A Mission to Mars

MCHE 201: Introduction to Mechanical Design
Spring 2017

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Abstract

The main objective of the Mission to Mars robot competition is to design an autonomous robot that performs various tasks on a solar system track to score points. The design must run alongside three other robots and compete to achieve the most points in a 30 second time frame. Problem Understanding shows that the key customer requirements consist of the demands presented in the Mission to Mars rules and that the most important engineering characteristic is to earn the maximum amount of points. From the results of the House of Quality, as well as a Function Tree and a Specification Sheet, three conceptual designs are configured. A Concept Evaluation, ~~is~~ preformed with a Third-Level Concept Evaluation Matrix and a Morphological Chart, shows that the final design chosen is the Darth Vader, which has a two story stationary base with three arms that can move simultaneously to perform different tasks. Darth Vader places d fourth in the Preliminary Contest and second in the Qualifying Round. However, for the Final Contest, the Darth Vader design did ~~does~~ not meet its expectation and ties to rank 17th with eight other teams, earning 2 of the 8 alloted performance points. Darth Vader also scores d 20th in the Judge's Scoring with a score of 6.83 out of 10, earning 3.28 of the 5 alloted points.

Good

Use past tense. It already happened.

1 Introduction

The primary objective of the Mission to Mars is to design a robot that autonomously completes a series of tasks within a 30 second time frame in order to score points. The design runs alongside three other robots on the solar system track as shown in Figure 1 [1]. There are four Teams Zones with boundaries clearly identified with different colors. Each design must start the competition with the design completely contained in the 2-foot by 2-foot Start Zone, as shown in Figure 2 [1]. Figure 3 shows that the Mars Landing Zone consists of a cylinder that is 22 inches in diameter and 6 inches in height [1]. Figure 3 also shows that the Mars Base platform is a taller cylinder that is contained within the Mars Landing Zone, 12 inches in height and 12 inches in diameter [1]. Following along with Figure 1, the tasks include bringing five astronauts to the Mars Base, planting a flag in the Mars Landing Zone, avoiding asteroids, collecting pre-launched fuel, and safely returning to Earth [1]. For each astronaut that remains completely in the rotating Mars Base, ten points are earned, and for each astronaut that makes it into the Mars Landing Zone or the volume above, but not the Mars Base, five points are earned. If the flag remains in the Mars Landing Zone after the allotted time is up, ten points are earned. For each asteroid remaining partially in the Team Zone after the 30 seconds is up, five points are deducted from the total, but for each asteroid remaining completely in the Asteroid Processing Zone after the time is up, each team receives five points. For each pre-launched fuel remaining completely in the teams Team Zone, ten points are earned. If at least one pre-launched fuel is collected, and the design resides completely out of the Team Zone when the time is up (meaning the device returns to earth or enters another Team Zone), 20 points are earned. The design must read a signal to start, run for 30 seconds, and stop in order to not be disqualified. Points are evaluated following each 30 second run.

The design is restricted to a base of 12 inches by 24 inches and a height of 18 inches. The cost of the robot may not exceed 100 dollars, and the robot may only use one Redboard, the elements of three Sparkfun kits, and a mechtronics kit. With the tools provided, the maximum number of motors that can run simultaneously is three, or two if the solenoid is used. The biggest challenge of the Mission to Mars is to create a design that can complete all tasks simultaneously with the restriction of only having three motors operating at once. Another challenge is creating a design that is reliable and robust enough to adapt to the changing environments of the solar system. Due to the design challenges faced, multiple designs are thoroughly evaluated before the selection of the final design in order to create a design that maximizes the satisfaction of the customer requirements. In Section II, the final design is presented with a detailed description of its functionality. In Section III, a Problem Understanding analysis is presented in order to determine the design necessary for the functionalities as well as the demands of the design, using a House of Quality, a Specification Sheet, and a Function Tree. Section IV demonstrates a Concept Evaluation in order to illustrate how the Good
final design is chosen, using a Third-Level Concept Evaluation Matrix and a Morphological Chart. Section V states the results of the final design as well as provides an analysis of its performance. Section VI summarizes the design, the tools used, and their results. Section VII includes the references used.

2 Final Design

maintain the use of names of functional parts within text

astronaut holder

The final design for the Mission to Mars competition is the Darth Vader design, shown in Figure 4. The design consists of a stationary two story base with arms that extend from both the top and bottom levels that complete different tasks simultaneously. The stationary structure allows for the design to be robust and adapt to changes in the track. The main function of the final design is to deliver the astronauts to the Mars Base. This task is completed when the scissor arm on the upper level of the robot extends until the astronaut holder is over the rotating Mars Base, as shown in Figure 5. To operate this arm, the Astronaut Arm DC motor pulls a string connected to the back legs of the arm. The back legs are suspended on a track to allow for the arm to move in a straight path. As the string gets tighter, the legs become closer together therefore extending the arm out to a length of 28 inches forward, measured from the end of the Start Zone. At the end of the arm is a toilet paper roll to hold the astronauts and flag in place until they are dropped into the Mars Base and Mars Landing Zone, shown in Figure 6. The astronauts and flag are released by a trapdoor that is operated by the Astronaut Door servo motor. Attached to the bottom of the cup is a Mars Base IR sensor. The Mars Base IR sensor operates by detecting the relative distance of objects in front of the sensor. The Mars Base IR sensor can detect the depth of the center to determine when the Mars Base is underneath it. Once the Mars Base IR sensor detects the Mars Base, it signals the Astronaut Door servo motor to move the trap door essentially dropping flag and the astronauts. As a default setting, if the Mars Base IR sensor does not detect the Mars Base within ten seconds the servo motor signals to drop the astronauts and the flag, landing them both in the Mars Landing Zone. The astronaut arm stays extended above the Mars Landing Zone for the remainder of the round.

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To collect pre-launch fuel, two arms are used on either side to collect four of the pre-launch fuels into the Team Zone. One arm, the left fuel arm, shown in Figure 7, is made from two thin 12-inch long, 3-inch wide pieces of wood connected together by a hinge. The two pieces begin at a right angle wrapping around the edge of the base in order to fit inside the start dimensions. A string is attached to the end of the left fuel arm and runs along the outside and is wound up by the Fuel Arm stepper motor. The two pieces of wood become straight making a 24-inch arm that swings around to collect two pre-launch fuel on the left side of the robot. A second arm, shown in Figure 8, is also used to collect fuel and begins flush with the front of the robot. The Fuel Arm DC motor, fastened to the front, drives the second arm, the right fuel arm. The right fuel arm has a total length of 26 inches, the arm is split in two different pieces, one is 20-inch long piece of wood, and the other is a 6 inch long piece of cardboard. The 20-inch piece of wood is attached to the small DC motor with a set screw to keep the piece set along the motor shaft. The 6-inch piece is attached to a servo motor, which is attached to the end of the 20-inch piece of wood. The 6-inch piece starts at 30 degrees making the arm shorter than the extended 26 inches. The right fuel arm rotates 200 degrees clockwise without touching anything on the track. Once the IR sensor reads the Mars Base, the Extension Servo motor is triggered and the 6-inch piece extends to make the arm the full 26 inches. The 110-degree counterclockwise rotation of the arm brings the two pre-launched fuel on the right side into the Team Zone.

be careful with commas

3 Problem Understanding

The main problem of choosing a final design is determining the most important customer requirements and choosing which design has the best specifications to meet these requirements. A House of Quality, shown in Table 1, displays the customer requirements as well as the engineering characteristics and how well they satisfy the customer requirements. Table 2 shows that the key customer requirements are for the robot to move autonomously, to have a base less than 12 inches by 24 inches, to have a height less than 18-inches tall, to start on a signal, and to be built in less than one month. These key customer requirements are demands given by Dr. Vaughan, and the robot must satisfy these customer requirements in order to not get disqualified. The calculations concerning the relationship between the engineering characteristics and the customer requirements show that the most important engineering characteristics are the amount of points earned, distance the robot travels from the Start Zone, speed of robot, and time spent testing the robot. Amount of points earned had the highest relative importance of 0.065 meaning this should be the main focus when creating the design. The Correlation Matrix, shown in Table 3, shows that the amount of points earned and the distance the robot travels have a strong positive correlation because the robot must move a certain distance to achieve the tasks for this competition.

Could expand this discussion. It is an important part of the support for the choice of your final design.

