BLRS 15” ROBOT: ITERATION 2 DESIGN BRIEF

Author	Date	Entry Type	Robot	Iteration
Jaden Hernandez	01/30/2024	Project Management	15”	2

Problem Statement

Within a two minute time frame, robots need to…

- Place Triballs inside of goals.
- Move Triballs to their alliance’s side of the field.
- Elevate themselves utilizing elevation bars.

Design Statement

Design, build, and program a robot that will be able to place Triballs inside of goals, move Triballs to alliance zones, and elevate on elevation bars.

Constraints

- The robot must fit within a 15” x 15” x 15” cube.
    - The robot must also not expand to become longer than 36” horizontally, although there is no limit vertically.
- The robot must have license plates visible on opposing sides.
- Any motorized actuators must be from the VEX V5 system, i.e. an 11W or 5.5W VEX V5 motor.
    - There is no limit to the number of motors that can be used.
- Any commercially available, unmodified pneumatic actuator can be used, so long as it is not charged to a pressure over 100 PSI.
- Any commercially available electronic component can be used, so long as it interfaces directly with the V5 Robot Brain.
- Some commercially available hardware is allowed to be used on a robot freely, such as:
    - Fasteners of any type
    - Bearings of any type
    - Springs
- Robots may utilize any parts fabricated by the team as long as they were manufactured from “raw stock”. Raw stock can come in the form of:

  - Sheet
  - Solid Billet
  - Solid Bar
  - Hollow Bar
  - Solid Rod
  - Hollow Rod / Tube
  - Angle
  - U-Channel and C-Channel
  - 3D Printer Filament
  - Synthetic Polymer

Criteria

We anticipate that at this point in the season, a “successful” robot can do the following:

- Place at least 14 Triballs in a goal
- Ensure any Triballs that were in the alliance’s offensive zone are scored.
- Elevate at least to “B” tier

Ideally, the most successful robot would be able to…

- Place as many Triballs in the goal as physically possible
- Clear the field of Triballs
- Elevate to the highest tier by the end of the match

Important Deadlines

- February 2, 2024: All robot subsystems should be brainstormed.
- February 3, 2024: Any CAD designs or prototypes should be completed.
- February 7, 2024: All mechanical work on the robot should be completed.
- February 8, 2024: Autonomous routines should be ready for use in matches.
- February 10, 2024: Illini Cornfield Clash
  - The robot should be fully built and programmed by any means necessary.

PROJECT ASSIGNMENTS (ITERATION 2)

Author	Date	Entry Type	Robot	Iteration
Jaden Hernandez	09/23/2023	Project Management	Both	2

<u>15" Robot Project Assignments</u>

Mechanics Specialists	Software Specialists	Strategy Specialists
Jaden Hernandez	Andrew Lu	Jaden Hernandez
Stuart Blank		Stuart Blank

<u>24" Robot Project Assignments</u>

Mechanics Specialists	Software Specialists	Strategy Specialists
Taylor Xu	Rocky Chen	Chris Jewell
Matthew Zimmerman		
Aaron Smith		
Isaac Spencer		

Mechanics specialists will be in charge of constructing the robot, software specialists will be in charge of programming the robot, and strategy specialists will advise strategically while documenting the design process.

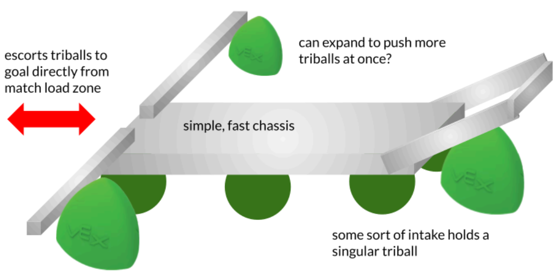
OVERARCHING ROBOT DESIGN BRAINSTORMING

Author	Date	Entry Type	Robot	Iteration
Jaden Hernandez	01/30/2024	Brainstorming	15”	2

