Under Control

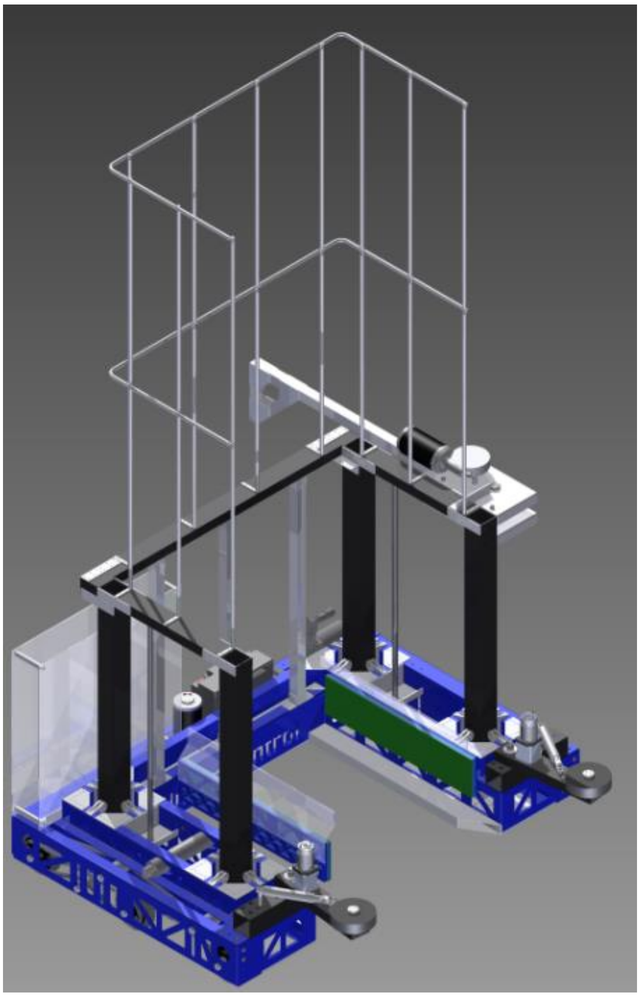
2015 Reaver Book

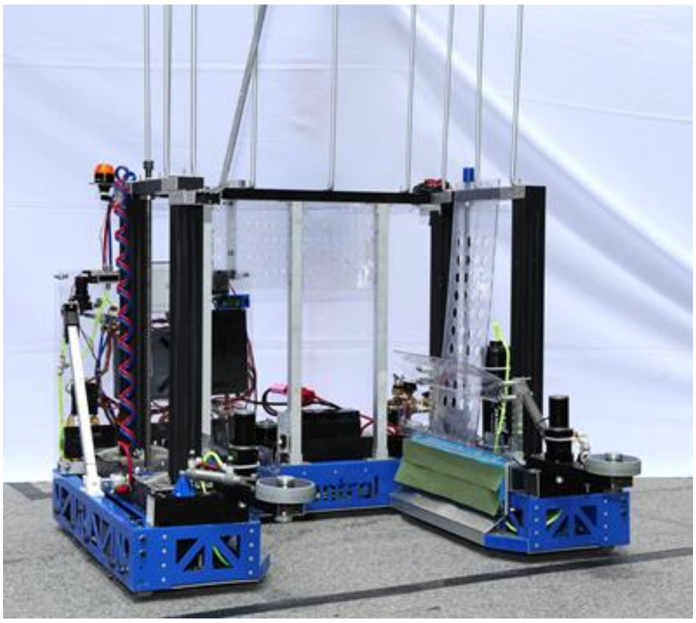
1. Introduction

The main objective of this book is to present a highly detailed look at how our 2015 robot works. We will be presenting a mechanical description of the robot, in which we will explain our design process and the technical specifications about each subsystem. Then we will proceed to make an analysis of our control system and how our code operates.