The Specification Sheet, shown in Table 4 and Table 5, is created to further evaluate the engineering characteristics and provide measurable values for the design. Some of the most important specifications are to run for 30 seconds, use 1 Sparkfun RedBoard, a height of 18 inches, a length of 24 inches, and a width of 12 inches. These are important when considering a design because these are specific rules created in ~~Dr. Vaughan's~~ the Mission to Mars rulebook. how are these reflected in the spec sheet?

The Function Tree, shown in Figure 8, determines what the robot needs to do in order to function successfully. The main goal of scoring points during the Mission to Mars is divided into subfunctions which include the tasks needed in order to score those points. These sub functions are further broken down until they cannot be further simpled. An important sub-function to accomplish the main goal is to deliver astronauts to the Mars Base. As seen in Figure 9, this function is broken down into specific functions consisting of locating the target broken into the some of the lowest sub-functions of drop down and release from robot.

4 Concept Evaluation

The Morphological Chart shown in Table 6, provides a visual representation of how each task in the Function Tree ~~are~~ can be accomplished. For example, there are four different options for how the asteroids can be moved. These options include a single cardboard arm that extends from the right side of the robot, a cardboard square trap that extends from the center of the robot, a cardboard trap held by two rods extending from the front legs, and two wooden arms extending from the front of the robot. Any of these four options are viable to be put on the final design. Each design follows a different path established by different colors to describe the functionality of each design.

The results from the Problem Understanding led to the creation of three initial designs. One design, called The Grabber, is a movable, wooden robot that uses the large DC motor, connected by a use names of functional parts within text

make sure referencing correct figures

gear to a rod, in order to drive the rear wheels, shown in Figure 10. The wheels are connected to a wooden base. This wooden base holds the three motors: stepper motor, large DC motor, and the small DC motor. There are two asteroid/fuel arms that extend from the sides of the robot once the robot moves towards the Mars Base. The arms begin in close proximity to each other, in order to fit the constraints of the box. When the signal is triggered, the arms open out and the robot moves forward. The arms close together to collect the asteroids and pre-launch fuel. These asteroid/fuel arms are each run by their own motor, one with the stepper motor and one with the small DC motor. A wooden rod extends from the top body of the cart that holds up a plastic cup, with the astronauts and flag inside, high enough to make it over the center of the Mars Landing Zone. An IR sensor is located on the bottom of the cup that senses when the Mars Base is underneath the cup, as shown in Figure 6. Once the IR sensor detects the Mars Base, it sends the information to a servo that then retracts the trap door on the bottom of the cup, allowing the astronauts to fall into the Mars Base and the flag to fall in the Mars Landing Zone. The arms then come in, grabbing the pre-launch fuel and asteroids, and the motor reverses, driving the robot back towards the Start Zone. The arms drag the asteroids and fuel along with the robot to the Asteroid Processing Zone. The arms then open up, leaving the fuel and asteroids in the Asteroid Processing Center, and the robot continues to move in reverse in order to get out of the Team Zone.

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The second alternative design, called The Net, also consists of a two-layered wooden platform that wheels out as a whole, shown in Figure 11. The large DC motor drives the rear axle by utilizing a set of gears and allows the robot to go forwards and backwards. The top layer has a drawer slider for an arm, that extends when a string is pulled by the small DC motor. At the end of the drawer slider arm, the same mechanism with the IR sensor, shown in Figure 6, is used to deliver the astronauts to the Mars Base and the flag to the Mars Landing Zone. On the bottom layer, there is a fuel/asteroid arm that acts like a capturing device that drops to collect asteroids when the robot moves closer to the Mars Landing Zone, shown in Figure 11. This capturing device is powered by two servo motors that are glued to the front two legs of the robot. There are two rods that are each connected to a servo motor at one end and are connected at the other end by a 22-inch long and 3-inch wide piece of cardboard. Once the astronauts are released into the Mars Base and the flag into the Mars Landing Zone, the other two servo motors are triggered and set the cardboard trap. As the robot goes into reverse and advances back towards the Start Zone, the cardboard trap rounds up all of the asteroids and places them in the Asteroid Processing Zone.

Same as which? Concept description should be independent.

The Third-Level Concept Evaluation Matrix allows for a numerical computation in order to pick the best design, as shown in Table 7. Each design is evaluated considering how they affect each engineering characteristic and assigned a number accordingly, as shown in Table 8. The Third-Level Concept Evaluation Matrix takes into consideration the customer requirements, their importance, and how well each prototype meets the requirements. The Darth Vader is chosen as the final design because the computations from the Third-Level Concept Evaluation Matrix imply that it is the best design. It scored a total value of 1934 with a relative importance of 0.775. The Darth Vader design proves to be superior in its strength and ability to adapt to any changes on the track. The Darth Vader also shows to have a ~~really~~ consistent arm to locate the Mars Base to deliver the astronauts, which is the task that could potentially score the most points ~~when compared to the other tasks~~. The Grabber design had a total of 1826 points and a relative importance of 0.672. The Net design had a total of 1877 points and a relative importance of 0.680. ~~Choosing a final design~~

~~was a challenge because of how well each design performed on the Third-Level Concept Evaluation Matrix.~~ ~~However~~, the Darth Vader design was chosen because it scored higher than the other two designs, but not by much. It also had more 10 values than any of the other designs, proving its superiority.

5 Design Performance Evaluation

The Darth Vader design performed highly in the Preliminary Contest, with an overall score of zero points in each of the three rounds. This was the fourth highest score out of 24 robot designs. The Darth Vader design performed best in the Qualifying Round. It tied for second place overall, earning a high seeding for the Final Contest. However, the Darth Vader design did poorly and did not meet expectations in the Final Contest. The design was eliminated after only two rounds of competition, and essentially performed none of the tasks required of it. The first round of the competition, the Darth Vader design was disqualified for breaking the rule of offending language. Therefore the Darth Vader placed fourth in that round and was unable to run on the track. During the setup time for this round, the robot falsely starts issuing the right fuel arm to become unattached to the Fuel Arm DC motor shaft. The second round of the competition followed directly after the first round, resulting in the right fuel arm to not be fixed. The left fuel arm worked as planned and collected fuel on the left side of the robot. However, the astronaut arm did not work as planned due to the fact of the interference from the paint. The astronaut arm's wheel and the paint created extra friction that the large DC motor could not overcome. Other small changes were made to the robot such as changing out the zip tie, and changing the position of the hole in top base that the string went through. These changes were made the night before the Final Contest and may have also affected the performance of the robot. The Darth Vader design received negative 15 points, placing third in that round. The Darth Vader design placed 17 out of 24 designs earning 2 out of 8 points for robot performance.

What mistakes were made in the design process that led to these problems? What assumptions did you get wrong?

The main solution to the problems faced at the Final Contest would be to not make changes on the robot so close to the Final Contest, even though some of these changes were unavoidable. One specific solution would have been to remove the paint and keep the bare wooden platform, however, presentation of the robot was a large part of the Final Contest, therefore that would not have been an ideal solution. The Judging of the Darth Vader occurred before the competition and was scored out of ten based on ingenuity, aesthetics, and presentation. The Darth Vader design ranked 20th out 24 in the Judge's Scoring with an overall score of 6.83 out of 10 points. The Darth Vader design scored 6.75 for ingenuity, 6.25 for aesthetics, and 7.50 for presentation. Of the alloted judging points, the Darth Vader received 3.28 out of 5 points. The Darth Vader design had a strong presentation but lacked in the aesthetics for the robot.

The budget for the Darth Vader design as seen in Table 9, was to keep all materials expenses under 100 dollars. The Darth Vader design stayed under budget by only spending 27.83 dollars. The most expensive item to build the Darth Vader design was the wood used to build the structure because it cost about ten dollars.