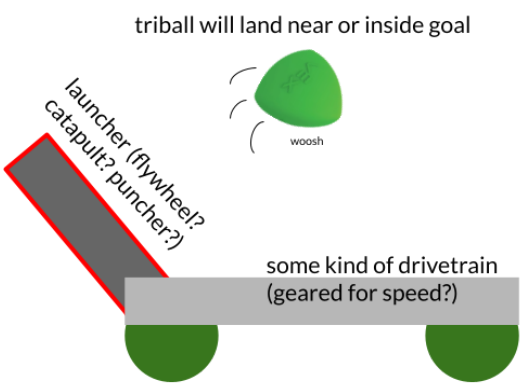
Based on what is known from the game analysis and design briefs done for both robots, we can start to consider what goals we want to achieve for our 15” robot. While we do not know the specifics of each robot yet, we should at the very least develop an overarching strategy that we can develop our robots around, then decide on subsystems based on that.

Possible Designs

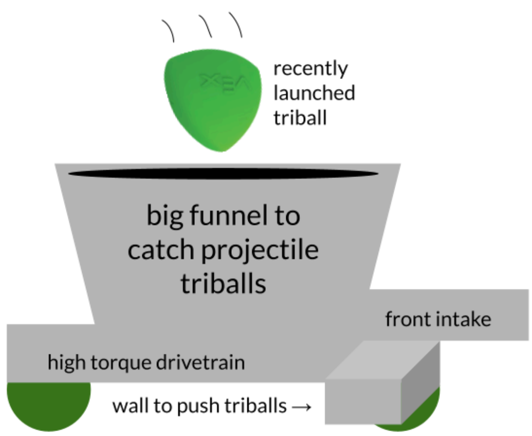
For the 15” robot, there are three possible types of robots to consider.



The first type of robot has been dubbed the **“shuttle” robot, which specializes in quickly escorting Triballs directly to the goal from the match load zone.** This would be extremely easy to make, requiring only an intake and a drivetrain, but may not be as efficient as a launcher/catcher duo.



The second type of robot would be some kind of **launching robot that could propel Triballs across the field.** This robot could work together with the 24” robot to quickly transport Triballs close to the goal to allow for streamlined scoring. At the very least, this robot would need a launching mechanism and a drivetrain. It also needs some sort of intake in order to take advantage of match load Triballs.



The third type of robot would complement the second type; **a robot that can catch launched Triballs and quickly deposit them in the goal.** It is important to note that due to the size constraints of this robot, this would not be as effectively executed as it would be with the 24” robot since the 24” robot would inherently have more “catching” range if it utilized this design. This design would need some sort of intake, a drivetrain, and potentially some kind of scoring aid to allow it to score multiple Triballs at once without breaking the possession limit of one Triball.

These robot designs will be evaluated based on three criteria:

- Feasibility: scaled from 1-3; how easily the robot design could be built/programmed
- Efficiency: scaled from 1-5; how quickly and effectively the robot design could score
- Synergy: scaled from 1-3; how well the robot could complement the other robot (24”)

	Feasibility	Efficiency	Synergy	Total
Shuttle	**3**	**5**	**2**	**10**
Launcher	1	5	3	9
Catcher	2	4	1	7

Utilizing the shuttling strategy on the 15” robot seems to be the best design because it is very simple to develop, but also is highly efficient with scoring because it ensures that pretty much any match loads that are utilized by the robot end up only in the goal. With our previous design, the launcher, the match loads could potentially be jeopardized and weaponized by the other alliance if we missed the catcher robot or got blocked.

Now that the overarching robot design for the 15” robot has been decided, the following needs to happen:

1. The overarching robot design for the 24” robot needs to be decided next.
2. The drivetrain design for this robot will need to be brainstormed.
3. The intake design for this robot will need to be brainstormed.
4. An elevation mechanism for this robot will need to be brainstormed.
5. If necessary, we can consider brainstorming an additional scoring aid for this robot.

From there, we can decide how this shuttle robot will ultimately be implemented for this second iteration.

ITERATION 2 GANTT CHART

Author	Date	Entry Type	Robot	Iteration
Jaden Hernandez	01/30/2024	Project Management	Both	2

Following the destruction of the robot designs from iteration 1, brainstorming and construction will immediately commence on the robots for iteration 2.

