Purdue SIGBots Wiki – Notion Notebook Complete

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Game Analysis [12/01]

date	@12/01/2023
Category	Game Analysis Identify The Problem
Authors	Max, Rohan, Purdue SIGBots
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Game Overview

VEX Robotics Competition Over Under is played on a 12'x12' square field. In Head-to-Head Matches, two Alliances (red and blue) with two Teams each compete in a 15-second Autonomous Period followed by a 1:45 Driver Controlled Period. The goal is to score more Triballs in Goals and Elevate at the Match end. An Autonomous Win Point is awarded for completing three assigned tasks. Robot Skills Matches involve one Robot scoring points independently for 1 minute.

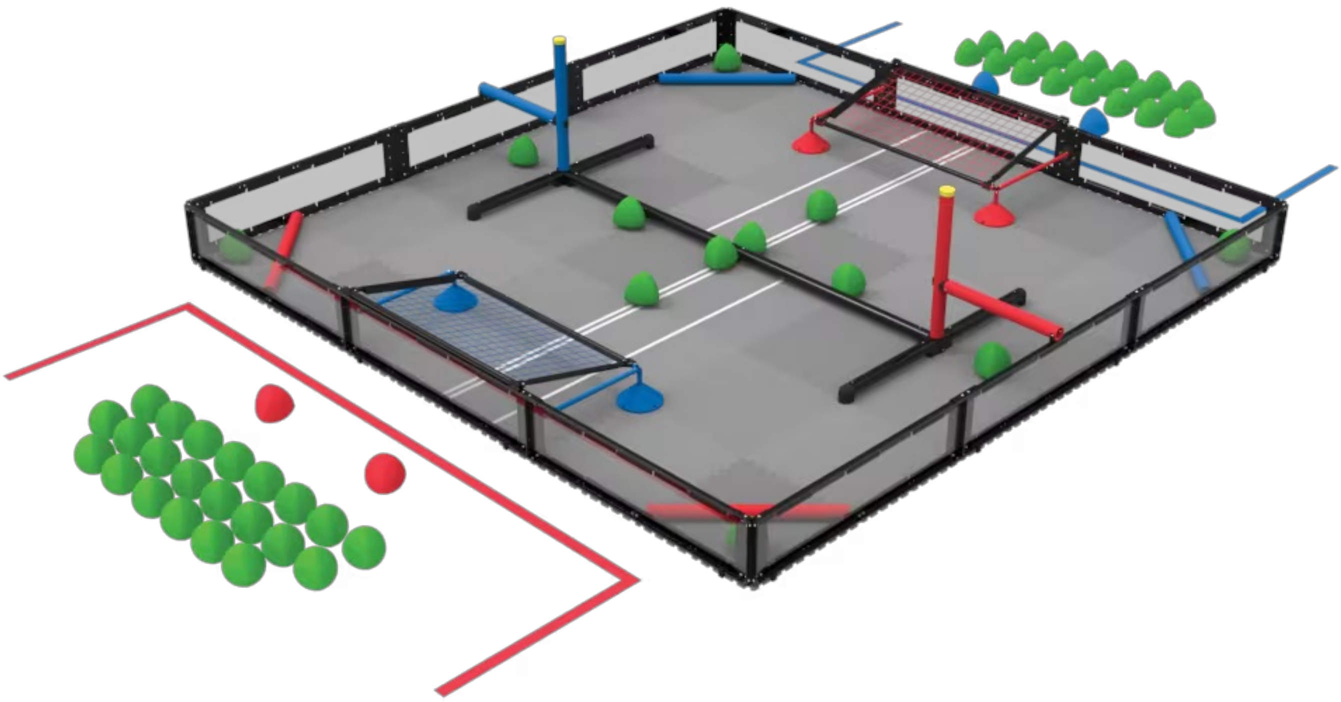

Figure 1 [Isometric Field View]

Game Objectives

- Score Triballs in offensive zones and goals
- Elevate the robot at the end of the match
- Score point in the autonomous period and complete the Autonomous Win Point Tasks

