Mission to Mars: Final Report

MCHE 201: Introduction to Mechanical Design

Spring 2017

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Abstract

Mission to Mars is a contest in which MCHE 201 students design and build autonomous devices to transport astronauts to Mars, plant a flag in the Mars Landing Zone, avoid and/or mine asteroids, collect pre-launched fuel, and safely return to Earth. The challenges a Mission to Mars device must overcome include limited time, budget, and materials as well as meeting the customer requirements. The final design is The E.T. This device moves forward on wheels to reach the competition zones. It extends an arm controlled by a drawer slide-pulley system to deliver the astronauts and flag to Mars. Grabbing arms extend from the sides of the device to collect pre-launched fuel and asteroids. An assessment of the problem understanding shows that the most important requirements are the Mission to Mars tasks and the ~~following:~~ materials and additional sensors cost less than $100, autonomously operate, and operate for 30 seconds only. The functionality of possible devices that satisfy the Mission to Mars problems is considered in possible design ideas, such as wheels for moving forward and extending arms to deliver astronauts. The Reach for the Mars, a stationary device with an extending arm and sweeper arm, and the Mars Tank, a tank-like device with a fixed arm, are two alternative devices considered for the Mission to Mars. Evaluating the three devices' effectiveness for meeting the customer requirements shows that The E.T. is the most effective design. The E.T. prototype was assumed to meet the customer requirements, including completing all of the Mission to Mars tasks. However, its performance revealed that the assumptions were wrong. Due to malfunctions with the power supply of the track, The E.T. only partially functioned. The device placed 17th in the final competition and 6th overall for ingenuity, aesthetics, and presentation.

Good

1 Introduction

The main objective of the Mission to Mars contest is for MCHE 201 students to design and build autonomous ~~devices~~ to complete space exploration tasks in the Solar System. The Solar System [1], seen in Figure 1, is the arena in which the devices will compete. The arena has four Team Zones. Each Team Zone includes the Start Zone, the Asteroid Processing, and the corresponding triangular section, excluding the circular center. Located throughout the Solar System are asteroids and pre-launched fuel. The devices, which begin the competition in the Start Zone, should complete within the Solar System the tasks of transporting astronauts to Mars, planting a flag in the Mars Landing Zone, avoiding and/or mining asteroids, collecting pre-launched fuel, and safely returning to Earth.

Each of these tasks contributes to the competition's scoring system. For the task of transporting astronauts to Mars, 5 astronauts (LEGO Minifigures) are given to each team for their device to transport either to the Mars Landing Zone or the Mars Base. Each astronaut contained in the Mars Landing Zone earns the team 5 points. Each astronaut completely contained in the revolving Mars Base earns the team 10 points. For the task of planting a flag in the Mars Landing Zone, transporting the flag to be completely contained in the Mars Landing Zone will earn the team 10 points. For the task of avoiding and/or mining asteroids, the team's device should relocate the 5 pre-placed asteroids (table-tennis balls wrapped in foil). Asteroids remaining in the team's triangular zone will penalize the team 5 points each. Asteroids relocated to the team's Asteroid Processing zone will earn 5 points each. For the task of collecting pre-launched fuel, the team's device should relocate the pre-placed pre-launched fuel (toy blocks). Each pre-launched fuel completely contained within the team's triangular zone earns the team 10 points. For the task of returning to Earth, the team's device should navigate to the Start Zone by the end of the competition. If the device is completely out of the team's designated competition zone and the team has collected at least one pre-launched fuel, the team will earn 20 points.

Good

The primary engineering challenge that the Mission to Mars faces is to design and build a device that earns enough points to win the contest while meeting the customer requirements. To design and build a device to overcome the primary engineering challenge, other challenges, such as limited budget, time, and materials, must also be overcome. The final design, The E.T., is designed to overcome~~s~~ these challenges and to meet the most important customer requirements. In Section 2, The E.T.'s design and functionality are discussed. An assessment of the design tools, such as the House of Quality, Specification Sheet, and Function Tree, used to understand the problem are presented in Section 3. Section 4 describes two alternative designs and evaluates how well each of the three designs meet the customer requirements. Section 5 presents the results of The E.T.'s performance.

This is a "team" challenge, not an engineering challenge

Good

2 Final Design

The E.T., seen in Figures 2 and 3, is the final design chosen. It is 23.5 inches in length, 11 inches in width, and 14 inches in height. The entire device moves forward and backward by the wheels connected to its base. The forward/backward motion of the wheels move it to and from the Team

Zone. At the very top of The E.T. is an astronaut transporting arm that extends by a drawer slide-pulley system. The astronaut transporting arm delivers the astronauts and the flag to the circular center of the Solar System and deposits them into the revolving Mars Base. Along the sides of the device are grabbing arms. These arms expand as the device moves forward into the Team Zone and close in on the asteroids and pre-launched fuel. As the device moves backward~~s~~ into the Team Zone, the grabbing arms transport the asteroids to the Asteroid Processing. The device returns to the Start Zone after collecting the pre-launched fuel, transporting the asteroids to the Processing Zone, and delivering the astronauts and flag.

For the device to reach the components in the Team Zone, ~~as well as the~~ Mars Landing Zone and Mars Base, it rolls forward on its four wheels. The driving motor, seen in Figure 4, drives the device. A band connects the shaft of the large DC motor to the front axle of the wheels. When the shaft rotates, the band rotates the axle. Thus, when the motor moves forward and backward, the entire device moves respectively.

Good

The drawer slide-pulley mechanism, shown in Figure 5, serves as the astronaut transporting arm. The drawer sliding stepper motor controls the movement of the astronaut transporting arm. The spool connected to the stepper motor's shaft has two cables secured to it. The other ends of the two cables are connected to the eyelet hook and loop through the stationary eyelet hook. As the stepper motor turns one way, it reels in one one cable while releasing the other cable. This causes the cables to extend the astronaut transporting arm through the drawer slide. When the stepper motor turns the other way, the arm is retracted back into the drawer slide.

two cables or two ends of one cable?

At the end of the astronaut transporting arm is the astronaut release mechanism, seen in Figure 5. The astronauts are transported in the basin above the rotating floor. When the astronaut transporting arm is extended over the revolving Solar System's circular center, the IR sensor senses the location revolving Mars Base. The astronaut releasing servomotor rotates the rotating floor outward when the revolving Mars Base is directly under the IR sensor, releasing the astronauts into the Mars Base.

Again, this should belong here to keep figures in order

The grabbing arms are extended and retracted by the small DC motor, as shown in Figure 4. The connecting rods push against the grabbing arms when the motor turns one way, extending the arms outward at 90 degrees. When the motor turns the opposite way, the grabbing arms are pulled back together.

3 Problem Understanding

To create a device to successfully complete the Mission to Mars, the customer requirements, engineering characteristics, target specifications, and device functions must be evaluated.

