"Necessity is the Mother of Invention"

"A need or problem encourages creative efforts to meet the need or to solve the problem. This saying appears in the dialogue Republic, by the ancient Greek philosopher Plato".
[www.dictionary.com]

2568K "1x 1x 35 L-Bar", VEX Aluminum Structure produced on "Autodesk Inventor"

Background
Having researched the 2019 VRC Challenge and early stages of the Design Process complete, it was time to start prototyping our robot. With 11 robots being built in our program, resources were scarce and the high school teams had gotten a head start on us. No 1x 2x 35 length aluminum structure could be found to build a Base Chassis and Expansion. We were left with scavenging parts from older robots, and found a few new pieces of 1x 3x C-channel. We were able to come up with enough aluminum structure for half of the robot subsystems we needed. So, we had to get creative and make a decision to deal with this set back. The shortage of structure ended up being a blessing in disguise.

In previous challenges, light robots were fast. Our State Champion high school team inspired us how they cut aluminum structure lengthwise to reduce weight and increase speed for their "In The Zone" 4-bar Cone Grabber. But, would it work on a larger scale with a chassis and a full expansion?

Ruling out steel as an option because it was too heavy, we modified 4 pieces of three-wide aluminum C-Channel which other teams deemed unuseful. In essence, we used half the usual material to build a full chassis and expansion system. We theorized it would result in a lighter and more compact system, allowing for the space needed for the Launcher and Ball Intake subsystems.

Modifying the 3-Channel for Expansion and Chassis:

1. First, our coach trained us how to use the band saw and sander.
2. Next, we set up a fence just the right width from the blade, ensuring a perfectly straight cut down the bar's length between the first and second column of holes.
3. This resulted in 2 usable pieces; a 1x 1x 35 L-Channel, the other was a 1x 2x 35 L-Channel.
4. The 1x 1x L-Channel was for the Expansion, which is the focus of our "Make it real Challenge". The 1x 2x 35 was for the Chassis.
5. Next, we sanded down the edges to stay rule compliant with smooth edges.

Fabrication of Expansion
Some pieces required shortening to produce the 6-Bar for placing Caps on the High Post. After the dry assembly, we bolted the system together to see its potential under manual power. After mounting the Expansion prototype to support Towers, we tested them with motor power. Here's what we learned:

Pros:

- Lightweight and fast acting.
- Less motor resistance and strain.
- Strong enough to work our Expansion and hold the Cap's weight.
- Slim and Compact: Our Expansion takes up less space allowing room for our Cap Claw, Launcher, and Sweeper.
- Initially a temporary solution until our shipment of structural aluminum arrived, we're so happy with the result, we've decided to keep it!

Cons:

- After cutting the bar, it lost structural strength compared to its original state due to decreased depth. (Although, it's strong enough to do the job!)
- The material is vulnerable to twisting forces. (We counter-acted this with horizontal struts.)
- Careful processing with power machinery is required.

Creating the 1x 1x 35 L-Channel on <u>Autodesk Inventor</u>:

For accuracy, we used a dial caliper to "Reverse Engineer" the 3-wide C-channel. We measured and recorded all dimensions and spacings.

We concluded the 3 C-channel was produced by a stamping process. To reproduce the part for manufacturing, our bar needed drawn as a "Sheet Metal" part with the "Pattern" feature. Both new to us.

How 1x L-Bar was modeled in Inventor:

1. A Face the thickness of 0.063" was created on a 17.5" x 1.10" rectangular sketch.
2. A diamond shape 0.15^{2}" was sketched 2.5" from the end of the bar, on the midline.
3. The diamond was patterned 6 times, then extruded (Extrusion 1) through the midline of the face.
4. Sketch 0.185^{2}" square 0.155" from the end and side edges of the rectangle's corner face.
5. Fillet corners of the square at 0.20".
6. Sketch horizontal midline on the face of the part
7. Mirror square across midline.
8. Pattern Squares (rectangular) 35 times every 0.5", then Extrude through. (Extrusion 2)
9. Sketch isosceles triangles on top and bottom edge of face 0.338" away from step 2 diamond. The sides were 0.55", and the base 2.10".
10. Mirror step 9 triangle along step 6 line for axis
11. Pattern (rectangular) both Triangles, 6 times at 2.5" apart across the face.
12. Extruded triangle to cut through. (Extrude 3)
13. Chamfer the part's 4 corners were at 0.06".
14. Fold horizontally along in step 6 line as axis.
15. Sketches were edited to make non-part lines invisible.

Conclusion

The physical fabrication was fun and the new “unofficial” product has withstood 5 tournaments and hours of practice. Being novice Inventor users only practicing in our PLTW classes, we used the “Help” topics to learn new features. We learned to use dial calipers and power machinery, too. This C-Channel “Reverse Engineering” task became an L-Channel “Innovation” that grew our CAD skills.

We used Tinkercad in the brainstorming process. Now, we feel more confident to use Inventor and the part files provided by VEX to make subsystem assemblies for our Engineer’s Notebook. Inventor drawings are a big part of our high school team’s Engineering Notebooks. We feel this challenge has given us a good head start on our future and look forward to more Autodesk Inventor projects in high school.

Our robot is a unique and effective high-post expansion robot thanks to our “Necessity of Invention”. We’ve seen this C-channel modification on robots at high-level tournaments, which indicates a need for this structure. Made available in multiple lengths, we feel our “1x Aluminum L-Channel” is a practical VEX product for the future.