SouthEast Conference Robot Project Proposal

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I. Introduction

The goal of this project is to build an autonomous robot that can navigate an L-shaped track designed after a Mardi-Gras decorated street within a three-minute time limit. The course will have additional challenges that the robot can complete for extra points. Initially, the plan is to build the robot to respond to manual commands to assist with mechanical errors, and then move on to complete autonomy. The team consists of two computer engineers, who will handle software and micro-controllers, and two electrical engineers, who will handle power and controls. This implementation will be completed no later than March 25, 2022, at which point the design will be finalized. This leaves a week for final testing before the competition begins on March 31, 2022. The proposed budget is $2000, but this number is subject to change as the team fulfills the final design of the robot. The team aspires to revive the Tennessee Tech IEEE chapter and inspire more students to join and compete in the future.

II. Background

The competition rules referenced herein are specified by the IEEE SECon Hardware Competition guidelines [1]. The competition will take place on a gameboard constructed from a single piece of 4' x 8' plywood decorated like a Mardi-Gras Street. The street itself will be a painted black roadway with white painted center lines. The black street will measure 16" wide, while the centerline will measure approximately 1". The street will also be lined with obstacles that the robot must avoid while navigating. One such obstacle will be a single powerline with two power line poles. The poles will be wooden dowels that measure 1.25" in diameter. The powerline will connect the two dowels on either side of the street. A rope will be used as the power line and will have at most a 3" sag that the robot will have to fit under. The street will also be lined with 2" barricades. There will be four 2" gaps in the barricades that a randomly placed marshmallow will be pushed through. Out of the four gaps, two of the gaps will be randomly closed off at the start of the round. The competition organizers have specified that none of the gaps will be within four inches of the powerline poles. The robot must stay on the street; however, the appendages of the robot are allowed to extend past the barricade. Beyond the barricades will be a sidewalk on either side. The sidewalk will contain opportunities to earn points. One opportunity will be four red 16-ounce solo cups placed randomly along the track. The red cups will represent trash bins along the sidewalk. Another game mechanic will be three randomly placed and vertical fishing nets measuring 8" in diameter. The last component of the sidewalk will be two wooden dowel trees measuring in 0.875" diameter and 2' in height. The trees will have a limb 21" above the base that extend 6" outward. Circular bead necklaces measuring in 2.5"-3" diameter will be placed on the limbs. The gameboard can be seen in **Figure 1.**

The robot itself will be constrained to one cubic foot at the beginning of each round; however, it may extend beyond the initial size constraint as long as obstacles are still avoided. The robot will need to have a clear start/stop switch for operation and an emergency stop switch. The robot will not be able to break apart or have any aerial or flying components. The competition also excludes any use of explosives, pyrotechnics, or toxic/corrosive materials. The team is responsible for protecting any sensors from potential outside interference. The gameboard will be elevated, so precautions must be taken to prevent the robot falling. All in all, the robot will need to present no harm to the judges or any spectators.

The robot will also have tasks to complete for points along with traversing the track. The point system can be seen in **Figure 2.** The design of the robot should maximize the possible points earned. Overall, the team will need to efficiently complete as many tasks as possible. The team will be penalized 1 point for any task that is attempted but not completed. The team can also be penalized 5 points for hitting an obstacle and 10 points for knocking over any obstacle. The team can also be disqualified. The main four actions that will disqualify the team include:

- Damage to the gameboard
- Venturing or falling off the gameboard
- Touching the robot after hands off
- Remotely operating the robot after hands off

The team can utilize the point system in Figure 2 to earn the maximum number of points. The team will be able to earn 1 put for pushing the marshmallow off the roadway; however, the marshmallow must not leave the ground while being removed from the track. The robot can earn 1 point for placing the beads into a trash bin or 2 points for shooting the bead into a fish net. The team will also obtain 1 point for each trash bin or fish net that has a bead in it. Beads must travel an aerial distance of 4" for the shot to count.

Aside from obstacles within the course, the team can earn points by adding decorations to the robot. For one, the team will need to decorate the robot to resemble a Mardi-Gras float. The team can earn 2 points for having a display that moves mechanically at least 4”. The team will earn an additional 2 points for a light up display. The team can also earn 2 points for having a speaker on the robot that plays a song.

Along with robot and gameboard specifications, the competition outlines rules for the game. The team will have to follow the rules to ensure that the robot is not disqualified. The competition will have three rounds: qualifying, semi-finals, and finals. All teams will compete in the qualifying round. The top twenty teams will compete in the semi-finals and then the best four teams will compete in the final round. The qualifying and the semi-finals will have two rounds. The best score out of the two rounds will be used for the overall round. The team’s round time will be used if the robot scores the maximum number of points. Each team will be assigned a play order in which the team’s robot will compete. The team must qualify 30 minutes prior to their scheduled play slot. From this time, the team will not be able to make any adjustments to the robot. The team will then be called two minutes prior and must arrive within the two minutes. Each team must designate a robot handler. The robot handler is the only person allowed within two feet of the gameboard. After arrival, the team will have one minute setup period before the round starts. The judges will then announce the start of the round. At this point, the robot handler will push the start button on the robot. The judges will signify the end of the round; however, a judge can call the round off early if a team member touches the robot. The team is also allowed to call the end of the round in case of an emergency. The team is also required to address the judges following the IEEE code of conduct. The only person that can address the judges is the team captain for written or verbal decision appeals. The appeals will only be accepted within five minutes after the team’s score is displayed. If the appeal is declined the team will be deducted 50 points. Above all, the team is expected to act in a calm, polite, and professional demeanor.

