Polycarbonate X-Drive Gusset

EZ Robotics

NEED Statement:

With the evolution of the VEX robotics competition, teams around the world have been endlessly optimizing established knowledge as well as implementing new methods to increase their competitive edge. One of the gateways for many new VEX teams to begin fabricating custom components is through the use of legal plastics such as polycarbonate. By utilizing polycarbonate and other plastics, teams can create unique components with specific holes rather than the standard increments provided by VEX metal for intakes and other mechanisms on robots. However, with the flexibility of parts created from plastics, many teams have begun to question the usage of materials such as Lexan ("Should Lexan usage be banned" - Vexforum) because of the ability of certain teams to CNC or machine their plastics.

The Part:

In this submission, VEX U Team EZ will be designing and fabricating polycarbonate x-drive gussets in order to show teams how they can produce their own plastic components without the use of a CNC or other machines.

X-Drives have been a recent hit among the VEX community after the Pilons (5225A) debuted their 120+ programming skills run (E-Bots Pilons Programming Skills Run) in the last season, Tower Takeover. Since then, many VRC teams have begun to attempt to build x-drives and utilize their programming potential. X-Drives have an advantage in many programming aspects as robots can achieve similar results with less turn making runs more consistent along with the ability to strafe.

Historically, X-Drives have been neglected as the complications of building each individual pod and bracing the drive often outweighed the benefits of the drive. Due to the slop in the 45-degree gussets provided by VEX and the difficulty to square the drive, many newer teams struggle to build their drive before starting on the rest of their robots. Furthermore, misalignment in drive pods can affect a robot's ability to drive straight. In combination with the necessity of building low friction drives and lesser power of 393 motors along with the loss of torque within the geometry of the X-Drives themselves (Aura X-Drive Math), X-Drives have not had much usage before the introduction of the V5 system.

However, V5 has brought about massive changes to the metagame of VRC as the new motors have 2.5x power over old 393 motors. With the extra torque from the motors, teams have opted to gear up their drives for speed. With the extra torque, X-Drives became more viable as the ratio of 3.25-inch-Omni wheels direct with a 200 rpm cartridge (48.131 inches/sec) was nearly comparable to some of the ratios ran by tank drives.

To solve the issues with slop and getting the right angles for an X-Drive, Team EZ will be creating an X-Drive gusset similar to the one employed by the Pilons to create a lighter, lower slop drive pod.

Design:

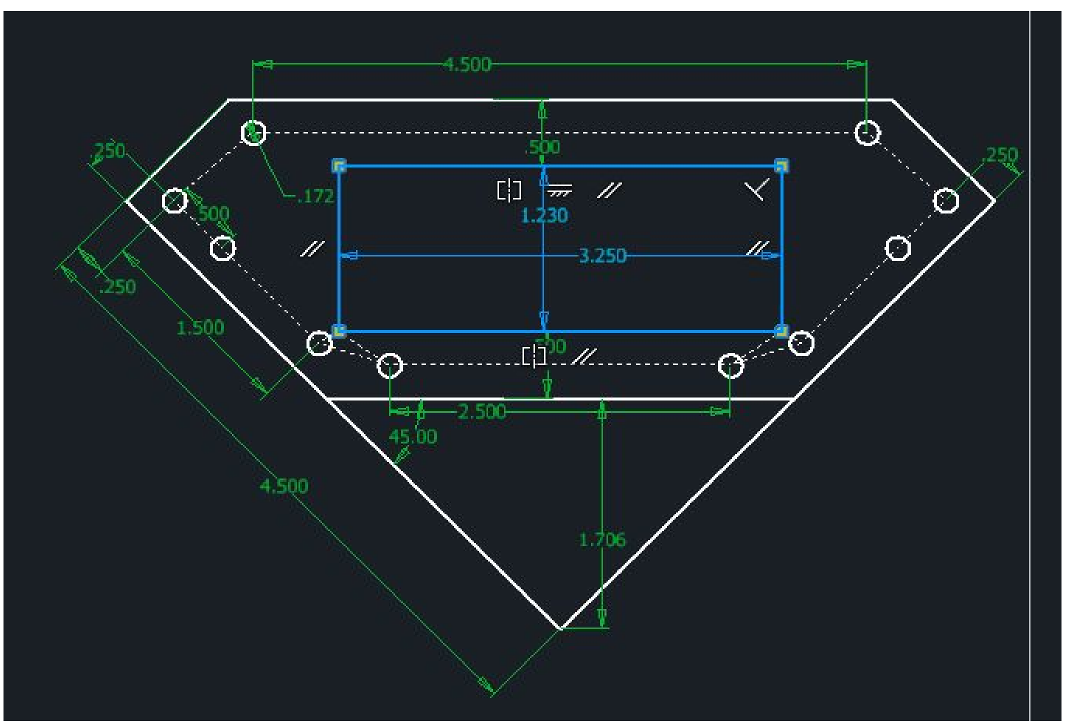
The design constraints for the X-Drive pods vary between a different number of factors from wheel size to drive pod length. In this version, the wheel being used is a 3.25-inch-Omni wheel. The traditional angle for X-Drives is 45-degrees and this will be used as the set angle for this part. Since these gussets will be made to align to c-channels produced by VEX, the distance between the holes on the piece will be in increments of a half-inch.

