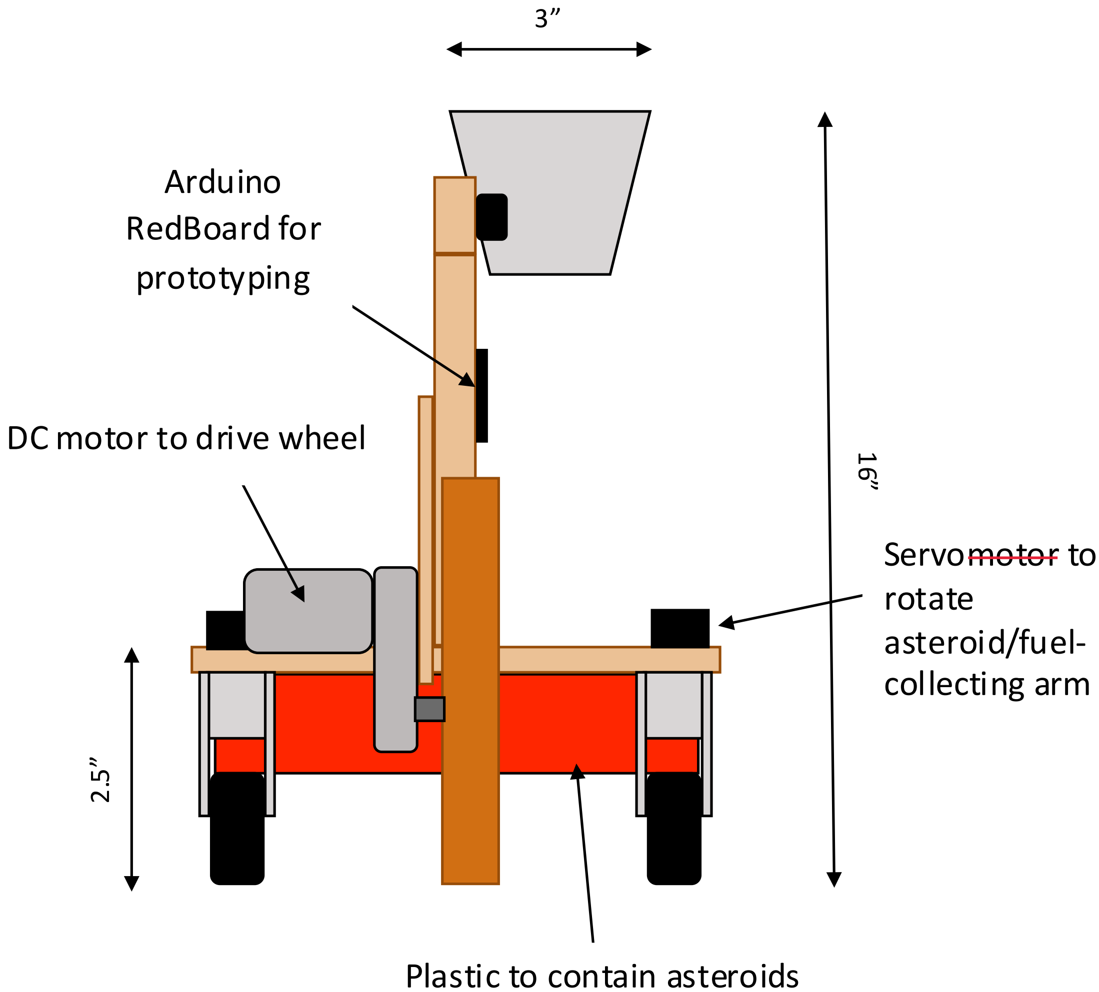


Figure 3: Final Design Rear View

better to give names
describing function

