RICO

OnyxTronix #2231

FIRST ISRAEL ישראל

2231

תיכון שהם
Shoham High School

מועצה מקומית שהם

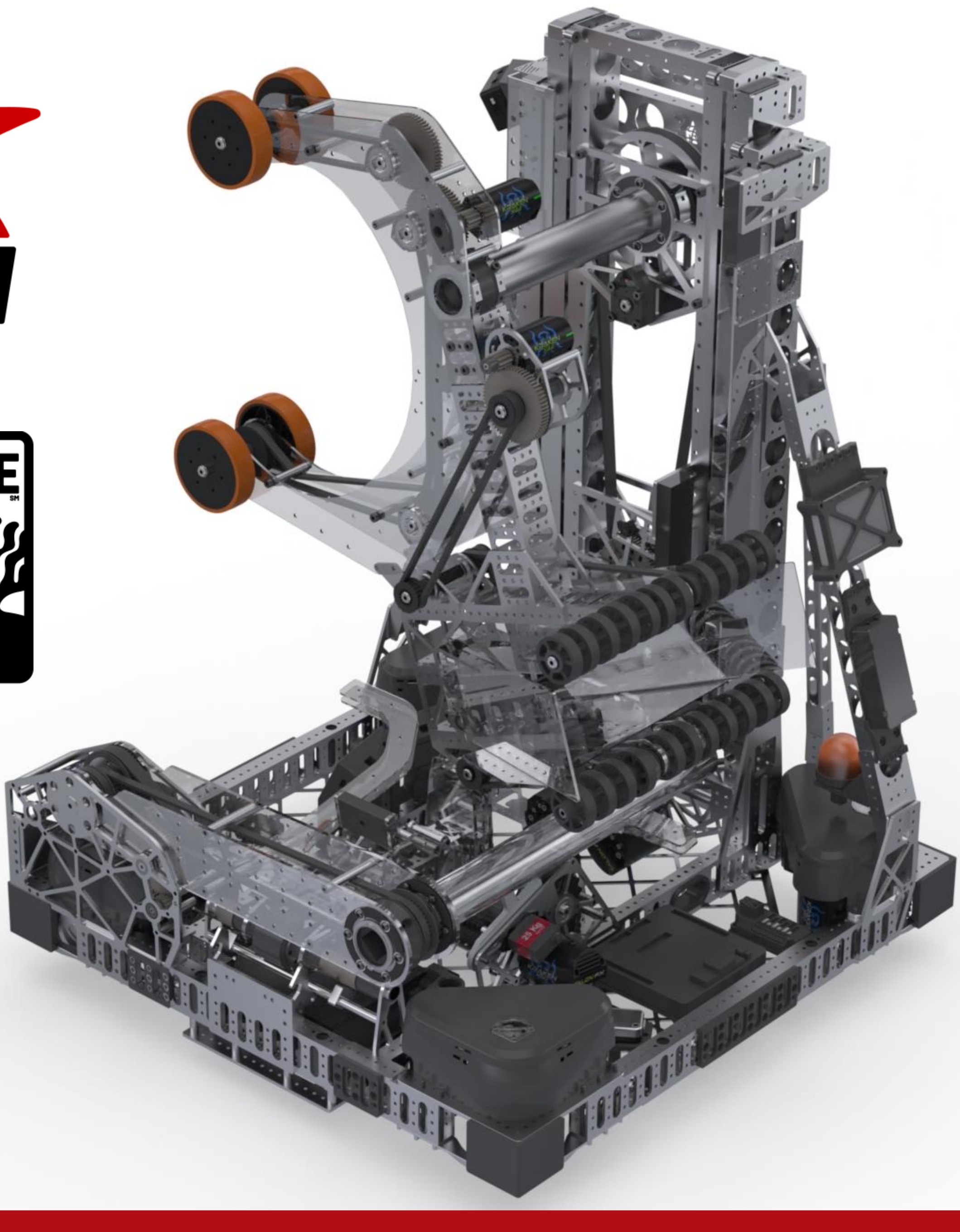
RICO

OnyxTronix 2025 Robot

2231

REEFSCAPE

PRESENTED BY HAAS Gene Haas Foundation



Science can amuse and fascinate us all, but it is engineering that changes the world

- Isaac Asimov

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REEFSCAPE[SM]

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Engineering Process

~2 Days~

Game analysis
QFD - defining and prioritizing the robot actions

Prototyping
validating ideas and finding of optimized setups

Week 1 – 5 Days

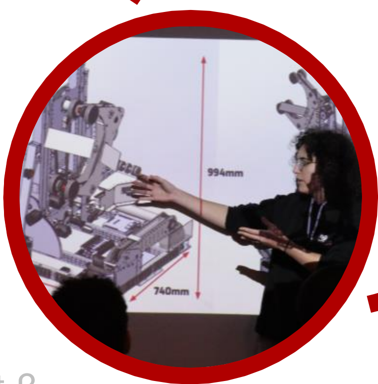
PDR
evaluation of systems prototypes and integrating into robot

Summary of week 1

CAD
developing robot 3D design model and integrating the different systems

7 Days

Prototype robot-proving the integration



CDR
final evaluation and revision of the robot 3D model

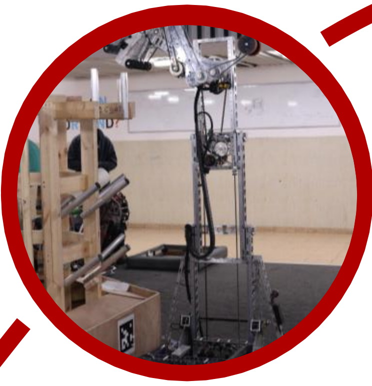
Summary of robot-β product

Testing & Modeling
mechanical test on robot-β in the same time as changing and improving the modeling for robot-ɑ

Finished modeling robot-ɑ in the end of week 4

Production & Assembly
production and assembly of robot-ɑ

In the end of week 5 – after 35 days robot-ɑ is assembled



Testing, improving
and fine tuning the different systems

Until the competition – changes\upgrades\additions in robot-ɑ

Production & Assembly
manufacturing robot-β in the workshop, while assembling it

Complete production and assembly in 5 days, after19 days robot-β is assembled and wired.

Game Analysis

QFD - Defining, prioritizing and brainstorming

1 Defining and prioritizing robot capabilities

Fundamentals Basic Abilities	Must have High priority	Advantage Mid Priority	Nice to have Low Priority
Low center of mass	**Score L1 – L4**	**Wide feeder intake**	**Double sided Algae scoring**
Score both game pieces instantly	**Hold 2 game pieces simultaneously**	**Scoring net from high point**	**Body climb**
passing between Cages	**Deep cage climbing**	**Algae floor intake**	**Object detection**
Minimal exit from frame perimeter	**Algae removal & net / processor scoring**	**Swinging cage handling**	**Coral conveying**
		Coral floor intake	**Shallow Cage climb**
instant intake ability for both game pieces	**intake vertical Coral from Coral station**		

2 Concepts Brainstorms

We spited the team into brainstorming rooms, with students from all sub teams (mechanics, hardware, outreach etc.) and brainstorm together how to implement the robot capabilities into mechanical systems for our robot. Prioritize which ideas we would like to test through the upcoming week – prototypes week. According to the game analysis and strategy priorities. we summarized the prototypes and analyzed the game once again with additional knowledge that we collected throughout the prototype week to avoid future mistakes and prevent time wasting.

