Southeast Con 2019 Competition Concept Generation

1.5 Concept Generation

The Concept Generation is the process of developing solutions for design problems. This process is needed to produce massive amount of unique solutions to a problem, while using logic and research to back them. This gives the team options when selecting their approach to the problem at hand. In this Concept Generation, the solutions for the Southeast Con 2019 Hardware Competition were generated based on the functions found within its modules. The solutions are group together based on module and function. The solutions will breakdown their benefits and downsides to their approach for that function. At the end of a group of solutions, a table will highlight essential data to differentiate between each solution.

1.5.1 Motion and Frame

In this section of the Concept Generation covers methods for motion during the competition at Southeast Con 2019. Also covers the solutions to battery and materials for the frame of the robot These ideas highlight and take advantage of the rules provided by the competition. To be an effective a motion solution, it must rotate at high rpm, produce enough torque to drive the robot, while not consuming to much power to be an effective frame solution, the materials must be strong enough to support the components of the robot while not consuming to much of the budget. To be an effective battery solution, the battery must provide enough power to the system's electronics while lasting long enough to make it through the competition.

1.5.1.1 Motors

SparkFun 3.2V DC stepper motor

The SparkFun 3.2V DC stepper motor divides a full rotation into several steps, quantizing the amount of turns need to complete a full rotation. This motor is useful in making accurate turns and movements. This motor would be useful in the vehicle navigation and the debris picking up component of the device. One downside to the motor is its considerably low rpm of 2,000.

Vex robotics 12V DC CIM motor

The Vex robotics motor has an operating range of 5-12V and has a relatively low rpm of 5,330. This motor would be useful in the debris picking up component of the robot. This motor is most notable for its relatively high stall torque of 2.41 N-m. One downside of this motor is its low rpm which would limit its use in high speed cases.

CE ROHS 7.2V CL-WS1512W gear brushless dc motor

A DC brushless motor is powered by DC current with an internal inverter that creates an AC current that powers a closed controller and controls the speed of the motor. DC brushless motors are most notable for having a high rpm of 33,000. These motors would be useful in controlling the speed and tires of the robot.

8VDC High Speed Motor

The 8V DC high speed motor has an operating voltage of 0-8 V DC and a relatively low current rating of 2 A. The motor is also notable for having a high rpm of 25,000. This motor would be useful in powering the movement and navigation of the robot. The motor also has a relative low cost of $5.95

Motor	Current Rating	Operating Voltage	RPM	Size
SparkFun Motor	2 A	3.2 V	2,000	2.22” x 2.22”
Vex Robotics CIM motor	2.7 A	12 V	5,330	2.5” x 2.5”
CE gear brushless motor	4.2 A	7.2 V	33,000	2.0” x 2.0”
8V DC High Speed Motor	2 A	8 V	25,000	1-3/8” x 15/16”

1.5.1.2 Frame Materials

Hard wood plywood

Hardwood plywood has a variety of uses but is most notable for its excellent strength and stiffness. Plywood is made by binding wood fiber sheets to form a composite. The material is also notable for having a relatively low density of 0.6 g/cm^3. A relatively low weight and durable frame made out of plywood would be useful in maintain high speeds and stability.

6060 Aluminum

6060 aluminum is an alloy made of 98% aluminum and 2% various other metals. A notable trait of the alloy is its considerably high yield strength of 26,000 psi. One downside of using the aluminum frame would be its high conductibility which could lead to short circuits if any loose connections would make contact.

Polycarbonate

Polycarbonates are most notable for being durable, tough, and easy to cast into several shapes. They also have a relatively low density of 1.2 g/cm^3 when considering their relatively high yield strength of 10,152 psi. Polycarbonates also good electrical insulators which would eliminate the risk of short circuits with the frame.

Fiberglass

Fiberglass is a plastic that is reinforced using glass fibers and is notable for its relatively high yield strength of 30,000 psi. The material also has a notably low density of 2.55 g/cm^3 when compared to metals. A frame made of this material would be useful in maintaining a sturdy robot.

