URC 2018

Rover Design Tips

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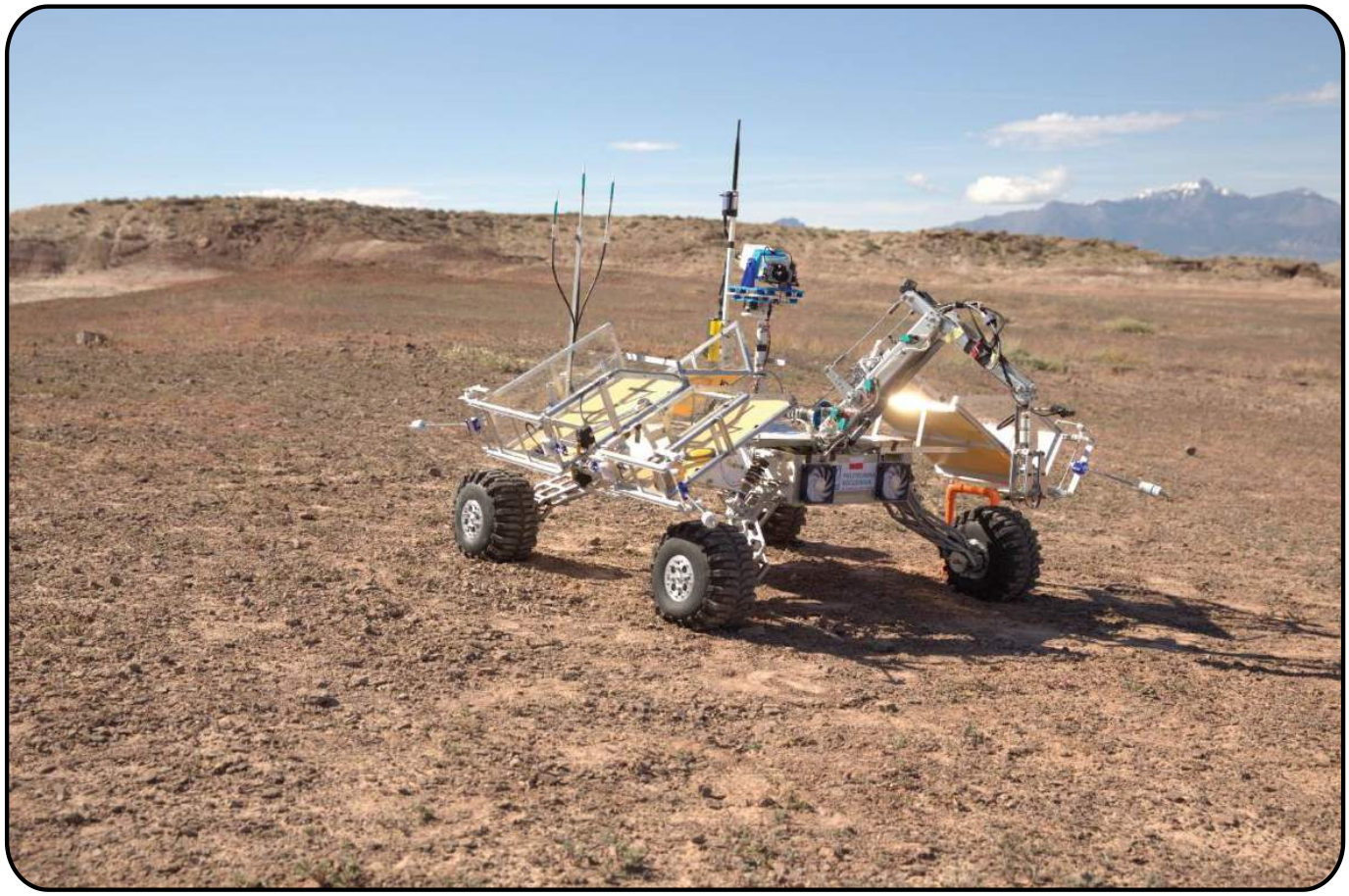
Welcome to Protocase's Rover Design Tips

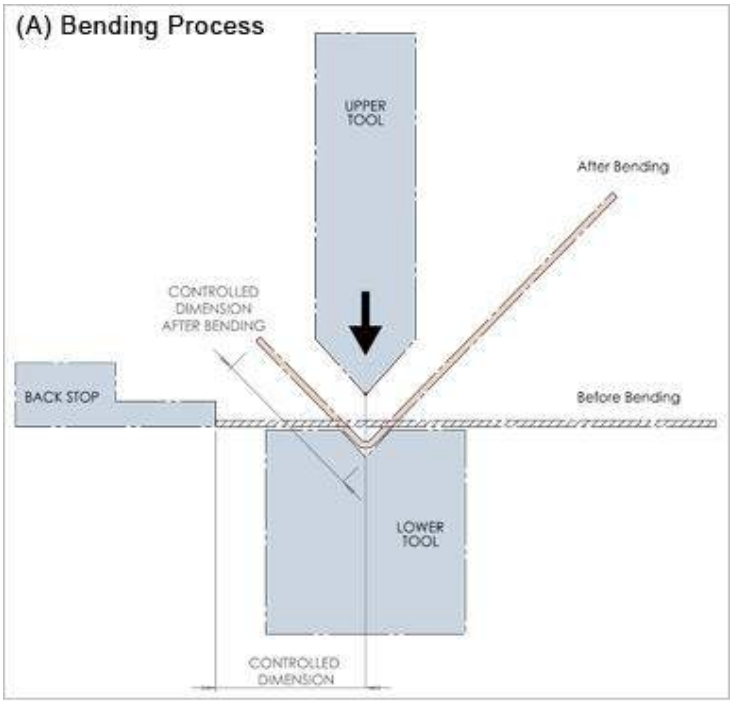
Whether you are designing from scratch or using one of our simple template design options, maximizing your time and budget is all about creating a "manufacturable" design. The following resource gives design advice from our Engineering and Design Services department and provides detailed information about tolerances, clearances, part modeling, metal selection, and finishes. By the end of this document, you will better understand Protocase's manufacturing capabilities, the material and components we stock and the services we offer. Use this document as your guideline when designing your rover to ensure your ordering process runs smoothly. Once your design is approved, it will be manufactured (typically within 2-3 days), and shipped to you as a professional-grade, fully-finished sheet metal and/or CNC machined product.