CONCEPTS

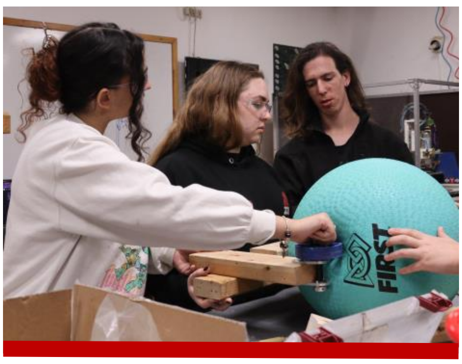
We built wood and aluminum-made prototypes, aimed at validating ideas that meet the requirements for the robot, according to the game analysis. We checked the feasibility, desired pressure, types of materials, sizes, and more.

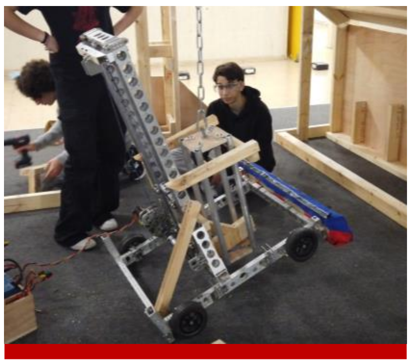
Proof of Concept

We built several concepts for each action that the robot needs to perform. That way, we could compare different concepts and find the one that led to the optimal result.

Optimizing Values

After proving the concept, we tested different pressures and sizes to find the best results for our priorities.





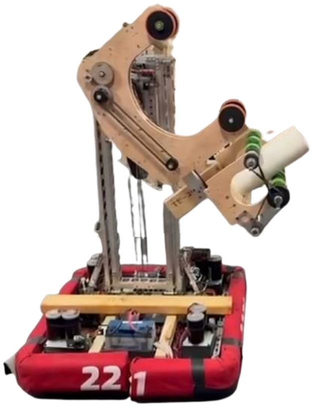
We conduct a **P**reliminary **D**esign **R**eview (**PDR**) meeting, selecting the designs for our robot.

After selecting each prototype individually, we intergraded them into a "prototype robot“ and ran integration and logic tests on it.

From concept to product

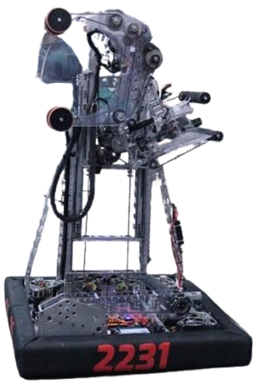
This year we developed our robot in three stages: **prototype bot, robot-β, robot-α**, in order to make the best robot possible. We made a fully detailed work plan and agile schedule to support this way of work and R&D

Prototype robot



Designed to ensure integration between all systems selected from the prototypes. After selecting the prototypes, we assembled them into a complete robot, and began integration and software algorithm tests

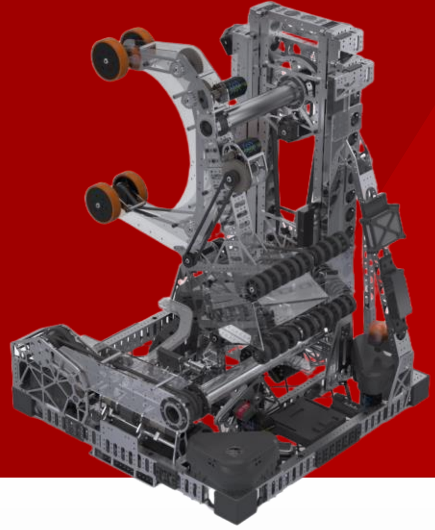
Beta robot



Robot-β is the first robot to be designed and assembled. After volume testing and integration of the prototype robot, on which we will perform tests of all mechanisms and their integration more precisely.

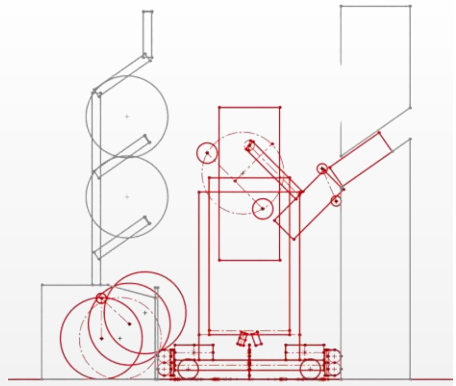
Alpha robot

After completing the design modification from the tests on Robot-β, we manufacture, assemble, and wire Robot-α. A robot that will be used for the competitions. all while updating Robot-β accordingly to **work simultaneously on both β and α.**



CAD

We 3D modeled each and every part of our robot in SOLIDWORKS to match our reliability and precision expectations. Throughout the years, we have developed several creative and unique features we are very proud of:



2D Modeling

We begin the CAD process by modeling a 2D sketch of each subsystem in order to determine the key dimensions of the system's geometry and simulate motion.

Unique SKU System

We use serial numbers for all our parts, for example:

Right Chassis Profile

25-102-03

2025 Year

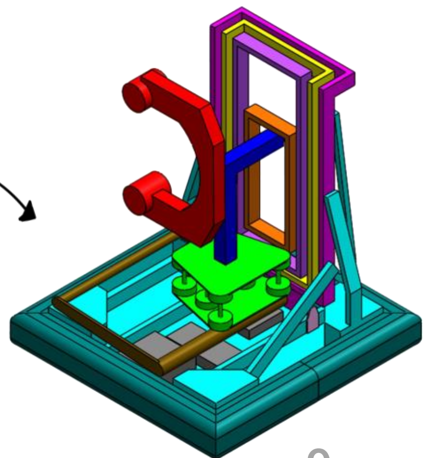
The first system

The second sub-system

The 3rd part in the sub-system

Using the SKU system simplifies the manufacturing, eliminating duplication of parts and streamlining the manufacturing process to be organized and efficient.

In order to avoid integration issues, we have created a simplified model of the robot that assists in understing the **volumes** of each system, ease of executing to robot model, and perform **geometric testing.**



Manufacturing the Robot

Before we begin manufacturing the robots, we hold a CDR - **C**ritical **D**esign **R**eview meeting, to summarize the 3D model, and receive remarks about the robot design and its function. To send it to manufacturing without any mistake.

Robot parts list

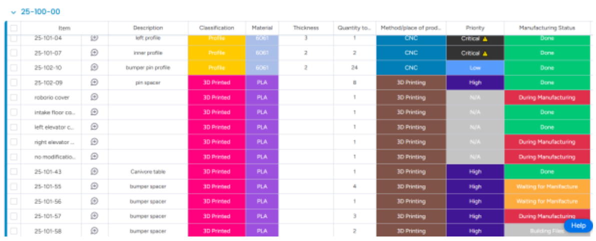
35% In-house 3D printers

15% In-house lathe machine

35% In-house CNC machine

15% Commercial off-the-shelf

We have created a **Bill Of Materials** table in monday.com to manage our process in the most professional way possible. We wrote for each part SKU, description, quantity, material, status, and much more.