Specific techniques must be utilized in order to successfully implement a design that meets the functional requirements of the competition. For example, specific protocols must be followed to interface with and control DC motors, such as pulse width modulation (PWM) and inverse kinematics. Pulse width modulation is used in motor control ”by driving the motor with a series of ”ON-OFF” pulses and varying the duty cycle, the fraction of time that the output voltage is ”ON” compared to when it is ”OFF”, of the pulses while keeping the frequency constant” [2]. This ON-OFF ratio determines the power supplied to the motor, where a larger ratio of ON to OFF results in greater power supply and vice-versa. Inverse kinematics refers to a mathematical process used to calculate the joint positions needed to produce a specific endpoint position [3]. Such a process may be used in the design of the robot’s arm to calculate the specific rotational angles of connected motor servos by simply providing such a system with a desired endpoint coordinate.

To implement the autonomy of the robot, a variety of sen-

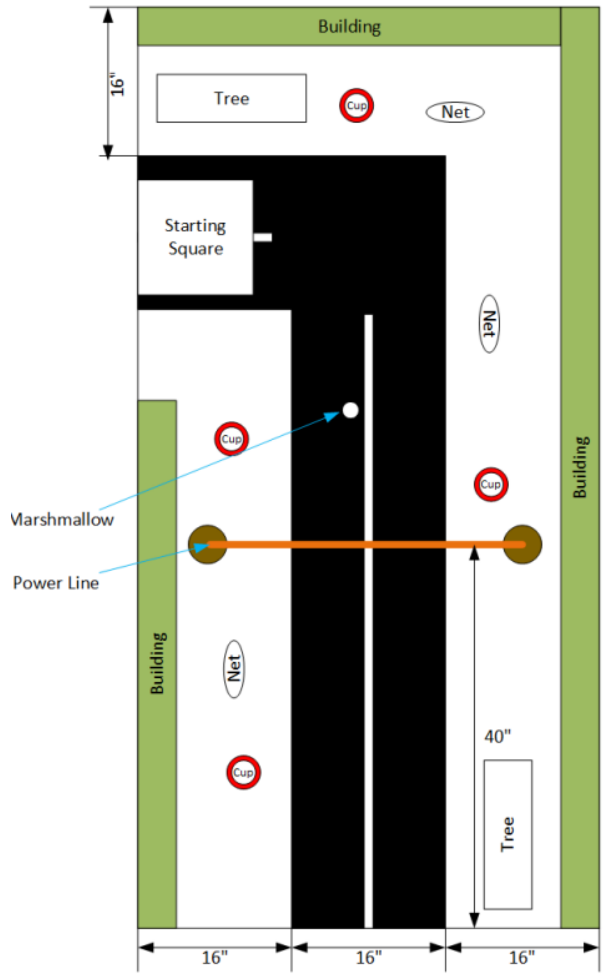

Fig. 1. Competition track layout.

Points	Task
+1 pt	Pushing a marshmallow off the roadway
+1 pt	Each bead dropped into a bin
+1 pt	Each trash bin with one or more beads in it
+1 pt	Each fish net with one or more beads in it
+2 pts	Each bead thrown into a fish net
+2 pts	Having a display that moves mechanically at least 4”
+2 pts	Playing a song
+2pts	Having a display that lights up
+5 pts	Completing the track, in one direction
+10 pts	Completing the track, in both directions (full loop)
-1 pt	Each bead/marshmallow attempted, but left on roadway
-5 pts	Touching any obstacles: barricade, trash bin, building, or power line
-10 pts	Knocking over any obstacles: barricade, trash bin, building, or power line
Disqualification	Damage to the game board, at the Judges discretion. Venturing off of the game board. Touching the robot after hands off. Remotely operating the robot after hands off.

Fig. 2. Competition point breakdown.

sors of varying types, such as radar, lidar, infrared, and laser, may be utilized. Depending on the type of sensor and its purpose, specific considerations must be taken to reduce interference and poor performance. Such complications may include lighting conditions, erroneous signals from other competitors or networking equipment, and flash photography.

III. Technical Overview

This project will consist of a variety of sub-systems, with each system requiring its own specific hardware, software, testing/verification, and skills to be developed. Individual sub-systems will then require interfacing to the central controller via standard protocols. These sub-systems must be outlined, designed, developed, and tested both independently and concurrently. By ensuring each sub-system complies to the standard interfacing protocols and meets the design requirements specified by the overarching system, each sub-system can be developed independently and then combined to complete the system. A high-level block diagram of the system is shown in **Appendix A** below.

