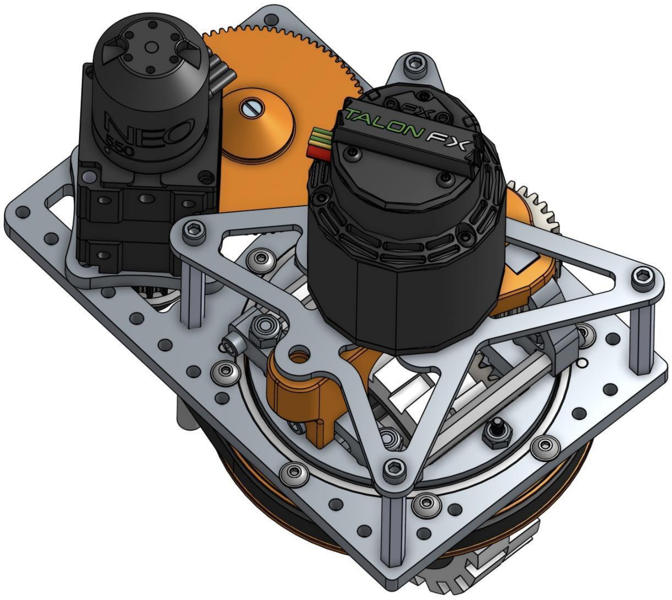
525 2021 Swerve Drive

The 525 way of life is accomplished by bettering ourselves and bettering our community to sustain *FIRST* in Iowa. Our team strives to reach others in our community and have a positive impact through STEM and *FIRST*. Robotics teams all create robots to compete in a game that changes every year. The robot we made for the 2021 Infinite Recharge season utilizes a ‘swerve drive’ system. This system allows the robot to move in any direction and at any angle of rotation. This is helpful in many situations, such as maneuvering into a position to interact with game pieces or avoiding defensive robots.

Goals

Wheel Size and Load

Over time, we determined that West Coast Products (WCP) wheel with belt tread would provide optimum traction but little resilience when hitting field bumps. Due to this factor, we decided to go with the 4” wheels that AndyMark provides. These wheels provide better resilience when hitting the field bumps but maintain adequate traction. However, they require a new bolt pattern that matches the bevel gear’s bolt pattern to be machined. 4” wheels allowed us to increase the speed of the robot and maneuver over obstacles better. Thus allowing us to utilize WCP 15/45 bevel gear set enabling the ½” hex head axle on the wheel to be structural. The module was designed in order to accommodate the parts that were available at the time. 4-inch AndyMark wheels fit as well as WCP wheels with accommodations which helps to provide versatility based on what products are available at the time.



Machine In-House

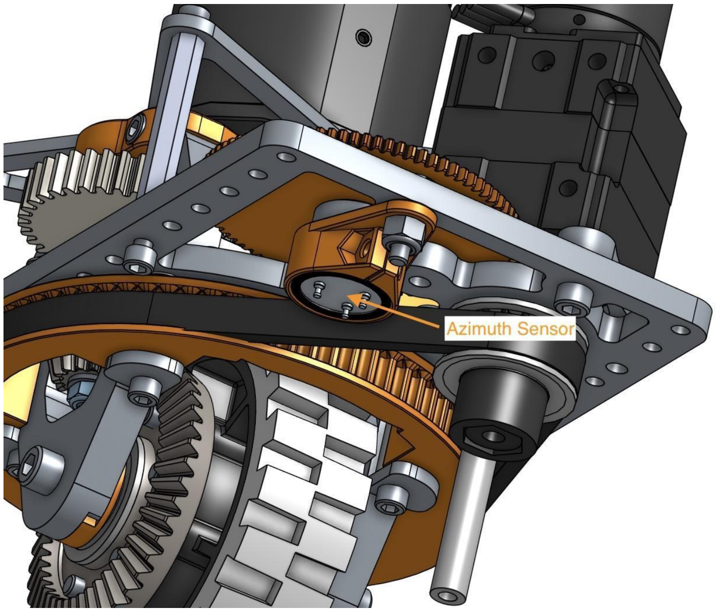
Another goal we had was to maintain the ability to manufacture parts needed for the assembly using equipment we had. This included a CNC router, 3D printer (printing PETG plastic). We chose to incorporate commercial off-the-shelf parts such as gears and bearings. This makes obtaining parts relatively simple. Four of the holes are drilled manually, and they were match drilled to fit with the inner plate. The box structure is formed by the side plates and the inner plate plus the standoffs. The shape is sturdy enough to hold the whole robot's weight.