When designing the X-Drive gusset, there are specific holes on the part which must be precise and others that do not require as much precision. For example, the holes aligning the long c-channels to the short ones at a 45-degree angle must be precise, or else the drive pod will not line up, however, an extrusion such as the one for the omni-wheel just has to be big enough to clear the wheel that it does not clip the polycarbonate.

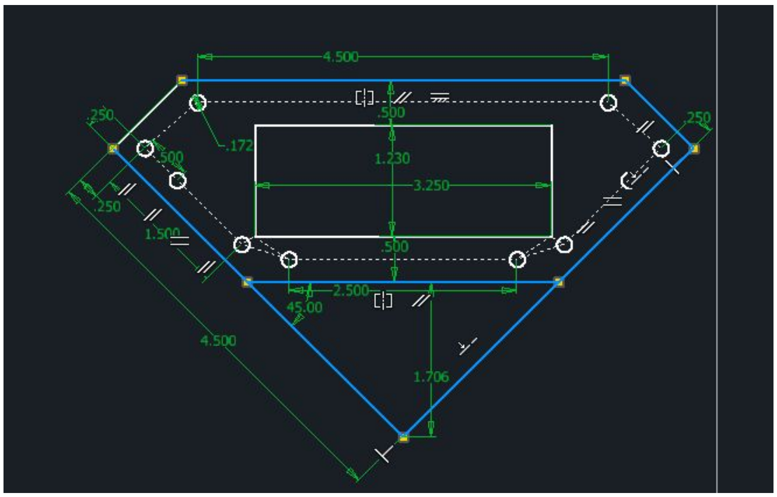
With the conditions above in mind, the first step to designing the part is to create a sketch in CAD. After starting the sketch, put in the constraints set earlier using dimensions like the angle of the drive pod.

All of the X-Drive gusset parts were designed in Autodesk Inventor 2021.

