Star Wars Contest and Concept Evaluation

MCHE 201: Engineering Design

Fall 2017

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What's going on with the spacing between your letters?

Avoid... This is basically = "we"

Abstract: — put on new page

The Star Wars competition is a contest in which Engineering students are asked to construct a robot that autonomously and electronically is able to move objects and place them in the correct positions. If these objects are in the correct position then the team receives points for it. In order to get these points, the team has to review several designs and choose which one would fit with the specifications of the game. After two alternative designs, a final design is choose that can complete this tasks. The theme of the competition is Star Wars, therefore all of the objects' names are associated with Star Wars. For example, aluminum foil balls will represent the force, sponges will represent TIE fighters and so on. The chosen design is capable of moving these objects in the right position using mechanisms, electronics, and a coding language. The design is composed of three fundamental parts: a force collecting gate that

will enclose the force units, two TIE fighter removers that extends by the tension of strings capable of sliding the TIE fighters of the board game an L shape arm or proton torpedo deliverer that goes over the exhaust port and releases the torpedo/key chains. Furthermore, the construction of the design was based on usage of the house of quality, specification sheet, function tree and an evaluation matrix. These design tools were utilized in order to gain a complete understanding of the problem and to make an ultimate choice on the final design.

Final contest results?

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

I. Introduction:

Engineering students were asked to design a robot capable of operating electronically, by program. This is not a simple task for the students since they had to learn various skills which include using sensors, electric motors, and writing codes for the device to operate. Students were provided with python coding language, a pyboard, which runs the code and transfers information to the DC motors and sensors. With these provided tools engineering students then needed to create a design capable of completing every task. These designs will contain mechanisms that are operated autonomously by the pyboard and the coding language. More specifically, the robots will need to place the "Proton Torpedoes", also known as the keychains, in the "death star" or "exhaust port", learn how to "use the lightsaber and the force" by placing the bowling pin and tennis balls on the jedi training zone (a 6'' by 2' rectangular zone), "save droids" (plastic toy blocks) by placing them completely into the team's zone, and finally destroy the "TIE fighters" (sponges) by knocking them out of their zones. To accomplish all of these tasks, several alternative designs were reviewed until an ultimate design was chosen that is simple and could potentially get the most amount of points. The design consists of various main components: torpedo deliverer or arm that extends on top of the exhaust port at the robot's proximity, side wings or TIE fighter removers that also extends out, a force collecting gate that encloses the force units and wheels capable of moving the robot close to objects. Saving the Droids or toy blocks were not a concern since the final design focus mostly on the tasks mentioned above. The

Talk about the design, not the class.

What are the engineering challenges?

This does not belong in the introduction.

Number all pages starting with the introduction section.

robot's components were analyzed and tested for the completion of every task successfully. Their functionality is simple and optimal.

End intro with "roadmap" sentence(s)

II. Final Design:

This sections needs to be much better organized.

The final conceptual design moves forward and backwards to approach the objects. When the robot moves forward, it pushes the bowling pin slightly so it can remains upright. The robot is also programmed to move a certain distance in which the device stops exactly when the pivot mechanism of the torpedo deliverer makes contact with the edge of the exhaust port delivering the torpedoes in it. After a few movements, the robot comes at rest then move backwards in position to drop the force collecting gate that will enclose the force units. When the force collecting gate is dropping, it pulls on the two strings that allows the TIE fighter removers to open. Then, the robot moves backwards again with the force units within the force collecting gate and with the TIE fighter removers in open position. While the robot is moving back to the start zone, the TIE fighter removers push the TIE fighters (sponges) off the board, while the device gets back to start zone. The full view of the final design is shown in Figure 1. reference earlier in paragraph