Material	Density	Cost	Yield Strength
Hardwood Plywood	0.6 g/cm^3	$13.27 per sheet	2,000 psi
6060 Aluminum	2.71 g/cm^3	$2.50 per kilogram	26,000 psi
Polycarbonate	1.2 g/cm^3	$10.50 per sheet	10,152 psi
Fiberglass	2.55 g/cm^3	$2.50 per pound	30,000 psi

1.5.1.3 Battery

HitLights 12V DC / 5V DC (USB) Rechargeable Lithium-Ion Battery

The HitLights 12V DC battery has an operating voltage range of 5-12V DC and has around 3500 mAh. The battery is most notable for having a compact design and can be used to power motors, cameras, and other robotic components. The battery can also be recharged several times and has several output ports for supplying a 5V source aswell.

Talentcell Rechargeable 6000mAh Li-Ion Battery Pack

The Talentcell battery has an operating voltage range of 12V and has around 6000mAh. The battery contains internal battery protection that improves its performance and life. The relative small size of this battery would benefit when implementing it onto the overall design. One downfall of the device is its slow recharge rate of 10 hours.

Tenergy 12V 2000mAh NiMH Battery Pack w/ Bare Leads

The Tenergy battery has an operating voltage of 12 V and a low amp hour of 2000. One upside of this battery is its relatively small size which could be helpful in minimizing the overall size of the robot and its weight. The low amp hours would make it less reliable when compared to other batteries when considering how often it would have to be charged.

Duracell Ultra 12V 8AH AGM SLA Battery

The Duracell Ultra battery was first intended to be used as backup power and has 50 to 150 cycles at 100% discharge. The battery has a relatively high amp hours of 8000 and has an operating voltage of about 12 V. The downside of the battery is its considerably large size. A battery like this would be useful in powering several components simultaneous without worry of it running out of power.

Battery	Wattage	Operating Voltage	Amp hours	Size
HitLights	24 W	12 V	3500	3.5 x 2.4 x 1.1 inches
Talentcell	20 W	12 V	6000	1.1 x 3.35 x 5.7 inches
Tenergy	15 W	12 V	2000	72 x 50 x 299mm
Duracell Ultra	20 W	12 V	8000	3.78 x 0.98 x 2.4 inches

1.5.2 Route Clearing Algorithm

One of the main goals of the Southeast Con competition is to remove debris from a specified area of the playing field. To do this competitively an autonomous robot must be able to quickly identify debris, travel to it, and remove it from the specified area. The solutions investigated in this section are using a predetermined path to blindly remove debris, use sensors to travel from debris to debris, use sensors to find debris along a predetermined route, and survey the field to plan an optimal route for collection.

1.5.2.1 Gathering Solutions

One of the main methods of gathering points in the Southeast Con competition is to remove debris from a specified area of the playing field. To be competitive, the robot must autonomously identify, travel to, and remove the debris quickly.

Predetermined Route

The first method investigated is for the robot to follow a path blindly and collect any debris it encounters. The strength of this method is it is simple, effective, and easy to implement. A major drawback to this design is that it is time consuming and requires more revolutions around the center structure than the other methods investigated.

Travel from Debris to Debris (No Predetermined Path)

Another method investigated is to ignore any type of predetermined path and simply have a sensor that searches for debris while the robot moves in a random direction. Once debris is identified the robot will travel to it, remove it, and resume searching for the next debris. This method relies on solely on the use of a sensor for navigating the playing field making collisions significantly more likely to occur. Like the first method the strength of this method is its simplicity, and ease of implementation.

Predetermined Route with Deviations for Debris

The next method investigated is a hybrid of the two previous methods. This method involves the robot traveling along a predetermined route while using a sensor to locate debris near it. Once a debris is spotted the robot removes it, and then resumes the predetermined route. This method reduces some of the weaknesses exhibited by the other method while only moderately increasing the complexity of the robot.

