Mission to Mars

Final Report

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Abstract

The report contains an overview of the Mission to Mars Competition, final design overview, alternative designs, and the problem understanding process. The competition includes a set of rules and specifications that had to be followed in order for the design to qualify. The final design was chosen based on engineering characteristics, customer requirements, and required specifications. Alternate designs were made and evaluated based on performance and deemed to be insufficient. The final design competed against other teams and was judged based on performance.

Way to general. What's unique about *this* report?

The abstract should summarize what is presented in the report, including key results.

I Introduction

In 1976, NASA held the first successful unmanned landing on Mars with the Viking 1. Since then, many exploratory missions have taken place to allow for a possible location for humans to live on rather than Earth. What makes these missions unique is the difficulty of getting to Mars.

For this Mission to Mars competition, the first objective is to transport Astronauts to the Mars Base. The Mars Base is a 12-inch-diameter rotating cylinder with a height of 12 inches surrounded by a 22-inch-diameter cylinder (Mars Landing Zone) with a height of 6 inches. Since the Mars Base is 12 inches in height and is surrounded by the Mars Landing Zone, designing a robot to successfully get the Astronauts to the Base will be an obstacle encountered during the designing process. Before each round of the competition, five Astronauts (LEGO Minifigures) will be provided to each team; delivering the Astronauts to the Mars Landing Zone results ~~to~~ in the team receiving 5 points for each Astronaut and for each Astronaut placed into the rotating Mars Base results in 10 points. The distance from the Start Zone to the center of the Mars Base is about 3 feet away which provides a challenge in designing a proficient robot to travel that distance. In order to receive the points for the Astronauts in the Mars Base, the Astronaut must be completely contained in the Mars Base. If the Astronaut is not completely contained in the Mars Base but is still in the Mars Landing Zone region, then Mars Landing Zone points will be given.

use exact wording/capitalization from Full Rules

The second task of this competition is planting a flag in the Mars Landing Zone. Before each round of the competition, a (small "desk" size) flag will be provided to each team; delivering the flag and having it fully contained in the Mars Landing Zone will result in 10 points. If the flag is not fully contained in the Mars Landing Zone no points will be rewarded.

capitalize, as stated in Full Rules

For the third objective, the robot must avoid and/or mine asteroids. In each zone, there are five asteroids (foil- wrapped table tennis balls); for each asteroid that remains in the team's zone, 5 points will be penalized. However, for each asteroid collected and placed completely in the team's Asteroid Processing zone, the team will ~~then~~ earn 5 points. Because of the complexity and difficultness of avoiding and/ or mining the asteroids, many challenges during the designing of the robot will be encountered such as developing a way for the robot to know where the asteroids are and how to collect them.

The fourth task of the competition is to collect pre-launched fuel; two pre-launched fuels (plastic toy blocks) will be located at the edges between the team zones. For each of these pre-launched fuels collected and placed completely in the team's zone will result in 10 points earned. Having these fuels placed at the edges between the zones presents ~~makes designing a robot to successfully complete this task~~ a challenge due to possibly encountering or running into other team robots. Encountering other team robots could result in a malfunction to a design or a failure in transporting the Astronauts to the Mars Base.

Once the mission is completed, the fifth and final objective is to safely return to Earth. Safely returning to Earth requires the device to be completely outside the team's zone at the end of the competition. If the device collects at least one pre-launched fuel and is completely outside the team's zone, 20 points will be earned. Failing to collect a pre-launched fuel and being outside the team's zone will result in no points earned. Completing this task will be a challenge during the engineering and designing of the robot because having the device travel straight towards the Mars Base originally and attempting to collect the fuel placed in between the boundaries of the team zone may cause the robot to travel contrarily with having additional weight added to the device when collecting the fuels.

The next section of the report will describe the functionality of the final design as a complete system and work toward a more detail description. ~~After,~~ S section 3 will provide readers with a better understanding of the functions of the final design and explain which customer requirements and specifications were key to the design. Section 4 will begin explaining two alternative designs and end with an evaluation of the three designs and why the final design was chosen over the two alternatives. ~~Then,~~ section 5 will discuss the robot's performance in the contest and how assumptions made affected the performance. Finally, S section 6 will summarize what was presented throughout the report.

II Final Design

Number and include figures and tables in the order that they are referenced in the text.