A. Central controller

In order to construct an autonomous robot, a central controller will be required to manage the underlying sub-systems and their function. This central controller is commonly attributed to possess the "intelligence" of a robot. This controller will be responsible for the decision making of the robot, as well as communicating the necessary actions and receiving input information from the various other systems. This unit will consist of either a microcontroller such as an Arduino or STM32 or a small "Card Computer" such as a Raspberry Pi. The skills required for the development of the central controller will be primarily software and programming based. A knowledge of microcontrollers, communication protocols, embedded systems, and operating systems will be vital for this component. Being the central system of the robot, the controller will have direct connections to each of the other subsystems. Each of these connections must be verified and confirmed to comply with the communication protocol used by the sub-system. Additionally, the decision-making process of the central controller must be validated using a testbench of input parameters.

B. Vision/Object Detection System

A vision or object detection system must be configured for the robot to autonomously navigate, identify objectives, and avoid obstacles. The two main components of this system will be the Sensor Hardware and the Detection Software. The complexity of this system will be dependent on the construction of these two components, and a variety of designs can be constructed using a varying level of both hardware and software complexity [4]. The vision system may be constructed using a small number of advanced hardware devices, which will then require more complex software to interpret and process the data. Inversely, a simpler software implementation may be designed that instead utilizes a large array of smaller, lower-function sensors. Once the specific design approach is determined, the necessary hardware and software requirements can be determined. Regardless of design, particular skills such as computer programming, hardware interfacing, and a knowledge of computer vision systems will be required. To test such a system, the interfacing between hardware elements must be verified. Also, the system must be tested in order to determine the accuracy of identifying different competition elements. Lastly, the information received by the Central Controller from the Detection Software must be compliant with the Central Controller's decision-making process.

C. Motor Control System

While the Vision System and Central Controller will primarily be responsible for the decision making and autonomous function of the robot, separate hardware and software will be required to execute the functions of movement, object collection and distribution, etc. This hardware and software will constitute the Motor Control System, and it encompasses both the driving motors for moving the robot along the competition surface and the servo motors used by the robot to collect and place the game pieces in each objective. The Motor Hardware and Servos will be driven by Control Software. This software will receive the "decisions" made by the Central Controller and convert them into Pulse Width Modulation (PWM) signals to be sent to Motor Hardware [5]. The exact hardware requirements for this system will depend on the choice of drivetrain and the desired method of collecting and distributing the game pieces. Additionally, hardware such as gears, wheels, belts and various actuators may be required. Because of the nature of this system, knowledge of mechanical concepts will be required for the design of the motor hardware. Other skills such as specific knowledge of controller hardware, control systems, and the physical limitations of components will be necessary for the design of this system. Testing the system will consist of measuring the signals to be sent from the Control Software to the hardware to ensure they accurately match the desired PWM parameters. Additionally, the Motor Control System should be tested independently of the Central Controller and decision-making system via manual operation. By verifying the behavior of the Motor Control System using manual signals, similar behavior can be expected when the robot is configured to operate autonomously.

D. Power System

In order to power the various sub-systems on board the robot, a power system must be developed. This system will be responsible for supplying the correct DC Power directly to each sub-system. A battery will serve as the power supply, but the exact size and rating of the battery will be based on the specific power requirements of the other systems. Additionally, specific circuitry for charging the battery and regulating power output for certain applications will be required, and the proper safety measures (circuit breakers, emergency stop switches, and fuses) must be integrated into the power supply system. A knowledge of batteries, power needs, PCB design, and proper electrical safety measures will be needed to design this system. Safety measures will include proper grounding and insulation and over current protections [6]. The power output by the system will have to be tested and verified that it meets the power consumption needs of the device. Extraneous systems must also be tested to ensure their maximum power consumption and current draw do not exceed the safety limitations of the power system. Lastly, safety measures such as fuses and emergency stops should be tested to ensure the proper behavior is exhibited in the event of a catastrophic failure.

E. Peripheral System

While not necessary to the autonomous operation of the robot, the competition outlines additional consideration for designs that include a display, music, and decorations. The Peripheral System will be responsible for controlling these additional functions. In order to complete these competition requirements, an LCD Display, speaker for playing music, and LED lights will be required. Additionally, software must exist in the Central Controller that controls these peripherals. Knowledge of these devices, file storage for audio files, and artistic creativity will be needed for this system. Testing methods will consist of verifying the hardware and software comply with the competition regulations and ensuring the peripherals do not interfere with the primary function of the robot.

F. Chassis

The chassis will serve as the housing for the other various sub-systems of the robot. The chassis must allow for access to the various sub-systems' ports and connections to allow for quick repair in the event of a minor failure. Additionally, the chassis must contain the start and emergency stop buttons, and they must be clearly marked. The chassis will also be responsible for housing the mechanism that will hold the game pieces once they have been collected. Knowledge of materials, 3D modelling software, and 3D printing will be required to design and build the chassis. The chassis must also be tested to ensure it is structurally sound enough to handle the forces of the Motor System, and it must be verified to fit within the size constraints as outlined by the competition.