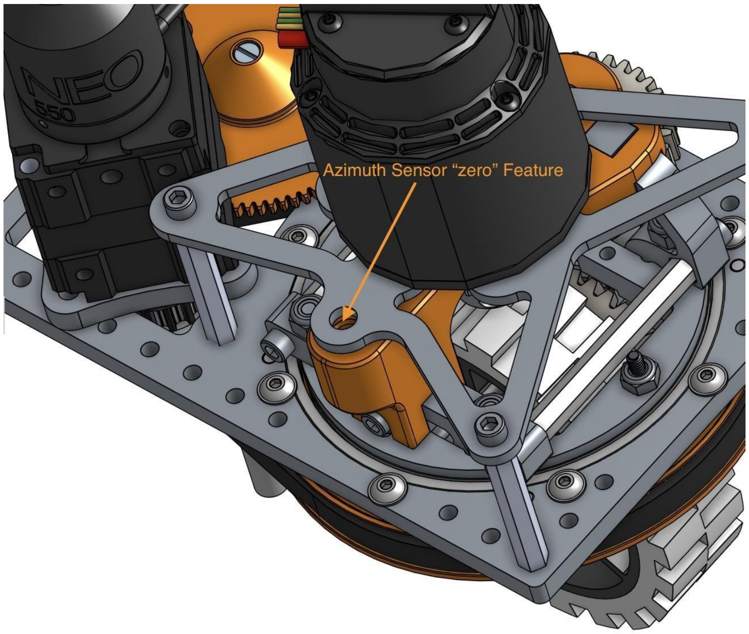
Speed

We set a no-load ground speed goal of 15ft/second and a yaw (rotation) speed of 200 rpm and up. Both of these were achieved through fine-tuning the ratios between the belt-driven yaw control and bevel gear system that transfers power to the wheel. 15 ft/second is a typical ground speed and the gear ratios were adjusted in order to achieve this goal. The speed of the robot is influenced by the gear ratios. The gears are set up in a way that you can change them based on your need for the competition and if you wanna go faster or slower. The module was created in a way that it can be used with modifications to the gears based on how much speed you want.

Analog Azimuth Sensor

We used an analog azimuth sensor to measure the angular rotation of the wheel. We chose to use a version that utilized a hall effect sensor because there is less wear on the components of the sensor and they are highly reliable. These sensors need to be zeroed from time to time, so we added a spot for a zeroing pin to be inserted to ensure the module was completely centered before zeroing. Our zeroing feature is very helpful because it means that exactly 0 volts aren’t required in order to calculate the straight-ahead voltage for each wheel. We can instead use the zeroing feature and then we know for sure that the voltage for straight ahead in each wheel is correct. The sensor is all in one sensor, meaning it provides the bearing for the gear, you don’t have to deal with issues that come with using magnets, the sensor has no dead spot, and it was simpler for us to use. Another plus of using the analog azimuth sensor is that it has a continuous signal and a closed-loop control. The continuous signal is helpful to have because we get constant feedback on the position of the wheel. In order to maintain the linear position of our wheels, we made the azimuth sensor, the neo 550, and the drivetrain all have the same gear ratios. If the gear ratios were different between the three locations then the things would get out of sync and the module would not be linear anymore.