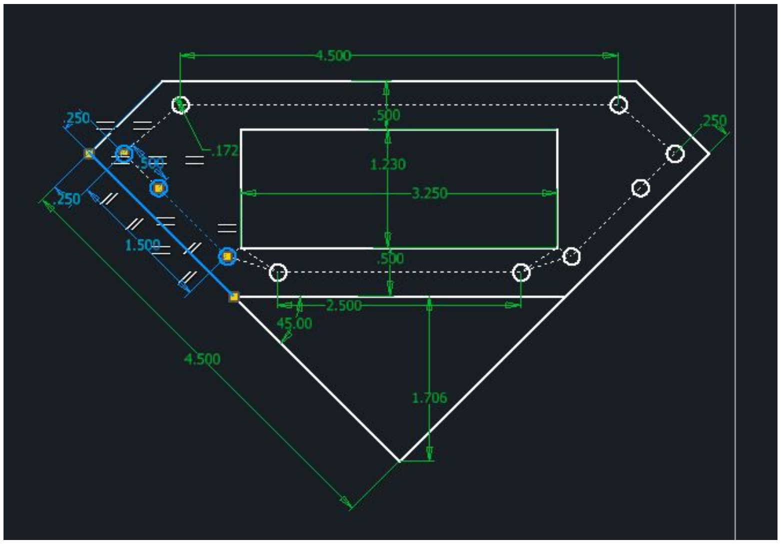
1. Create a sketch and make a rectangle that will be cutout for the wheel. The rectangle's dimension just needs to clear the omni-wheel. This will be used to basis the rest of the dimensions off of.



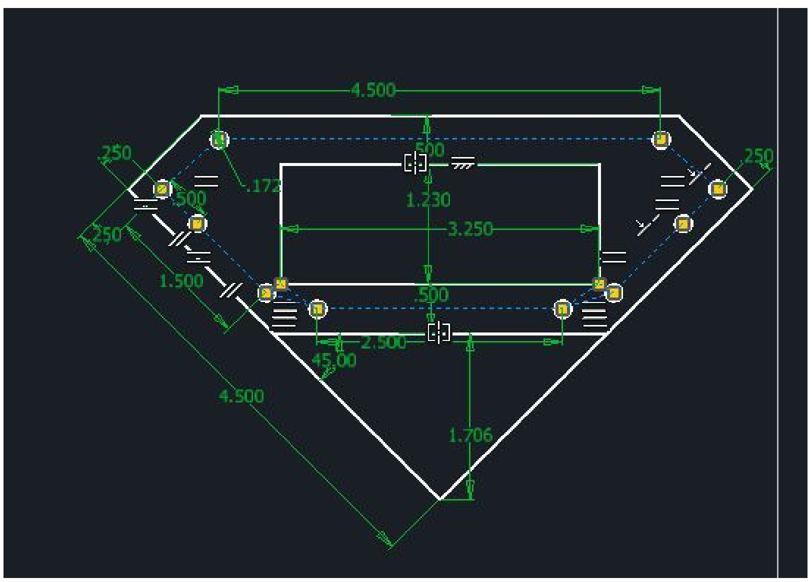
2. Place two lines above and below the rectangle and space it half an inch. This will be the outer part of the gusset adjacent to the wheel and fit right ontop of the c-channels. Place two perpendicular lines that are 4.5 inches in length and dimension it 45 degrees to the bottom line below the rectangle and space it 1.706 inches down from the line as well at the point of intersection. Place and attach two more lines to close up the part and make them parallel to the corresponding perpendicular lines across.