Field Layout

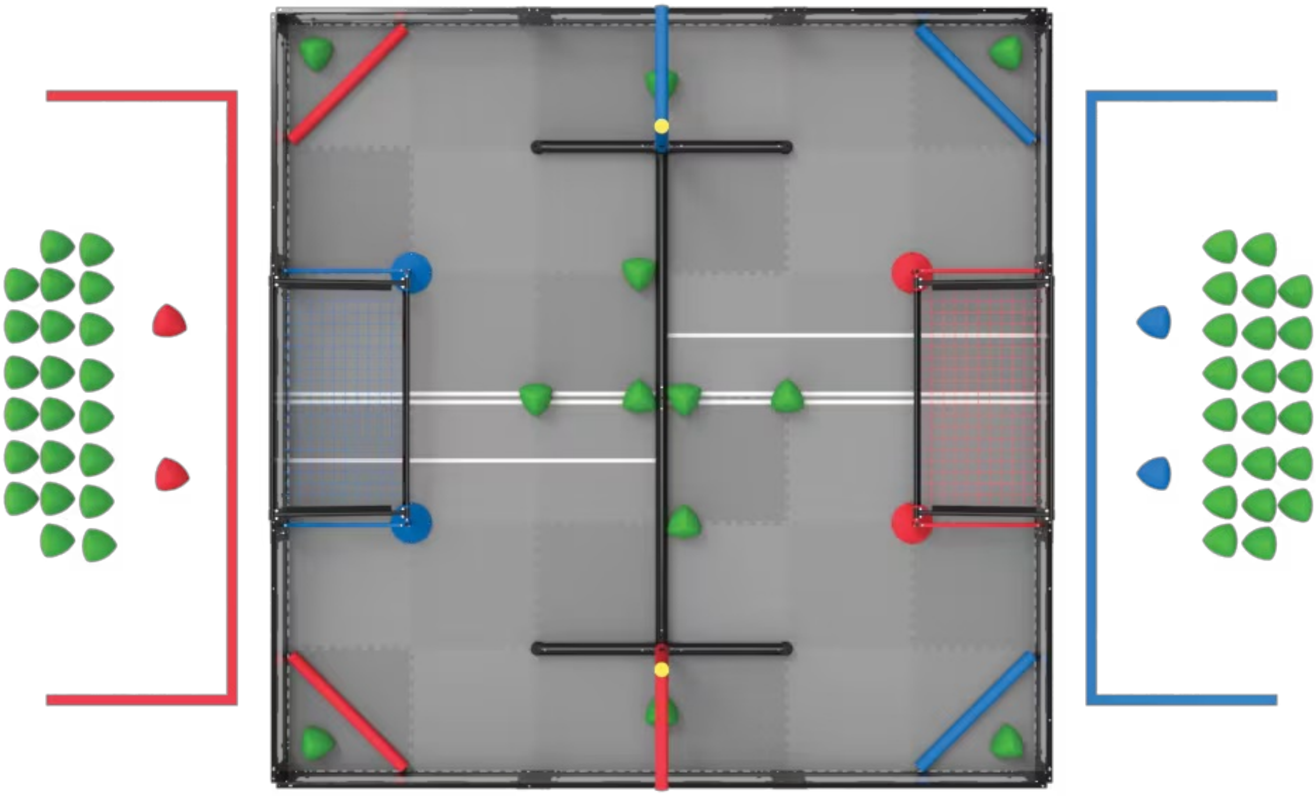

Figure 2 [Top Down Field View]

On any given field for [game name], there are:

- 60 Triballs
    - 12 start on the field
    - 44 start as match loads, 22 for each alliance
    - 4 colored Alliance Triballs that can be used as Preloads for each alliance
- 2 Goals, 1 for each alliance
- 4 Match Load Bars / Match Load Zones, 2 for each alliance
- 2 Elevation Bars, 1 for each alliance
- A Barrier and Autonomous Line each bisecting the field

At the beginning of a match, robots will start at the edge of the field perimeter to the right of each Alliance Station.

Game Element Breakdown

Figure 3 [Triball]

A Triball has the following properties:

- Bright green in color
  - Very visible to Vision Sensors and Optical Sensors; simple color signature
- “Reuleaux tetrahedron” shape
  - It is a shape of constant width that can roll smoothly but unpredictably on a flat surface. It is unpredictable on how well it fits in tight spaces.
- Composed of HDPE plastic, which produces a rough texture on its surface
  - Should be hard with very little compliance
  - Hardness may change its energy upon collision from a slapper or a puncher.

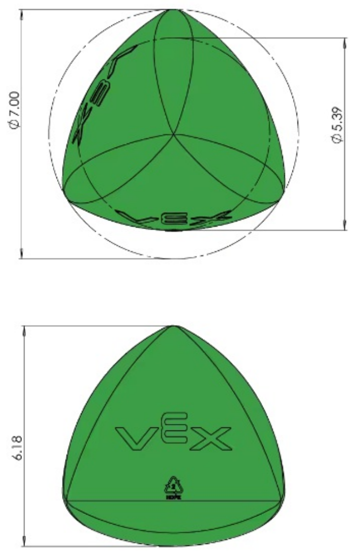

Figure 4 [Triball dimensions (per appendix A)]

- Weighs anywhere from 103 grams to 138 grams.
  - This is very light, meaning pushing or launching Triballs can be elements of a potential game strategy

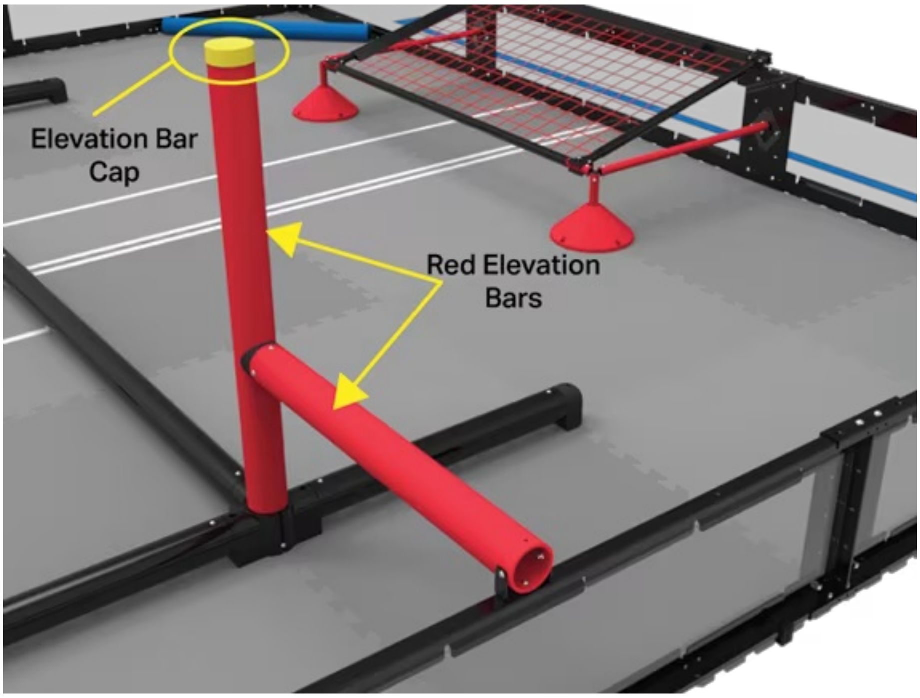

Figure 5 [Elevation Bar]

A Goal has the following properties:

- The goal is composed of colored PVC pipes and covered by colored netting.
    - If Triballs end up on top of the colored netting, they are awarded to the opposing team as potential match loads.
- The goal is 39.37 inches long, 23.08 inches deep, and 5.78 inches tall.
    - Because the goal's height is nominally 0.4 inches smaller than the linear height of the Triball, it will take an extensive amount of force to push Triballs in most likely (needs future testing).