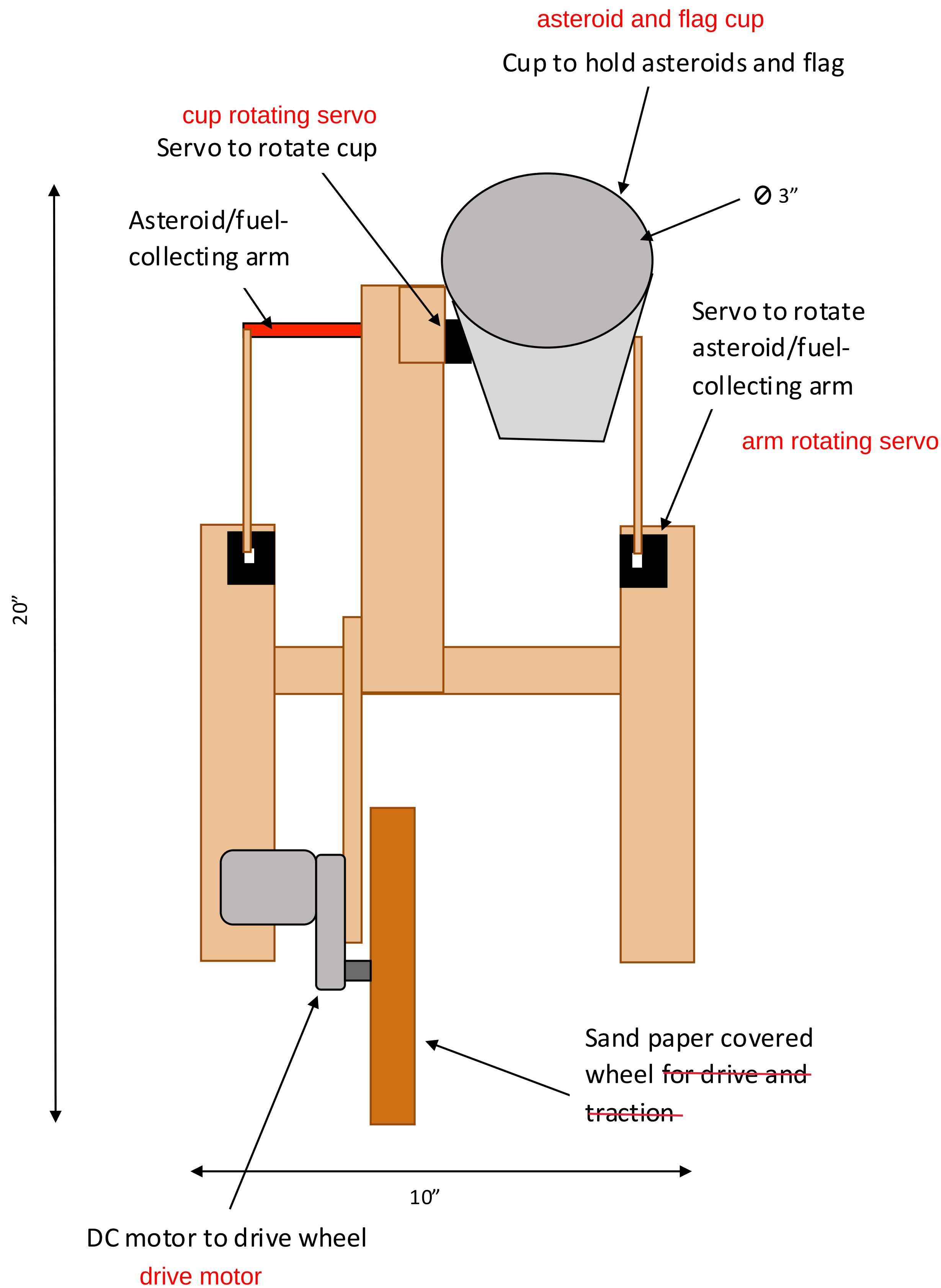


Figure 4: Final Design Top View

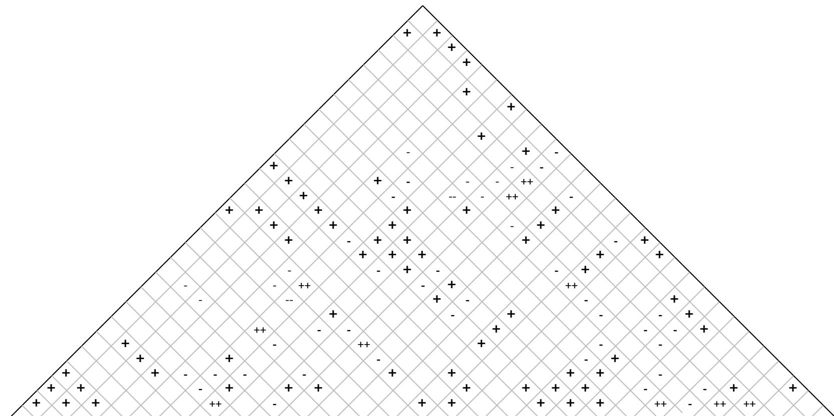
Table 1: Mission to Mars House of Quality