Move figures/tables to top or bottom of column

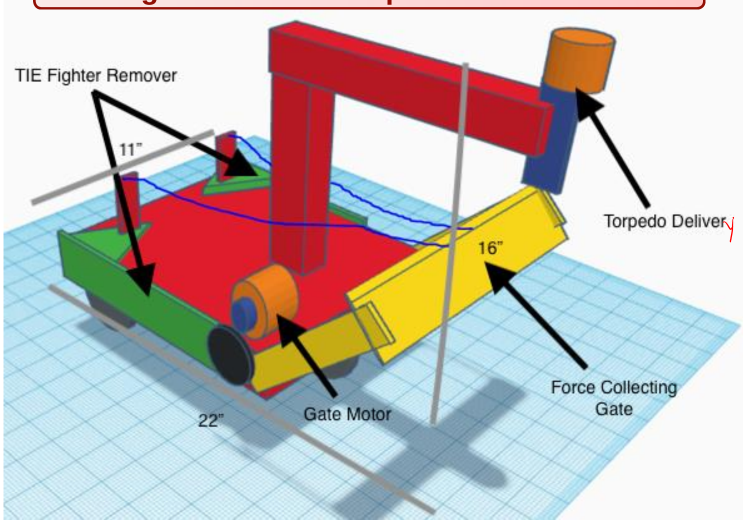


Figure 1: Full view of the robot

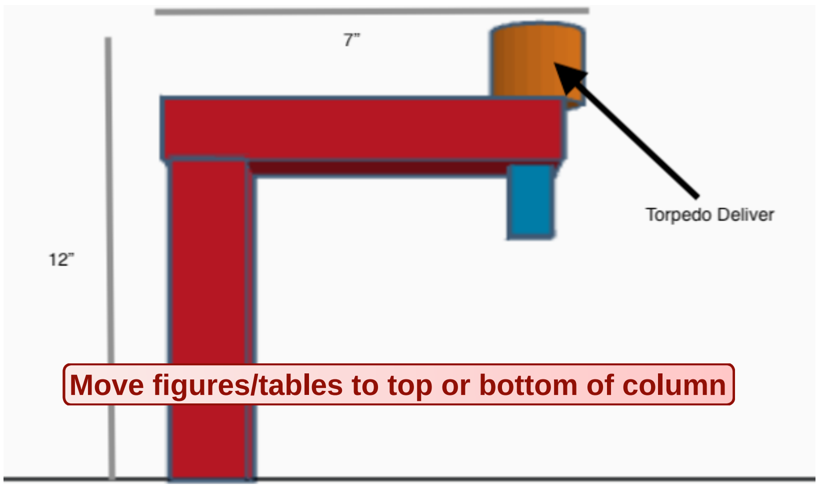
The final design was chosen because of its simplicity and its optimal capacity of getting the most amount of points. This final design consists of a platform that holds the force collecting gate, an L-shaped arm defined as the torpedo deliverer, and two side wings defined as the TIE fighter removers. The robot also contain wheels that allow it to move and approach the objects. The force collecting gate goes from about a 90 degree angle to a 0 degree angle, allowing the force collecting gate to enclose the force units. The bowling pin will also be enclose within the force collecting gate. The force collecting gate operates with a small DC motor that has a gear attached to the axle. The rotation of the DC motor's gear will rotate another gear connected directly to the the frame of the force collecting gate. The force collecting gate is made out of sheet metal, wood and paint brushes. Sheet metal is a light and strong material that could be cut and bend easily for the making of the force collecting gate. The gate also has a frame made out of wood enclosed by the sheet metal. The paint brushes were utilized to compose the bottom of the gate. The purpose of the paint brushes is to ensure that when the gate drops the bristles of the

Save for concept evaluation section

Maintain consistent tense

brushes bend at contact of any surface making it easy for the gate to enclose the force units. The probability of getting more force unit balls are higher with the usage of the brushes because the bristles can slight push them inside the gate. The force collecting gate is shown in figure 1.

The torpedo deliverer will be composed of a L-shaped wood arm long enough to reach the exhaust port when the robot approaches it and a pivot mechanisms that drops the key chains (torpedo protons) inside the exhaust port. The pivot mechanism has a cup that will contain the torpedoes and lever arm attached to the bottom of it. This lever arm will be attached to the main static portion the torpedo deliverer. When the robot moves forward, the lever arm will make contact with the edge of the exhaust port causing the mechanism to launch the torpedoes in it. ~~The torpedo deliverer is~~ shown in figure 2.



Move figures/tables to top or bottom of column

Figure 2: Side view of the torpedo deliverer.