3.1 House of Quality

The customer requirements and engineering characteristics are related in a House of Quality, seen in Table 1. The customers considered for the Mission to Mars include Dr. Vaughan, the contest judges, and the team creating the device. The customer requirements are listed and ranked based on importance in the House of Quality. Among the most important customer requirements are the Mission to Mars tasks described in Section 1. These customer requirements are ranked as some of the most important because meeting these requirements will earn points towards winning the contest. However, they are ranked at different importances among themselves because some are easier to meet and score more points. For example, avoiding asteroids has greater importance than mining asteroids because each asteroid left in the team's triangular zone will result in point reduction. Other important customer requirements include the following: materials and additional sensors cost less than $100, autonomously operate, operate for 30 seconds only, and consistent performance. These requirements should be largely considered in designing a device.

The engineering characteristics are related to the customer requirements in the correlation matrix in the House of Quality. Their relationships are used to rank the importance of the customer requirements. The highest ranking engineering characteristics in descending order of absolute importance are as follows: time the device takes to operate mission, number of mission tasks that can be completed, total points mission earns, length of code, and number of motors. These characteristics can be measured and should be considered in a design that ~~would meet~~ meets the customer requirements.

Good

Also shown in the top part of the House of Quality are the directions of improvement for the engineering characteristics and the correlations between each engineering characteristic. The directions of improvement show that number of mission tasks that can be completed and total points mission earns should be maximized while dimensions, such as length, width, height, and weight, should be minimized. The correlations between each engineering characteristic show numerous relationships. Time the device takes to operate mission has strong positive correlations to other characteristics, including distance the device moves and number of mission tasks that can be completed. Increasing either the distance the device moves or the number of mission tasks that can be completed will directly increase the time the device takes to operate the mission. ~~The relationship of how one engineering characteristic affects the others should also be considered in a design because altering one characteristic may have a negative correlation on another.~~

3.2 Specification Sheet

The Specification Sheet, seen in Tables 2 and 3, sets target values for designing a device to satisfy the customer requirements. The specifications that are related to meeting the important customer requirements and that are demands are the following: total cost less than $100, uses 1 RedBoard, and device must shut down at the end of 30 seconds from start. Although these are demanded specifications, the specifications that are wants for some of the important customer requirements include total cost less than $75 and device ceases operations at the end of 25 seconds. ~~It is important that the device meets the demanded specifications, but the corresponding wanted specifications are preferred.~~

These don't really add anything to the discussion or better help your reader understand your design.

3.3 Function Tree

The Function Tree is shown in Figure 6. The main function of the device is to complete the Mission to Mars. In order to achieve this main function, the device must have the following sub-functions: operate autonomously, transport astronauts, plant flags in Mars Landing Zone, avoid asteroids, mine asteroids, collect pre-launched fuel, and return safely to earth. To complete each of these sub-functions, more sub-functions follow. For example, in order to collect pre-launched fuel, the device must detect the location of pre-launched fuel, trigger the mechanism to grab and/or transport the pre-launched fuel, and move the pre-launched fuel into team zone. The device should be capable of doing all of these sub-functions to complete the Mission to Mars.

What are the most important functions? Why?

4 Concept Evaluation

The E.T., as presented in Section 2, is the chosen final design. An evaluation of it and two other alternative designs are considered for how well each satisfies the customer requirements. The Morphological Chart, shown in Table 4, lists the subfunctions from the lowest level of the Function Tree. These subfunctions are further labeled according to their main function to distinguish the otherwise similarly worded lowest level subfunctions. In the Morphological Chart, components of three possible designs are mapped with the arrows. For the final design, the components to complete the functions include wheels, a drawer slide, grabbing arms, a servo, timing, and an IR sensor. The two alternative designs were mapped similarly.

use the same wording

The first alternative design is the Reach for the Mars device, seen in Figures 7 and 8. This device's base remains stationary in the Start Zone. The extending arm on the top of the device is controlled by the arm extending motor. A cable connects to the motor shaft, runs behind the pin, and connects to the other end of the extension arm. When the motor turns, the string is wound around the shaft, extending the extension arm. The astronaut release mechanism uses an IR sensor and rotating floor to release the astronauts into the Mars Base. When the IR sensor detects the Mars Base, the astronaut release servomotor moves the rotating floor, releasing the astronauts. The sweeper arm is attached directly to the sweeping motor. It rotates about the motor 270 degrees, pushing the asteroids out of the Team Zone.

Good

The second alternative design is the Mars Tank, shown in Figures 9 and 10. This device moves forward with a wheel and track system driven by the driving motor. Attached to the body is a fixed arm. This arm, containing a basin for the astronauts, transports the astronauts to Mars, and an IR sensor detects the location of the revolving Mars Base. A solenoid is extended to hold the floor of the basin containing the astronauts. When the IR sensor detects the Mars Base, the solenoid retracts, releasing the astronauts. The front of the device has a bracket for collecting asteroids. Two servo motors are connected to either end of the bracket. The ~~bracket control~~ servomotors control the movement of the bracket so that it lifts up when moving forward and down when moving backwards, allowing for asteroids to be collected and mined.

The three designs are compared in the Evaluation Matrix, shown in Table 5. The E.T. has the highest relative total at 0.61 ~~compared to the other designs~~. The Mars Tank and the Reach for the Mars both have a relative total of 0.53. The E.T. has the highest score because it transports astronauts to Mars Base, mines asteroids, and collects pre-launched fuel. The Reach for the Mars device is not as effective because it is not able to meet as many customer requirements. For example, it cannot mine asteroids. The Mars Tank also does not satisfy as many customer requirements. For example, it is not able to collect any pre-launched fuel or return to Earth. The E.T. is the most effective design in meeting the customer requirements.

5 Design Performance Evaluation

The E.T. prototype was constructed for the final competition. It was assumed to complete all of the Mission to Mars tasks, including transporting astronauts to the Mars Base, planting a flag in the Mars Landing Zone, avoiding and/or mining asteroids, collecting pre-launched fuel, and safely returning to Earth. It was also assumed to meet the important customer requirements, such as costing less than $100, operate for 30 seconds only, and consistent performance.

Did it meet these or not?

The E.T.'s performance did not successfully complete the Mission to Mars. For the first round of competition, the device placed first among the three other teams with a total of 15 points. Although it won the first round, The E.T. did not complete all of its functions. The device was only able to drive forward, extend the astronaut transporting arm, and open its grabbing arms. It did not release the astronauts into the Mars Base, drive backward~~s~~, close the grabbing arms to mine the asteroids, or collect pre-launched fuel. It did not win the second round of competition with its score of -30 points due to the same function errors. It is assumed that it did not function properly for the first two rounds due to faults with the arena's power supply. The third and final round of The E.T.'s competition resulted in a disqualification due to unanticipated movement of the device before the start of the competition. Its final ranking was 17th place, tied with 7 others. For the judge's scoring, The E.T. placed 6th place overall for ingenuity, aesthetics, and presentation.

What is your support for this assumption?

The assumptions pertaining to the device completing Mission to Mars tasks did not hold in the competition performance. Examination of the device's performance not on the competition arena revealed that The E.T. was fully functioning. It is assumed that it did not function properly for the first two rounds due to faults with the arena's power supply. The assumptions that it would operate for 30 seconds only and perform consistently also were not true. Assumptions that did hold include costing less than $100 and clean, aesthetic design. The bill of materials is listed in Table 6.