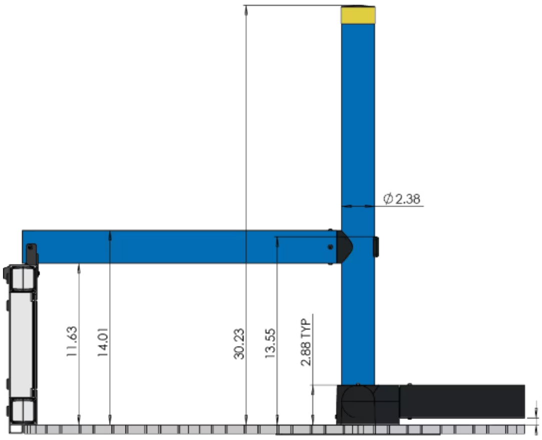

Figure 6 [Dimensions of the Elevation Bars (per appendix A)]

The elevation bars have the following properties:

- The elevation bars are 2.375 inch diameter PVC pipes, with a yellow, rubber cap wrapped around the top of the vertical elevation bar.
    - These essentially act as a divider in the center of the field.
    - The yellow, rubber cap does not count as the elevation bar.
- The horizontal elevation bar is situated 11.63 inches above the field tiles, effectively forming a "tunnel" below. The top of the vertical elevation bar, which is exactly perpendicular to the horizontal one, is 30.23 inches above the tiles
    - While the vertical bar's maximum height is extremely high, (more than two times the maximum height of a 18" robot) the height of the horizontal bar is quite low at 11.63 inches, which may mean that the robot's height will need to be highly dynamic.

Scoring Breakdown

Points are scored by an alliance when the following occurs:

- A Triball is placed in…
  - Goal
  - Offensive Zone
- The alliance wins the autonomous bonus
- A robot hangs on the Elevation Bar at the end of the match

	Object Point Value	Total Object Amount	Maximum Points Possible	Percentage of Possible Points
Triball in Goal	5	60	300	86.2%
Triball in Offensive Zone	2	60	120	34.5%
Robot Elevated	5 - 20 points (based on height)	2	40	11.5%
Autonomous Bonus	8 points	1	8	2.3%
Total			**348**	**100%**

Figure 7 [Table of point value to object amount for each game element]

- Scoring Triballs in the goal makes up a considerable amount of the possible points in a match, arguably making it the most viable way to score points.
- Simply having Triballs in the offensive zone can add up over time if there are a lot of them in the zone as well, with it making up the second most amount of points.
- Robot elevation can be a considerable swing if a match is close, with there being 40 points possible for an alliance if both robots can end up in the highest tier.

Important Rules to Consider

- SG2: Horizontal expansion is limited to 36”.
  - If we consider any sort of mechanism that will change the horizontal size of our robot, we need to be mindful of this limitation.
- SG3’s Note: Triballs that come to rest on top of a goal can be retrieved by a drive team member.
  - Our drive team members will need to remember to do this if this occurs, because it will give us more ammunition to score with.
- SG7: Possession is limited to one Triball.
  - This seems like a rule that could be easily broken if we are not careful, so our design should probably have failsafes in place to prevent us from breaking this rule.
- SG8: Stay out of the opponent’s goal unless they are double-zoned.
  - Double-zoning: when two robots of the same alliance are in the same zone, whether it is offensive or defensive.
  - Drive team members will need to be vigilant about any potential double zoning instances for either our alliance or the opposing alliance so that we may rectify or take advantage of the ability to descore.
- SG11: Elevation is protected during the last 30 seconds of a match.
  - Our robots must take caution to not touch opposing robots who are touching their elevation bar, elevated, or their elevation bar at all.

Potential Strategies

Offensive Strategies

- Try to shoot Triballs directly into the goal from the match load zone.
  - This would probably be difficult considering that the goal is shorter than the Triball, so it would likely take a tremendous amount of launch velocity to get a Triball into the goal.
- Gather a bunch of Triballs in front of the goal, and then push all of them into the goal at once.
  - Note: pushing is not considered possession as long as the pushing surface is flat or convex.
  - This may require a mechanism that would allow the robot to expand far enough to push all of the Triballs at once.

- Pass Triballs to a partner from the match load zone, and then have the partner follow through by pushing the Triball into the goal.
    - While this method could be slower, it is arguably more accurate since it does not require precision from the shooting mechanism.

Defensive Strategies

- Force opponents to double zone so that Triballs can be descored from their goal.
    - Forcing a double zone situation would probably be extremely difficult and would take a very powerful drivetrain.
    - This strategy would surely take place towards the end of a match when the most amount of Triballs are in the goal rather than earlier on.
- Since vertical expansion is not explicitly limited and the horizontal expansion is relatively relaxed, the robot could have blocking capabilities to block Triballs.
    - Blocking match load shooting might become very prevalent later in the season because it seems like the easiest way to defend the opposing team since match load shooting is conversely the fastest way to score.
- Because shooting from the match load zone is so prevalent, the robots need to be able to push them to cause them to misalign their shots.
    - Pushing is an inexpensive way to mess up match loads from the other team, whereas the prior strategy requires an entire mechanism.

Identify The Problem [12/02]

date	@12/02/2023
Category	Identify The Problem
Authors	Max, Rohan, Purdue SIGBots
Ready	☑
Exported	☐
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Problem Statement

Today, we will identify constraints for the chassis of our first robot.

The robot must be designed, built, and programmed by December 16th for our first competition.

The first and most important design consideration of the skills robot will be figuring out how to design a chassis which will maximize our skill score. In order to do so, the robot will need to meet the following criteria:

- Create a chassis design which can work in conjunction with our Triball Launcher and Endgame Hanging Mechanism.
- Make the chassis design easy to fix and require little maintenance.
- Creating an effective drive train and wheels which will work well with a 300 rpm gear ratio.
- Be able to move quickly around the field

Design Statement

By the end of the week, we want to design, build, and program the chassis of our robot and leave space for future development after the 12/16 competition.