6 Conclusion

The Mission to Mars competition required a robot to be designed that can navigate autonomously to complete predetermined tasks alongside other robots on the solar system track. Robots earned points based on which of these tasks were completed. A thorough Evaluation of Problem Understanding and Concept Evaluation, determined how the robot needed to be built and what tasks the robot needed to preform well. The key customer requirements showed the demands that were set in the competition rules, such as fitting in the dimensions of the box. The most important engineering characteristic proved to be to score the maximum amount of points. Using these results from Problem Understanding, a Concept Evaluation compared the functionality of three designs in order to determine which of the designs was to be the final design. The Darth Vader design achieved the most points from the Third-Level Concept Evaluation Matrix, making it the best design out of the three choices. The Darth Vader design consisted of a two story, stationary base that included different arms that moved simultaneously on the top and the bottom bases to complete different tasks. This design was found to be superior because of its robust design and consistency of the asteroid arm. The final design showed to meet the expectations of the competition and score fourth in the Preliminary Contest and second in the Qualifying Round. The Darth Vader design failed to meet the expectations from the previous rounds and placed 17th in the Final Contest. In the Judges' Scoring, the Darth Vader design placed 20th because of its low score in aesthetics. Darth Vader showed to be a consistently successful design overall, even though the performance of the robot did not reflect this in the final contest.

ok

7 References

[1] http://crawlab.org/classes/MCHE201_Sp17/Projects/MCHE201_FinalProject_Spring2017.pdf

[2] http://www.parallax.com/product/28995

[3] http://www.sparkfun.com/products/11015

[4] http://www.waveshare.com/wiki/Color_Sensor

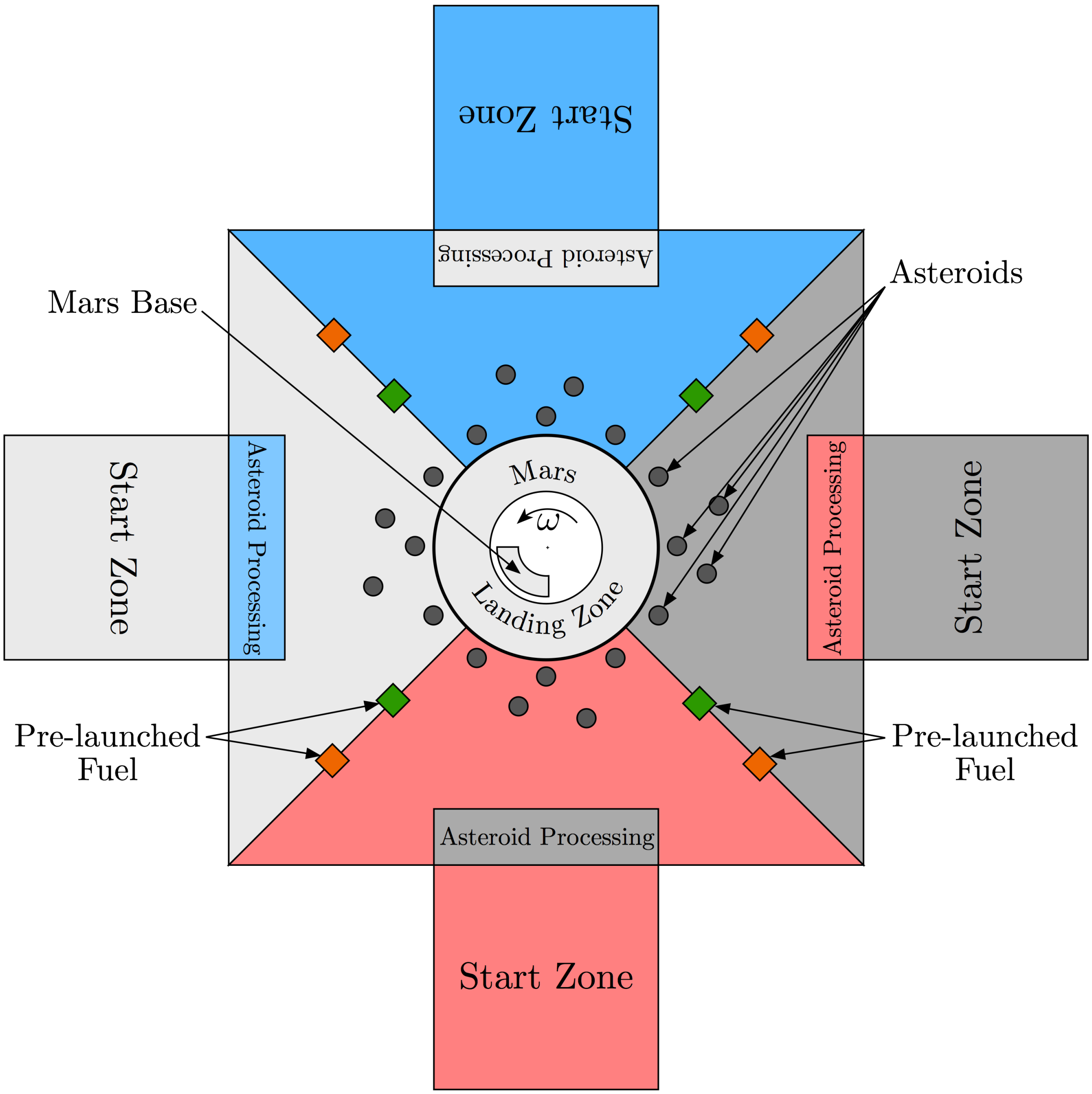


Figure 1: The Solar System [1]

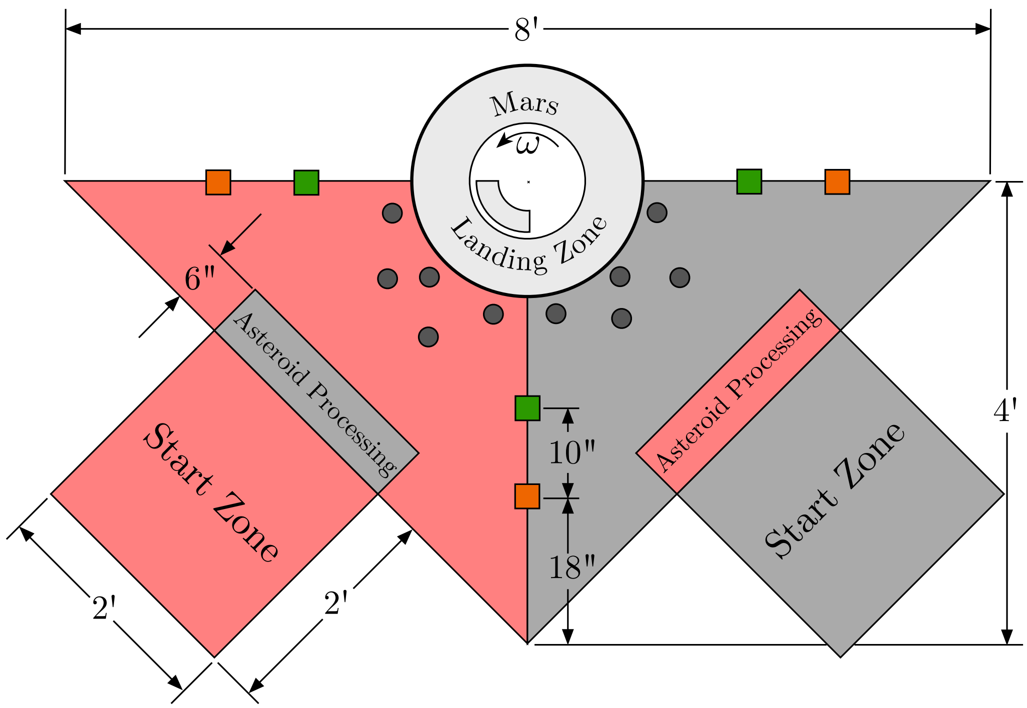


Figure 2: The Solar System Dimensions [1]

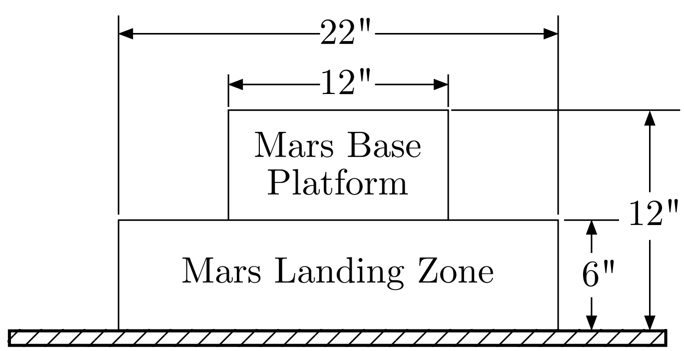


Figure 3: Mars Dimensions [1]