Why? We didn't hear/ see this issue from any other teams.

6 Conclusion

The E.T. was a Mission to Mars device that was assumed to complete the tasks of transporting astronauts to Mars, planting a flag in the Mars Landing Zone, avoiding and/or mining asteroids, collecting pre-launched fuel, and safely returning to Earth. The device was designed to roll forward and backward~~s~~ on wheels, extend an astronaut transporting arm using a drawer slide-pulley system, release asteroids into the revolving Mars Base, collect pre-launched fuel and asteroids with grabbing arms, and mine asteroids. The important customer characteristics were the Mission to Mars tasks, materials and additional sensors cost less than $100, autonomously operate, and operate for 30 seconds only. The customer requirements, engineering characteristics, and device functions were considered in design ideas. The Reach for the Mars device extends an arm for transporting astronauts and sweeps asteroids and the Mars Tank uses a wheel and track system to move forward and a fixed arm for transporting astronauts. When the three designs are evaluated in regard to the customer requirements, The E.T. had the highest relative total at 0.61. Although the device was designed to successfully ~~complete~~ compete?, it did not function properly in its final competition performance, earning 17th place for the competition and 6th place for ingenuity, aesthetics, and presentation.

7 References

[1] J. Vaughan, "Mission to Mars," March 2017.

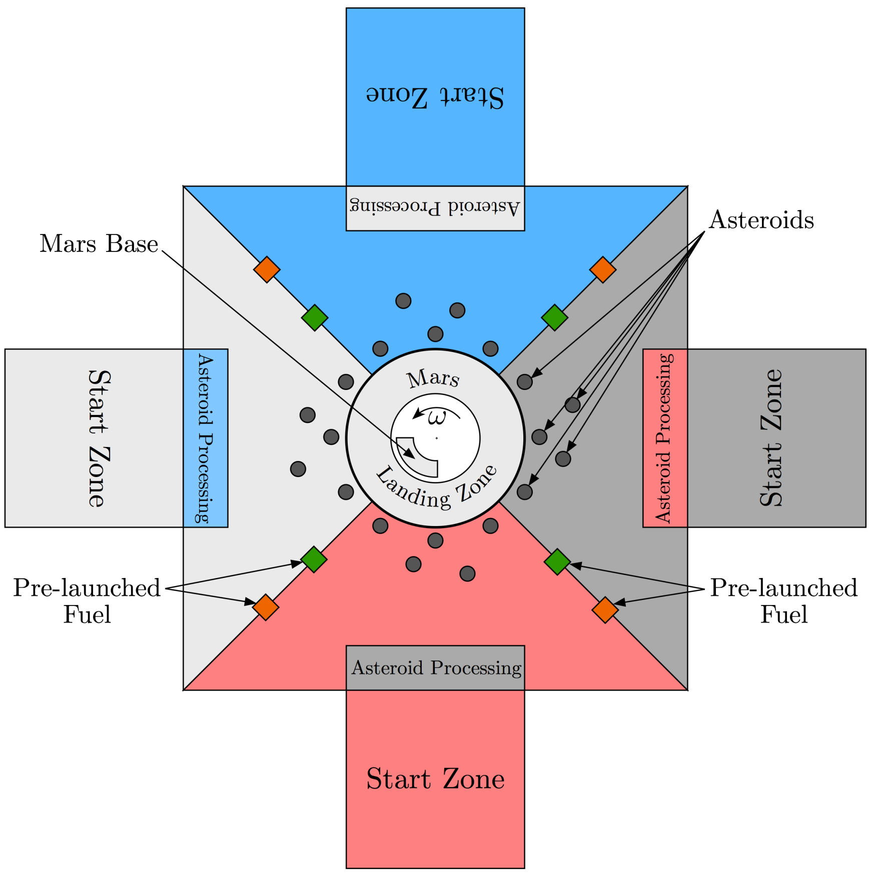


Figure 1: The Solar System [1]

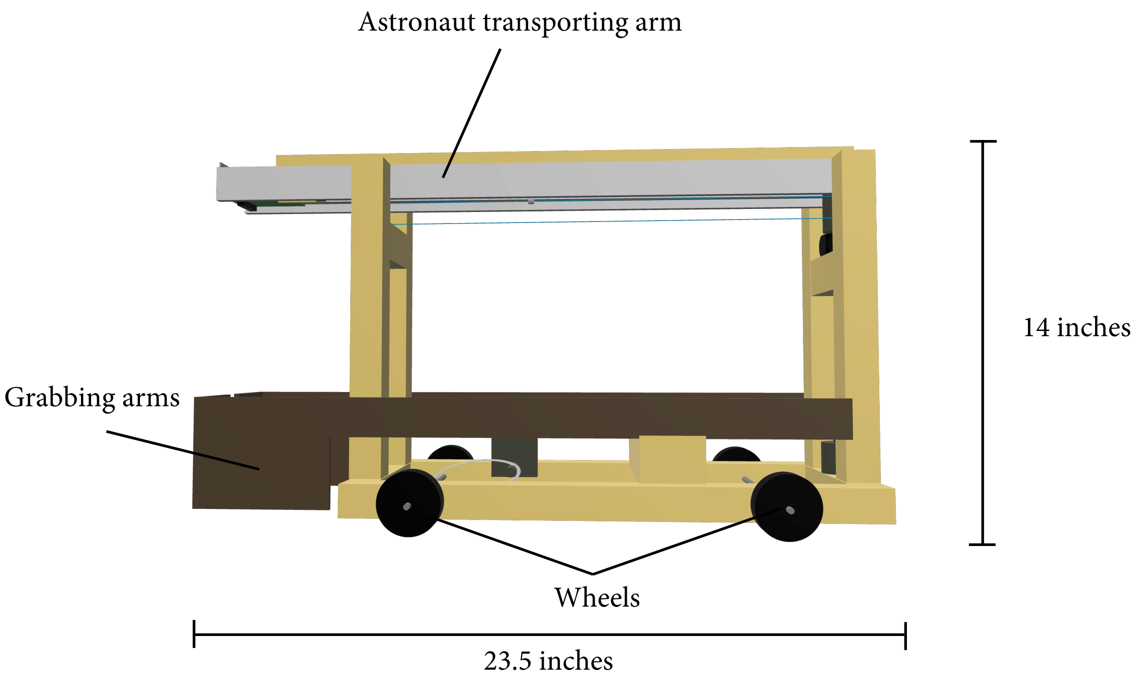


Figure 2: Side View of The E.T.