Figure 3 shows the selected final design, which is based on a rolling cart-like device built from a rectangular wooden frame with two wheels mounted on the front and one power wheel on the rear axle. The front wheels are free to rotate, whereas the rear wheel is locked to the axle. A large DC motor drives a gear train, which rotates the axle, thus driving the device forward to the Mars Base ~~Zone~~, and ~~then~~ rotates in the opposite direction to drive ~~driving~~ the device backward~~s~~ out of the team zone; no steering system is implemented. What allows the device to travel forward in a straight path is the weight distribution and the two wheels mounted near the front of the device.

The lower portion of the rectangular frame covers more area and provides sufficient room to mount the delivery arm. This allows the device to travel much closer to the outer cylinder (Mars Landing Zone) because the bottom portion of

Number and include figures and tables in the order that they are referenced in the text.

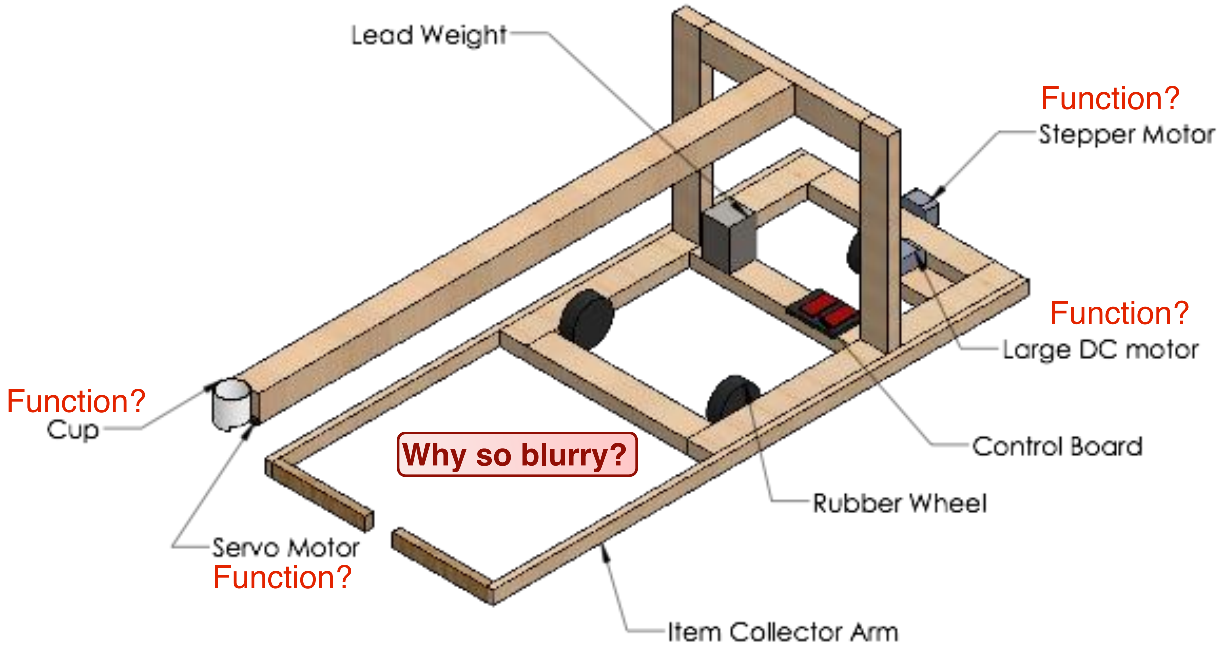
the frame is shorter in length. The delivery arm shown in Figure 3, consists of a

Label on Figure 3.

supported wooden arm mounted to the lower frame; at the front end of the delivery arm is a mounted cup. This cup is where the astronauts and flag are ~~is~~ loaded into before they travel to the Mars Base. A servo-controlled gate opens ~~will open~~ the flooring of the cup once the arm is positioned above the rotating cylinder (Mars Base), allowing the astronauts to fall in~~to~~.

A stepper motor opens two wooden arms that extend out which allow~~s~~ the device to collect/ and or mine the asteroids and collect the pre-launched fuel. The stepper motor opens these two arms by turning the axle, that has a string wrapped around it, connected to the two arms on the other end. As the axle turns, the string pulls on the arms opening them. Once the robot is close enough to the Mars Landing Zone, the stepper motor turns the axle in the opposite direction providing slack in the string. The two arms then close against the outer cylinder and, once backing up, two retractable lanyards pull on the arms closing them with pre-launched fuel and asteroids trapped inside. These two arms stay in a closed position as the device begins to travel backward~~s~~ toward the start zone, dragging the items collected into the Asteroid Processing zone. With fine-tuning of the coding and a solid construction, the device should consistently score the maximum amount of points for each trial. This maximum score is 125 points per run, which is respectable given the device's ease of programming and construction.