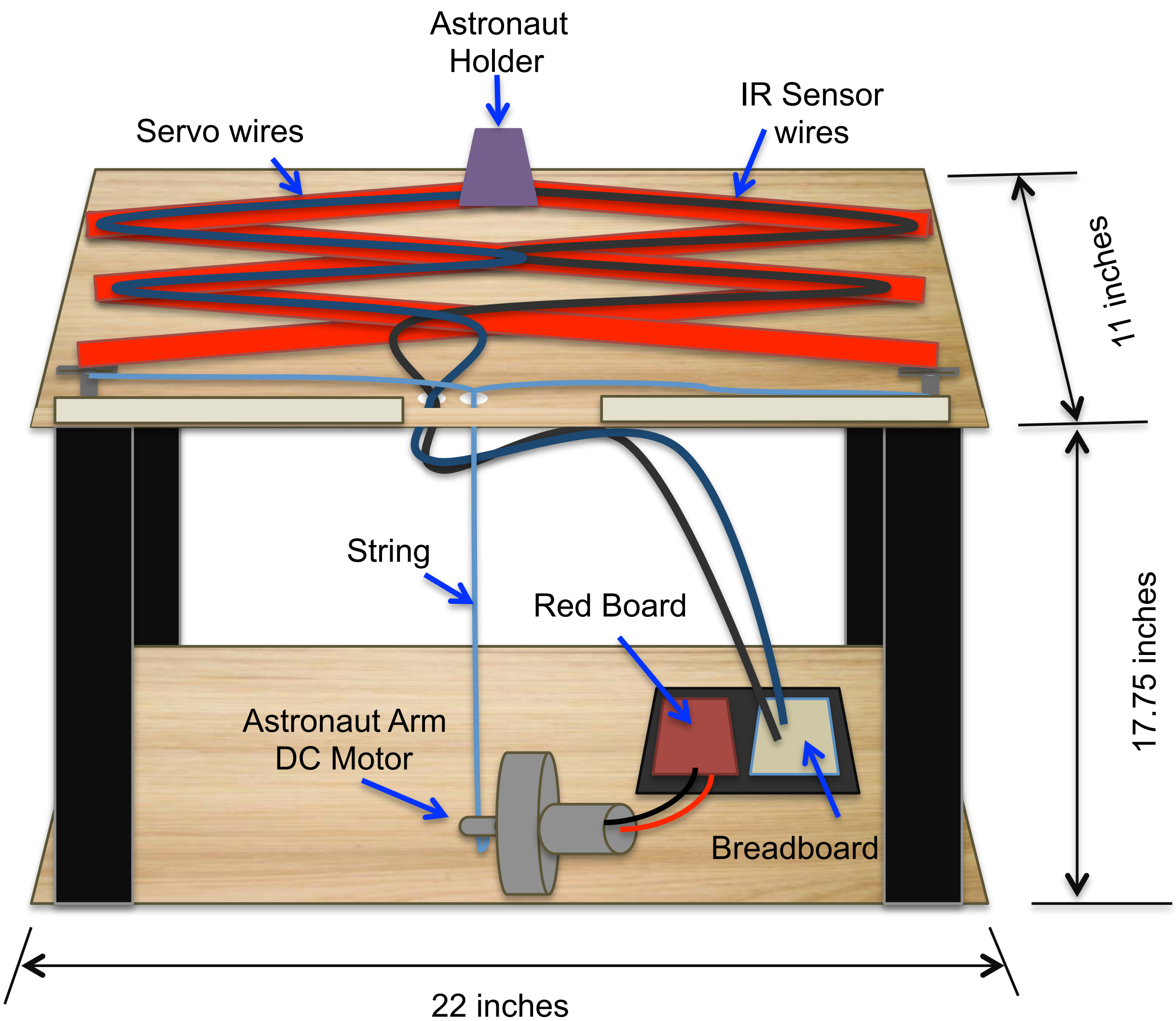


Figure 4: The Darth Vader design

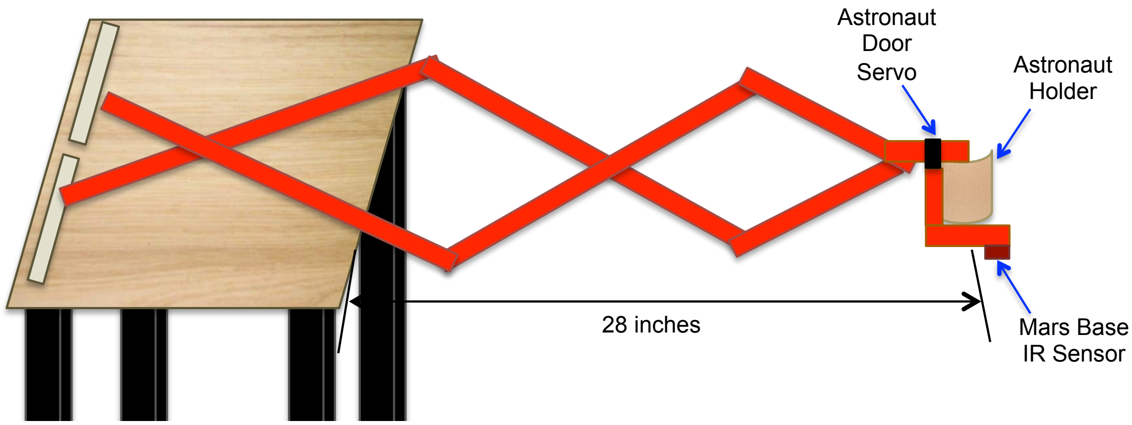


Figure 5: The Extended Astronaut Arm

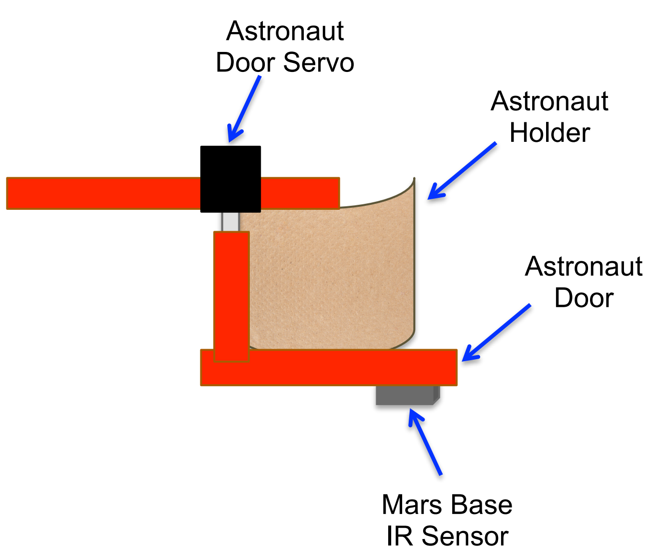


Figure 6: The Astronaut Delivery System

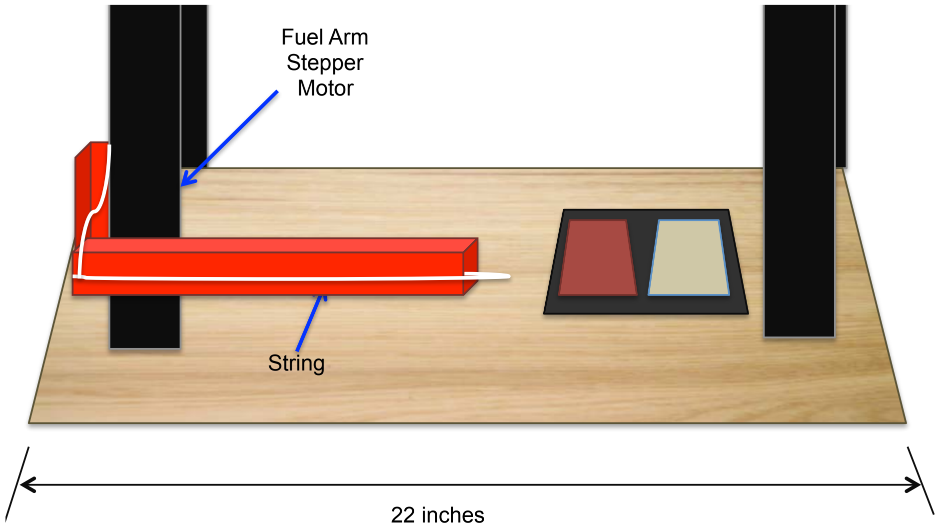


Figure 7: The Left Fuel Arm

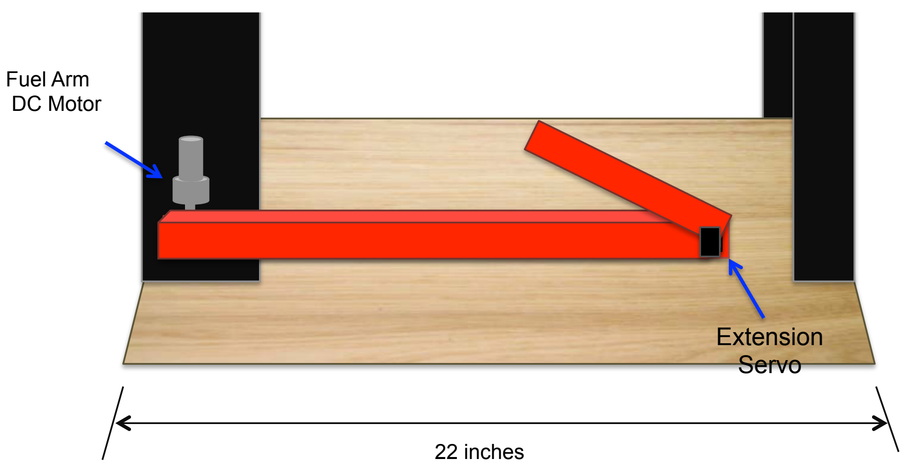


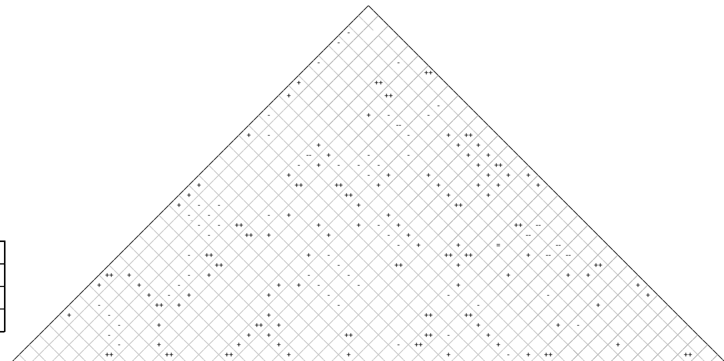
Figure 8: The Right Fuel Arm

Table 1: The House of Quality

◉	Strong
▣	Medium
△	Weak

▲	Maximize
▼	Minimize
x	Target

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

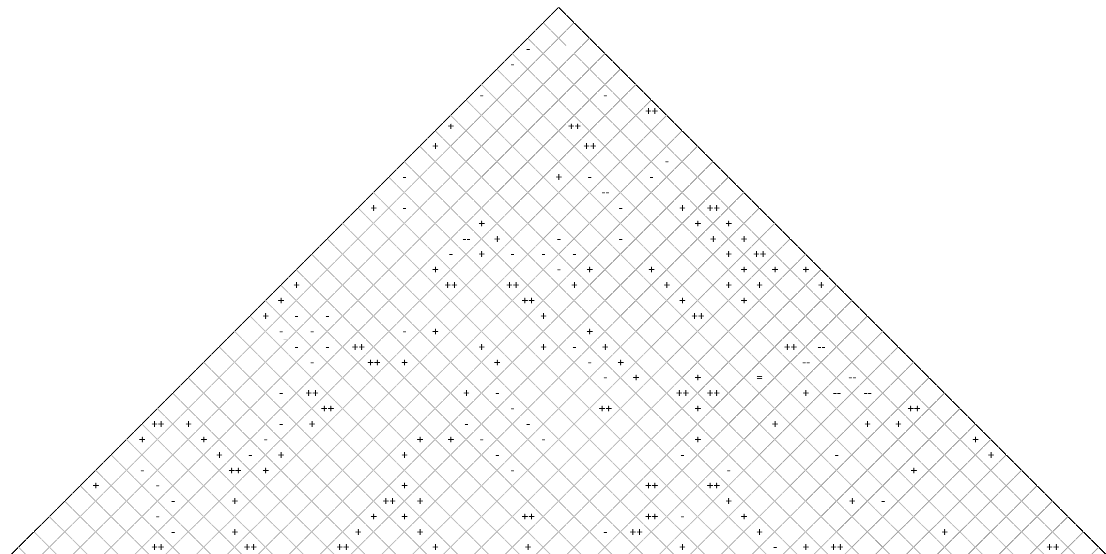


Importance	Customer Requirements / Engineering Characteristics	Weight of total robot	Length of total robot	Height of total robot	Width of total robot	Time of operation	Speed of robot	Production time	Cost of materials	Amount of different materials	Weight of electronics	Amount of points earned	Amount of astronauts delivered to base	Amount of fuel collected	Amount of asteroids mined	Distance robot travels from start zone	Time to deliver astronauts	Time to setup	Time to take down	Acceleration of robot	Programming time	Voltage absorbed by electronics	Size of Arduino file	Number of wires	Speed of motor	Distance flag lands from the landing zone	Number of moving parts	Tourque of motor	Amount of steps to set up	Amount of step to take down	Parts per millionth explosives	Weight Distribution	Rate of Corrosion	Number of motors	Number of sensors	Range of sensors	Time spent testing robot	
	Direction of Improvement	▼	x	x	x	x	▲	▼	▼	▼	▼	▲	▲	▲	▲	x	▼	▼	▼	▲	▼	▼	▼	▼	▲	x	▼	▲	▼	▼	▼	x	▼	x	x	▲	▲	
10	Dimensions of 1 ft by 2 ft		◉		◉				△	△																						△						
10	Less than 18 inches tall			◉					△																							▣						
9	Transport astronauts to the Mars base			△			△					◉	◉			▣	▣			△							△											
10	Moves Autonomously					◉	△	▣				▣					▣			△	◉		◉		△			△							△		▣	
9	Plant a Flag in the Mars landing zone			△			△					▣				▣										◉	△							▣				
7	Returns to Earth		△			▣	▣					△		▣		◉	△			▣					△		△	△										
6	Avoids obstacles of opponents						△			◉		▣			▣	△				△							△	△				△	△		▣	◉		
7	No explosive materials								△	△		△										▣									◉							
8	Uses only one RedBoard									△	△										▣	△	▣	▣			△											
8	Uses only components from 3 SIK kits									△	▣										△	△	△	▣								△						
8	Uses only components in MCHE201 Kit									▣	◉														△		△	△						◉	▣			