G. Common Requirements

While some aspects of each sub-system's design will be unique, many commonalities will exist between sub-systems as well. Beyond basic electrical components and a general understanding of Electrical and Computer Engineering concepts, specific hardware components, technical skills, and testing methods will be shared across many aspects of the project.

Components used throughout the design but are not specific to a given subsystem include:

- Wiring
- Fastening hardware (screws, bolts, nuts, etc.)
- Electrical connectors
- An accurate model of the competition environment and all associated components

Skills needed across each subsystem include:

- Component selection and testing
- Simulation
- Programming experience (languages may include C, C++, Python, etc.)
- Electrical wiring and soldering
- Operation of lab equipment (digital multimeter, oscilliscope, function generator)
- Schematic capture

Testing Methods to be utilized across the project will include:

- Simulation and verification of measured values
- Input and output signal analysis using lab equipment as a stand in for other subsystems
- Software testbenches and code review
- Inter-system interface verification

Additionally, a final system checkout will be necessary to ensure the hardware has met the competition specifications and is functionally ready for the SoutheastCon Competition. In this final checkout, the entire system will be compared to the desired behavior and the competition specifications. The robot will also be required to conduct a "live" competition environment demo.

IV. Outcomes and Deliverables

Coming out of this project, members will have experience working on a real-world engineering project. This includes project management, working as a team, design process, and problem solving. Members will also broaden their knowledge of engineering topics related to their discipline. The team members will gain a vast knowledge of robotics, an area to which they have no knowledge.

The principal deliverable of this project will be a fully autonomous robot. Ideally, it will perform all tasks outlined in the project specifications and will adhere to competition rules outlined before. Of course, many small deliverables have been outlined by the team, which is integrated into the project timeline. Deliverables are as defined in by the measures of success.

V. Obstacles

The largest obstacle in this project is that members of the team have little to no experience building and programming a robot; however, members have vast knowledge of electrical and computer engineering topics that will provide a strong foundation for overcoming the task at hand. Members have experience with programming, power, controls, electrical components, isolated testing, microcontrollers, and computer aided design (CAD). While these areas will prove useful, there are still some skills, such as 3D printing, communication protocols, and autonomous/sensor programming, that the team is not experienced in. Overcoming this problem will require research in areas with no experience and continued learning in areas where members already have experience.

Due to the ongoing Covid-19 pandemic, there is a computer chip shortage [7]. This may lead to supply issues for necessary computing components. To resolve this, the team will complete design work as soon as possible to ensure early ordering of chips. One obstacle the team has already encountered is scheduling conflicts, and this is expected to continue as the project progresses. Another obstacle will be the possibility of purchasing components that do not perform their expected behavior. This is expected due to the lack of experience by the team, and it must be mitigated by thorough testing and allowing for enough time to select and order replacement components should the need arise.

Additional obstacles present themselves in the project specifications. The arm must reach the branch of the trees, a height of 21", but the power line is 2' tall with up to 3" of vertical slack. This means the arm will need to extend to retrieve the beads from the tree, and then retract to avoid hitting the power line. The robot will also need to differentiate between the nets and the power poles, but most sensors are unable to detect soft materials, so the team will need to come up with a different method of detecting where to shoot the beads. This presents another problem; the shooting apparatus will need to have enough friction to launch the beads, while avoiding objects on the sidewalk. Although the rules specify that the robot must be contained in one cubic foot at the start, doing so will not allow the robot to turn without touching the barricades because the diagonal dimension is slightly larger than 16".

VI. Measures of Success

The team's success will be divided into two parts: engineering success and competitive success. The engineering measures of success will be evaluated based on meeting the specifications and objectives of the competition while staying within the constraints set forth by the SECon organization. The team is expected to carry out many test-runs and evaluations throughout the process of building the robot, and many of these tests are expected to be reliant on trial and error. Whether or not these test-runs are deemed successful depends on if the robot is able to perform as expected given the objectives as well as the constraints.

One of the most crucial specifications to which the robot must adhere is the size spec. The competition rules state that the robot must be contained within one cubic foot. The team will have to take this into consideration throughout the entire design process. Abiding to this spec is crucial to the team's competitive success as not doing so will result in instant disqualification.

The building process of the robot is expected to consist of many stages. For example, the team believes that the first objective is to build a robot that can move manually. The manual motion of the robot will need to be thoroughly tested. To carry out testing of the robot's mobility, a replica of the competition track will be necessary. Once the drivetrain is designed and assembled, the team will carry out tests using the track. The first tests that the team conducts will be manually moving the base of the robot, as well as testing its maneuverability. Manual testing of the drivetrain will consist of giving the main microcontroller velocity and direction commands that will be translated to the motor via an intermediary motor driver. The main goal of these tests is to prove that the method of motor control is feasible and the robot is in fact able to fully navigate the track.

