Team N-MCHE 201

Final Report

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need at least 1-2 sentences to introduce the competition...the reason you made the robot

Abstract:

what are some engineering challenges?

This report details the concept evaluation process used for a robot. The problem was defined using the House of Quality. The customer requirements are rules for the contest and are weighed against the engineering characteristics of the robot. These engineering characteristics size dimensions of the robot and the robots average speed. These engineering characteristics fulfill the customer requirements and provide solutions to the problem. Other tools such as the Specification Sheet and the Function Tree guide the design process and ensure that these customer requirements are met. An example would be a goal for average speed in the Specification Sheet and by meeting this goal, the robot fulfills the customer requirement of completing the contest within a set time frame. The Sweeper robot is the final design which travels forward and backward and collects asteroids, fuel, and delivers the astronauts and flag with a series of motorized and falling arms. The evaluation matrix picks out the best design out of several prototypes. The Sweeper Robot had the highest score in the evaluation matrix and is the best solution to the problem considering the customer requirements and the rules and the guidelines set by the contest. Overall, the final design placed ninth in the final contest. Judging results?

what does this sentence mean?

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

INTRODUCTION:

Due to the need for constant advancements in space exploration and travel, it is important to keep fueling the advancement with capable engineers and scientists. A contest embodies this test of ingenuity and knowledge by pitting an autonomous robot against a simulated space mission and evaluating it on a numerical scale. With limited size and time, the robot must complete the tasks while interacting with other robots and score the highest to be declared the winner. The problem, however, is how an autonomous robot can be designed so that it earns every point in the contest, adheres to the rules and guideline of the contest, and is robust to abnormalities and changes in the environment.

The challenges associated with the problem revolve around the point system. To earn all the points, each task must be fully completed within a thirty-second-time frame and includes delivering astronauts, placing a flag in the Mars Base, collecting asteroids, collecting fuel, and returning to Earth. Each task has a point value that corresponds to how well the task was completed. For example, each astronaut delivered to the Mars Landing Zone earns the robot five points. However, an additional five points can be earned if the astronaut lands in the rotating Mars Base, making the total per astronaut rise to ten points. In addition to bonus points, some tasks have penalties such as the collecting asteroids. For each asteroid completely contained in the Processing Zone, five points are added to the robot's score. On the other hand, five points are deducted if the asteroids are in the robot's mission zone and are not in the Processing Zone and zero points can be earned if the asteroid is removed from the mission zone completely. Planting the flag in the Mars Landing Zone earns the robot ten points if the flag is fully contained in the designated area. Each fuel completely collected in the mission zone earns the robot ten points and once a fuel has been collected, the robot may leave its mission zone by any means for an additional twenty points.

In addition to these tasks that strictly define the robot's success, it must also avoid being disqualified by following a set of rules including a set of maximum dimensions, limited set up time, and a limited number of motors and actuators. If any of these rules are broken, the robot automatically fails because it cannot complete the tasks at all. The point system and the rules act as the challenges for the robot and are the focus point of robot so that its functionality maximizes points earned and still follows the rules. The next section of the report will talk about the final design and its functionality followed by a section that discusses the problem understanding and how the criteria for the robot's design were developed. Following the problem understanding section is a section on the two alternate designs and how they compare to the final design. The report is wrapped up with a section about the performance of the final design in the contest and a conclusion section to recap the report.

What are the engineering challenges?

informal

FINAL DESIGN:

The final design is a robot that can complete each task in a competition setting against other devices. The robot can be placed in the starting area and activated remotely with a start button and perform each of its tasked in a timed, sequential order to remain within the thirty-second-time frame. As seen in Figure 1, The Sweeper Robot has a front axle that is powered by a large DC motor which propels the robot forward to reach the Mars Landing Zone. While it is moving forward, its wooden arm tucked under the base opens to one hundred and twenty degrees and collects the fuel and the asteroids in a

give names reflecting functionality and match to figures compartment under the robot. The robot is equipped with another wooden arm mounted to a stepper motor that flips the basket over and delivers the astronauts and the flag into the Mars Landing Zone and potentially the Mars Base. The large DC motor can also move the robot backward to transport the asteroids to the Processing Zone and to drive the robot off the mission zone. The robot can easily be reset as the code allows for it to return to its starting position when it finishes its trial which cuts down on set up time by eliminating the need to be boxed to check its size. Also, the precise timing of the device eliminates the need for sensors that could potentially be triggered by other robots and interfere with the robot's functionality. This makes the robot robust to any possible competing robot that could throw something in front of a sensor and trigger an action too early. The tires on the robot are high enough to prevent the robot from rubbing on the ground and getting stuck as the track is not perfectly level everywhere. Again, this makes the design robust and able to compete in any conditions and from any starting position.