Another feature of this robot is the TIE fighter removers, shown in The TIE fighter removers reach out for the TIE fighters sliding them off the table when the robots moves back to the starting zone. The TIE fighter removers are ~~also~~ made out of sheet metal. This mechanism opens when the force collecting gate drops. There are two strings attached to the front of the force collecting gate's frame. These strings are pulled and through another pivot mechanism the TIE fighter removers swing open. The TIE fighter removers are attached to the robot's platform with one nail on each of them and with a small lever arm the TIE fighter removers open to about 50 degree angle relative to the sides of the platform when the string is pull by the force collecting gate. This angle allows the sponges to be pushed out of the team's zone. ~~The TIE fighter removers are~~ in green for better visualization ~~shown~~ in figure 3.

Why the extra space?

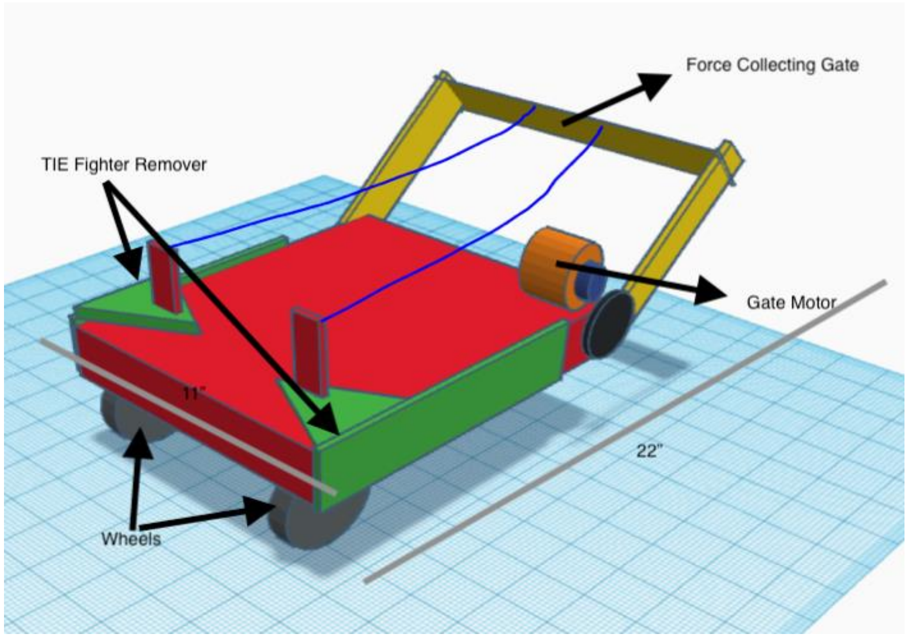


Figure 3: back view of the robot's platform.

Finally, this design contains three wheels: two back wheels connected through an axle that will spin freely when the front DC motor moves the front wheel. The front wheel that has an axle with a gear connected to it. This gear is at contact with the gear attached to the bigger DC motor's axle. When the bigger DC motor rotates the gear it rotates the other gear attached to the wheel's axle causing the whole robot to move forward and backwards.

spaq

III. Problem Understanding :

Design tools are helpful for engineers to understand problems in a more specific way. There are design tools that help engineers understand what is the actual problem of the design by taking into account what are the features the customers would like as well as what features would be desired or wished for the design. These design tools are known as the house of quality, specifications list function tree as well as others. For the star wars competition the objective is to get the most amount of points by also following customer requirements, in this case, the rules of the game. The design becomes more limited when following the rules of the game. For example; one rule or customer requirement is that the device must fit within a wooden box of certain dimensions if not then the team is disqualified. The engineering characteristic associated to this customer requirement would be that height, width and length of the device. Table 1 shows this correlations between customer requirements and Engineering Characteristics.

These are not equivalent!

There are many cust. rq. that are beyond the rules.

Why the extra space?