Survey the Field and Plan an Optimal Route

This method involves the robot traveling to several predetermined locations and surveying the field. Form this survey the robot calculates an optimal route to gather all the objects identified as quickly as possible. This method is the most efficient of the algorithms and has the fewest number of revolutions around the center structure. However, it is significantly more complex and will take sum time to survey the field.

Table 1
Different Algorithms and their Parameters.

Method	Time Estimation	Complexity	Number of Revolutions	Ease of Implementation	Possibility of Collisions
Predetermined Route	4-6 minutes	Simple	Many	Easy	Low
Debris to Debris	4-6 minutes	Simple	Moderate	Easy	High
Predetermined Route with Debris Searching	2-3 minutes	Moderate	Moderate	Easy-Moderate	Low-moderate
Survey and Route Planning	2-3 minutes	Complex	Few	Difficult	Low

1.5.2.2 Microcontrollers

The brain of this project is the microcontroller. The selection of which microcontroller to use will determine a large portion of what the robot can accomplish. Many microcontrollers reviewed for this project behave more like small computers rather than just a microprocessor. Some of the advantages of using this style of microcontroller is the large number of integrated features associated with them. Some of the features include memory, microprocessor, clock, variety of I/O ports, PWMs, analog to digital converters, and built in signal conditioning.

For this project a microcontroller will be selected primarily on processing performance, operating temperature, voltage requirements, and memory available. These attributes were selected to ensure the robot has the required computing power and physical properties to operate sufficiently for the 3-minute round of competition.

Concept 1: Raspberry Pi 3 model B+

This microcontroller is 85 by 56 mm and is of moderate size compared to many microcontrollers reviewed for this project. The design for this project will not use most of the 1.4 GHz processing power or the 1 GB of memory available. The primary strength of this microcontroller is the large community surrounding it that allows for a variety of approaches to any problems that may arise. The Raspberry Pi is guaranteed for a temperature range of 0 to 70 C which is well within the confines of the Southeast Con competition.

Concept 2: Arduino Mega 2560 Rev 3

The largest of the microcontrollers reviewed is the Arduino Mega 5260, at 101.5 by 53.3 mm. The Arduino board contains a weaker chip than that of the Raspberry Pi (16 MHz), and significantly less memory (256 KB). It has a similar power usage and temperature range compared to the other microcontrollers. Like the Raspberry Pi the Arduino features easy to learn code and a prolific user base that provides support for a large variety of problems commonly encountered.

Concept 3: Teensy 3.6

The smallest of these types of boards is the Teensy 3.6, at 62.3 by 18 mm. Despite being the smallest board, it boasts a processing power of 180 MHz with 4 KB of EEPROM memory. It uses a range of 4.5 to 5.5V. This board can withstand temperatures that are about average for most microcontrollers -40 to 85. The primary strength of this microcontroller is that it utilizes a derivative of the Arduino IDE allowing for code to be easily transferred between the two controllers.

Concept 4: BeagleBone Blue

The BeagleBone Blue is a unique microcontroller because it is specifically designed for robotics. It has a similar size to the previous microcontrollers of 89 by 54.6 mm. The operating temperatures are also average for printed circuit boards (PCBs) which -40 to 85 C. One drawback to this microcontroller is the operating voltage is large (9 to 18 V). The processing power and memory are comparable to that of the Raspberry Pi, 1 GHz and 512 MB. Like the Arduino and Raspberry Pi Beagle bone has a large user base that makes the coding process significantly easier.

Table 2
Different Microcontrollers and their Parameters.