Constraints

- 18” x 18” x 18”
- Use 4 motors or less
- Be under 6” tall to go under the goals and de-score

Criteria

1. Remain flexible with regards to adding further subsystems
    a. The chassis design should be able to support the Triball Launcher and Endgame Hanging Mechanism
2. Ensure that the chassis is durable and able to be maintained easily
3. Function using a 200 rpm gear ratio and perform well in testing
4. Cross the field quickly and without difficulty

Important Deadlines

- 12/10/2023: Complete the drive train and test for effectiveness
- 12/16/2024: First competition

Brainstorm Solution [12/04]

date	@12/04/2023
Category	Brainstorm Solution
Authors	Max, Rohan, Purdue SIGBots
Ready	☑
Exported	☐
Archive	☐

Problem

We need a robot that can confidently traverse the field and maneuver to manipulate game elements and interact with field elements to score points

The ideal chassis should be able to:

- Quickly traverse the field
- Maneuver easily around field elements and opposing robots
- Be adaptable to multiple gameplay strategies

Potential Solutions

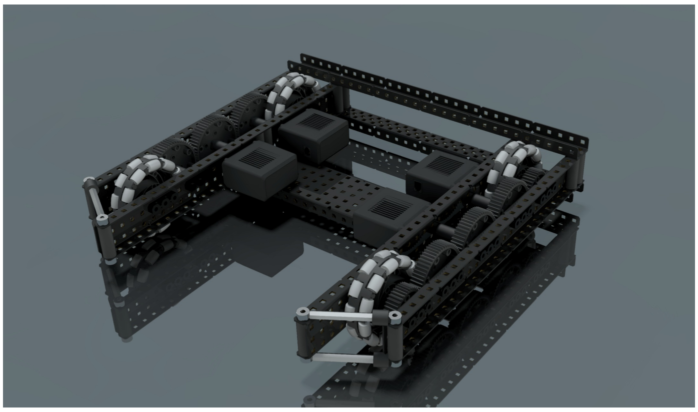


Figure 1 [Tank Drive] - Xenon27 Vex Forum

- Tank Drive
  - A tank drive in robotics refers to a common and simple drive system where two separate sets of wheels on each side of the robot are independently powered. By adjusting the speed and direction of each set of wheels, the robot can achieve basic movements such as forward, backward, and turning.
  - A tank drive has lots of pushing power when compared to other drive options and is very efficient at forward and backwards movement. The tank drive is easy to build and historically reliable which is important with the tight time frame that the team has to construct it.

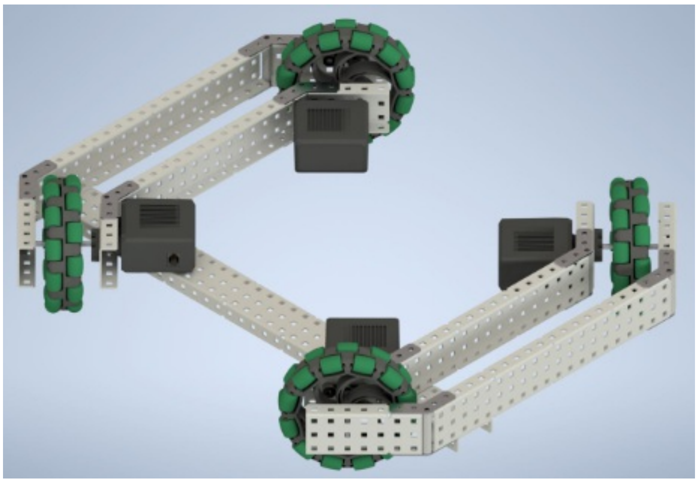


Figure 2 [X Holonomic Drive] - Purdue SIGBots Wiki

- Holonomic X Drive
    - An X holonomic drive is a robotic drive system that allows for omnidirectional movement with precise control in any direction, utilizing mecanum or omni-wheels arranged in an X-shaped configuration. This design enables the robot to smoothly translate and rotate without changing its orientation, making it highly maneuverable in tight spaces.
    - An X holonomic drive allows for versatile maneuverability around the field with motion in all directions without turning the chassis. X Holonomic Drives also have a higher speed with identical gearing to that of Tank Drives.

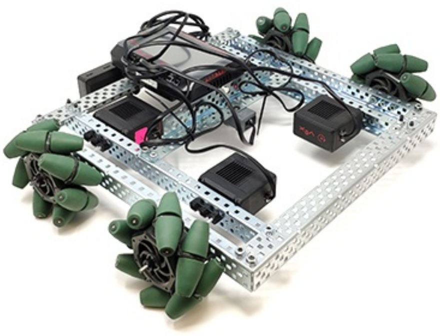
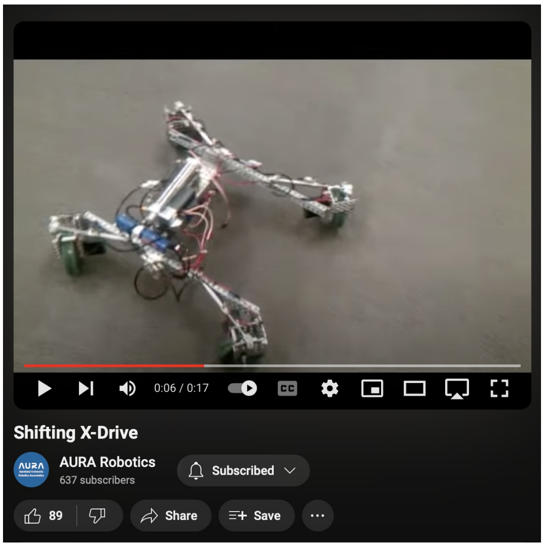


Figure 3 [Mecanum Drive] - CS STEM Network

- Mecanum Drive
    - A holonomic drive in robotics allows for advanced maneuverability by employing wheels that can move independently in any direction, providing omnidirectional motion. This design enables the robot to seamlessly translate and rotate with precision, offering enhanced agility and control in navigating complex environments while maintaining a simple construction compared to other holonomic drives.
    - A Mecanum drive for this game gives lots of the benefits for maneuverability that come with a holonomic drive. Mecanum drives don't have the additional speed that Holonomic X drives have. Mecanum drives have a simpler construction than X Holonomic drives with all 4 wheels still being parallel similar to tank drives.