Date	15” Mechanics	15” Software	24” Mechanics	24” Software
01/31/2024	BRAINSTORM SUBSYSTEMS		BRAINSTORM SUBSYSTEMS	
02/02/2024	CONSTRUCT DRIVETRAIN	PROGRAM DRIVETRAIN	CONSTRUCT DRIVETRAIN	PROGRAM DRIVETRAIN
02/05/2024	CONSTRUCT INTAKE	PROGRAM INTAKE	CONSTRUCT INTAKE	PROGRAM INTAKE
02/07/2024	CONSTRUCT ELEVATION	AUTONOMOUS ROUTINES	CONSTRUCT ELEVATION	AUTONOMOUS ROUTINES
02/09/2024	**ROBOTS**	**MUST**	**BE**	**FINALIZED**

Our next tournament takes place on February 10, which puts us in quite the time crunch for development on both robots.

After the Illini Cornfield Clash on February 10, we can determine if we want to move forward with these robot designs for the Purdue SIGBots Slam and Jam tournament and the World Championship.

CHASSIS DESIGN BRAINSTORMING

Author	Date	Entry Type	Robot	Iteration
Jaden Hernandez	01/31/2024	Brainstorming	15”	2

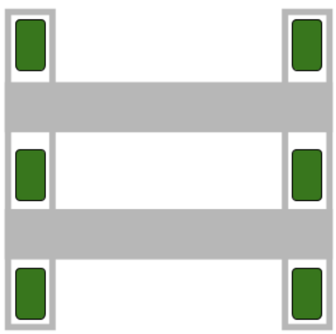
General Constraints

Since the 15” robot is the smaller of the two, the goal for a drive base is for it to be fast, maneuverable, and compact. It should have the ability to cross the barrier without trouble and have a low center of gravity to keep it from tipping while crossing. Finally, it should have enough strength to push Triballs into every portion of the goal.

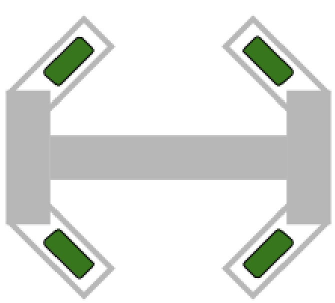
Design Choices

Ideally, the 15” robot should be a fast robot to circumvent oncoming defense as needed. Therefore, speed and maneuverability is of the utmost importance in terms of criteria. Of less importance are the agility and torque/pushing power of the drivetrain, though these still need to be considered as part of the general constraints.

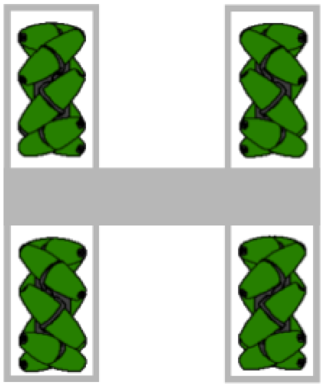
First, we need to decide what drivetrain architecture to abide by. There are three potential solutions for this.



The first possible design is a typical six wheeled tank drive. Because the wheels are oriented straight and will most likely feature two traction wheels with four omnidirectional wheels, it inherently has a good amount of traction and torque, but can be geared up to go faster at the sacrifice of torque. The tank drive is reliable due to its simplicity and has favorable geometry for climbing the barrier.



The second possible design is a four wheeled X-drive. Because of the wheels’ 45 degree slant, the X-drive will inherently be extremely fast but at the significant expense of torque. Its strafing ability is intriguing, but may or may not fit with the team’s strategy. Additionally, since an X-drive cannot realistically be built with traction wheels, it does lose out on some traction which gives it less pushing power. The shape of the X-drive may make it difficult for the robot to climb over the barrier, as the position and orientation of the wheels is not ideal for climbing.



The third and final possible design is a mecanum wheel chassis. Because of the nature of the conical rollers, the chassis is able to strafe, but more inefficiently than the X-drive while also losing out on traction due to the lessened contact patch between the rollers and the field tiles. Unlike the X-drive, it has basically the same amount of speed and torque as a tank drive when going forward but cannot utilize all of its torque due to traction issues. A chassis with this wheel formation may struggle to climb the barrier as it gets longer since there is no center wheel set to help push it over the barrier, leading to a “beaching” risk.