Good

◉	Strong
▣	Medium
△	Weak

▲	Maximize
▼	Minimize
x	Target

++	Strong Positive
+	Positive
-	Negative
--	Strong Negative



Importance (1-10)	Customer Requirements \ Engineering Characteristics	Cross-sectional area of body	Total length of body	Total height of body	Total width of body	Total weight of body	Cost of components	Time it takes to complete mission	Maximum speed	Object detection distane	Programming time	Angle of turning	Cost of program	Maximum travel distance from power source	Maximum impact force before failure	Number of parts	Setup time before mission	Time it takes to remove from track	Load capacity	Time it takes to return to Earth	Time it takes to reach Mars	Average acceleration	Average deceleration	Distance required to come to complete stop	Construction time	Size of program	Program upload time	Number of DC motors	Number of points earned
	Direction of Improvement	X	X	X	X	X	▼	X	▲	X	▼	▲	▼	▲	▲	▼	▼	▼	X	X	▼	X	▲	▼	▼	▼	▼	X	▲
10	Autonomous	◉					▣		▣	◉	◉		◉			▣	▣			◉	◉	◉	◉	▣		◉	◉	▣	◉
7	Lightweight	▣	◉	◉	◉	◉	▣		▣						▣	◉			◉			◉	◉					▣	
10	No more than 1ftx2ftx18in	◉	◉	◉	◉																				◉				◉
10	Can move		△	△	△	▣			◉		△	▣				△	△					◉	◉		◉			◉	◉
10	Cost no more than $100						◉	◉	△				◉		▣	▣			△										◉
6	Minimal number of parts	◉				◉					▣		△		△	◉	△	△	▣						◉	▣		△	
8	Runs the same everytime						△		△		▣		△			▣	△	▣		▣	▣	◉	◉	◉	▣	△		△	△
7	Programmed using basic functions								△	△	◉		◉			▣	▣	△		△	△				▣	◉	◉		
6	Parts don't break off	▣	▣	▣	▣		△								◉	△			◉						▣				△
10	Carry astronauts to base		△	△	△						△			▣	△		△		◉		◉	△	△	△				△	▣
6	Starts off in equilibrium state	△	△	△	△			◉		◉	▣	◉	△	△	△				▣	▣				△		▣	△		◉
5	Mine asteroids	△	△	△	△	▣		◉		◉	▣	◉	△	△	△	◉			▣	▣	◉			△	△	▣	△	△	◉
6	Collect pre-launched fuel		△	△	△	▣				◉	▣	◉	△		△				◉	◉	◉			▣	△	▣	△	△	◉
9	Can pickup and let go of objects						△			▣	▣		△			▣	△		◉						△	▣	△	△	△
8	Can return to Earth		△	△	△			◉	△		△	▣	△							◉	◉	△	△	△		△	△	▣	▣
5	Completes mission within specific time period		△	△	△			◉	▣	△	△		△							◉	◉	△	△	△		△	◉		◉
2	Aesthically pleasing	△					△										△								▣				
10	Utilizes only electrical and gravitational energy					△	△		◉		△		△	◉			▣		△			▣	▣	▣	△			▣	▣
9	Change direction of movement		△	△	△			△			▣	◉	△	△						▣	▣			▣	△	△	△	◉	
10	Maximizes points earned		▣	▣	▣			◉			△						◉	◉	△	◉	▣						▣		◉
6	Can acknowledge external movement(s)							▣		◉	▣		△			▣				▣	△					▣	△		
5	Can sense external obstacles							△		◉	▣					▣				▣	▣			△		▣	△		
10	Not wireless					◉	△		△			△		◉		◉	▣	▣				△	△				▣		▣
5	Quick prep time for mission		▣	▣	▣	▣		◉								△	◉			△	△						◉		
8	Plant flag on mars base		▣					△		▣	△	▣							▣		△			◉					◉
10	Triggered by start plugs							▣			◉					△										▣		△	▣
	Absolute Importance	286	309	275	275	295	186	511	289	405	484	322	321	230	138	448	277	157	447	480	518	378	368	288	342	342	357	330	878
	Relative Importance	0.0288	0.0311	0.0277	0.0277	0.0297	0.0187	0.0514	0.0291	0.0408	0.0487	0.0324	0.0323	0.0231	0.0139	0.0451	0.0279	0.0158	0.045	0.0483	0.0521	0.038	0.037	0.029	0.0344	0.0344	0.0359	0.0332	0.0884

be careful with lines

Good

Table 2: Mission to Mars Specification Sheet

		Specification for:	Issued:	3/14/17
		Mars Astronaut Transporter	Page 1 of 1	
Changes	D/W	Requirements	Responsibility	Source
		Safely transport austronauts to base and plant flag		
		Geometry		
3/15/17	D	1'x2' physical footprint	Design/Build Team	Dr. Vaughn
3/15/17	W	10"x22" physical footprint	Design/Build Team	Design/Build Team
3/15/17	W	Max Height of 16 inches	Design/Build Team	Design/Build Team
3/15/17	D	Max Height of 18 inches	Design/Build Team	Dr. Vaughn
3/15/17	D	Robot stay within 2'x2' start zone	Design/Build Team	Dr. Vaughn
3/15/17	D	Team stays outside 3' perimeter around competition area	Design/Build Team	Dr. Vaughn
3/15/17	D	Crossectional Area of right and left sides < 14"x16"		
		Kinematics		
3/15/17	W	Max speed > .5 ft/s	Design/Build Team	Design/Build Team
3/15/17	W	Average acceleration < .5 ft/s^2	Design/Build Team	Design/Build Team
3/15/17	W	Average decceleration > .3 ft/s^2	Design/Build Team	Design/Build Team
3/15/17	D	Traveling distance from power outlets < 6ft	Design/Build Team	Design/Build Team
3/15/17	D	Turning radius < 2ft	Design/Build Team	Design/Build Team
3/15/17	D	Stopping distance < .5 ft	Design/Build Team	Design/Build Team
		Forces		
3/15/17	W	Total Weight < 10lbs	Design/Build Team	Design/Build Team
3/15/17	D	Support > 1lbs	Design/Build Team	Design/Build Team
3/15/17	W	Survive impact force of at least 3lbs	Design/Build Team	Design/Build Team
		Energy		
3/15/17		Size of program < 32KB	Design/Build Team	Design/Build Team
		Safety		
3/15/17	D	Stay outside the 3' perimeter around the course	Design/Build Team	Dr. Vaughn
3/15/17	D	Damage 0 track components	Design/Build Team	Dr. Vaughn
3/15/17	D	Damage 0 track components	Design/Build Team	Design/Build Team
3/15/17	D	0 items leave the 3' perimeter	Design/Build Team	Dr. Vaughn
		Assembly		
3/15/17	D	Number of parts < 50	Design/Build Team	Design/Build Team
3/15/17	W	Total construction time < 2 weeks	Design/Build Team	Design/Build Team
3/15/17	D	Total construction time < 4 weeks	Design/Build Team	Dr. Vaughn
3/15/17	W	Programing time < 1 week	Design/Build Team	Design/Build Team
3/15/17	D	Numer of DC motors > 1	Design/Build Team	Design/Build Team