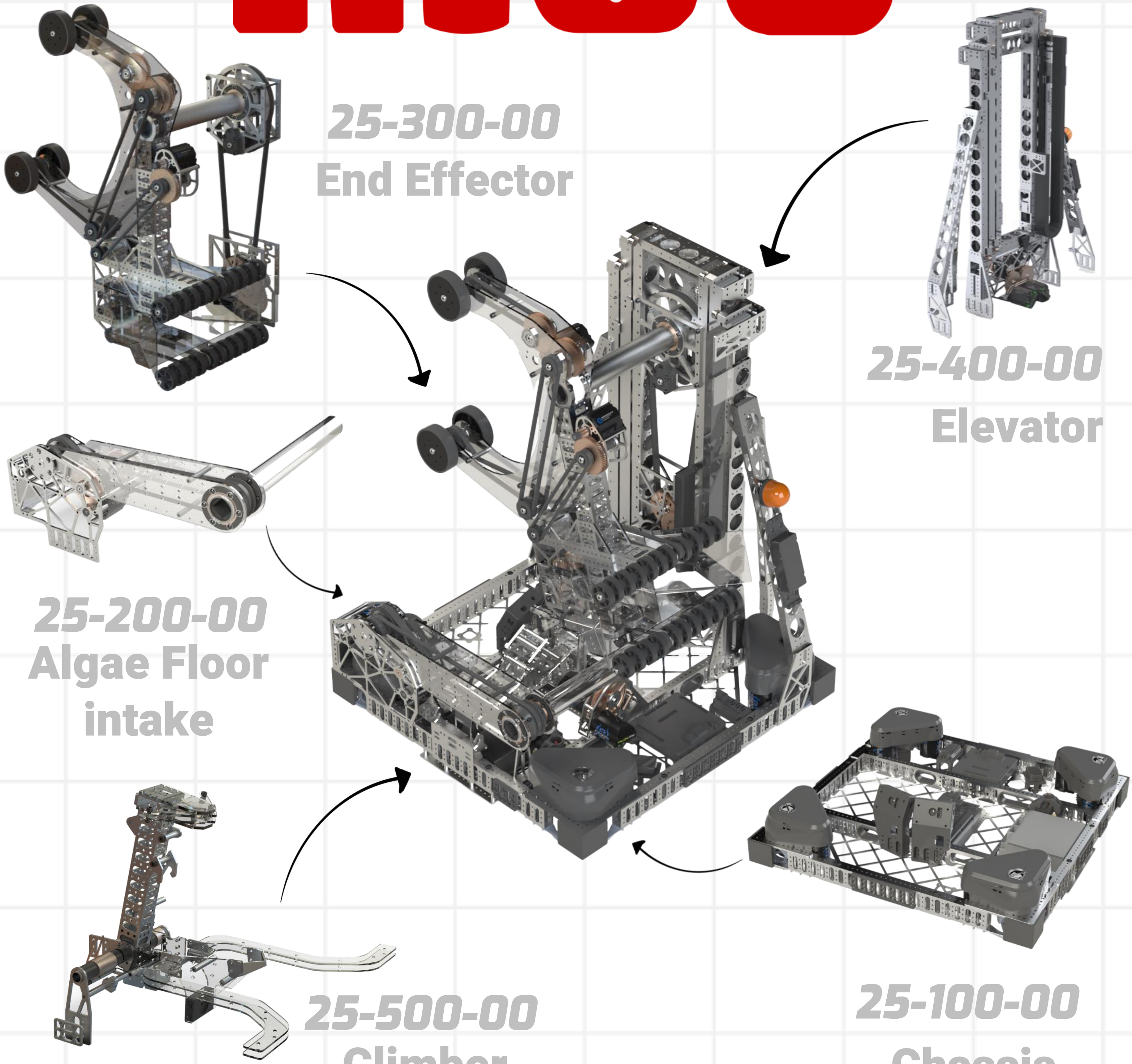
25-100-00

Item	Description	Classification	Material	Thickness	Quantity to...	Method/place of prod...	Priority	Manufacturing Status
25-101-04	left profile	Profile	6061	3	1	CNC	Critical	Done
25-101-07	inner profile	Profile	6061	2	2	CNC	Critical	Done
25-102-10	bumper pin profile	Profile	6061	2	24	CNC	Low	Done
25-102-09	pin spacer	3D Printed	PLA		8	3D Printing	High	Done
roborio cover		3D Printed	PLA		1	3D Printing	N/A	During Manufacturing
intake floor co...		3D Printed	PLA		1	3D Printing	N/A	Done
left elevator c...		3D Printed	PLA		1	3D Printing	N/A	Done
right elevator ...		3D Printed	PLA		1	3D Printing	N/A	During Manufacturing
no modificatio...		3D Printed	PLA		1	3D Printing	N/A	During Manufacturing
25-101-43	Canivore table	3D Printed	PLA		1	3D Printing	High	Done
25-101-55	bumper spacer	3D Printed	PLA		4	3D Printing	High	Waiting for Manifacture
25-101-56	bumper spacer	3D Printed	PLA		1	3D Printing	High	Waiting for Manifacture
25-101-57	bumper spacer	3D Printed	PLA		3	3D Printing	High	During Manufacturing
25-101-58	bumper spacer	3D Printed	PLA		2	3D Printing	High	Building Fil[illegible]

The order of the manufacturing process is according to mechanisms. Firstly, we manufacture all parts of the first mechanism that have been prioritized, and only then do we move on to the next mechanism allowing us to assemble mechanisms at the time of manufacturing the other, optimizing our assembling time.

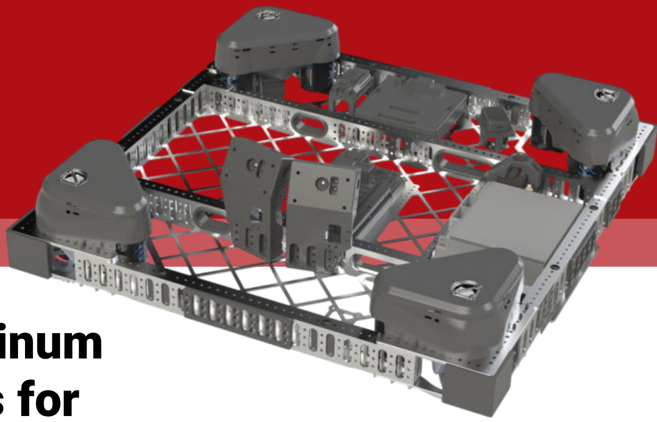
Following the production of two robots, in robot-β, our prioritization is different - speed will be more important than quality, but to a certain extent, we gave up on the material weight removal in the various parts, thus saving valuable time. In contrast to robot-α, where quality is important, as well as speed, therefore the parts are manufactured in house more carefully and sometimes outsourced.