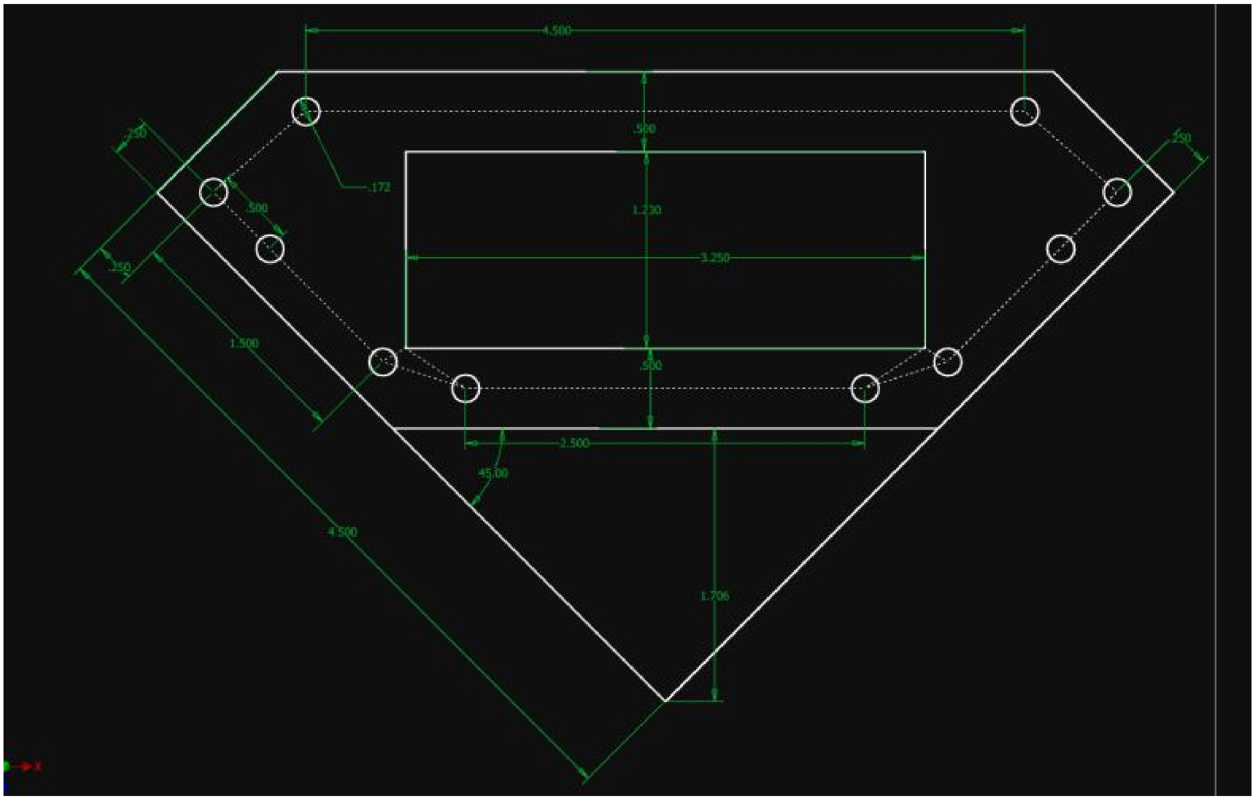


3. With the outline complete the holes can now be dimensioned and construction lines can be made through the centerpoints of the circles. Place a circle with a diameter of .172 on the left and dimension it a quarter of an inch (.250) away from the outer two lines in the outline. Then add another circle (all circles will have diameter of .172) half an inch away for the next hole (half inch increments are the distance between vex holes). Place another circle 1.5 inches away from the original circle and place a construction line through the circles that is parallel to the outline.
    a. The circles are 1.5 inches apart even though the c-channel it lies on is 4 holes (which should be a length of 2 inches) is because the dimension line takes into account the distance between the center points of the circle.