Supporting Data



This video from 2012 did a really good job at showing how holonomic drives affect the speed of a chassis. We know that the speed when compared to a nearly identical tank drive (same rpm and wheel diameter) is sqrt(2)/2 times faster.

PurdueSIGBots. (n.d.). Tank Drive. Purdue Robotics Wiki. Retrieved [12/04/2023], from https://wiki.purduesigbots.com/hardware/vex-drivetrains/tank-drive

PurdueSIGBots. (n.d.). Holonomic Drive. Purdue Robotics Wiki. Retrieved [12/04/2023], from

https://wiki.purduesigbots.com/hardware/vex-drivetrains/holonomic-drive

PurdueSIGBots. (n.d.). Mecanum Drive. Purdue Robotics Wiki. Retrieved [12/04/2023], from

https://wiki.purduesigbots.com/hardware/vex-drivetrains/mecanum-drive

Select Best Approach & Plan [12/05]

date	@12/05/2023
Category	Plan, Select Best Solution
Authors	Max, Rohan, Purdue SIGBots
Ready	☑
Exported	☐
Archive	☐

Problem

We need to design a chassis to be used for our first robot for the Vex Robotics Competition game Over Under

Potential Solutions

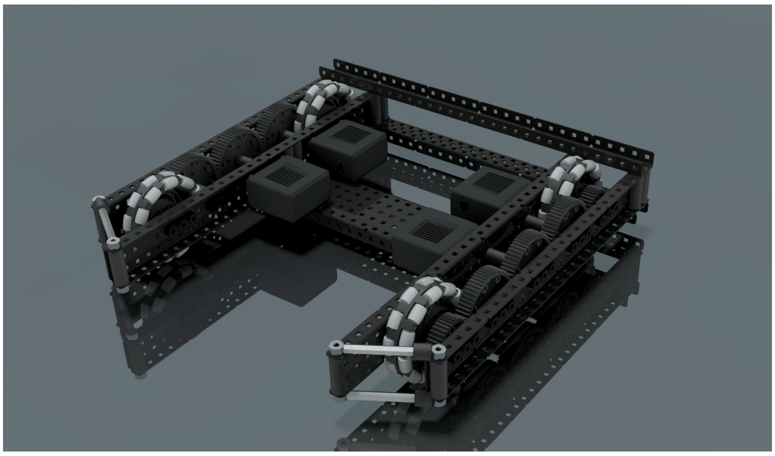


Figure 1 [Tank Drive] - Xenon27 Vex Forum

Tank Drive

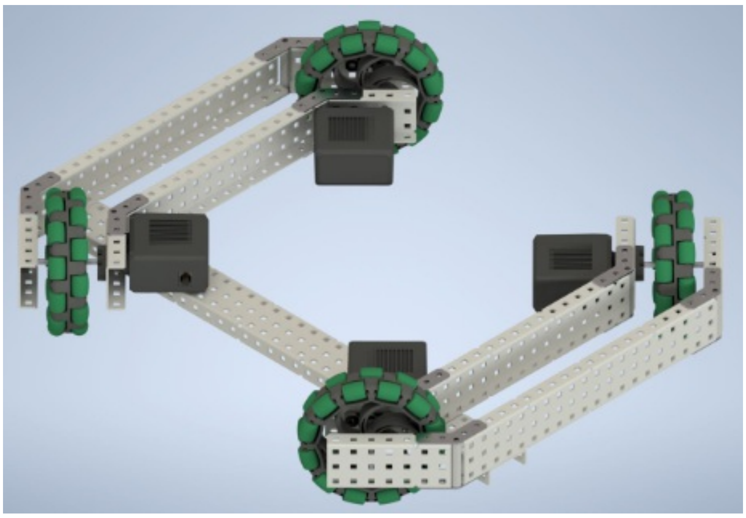


Figure 2 [X Holonomic Drive] - Purdue SIGBots Wiki

X Holonomic Drive

Figure 3 [Mecanum Drive] - CS STEM Network

Mecanum Drive

Decision Matrix

There are 3 criteria that will be used to determine which chassis implementation is best:

- Speed - Given identical wheel diameter and rpm, the speed at which the drive can traverse the field. This is important as we need to be able to move faster than opponents to control Triballs.
- Maneuverability- Directions that the chassis can move and the efficiency that it moves in those directions. This is important as we will need to be able to move around obstructing field elements as well as opposing robots.
- Ease of Construction/Programming - How quickly and reliably we believe we can build and program the chassis as we have a competition quickly approaching.

	Speed	Maneuverability	Ease of Construction/Programming	Total
Tank Drive	4/5	3/5	5/5	12 / 15
X Holonomic Drive	5/5	4.5/5	3/5	12.5 / 15
Mecanum Drive	3.5/5	4/5	4/5	11.5 / 15

We have decided to use an **X Holonomic Drive**. We have chosen this because of it's efficiencies in speed and maneuverability. The lack of degrees of motion for the Tank Drive holds it back even with the benefit of it's speed since we will benefit greatly by having the ability to strafe. The Mecanum drive is hurt because of the weight and size of the Vex 4" mecanum wheels that we would have to use. Additionally, we like the speed of holonomic drives.