8	Does not damage other robots											△				△						▣					▣	△			▣		△					
8	Uses only electric and gravitational energy						▣									▣	▣			▣		△			△	▣								△				
7	Collect Pre-Launched Fuel											▣		◉		△											△											
7	Mine asteroids											▣			◉	△																			△	△		
8	Shock proof						△		△											△		▣		△							△							
4	Visually appealing								▣															△														
8	Removed in under 2 minutes, 30 seconds	△	△	△	△						△	△							◉											◉							▣	
8	Set up in under 3 minutes, 45 seconds	△	△	△	△						△	△						◉											◉								▣	
7	Costs less than $100								◉	▣		△																										
8	Stops moving after 30 seconds					◉	△					△					▣			▣	△		▣				▣										▣	
9	Starts on signal					▣						△	△			△	▣				△		△												▣		▣	
7	All parts stay intact	△					▣		△	▣									▣	△		△		△							▣		▣	△				
5	Less than 20 pounds	◉								△	◉							▣	▣													▣						
5	Transported as one rigid body	▣		△						△	▣							◉	◉										▣	▣								
8	Moves Forwards						◉						▣		△	◉	▣				△		△		△	▣								▣				
7	Moves Backwards						◉									◉					△		△		△													
8	Earns at least 75 points					△						◉	◉	▣	▣		▣	△	△	△															△	△	▣	
6	Safety for bystanders								△													△									▣							
4	Less than 3 steps to assemble																	▣											◉									
4	Less than 3 steps to disassemble																		▣											◉								
3	Recyclable Parts								◉	▣																							△					
8	Locate Mars Base							△				△	▣				▣									▣									▣	◉		
8	Navigate to Mars Base						▣					△	◉			▣	▣				▣					▣		▣							▣	▣		
8	Does not damage track	△										△								△		▣									◉							
6	Repeatable functions					▣		△					△								▣						△							△			◉	
7	Locate Asteroids							△				△			◉																				▣	◉		
7	Locate Pre-Launch Fuel							△				△		◉																					▣	◉		
6	Few moving parts						△	▣		△		△	△	△	△									△			◉							▣				
8	Built in 1 month							◉	△			△													△		△										◉	sum
	Absolute Importance	91	113	129	106	236	318	148	158	199	180	378	294	177	182	343	235	152	173	125	196	130	170	73	56	177	162	186	123	123	206	69	38	162	184	291	303	5856
	Relative Importance	0.016	0.019	0.022	0.018	0.04	0.054	0.025	0.027	0.034	0.031	0.065	0.051	0.03	0.031	0.059	0.04	0.026	0.03	0.021	0.033	0.022	0.029	0.012	0.01	0.03	0.028	0.032	0.021	0.021	0.035	0.012	0.006	0.028	0.032	0.05	0.052	