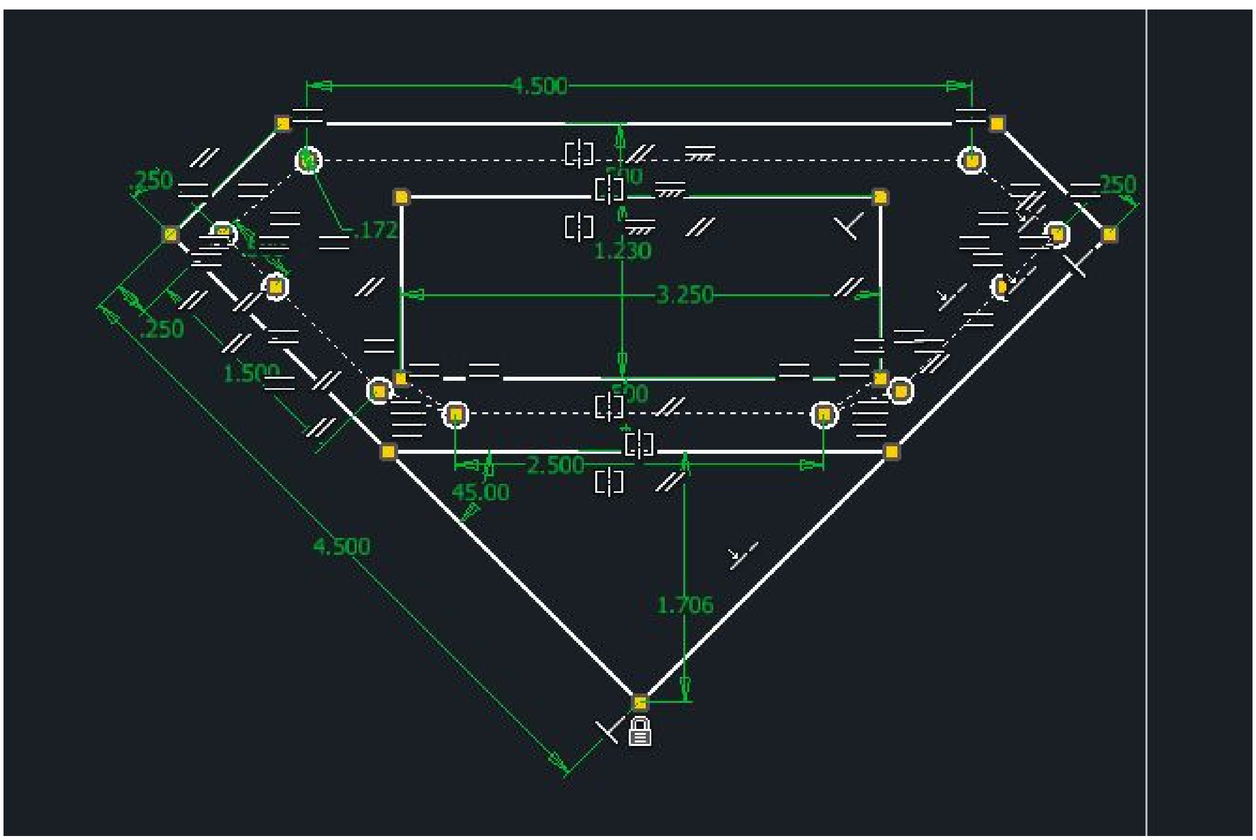


4. Place two circles at the top with a center to center distance of 4.5 inches apart. Then do the same at the bottom placing two circles with a center to center distance of 2.5 apart. Now draw construction lines between all the the circle's centers from the parallel construction line earlier.





Sketch With Dimensions



Sketch with Dimensions and Geometry Constraints

An alternative to sketching the dimensions from preset constraints is to create a sketch on preplaced c-channels in cad and project their geometry to get their holes and create dimensions around those holes. C-channels and other VEX parts can be found for CAD use in the Vex CAD Discord Server (https://dishttps://discord.gg/BKV3DJmcord.gg/BKV3DJm).

1. Place c-channels for the drive and drive pod and angle constraint the pod c-channel at 45-degrees. Then place another c-channel so the wheel will not be cantilevered. The spacing can be any distance which clears the long drive channels.
2. Start a sketch on the c-channels and project the geometry of the holes at the edge of the c-channels. The lines on the edge of the c-channel can also be projected as construction lines to reference for the rest of the part.
3. After the holes are sketched, the outline of the part can be done by making lines around the preplaced c-channels. The distance between the rectangular cutout for the omni-wheel is half an inch because vex c-channels share the same width. The dimensions for the rest of the part can be lessened to save room in the total limit. Furthermore, splitting the part into two pieces will also save some polycarbonate as the gussets only need to be on each side of the c-channels rather than one whole part.