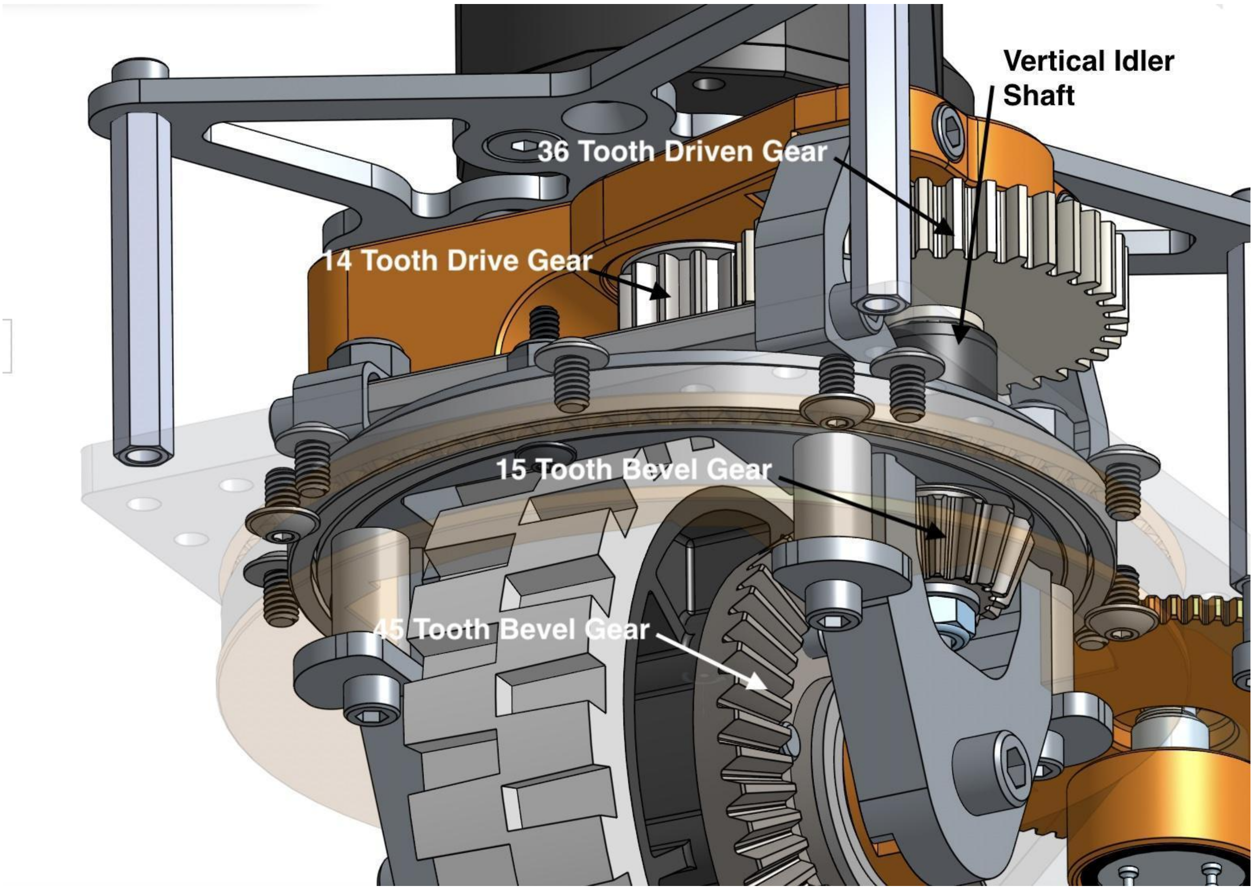


Footprint

We designed our modules to minimize the weight and footprint of the swerve system to allow for flexible packaging in the chassis. The system is also modular, allowing for each individual swerve module to be replaced/removed independently. The ¼” plate that the modules are built on easily mount to the frame of the robot and can be easily changed to accommodate different robots and games. This method of mounting the swerve modules allows them to be positioned as close to the edge of the robot as possible, ensuring the largest possible wheelbase. The wheels are as close to the edge as possible to help with stability. We have made the bottom plat compatible with any other robot design in the future.