Table 1: House of Quality

~~House of Quality~~

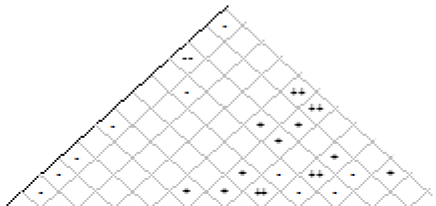
Star Wars Project

Monday Oct. 30, 2017

Key of Symbols

●	Strong	9
▣	Medium	3
△	Weak	1
▲	Maximize	
▼	Minimize	
x	Target	
++	Strong Positive	
+	Positive	
-	Negative	
−	Strong Negative	

Why so blurry?



Importance	Direction of Improvement	▼	x	x	x	x	▼	▼	▼	▼	▼	▼	x
Importance	Customer Requirements / Engineering Characteristics	Weight of the device	Height of the device	Width of the device	Length of the device	Voltage the device uses to operate	Total run time from start to finish	Total number of parts	Total number of moving parts	Total cost of production	Total number of motors used	Total number of sensors	Speed of each motor
10	Accomplish tasks within 30 seconds	▣				△	●			△			●
5	Avoid falling off the platform		△										△
9	Collect the force and pull it to the jedi training zone						▣	△	△	△	●	●	△
9	Pull the lightsaber into the jedi training zone						△	△	△	△	●	△	
8	Pull droids into own territory		▣				▣	△	△	△	●		△
10	Push tie fighters off of the track		▣				△	△	△	△	●		△
8	Place torpedoes into exhaust port				△		▣	△	△	△	●	▣	△
8	Device has to move back to start zone						▣	△			▣	▣	
10	Must fit in a 12"x18"x24" box	△	●	●	●					△			
10	Electronically Autonomous					△				▣		△	
9	Cost of materials must be under $100									●			
10	Must shut down when round is finished						△					▣	●
5	Innovative Design						△	▣	▣	△	▣	▣	
8	Must not put any bystanders in danger											△	△
4	Visually Appealing		△	△	△								
10	Wired correctly so motor shield doesn't burn										△		
6	No adjustments needed between rounds							▣	▣			△	△
	Relative Importance	30	151	94	102	19	222	85	77	180	445	207	232
	Absolute Importance	0.02	0.08	0.05	0.06	0.01	0.12	0.05	0.04	0.10	0.24	0.11	0.12

nearly impossible to read

Another design tool used was the specification sheet. The specification sheet help decide which features are required and which ones are desired. This planning tool help visualize who carries the responsibility to fulfill each requirement and the source that each requirement came from. The specification sheet is shown in Table 2. For example, the height, length, and width are are controlled by the rules, therefore they are demands. Also shown in the specification sheet are some wished features that are not necessarily demands. The wishes are usually what makes the design unique from others and improves the design past just the basic requirements.

Such as? what are important ones for this design?

Why so blurry?

Table 2: Specification Sheet

		Specification for:	Issued:	MM/DD/YY
		Star Wars Competition	Page # of N	
Changes	D/W	Requirements	Responsibility	Source
		Create a device that can autonomously move objects		
		Geometry		
	D	Height < 18"	Design Team	Star Wars Rules
	D	Length < 24"	Design Team	Star Wars Rules
	D	Width < 12"	Design Team	Star Wars Rules
		Kinematics		
	W	Device must move torpedoes 27.6" to the exhaust port	Design Team	Star Wars Rules
	W	Device must move tie fighters 11" backwards to knock them off the track	Design Team	Star Wars Rules
	W	Device must reach out 18" in order to pull droids into its territory	Design Team	Star Wars Rules
	W	Device must move the lightsaber backwards 5" to get it into jedi training zone	Design Team	Star Wars Rules
	W	Device must move the force 20" backwards into the jedi training zone	Design Team	Star Wars Rules
		Forces		
	W	All motors used to move objects must be able to move objects that weigh up to 1lb	Design Team	Design Team
	W	Motor used to move the entire device must put out at least 40N*cm of torque	Design Team	Design Team
		Energy		
	D	Device must use a 12V power supply to power the device	Design Team	Star Wars Rules
		Materials		
	W	Main structure must be able to support at least 8lbs	Design Team	Design Team
	D	No more than 3 motors	Design Team	Star Wars Rules
	W	3 rubber wheels	Design Team	Design Team
		Signals		
	W	Device must start operating within 2 seconds of being activated	Design Team	Design Team
		Safety		
	D	Must not cause any danger to bystanders within 5' of the track	Design Team	Star Wars Rules
		Disassembly		
	D	Device must be removed from the track within 2.5 minutes	Design Team	Star Wars Rules
		Production		
	D	Total time to build < 5 weeks	Design Team	Star Wars Rules
		Assembly		
	D	Device must be ready at least 15 seconds prior to the round	Design Team	Star Wars Rules
	D	Must be able to completely set up device within 3 minutes and 45 seconds	Design Team	Star Wars Rules
		Operation		
	D	Device must be coded so that it can operate autonomously and shut down on its own after 30 seconds of being activated	Design Team	Star Wars Rules
		Costs		
	D	Building materials < $100	Design Team	Star Wars Rules
		Schedules		
	D	Device must be ready for preliminary competition by Nov. 2	Design Team	Star Wars Rules
	D	Device must be ready for the Qualifing Round by Nov. 15	Design Team	Star Wars Rules
	D	Device must be ready for the final competition by Nov. 21	Design Team	Star Wars Rules