Microcontroller	Voltage Requirement (Volts)	Operating Temperatures	Size	Memory Storage	Processing Performance
Raspberry Pi B+	4.5 – 5.5 V	0 to 50 C	85 by 56 mm	1 GB	1.4 GHz
Arduino Mega 2560	4.5 – 5.5 V	-40 to 85 C	101.5 by 53.3 mm	256 KB	16 MHz
Teensy 3.6	4.5 – 5.5 V	-40 to 85 C	62.3 by 18 mm	4 KB EEPROM	180 MHz
BeagleBone Blue	4.5 – 5.5 V	-40 to 125 C	89 by 54.6 mm	512 MB	1GHz

1.5.3 Sorting Hardware and Software Solutions

In this part of the Concept Generation, the sorting hardware and software functions are given multiple solutions in completing their task. The Gathering Solutions looks how the robot can gather space debris in the most efficient way. The Sorting Solutions assumes that space debris is gathered and finds ways to color code them. The Storage Solutions recognizes that there are multiple ways to store the space debris.

1.5.3.1 Gathering Solutions

In this section of the Concept Generation covers methods to gather space debris during the competition at Southeast Con 2019. These ideas highlight and take advantage of the rigid rules provided by the competition. To be an effective a gathering solution, it must gather the maximum amount of space debris in the shortest amount of time.

Don’t Gather Space Debris

This solution relies on the fact there are other ways to win the competition. A competing robot can win the tournament without gathering or interacting with the space debris by simply doing counter-clockwise orbits with the second region. For a robot to have a competitive chance doing this solution it must take the shortest route about the center and rotate as quickly as possible, while the competing robot is focused on gathering space debris. Assuming that the robot uses the maximum size of 9” by 9” by 11” (L X W X H) the robot’s shortest route is about from the center is 12.5” radius circle. To sustain this route without slipping out of the region, it must not travel faster the 4.5 ft/s. If the robot were to start in this region and travel within it at maximum speed, it would gather 1305 points. If the robot was design like this, it would require a light weight design and high rpm motors. 72W to 200W of power would be needed to drive low torque and high rpm motors. Also recommend that an avoidance module be installed to avoid collision with the center mass and other robots.

Extendable Arm System

This method stems from where the rules permit a robot may extend 3” by 3” by 3” (L X W X H) structure to gather space debris. To do this though, the robot is not allowed to move. The robot would extend an arm with three pivot points. One to rotate around 360 degrees about the robot. Another to arc the arm over the space debris. Lastly one more to find the right angle to gather the space debris. An adhesive substance or suction would be placed at the end of the arm to interact with the space debris. A grip or mouth would not be used because the limitation on space from the rules. Several sensors would also be needed to recognize and guide the arm to the space debris. It would take an estimated five to ten seconds to gather the space debris with this method.

Dual Brush System

For this solution follows the similar approach to that of a street sweeper. Two brushes would be located at the front corners of the robot. A motor and belt system would be used to drive these brushes. The mouth of the robot would be 7.2 inches wide due to the robot needing 80% of its perimeter covered by a bumper. Since the robot does not have to extend out of its area, the robot does not need to stop. It is recommended for this design to maximize speed to take advantage of not needing to stop. Sensors would be needed so that the robot could guide its mouth to the space debris. One to three seconds would be needed to digest the space debris.

Gathering Methods	Max possible points	Power consumption	Gathering Time	Motor Count
Don’t Gather Space Debris	1305	72W – 200W	0s	2
Extendable Arm System	360	60W – 150W	5s - 10s	3

Dual Brush System	360	36W – 100W	1s – 3s	1

1.5.3.2 Sorting Solutions

In this section of the Concept Generation covers methods to sort space debris during the competition at Southeast Con 2019. These ideas are necessary for designs that gather space debris and plan to deposit space debris in color specific homes. To be an effective a sorting solution, it must sort the space debris in a reasonable time with a minimum amount of motors. In this section it uses "working space", which refers to the space needed before the space debris can enter the sorting mechanism. This function is important, so the robots can maximize amount of points it can by placing the space debris in matching color homes.