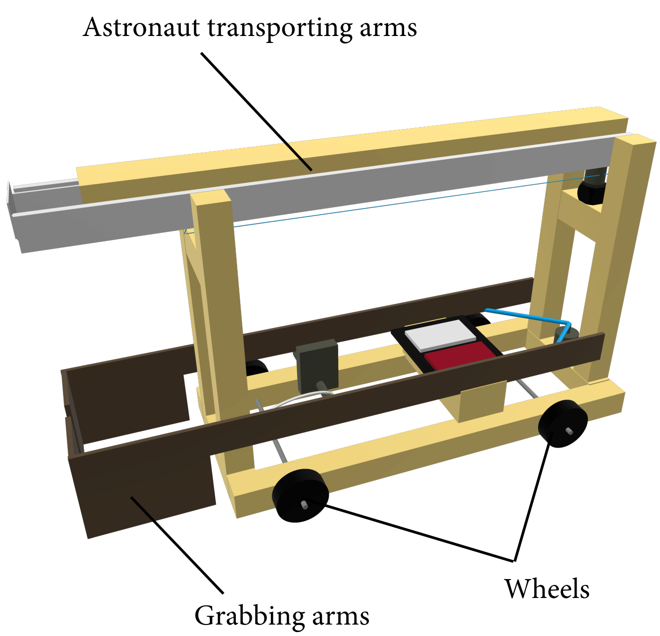


Figure 3: Isometric View of The E.T.

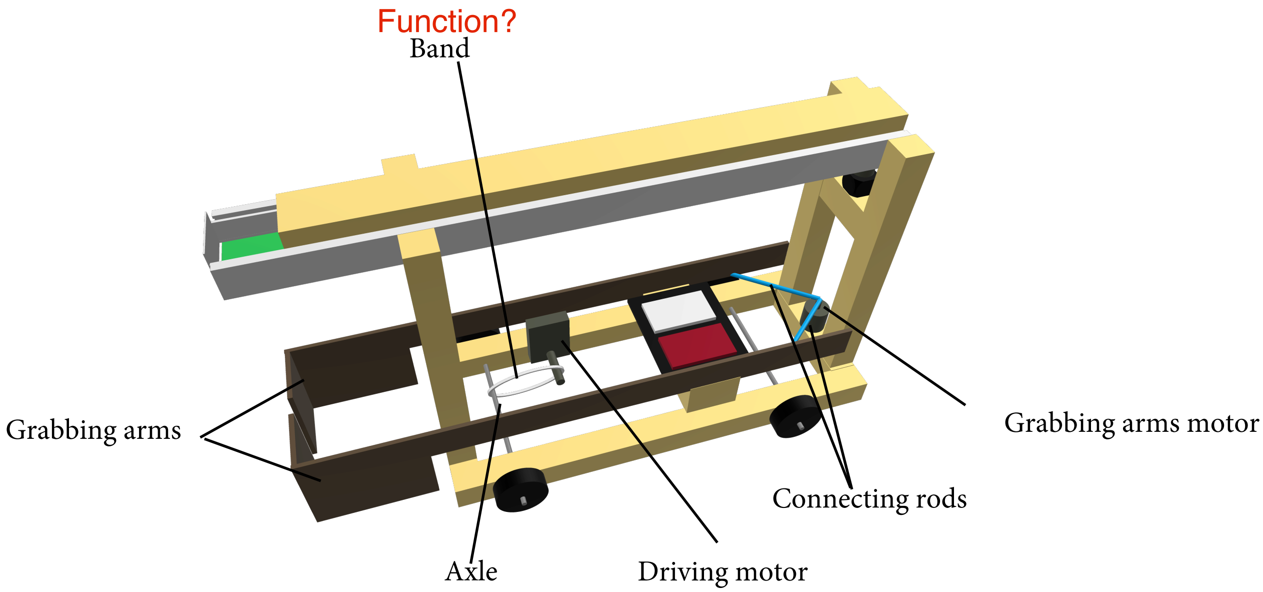


Figure 4: Inner Components of The E.T.

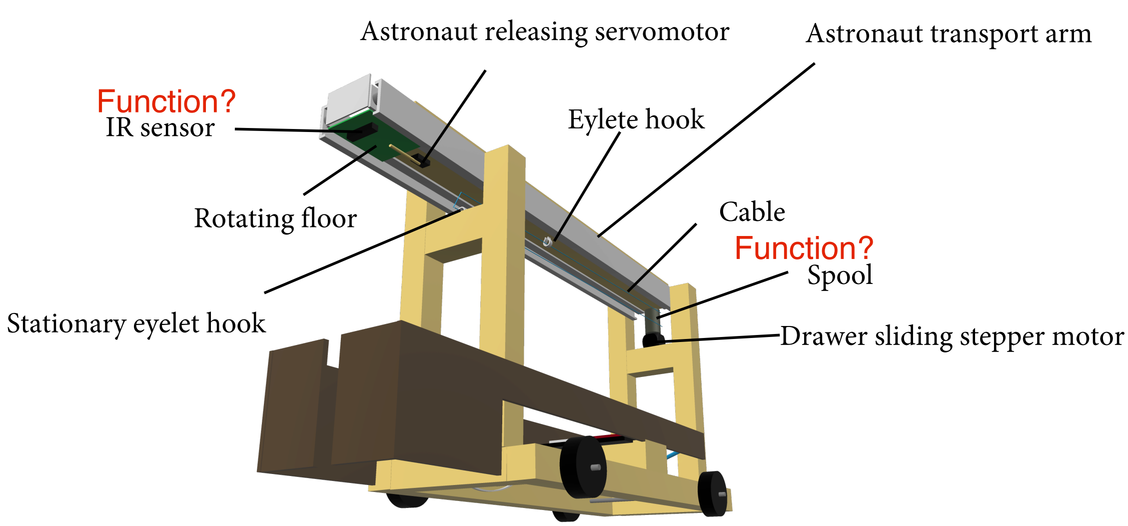
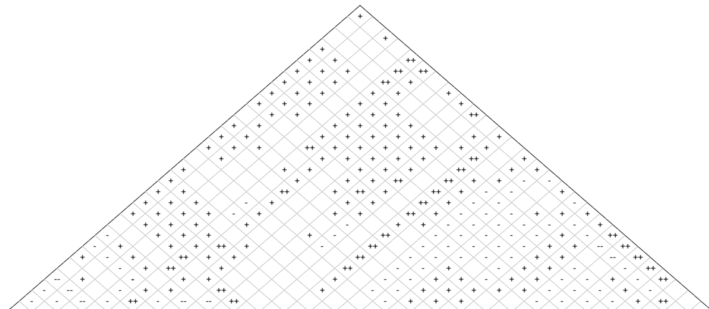


Figure 5: Drawer Slide-Pulley Mechanism of The E.T.