Justification

The Holonomic X Drive will be best because:

- The speed of a Holonomic X Drive is sqrt(2)/2 times faster than a Tank Drive of the same rpm and wheel diameter. Additionally, this speed is kept for both forward movement and strafing unlike the Mecanum Drive that has reduced speed in the 4 cardinal directions.
- The maneuverability of the Holonomic X Drive is very strong with the ability to rotate on a point, and also move in all 4 cardinal directions at identical speeds. The Tank Drive can only move forward/backwards and the Mecanum Drive has the same motion as the X Holonomic but far slower as energy is lost.
- The Ease of Construction/Programming is not the strongest for the X Holonomic Drive as we don't have experience building it, but there are lots of resources on the amazing Purdue SIGBots Wiki. Both the Tank Drive and Mecanum Drive are simpler to build since the wheels are parallel.

Implementation Plan

Over the coming days, we need to do more sketching to plan out the drive and decide on an RPM and wheel diameter. We will then move into CAD to plan out the construction before coming together to build the chassis.

We have a competition on December 16th, so we need to have time to build, program, test, and practice driving our robot before then.

Build Log [12/07]

date	@12/07/2023
Category	Build Log
Authors	Max, Rohan, Purdue SIGBots
Ready	☑
Exported	☐
Archive	☐

Goals

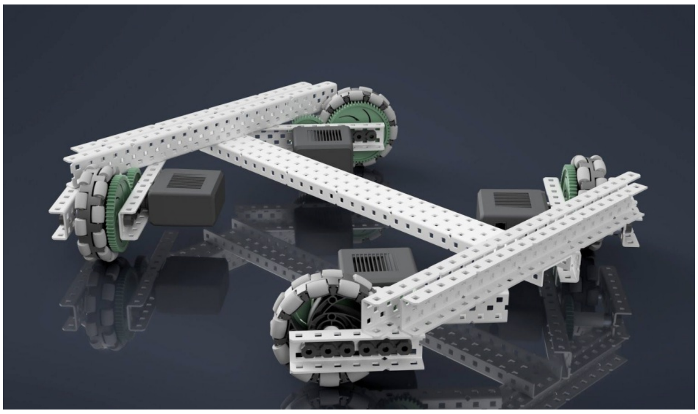
- Decide on Speed (Including wheel diameter and motor rpm)
- Sketch out a Holonomic X Drive plan
- Design the chassis in CAD
- Build the chassis
- We have a tournament on the 16th, so would like to complete the build of the chassis today so we can program, and test in the next 2-3 days and allow us to practice driving for a week.

Sketches

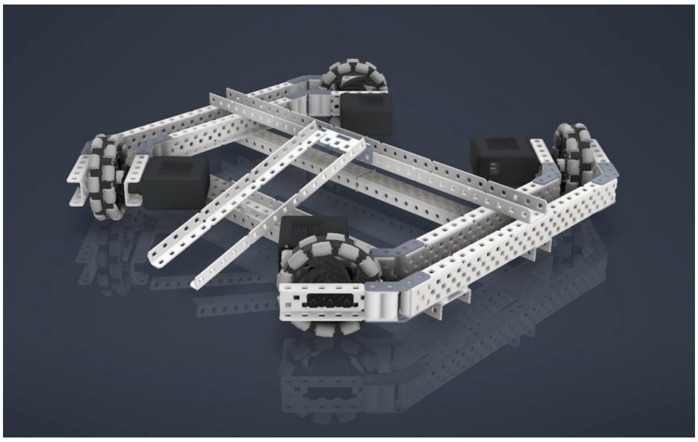
[Include sketches of the component]

[Describe the intended use]

Prototypes

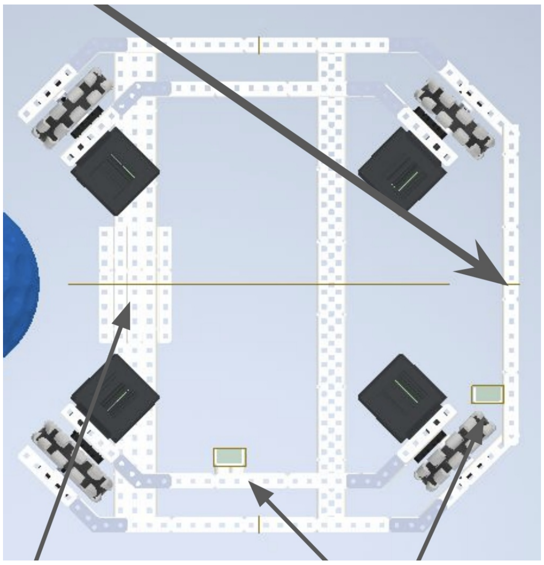


Design option without the use of 45 degree gussets where the angles are built using the offset of 2 outer c channels



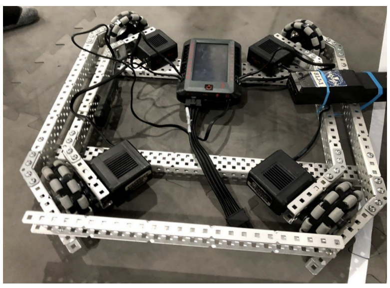
Simple design option using Vex 45 degree gussets with boxed connections

We decided to use the simpler design because of the time constraints that we are under. This also has a lower profile and lighter design that will help us as we continue to move forward. The complexity comes from making the holes align along the front, and through the center.

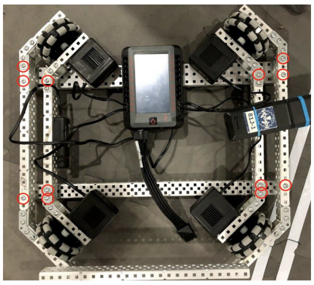


Top down view of a refined chassis with fixed hole alignment along the center and better allignment in the rear.