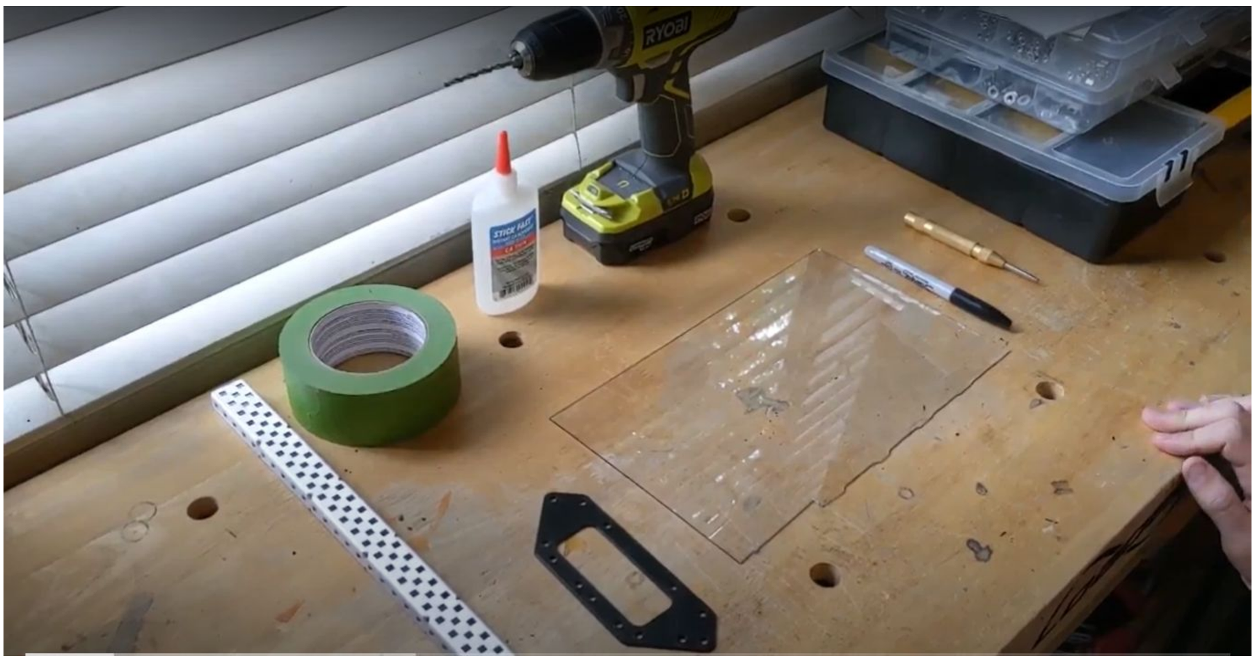
X-Drive Gusset CAD Assembly

The overall design is trying to simplify the construction of X-Drives to help teams past the first hurdle of building one before attempting to tackle the rest of the complexities of an X-Drive. Teams can also save polycarbonate if they spilt the gusset into two parts and shorten the material connecting the mirrored sides.

Fabrication:

In the fabrication process, the tools being used to create the part are the following: polycarbonate, straightedge, marker, drill, #19 drill bit, exacto knife, scroll-saw.