Include figures and table inline with the text *or* place them at the end of the report. Don't mix styles.



Number and include figures and tables in the order that they are referenced in the text.

Figure 3: Final Design

III Problem Understanding

A little too form-centric. Could delete and start with 3rd paragraph.

A thorough analysis of the problem is required, before the construction begins, to allow for a smooth transition; knowing the contest rules, regulations, and details is important prior to designing the robot to ensure that the build is eligible for the Mission to Mars competition. Multiple design tools are useful for recognizing the challenges and all parts of the main problem.

The complexity of designing a working device becomes easier with the ~~help~~ use of a House of Quality, Specification Sheet and Function Tree which help~~s~~ ~~with~~ ~~breaking~~ to break down bigger objectives/problems into simpler, more achievable tasks. The combination of these tools will help to provide a good starting point during the designing process because it allows thoughts and ideas to be in a well an organized manner, rather than picking design concepts with no consideration of how they may relate to other aspects of the problem.

In the House of Quality, customer requirements are assigned a numerical value based on importance. The important requirements seen on the house of quality was a requirement that the device by no larger than 12”x18”x24” and to operate autonomously, so engineering characteristics were then formulated to

Reference and discuss the tools. More detail is needed for all of these. They support the choice of the final design.

best meet the requirements of the customer. In the Function Tree, ideas were formulated with increasing specificity, to break down each requirement to its most basic of steps. To continue with the previous example, autonomous operation, in the function tree, ideas were stated to show the increasingly detailed steps required to meet that customer requirement. Each of these design tools were used together to identify key steps necessary to design a product best suited for mission accomplishment.

IV Concept Evaluation

~~Because there are many different combinations of possible points awarded,~~ there is a great variety of design ~~elements~~ considerations for the device. Complexity is limited by a budget of $100, ~~and~~ the Sparkfun kit devices and components given by the professor. Three robot ~~concepts~~ designs were developed ~~,~~ and were somewhat iterative ~~from concept to concept~~. The robot ~~concept~~ design with the highest scoring potential was selected, mainly because it satisfied the customer requirements best in the Evaluation Matrix shown in Table 1. However, two alternative deigns were proposed and considered.

Wait until the Eval Matrix is discussed to mention it (after all designs are mentioned)

Number and include figures and tables in the order that they are referenced in the text.

The first alternative design, shown in Figure 1, is the simplest design. The bottom and top portions of the frame have identical dimensions, and the robot utilizes tow subsystems: the swinging arm and a delivery chute. This device is immobile and stays in the Start Zone. A stepper motor ~~first~~ spins the top arm 180 degrees to ~~then~~ form one long arm, and ~~then~~ the large DC motor turns the bottom arm swinging both arms 180 degrees as one 3-foot arm. A servo gate fixed to the bottom flooring of the chute opens once the arm is directly over the Mars Base. Once the servo opens, the Astronauts and flag fall into the Mars Base and then both arms spin back retracting to its starting position.

The second alternative design, shown in Figure 2, adds complexity. This design consists of two telescoping arms that retract inwards and outwards. The top arm has a box mounted to the end of it, which extends out over the Mars Base, tilting downward dropping both the flag and Astronauts into it. Once that task is complete, it ~~then~~ retracts back resting on top of the base. Another function of this design is ~~,~~ a bottom arm extending outward with a flat plastic piece mounted to the end, shown in Figure 2, which then retracts inwards once reaching the Mars Landing Zone. The arm begins dragging along the ground pushing the asteroids back toward~~s~~ the starting position and into the Asteroid Processing Zone. Once these two functions are complete, both arms should be retracted back into ~~its~~ their original positions

By examining the Evaluation Matrix in Table 1, it is clear why the chosen final design is superior. The first alternative design, which consist of the two rotating arms, can earn a maximum score of 80 points, because it starts and ends in the Start Zone and can drop the Astronauts and flag into the rotating Mars Base. Even though the second design was more complex and difficult to build than the first, it can earn a maximum score of 95 points because it can drop the Astronauts and flag into the Mars Base along with collecting the asteroids into the Asteroid Processing Zone and starting and ending in the Start Zone. Although these two designs were less complex, easier to build and coding took less time to complete, the final design was superior because it could complete all tasks and earn the maximum amount of points in the Mission to Mars Competition.