RICO


25-300-00
End Effector
25-400-00
Elevator
25-200-00
Algae Floor
intake
25-500-00
Climber
25-100-00
Chassis

Chassis

25-100-00



A closed chassis consisting of 4 aluminum profiles and 2 additional inner profiles for reinforcement and systems integration

Consisting of 4 SDS MK4i Swerve modules, each powered by 2 Kraken X60 motors with a gear ratio of 1:7.2
We chose to change the gear ratio to L2 with a T13 gear instead of a T14 to have higher acceleration in exchange of lowering the maximum velocity of the system

14.6kg

The battery is lowered under the chassis in order to lower the center of mass of the robot

Custom lightweight 3D prints for covering and protecting the Swerve modules

Slots in the inner profiles for a comfortable and safe cable passage

5.5 **m/s^2 Maximum acceleration**

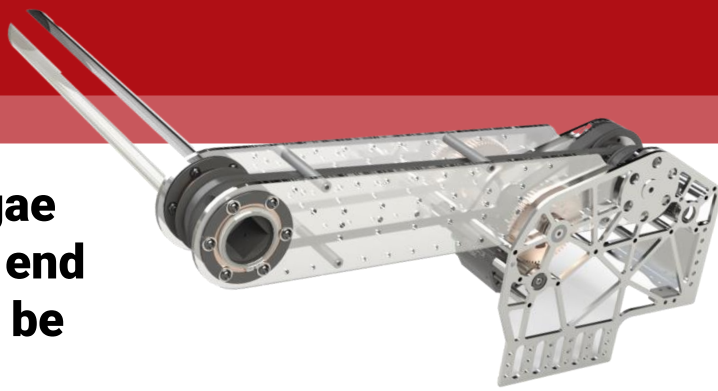
Checks the input and eliminates involuntary movements like collisions with other robots for a stable, professional, and smooth ride.

Using functions from advanced libraries in order to make the swerve faster and more sensitive

Autonomous driving to the REEF from every point on the field using AutoPilot powered by Vision and odometry

Ground Intake

25-200-00



The system was designed to intake Algae from the floor and transfer them to the end effector in 0.5 seconds. It was made to be robust and withstand collisions.
The system consists of 2 Kraken X60 motors:

- **one for opening the system with a gear ratio of 1:9.6**
- **one for powering the intake tube with a gear ratio of 1:4.5**

3.2kg

The intake tube is held from 1 side only in order to save space inside the robot

The main structure is made of polycarbonate in order for it to be flexible and withstand collisions while opened outside the robot perimeter

0.5 Seconds for intake

Integration of the event sequence between the Ground Intake opening and the End Effector

The system is closed using a limit switch inside the End effector

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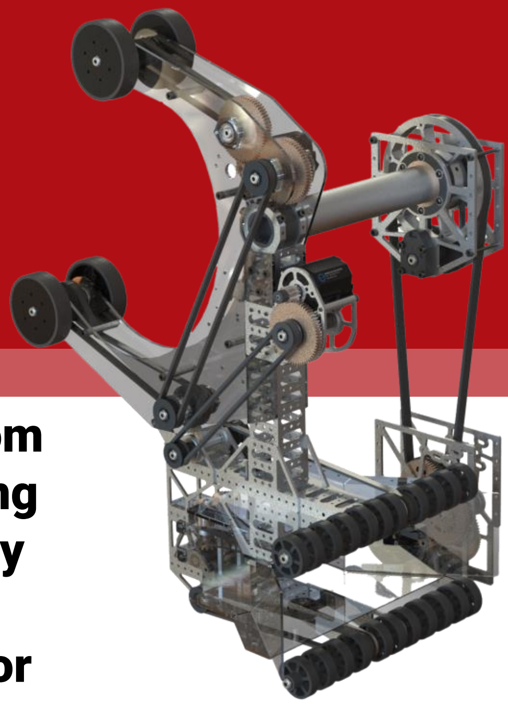
End Effector

25-300-00



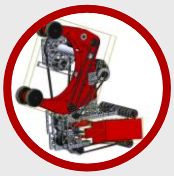
The system was designed to collect Corals from the feeder and Algae from the REEF and scoring them. The rotation of the system is powered by a Kraken X60 motor and each of the end mechanisms is powered by a Kraken X44 motor

For the Algae and the Coral intake there's a gear ratio of 1:5 each, and for the rotation of the system the ratio is 1:95

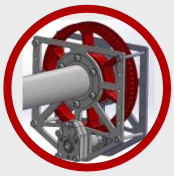
The rotation of the end effectors helps saving time in driving between the feeder and the REEF, and holding 2 game pieces simultaneously with the ability to score them independently

9.4kg

Angle inversion in the Coral mechanism drive using Bevel Gears **to save space and weight**



Both mechanisms are made of **polycarbonate** to reduce weight at the far end of the system, thereby decreasing the moment of inertia



System rotation by using a **self-made** timing wheel to create **maximum stability** and keeping the weight as low as possible

0.8 Seconds for intake - score rotation

The coral navigates through the coral intake by using 2 distance sensors according to the difference between the arrival times of the coral to the sensor

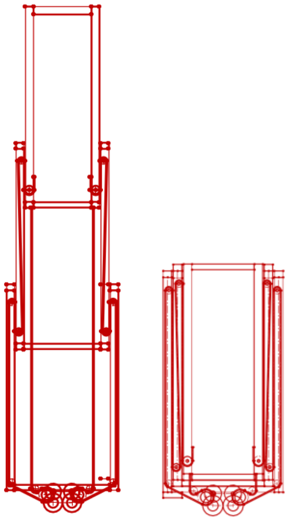
The system rotates in a way that considers the direction the robot is driving and its location

An algae ejection formula using a ball navigation mechanism and the robots location

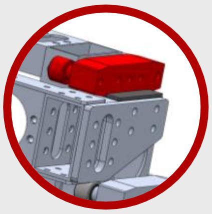
Elevator

25-400-00

The system was designed to be able to reach a height that allows feeder intake, all REEF levels and net scoring in a fast and efficient way while keeping maximum stability.
the system is powered by 2 Kraken X60 motors with a gear ratio of 1:9.3



10kg



Self-made bearing blocks inside the profiles that keep the elevator stages fixed

Both motors are connected by gears to ensure symmetrical movement

operation by open timing belts which provide better stability and more control over the tension of the belt & the elevator's movement

0.7 Seconds for full opening

Controlled using the robot's location and considering the mechanisms weight and the force that the strings activate

The change in the elevators speed considers the speed of the rest of the mechanisms to avoid an overload on the mechanism

Coded to perform multi-systemic sequences with integration considering End Effector