PROBLEM UNDERSTANDING:

A House of Quality is used to determine the problem and some of the guidelines for the design. The House of Quality organizes customer requirements and engineering characteristics and evaluates them on a scale of importance. The customer requirements are guidelines or demands set by the consumer of the design and the engineering characteristics are the measurable aspects of the design. For example, in Table 1, the House of Quality shows that the most important engineering characteristic is the width of the robot. This means that the width of the robot affects many customer requirements and is important to the success of the design. Therefore, the width of the robot should be under twenty-four inches so it fulfills the customer requirements associated with it and fulfills the dimensions set by the rules. Some key customer requirements include precise positioning, not exceeding dimension limit, and final cost of design within the set budget. These customer requirements are affected by the width of the design which supports the importance of that engineering characteristic. By following this process with every engineering characteristic and balancing them with respect to their importance to the requirements, all the customer requirements will be met and the design can be revised into a final design. not necessarily

Be more concise here, so you can spend more space discussing specs. of this design problem

A Specification Sheet is used to document the numerical goals for the design and to create a checklist to ensure that the design is meeting the customer requirements. Because the goals are numerical, measurable quantities, they are easy to check. These goals come from the customer requirements and engineering characteristics from the House of Quality which means that if the design meets the goals, it is a successful design. Table 2 shows the Specification Sheet and the various goals associated with the design. Each goal is divided into two categories: demands and wants. The demands are goals that represent the ~~bare~~ minimum required to fulfill a customer requirement and must be met if the design is to be considered for the final selection. For example, a demand of the design is to be under eighteen inches in height to avoid disqualification from the contest. ok The wants are improvements on the demands and are not required to be met for the design to be successful. For example, a want for the height of the robot would be to make it sixteen inches tall which would make the dimension-checking process easier. The more wants that are fulfilled in addition to the demands, the better the design will be at fulfilling the customer requirements.

A Function Tree is used to break up the large, difficult task into several manageable tasks. The Function Tree used in the design is shown in Figure 2 and divides the tasks required to make an autonomous robot that can compete in the competition into various level of complexity. For example, near the top of the function tree is the “Collect Asteroids” task. This task is difficult to handle at once and has been broken down into three easier sub-tasks which take up a lower row of the function tree. These tasks are not only easier to handle but will also complete the “Collect Asteroid” task once they are completed. Once all the sub-tasks have been complete, the robot’s functionality is complete and the process of designing different prototypes can begin.

be specific, give examples of subfunctions

CONCEPT EVALUATION:

The Sweeper Robot, which is shown in Figure 1, is not the only prototype. Figure 3 shows The Boxer Robot, which utilizes a set of arms that are powered by servo motors and can open to thirty degrees. This allows the Boxer to open its arms and use the metal sheets attached to the ends to close behind the asteroids and box them in a small space. The Boxer also utilizes a different delivery system for the astronauts and flag as they are placed on the loose bench above the arms. When the robot impacts the Mars Landing Zone, the bench launches forward using the momentum provided by the robot and lands in the Mars Landing Zone. The asteroids can also be easily transported to the Processing Zone using the enclosure created around the asteroids and moving the robot backward with its motor driven gear and axle. Figure 4 shows the final design prototype; The Scrapper Robot. This robot style has a metal guard that scrapes the asteroids close to the body of the robot and allows the robot to know precisely where the asteroids are located for their precise transportation. The Scrapper also uses a motor and a wooden arm to launch the astronauts out of a basket much like The Sweeper Robot.

The three robots share many of the same basic functions, but utilize different mechanical systems to perform the actions. The Sweeper Robot, however, is better than both the Boxer and the Scrapper in that is it equipped to collect both fuel and asteroids easily without the need of steering or interaction with other robots. This allows for the maximum amount of points to be earned during the contest and represents the ideal solution to the problem at hand. Table 3 shows the Evaluation Matrix and how each robot compares to each other with respect to the customer requirements. Each robot earns a score based on how well it fulfills a customer requirement and how important the customer requirement is. Using the total of all three robots, a relative total is calculated and the relative total determines which robot is the best at solving the problem and succeeding in the competition. Again, in Table 3, the relative total for The Sweeper Robot is the highest out of the three designs which means that The Sweeper Robot is the best design to compete in the competition. Therefore, The Sweeper Robot is chosen as the final design.

relate this to the eval. matrix.

Why? What cust. req. is it better at? Expand this discussion to better support the choice of your design.