Good

Table 1: Mission to Mars House of Quality



Importance (Scale: 1-10)	Customer Requirements / Engineering Characteristics	Length of device before start	Width of device before start	Height of device before start	Weight of entire device	Number of sensors	Number of motors	Number of different additional materials	Cost of construction materials	Cost of additional sensors	Total cost	Time it takes to setup device for mission	Time the device takes to operates mission	Time it takes to clean up device after mission	Voltage from RedBoard USB power supply	Voltage from motor shield power supply	Distance from device to team zone	Distance device moves	Distance device reaches to access Mars	Speed of motors	Range of IR sensors	Number of pre-launch fuel device can transport into team zone	Number of mission tasks that can be completed	Number of astronauts device can deliver to Mars	Number of asteroids device can avoid	Number of asteroids device can mine in Processing Zone	Number of lines of code	Memory code uses	Total points mission earns
	Direction of Improvement	▼	▼	▼	▼	x	x	▼	▼	▼	▼	▼	x	▼	x	▲	▼	▼	▲	▲	▼	▲	▲	▲	▲	▲	▼	▼	▲
8	Transport astronauts to Mars Landing Zone	▣	△	▣		△	▣			△	△		◉	▣	△	△		▣	◉	▣	▣		◉	▣	△	△	▣	▣	◉
9	Transport astronauts to Mars Base	▣	△	▣		▣	▣			△	△		◉	▣	△	△		▣	◉	▣	◉		◉	◉	△	△	▣	▣	◉
8	Plant a flag in Mars Landing Zone	▣	△	◉			▣			△	△		◉	▣	△	△	△	▣	◉	▣	▣		◉	△	△	△	▣	▣	◉
9	Avoid asteroids	△	△	△		▣	▣			△	△		◉	▣	△	△	▣	▣	▣	▣	▣	△	◉	△	◉	▣	▣	▣	◉
6	Mine asteroids	△	△	△		▣	▣			△	△		◉	▣	△	△	▣	▣	▣	▣	▣	△	◉	△	▣	◉	▣	▣	◉
8	Collect pre-launched fuel	▣	△			▣	▣			△	△		◉	▣	△	△	▣	▣	▣	▣	▣	◉	◉	△	△	△	▣	▣	◉
9	Safely return to Earth	▣	▣			△	◉			△	△		◉	▣	△	△	▣	◉	△	▣	▣	▣	◉	△	△	△	▣	▣	◉
5	Robust to deviations in the Solar System	△	△			▣	△	△	△	△	△		▣		△	△	▣	△	▣	△	◉	△	▣	▣	▣	▣	▣	▣	▣
4	Performs mission in the Solar System (team zone)	△	△				△			△	△	△	▣		△	△	▣	▣	△	△	▣	▣	▣	△	△	△	▣	△	▣
10	Materials and additional sensors cost less than $100	▣	▣	▣	△	◉		◉	◉	◉	◉						△				△	△	△	△	△	△			
9	Use one Arduino controller only						▣					△	▣		◉	◉		△	△	▣	△	▣	▣	▣	▣	▣	▣	▣	▣
6	Limited to three SIK servomotors						◉					▣	▣		△	▣	△	▣	▣	▣		△	▣	▣	▣	▣	▣	▣	▣
6	Limited to motors provided in mechatronics kit						◉					▣	▣		△	▣	△	▣	▣	▣		△	▣	▣	▣	▣	▣	▣	△
7	Detect objects in the Solar System using sensors					◉				◉	△	▣	▣		▣	▣	△	△	△	△	◉	▣	▣	△	▣	▣	▣	▣	△
10	Autonomously operate					▣	▣			▣		△	▣		▣	▣		▣	▣	◉	▣	▣	▣	▣	▣	▣	▣	▣	△
10	Operate for 30 seconds only					△	△					△	◉	△	▣	▣	△	▣	△	▣			◉	▣	▣	▣	▣	▣	▣
8	Cease all operations after 30 seconds											△	◉	△	▣	▣				△							▣	▣	▣
8	Device setup time less than 3.75 minutes	△	△								△	◉	△				▣										▣	△	
8	Device cleanup time less than 2.5 minutes	△	△								△	▣	△	◉				△											
7	Width less than 1 foot at start of competition	▣	◉	△	△			▣	△		△		△	△			△		△		△	△	△	△	△				
7	Length less than 2 feet at start of competition	◉	▣	△	△			▣	△		△		△	△			△		△		△	△	△	△	△				
7	Height less than 18 inches at start of competition	▣	▣	◉	△			▣	△		△		△	△					△		△	△	△	△	△				
5	Weight light enough to be lifted and transported	▣	▣	▣	◉		△	▣	△		△	▣		▣						△									
6	Act as a rigid body before start	▣	▣	▣	△			▣				△	△														△	△	▣
8	Device operation safe to bystanders											△			△	△		△	△	△	△						△	△	
7	No damage to competition area by device							△				△		▣	△	△	△	△	△	△	△						△	△	
9	No damage to device components upon operation						△	▣				△		▣	△	△		△	△	△	△						△	△	
7	Activated by start plugs						△					△	▣	△	◉	◉							△				▣	▣	△
6	Recognize that start plugs close the circuit											△	▣	△	◉	◉							△				▣	▣	△
5	Able to access power outlets	▣	▣	▣								▣	△	▣	◉	◉							△				△		
7	Powered by motorshield power supply						▣					▣	△	△	△	◉				▣			△				△	△	△
7	Powered by USB power supply						▣					▣	△	△	◉	△				▣			△				△	△	△
5	Uses gravitational energy				◉							▣	△	△									△	▣			△		△
6	Clean, aesthetic design	△	△	△			△	◉	▣	△	△																		
6	Design unique from others	△	△	△		▣	▣	△	△	△	△	▣	▣	▣	△	△	△	△	△	▣	▣	▣	◉	▣	▣	▣	▣	▣	▣
10	Consistent performance					▣	▣				△	△	▣	▣	▣	▣	△	△	△	▣	▣	▣	▣	▣	▣	▣	▣	▣	▣
5	Avoids disqualifications	▣	▣	▣					△	△	▣	▣	▣	▣									△				▣		
7	Concise coding					▣	▣					▣	◉							△	△		▣	▣	▣	▣	◉	◉	▣
8	Construct completely functioning device in three weeks	△	△	△		▣	▣	▣			△	△											△				▣	△	
	Absolute Importance	384	318	328	127	414	574	330	150	266	250	397	1051	473	565	589	231	403	476	507	495	303	933	412	407	368	636	571	784
	Relative Importance	0.03	0.02	0.03	0.01	0.03	0.05	0.03	0.01	0.02	0.02	0.03	0.08	0.04	0.04	0.05	0.02	0.03	0.04	0.04	0.04	0.02	0.07	0.03	0.03	0.03	0.05	0.04	0.06