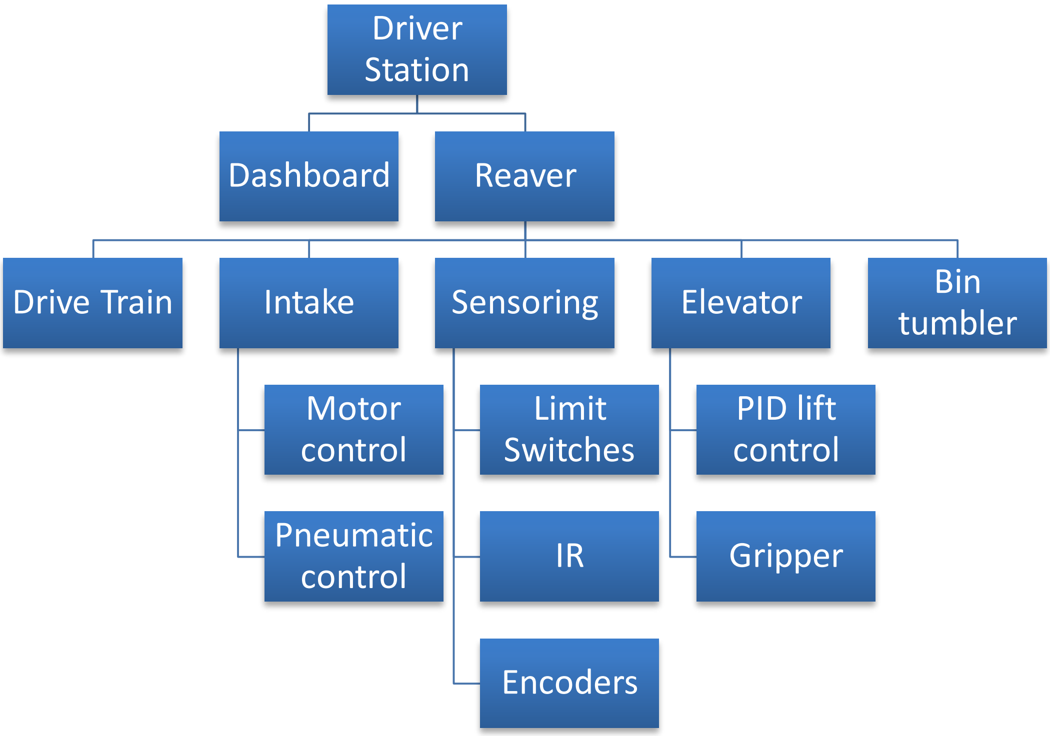
1.1 The Robot

Under control's 2015 robot is called Reaver, it is 77.5in tall, 42in wide, and 28in long and weighs 110 pounds. Therefore, it requires minimum effort to make it fit into the transport configuration; here we have a finished CAD model and the real robot:





The next chart shows how the Robot subsystems interact with each other and exemplifies the robot operation:



1.2 Strategy

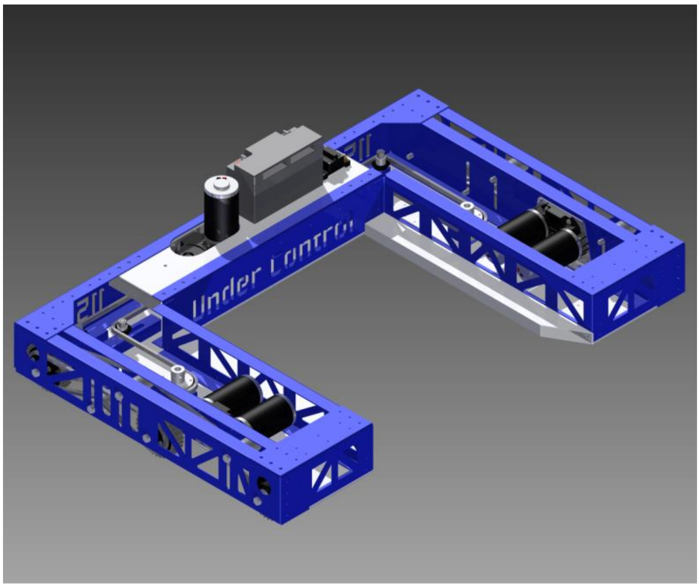
We decided to avoid relying on the other teams in our alliance too much. That was achieved by utilizing our versatile mechanism to grab all the game objects in most of the possible configurations they can be and developing mechanisms that allow us to score during autonomous mode without help from our partners.