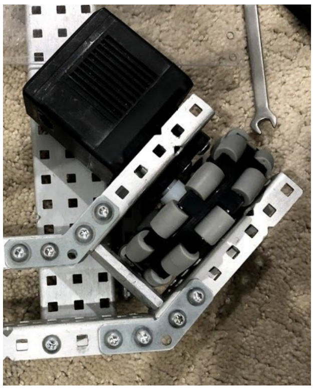
Outcome



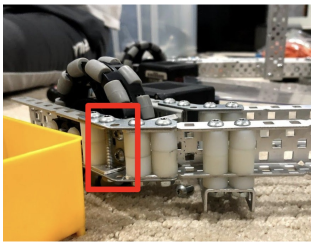
Overall completed chassis build



Top down chassis build

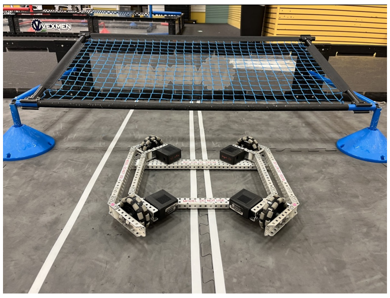


Drive pod close up view

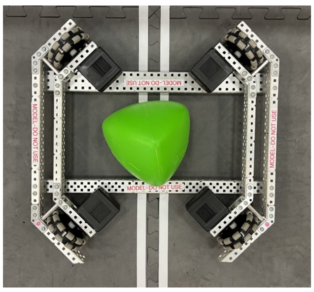


Boxed c channels for rigidity around gussets.

We have completed building the chassis. Above are some photos. Below are some photos on the Over Under field.



chassis near goal



chassis with Triball

Next Steps

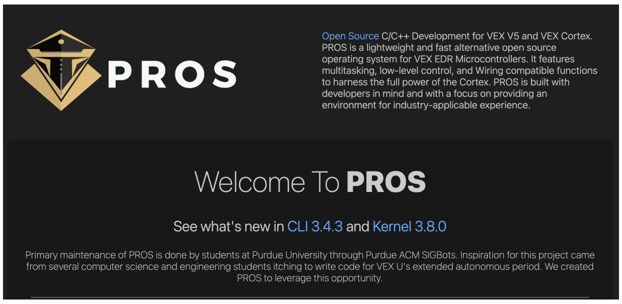
We need to program the chassis.

Programming Log [12/09]

date	@12/09/2023
Category	Programming Log
Authors	Max, Rohan, Purdue SIGBots
Ready	☑
Exported	☐
Archive	☐

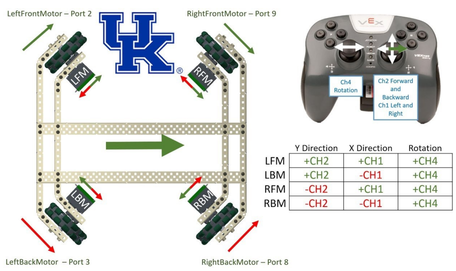
Goals

- Program a drive function for the chassis
- The drive code needs to be completed by early tomorrow so we can move forward with testing and then have until 12/16(first competition) to practice and refine.



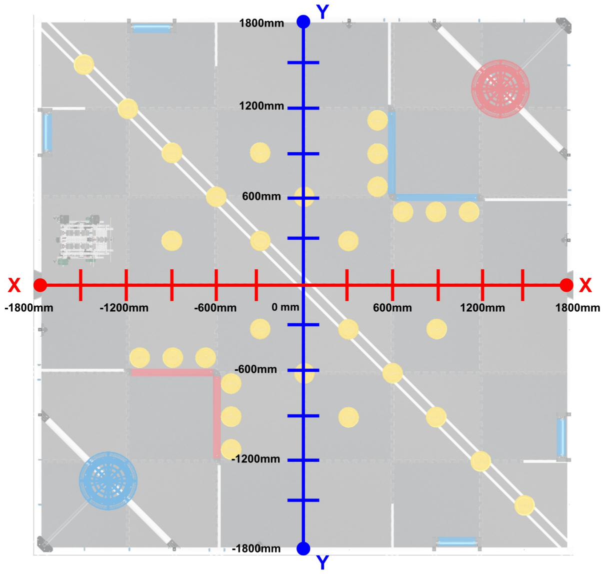
As a note, we use PROS

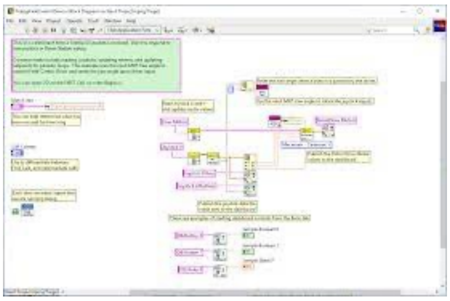
Outline

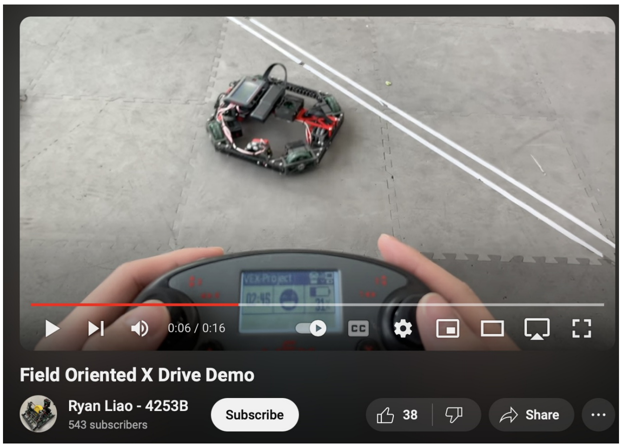


	Y Direction	X Direction	Rotation
LFM	+CH2	+CH1	+CH4
LBM	+CH2	-CH1	+CH4
RFM	-CH2	+CH1	+CH4
RBM	-CH2	-CH1	+CH4

We would like a field centric control of the chassis meaning that the vertical stick will always move towards the Y axis on the field, and the horizontal stick will move along the X axis. The left joystick will be used to rotate the drive.