Line detection will be another important aspect of the engineering success of this project. The robot will need to be able to follow a white line on the track at a reasonable speed without deviating too much from the center. To accomplish this, the robot will have to be self-correcting. The team will once again use the replica of the competition board to fine tune the navigation aspect of the robot. The team's goal is for the robot to complete the entire track and all tasks without losing its position on the line. It is desired that the robot will be able to move at a velocity of up to 2ft/s without deviating from the line. This will require the team to conduct many trials to tune the self-correcting aspect of the robot that will focus on finding the correct PID coefficients to program into the motor interface.

One aspect of the competition is to identify and safely remove a marshmallow from the road. In order to do this, the robot must identify the marshmallow and the appropriate gaps in the barricades. During trial runs, the robot should correctly identify these components of the gameboard and complete the task on at least 85% of attempts.

Bead obtainment and placement are the main tasks that the robot will need to excel at, and as such the team will need to ensure that the robot collects as many beads as possible. Collecting beads will require some sort of armature, and the team will need to develop a finely tuned system to carry out this task. The team would like to be able to collect 90% of the available beads and accurately launch 95% of the collected beads into the nets. Testing this system will require that the team hang beads in the same manner that they will be hung during the competition. After this, the team will focus on creating the most efficient system possible to obtain the beads using the designed armature. In addition, sorting the beads is also a point of interest for the team's success. It is desired that the obtained beads be separated into three containers, i.e., equal to the number of nets along the track. Because there are no additional points available for the number of beads that end up in nets, the team's goal is that each container contains at least one band of beads. Finally, the time it takes to obtain all of the beads will also need to be minimized. The time goal for obtaining beads at both ends of the track is 20 seconds for each tree. In the case of firing the beads into nets, the team has set a time goal of 20 seconds. This time includes the moment a net is detected to the moment that the robot is driving again. With the target of shooting beads into all 3 nets, this gives the robot a cumulative time of 1 minute to complete this task. When adding together the times for obtaining beads as well as launching them, the robot has 1 minute and 40 seconds in total, giving the robot an additional 1 minute and 20 seconds to traverse the track and attempt to move the marshmallow.

Target detection, i.e., knowing when to shoot the beads, is crucial for the success of this project. It is highly undesirable for the robot to launch the beads at the wrong time/target. As such, the targeting system and launching mechanism will need to be heavily tested. Once the motor control has been tested and tuned manually, the robot must use sensors in order to navigate and control the motors itself. The goal is that when a net is detected, the robot will line itself up with the target and fire the beads as closely to the center of the net as possible. This will require that the team sets up nets along the replica track and allows the robot to attempt to detect them. Routines will be written within the main processor that will control the recognition of the nets and the aiming of the launching mechanism. The detection rate of nets is desired at 100%, as it is more advantageous to launch beads into all of the nets. This will require precise mounting of the sensors to the robot chassis and documenting detection rates in order to get as close to this goal as possible.

If the team is able to build a robot that incorporates all of the objectives set forth by the competition, and these functionalities are verified and determined to be fulfill the constraints, the overall effort of the team, as well as the final product, will be deemed a success.

The team's success will be further evaluated on its ability to produce a product that performs well in competition. The target of the team is to accumulate the maximum available points for traversing the track in both directions, launching beads into all of the available nets, including all of the peripheral/aesthetic tasks, and avoiding touching any obstacles or damaging the track. Adding the available points for these tasks give the team a target of obtaining 40 points. If the final product meets the measures of success highlighted in the previous sections, the overall effort of the project will be considered a success.

VII. Budget

This budget will serve as a preliminary estimate of the cost of the project and a metric to determine the project's financial feasibility. Exact component costs will become finalized in the later design phases as more specific details are known. The budget is broken down on a sub-system by sub-system basis. Each component price is listed as a range of the unit price. The total component cost range is then calculated by multiplying the lowest quantity by the lower bound of the range and the largest quantity by the upper bound. Total ranges for each sub-system, and the system total are then calculated by summing the lower and upper bounds of each component, respectively. A 50 percent margin of error is then added to the total to account for additional components and price changes/shipping costs. The final grand total is then listed at the bottom of the table.

Subsystem/Component	Qty.	Unit Cost	Total Cost
Central Controller			
Microcontroller	1	\$20-\$50	\$20-\$50
Total			\$20-\$50
Vision System			
Object Detection Hardware	1	\$30-\$80	\$30-\$80
Navigation Hardware	1	\$20-\$50	\$20-\$50
Total			\$50-\$130
Motor Controller			
Motor Driver/PWM Chip	1	\$10-\$20	\$10-\$20
Brushless Motor	2-4	\$5-\$25	\$10-\$100
Servo Motor	3-6	\$10-\$40	\$30-\$240
Servo Mounting Bracket	3-6	\$5-\$10	\$15-\$60
Total			\$65-\$420
Power Supply System			
Battery	2	\$20-\$40	\$40-\$80
Switch	2	\$5-\$10	\$10-\$20
Fuse	10	\$0.80 - \$1	\$8-\$10
Custom PCB	1-3	\$10-\$50	\$10-\$150
Total			\$70-\$260
Peripheral System			
LEDs	10-30	\$1-\$2	\$10-\$60
LCD Display	1	\$5-\$20	\$5-\$20
Speaker	1-2	\$2-\$10	\$2-\$20
Total			\$20-\$100
Chassis			
3D Printer Filament	1-3	\$5-\$20	\$5-\$60
Total			\$5-\$60
General			
Fasteners	N/A	N/A	\$20-\$50
Wiring	N/A	N/A	\$20-\$50
Construction Materials (Game Board)	N/A	N/A	\$80-\$150
Total			\$140-\$250
System Total			\$370-\$1270
Error Margin/Redundancy			50%
Grand Total			**\$550-\$2000**