Elevator meets Rubik's cube approach

This solution follows the idea of the rotation of a Rubik's cube with a delivery system of a rising plane. For this idea to work, a rigid storage solution that can be rotated must be used with idea. How this idea works is by pushing the space debris into a storage chamber and rotating the storage unit put the space debris in the right color. This design follows five steps. Step 1, the space debris is lifted to the matching color storage chamber. A color sensor would be placed at the elevator to notify the rotating storage component of what color chamber to rotate to. Step 2, the storage space would be rotated by 45 degrees so that the space debris would not fall back into the elevator chamber. Step 3, the elevator would be lower back down to collect another piece of space debris. Step 4, once another space debris is loaded, the elevator will rise 0.5". Then the storage component would be rotated to the proper color chamber. The space debris is lifted so the space debris within the storage solution does not fall back down. Step 5, lastly the design would lift the space debris into the storage component. This design would need two motors, one to drive the elevator and another to rotate the storage component. This design would expect to take five to twenty seconds to sort the debris, because of the multiple steps and presence of stepper motors. A working volume of 2.5" by 2.5" by 2.5" (L X W X H) is needed to hold a piece of space debris while the system sorts.

Lane Driver

This solution idea develop base on guide rails found in bowling. A rigid storage solution would be needed to be placed below or have an opening to each color chamber for this solution. This idea works buy pushing and guiding space debris to a color chamber by shifting the internal sorting chamber. This solution can be done within four steps. Step 1 load the space debris into the sorting chamber. Step 2, shift sorting chamber to the color chamber. Step 3, discard space debris into the color chamber. Step 4 is to return to the starting point. There will be three motors needed. One for injecting the space debris into the sorting chamber. The second one is needed to shift the sorting chamber around. The shifting of the sorting chamber may go in about a line or circumference depending on the opening of the storage component. A working volume would of 5” by 5” by 5” (L X W X H) would be need to hold two pieces of space debris, because to wait to load into the sorting chamber. Expected wait for each sorting would five to fifteen seconds because of the need for stepper motors. Lastly a sensor would be needed in the sorting chamber to recognize the color of the space debris.

Linear Memory

This solution for the sorting component of the robot takes advantage of the presence of a microprocessor. This design is rather simple compare to the other solutions, the sorting component would memorize the location of the color of space debris in a line of space debris. This design only takes two steps to complete its cycle. Step 1 is to load the space debris into the sorting chamber and recognize the its color. During this step, the microprocessor will memorize the color and the position number of the space debris. Step 2 would just simply load the space debris into the storage component. A linear storage component would be needed so the space debris would not get out of line. Only one sensor would be needed to recognize the color of the space debris. One motor will also be needed to drive the space debris into the linear storage component. The time to sort would take one to five seconds to memorize and store the space debris. It should be noted that when it comes time to place the sorted space debris, the robot will have to run to each home base for each cube to sort the space debris into the proper home. The other option would be to gather space debris in color groups so when returning the space debris home will not be as time costly.

[Type]	Sorting Time	Working Volume (L X W XH)	Motors	Recommended Storage Solution	Steps

Elevator meets Rubik's cube approach	5s – 20s	2.5" X 2.5" 2.5"	2	Rigid	5
Lane Driver	5s – 15s	5" X 5" X 5"	3	Rigid	4
Linear Memory	1s -5s	2.5" X 2.5" 2.5"	1	Linear	2

1.5.3.3 Storing Solutions

In this section of the Concept Generation covers methods to store space debris during the competition at Southeast Con 2019. These ideas are necessary for designs that gather space debris. To be an effective a storage solution, it must hold the maximum of space debris while keeping it sorted. This function is important, so the robot can bring space to zone one and home bases.

Boxed Storage System

This design follows that of a simple box. The internal area of the box would be 5" by 5" by 6.5" (L X W X H) with four vertical areas divided by four walls. The size would cover the smallest amount volume to fit all pieces of space debris and the walls would be used to keep the space debris sorted. Due to the volume that the box takes, it would have to be place directly above or below the sorting mechanism. Also recommended that to have weights to lower part of the frame to shift the center of mass.