Table 2: The Customer Requirements

Importance	Customer Requirements
10	Dimensions of 1 ft by 2 ft
10	Less than 18 inches tall
9	Transport astronauts to the Mars base
10	Moves Autonomously
9	Plant a Flag in the Mars landing zone
7	Returns to Earth
6	Avoids obstacles of opponents
7	No explosive materials
8	Uses only one RedBoard
8	Uses only components from 3 SIK kits
8	Uses only components in MCHE201 Kit
8	Does not damage other robots
8	Uses only electric and gravitational energy
7	Collect Pre-Launched Fuel
7	Mine asteroids
8	Shock proof
4	Visually appealing
8	Removed in under 2 minutes, 30 seconds
8	Set up in under 3 minutes, 45 seconds
7	Costs less than $100
8	Stops moving after 30 seconds
9	Starts on signal
7	All parts stay intact
5	Less than 20 pounds
5	Transported as one rigid body
8	Moves Forwards
7	Moves Backwards
8	Earns at least 75 points
6	Safety for bystanders
4	Less than 3 steps to assemble
4	Less than 3 steps to disassemble
3	Recyclable Parts
8	Locate Mars Base
8	Navigate to Mars Base
8	Does not damage track
6	Repeatable functions
7	Locate Asteroids
7	Locate Pre-Launch Fuel
6	Few moving parts
8	Built in 1 month

Table 3: The Roof of The House of Quality



Engineering Characteristics	Direction of Improvement
Weight of total robot	▼
Length of total robot	X
Height of total robot	X
Width of total robot	X
Time of operation	X
Speed of robot	▲
Production time	▼
Cost of materials	▼
Amount of different materials	▼
Weight of electronics	▼
Amount of points earned	▲
Amount of astronauts delivered to base	▲
Amount of fuel collected	▲
Amount of asteroids mined	▲
Distance robot travels from start zone	x
Time to deliver astronauts	▼
Time to setup	▼
Time to take down	▼
Acceleration of robot	▲
Programming time	▼
Voltage absorbed by electronics	▼
Size of Arduino file	▼
Number of wires	▼
Speed of motor	▲
Distance flag lands from the landing zone	x
Number of moving parts	▼
Tourque of motor	▲
Amount of steps to set up	▼
Amount of step to take down	▼
Parts per millionth explosives	▼
Weight Distribution	x
Rate of Corrosion	▼
Number of motors	x
Number of sensors	x
Range of sensors	▲
Time spent testing robot	▲

Good

Table 4: The Specification Sheet

		Specification for:	Issued:	3/10/17
		Spring 2017 Robot Competition	Page 1 of 1	
Changes	D/W	Requirements	Responsibility	Source
3/10/17		Autonomously Navigate and Score Maximum Points		
		Geometry		
3/10/17	D	Height < 18 inches	Design Team	Dr. Vauhgan
3/10/17	D	Width < 12 inches	Design Team	Dr. Vauhgan
3/10/17	D	Length < 24 inches	Design Team	Dr. Vauhgan
3/10/17	W	Height < 16 inches	Design Team	Design Team
3/10/17	W	Width < 11 inches	Design Team	Design Team
3/10/17	W	Length < 22 inches	Design Team	Design Team
		Kinematics		
3/10/17	D	Robot moves 2 ft/s	Design Team	Design Team
3/10/17	W	Robot moves 5 ft/s	Design Team	Design Team
3/15/17	D	Moves forward 1.8 feet	Design Team	Design Team
3/15/17	W	Moves forward 2.5 feet	Design Team	Design Team
3/15/17	D	Moves backwards 1.8 feet	Design Team	Design Team
3/15/17	W	Moves backwards 2.5 feet	Design Team	Design Team
3/15/17	D	Robot accelerates at 1 ft/s^2	Design Team	Design Team
3/15/17	W	Robot accelerates at 2ft/s^2	Design Team	Design Team
		Forces		
3/10/17	W	Weight of frame < 15 pounds	Design Team	Design Team
3/10/17	W	Weight of motors and sensors < 3 pounds	Design Team	Design Team
3/10/17	W	Total weight < 20 pounds	Design Team	Design Team
		Energy		
3/10/17	D	Electrically powered for 30 seconds	Design Team	Dr. Vauhgan
3/10/17	W	Gravitational energy used for 30 seconds	Design Team	Dr. Vauhgan
		Materials		
3/10/17	D	1 Sparkfun Redboard	Design Team	Dr. Vauhgan
3/10/17	W	3 Sparkfun Servos	Design Team	Dr. Vauhgan
3/10/17	D	1 Stepper Motor	Design Team	Dr. Vauhgan
3/10/17	D	2 DC Motor	Design Team	Dr. Vauhgan
3/10/17	D	1 IR Sensor	Design Team	Dr. Vauhgan
3/10/17	W	Materials last for 100% of runs	Design Team	Dr. Vauhgan
		Signals		
3/10/17	W	Less than 3 feet of wire	Design Team	Design Team
3/10/17	D	1 Arduino File	Design Team	Dr. Vauhgan
		Safety		
3/10/17	D	100% of materialls not explosive	Design Team	Dr. Vauhgan
3/10/17	D	100% of track not damaged	Design Team	Dr. Vauhgan
3/10/17	D	100% of other robots not damaged	Design Team	Dr. Vauhgan
3/10/17	W	Power source does not exceed 100 degrees F	Design Team	Design Team

be careful
with lines

Table 5: The Specification Sheet Continued

		Production		
3/10/17	D	Produced < 50 Hours	Design Team	Design Team
3/10/17	W	Produced < 40 Hours	Design Team	Design Team
		Quality Control		
3/10/17	D	Produce 1 robot	Design Team	Dr. Vauhgan
		Assembly		
3/10/17	D	Setup < 3 min. 45 sec.	Design Team	Dr. Vauhgan
3/10/17	W	Setup < 2 min. 45 sec.	Design Team	Design Team
3/10/17	D	Dissassembly < 2 min. 30 sec.	Design Team	Dr. Vauhgan
3/10/17	W	Dissassembly < 2 min.	Design Team	Design Team
		Transport		
3/10/17	D	Moves as 1 rigid body	Design Team	Dr. Vauhgan
3/10/17	W	Able to be transported by 1 person	Design Team	Design Team
		Operation		
3/10/17	D	Runs for 30 seconds	Design Team	Dr. Vauhgan
3/10/17	D	Shuts down after 30 seconds	Design Team	Dr. Vauhgan
3/10/17	W	Runs for 27 seconds	Design Team	Design Team
3/10/17	W	Places 5 Lego men in Mars Base	Design Team	Dr. Vauhgan
3/10/17	W	Places 1 flag in Mars Landing Zone	Design Team	Dr. Vauhgan
3/10/17	W	Places 5 ping-pong balls in Asteroid Processing Zone	Design Team	Dr. Vauhgan
3/10/17	W	Places 2 toy blocks in Team Zone	Design Team	Dr. Vauhgan
3/10/17	W	Robot is outside Team Zone at 30 second mark	Design Team	Dr. Vauhgan
3/10/17	W	Repeats 5 tasks every round	Design Team	Dr. Vauhgan
		Costs		
3/10/17	D	Total cost < $100	Design Team	Dr. Vauhgan
3/10/17	W	Cost of construction materials < $40	Design Team	Design Team
3/10/17	W	Cost of making the frame < $30	Design Team	Design Team
		Schedules		
3/10/17	D	Preliminary Contest held on 3/23/2017	Design Team	Dr. Vauhgan
3/10/17	D	Qualifying Round held on 4/04/2017	Design Team	Dr. Vauhgan
3/10/17	D	Final Contest held on 4/11/2017	Design Team	Dr. Vauhgan