No wants/wishes here?

Specs should be solution neutral

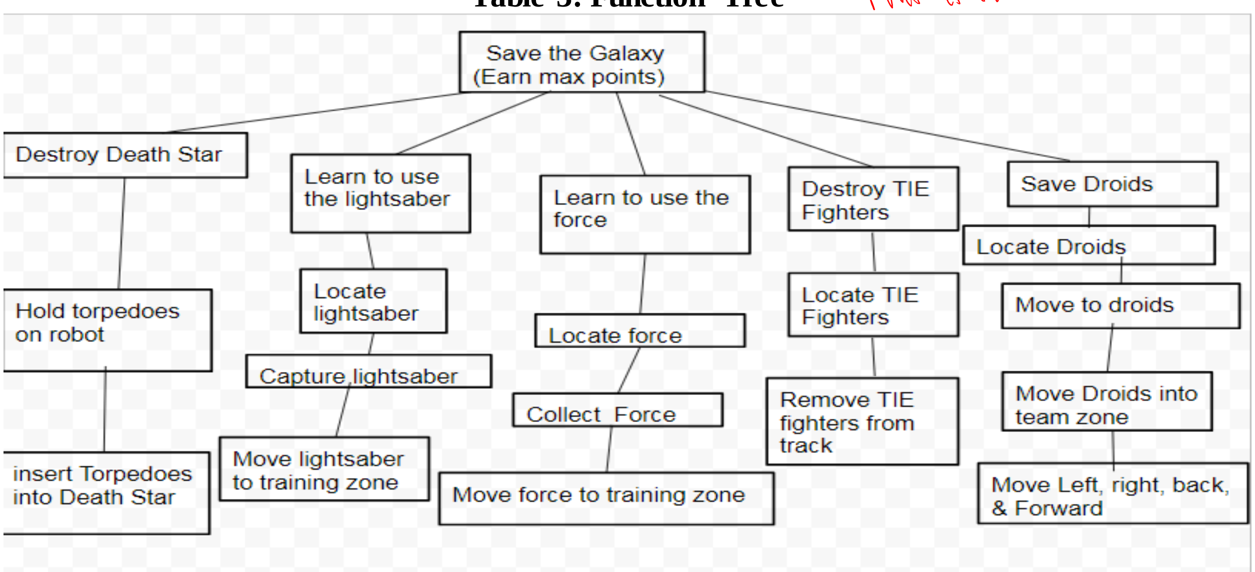
The Function Tree was also used in the development of the final design. The Function Tree is a problem understanding tool which helps engineers gain a better understanding of how the device works and how each part of the device contributes to other parts' function. It starts by listing the main objective of the device at the top. Then, underneath that, it lists the next most general movements the device makes in order to accomplish the main objective. From there it keeps listing the movements that cause the function above it to work until it gets down to the most basic parts and movements the device has to accomplish. This gives engineers a better understanding of how all of the functions relate to each other. In Table 3, it's easy to see how each function contributes to making the device achieve its overall goal.

Way too general, what are important functions in this design process?