With all of these factors in mind, a decision matrix can be used to determine the best chassis design. The decision matrix will be determined with the following categories:

- Speed: rated from 1-5; how fast the drivetrain traverses the field
- Maneuverability: rated from 1-4; drivetrain directional movement capabilities
- Agility: rated from 1-5; how easily/efficiently the drivetrain can climb the barrier
- Torque: rated from 1-3; how effectively the robot can push other objects

	Speed	**Maneuverability**	**Agility**	**Torque**	**Total**
Tank	3	1	5	3	12
X-Drive	5	4	1	1	11
Mecanum	**3**	**3**	**4**	**2**	**12**

The mecanum drive will be the most reliable drivetrain for the 15” robot mainly due to its maneuverability while still maintaining a decent deal of pushing power, speed, and barrier clearance.

Conclusion

- In order to maximize drivetrain power, we think that we could potentially create a six motor mecanum chassis rather than only using four motors. Doing so would add an additional set of omnidirectional wheels in the middle which may lessen the odds of beaching.
- This drivetrain will be fully designed in CAD to determine spacing, since the 15” is a compact package. Once it is designed, we can then develop a formal plan to actually construct the drivetrain.

CHASSIS ITERATION 2 DESIGN

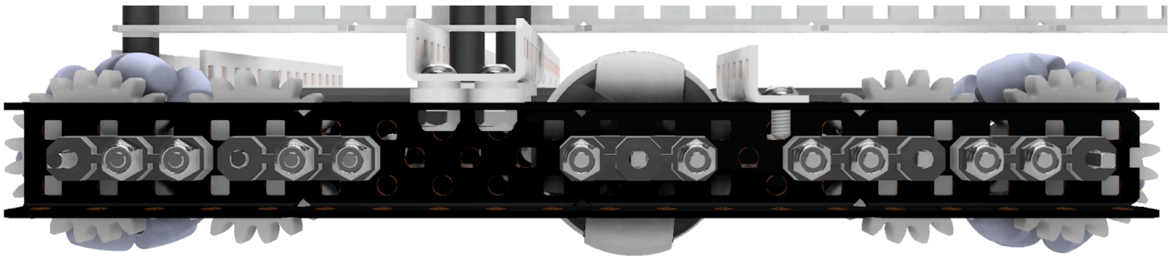
Author	Date	Entry Type	Robot	Iteration
Jaden Hernandez	02/03/2024	Mechanics	15”	2

We will design the second iteration of the 15” robot’s chassis using Autodesk Inventor, then construct the solution immediately after.

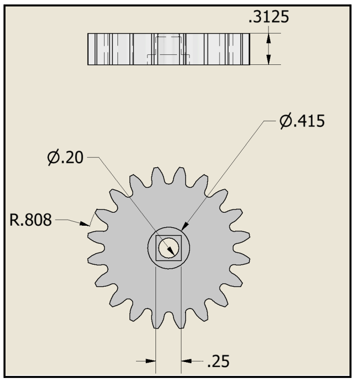
Goals

- Create a chassis that is fast, simple, and low-profile.
- Develop a chassis structure that is serviceable and easy to construct.
- Utilize at least six motors on the chassis.