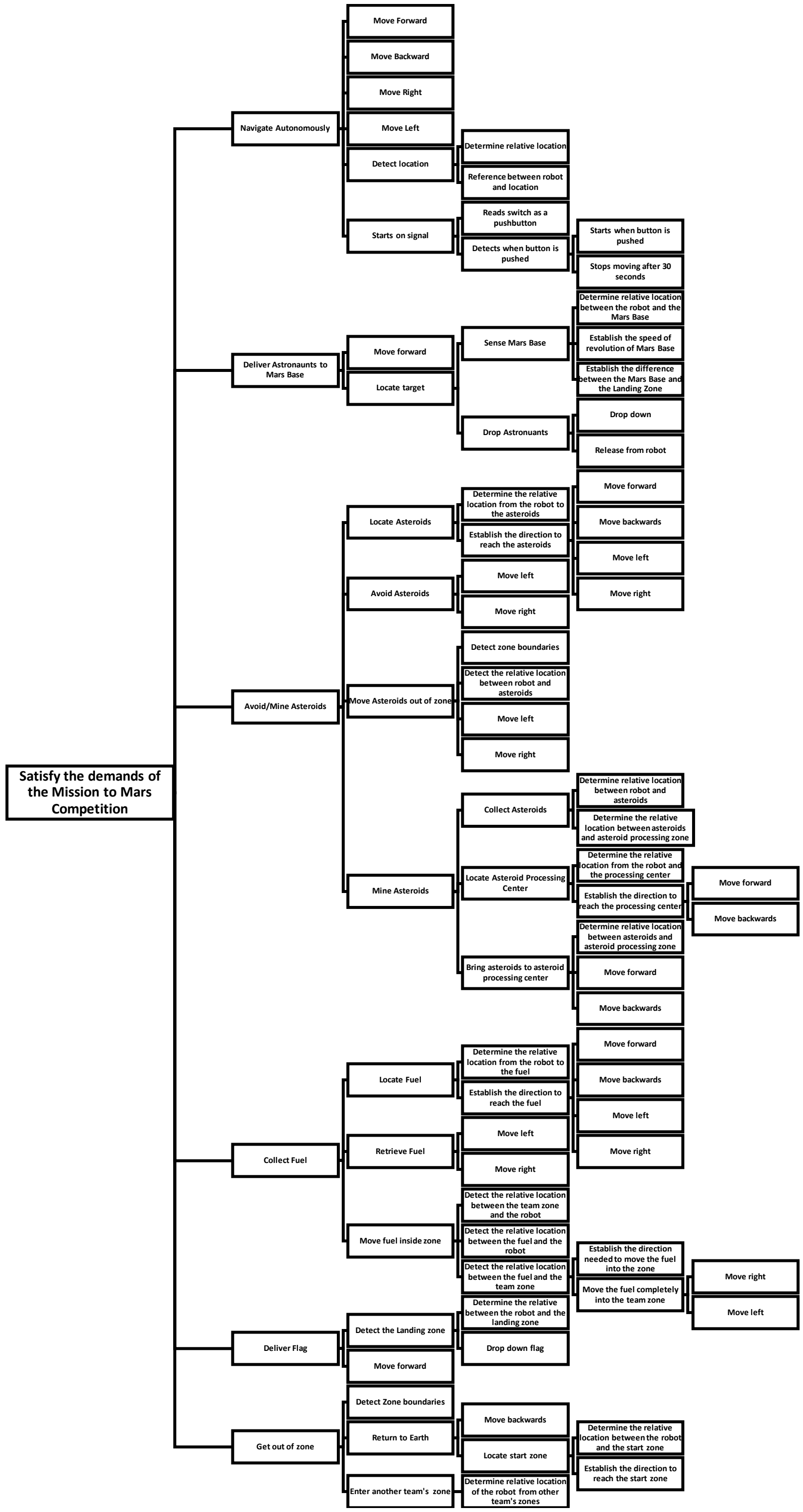


Figure 9: The Function Tree

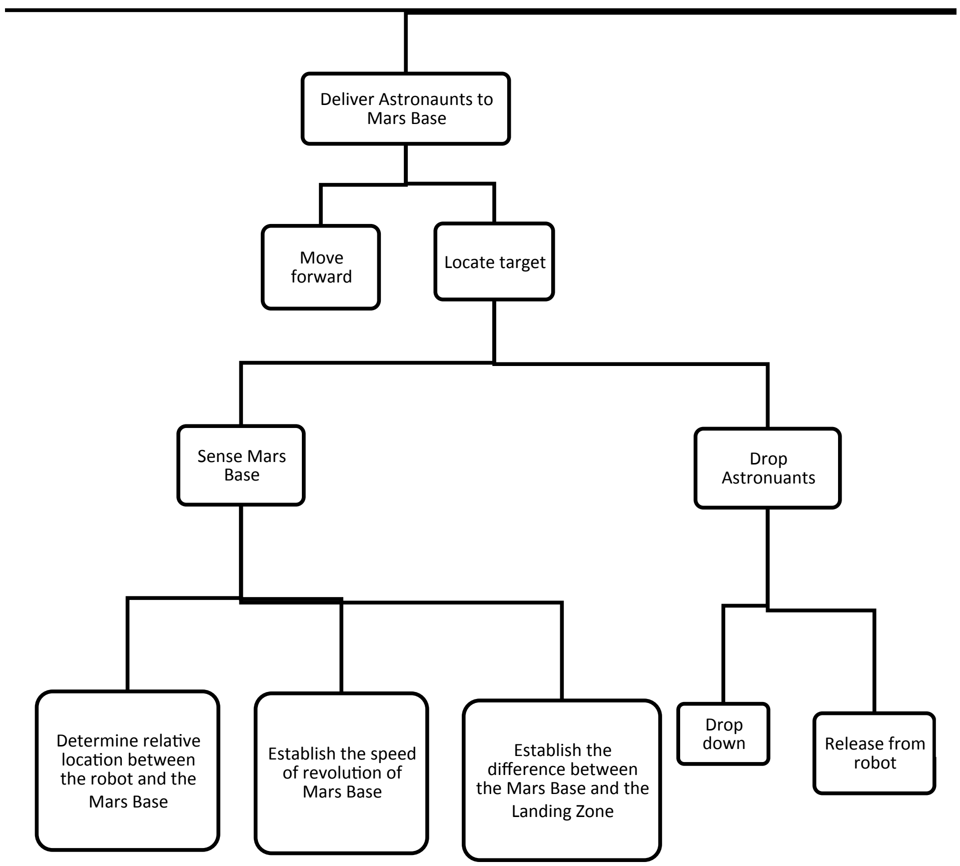


Figure 10: The Astronaut Sub-Function

give name describing function...