DESIGN PERFORMANCE EVALUATION:

informal

The robot’s performance in the contest was lackluster overall. With a ninth-place finish, the Sweeper failed to perform. The main cause of the problem was a failure to reset the robot properly as some of the parts shifted after a hard impact with the ground when the robot rolled off the track. However, the assumptions made about the contest and the robot itself were still correct. The first round of the

Every assumption made was correct?

contest was a first-place victory, but the next two rounds were a third and fourth place rankings which shows the difference in the slight displacement of one mechanical part. Had the problem been detected, the robot would have easily won in the second round, securing it a higher standing in the rankings.

Judging results?

CONCLUSION:

engineering challenges?

In conclusion, the problem was solved through a study of the guidelines and rules of the contest and applications of the project planning tools. The House of Quality defined the important engineering characteristics that affected the customer requirements such as the size dimensions and the robot's speed. The Specification Sheet set goals for the robot to achieve to fulfill the customer requirements such as being under twelve inches in width and moving faster than four meters per second. The Function Tree defined the basic functions for each robot and provided a basis for building each robot. Each design used these trivial tasks, such as moving forward or swinging an arm, to build up its functionality and complexity until it could complete the contest and solve the problem. The Sweeper robot could travel forward and backward and collect asteroids by way of swinging flexible arms and capturing the asteroids for transport. The robot could also throw the astronauts into the center with another arm and collect fuel to return to Earth with a drop-down arm. The Evaluation Matrix decided which design was the best. The Sweeper Robot received the highest total in the Evaluation Matrix and thus it is chosen as the solution to the problem. Overall, the final robot design placed ninth in the contest.