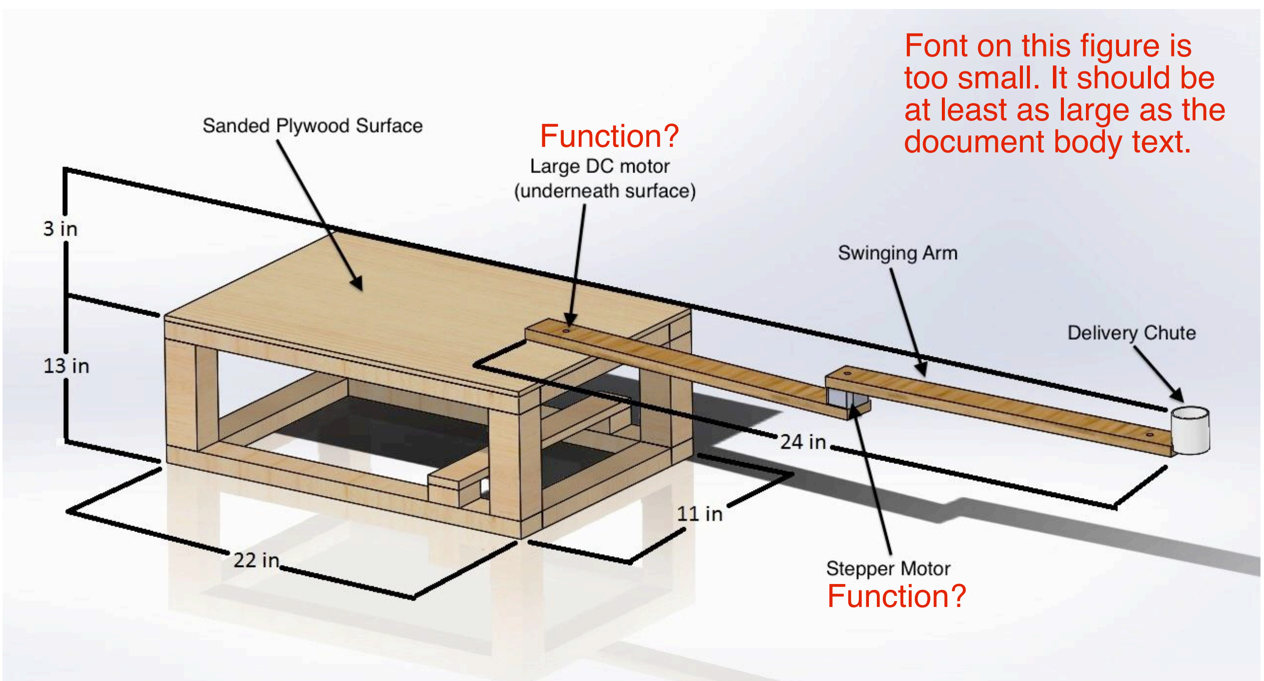


Figure 1: Alternative Design 1

Number and include figures and tables in the order that they are referenced in the text.