◉	Strong
▣	Medium
△	Weak

▲	Maximize
▼	Minimize
x	Target

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

Good

Table 2: Mission to Mars Specification Sheet

		Specification for:	**Issued:**	**3/31/2017**
		Mission to Mars	**Page 1 of 2**	
Changes	**D/W**	**Requirements**	**Responsibility**	**Source**
	D	Create device to compete in Mission to Mars contest	Team B1	Mission to Mars
		Geometry		
	D	Length of device before start < 24 inches	Team B1	Mission to Mars
	W	Length of device before start < 23 inches	Team B1	Team B1
	W	Length of device before start > 20 inches	Team B1	Team B1
	D	Width of device before start < 12 inches	Team B1	Mission to Mars
	W	Width of device before start < 11 inches	Team B1	Team B1
	W	Width of device before start > 8 inches	Team B1	Team B1
	D	Height of device before start < 18 inches	Team B1	Mission to Mars
	W	Height of device before start < 17 inches	Team B1	Team B1
	W	Height of device before start > 15 inches	Team B1	Team B1
		Kinematics		
	D	Speed of motors > 0.2 ft/s	Team B1	Team B1
	W	Speed of motors > 0.5 ft/s	Team B1	Team B1
	D	Acceleration of motors > 0.2 ft/s/s	Team B1	Team B1
	W	Acceleration of motors > 0.5 ft/s/s	Team B1	Team B1
	D	Moves forward 23 inches	Team B1	Team B1
	W	Moves forward 33 inches	Team B1	Team B1
		Energy		
	D	100% of energy either gravitational or electromechanical	Team B1	Mission to Mars
	D	12V power supply for motors	Team B1	Mission to Mars
	D	5V power from USB for RedBoard	Team B1	Mission to Mars
		Materials		
	D	Use ≤ 3 servomotors from SIK kits	Team B1	Mission to Mars
	D	Use 1 RedBoard	Team B1	Mission to Mars
	W	Use ≤ 2 breadboards	Team B1	Team B1
	D	Use components from 3 SIK kits, except DC motors	Team B1	Mission to Mars
	W	Use ≥ 4 IR sensors	Team B1	Team B1
	D	Use ≤ 2 DC motors from mechatronics kit	Team B1	Mission to Mars
	D	Use ≤ 1 stepper motor from mechatronics kit	Team B1	Mission to Mars
		Signals		
	D	Device operates in < 1 second from start plug activation	Team B1	Mission to Mars
	W	IR sensors detect objects within 30 cm	Team B1	Team B1
		Safety		
	D	100% of track not damaged by device	Team B1	Mission to Mars
	D	100% of competitors not damaged by device	Team B1	Mission to Mars
	D	100% of bystanders unharmed by device	Team B1	Mission to Mars
	D	100% of device undamaged	Team B1	Mission to Mars

Table 3: Mission to Mars Specification Sheet (continued)

		Specification for:	Issued:	3/31/2017
		Mission to Mars	Page 2 of 2	
Changes	D/W	Requirements	Responsibility	Source
		Assembly		
	W	Assembly for preliminary contest < 15 hours	Team B1	Team B1
	D	Assembly time for preliminary contest < hours		
	W	Assembly for qualifying round < 35 hours	Team B1	Team B1
	D	Assembly for qualifying round < 40 hours		
	W	Total assembly time < 50 hours	Team B1	Team B1
		Transport		
	D	Moves as 1 rigid body	Team B1	Mission to Mars
	D	Transport > 5 times to open lab hours	Team B1	Mission to Mars
	D	Transport 1 time Blackham Coliseum	Team B1	Mission to Mars
		Operation		
	D	Device setup < 3.75 minutes	Team B1	Mission to Mars
	W	Device setup < 2 minutes	Team B1	Team B1
	W	Device cleanup < 1 minute	Team B1	Team B1
	D	Utilizes 1 Arduino code to perform tasks	Team B1	Mission to Mars
	W	Collect ≥ 2 pre-launched fuels	Team B1	Mission to Mars
	W	Deliver 5 astronauts to Mars Landing	Team B1	Mission to Mars
	W	Deliver 5 astronauts to Mars Base	Team B1	Mission to Mars
	W	Plant flag in Mars Landing	Team B1	Mission to Mars
	W	Avoid 5 asteroids	Team B1	Mission to Mars
	W	Mine 5 asteroids	Team B1	Mission to Mars
	W	Return to Earth by 30 seconds from device start	Team B1	Mission to Mars
	W	Device ceases operations at the end of 25 seconds from start	Team B1	Team B1
	D	Device must shut down at the end of 30 seconds from start	Team B1	Mission to Mars
		Maintenance		
	W	Perform > 50 runs with consistency	Team B1	Team B1
		Recycling	Team B1	
	W	Repairs take < 2 hours	Team B1	Team B1
		Costs		
	W	Cost of additional sensors < $20	Team B1	Team B1
	D	Cost of additional sensors < $50	Team B1	Team B1
	W	Cost of construction materials < $30	Team B1	Team B1
	D	Cost of construction materials < $50	Team B1	Team B1
	W	Total cost < $80		
	D	Total cost < $100	Team B1	Mission to Mars
		Schedules		
	D	Have final concept completed by March 31	Team B1	Mission to Mars
	D	Have preliminary device complete by March 23	Team B1	Mission to Mars
	W	Have final device complete by April 6	Team B1	Team B1
	D	Have final device complete by April 11	Team B1	Mission to Mars