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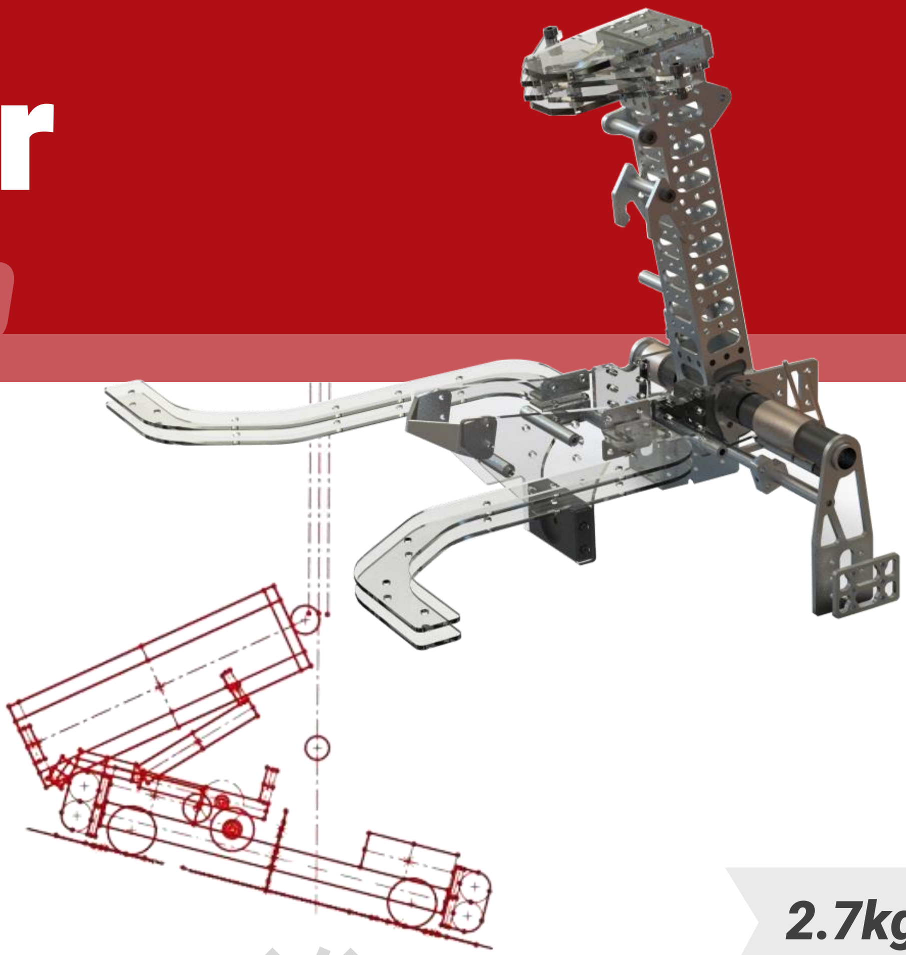
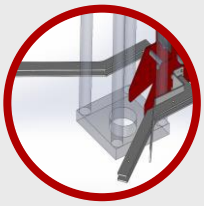
Climber

25-500-00



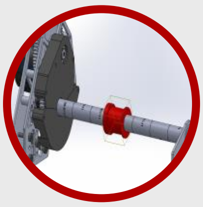
The system was designed to lift the robot while grasping the DEEP CAGE in a balanced way without touching the ground.
The system is powered by a Kraken X60 motor with a gear ratio of 1:21.6

2.7kg



The system has a “leg” responsible for holding the CAGE in place during climbing which stays locked using hooks

The “beak” is a passive mechanism that clamps onto the CAGE using the robot’s weight



Throughout the game the leg is held closed by hooks geometrically designed to pull it to the opposite direction

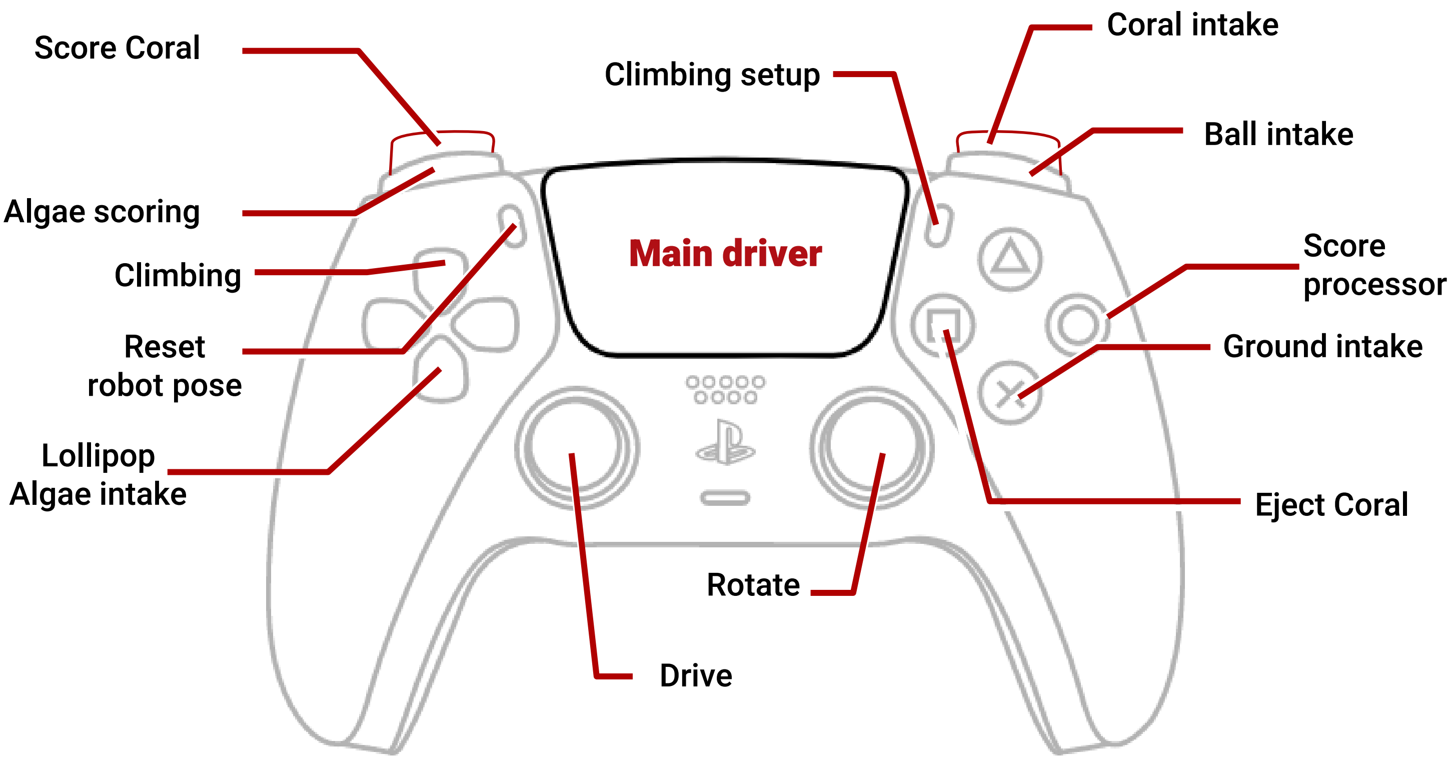
1.0 Seconds until the robot’s in the air

The system is designed to find the optimal speed at which the robot is stable and the system's operation time is minimized