better to label parts with a name reflecting functionality

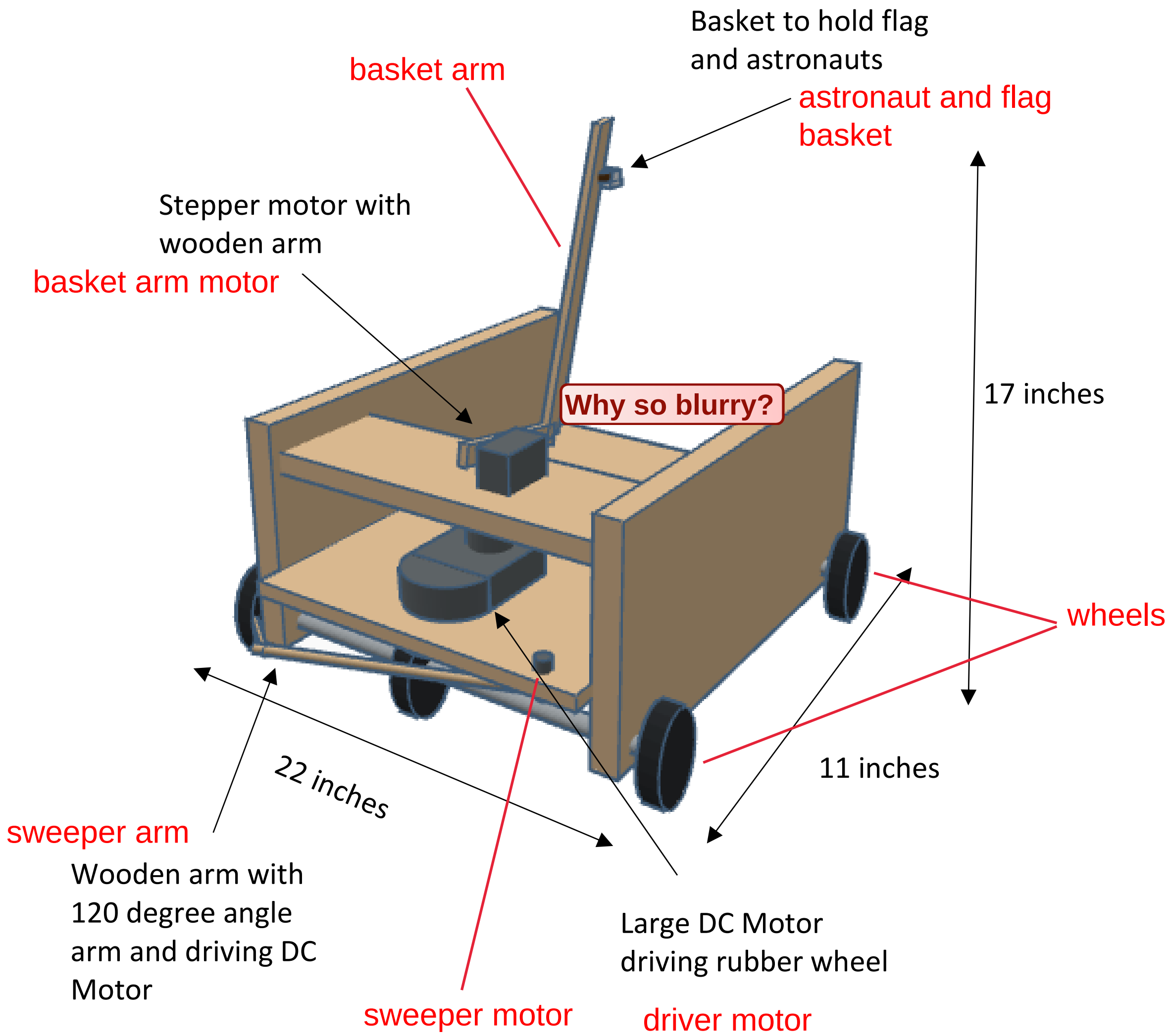
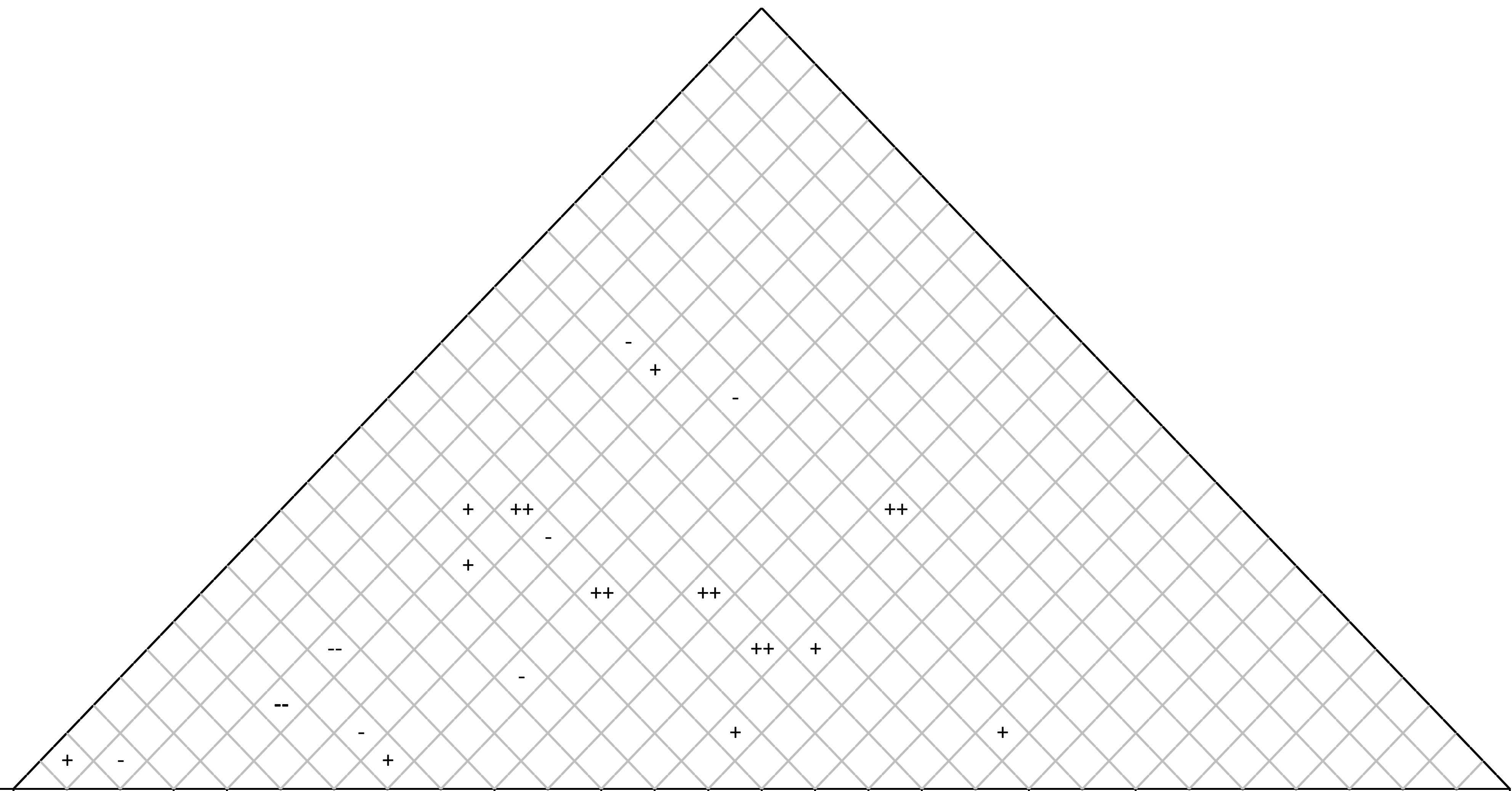


Figure 1 – The Sweeper Rover

Table 1 - House of Quality

Caption font should match the document body text.