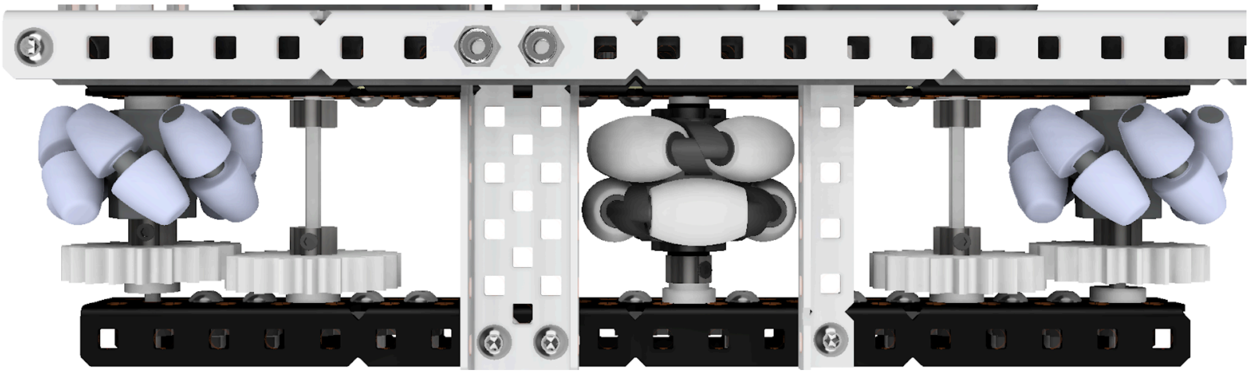
Design Process



First, we had to determine the wheel spacing on the chassis. There are three wheels on each side of the chassis; two mecanum wheels, and one omnidirectional wheel positioned on a 20-hole C-channel as shown in the figure above.



While the omnidirectional wheel is directly driven by a 600 RPM 11W motor, the mecanum wheels are offset by a simple gear train consisting of two identical, custom 20-tooth spur gears. Forming a 1:1 gear ratio, the output angular velocity of the mecanum wheels should also be 600 RPM. The reason for implementing the gear train for the mecanum wheels was so that the motors could be placed further back on the chassis to allow more space for a Triball to sit in our future intake.



Next, we had to determine how far the wheels and gears would be spaced away from the inner drive channel. As seen in the figure, there is about a 2” gap between the inner and outer drive channel, as evidenced by the four-hole gap in the C-channel. For the mecanum wheels, the spacing that nominally fills this gap (within 1/32” tolerance) from outside to inside is:

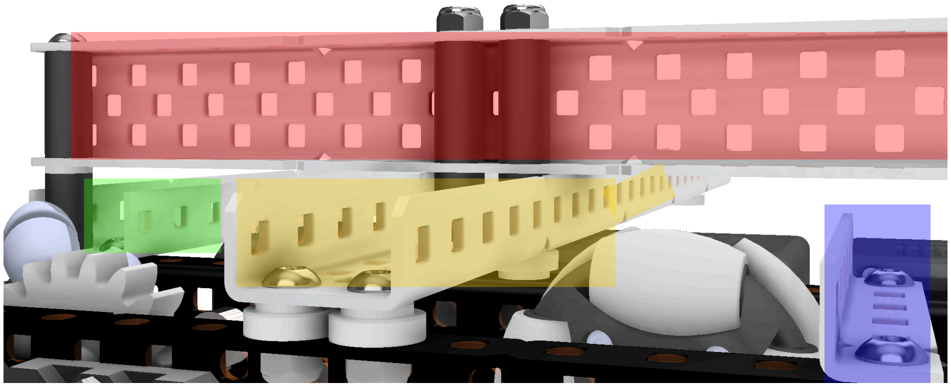
⅛” Spacer	20T Spur Gear	Shaft Collar	Mecanum Wheel	⅛” Spacer

Meanwhile, for the shaft driving the omnidirectional wheel, from outside to inside:

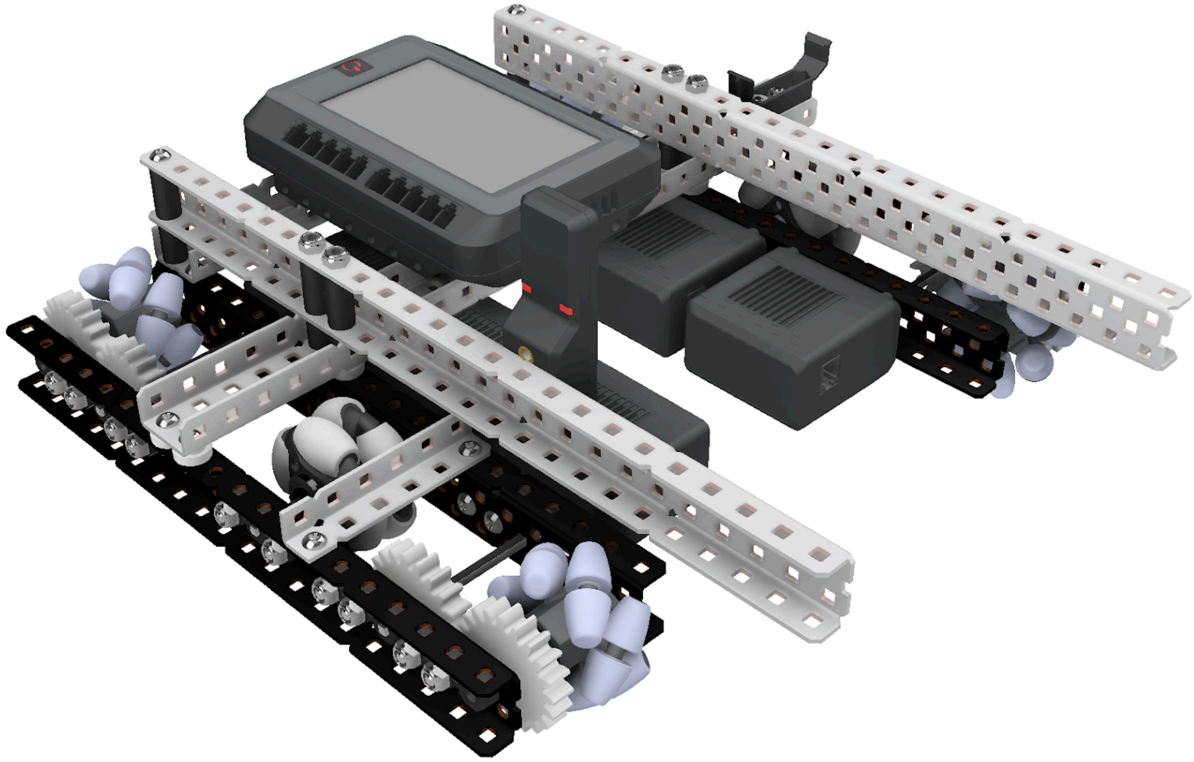
⅛” Spacer	1/16” Spacer	Shaft Collar	Omnidirectional Wheel	1/16” Spacer

And for the shaft driving the gear that drives the mecanum wheel shaft:

⅛” Spacer	20T Spur Gear	Shaft Collar	Shaft Collar	1/32” Spacer



Next is to add the drivetrain peripherals, which includes a 25-hole C-channel acting as a crossbar going all the way across the chassis, a 6-by-1-hole L-channel stretching from the inner and outer frame, a 15-hole C-channel acting as a crossbar between the two opposing inner frames, and the subsystem mounting point, which is a 25 hole C-channel.



By mirroring the schematics of the inner and outer drive channels on the other side of the chassis, we can complete the structure of the entire chassis. The V5 Robot Brain, V5 Robot Radio, and V5 Battery Clip are pictured, but may move later depending on space constraints.

In the next entry, we will showcase the actual construction of the chassis, because the construction of it is deeply intertwined with the construction of the intake. Therefore, the construction of both the intake and chassis are essentially combined logistically. Ideally, the chassis will be built as pictured in the CAD renders.

INTAKE ITERATION 2 PROTOTYPING

Author	Date	Entry Type	Robot	Iteration
Jaden Hernandez	02/03/2024	Brainstorming	15”	2

With the chassis fully designed in Inventor, it will be constructed as pictured in addition to the intake prototypes that will be considered.

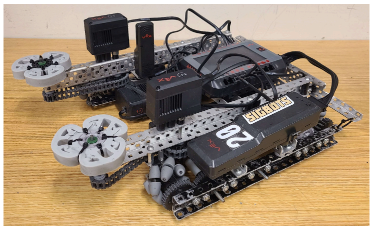
Define the Problem

Our robot needs to be able to intake Triballs effectively and quickly. An ideal intake should be able to:

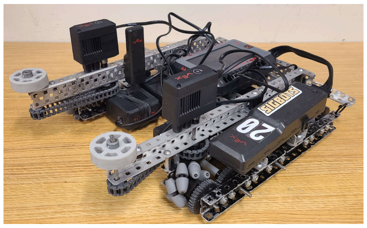
- Score Triballs in the goal.
- Intake Triballs from anywhere in the general field area.
- Push Triballs over the center barrier.