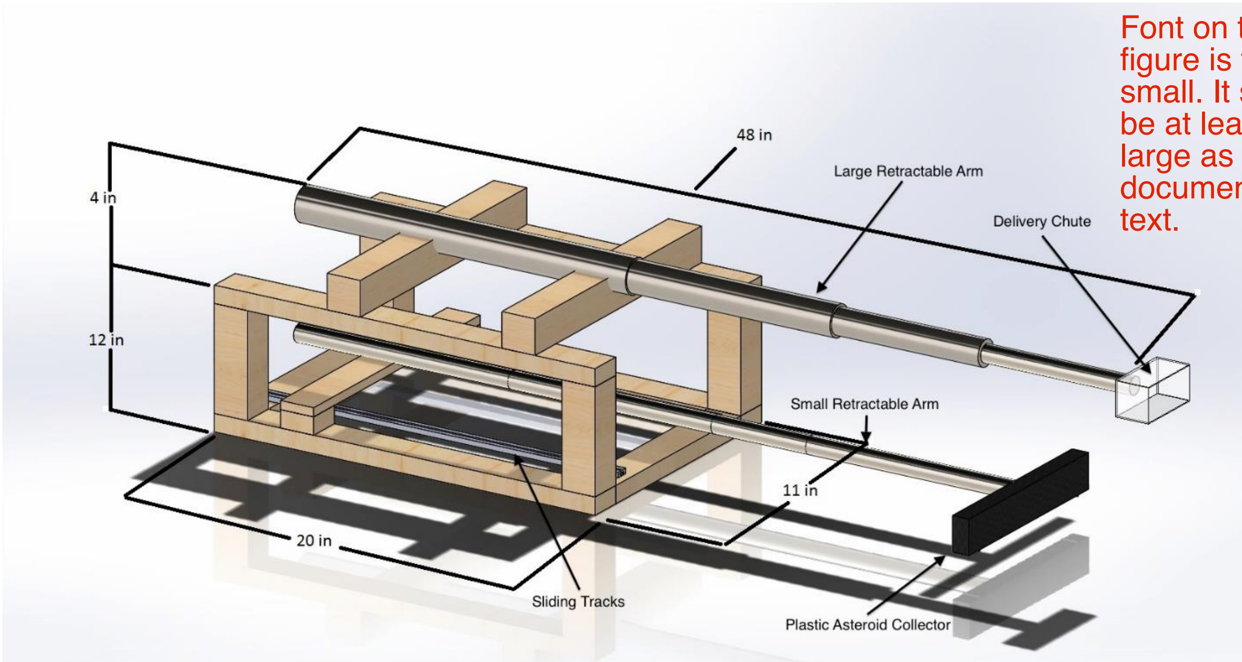


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Figure 2: Alternative Design 2

Table 1: Evaluation Matrix

Importanace	Customer Requirements	Final	Boom Arm	Stationary Swing Arm
	Autonomous navigation	5	0	0
	Less than 12 inches wide	5	5	5
	Less than 24 inches long	5	4	4
	Less than 18 inches tall	5	5	5
	Cost less than $100	5	5	5
	Transport astronauts to Mars Landing Base	8	3	3
	Avoid asteroids on the way to destination	8	3	2
	Return to port	8	10	10
	Collect fuel	8	0	2
	Complete mission safely	10	10	10
	Operate 3 times within 5 minutes	10	10	10
	Plant flag in landing zone	10	5	5
	Collect asteroids	8	2	0
	Dock successfully	8	2	2
	Easy to program	8	9	8
	Easy to construct	4	6	9
	Consistent performs well	9	3	6
	Achieve highest score possible	10	8	5
	Total	134	90	91
	Relative Total	6.70	4.50	4.55

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

V Design Performance Evaluation

In the Mission to Mars competition, the robot performed better than expected coming out 8th overall in the contest. The design completed the mission well in the first three runs, but ~~then~~ ran into obstacles in the final two runs. Some problems that were encountered included~~:~~ bumping into other robots which led to the device traveling off of ~~different from~~ its set path, parts burning out which made task and objectives harder to complete, unstable components becoming loose, and lack of power in the stepper motor. In the first run, the robot came out first, second run second and third run first. The Astronauts and flag were dropped each time in the Mars Landing Zone receiving the points rewarded for that completion. The device was only able to collect two to three asteroids and one pre-launched fuel due to low tension required in the string that was wrapped around the stepper motor, make into another sentence rather than use parenthesis (had to be low enough to allow for stepper motor to open). In the fourth run, the robot encountered two opponent devices at the Mars Landing Zone which prevented the robot from dropping the Astronauts and flag in the Mars Landing Zone. For the fifth and final run, the servo motor burned out and why? failed to release the Astronauts and flag.

The design of the robot had potential, but proved to be inconsistent in the competition. These inconsistencies led to problems in competition from unexpected obstacles. The use of wide reaching arms to gather items was a good idea when competing alone, but was problematic when running side by side with other robots with similar designs. The arms would collide and cause the robot to go off course. One event that was also not predicted was the servo motor burning out. Other factors that were not accounted for were asteroids being pushed into the team zone (less possible points able to be scored) and the smoothness of the track (~~although not entirely bad,~~ led to robot going farther than expected).

There were some issues that were expected in the event after testing the device on the track multiple times. The first issue expected was parts of the device breaking down or malfunctioning due to multiple runs of the competition. A small toolkit, two spare wheels, and extra components were brought in the occurrence of an accident. There was insufficient time to replace the motor before the final round. Another anticipated event was the difficulty of the boxing.

In order to account for this, the robot was made well under specification size. This allowed for quick and easy removal of the box before each round.

VI Conclusion

The final design that was chosen to compete in the Mission to Mars competition performed well and made it to the consolation round. Problems arose that were not anticipated in the contest that stopped it from scoring the maximum points. The alternative designs were passed over when considering the final design because of how well theoretically each could perform. Engineering characteristics, customer requirements, and required specifications were all considered when coming up with the final design. Overall the final design completed the mission and was evaluated post competition to see what could have been improved and what design adjustments needed to be made.

name them

Need to include key results (final score? judging score? assumptions, etc.)

All specifications should have numerical targets.

Number and include figures and tables in the order that they are referenced in the text.