2. Mechanical

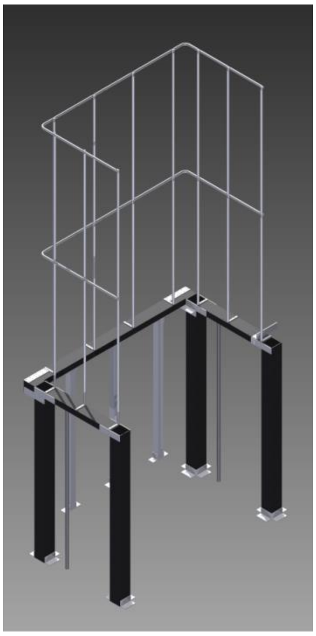
This year's robot was projected with mechanical reliability in mind, being able to adapt to the all the different conditions it could face in a match. This year the design was separated in a few different modules with different purposes, these modules are the following.

2.1 Drivetrain

The Robot is driven by a 6 wheel custom drivetrain, powered by two CIMple boxes, one on each side of the robot, with two CIMs on each gearbox. The rotation is transmitted to the vex versa W tread wheels trough a system of chains, which go from the gearbox to the front wheel, from the gearbox to the back wheel and from the back wheel to the middle wheel. This disposition was chosen to enable the tensioning of all chains, which would be impossible with chain going from the gearbox to the middle wheel due to their proximity. The drivetrain is geared for a maximum speed of 9ft/s to increase the acceleration of the robot and make it possible to reach top speed in this year's smaller field. We chose to use a custom drivetrain to be able to hold stacks inside the robot for a better stability.



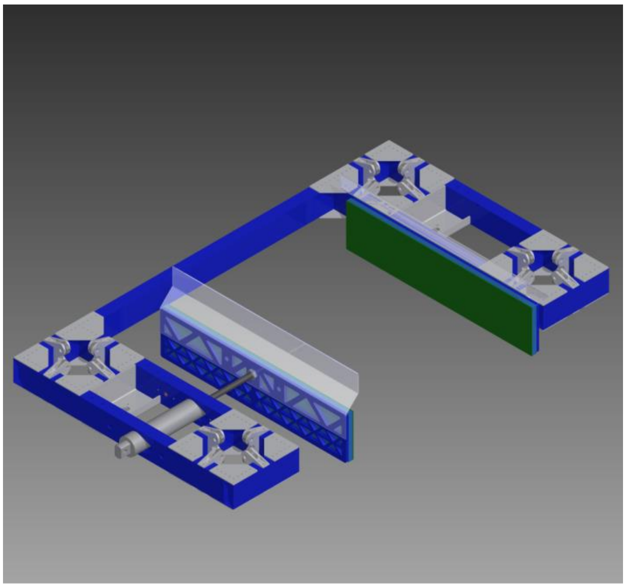
2.2 Tower



The tower is a subsystem used to guide the elevator and hold the threaded rod. It is composed by four 2” x 2” vertical aluminum tubes connected at the top to provide support to the four tubes and other systems. At the top of the tower there is an extremely light grid made of round aluminum tubes that provide support for stacks and bins without lifting the robot’s center of mass too much or adding too much weight.

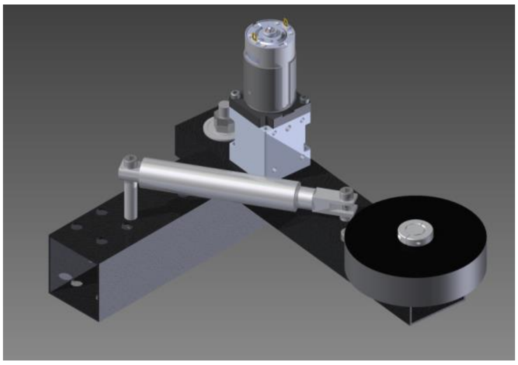
2.3 Elevator

The elevator is a subsystem made with rectangular aluminum tubing, using a custom linear guide that supports the elevator against the tower using bearings for less energy loss compared with cots linear guides. The elevator uses a pneumatic cylinder to apply pressure on bins, holding them with tread and enabling the Lexan on the grabber to enter the edge of the totes, holding them. The polycarbonate has a pattern specially made to enter the edges of the totes and hold the pile with a slight angle increasing its stability. It is powered by a CIM motor trough a CIMplebox, which controls two threaded rods simultaneously, keeping the angle of elevator from changing and moving the elevator up 1ft/s.