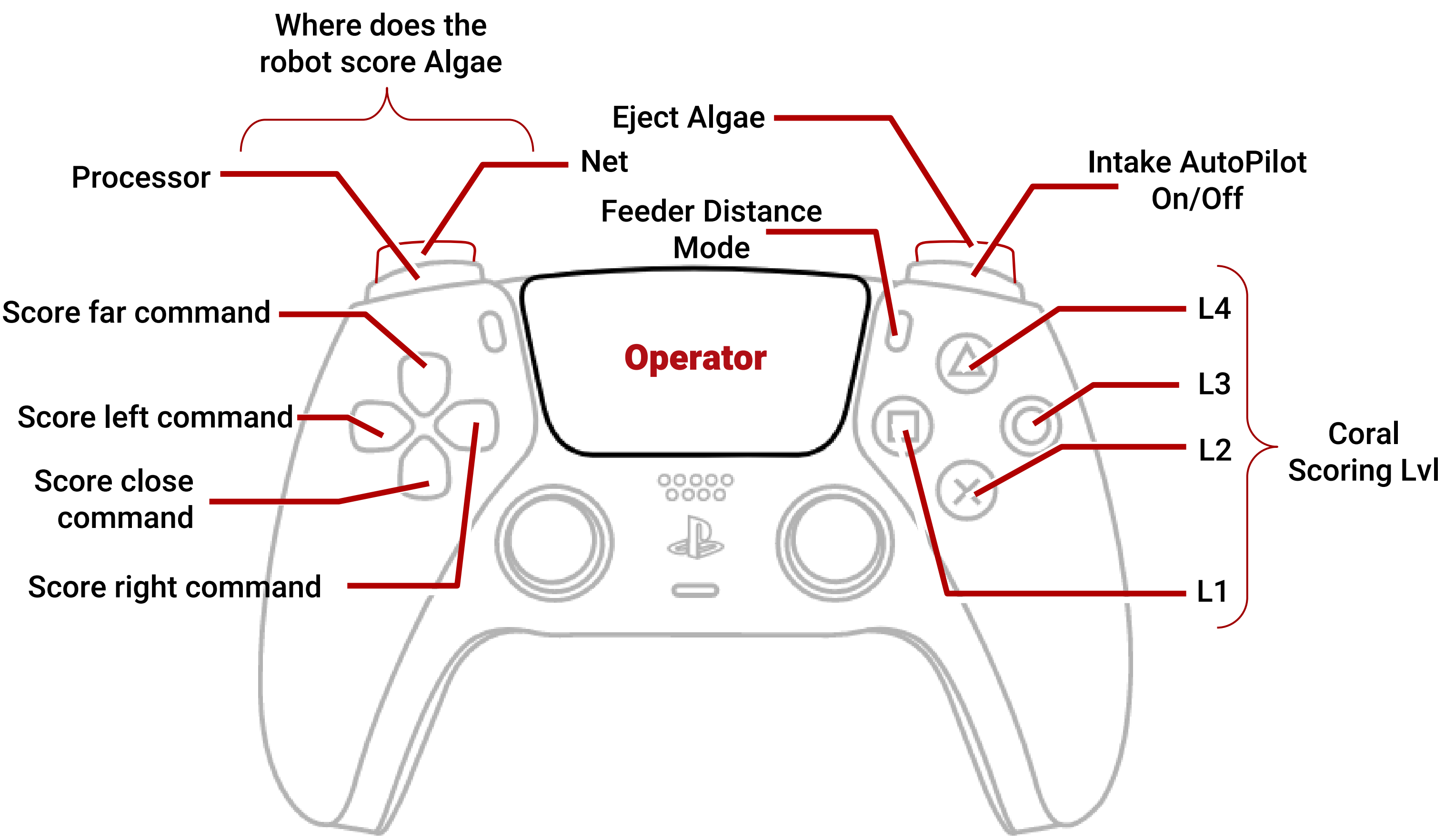
Climbing position control using an encoder sensor for the motor and utilizing conversion ratios

We used PID control to operate the climbing motor to ensure the mechanism reaches the end point at the optimal speed

Controlling the Robot



Controlling the Robot



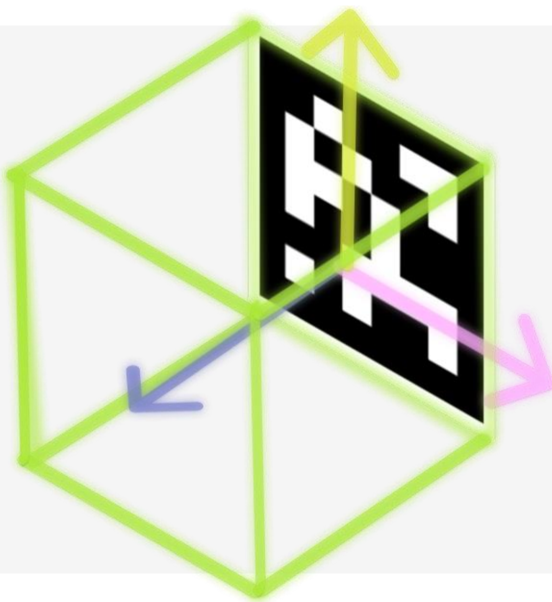
VISION

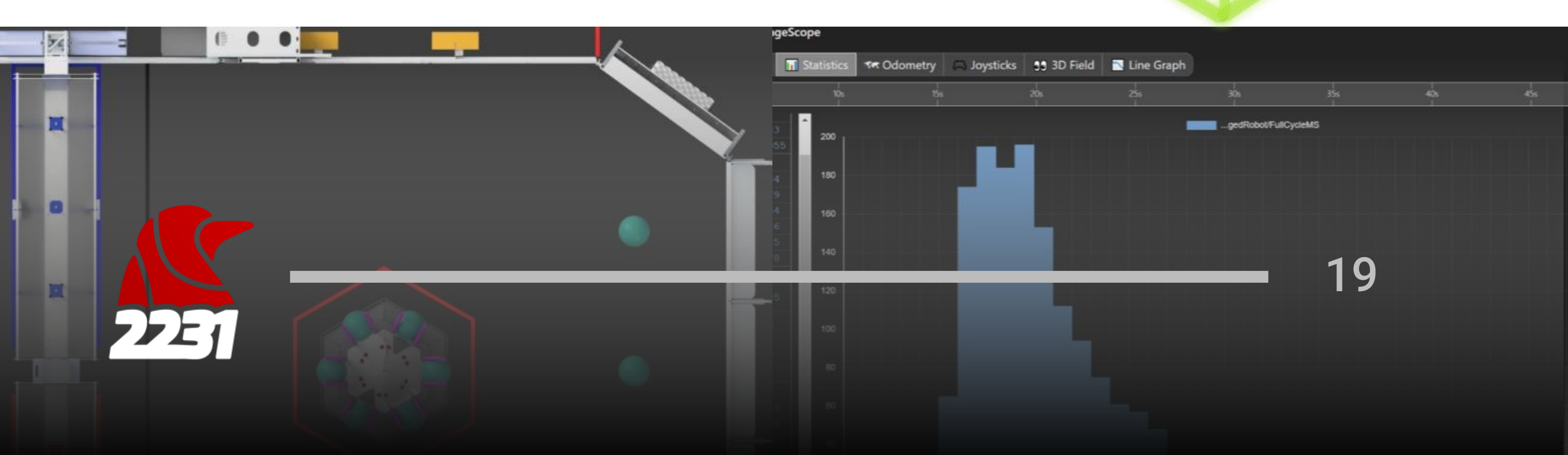
RICO is equipped with two Limelight 3G cameras and one Limelight 3 camera, enabling object detection & AprilTag recognition.

RICO uses AprilTags for precise intaking and scoring by accurately estimating its position on the field and aligning with game stations. While AprilTags provide real-time 3D positioning, factors like distance, camera quality, and motion can cause inaccuracies. To counter this, we developed a dynamic system with a Kalman Filter that combines AprilTag data and odometry. The system prioritizes reliable data, giving more weight to closer, higher-quality detections, ensuring accuracy within two centimeters.