Good

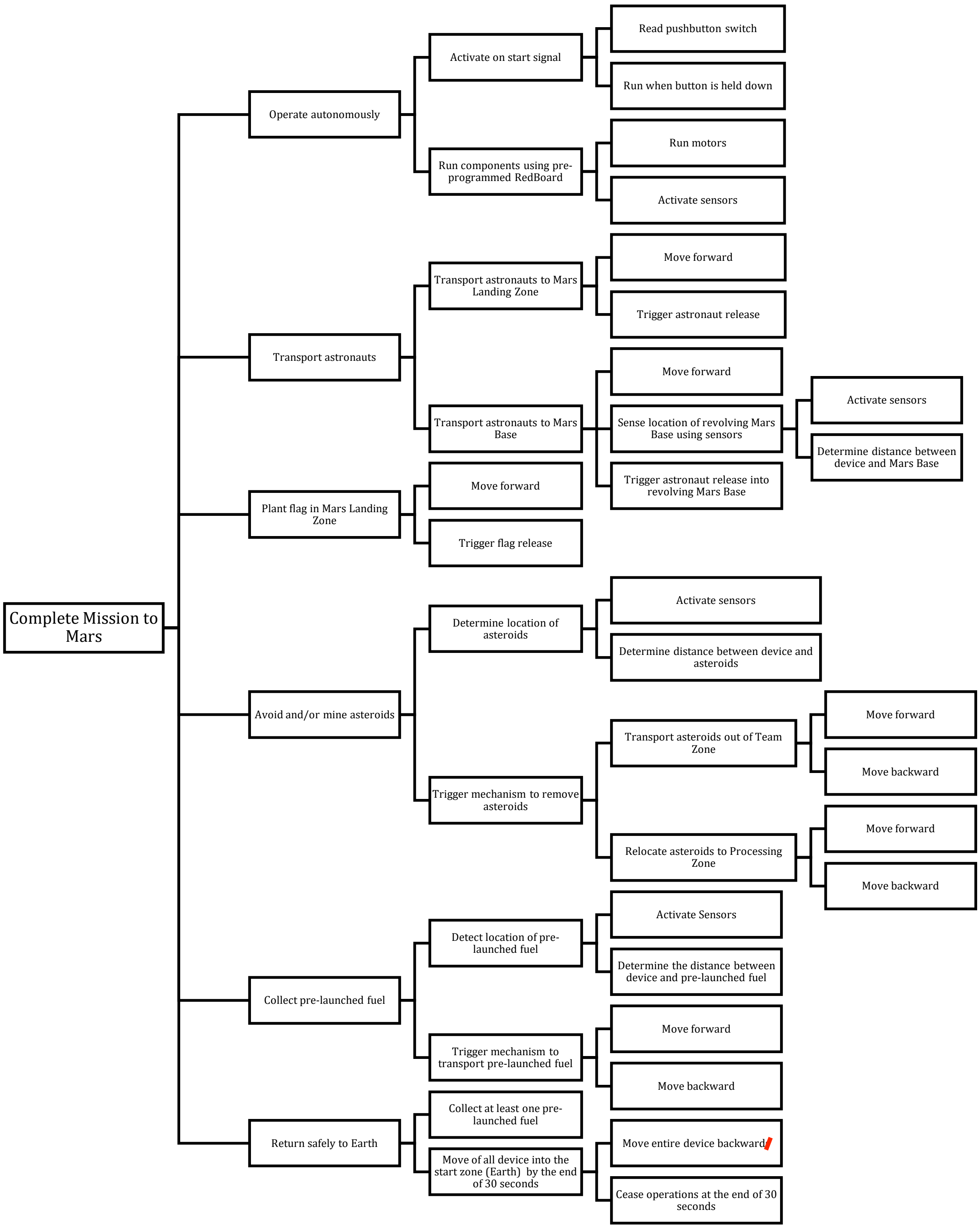


Figure 6: Mission to Mars Function Tree

Table 4: Mission to Mars Morphological Chart

Match to lowest level of subfunctions in Function Tree

More ideas would be better.

Subfunction	Idea 1	Idea 2	Idea 3	Idea 4
Move forward/backward for entire device	Wheels	Stationary	Track	
Move forward for astronauts	Fixed arm	Drawer slide	Scissor extension	Extending arm
Move forward for flag	Fixed arm	Drawer slide	Scissor extension	Extending arm
Move forward/backward for asteroids	Grabbing arms	Dropping bracket	Sweeping arm	
Move forward/backward for pre-launched fuel	Grabbing arms	Dropping bracket	Sweeping arm	
Trigger astronaut release	Solenoid	Servo	Tipping device	
Trigger flag release	Solenoid	Servo	Tipping device	
Determine distance between device and Mars Landing Zone	IR sensor	Timing		
Determine location of revolving Mars Base	IR sensor	Timing		