Importance	Customer Requirements	Length of robot < 12 inches	Height of robot < 18 inches	Width of robot < 24 inches	Number of sensors	Large motor RPM	Weight of Robot	Set up time	Time to complete run	Total cost	Maximum possible score	Build time	Volume of collected items	Power supply wattage	Distance sensors can reach	Average speed of robot	Consistancy of preformance	Number of task able to complete	Small motor RPM	Distance from bottom of robot to ground	Maximum distance robot can travel	Number of wires	Maximum supported weight
	Direction of Improvement	X	X	X	▲	▲	▼	▼	X	▼	▲	▼	▲	▲	▲	▲	▲	▲	▲	▼	▲	▼	▲
6	Electrically powered			▣	◉	◉				▣				◉		△			◉			◉	
9	Operate autonomously			△	◉		▣	▣	△	▣	▣				◉		▣						
9	Cost is within budget	▣	▣		▣		▣			◉				▣	▣				▣				
5	Repeatable functions							◉	△									△			▣		
6	Find and retrieve beacons				◉			◉	▣		◉		◉				△	◉					
5	Precise positioning	◉	▣	◉	◉	▣	△			▣					◉		◉	▣		▣			
7	Drive forward and backward				▣	▣	△									△				▣		△	
8	No damage to track																						
9	Run within allowed run time								◉					▣		◉	▣	△	◉				◉
4	Deliver astroids to processing zone										◉		◉				△	◉					
3	Determine location of beacons				◉				△				△		◉		▣	▣			▣		
6	No explosive reactions										△												
8	Set up within allowed time	▣	▣	▣				◉	△			▣						△				△	
9	Does not exceed dimension limit	◉	◉	◉				△			△	▣								◉			
7	Determine distance to landing zone				◉				△						◉			△					
8	Finish building in time for competition	▣	▣	▣								◉											
6	Does not damage other robots										△					△					△		
7	Deliver astronaut to mars base										◉		▣				△	◉	△				△
6	Put flag on mars base										◉		▣				△	◉	△				
6	Collect fuel										◉		◉				△	◉	△				△
7	Finish round outside of zone	▣									◉					△	△	◉	▣		◉		△
		254	201	223	388	102	84	216	137	161	381	140	199	126	252	107	165	385	218	129	101	69	101
		6.14%	4.86%	5.39%	9.37%	2.46%	2.03%	5.22%	3.31%	3.89%	9.21%	3.38%	4.81%	3.04%	6.09%	2.59%	3.99%	9.30%	5.27%	3.12%	2.44%	1.67%	2.44%

4139

why include if nothing listed?

be careful of line types

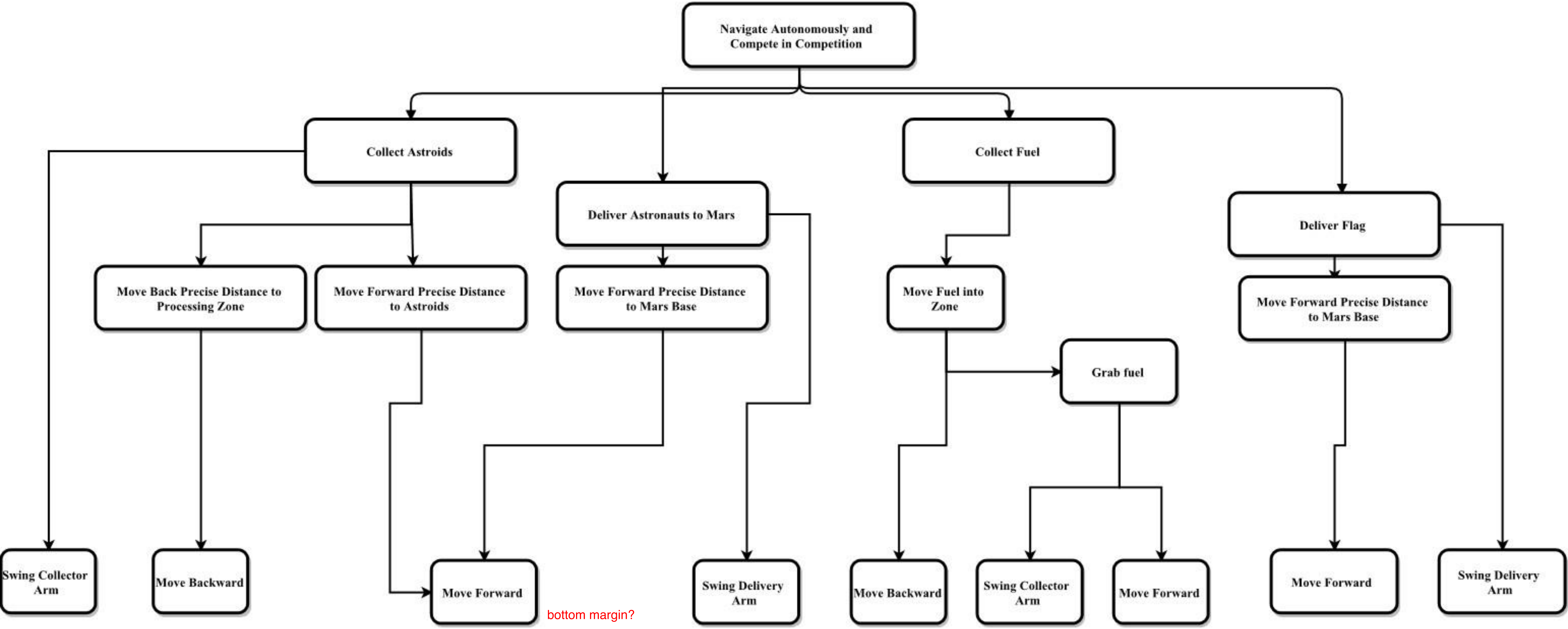
◉	Strong	▲	Maximize	++	Strong Positive
▣	Medium	▼	Minimize	+	Positive
△	Weak	X	Target	-	Negative
				--	Strong Negative