Simple Sack System

This solution mirrors that of a trash bag. The internal area would expand to 5" by 5" by 6.5" (L X W X H) and would expand when space debris is added. This design does not keep the space debris sorted or organized, so it recommended for designs with no sorting mechanism and taking the space debris straight to home. This design is space friendly due to its collapsing nature, however the space debris must be deposited directly above the sack or have a door present to prevent the space from spilling out.

Horizontal Lane Storage System

This design had center of mass in mind. The internal area can hold up to 6.5" X 6.5" X 2.5" (L X W X H), or only the maximum amount of 9. The three less pieces of space debris are due to keeping all pieces of space debris on one level and within the maximum length and width the robot may be during the competition. This design however is meant for design trying to avoid top heavy designs and a center of mass closer to the ground. This will have four walls to keep the space debris sorted. The space debris must be placed from the top of the storage system to keep the space debris organized.

[Type]	Volume (L X W X H)	Amount of Space Debris	Keeps the Space Debris Sorted
Boxed Storage System	5" X 5" X 6.5"	12	Yes
Simple Sack Storage	5" X 5" X 6.5"	12	No
Horizontal Lane Storage System	6.5" X 7.5" X 2.5"	9	Yes

1.5.4 Returning home module

One part of requirement of competition where we can get lots of points at is returning home. The home is home base which is the colored corner where it begins. To have the robot autonomously get back to the home base, we need to let the robot drop off the specific debris to colored corner first, then locate where it is and where the home base is, finally, the robot will be able to head back.

1.5.4.1 Localization Solutions

To get to a specific place in the playing field to accomplish some goals like dropping off the debris, the robot needs to know where it is first which is localization. Only with knowing both the position of the robot and the destination, the robot can do next step which is moving.

Distance from walls

The first method is locating the robot by several IR sensors. Since the playing field will be surmounted by four walls which is east to be detected by the IR sensor, we can measure the distance from each wall to locate the robot. The advance of this method is that it is easy and clear to operate. The problem of this method is that as the robot will be moving by orbit, we cannot ensure that the sensor is perpendicular to one of the wall which means it won't be precise enough.

Color of Spacetel

The second method is enlightened by the spacetels located on the orbit line. For returning home, the robot only need to know which quarter of the field it is in.Since there are four LED obstacles which is the same amount of the color of the objects. We can approximately get the location of the robot by detecting the color of nearest spacetel which can be accomplished by the camera which is for sorting debris. The advantage of this solution is that we don't need to add any more sensors to get the location. The disadvantage is that we can't get precise location.

Self-localization based on gyro and code disk

The third method to locate the robot is using a code disk and a gyro. We can regard the playing field as a coordinate system, and its origin point is the home base where it begins. With a gyro we can get the angle of the path of the robot while with a code disk we can get the length of the path of the robot. The advantage of this method is that the location is described as coordinate, so it is much more precise and fast. The disadvantage is that we need to add two sensors to the robot and the size of the robot is limited.

Locate and go

The fourth method is the hybrid of the first and second methods. With recognizing the color of the nearest spacetel we can tell which quarter it is in. And with the IR sensor, the robot can adjust the direction of moving to get to the colored corner. The advantage of this method is that we don't need to use IR sensor when moving by an orbit. The disadvantage is that it won't be very efficiency.

Table 1

Different references and their parameters

method	Time estimate	Accuracy	Ease of implementation	Possibility of error	Size of sensor required
Distance from walls	30 seconds	moderate	moderate	moderate	low
Color of spacetel	20 seconds	low	easy	high	none
With a gyro and code disk	15 seconds	high	very difficult	moderate	high
Locate and go	40 seconds	moderate	difficult	low	low
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1.5.4.2 Wheels

The competition our robot will join in is a time limited competition. So the speed is an important factor to get more points. Despite the power of the motor, the wheel is another factor to the speed. A better wheel could give more ground holding and friction. With more friction, the robot can overcome more centripetal force and generate a bigger acceleration.