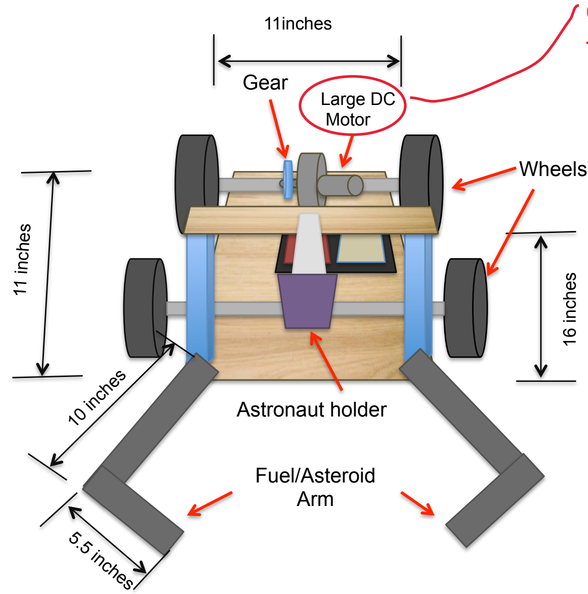


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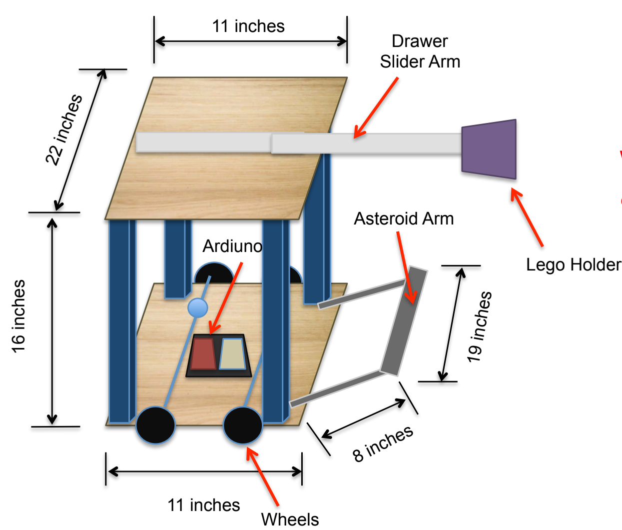
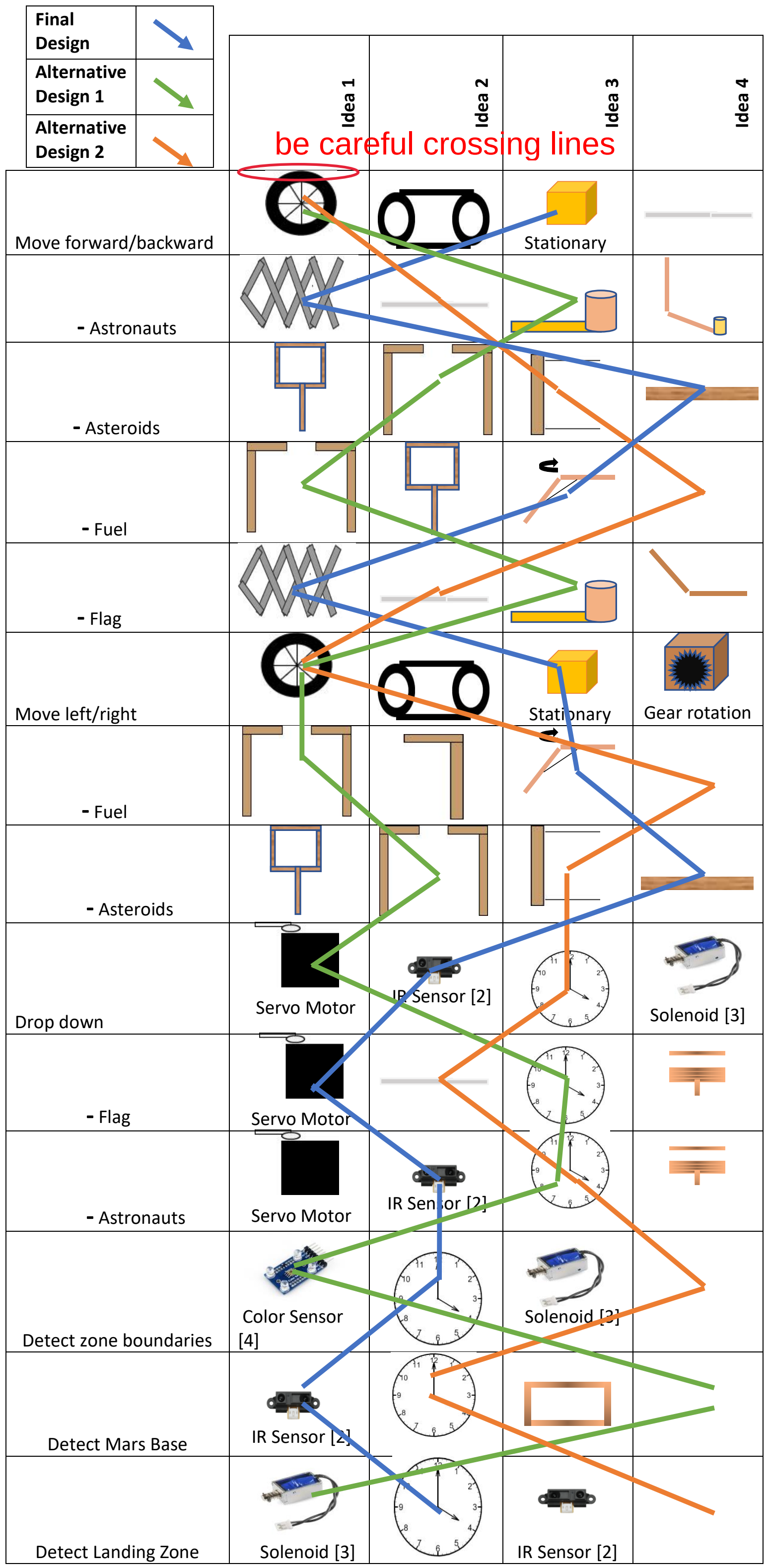
Figure 11: The Grabber Design



what drives the arms and wheels?

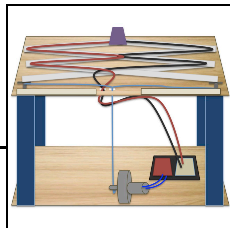
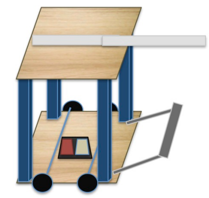
Figure 12: The Net Design

Table 6: The Morphological Chart



Good

Table 7: The Third-Level Concept Evaluation Matrix

Importanace	Customer Requirements			
10	Dimensions of 1 ft by 2 ft	5	9	8
10	Less than 18 inches tall	4	7	8
7	Transport astronauts to the Mars Base	9	10	10
10	Moves autonomously	10	8	7
5	Plant a flag in the Mars Landing Zone	4	9	7
4	Returns to Earth	3	8	8
5	Avoids obstacles of opponents	10	2	4
10	No explosive materials	10	10	10
10	Uses only one RedBoard	10	8	7
10	Uses only components from 3 SIK kits	7	5	6
10	Uses only components in MCHE201 kit	6	4	3
10	Does not damage other robots	10	8	7
10	Uses only electrical and gravitational energy	7	8	8
6	Collect Pre-Launched fuel	4	7	9
3	Mine asteroids	3	9	5
4	Shock proof	8	2	4
2	Visually appealing	4	4	3
10	Removed in under 2 minutes, 30 seconds	6	6	5
10	Set up in under 3 minutes, 45 seconds	4	5	6
10	Costs less than $100	7	5	5
10	Stops moving after 30 seconds	9	4	5
10	Starts on signal	8	7	6
3	All parts stay intact	3	6	5
1	Less than 20 pounds	3	7	8
3	Portable	2	8	9
4	Moves forwards	9	9	10
4	Moves backwards	2	6	7
7	Earns at least 75 points	7	6	5
6	Safety for bystanders	10	7	6
4	Less than 3 steps to assemble	8	4	6
4	Less than 3 steps to disassemble	6	7	5
1	Recyclable parts	7	4	3
8	Locate Mars Base	9	8	9
7	Navigate to Mars Base	8	9	10
10	Does not damage track	7	6	7
10	Repeatable functions	9	7	10
4	Locate asteroids	5	8	6
3	Locate pre-launched fuel	4	8	9
5	Few moving parts	9	3	3
9	Built in one month	8	6	9
3	Locate other robots	5	7	8
	Total	1934	1826	1877
	Relative Total = Total/Number of Criteria	0.47	0.45	0.46

font could be larger

Table 8: The Key for the Third-Level Concept Evaluation Matrix

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

Table 9: Money Spent on the Robot

Item	Store Purchased	Total Price	Percent of Product Used	Relative Price
Compact Drying Rack	Target	$14.99	33.00%	$5
Sheet Wood	Home Depot	$8.00	100%	$8.00
1x1 in wood	Home Depot	$1.89	50%	$1.00
Craft Wood	Micheals	$4.99	50.00%	$2.50
Toilet Paper Roll	Walmart	$0.02	100%	$0.02
Wires	Amazon Prime	$14.50	25.00%	$3.25
Craft Wood	Micheals	$3.99	50.00%	$2.00
Closet Track & Hinges	Home Depot	$16.99	25.00%	$4.17
Wheel	Home Depot	$3.89	100.00%	$3.89
Total				**$29.83**