Why the extra space?

Table 3: Function Tree

This is not a function tree.

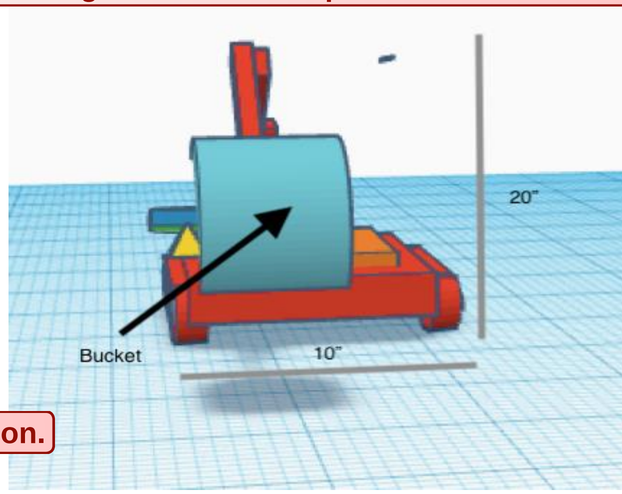


IV. Concept Evaluation:

Two alternative designs were considered before deciding on the final design. The first alternative design was designed with a hydraulic excavator in mind. The wheels were designed using caterpillar tracks to move to the target with ease as shown in Figure 3 and 4. The arms extends so the bucket could scoop up the force (aluminum foil balls). The bucket would also drop the torpedoes in the exhaust port. This alternative design would have not been able to easily accomplish all the tasks put forth. This is mainly because it would have been too challenging to program the device to be accurate enough to scoop up each individual ball and place them into the jedi training zone. Therefore the design was not chosen as the final design.

Save problem for eval. matrix discussion

Move figures/tables to top or bottom of column



for both

Label parts according to their function.

Why so blurry?

Figure 3: Front view of first alternative design.

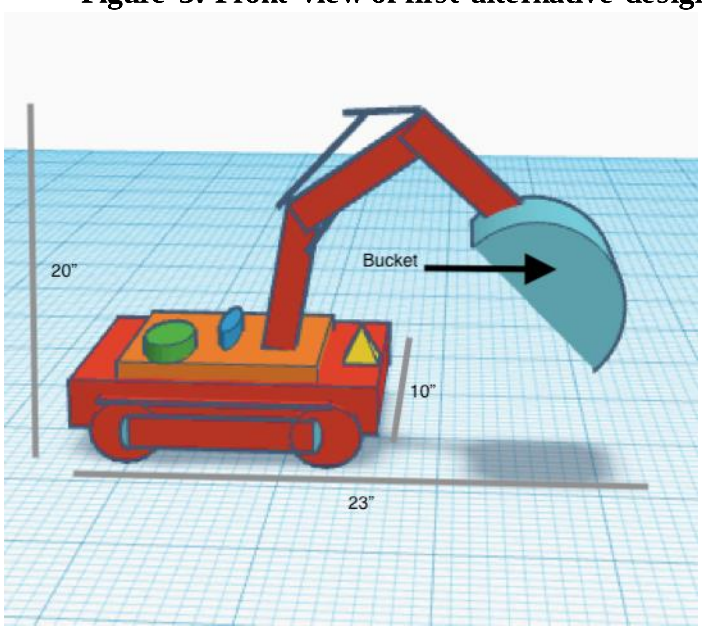


Figure 4: side view of first alternative design

~~The second alternative design would have accomplished more tasks than the first alternative design.~~ The second alternative design had wings on both sides of the main body that would come forward and open to push the sponges off the board. It also had an arm that extended with a scissor like mechanism, capable of grasping objects. Figure 10 and 11 shows the second alternative design. The reason this design was not used was because it would not have

Save for eval matrix discussion.

been able to move the droids into its territory. Also from the Third- level Evaluation Matrix the design did not meet as much of the criteria as the chosen design.