TABLE 2 - Specification Sheet

why include if nothing listed?

		Specification for:	Issued:	3/10/2017
		Final Project	**Page 1 of 1**	
Changes	**D/W**	**Requirements**	**Responsibility**	**Source**
		A robot that can compete and win in competition.		
		Geometry		
	W	No more than 16 inches tall	Team	Sam
	W	No more than 22 inches in length	Team	Sam
	W	No more than 10 inches in width	Team	Sam
	D	No more than 18 inches tall	Team	Dr. V
	D	No more than 12 inches in width	Team	Dr. V
	D	No more than 24 inches in length	Team	Dr. V
		Kinematics		
	W	Run at 4 m/s	Team	Conner
		Forces		
	W	Withstand a 100N impact	Team	Conner
		Energy		
	D	Must be powered for 30 seconds	Team	Dr. V
		Materials		
	D	Use only the extra materials given and at most $100 more	Team	Dr. V
	D	Use no more than 3 SparkFun kits	Team	Dr. V
		Safety		
	D	No intentionally harmful parts	Team	Dr. V
	D	No explosives	Team	Dr. V
		Ergonomics		
	D	Must run autonomously	Team	Dr. V
		Quality Control		
	W	Robot is 100% consistent	Team	Sam
		Assembly		
	D	Must be setup within 3 min 45 sec	Team	Dr. V
	W	Can be setup within 3 min	Team	Conner
		Transport		
	W	Transport 5 Lego men to the mars landing zone	Team	Jonmichael
		Operation		
	D	Run all tasks in the round in no more than 30 seconds	Team	Dr. V
		Maintenance		
	W	Robot is tested 3 days before each competition	Team	Conner
		Recycling		
	D	All competition components on board are resuable	Team	Dr. V
	D	Mechatronics kit has 0 broken parts after competition	Team	Dr. V
		Costs		
	W	Spend no more than $50	Team	Jonmichael
	D	Spend no more than $100	Team	Dr. V
		Schedules		
	W	Finish building robot by Preliminary Competition	Team	Dr. V

This is not a Function Tree. Please review and see one of us if you have questions.



bottom margin?