Table 2: Specification Sheet

	Mission to Mars - Team B7 Specification Sheet			3/15/2017 Page 1
Changes	D/W		Responsibility	Source
3/15/2017	D	Autonomously Deliver 5 Astronauts to Mars Base	Team 3	
		Geometry		
3/15/2017	D	Cannot exceed 24" x 12" in width and length No wants/ wishes on device size?	Tyler Devillier	Vaughan
3/15/2017	D	Cannot exceed 18" in height	Tyler Devillier	Vaughan
3/31/2017	W	Must be able to box in no longer that 30 seconds	Hunter Dooley	Team B7
		Kinematics		
3/15/2017	W	Efficient movement of all components Numerical target?	Tyler Devillier	Team B7
3/15/2017	W	No interference in the movement of components	Tyler Devillier	Team B7
		Materials		
3/15/2017	D	Material weighs no more than 10 ounces	Tyler Devillier	Team B7
3/15/2017	W	Material stiffness suitable for weight of components	Tyler Devillier	Team B7
3/15/2017	D	High strength to weight ratio for components Numerical target?	Tyler Devillier	Team B7
3/31/2017	W	Materials cost no more than 75% of alloted budget	Tyler Devillier	Team B7
		Energy		
3/15/2017	D	Uses potential or electromagnetic energy	Team B7	Vaughan
3/15/2017	D	Uses provided electromagnetic components only	Team B7	Vaughan
		Assembly		
3/15/2017	D	Initial setup completed in less than 4 minutes	Team B7	Vaughan
3/15/2017	D	Can't use stored energy excluding gravity	Tyler Devillier	Vaughan
		Maintenance		
3/15/2017	W	Must be durable for several iterations	Team B7	Team B7
3/31/2017	D	Must be able to reset in less than 5 seconds	Team B7	Team B7
		Safety		
3/15/2017	D	Must be able to operate safely as to not injure bystanders	Trey Bonin	Vaughan
3/15/2017	D	Must not damage self or surrounding areas	Hunter Dooley	Vaughan
		Cost		
3/15/2017	D	Cannot exceed a budget of $100.	Trey Bonin	Vaughan
3/31/2017	D	Must not use any motors not included in kit	Team B7	Vaughan
		Operation		
3/15/2017	D	Must complete all tasks orderly and logically	Hunter Dooley	Vaughan
3/15/2017	W	Accurately-timed functions	Hunter Dooley	Team B7
3/31/2017	D	Read complete/incomplete circuit	Tyler Devillier	Vaughan
		Forces		
3/15/2017	W	Provide the forces necessary to collect fuel into zone	Trey Bonin	Team B7
3/15/2017	W	Provide the forces necessary to collect asteroids into collection area	Trey Bonin	Team B7
3/15/2017	W	Provide the forces necessary to deliver payload into landing zone	Trey Bonin	Team B7
3/15/2017	W	Provide the forces necessary to plant flag on objective area	Trey Bonin	Team B7