Table 2: Mission to Mars Specification Sheet Cont.

		Operation		
3/15/17	W	Deliver 5 astronauts to the outer or inner areas	Design/Build Team	Design/Build Team
3/15/17	D	Deliver 3 astronauts to the outer or inner areas	Design/Build Team	Design/Build Team
3/15/17	D	Deliver > 3 astronauts to the outer area	Design/Build Team	Design/Build Team
3/15/17	W	Collect >= 2 asteroids	Design/Build Team	Design/Build Team
3/15/17	W	Clear zone of all asteroids	Design/Build Team	Design/Build Team
3/15/17	D	30 second operation time	Design/Build Team	Dr. Vaughn
3/15/17	W	< 27 second operation time	Design/Build Team	Design/Build Team
3/15/17	W	Collect at least one fuel source	Design/Build Team	Design/Build Team
3/15/17	W	Drop 0 astronauts	Design/Build Team	Design/Build Team
3/15/17	D	Object detection distance < .5 ft	Design/Build Team	Design/Build Team
3/15/17	W	Total setup time < 2 min	Design/Build Team	Design/Build Team
3/15/17	D	Total setup time < 4 min	Design/Build Team	Dr. Vaughn
3/15/17	D	Track removal time < 1 min	Design/Build Team	Design/Build Team
3/15/17	W	Reach Mars < 10 sec	Design/Build Team	Design/Build Team
3/15/17	D	Program upload time < 10 sec	Design/Build Team	Design/Build Team
3/15/17	D	Plant 1 flag on mars	Design/Build Team	Design/Build Team
3/15/17	W	Max points earned > 60	Design/Build Team	Design/Build Team
		Maintenance		
3/15/17	W	Operate at least 5 times without re-adjustments	Design/Build Team	Design/Build Team
3/15/17	D	Operate at least 3 times without re-adjustments	Design/Build Team	Design/Build Team
		Costs		
3/15/17	D	Budget cap of $100	Design/Build Team	Dr. Vaughn
3/15/17	W	Spend < $60 on construction materials	Design/Build Team	Design/Build Team
3/15/17	W	Spend < $40 on machinery and wiring	Design/Build Team	Design/Build Team