Final Design
Alternative Design 1
Alternative Design 2

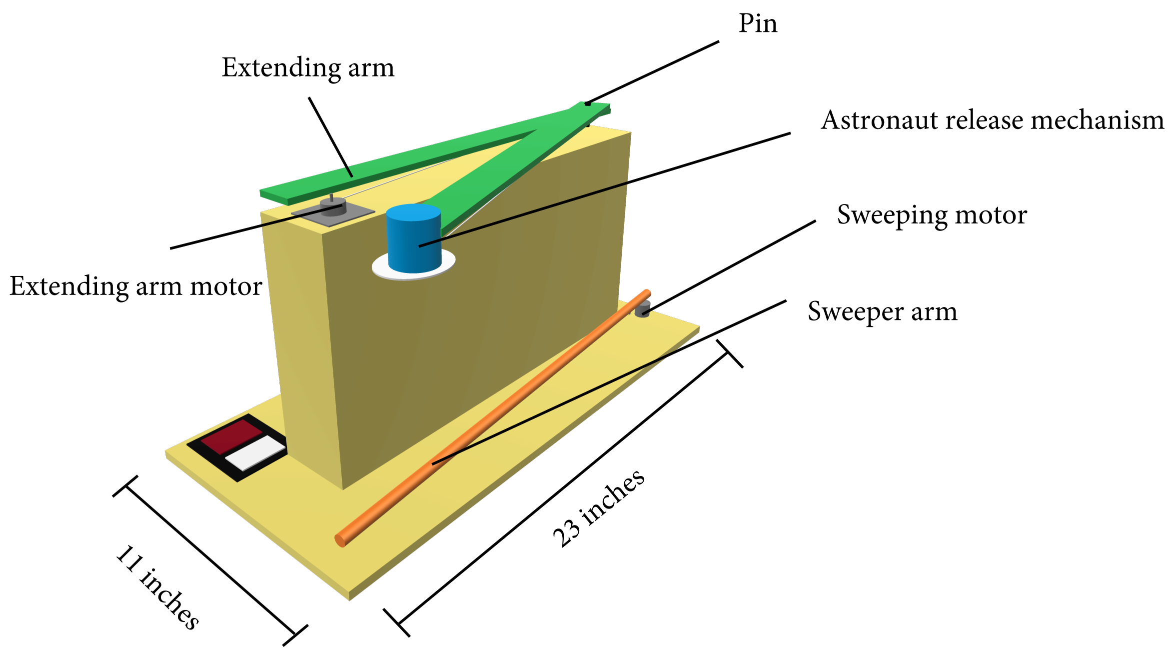


Figure 7: Isometric View of Reach for the Mars

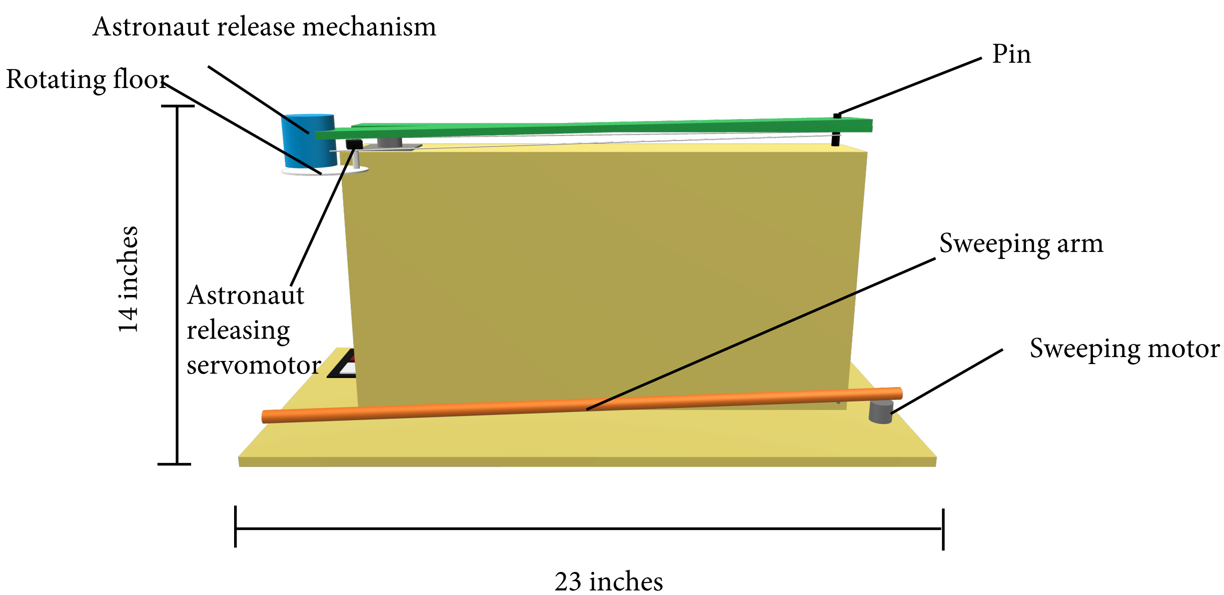


Figure 8: Side View of Reach for the Mars

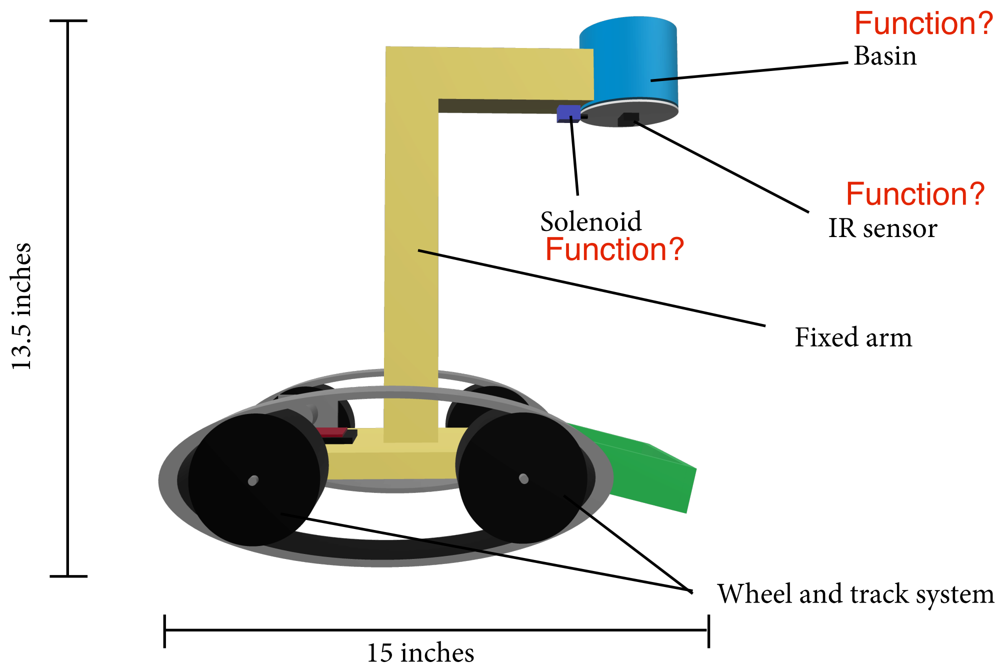


Figure 9: Side View of the Mars Tank

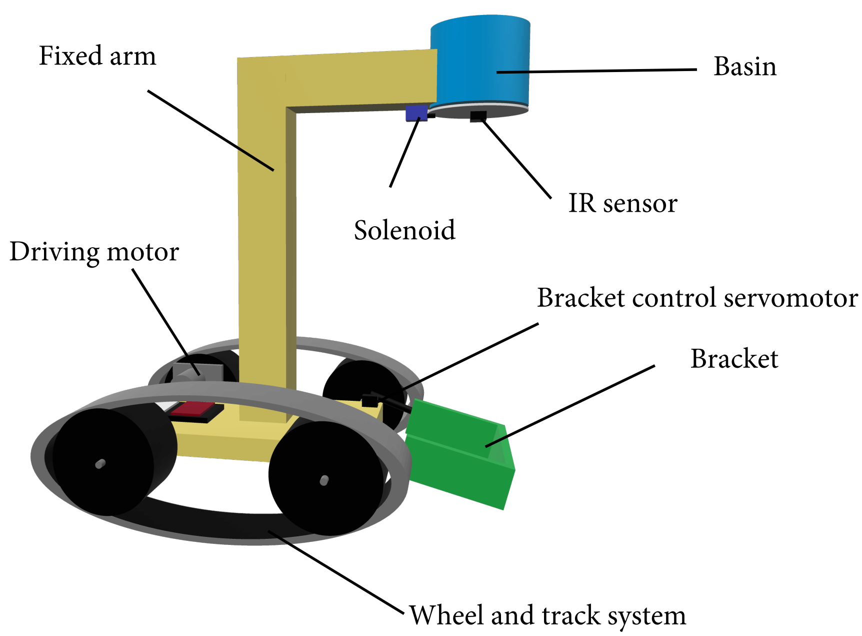
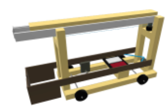
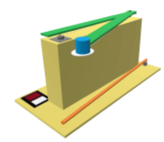
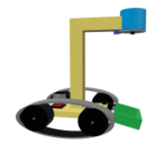


Figure 10: Isometric View of Mars Tank

Table 5: Mission to Mars Evaluation Matrix

Why the extra space?

Importance	Customer Requirements			
8	Transport astronauts to Mars Landing Zone	9	6	8
9	Transport astronauts to Mars Base	8	5	8
8	Plant a flag in Mars Landing Zone	7	4	7
9	Avoid asteroids	9	9	5
6	Mine asteroids	9	0	5
8	Collect pre-launched fuel	8	5	0
9	Safely return to Earth	7	8	0
5	Robust to deviations in the Solar System	5	7	4
4	Performs mission in the Solar System (team zone)	8	8	8
10	Materials and additional sensors cost less than $100	7	8	6
9	Use one Arduino controller only	10	10	10
6	Limited to three SIK servomotors	8	9	9
6	Limited to motors provided in mechatronics kit	10	10	10
7	Detect objects in the Solar System using sensors	10	9	10
10	Autonomously operate	10	10	9
10	Operate for 30 seconds only	9	7	7
8	Cease all operations after 30 seconds	10	7	9
8	Device setup time less than 3.75 minutes	7	5	8
8	Device cleanup time less than 2.5 minutes	9	9	9
7	Width less than 1 foot at start of competition	8	5	9
7	Length less than 2 feet at start of competition	8	5	9
7	Height less than 18 inches at start of competition	9	7	9
5	Weight light enough to be lifted and transported	7	2	8
6	Act as a rigid body before start	9	8	9
8	Device operation safe to bystanders	8	6	9
7	No damage to competition area by device	9	9	9
9	No damage to device components upon operation	8	9	8
7	Activated by start plugs	10	9	10
6	Recognize that start plugs close the circuit	9	8	9
5	Able to access power outlets	10	10	6
7	Powered by motorshield power supply	9	10	10
7	Powered by USB power supply	7	8	6
5	Uses gravitational energy	7	7	8
6	Clean, aesthetic design	10	9	7
6	Design unique from others	9	7	5
10	Consistent performance	7	6	5
5	Avoids disqualifications	9	8	7
7	Concise coding	8	9	9
8	Construct completely functioning device in three weeks	6	5	6
	Total	2372	2060	2085
	Relative Total = Total/Number of Criteria	0.61	0.53	0.53

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

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Table 6: The E.T.'s Bill of Materials

Material	Amount	Cost
Wood	6.5 feet	$6.14
Wheels	4 wheels	$17.97
Metal rod	22 inches	$1.22
Driving band	1 band	$2.27
Drawer slide	1 24-inch drawer slide	$7.97
Cable	5 feet	$4.00
Spool	1 spool	$6.01
Eyelet hooks	2 hooks	$0.20
Paint	2 cans	$9.12
Zip ties	10 ties	$1.28
	Total Cost	$56.18