Airless wheel

Airless wheel is the wheel which is solid inside. Because the inside of the wheels is solid, the wheel can carry more weight. But for our robot, this is simply unnecessary since the designed weight of our robot will not be over 5 pounds. The disadvantage of the wheel is that the contact area between the wheel and the field is very little.

Air wheel with high pressure

High pressure air wheel is made of rubber with high pressure inside the wheel. The advantage of the wheel is decreasing the friction between ground, so in the meantime, it will increase the efficiency of moving. The disadvantage of this wheel is that this kind of wheel will decrease the friction which is important to keep the robot from drifting. So even if the efficiency is rather high but the speed still needs to be limited in a low level.

Air wheel with medium pressure

Medium pressure wheel is the wheel with medium pressure in the inner ring of the wheel. The advantage of this wheel is that it will keep the friction in a viable level while increasing the efficiency of the wheel. The disadvantage is that it may not carry a heavy equipment on the robot.

Meconium wheel

Meconium wheel is a design for a wheel which can move the robot in any direction. It is a conventional wheel with a series of rollers attached to its circumference. These rollers typically each have an axis of rotation at 45° to the plane of the wheel and at 45° to a line through the center of the roller parallel to the axis of rotation of the wheel. The advantage of this wheel is that it can quickly move to any position. The disadvantage is that the price is very high, and it may cannot perform well on the carpet.

Type	Price	Friction value	Reliability	Ease of programming	Load
Airless wheel	low	0.2	medium	easy	high
High pressure wheel	low	0.3	medium	easy	high
Medium pressure wheel	low	0.6	medium	easy	medium
Meconium wheel	high	0.5	low	difficult	medium

1.5.5 UFO Avoidance Algorithm

An important constraint set forth by the Southeast Con Robotics Competition Committee is to have a robot capable of navigating around the competition's playing field, without colliding with any other UFOs roaming the field. To meet this requirement in a competitive atmosphere, the Southeast Con Robotics team's autonomous robot must be able to detect any object quickly and from a distance this is greater than 80 cm., as this will provide enough time for the robot to adjust its moving path. One of the main issues that has identified by the team, is that each set of obstacles that the robot will detect will varying size diameters; so, the robot must be able to know when the detected object is another UFO, a debris that is will need to collect, or field architecture set up at a fixed location. To deal with the challenge of differentiating between debris and another UFO or field architecture, various long-distance IR sensors and a real-time, Arduino compatible video camera will used. The presented solution will allow for a more accurate detection mechanism for the robot, which in turn will allow for a faster response to sudden changes to robot's traveling route.

1.5.5.1 Avoidance Solutions

As stated previously, the avoidance of other robots in the playing field is an important constraint set forth for the competition; and to deal with this, various possible solutions have been presented and will be discussed more in depth below.

Predetermined object size

The first method presented will rely on a preprogramed algorithm that would allow for the robot to know the dimensions of the debris it is collecting before entering the competition. This will method would require minimal resources, as all debris dimensions have been proved with the competition rules. This process will allow for a faster navigation time through the field, as the robot will have the knowledge to avoid any detected object that is bigger than the preprogrammed dimensions. With the use of Pixy2 camera or the TTL Serial JPEG Camera, the detection and recognition process will be sped up as these two cameras will allow for real time image processing.

Stopping and Scan Surrounding

This approach will result in safer navigation through the field, as the robot will be static when it surveys its surrounding. The algorithm required to achieve this method be relatively simpler than those of the other two methods examined. Although this method of object avoidance will guarantee the most success in preventing collusion, stopping and then scanning its surrounding will result a much slower moving robot. Furthermore, the amount of time needed to stop, scan, and move will put the robot at a disadvantage in the second round of the competition.