Fig. 3. Itemized cost breakdown.

VIII. Project Schedule

The project timeline is based on the outline provided in the course syllabus. It is comprised of three overarching sections: Design Phase One, Design Phase Two, and Development/Testing. Each of the three main sections have various tasks and deadlines within them.

During Design Phase I, the team will independently research the various subsystems outlined in the proposal and try to come up with the most viable, cost-effective solution. Although research will be conducted independently, it is important that the team members discuss what they find during team meetings in order to address issues of compatibility, cost, etc. Team assignments for the preliminary research phase are as follows: Daniel (Microcontrollers), Lexi (Vision System and Peripheral Systems), Sawyer (Power Distribution), and Chase (Motor Control/Drivetrain). Preliminary research should be completed along with a draft for Design Phase I by October 4th.

After the preliminary research and draft have been completed, the team will begin work on finalizing the first design for Design Phase I. This phase will be where the team discusses the viability and compatibility of each of the members' findings in the previous phase. Design Phase I will see the team have a general idea for a solution as well as having selected the parts that will comprise the main subsystems. Design Phase I should be completed and finalized by October 18th.

Design Phase II is where the team will begin the detailed design and analysis of their proposed solution from Design Phase I. During this phase, the team will have already finalized all of the various parts that will be used in the design and will be working on the interfacing of the subsystems. This phase will see the team design the chassis and wheelbase, as well as complete the wire layout. The team should have a draft by November 24th. Following the draft of Design Phase II, the team will need to begin ordering parts. As of the creation of this proposal, the team's designated parts acquirer will be Sawyer. The team will need to have their final design verified before moving on to the final phase. The final draft of Design Phase II will be completed by December 6th.

Due to Christmas break, Development and Testing will begin on January 10th, 2022. It is expected that all parts will have been ordered prior to this stage. This phase will see the team actualize its design. During this phase, the team will get the various subsystems of the design to at first work independently, and then as a unit. Although it is expected that each team member will play a role in all aspects of development, they will also have aspects of the product that they are considered responsible for. Daniel will oversee interfacing all subsystems with the central controller. Lexi will be responsible for programming the vision system and peripherals. Sawyer will oversee power distribution and wiring. Finally, Chase will be responsible for programming the motor controllers and building the drivetrain system/chassis. The hard deadline and competition date of this project is March 31st, 2022; however, the team should have a functioning product that meets competition specifications by March 25th.

IX. Broader impacts

It is possible that this project will have some effects on the school, including its perception throughout the region. Throughout the design and building process, it is expected that the team will take on some members from the IEEE chapter in small capacities. A project such as this has the potential to attract current members as well as new members to the chapter. In addition, the team performing well in competition will reflect well on the school, specifically Tennessee Tech's Electrical and Computer Engineering program. Performing well in competition may catch the attention of prospective students who are interested in engineering and will make a case for what Tech's engineering program has to offer compared to many other programs in the region. In addition, it may open other opportunities for future capstone groups to participate and compete in similar competitions.

Furthermore, this project may open a door to integrating automated vehicles on Tennessee Tech's campus. Automated vehicles are already being used on some campuses in the United States. For example, the food delivery company GrubHub has partnered with 250+ college campuses to implement

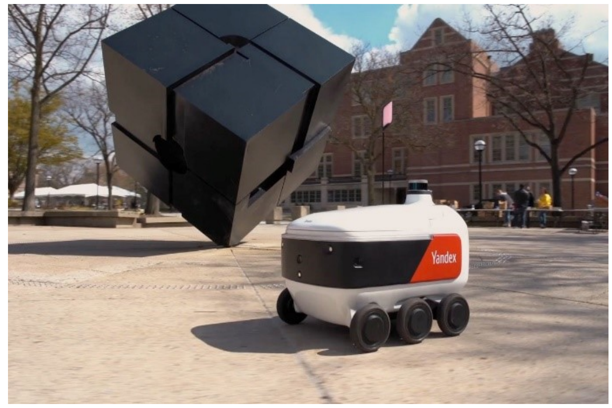

Fig. 4. GrubHub automated food delivery vehicle.

small, automated food delivery vehicles. Food delivery is just one of many opportunities to integrate these vehicles. Autonomous vehicles may also be used in sanitation, tours, crime prevention, etc. Of course, with increasing automation, there is the potential to eliminate some jobs. As in the GrubHub example, there are inevitably some food delivery drivers that are going to be displaced by this new technology. In the example of sanitation and tours, there are currently full time as well as student workers who handle these jobs. The ethical questions of this technology will need to be answered as it becomes a more viable solution for colleges across the country. There is also the question of safety in implementing these vehicles on campuses. Currently, Tech's campus sees considerable car traffic. Autonomous vehicles have the potential to pose a hazard to divers on campus. As Tech becomes a more foot-oriented campus, as is outlined in the "Master Plan," these risks will be reduced considerably.