better to label parts with a name reflecting functionality

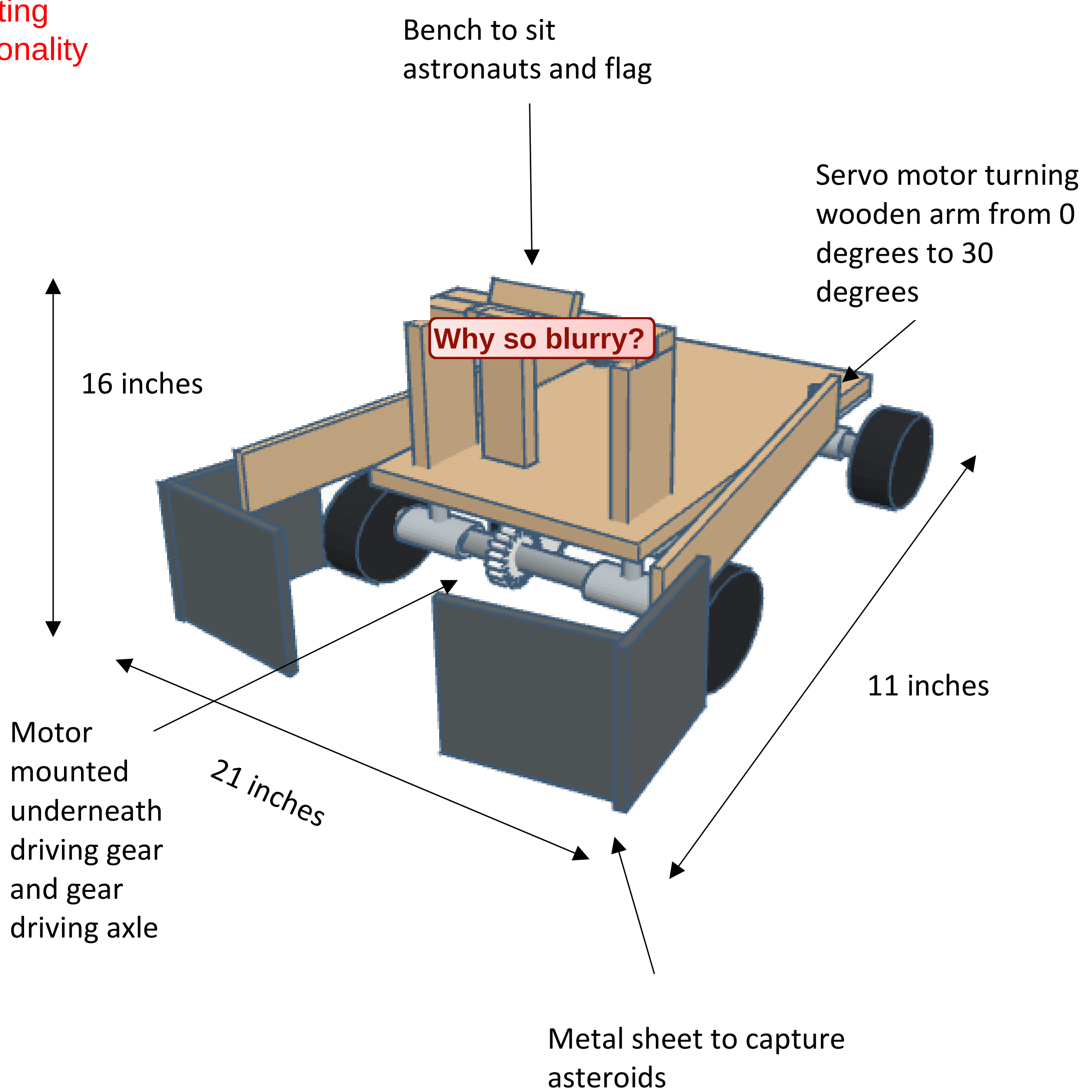


Figure 3 – The Boxer Rover

better to label parts
with a name
reflecting
functionality

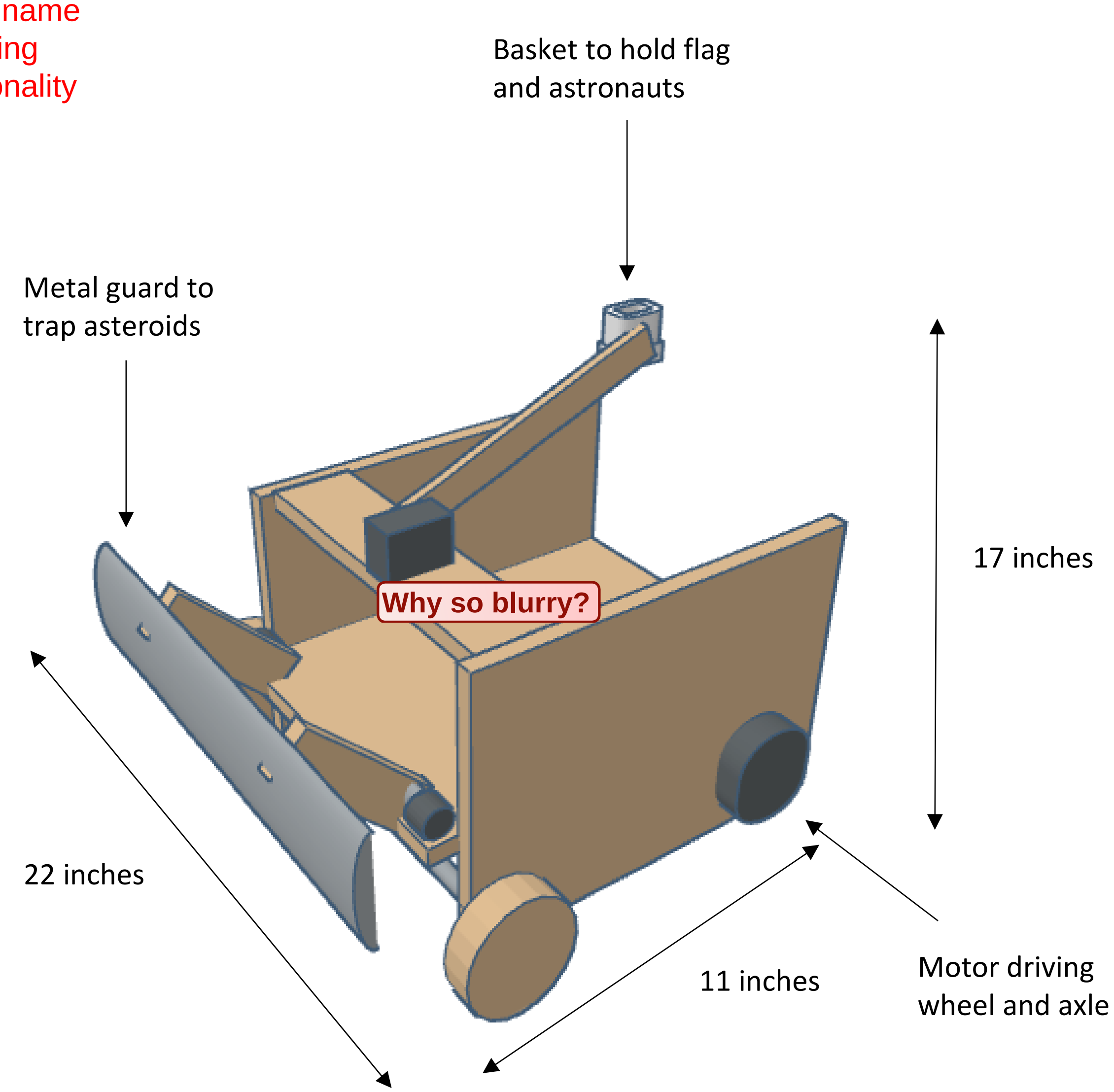
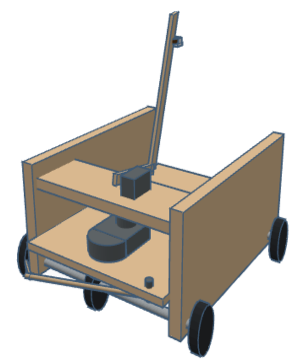
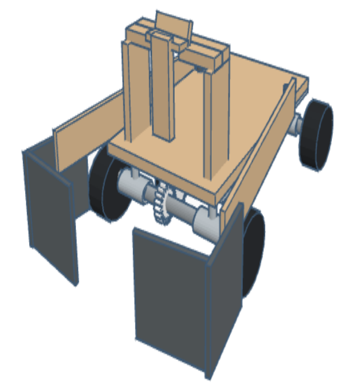
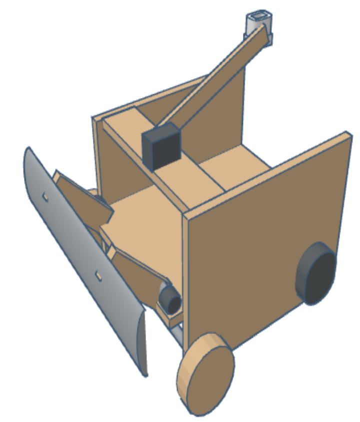


Figure 4 – The Scraper Rover

Table 3 - Evaluation Matrix Comparing the Three Designs

		1	2	3
				
Importanace	**Customer Requirements** These should match those in the HoQ.	The Sweeper Rover	The Boxer Rover	The Scraper Rover
9	Operate autonomously	7	7	7
6	Find and retrieve beacons	3	8	5
8	No damage to track	9	7	5
7	Drive forward and backward	8	9	7
3	Determine location of beacons	8	5	5
8	Set up within allowed time	6	6	8
9	Does no exceed dimension limit	8	8	8
5	Reapeatable functions	7	6	6
7	Determine distance to landing zone	6	6	5
7	Deliver astronauts to mars base	5	9	7
6	Plant flag on mars base	9	9	7
6	Collect fuel	6	5	6
	Total	**603**	**578**	**525**
	Relative total	**0.35**	**0.34**	**0.31**

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