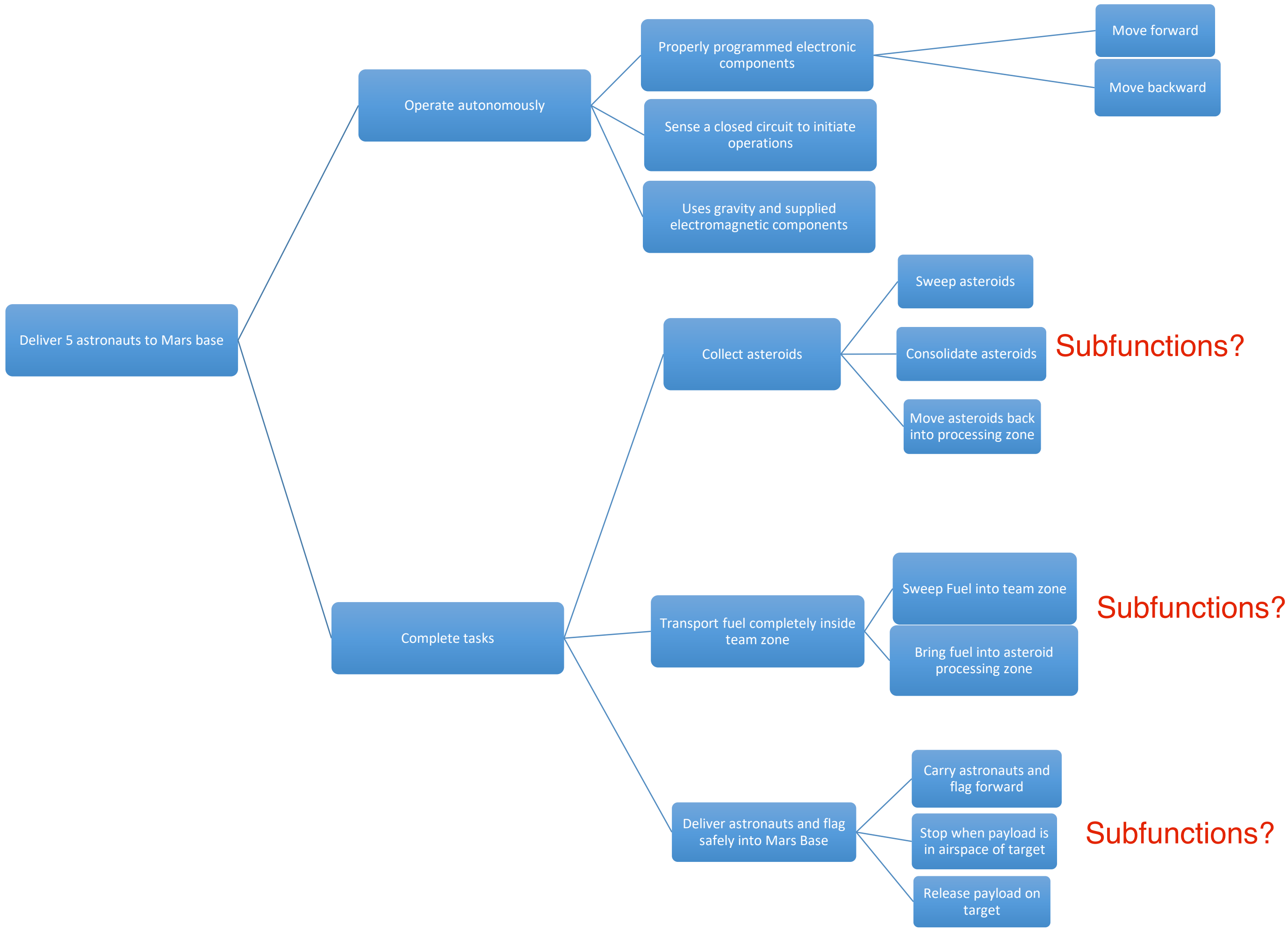


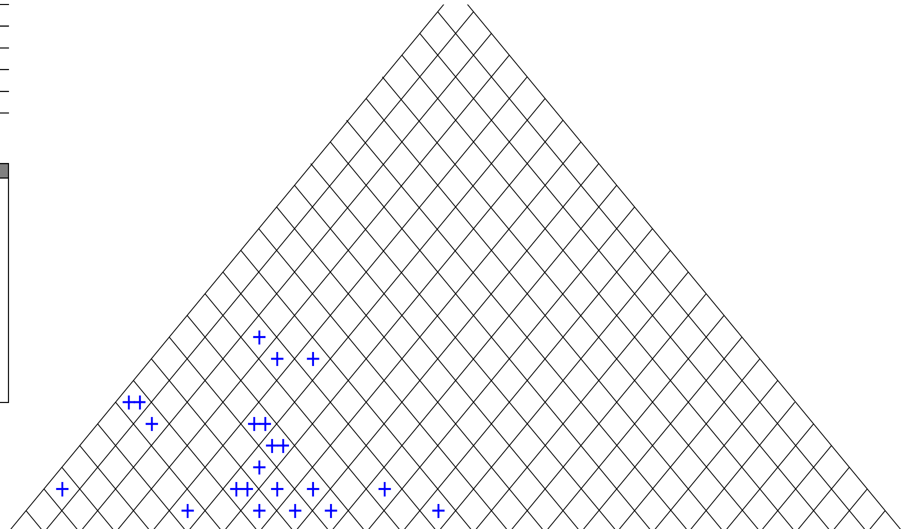
Figure 4: Function Tree

Table 3: House of Quality

Expand

Legend		
Θ	Strong Relationship	9
O	Moderate Relationship	3
▲	Weak Relationship	1
++	Strong Positive Correlation	
+	Positive Correlation	
−	Negative Correlation	
▼	Strong Negative Correlation	
▼	Objective Is To Minimize	
▲	Objective Is To Maximize	
x	Objective Is To Hit Target	

Engr. Char. should be solution neutral.



Of what?