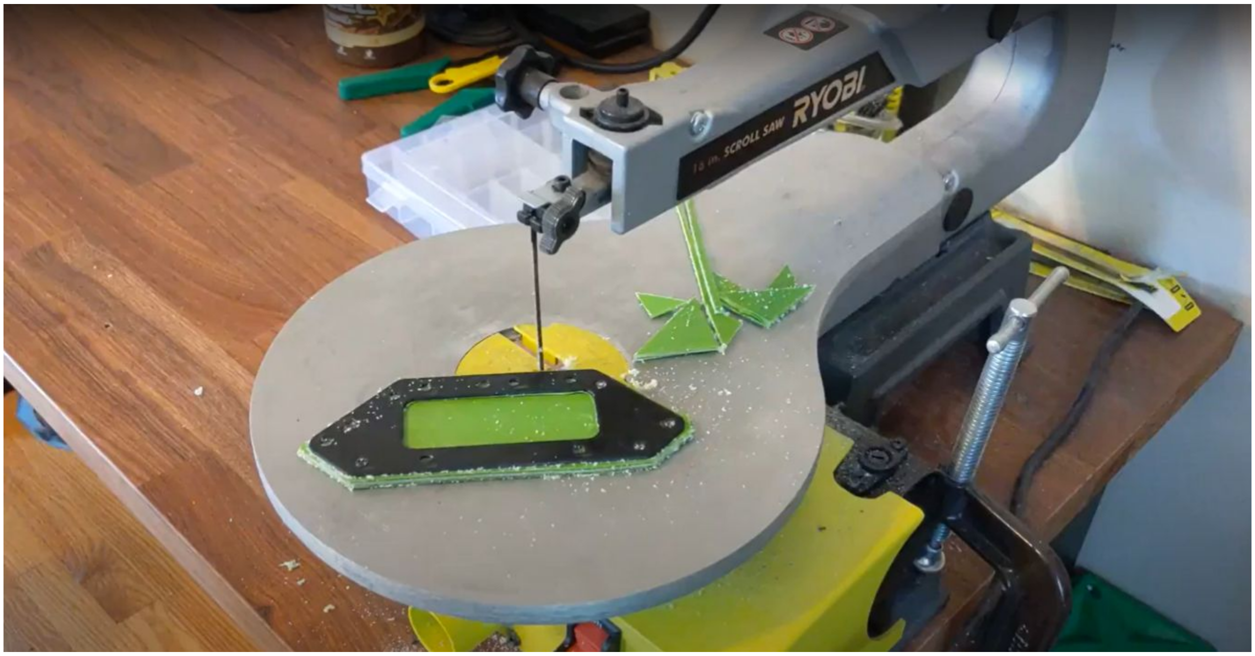
1) The first thing necessary for the fabrication process is to use a reference for your part. This can be achieved by printing the design onto a sheet of paper. The issue with a printed sketch is that it is very easy to be inaccurate. The reference that Team EZ used was 3D-printing an object extrusion of the sketch. This gives a physical part to reference holes and cut the polycarbonate against, thus increasing the accuracy of the finished product.



2) When drilling holes the drill bit will walk in a direction decreasing accuracy. If two holes were walking in opposite directions, the holes will have more errors. Team EZ’s solution was to connect two pieces of polycarbonate together, therefore the parts will be produced as one and be perfectly concentric. Before connecting two pieces together, one can cut enough stock for the parts required from a bigger sheet (there are 8 parts in this case). To connect the stocks, painter’s tape is placed on both sides of two polycarbonate pieces and glued together. Painters tape is used so no glue is ever touching the polycarbonate, and everything can be removed at the end. After they are glued together, more painter’s tape is added to the now connected stock and the 3D print is glued to the contraption.

3) After attaching the 3D print, it can be used as a guide to drill the holes into the polycarbonate. When drilling the holes, try to keep the drill straight and if possible, use a drill press. A #19 drill bit will give the least amount of slop for 8-32 screws.