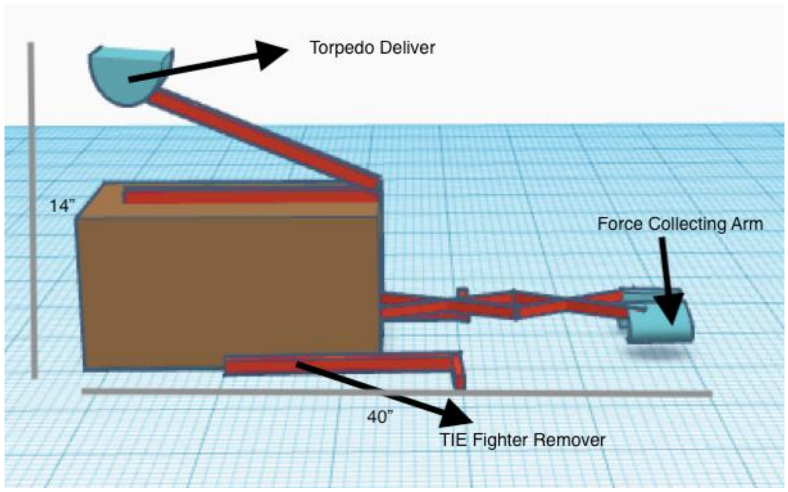


Figure 5: side view of second alternative design

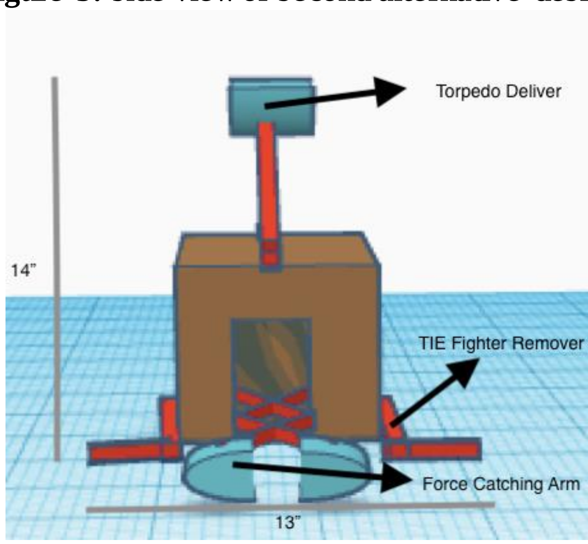
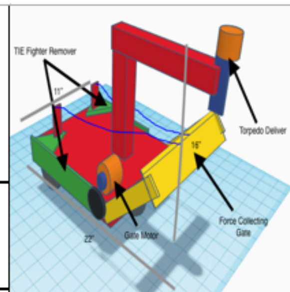
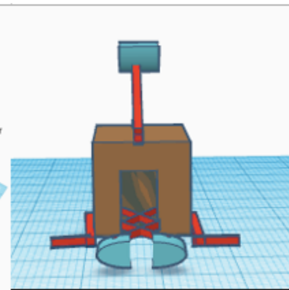
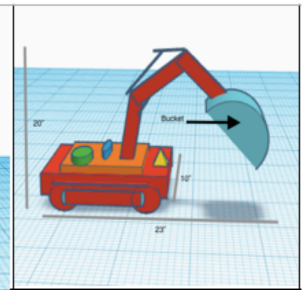


Figure 6: Front view of second alternative design

Why the extra space?

avoid using screenshots

These should exactly match those from the HoQ

Importanace	Customer Requirements			
10	Use the force	8	6	8
6	use the lightsaber	8	7	7
9	Accomplish tasks in 3 tries	9	6	6
9	Accomplish tasks in 30 seconds	10	8	4
8	Save Droids	8	9	7
9	Destroy TIE Fighters	9	4	6
7	Destroy Death star	9	6	7
8	Move back to start zone	10	0	9
10	Fit in an 18"x12"x24" box	10	3	9
10	Avoid falling of the platform	7	10	6
10	Electronically Autonomous	10	10	10
10	Cost of materials under $100	10	9	10
	Total	957	698	793
	Relative Total = Total/Number of Criteria	0.80	0.58	0.66

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.

The final design was chosen because when comparing to the alternate designs it completed the most customer requirements.

Such as?... Why? You need to justify this statement.