X. References

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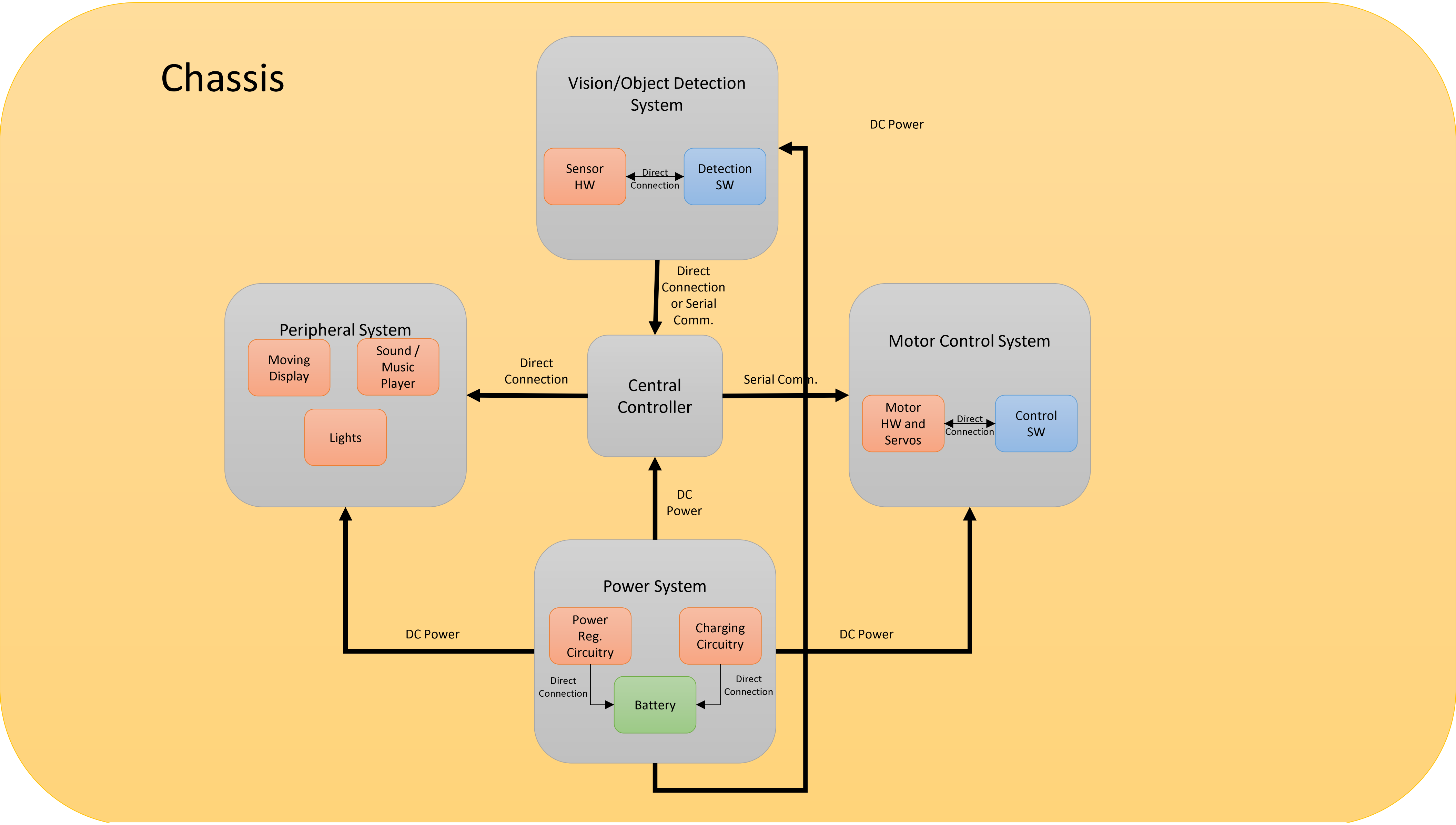
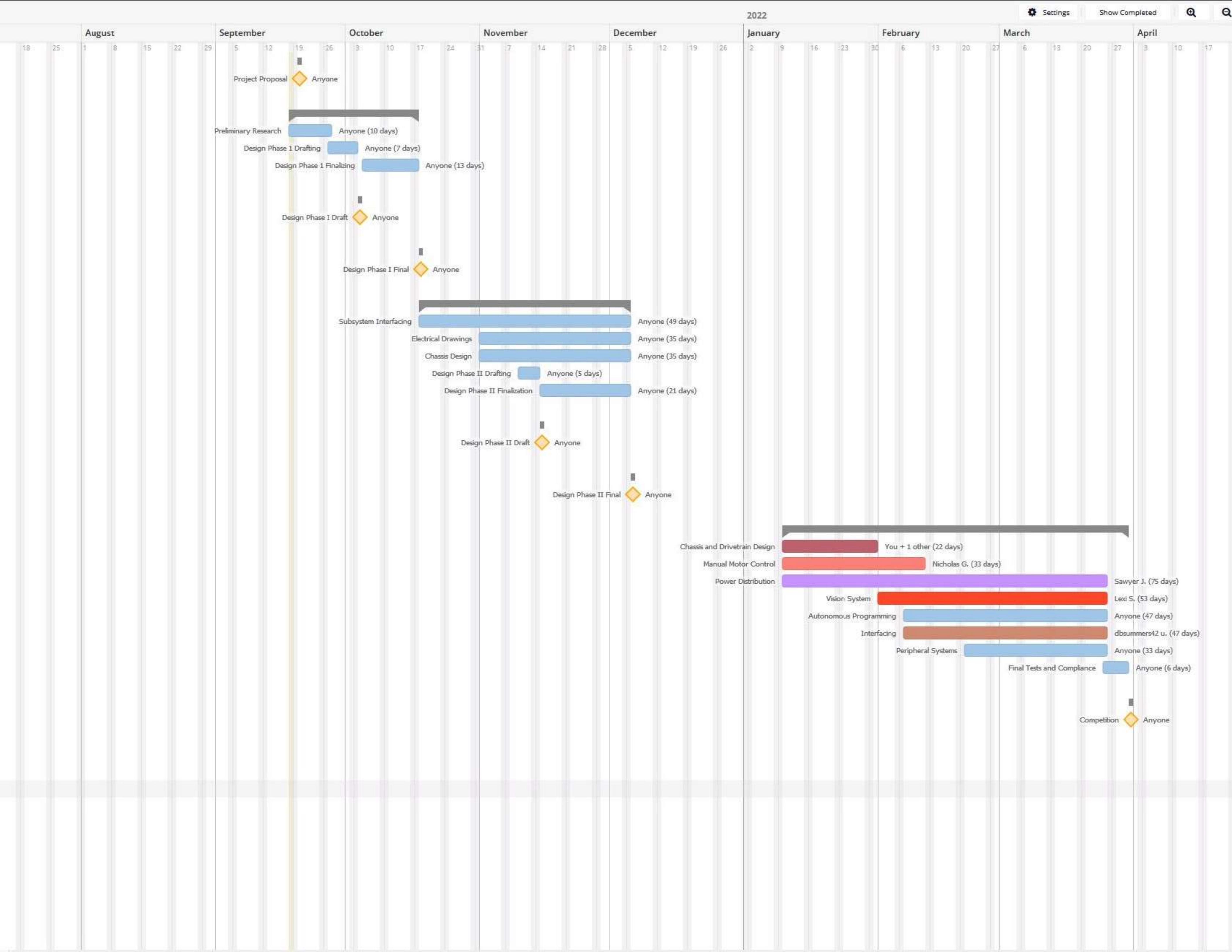