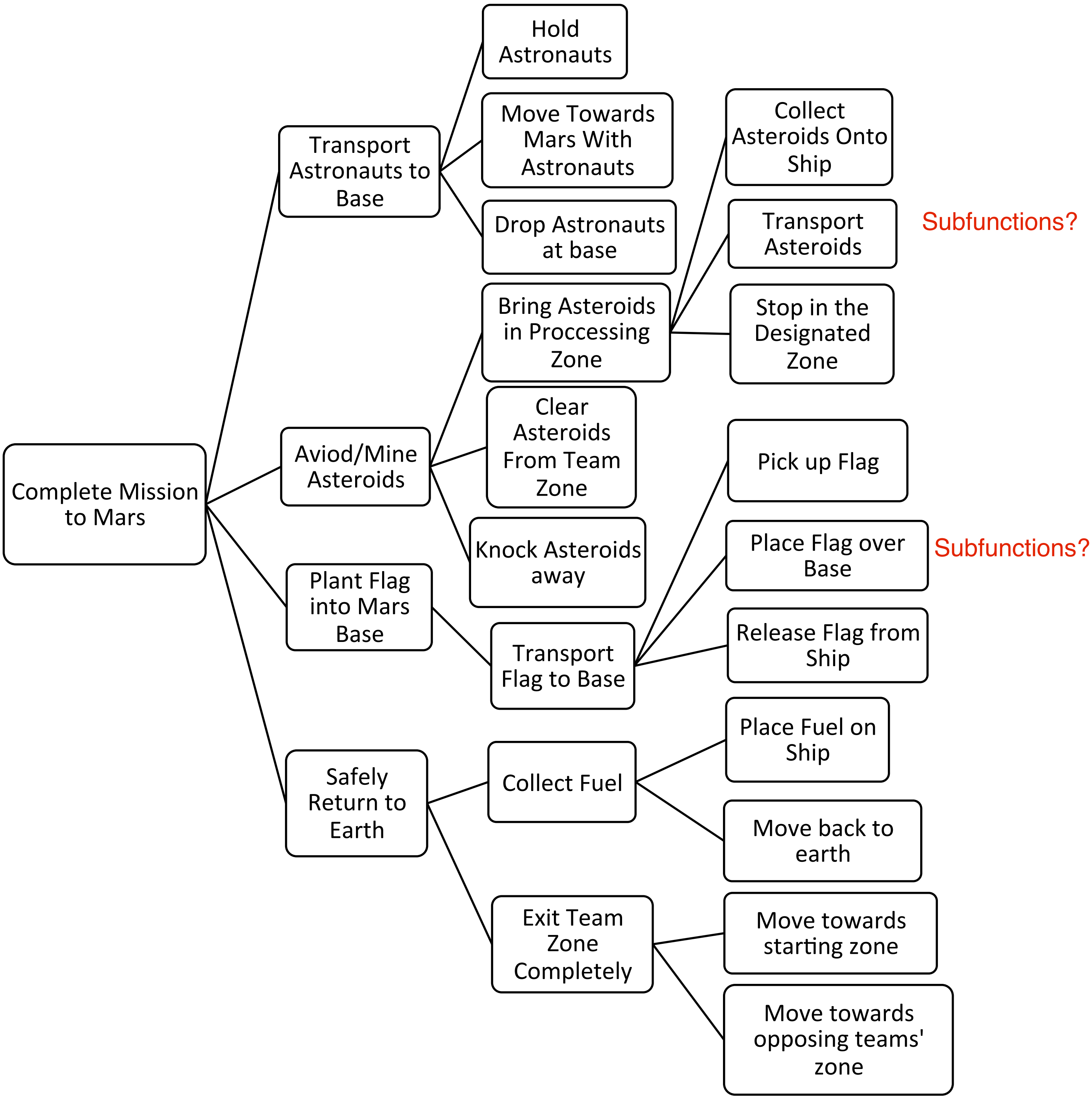


Figure 5: Mission to Mars Function Tree

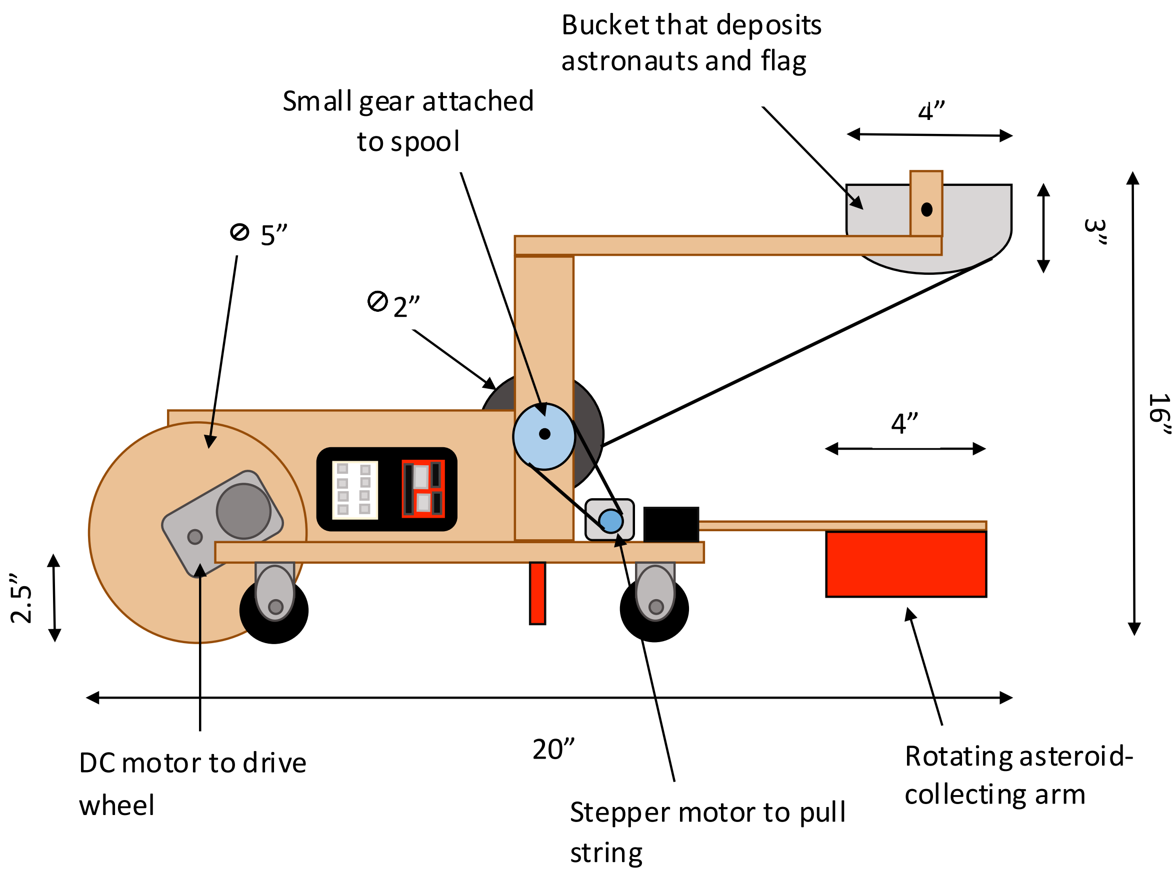


Figure 6: Pulley Alternate Design Side View

better to give names describing function

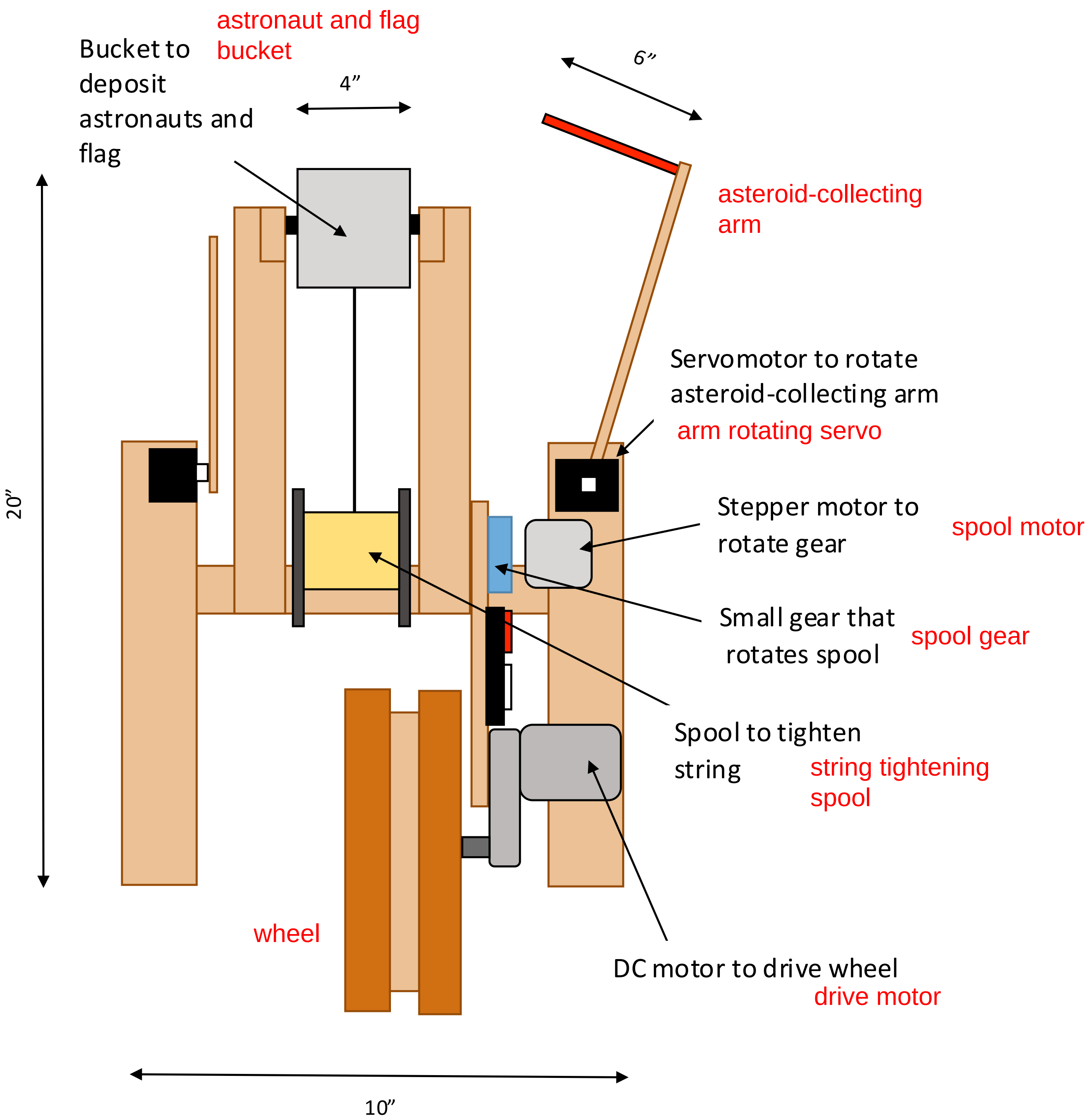


Figure 7: Pulley Alternate Design Top View

better to give names describing function

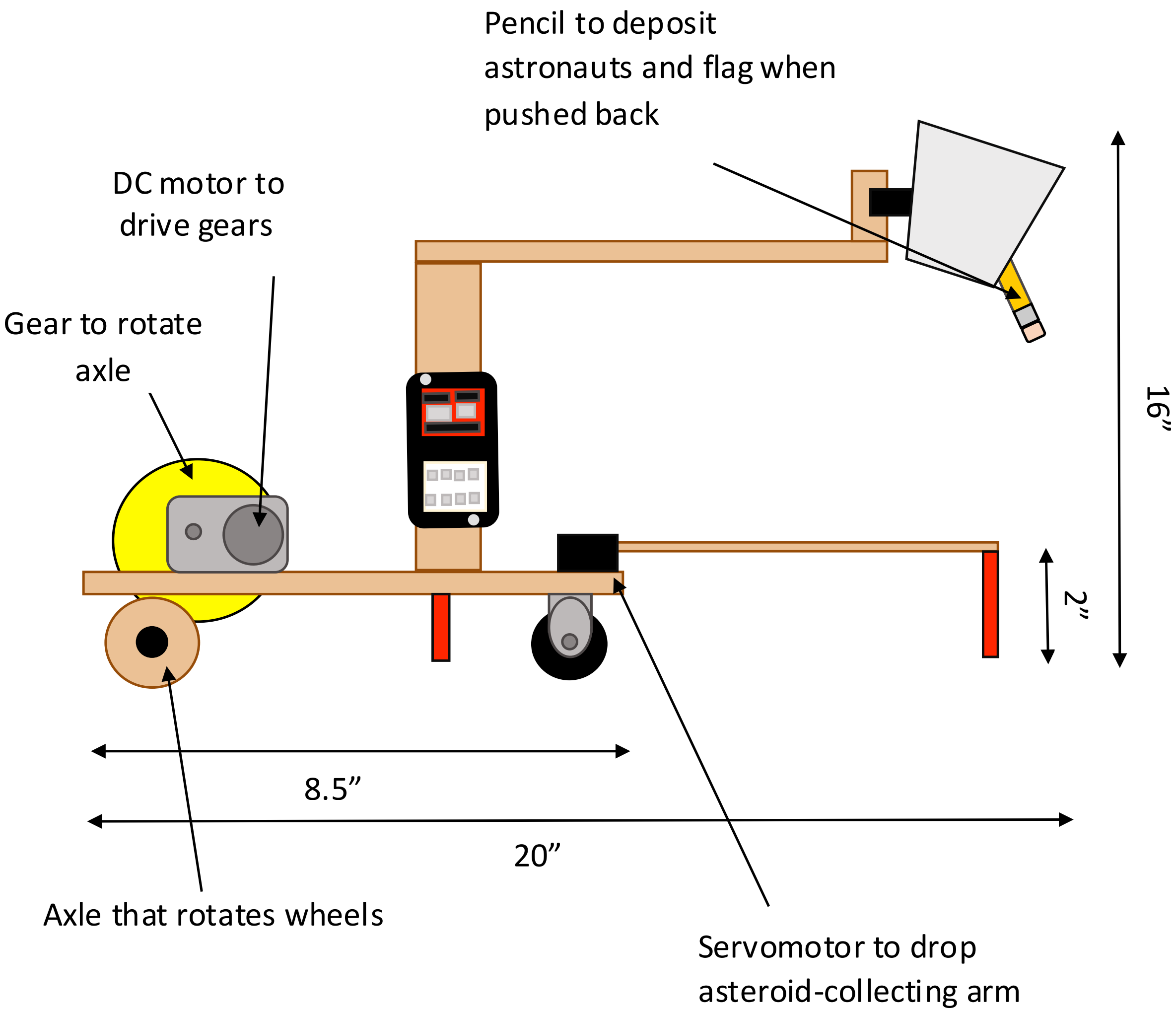


Figure 8: Pencil Alternate Design Side View

better to give names describing function

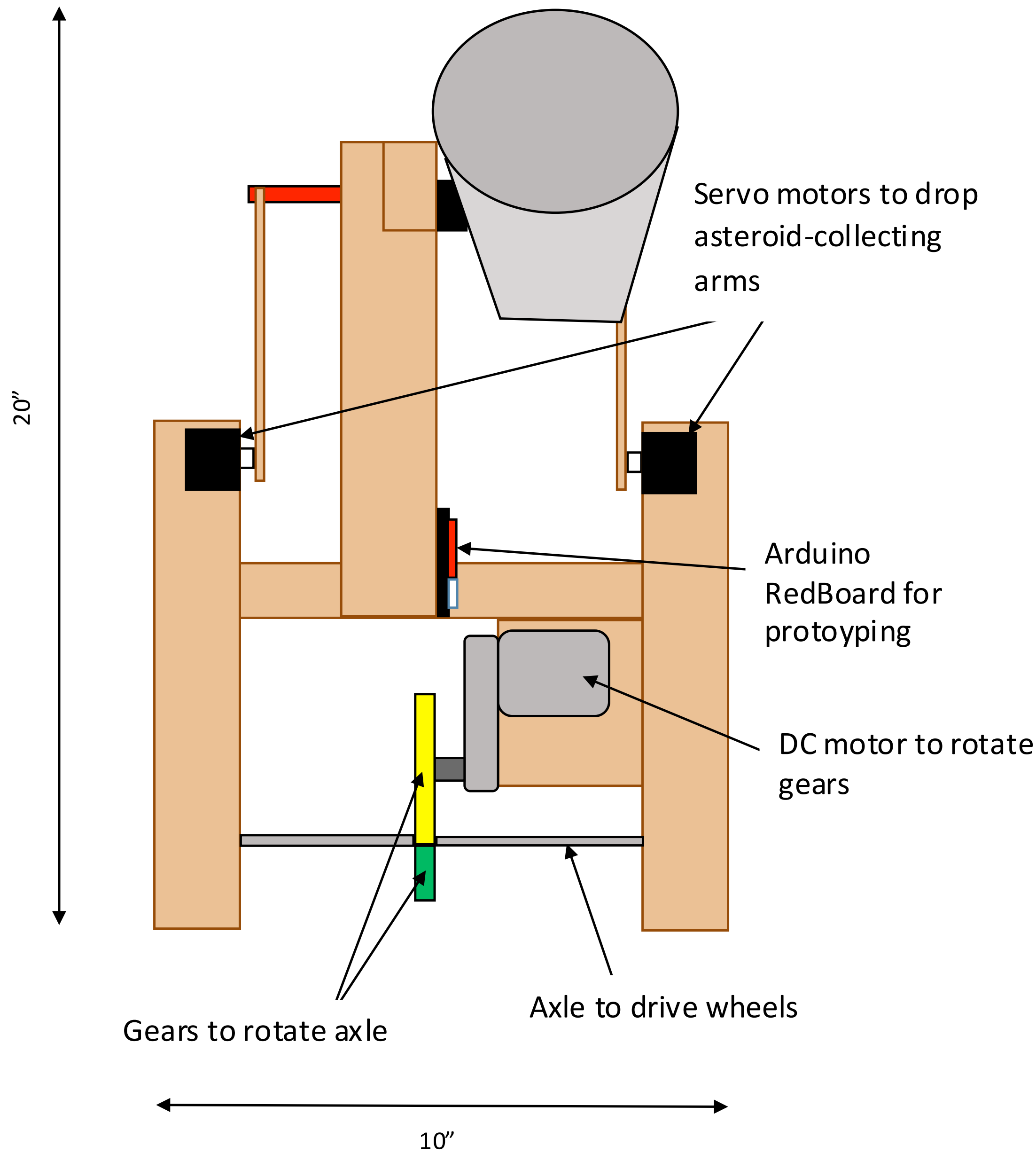
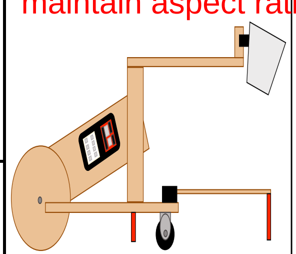