V. Design Performance Evaluation

Before the final competition the robot was tested numerous times. Everything seemed to be in order but there was a high probability of error since the objects were never put in the exact same place after each round. If the objects are in unwanted position this could potentially affect the performance of the robot. There are many factors that could affect the robots performance such as gears coming loose as well as the chance that a neighboring teams robot could possibly come into your territory and move your objects from their original position. The performance of the robot varied at every round, in some rounds more points were earned than in other rounds. In the first round, a lot of points were achieved since the robot ran as it was supposed to but the force collecting gate got stuck on top of the of the force. Therefore, when the robot began to move backwards, it was unable to contain most of the force since the gate failed to come down far enough leaving all but one the aluminium foil balls behind. This also affected the position of the force collecting gate that later needed to be readjusted. Even though the force collecting gate did not worked as suppose to, the TIE fighter removers were able to extend and knock the TIE fighters off the table. The torpedo deliverer was able to get all the torpedoes in the exhaust port. All these achieved tasks totaled to 40 points being greater than all 3 of the other teams' performances. During the second round, the robot ran as it was supposed to but the string connecting the force collection gate to the TIE fighter removers got hung up on top of the lightsaber (bowling pin) preventing the force collection gate from coming down all the way. This also prevented the TIE fighter removers from fully extending. For this round only one TIE fighter was removed but the torpedoes were delivered successfully. For the last round the torpedoes were delivered and the TIE fighters were not knocked off of the track as they were supposed to be. However, the robot failed to collect any of the force because the string got hung up on the bowling pin again. Therefore, the robot did not earn enough points in the last round to move on to the next rounds.

So... shouldn't you have designed for this???

The force collecting gate did not work at the competition since it needed to be larger and it needed to dropped with precision to contain all the force units. The force collecting gate would work in some occasions but it would contain only very few force units. In order to collect the most amount of force, paint brushes were place on the bottom part of the gate. This allowed the gate to sweep some of the force units within the gate and sometimes keep some of the force units betweens the brushes' bristles. The results of the competition showed that the the force collecting gate is not ideal since it needs to enclose a larger area to ensure more of the force units to be dragged into the jedi training zone. Another feature that could have been added to the robot is a arm powered by the stepper motor that grabs the bowling and pin and releases it on the jedi training zone. The torpedo delivering system never fail during the testing and during the competition. This feature would be kept intact for the improvement of the robot. The TIE fighters were knocked off from the board game but sometimes the robot would not get them off. The general improvement for the design is to get a larger force collecting gate or gate able to extend to enclose the force with more precision. The precision needed for the force collecting gate can be enhanced with sensors. For example, as the robot gets to a certain distance from the exhaust port the gate would be drop precisely between the force and the edge of the dead start's circumference. The last feature that could be added for the improvement of the robot would be a system able to move the droids in the team's zone. This could also be enhanced with a larger force collecting gate or with a longer wings or TIE fighter remover system.

relate back to the design process. what cust. req were correct? which were incorrect?

Judging Results?

IV. Conclusion:

For the Star Wars competition, MCHE 201 students were asked to build a robot capable of doing tasks autonomously. The challenge for this competition is to make the robot work by using coding language, electronics, DC motors and sensors. The final design was constructed to potentially complete every the task successfully by keeping in mind the game's rules and the customer requirements. The final design is composed of 4 main components that enables the robot complete to grab and move objects to different places. These main components are the torpedo deliverer, the TIE fighter remover, the force collecting gate and wheels. The tasks for the Star Wars competition are moving force units and lightsaber in the Jedi training zone, moving the Droids into the team's zone, placing three key chains in the exhaust port and finally knocking the TIE fighters off of the team's zone. In order construct such the final design capable of completing these tasks, two other alternative designs were reviewed before making and ultimate decision in which the design to work on. This final design was chosen on the basis of potentially getting the most amount of points, less failure probabilities, simplicity, etc. During the final competition, it was visible that the probability of error is very high because of the variations of objects on the board game at every round and because of the robot's propensity of failure. These errors give information about features that need to be change or improve in the robot. With the right changes and improvements the robot can optimize its performance.

awkward

avoid this style

Results?

The conclusion should summarize what was presented in the report, including key results.