Chassis
Vision/Object Detection System
Sensor HW
Direct Connection
Detection SW
DC Power
Direct Connection or Serial Comm.
Peripheral System
Moving Display
Sound / Music Player
Lights
Direct Connection
Central Controller
Serial Comm.
Motor Control System
Motor HW and Servos
Direct Connection
Control SW
DC Power
Power System
Power Reg. Circuitry
Charging Circuitry
Direct Connection
Battery
Direct Connection
DC Power
DC Power


Settings
Show Completed
2022
August
September
October
November
December
January
February
March
April
18 25 1 8 15 22 29 5 12 19 26 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 6 13 20 27 6 13 20 27 3 10 17
Project Proposal
Anyone
Preliminary Research
Anyone (10 days)
Design Phase 1 Drafting
Anyone (7 days)
Design Phase 1 Finalizing
Anyone (13 days)
Design Phase I Draft
Anyone
Design Phase I Final
Anyone
Subsystem Interfacing
Anyone (49 days)
Electrical Drawings
Anyone (35 days)
Chassis Design
Anyone (35 days)
Design Phase II Drafting
Anyone (5 days)
Design Phase II Finalization
Anyone (21 days)
Design Phase II Draft
Anyone
Design Phase II Final
Anyone
Chassis and Drivetrain Design
You + 1 other (22 days)
Manual Motor Control
Nicholas G. (33 days)
Power Distribution
Sawyer J. (75 days)
Vision System
Lexi S. (53 days)
Autonomous Programming
Anyone (47 days)
Interfacing
dbsummers42 u. (47 days)
Peripheral Systems
Anyone (33 days)
Final Tests and Compliance
Anyone (6 days)
Competition
Anyone