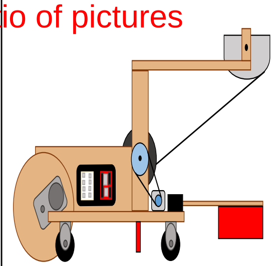
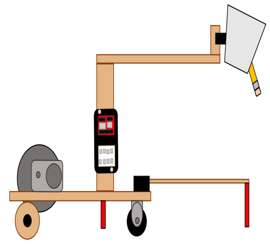


Figure 9: Pencil Alternate Design Top View

Good

Table 3: Mission to Mars Third-Level Evaluation Matrix

maintain aspect ratio of pictures

Importanace	Customer Requirements			
10	Autonomous	10	10	10
7	Lightweight	8	7	9
10	No more than 1ftx2ftx18in	10	10	10
10	Can move	9	9	8
10	Cost no more than $100	9	8	10
6	Minimal number of parts	8	6	9
9	Runs the same everytime	8	7	7
7	Programmed using basic functions	8	8	9
6	Parts don't break off	8	8	8
10	Carry astronauts to base	9	9	8
10	Avoid and/or mine asteroids	7	6	6
7	Collect pre-launched fuel	8	0	0
10	Start off in equilibrium state	10	10	10
5	Can pick up and let go of objects	0	0	0
9	Can return to Earth	8	8	8
10	Completes mission within specific time period	8	8	8
4	Aesthetically pleasing	7	7	6
10	Utilizes only electrical and gravitational energy	9	9	9
3	Change direction of movement	0	0	0
10	Maximizes points earned	9	5	5
6	Can acknowledge external movements	0	0	0
5	Can sense external obstacles	0	0	0
10	Not wireless	10	10	10
9	Quick prep time for mission	8	6	7
10	Plant flag on Mars base	8	6	6
10	Triggered by start plugs	10	10	10
	Total	1688	1506	1550
	Relative Total = Total/Number of Criteria	0.65	0.58	0.60

Pts.	Meaning	5	Satisfactory
0	Unsatisfactory	6	Good, but drawbacks
1	Inadequate	7	Good
2	Weak	8	Very Good
3	Tolerable	9	Exceeds Req.
4	Adequate	10	Ideal Solution

this section goes
after conclusion
before figures

7 References

[1] The University of Louisiana at Lafayette. (2-21-17). “The MCHE 201 Solar System.” “Mission to Mars.” [online]. Available: http://www.ucs.louisiana.edu/~jev9637/MCHE201_MissionToMars.html