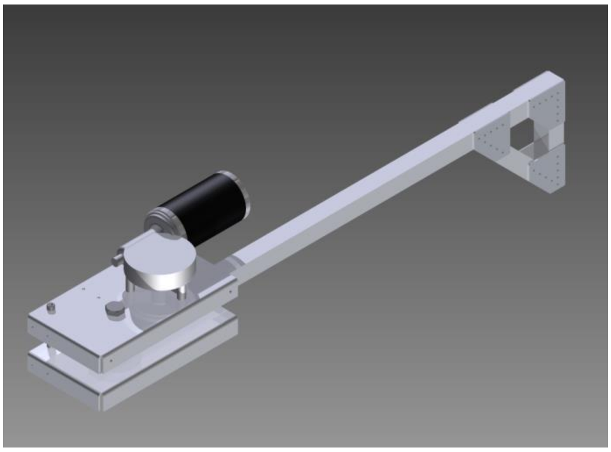
2.4 Intake

The intake is a subsystem divided into right and left sides, the intake is used to pull totes inside the robot more easily. It uses two wheels spinning inwards and making pressure against the sides of totes to grip and pull them inside. The intake uses pneumatic cylinders to act as a spring that can be regulated by the pressure used to actuate it. Each wheel is powered by a bag motor trough a Vex planetary gearbox and a chain inside the aluminum tube, reaching up to 280 RPM.



2.5 Bin Tumbler

The bin tumbler is an optional subsystem in the robot that can be used during autonomous mode to knock bins out of the robot's way enabling it to score a tote set. It uses an aluminum tube to hit the side of bins and knock them over. The system is powered by a CIM motor trough gears and a worm gearbox with a custom coupler to attach them together.



3. Control System

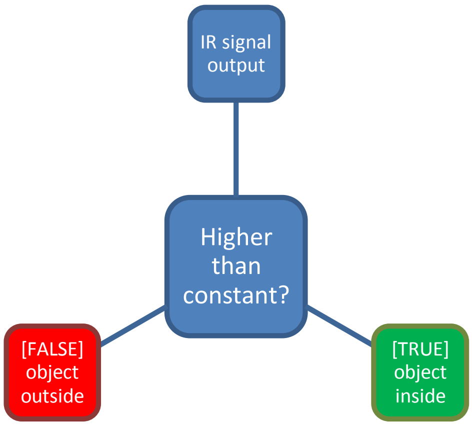
In this section we will make a highly and detailed analysis about control system and all derivate of it such as robot sensors, subsystem control and the autonomous mode

3.1 Sensoring

Reaver has three types of sensors, the Infrared proximity sensor, limit switches and the motor encoders. In this chapter, we will explain how each sensor aids Reaver to successfully stack Totes and Bins.

3.1.1 Infrared Proximity Sensor

The IR sensor is used to detect when the robot has collected a Tote or Bin. It does so by comparing the sensor output with a stipulated constant and acting as described on this diagram:



The sensor used for this task was a *Sharp GP2Y0A21YK.*

3.1.2 Encoders

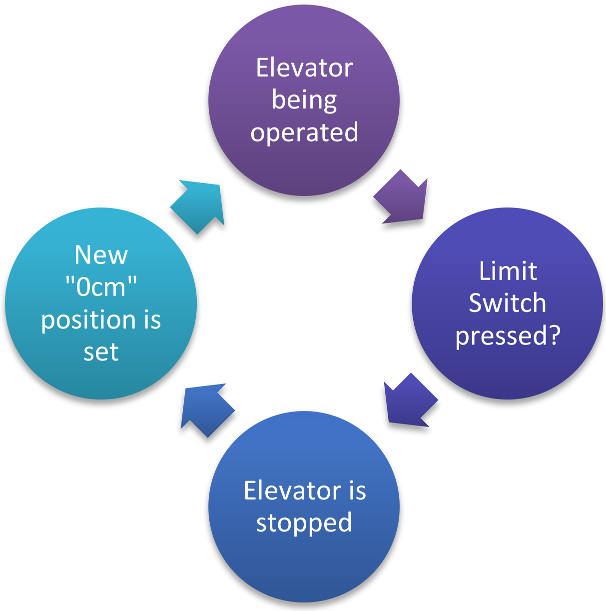
Reaver has three encoders, one for each side of the drivetrain, and one for the elevator.