Potential Solutions

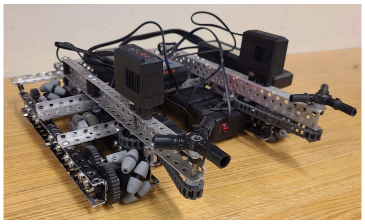
Some prototypes that we have constructed for testing include the following:



Cardioid Flex Wheels (3”)
The first design we considered is using the cardioid-shaped flex wheels from the iteration 1 of the intake as the intake wheels.



1.625” Flex Wheels
The next design is straightforward: using 1.625” OD flex wheels to intake. These are lightweight and easy to put onto the intake.



Surgical Tubing Rollers
The final design considers using a series of three surgical tubes in a triangle formation to effectively act as flaps to pus the Triball into the robot.

Testing

With these prototypes, we were looking to test two main things: intake speed and grip. To do this, we arranged the following procedure:

1. Set up the robot in front of any goal, facing either elevation bar.
2. Place a Triball about half a tile in front of the robot.
3. Activate the intake, then have the robot drive towards the Triball until it reaches the Triball. Wait for the Triball to be fully inside the intake cavity.
    a. Record how long it took for the Triball to enter the intake cavity.
4. Drive backwards at full speed until the robot contacts the field perimeter.
    a. Record whether or not the Triball exited the robot.

Using this procedure, we tested the three intake types in five trials and collected the following data on how long it took to :

Intake Speed			
Trial	**Cardioid (s)**	**Flex Wheel (s)**	**Tubing (s)**
1	2.76	0.76	1.30
2	2.45	0.55	1.21
3	1.39	0.53	1.63
4	2.90	0.78	1.49
5	3.18	0.81	1.77

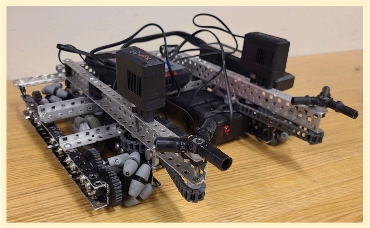
Key: Triball stayed in robot | Triball exited robot

Decision Matrix

Based on the data we gathered from the prototypes, we can determine the best intake design based on the following criteria:

- Speed: scaled from 1-5; how fast the Triball enters the intake cavity
- Security: scaled from 1-5; how well the intake design holds onto the Triball
- Space Efficiency: scaled from 1-3; how little space the intake design will take up

	Speed	Security	Space Efficiency	Total
Cardioid	1	5	1	7
Flex Wheel	5	1	3	9
Tubing	**4**	**4**	**2**	**10**



Based on this decision matrix, the tubing intake would be the best design to move forward with because it does well at securing the Triball while still being relatively fast at intaking. It is also pretty small and lightweight, which should detract less from the performance of other subsystems on the robot.

Implementation Plan

Conveniently, since the tubing intake was the last intake we tested as a prototype, it is still on the robot and therefore can remain as is. Therefore, the preferred intake for this robot is already constructed.

TOURNAMENT BRIEFING: Illini Cornfield Clash

Author	Date	Entry Type	Robot	Iteration
Jaden Hernandez	02/04/2024	Strategy	Both	2

On February 10, 2024, team BLRS will be attending the Illini Cornfield Clash tournament to test out and understand the elusive “shuttle” strategy. After such a stark change in overarching robot design, we decided that we had no choice but to attend this tournament, as we needed practice with our new strategy.