https://www.youtube.com/watch?v=1-pkqckd6Y0

Prototypes

Below is the initialization of our IMU sensor to allow for tracking of our field centric code

```
void initialize() {
 pros::IMU imu(9);
 imu.reset();
 pros::lcd::initialize();
 pros::lcd::set_text(1, "Hello PROS User!");

 pros::lcd::register_btn1_cb(on_center_button);
}
```

Below is the drive control code for Field Centric Control

```
void opcontrol() {
```

```
  pros::Controller master(pros::E_CONTROLLER_MASTER);
  pros::Motor FL(-1);//Declare Front Left Motor Port
  pros::Motor FR(2);//Declare Front Right Motor Port
  pros::Motor BL(-19);//Declare Back Left Motor Port
  pros::Motor BR(15);//Declare Back Right Motor Port

  while (true) {
       int forward = master.get_analog(ANALOG_LEFT_Y); //Measure Left vertical joystick for Y axis motion
       int strafe = master.get_analog(ANALOG_LEFT_X); //Measure Left horizontal joystick for X axis motion
      int rotate = master.get_analog(ANALOG_RIGHT_X); //Measure Left vertical joystick for rotation

     FR.move(forward - strafe - rotate);
     BR.move(forward + strafe - rotate);
     BL.move(forward - strafe + rotate);
     FL.move(forward + strafe + rotate);

         pros::delay(10);
     }
 }
```

Outcome

The code works

Next Steps

Now that we have a constructed chassis that is programmed, we need to do testing, and make sure that it is ready for competition. We will take the next week to test and practice driving.

Testing Solution [12/10]

date	@12/10/2023
Category	Testing
Authors	Max, Rohan, Purdue SIGBots
Ready	☑
Exported	☐
Archive	☐

Component Overview

As described in the previous build entry, we will be testing the drive train we have recently constructed.

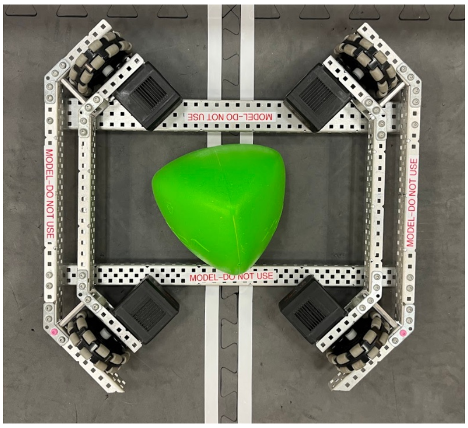


Figure 1: Completed Chassis

We will be testing to make sure the drive train functions as intended, as well as meets our performance criteria of crossing the field quickly.

Testing Plan

1. Ensure that the drive train is placed in a consistent starting position against the field perimeter.
2. Move the drive train at full speed across the field.
3. Stop the drive train as it hits the field perimeter on the opposing side of the field.
4. Time the test from the start of movement to the end of movement.

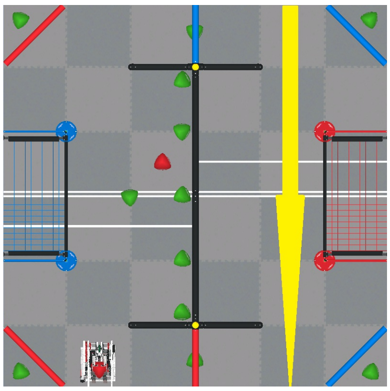


Figure 2: Testing Path, image from kb.vex.com

Testing

	[Attempt 1]	[Attempt 2]	[Attempt 3]	[Attempt 4]	[Attempt 5]
Time to cross the field	2.5s	2.3s	2.3s	2.4s	2.2s

Outcome & Next Steps

- It takes our drive train an average of 2.34 seconds to cross the field, with a range of 0.3 seconds between attempts
- This is fairly quick, and meets our criteria of having an efficient, quick drive train
- As our drive train meets the performance criteria set in our design brief, we can proceed to designing further subsystems

Tournament Recap [12/16]

date	@12/16/2023
Category	Testing, Tournament Recap
Authors	Max, Rohan, Purdue SIGBots
Ready	[x]
Exported	[ ]
Archive	[ ]

Premise

Match photo from competition hosted by the wonderful Purdue SIGBots

On 12/16/2023, we attended The Wonderful Purdue SIGBots Blended Competition in West Lafayette, Indiana which had a total of 60 competing.

Performance

Matches

Rank	2	**Record**	5-1-0
WP	11	**CCWM**	88.2
AP	40	**OPR**	104.5
SP	406	**DPR**	16.3

Outcome: Selected by 1st seed alliance and went on to win finals 199 to 100.

Robot Skills Challenge

Rank	1	Total Score	392
Driver Score	215	Programming Score	177
Driver Attempts	3	Programming Attempts	3

We had a very bad attempt for both driver and programming where motors died and axles came out. We ran all 6 attempts before qualifications started to tune the robot. We got identical scores for the next 2 of each runs.

Subsystems

Chassis

The chassis worked amazing except the first two skills runs. We are the number one team in the world for skills with just a chassis, so we know it is strong. It held up in competition as well.

Takeaways

- Match Strategy:
  - Our match strategy was flawless. We tipped in one match that we lost, but we played well before that.
- Robot Skills Challenge:
  - We're #1 in the world. There is always room for improvement in the future though so we will keep practicing
- Subsystems:
  - Add anything above the chassis to do better.

Next Steps

We will work through more of the engineering design process to design the remainder of the robot.

Innovative Feature

Category	Innovation
Authors	Max, Rohan, Purdue SIGBots
Ready	☑
Exported	☐
Archive	☐

Brief Description of the novel aspect of the team's design being submitted:

On our chassis, we used 1.25" screws with sandwiched spacers inside the c-channels to increase the strength of our connections between gussets. We call this innovative feature "Boxing" and are really excited to show it off and test it in competition.

Identify the page numbers and/or the section(s) where documentation of the development of this aspect can be found:

15-17