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality (a.k.a. "Customer Requirements" or "Whats") / Quality Characteristics (a.k.a. "Functional Requirements" or "Hows")	Arm Size	Length	Width	Height	Cost of build	Sweeper size	Travelled Distance	Target score	Trial time	Number of sensors	Setup time	Storage capacity	Weight of build												
				Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
				Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)	▲	x	x	x	▼	x	x	▲	▼	x	▼	▲	x												
1	9	7.2	9.0	Autonomous navigation	Θ							O	O	O	▲														
2	9	7.2	9.0	Less than 12 inches wide	Θ		Θ		▲							▲	▲												
3	9	7.2	9.0	Less than 24 inches long	Θ	Θ			▲	O						▲	▲												
4	9	7.2	9.0	Less than 18 inches tall	Θ			Θ	▲								▲												
5	9	7.2	9.0	Cost less than $100	▲	▲	▲	▲	Θ					▲			▲												
6	9	5.6	7.0	Transport astronauts to Mars Landing Base	Θ	▲					▲	Θ	O	O															
7	9	4.0	5.0	Avoid asteroids on the way to destination							O	Θ	O	O		▲													
8	9	6.0	7.5	Return to port							Θ	Θ	O	▲															
9	9	4.0	5.0	Collect fuel			Θ			O	▲	Θ		▲															
10	9	2.4	3.0	Complete mission safely	Θ						▲																		
11	9	5.6	7.0	Operate 3 times within 5 minutes							▲		Θ		O														
12	9	4.4	5.5	Plant flag in landing zone	Θ	▲					O	Θ	O	O		O													
13	9	4.4	5.5	Collect asteroids		▲					O	Θ	O	Θ		O													
14	9	4.8	6.0	Dock successfully	O	▲					O	Θ	O	▲															
15	9	6.4	8.0	Easy to program	Θ						O	▲	O	O															
16	9	6.4	8.0	Easy to construct	Θ	▲	▲	▲	▲	O				▲		▲	O												
17	3	5.6	7.0	Consistent performs well	O						▲	O	O	▲															
18	9	4.0	5.0	Achieve highest score possible	Θ					Θ	▲	Θ		▲															
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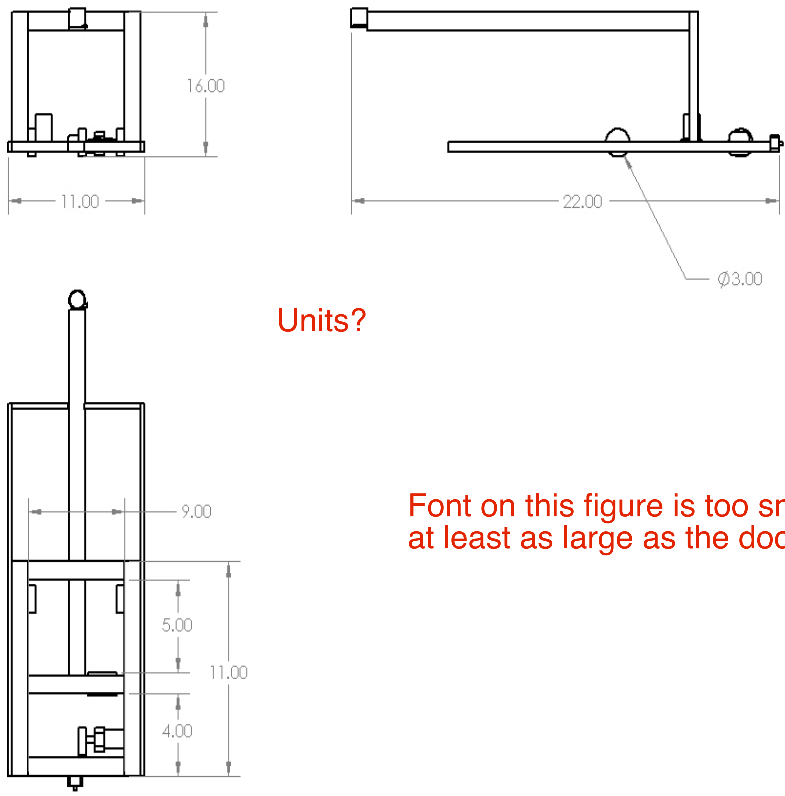
				Target or Limit Value																									
				Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)																									
				Max Relationship Value in Column	9	9	9	9	9	9	9	9	9	9	3	3	3												
				Weight / Importance	562.7	98.0	114.9	78.7	93.2	89.2	153.8	381.1	196.4	161.0	24.1	51.4	48.2												
				Relative Weight	27.4	4.8	5.6	3.8	4.5	4.3	7.5	18.6	9.6	7.8	1.2	2.5	2.3												



Units?

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Figure 5: Dimensions of Final Design