Surveying Field While Moving

This final method for object detection and avoidance will require the most time to develop, due to the reliance on quick categorization of objects detected. For this avoidance algorithm to produce the desired results, the use of predetermined object sizes and quick responding sensors will be need. One of the drawbacks of use this method of object avoidance is the high risk of colliding with other objects in the field; this is due to the fact that the robot will be constantly moving and adjusting it debris clearing path once an obstacle is detected. Although, this may be more difficult to achieve, the use of this surveying algorithm will allow for a faster navigation time, as the time spent detecting and categorizing a detected object is less than the other two methods presented.

Table 1
Different Algorithms and their Parameters

Method	Time Estimation	Complexity	Avoidance Percentage	Ease of Implementation	Possibility of Collisions
Predetermined Object Size	3 - 4 minutes	Simple - Moderate	80 – 90 %	Moderate	Low - Moderate
Stop and Scan Surround	4 - 6 minutes	Simple	95 - 99 %	Easy	Low
Surveying Field While Moving	2-3 minutes	Moderate	70 – 80 %	Moderate - Difficult	moderate

1.5.2 Sensors

The most important component needed to achieve a high detection and avoidance ratio is the use of sensors. The number of sensors needed will vary depending on the quality of the ones chosen for the final robot design, therefore various sensors will be examined and compared to illustrate the pros and cons of using a specific sensor.

Concept 1: Pixy2 CMUcam5 Sensor

The Pixy2 camera allows for the observation of both flat and 3d objects, as this Arduino compatible camera is able to provide a 3-dimension feedback of what is being observed. Furthermore, this video camera allows for categorizing each objected detected in relation to the color and size of the object at a faster time frame, due to its 60-fps frame rate. Because this camera has a companion web application, it is possible to program camera send a specific feedback to the Arduino microcontroller, and therefore increase the potential utility of this device. With a 60-degree horizontal and 40 degree vertical, the Pixy2 cam allows for wider viewing angle, which would allow for better detection of objects in the field.

Concept 2: TTL Serial JPEG Camera with NTSC Video

The TTL JPEG camera allows for the capturing of objects in jpeg format or videos at a frame rate of 30 fps, allowing both fast image process. Similar to the Pixy2 camera, this JPEG camera voltage requirement ranges around 5V, which is ideal for the use with any microcontroller. A notable feature for this device is its 60-degree vertical and horizontal viewing angle, which is wider when compared to the Pixy2 camera; however, due to the frame rate of 30 fps there may be some slight time increase in analyzing the object detected and categorizing it as a UFO or debris.

Concept 3: IR Distance Sensor (20cm-150cm Range)

This 20 – 150 mm range IR distance sensor provides enough detection range to allow for a reasonable response times for the robot. With a 150 mm max detection distance, this IR sensor allows for good range detecting an object and avoiding the detected object. One drawback with using this sensor is that it is only capable of objects straight ahead of it, so this will require the robot to rotate to scan the surrounding area.

Concept 4: IR Distance Sensor (100cm-500cm Range)

The 100 – 500 cm range IR distance sensor provides a very reliable detection distance, allowing for quicker time to examining objected detected and categorizing the item as debris or a UFO that needs to be avoid. This sensor has the same voltage requirement is the sensor previously examined, however, it is a bit bigger, with more than twice the max detection range. As with the previous IR sensor, this distance sensor can only detect an object at a linear path or in other words it can only detect something that is straight ahead of it.

Table 2
Different Sensors and their Parameters

Sensors	Voltage Requirement (Volts)	Output Format	Size	Frame Speed	Viewing Angle
Pixy2 CMUcam5	5 V	Video	38mm x 41.91mm x 15.24mm	60 fps	60 Degree (Horizontal), 40 Degree (Vertical)

TTL Serial JPEG Camera with NTSC Video	+5 V	JPEG	32mm x 32mm x 32mm	30 fps	60 Degrees
IR Distance Sensor (20cm-150cm Range)	5 V	analog voltage	21.66mm x 44.39mm x 18.67mm	N/A	0 Degrees (Linear)
IR Distance Sensor (100cm-500cm Range)	5 V	analog voltage	58mm x 17.6mm x 22.5mm	N/A	0 Degrees (Linear)