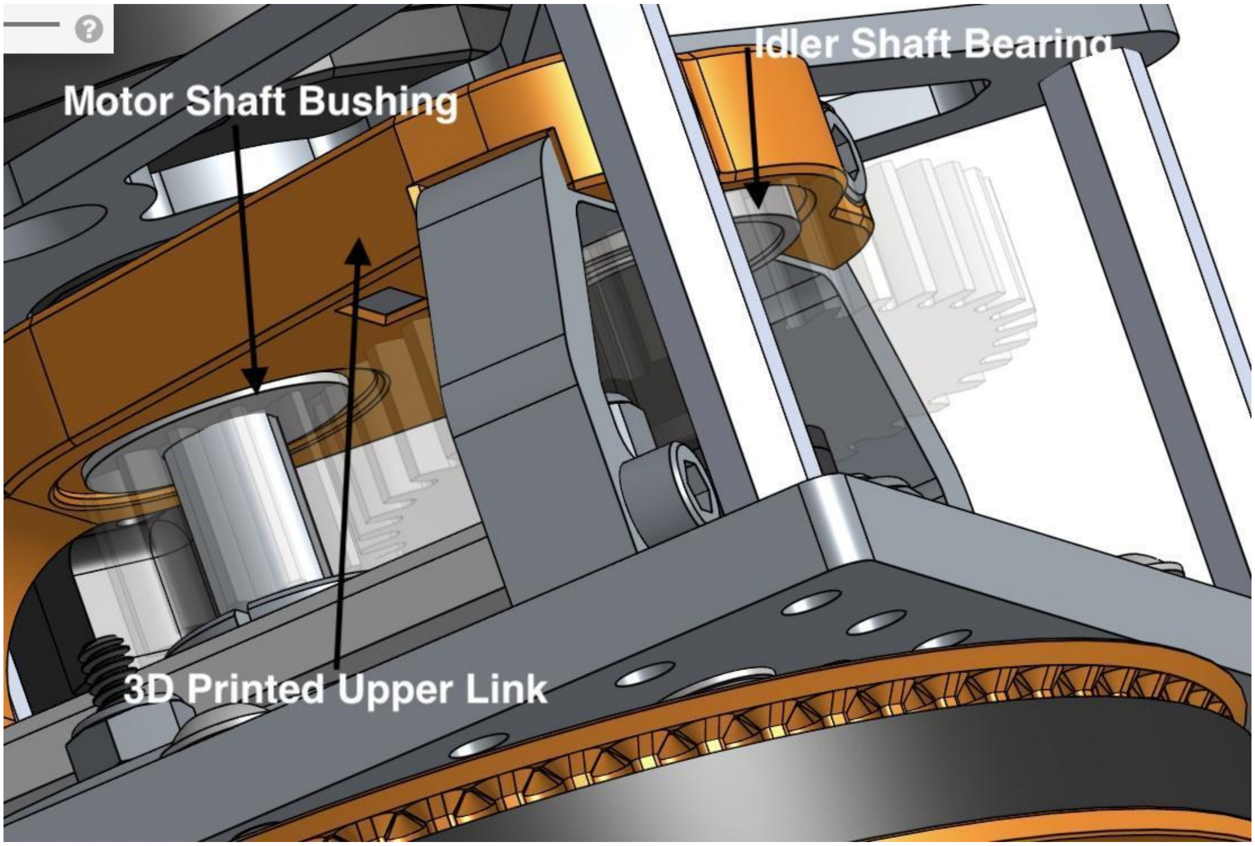
Gearing

The Falcon 500 drive motor with an 8mm ThriftyBot output shaft enables commercial of the shelf 8 by 19 bering drives a 14 tooth gear which meshes with a 36 tooth gear on the vertical idler shaft. The 15 tooth bevel gear on the idler shaft meshes with a 45 tooth gear attached to the wheel. This geartrain results in a no-load ground speed of 14.4 ft/sec. There are other possible configurations of the gears on the idler shaft that result in different torques and speeds (16/34 for 17.5 ft/s, 15/35 (from AndyMark) for 15.9 ft/s, 13/36 for 13.4 ft/s, 12/38 for 11.7 ft/s, and 11/38 for 10.7 ft/s). This allows for the module to be optimized depending on the game.



Bearings

Bearings on the motor shaft and on the ⅜” hex idler shaft are embedded into the 3D printed part to ensure the correct center-to-center distance.



Yaw Control

We utilized a NEO 550 motor with a VersaPlanetary 10:1 reduction. This motor drives an 18 tooth pulley which in turn drives a 72 tooth 3D printed pulley through a 5M 9mm belt. This results in a standard 275 rpm no-load rotational speed.

Wheel Replacement

Because the wheels experience the most wear out of the system, they are easily replaceable. The axle that the wheel is mounted on is attached to the module by two screws. Once these are removed the axle drops out where a new wheel can easily be installed.

Potential Future Considerations

We are continuing to investigate other methods of driving the Azimuth sensor. The current system works fine but has a large footprint. By decreasing the footprint of this system we could decrease the overall footprint of the entire system. The current design depends on the drive belt not slipping to ensure the rotation sensor is accurate. While we have not experienced drive belt slippage, a sensor-driven by a 1:1 ratio would ensure the sensor correctly measures the azimuth angle in every possible scenario. Another change that could reduce the footprint size is switching the VersaPlanetary output shaft to a ⅜" output shaft to allow for the gear combination to be 17/68. The challenge with this is avoiding interference between the yaw sensor and belt. We have had no issues after many hours of practice along with 15+ matches at R20C and 15+ matches at Cowtown Throwdown. The hall effect sensor is connected to the driveshaft, not the driven wheel which could be a potential failure if the belt skips a tooth.

However, we haven't had that issue yet. Even if a tooth breaks, it seems that it couldn't slip regardless.

Software

Software is based on the theory of observation in this paper. When we wrote the software we abstracted all of the dimensional units out to make them percentages. The only dimensional measure required is the distance between the swerve drive module and the center of the robot. The dimension is given in x,y coordinates. As an example, during prototyping, we had a three-wheeled robot and we could use the percentages on that robot even though it had 3 wheels instead of 4.

https://dominik.win/blog/programming-swerve-drive/