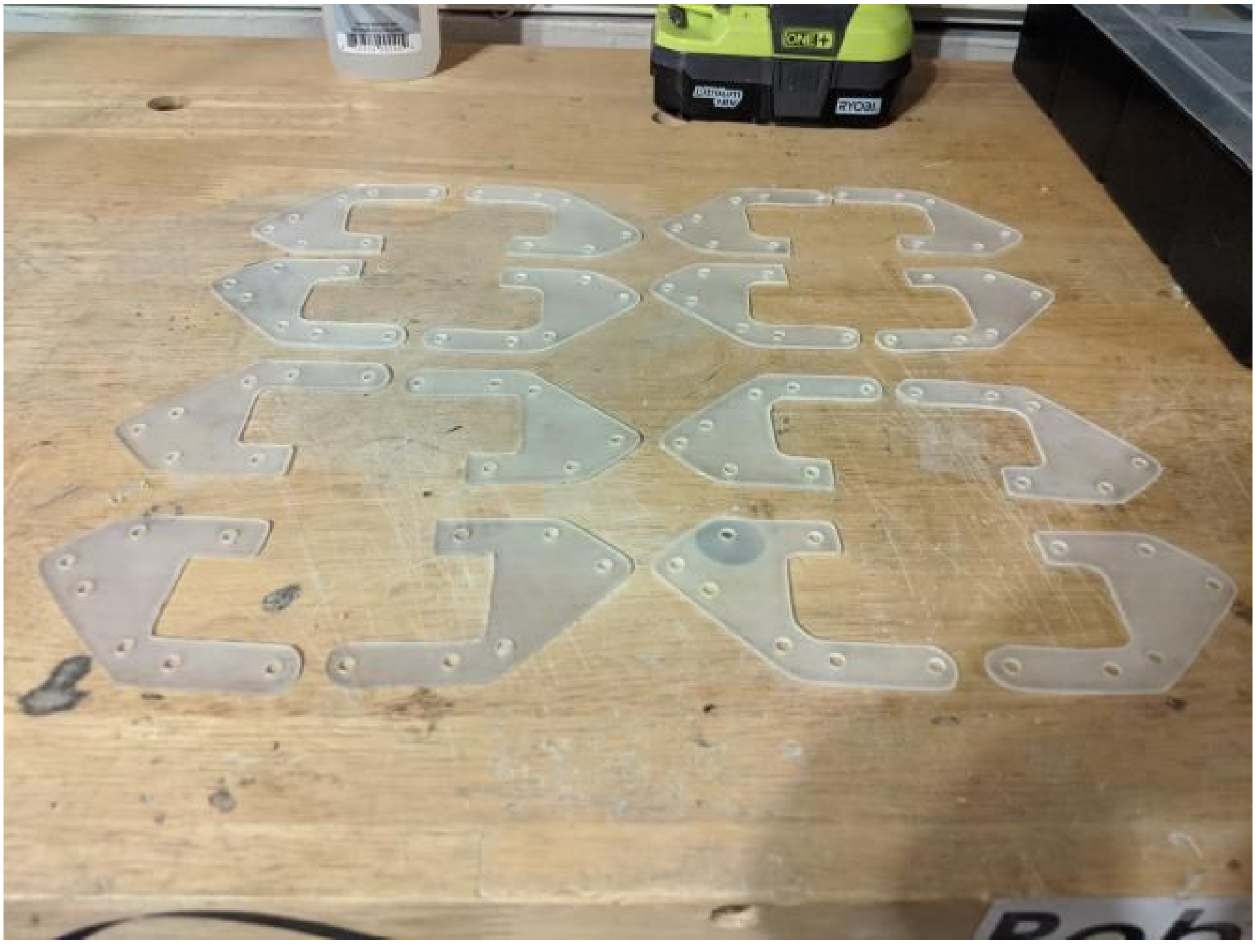
4) Now that all the precise tasks are done, the only step left is to cut out the part and the hole for the omni-wheel. Team EZ prefers to use a scroll-saw however teams can use whatever is at their disposable (dremels, bandsaws, tinsnips, etc.). These cuts don't need to be very accurate as long as their tolerances clear (i.e omni-wheel doesn't clip). The holes are the only precise part as they hold the angle of the drive pods.



5) If the part needs deburring this can be done with a deburring tool, file, or belt sander. Teams also have the option of “frosting” their polycarbonate by sanding it with 400 grit sandpaper, however, this is purely aesthetic.

Photos of Finished Part:

Unfrosted X-Drive Gussets



Frosted X-Drive Gussets

Half of X-Drive gusset