Always on Track

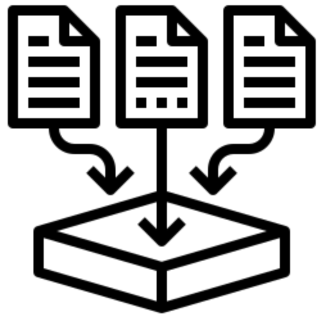
RICO features an AI-powered autonomous ground intake for Algae collection. Upon driver command, it identifies Algae locations and autonomously navigates to collect them, improving efficiency and simplifying driver control.





LOGGING SYSTEM

Understanding the **critical need for real-time system tracking**, we developed a **comprehensive logging infrastructure** that documents every measurable aspect of RICO during a match. This system tracks the speed of every mechanism, target locations, robot positioning, AutoPilot actions, and driver inputs—allowing for in-depth performance analysis and rapid troubleshooting.



To handle this large volume of data, we use **simulations and AdvantageScope**, enabling full match replays and real-world comparisons. This system proved invaluable at **ISR #4**, where we diagnosed an IMU inconsistency affecting odometry. By pinpointing a discrepancy between our **Limelight 3G camera data and robot positioning**, we swiftly replaced the cameras—restoring autonomous consistency and securing our event victory.

We also log **state transitions**, such as intake sensor readings that confirm game piece obtainment, ensuring **seamless multi-system coordination**. Additionally, we monitor the robot's orientation relative to its intended path, refining automation accuracy.

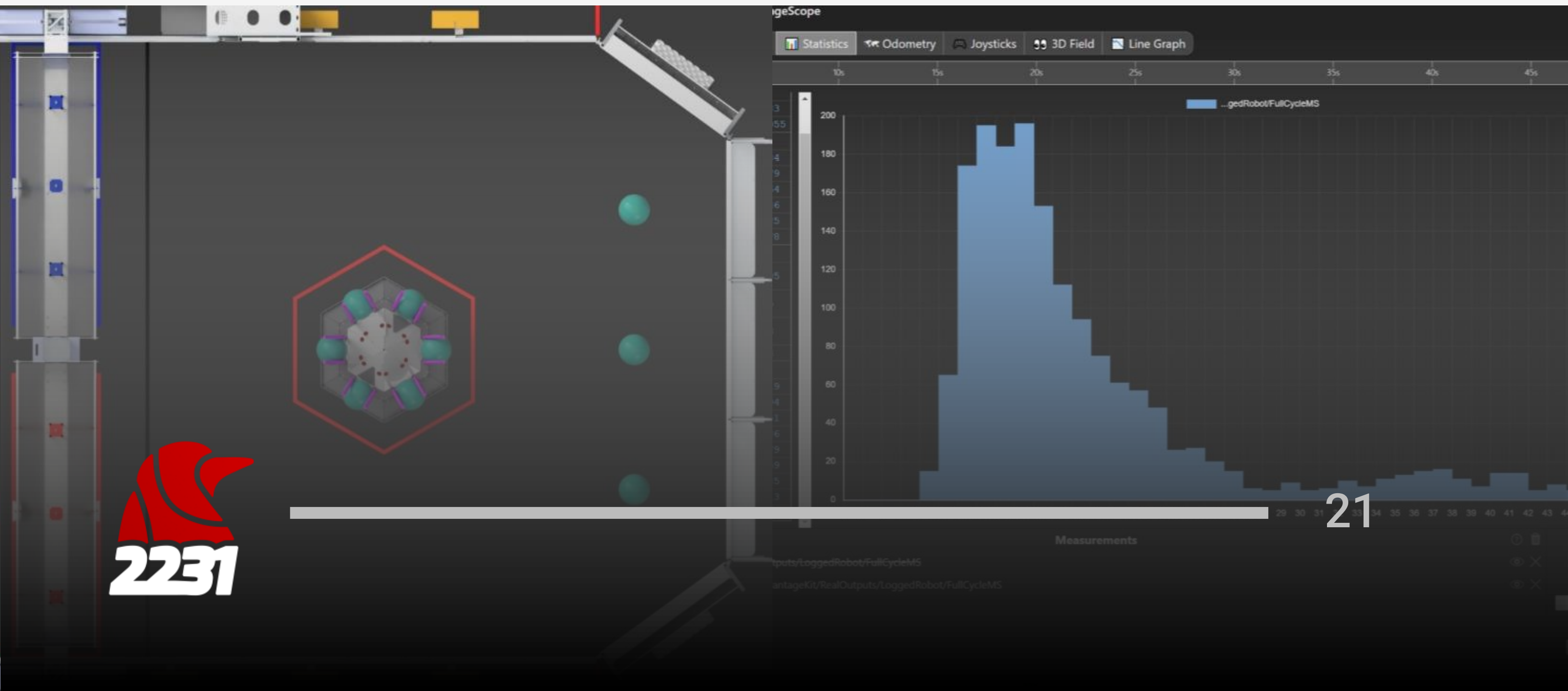
2231

HUMAN INPUT

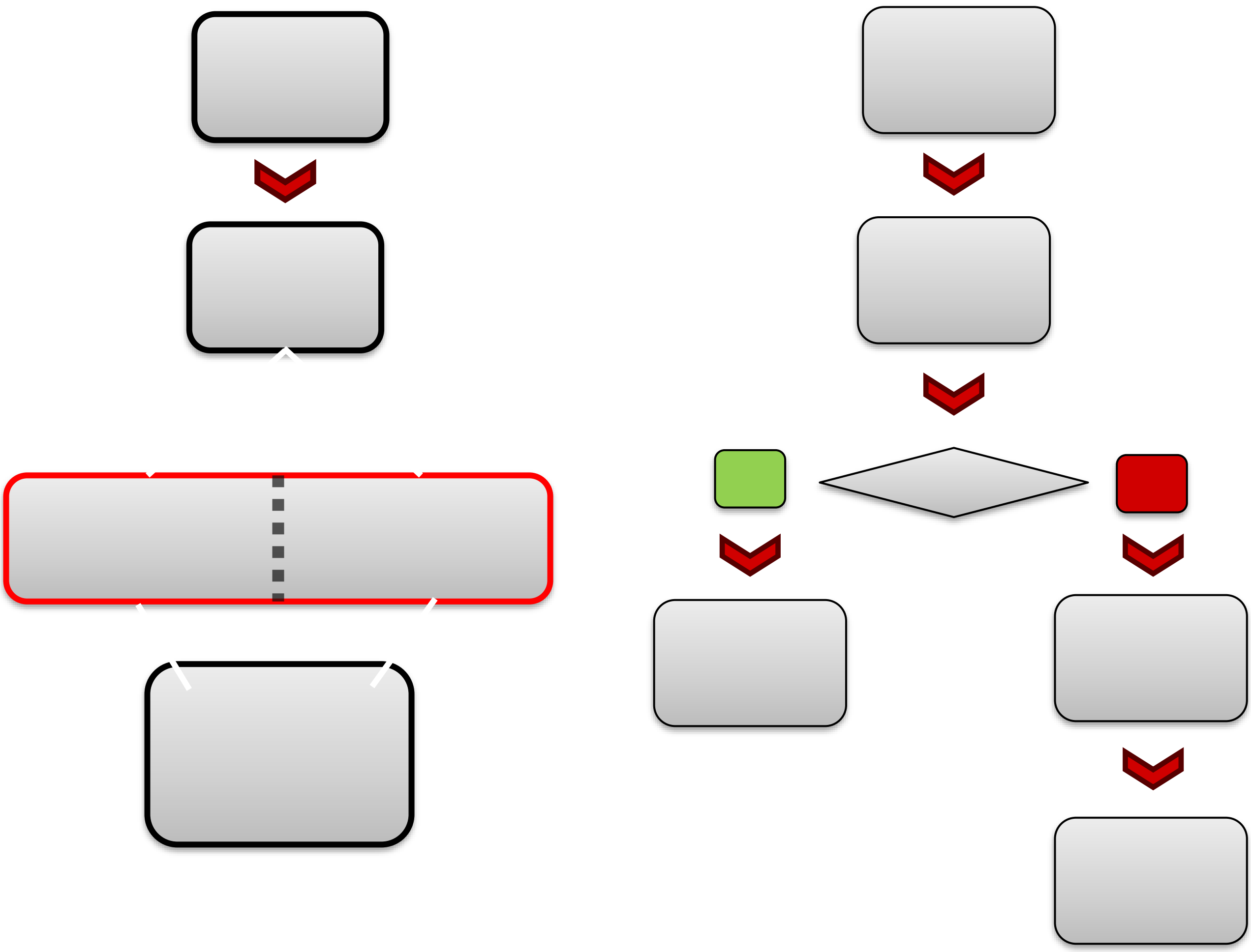
RICO is controlled by two drivers using separate controllers. The main driver handles movement, intaking, scoring, and climbing, executing actions instantly. The operator manages strategy, scoring height, and real-time field analysis, providing crucial updates to optimize driver performance.