The drivetrain encoders for sensing the robot position during the autonomous mode. The encoder on the elevator allow us to calculate the height of the elevator with a 7mm error. With this information, we applied a PID system to smoothly control the movement of the elevator. The sensors used for both the drivetrain and the elevator are US Digital E4P encoders.

3.1.3 Limit Switches

There are two limit switches in Reaver`s sensing system, one in the elevator and one in the Bin tumbler.

The elevator`s limit switch is located at the lowest point to witch the elevator can descend. This allows Reaver to automatically stop the elevator when the limit switch is pressed, avoiding damaging the robot structure, and resets the encoder count. Therefore, every time the elevator reaches its lowest position it also re-calibrates the encoder`s zero position.



The Bin tumbler`s limit switch is located is activated when the Bin tumbler is at its “ready to fire” position”. It tells the robot when this system is ready to be used again and prevents the robot from being hit by the Bin tumbler.

3.2 Detailed Subsystem Control

In this chapter we will explain how each subsystem is controlled, and how they were programmed to aid the driver`s work during the Tele-operated period.

3.2.1 Drivetrain

The drivetrain consists of 6-wheel tank drive; two Logitech Attack 3 Joysticks are used to control it during the tele-operated period. During the autonomous mode, the robot reads the output of two encoders attached to each side of the drivetrain and uses this information to move precisely around the field.

3.2.2 Elevator and Intake

The Elevator and the Intake subsystems have been joined in this section because they are operated together during the matches.

As these subsystems have to execute very repetitive actions and are easily predictable, they have been semi-automated. This allows one of the drivers to focus on the game rather than just the robot operation. The automation also prevents damage to the robot by tremendously reducing the human-errors during the operation.

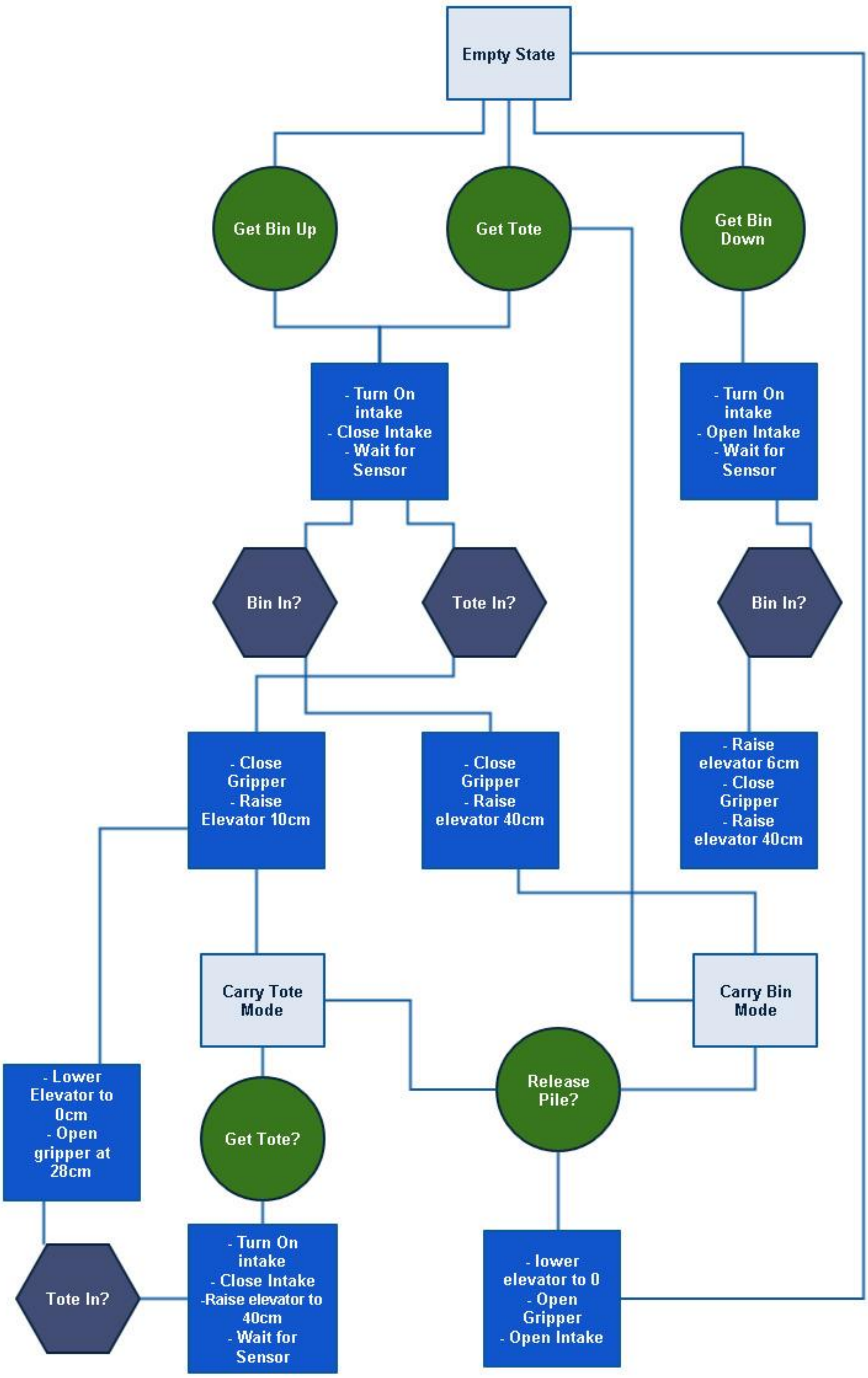
The effective use of this automation has allowed our drivers to control this entire subsystem by using these four buttons:

- Get Bin up;
- Get Bin down;
- Get Tote;
- Release pile.

To be prepared for any incidents that might happen during the match, we have added override controls to these automations. This means that, even with the subsystem semi-automated, the driver can manually control each action of this system at any moment during the match. These overrides are:

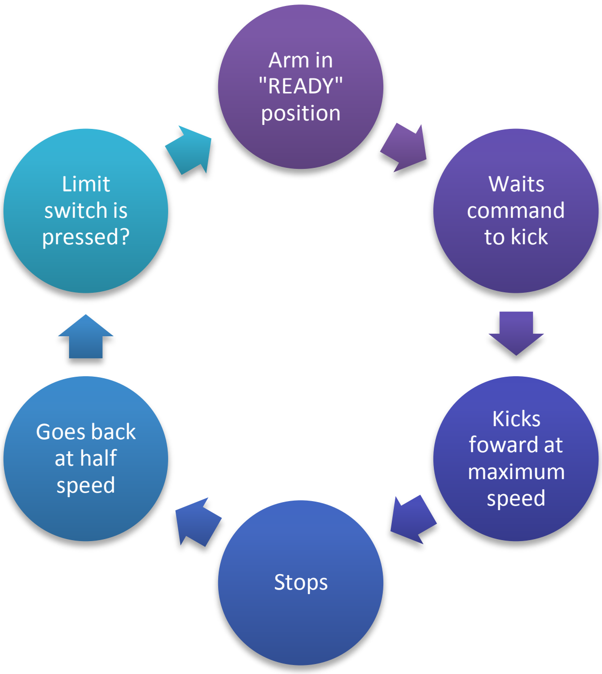
- Open and close the Intake;
- Turn on or off the intake;
- Control of the elevator`s height;
- Control of the “object collected” signal sent by the IR.

The whole process can be studied in the following chart:


Empty State
Get Bin Up
Get Tote
Get Bin Down
- Turn On intake
- Close Intake
- Wait for Sensor
- Turn On intake
- Open Intake
- Wait for Sensor
Bin In?
Tote In?
Bin In?
- Close Gripper
- Raise Elevator 10cm
- Close Gripper
- Raise elevator 40cm
- Raise elevator 6cm
- Close Gripper
- Raise elevator 40cm
Carry Tote Mode
Carry Bin Mode
Release Pile?
- Lower Elevator to 0cm
- Open gripper at 28cm
Get Tote?
Tote In?
- Turn On intake
- Close Intake
-Raise elevator to 40cm
- Wait for Sensor
- lower elevator to 0
- Open Gripper
- Open Intake

3.2.3 Bin Tumbler

Even though the Bin tumbler is designed to be used during the autonomous mode, it can also be controlled during the Tele-operated period. However, in both periods the bin tumbler is programmed so that it does not harm the robot due to human error. It operates as follows:

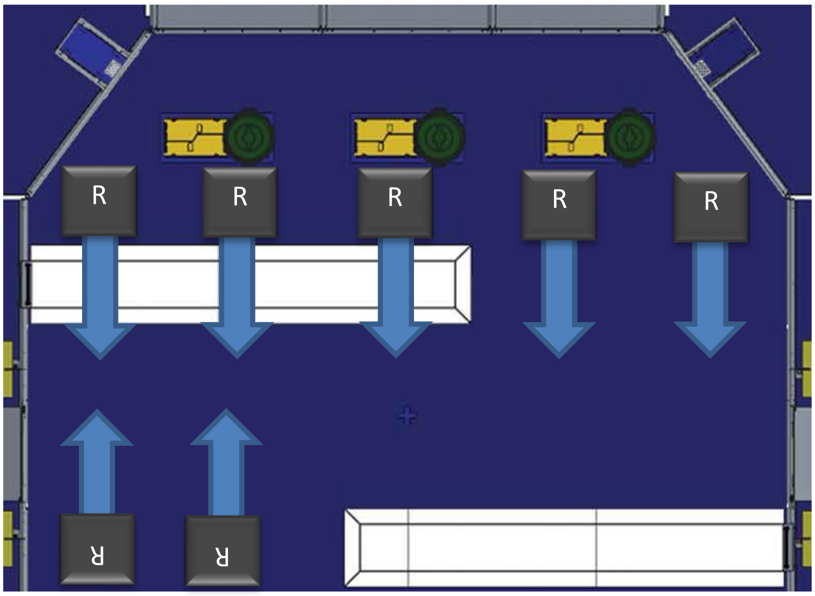


3.3 Autonomous

In this section we will explain how our autonomous code works, currently, we have three different autonomous modes that we can use depending on how our alliance strategy goes. To switch between them we only need to select the desired mode on our dashboard before a match.

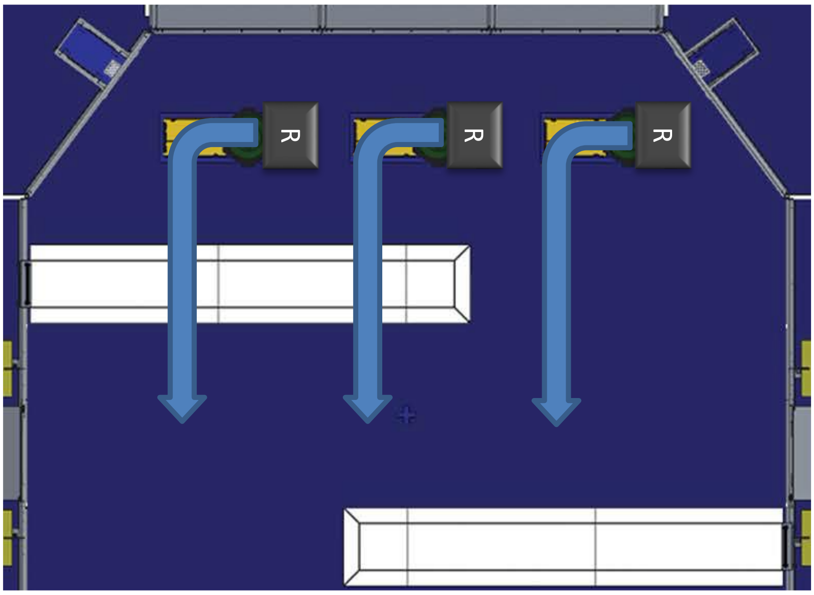
3.3.1 Drive Forward

This is the simplest one, in which we just move forward making Reaver stop inside the Auto Zone. It is very reliable and can start from several positions in the field.



3.3.2 Tote and Bin

The objective of this autonomous is to pick up a yellow Tote and a Bin, and place them, and the robot itself, inside de Auto Zone. To do so, Reaver starts the match facing any of the three Bins. When the match starts, it collects the bin and pushes the yellow tote into the Auto Zone. It does not collects the yellow tote, so we do not have to release it before we start building our first stack.



3.3.1 Tote stack

In this Autonomous mode, Reaver starts the match facing the yellow tote at the left side of the field. It goes forward and collects the three totes while using the Bin tumbler to kick the Bins out of the way. Then it places the three totes and itself inside the Auto Zone.