Tournament Name	Illini Cornfield Clash - University of Illinois Urbana-Champaign
Date	02/10/2024
Registered Teams	11 / 16
Address	1208 South 4th Street, Champaign, Illinois 61820
Awards	Tournament Champions, Excellence, Design, Robot Skills Champion, Judges

There will be eleven teams in attendance including BLRS and BLRS2. These teams are listed below:

Team	Team Name	Organization	Location
BLRS	**Purdue SIGBots**	**Purdue University**	**West Lafayette, Indiana, United States**
BLRS2	Purdue SIGBots	Purdue University	West Lafayette, Indiana, United States
BU	Bradley Vex U	Bradley University	Peoria, Illinois, United States
CTRLZ	CtrlZ		Brillion, Wisconsin, United States
EGRT1	The Titans	UW Oshkosh Engineering and Computer Science Club	Oshkosh, Wisconsin, United States
FOUR4	RoboClaws	Rogers State University	Claremore, Oklahoma, United States
HAIL	Team HAIL	University of Michigan	Ann Arbor, Michigan, United States
ILLIN1	Illini VEX Robotics	University of Illinois Urbana-Champaign	Champaign, Illinois, United States
ITR	Illinois Tech Robotics	Illinois Institute of Technology	Chicago, Illinois, United States
MSU	Spartan Robotics	Michigan State University	East Lansing, Michigan, United States
NUKE	NUKE Robotics	Northern Kentucky University	Highland Heights, Kentucky, United States

ILLINI CORNFIELD CLASH TOURNAMENT RECAP

Author	Date	Entry Type	Robot	Iteration
Jaden Hernandez	02/11/2024	Strategy	Both	2

Premise

BLRS gathers around the Design Award trophy following the conclusion of the tournament

On February 10, 2024, we attended the Illini Cornfield Clash tournament in Champaign, IL which had a total of 8 teams competing.

Performance

Matches

Rank	4	Record	4-3-0
WP	8	CCWM	26.71
AP	40	OPR	75.14
SP	259	DPR	48.43

Outcome: BLRS is disqualified in quarterfinals against NUKE (0-57)

Robot Skills Challenge

Rank	N/A	Total Score	N/A
Driver Score	N/A	Programming Score	N/A
Driver Attempts	0	Programming Attempts	0

We did not attempt the Robot Skills Challenge at this tournament.

Subsystems

Drivetrain

The 15” robot’s drivetrain was quick but was not as reliable as we would have liked with strafing. The biggest reason for this lack of consistency in strafing was the fact that the square inserts in the drivetrain gears kept coming out during matches, which meant that the motor was not truly driving the mecanum wheels. While we were still able to drive straight when it came to forward and backwards movement, any lateral movements were effectively reduced to a turn. Additionally, not being able to go over the center barrier consistently was a considerable disadvantage.

The 24” robot’s drivetrain was somewhat fast and certainly powerful, but still struggled to accelerate simply due to the robot’s sheer size. In two matches, we found that the wedge we had placed on the back of the chassis to push Triballs over the center barrier unfortunately made it far too easy for us to tip over opposing robots, which led to a disqualification in our quarterfinals match against NUKE.

Intake

We really liked how the 15” robot’s intake performed during the tournament; it was reliable as long as its chain did not snap, and could easily push Triballs over the center barrier or score them in the goal as necessary. However, we think that we could get the same functionality with a vertical intake rather than the current flat, horizontal-style intake. The intake will certainly need to be reiterated.

The 24” robot’s intake was a notable improvement from its previous intake, and had no trouble holding onto Triballs as the robot went over the center barrier. It could score Triballs in the goal easily, and was a staple for winning matches against our opponents.

Elevation

The 24” robot was the only robot that had an elevation scheme due to time constraints. This elevation, which was reliant on balancing on the center barrier, was inconsistent because it depended on what degree the hook around the vertical elevation bar was actually wrapped around. In some cases, the robot unfortunately contacted the field tiles rather than being elevated. For a future iteration, we would like to consider a higher tier elevation, even if it seems less feasible.

Takeaways

Match Strategy:

- **The autonomous period is key.** This tournament, because we had less time to program autonomous routines, we found that in some matches, we fell a bit short because we had too few Triballs in the goal to start driver control with.

Conclusion:

Following this tournament, we think that the 15” robot will need to be fully reiterated, but we are unsure if we can realistically reiterate the 24” robot fully because of the upcoming Purdue SIGBots Slam and Jam tournament on 2/24/2024.