Automation to the MAX

Over 70% of RICO’s movements are autonomous, powered by our AutoPilot algorithm. The driver navigates to key field areas, such as the reef’s side for scoring, and from there, RICO takes over—executing precise intaking and scoring actions based on its location.



CONTROL SEQUENCE

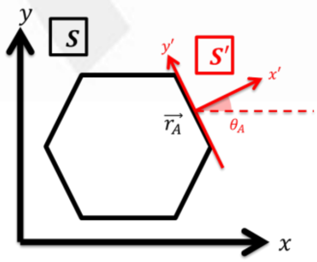


AUTO PILOT

The autopilot system knows to get end points and generates an optimal course to the end point which leads it to that point - the accuracy weve reached when calculating the robots location allows us to perform every action and multi-systemic sequence with maximum efficiency and reliability.

The system is operated using three PID controllers which run a multi-dimensional movement profile for the different freedom levels of the robots movement - which allows it to track the movement on the planned course.

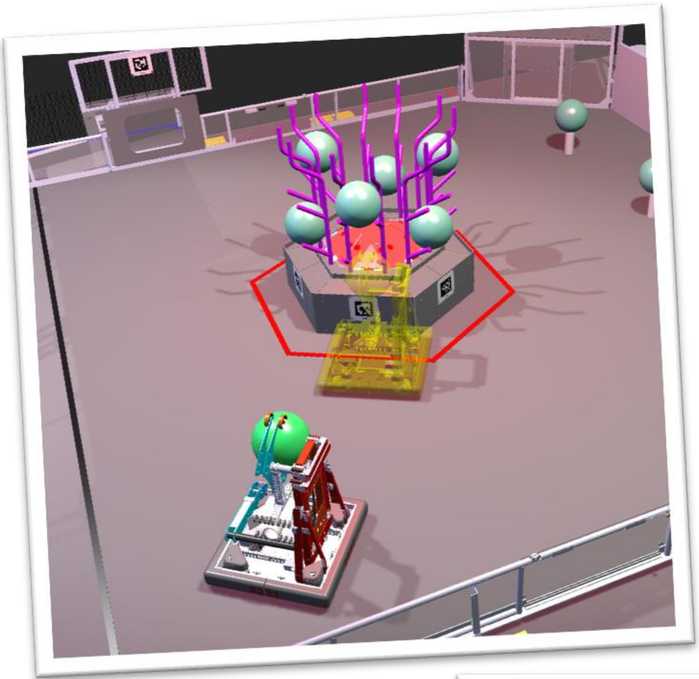
We estimate the robots location using our Vision system and our odometry calculations,
We reached a level of accuracy which allows us to estimate the location of the robot with a deviation of no more than 2 centimeters.

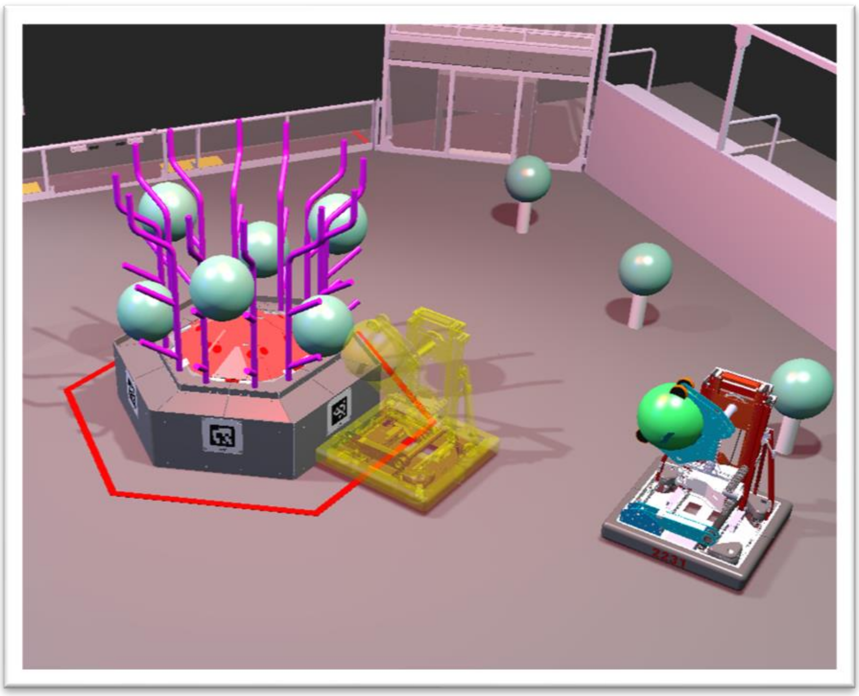


$$\vec{r_0} = R(-\theta_A) \cdot \vec{r_0}' + \vec{r_A} \Longrightarrow \begin{pmatrix} x_0 \\ y_0 \end{pmatrix}$$

$$= \begin{pmatrix} \cos(\theta_A) & \sin(\theta_A) \\ -\sin(\theta_A) & \cos(\theta_A) \end{pmatrix} \cdot \begin{pmatrix} x_0{}' \\ y_0{}' \end{pmatrix} + \begin{pmatrix} x_A \\ y_A \end{pmatrix}$$

AUTO PILOT





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TAILORING INTEGREATED SOLUTIONS

LEDICO

Qualcomm

extal
We know aluminium

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Alcon
Systems

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