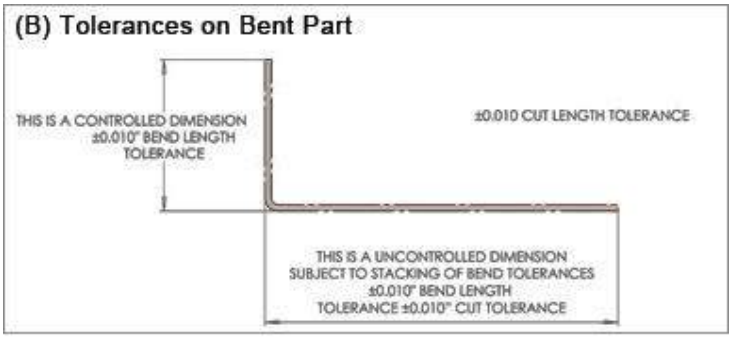


URC DESIGN TIPS

TOLERANCES

- Tolerance on variation of size and position of cutouts and profiles is +/- .005" (0.13mm).
- We have an in-house tolerance of +/- .01" (0.25mm) per bend. This can stack with multiple bends. This needs to be taken into account when fitting parts together with bends.
- We have a bend angle tolerance of +/-1°.
- Welding can also cause dimensional variation and warpage. Tolerances are dependent on the exact nature of the parts and welds. Please be sure to discuss important tolerances with Protocase staff when welding is required.
- See Figure "A" and "B" below for clarity.





CLEARANCES

- Add clearance between mating parts. Typically .010" between mating surfaces of parts. More clearance may be required depending on the complexity of the part.

PART MODELLING

- Our preferred CAD 3D file format is Solidworks, but we can work with a number of exported formats. Such as, Parasolid (x_t, x_b) .STP (step), .IGS (iges) , PRO E, SAT, and SolidEdge. Most CAD software should be able to export to one of these formats. We can also work with 2D drawings, such as .DXF, and .DWG.

- Our default units are decimal inch. However, we can work in any units so feel free to use metric if you wish. But if you are using metric units, please let us know so we can avoid delivering unexpected results.

- When we model our parts, we will typically use the nominal value of the sheet metal gauge. Example – if you were creating a part made of 18 gauge Cold Rolled Steel, we would model the part at .048". This has been an issue in the past when we have had to either increase or decrease the thickness of the customers submitted part. When we are decreasing or increasing the thickness, we cannot determine what side of the metal to add/remove the thickness to as we did not design the part.

- Ensure parts are modeled at uniform thickness as per requested gauge.

- Please try your best to fully constrain the sketches in your 3D model. Not having a sketch fully constrained can lead to unwanted dimensional shifts.

- We cannot cut dense vent or cutout patterns on our laser without causing the metal to warp. If a part requires such a pattern, we can mill it out of Aluminum on our Router table or if the part is steel or stainless we can add pattering using our mills. You can also ask your account manager about our perforated sheet metal.

- When parts require countersinking, our standard available angles are 82°, 90°, 100°, and 120°. Also please make it clear whether it is for a #4, #6, M3, M4, etc.

- When parts require tapped holes, please try and use the "Tap Drill Diameter" option in your software, as our laser will be cutting the drill diameter size hole. Thread and pitch are a requirement as well.

- Size cutouts for Self clinching fasteners (PEM) to the manufacturer recommended cutout size.

- Size clearance holes appropriately. Take into consideration the part tolerance when sizing these. Clearance should be able to handle worst case tolerance results. Typically we leave .02"-.03" clearance for connectors and over size screw holes by .025"-.030" over the screw OD. More clearance may be required depending on the complexity of the part. Keep in mind powdercoat will add approximately .003"-.005" per side.

- Every bent sheet metal part must have an inside and an outside bend radius. We stock different tools to achieve these bend radii, if you require a specific size radius please make that clear and we can try and get as close to it as possible.

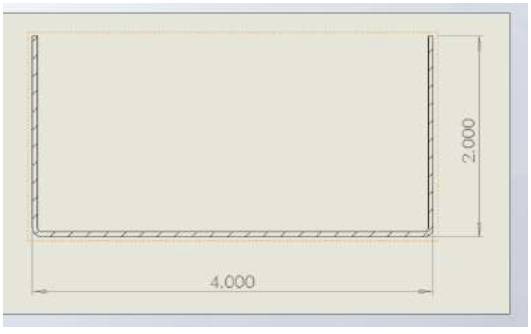
- We have had a lot of issues in the past where cutouts are placed too close to a bend. For thinner gauges, we can typically achieve a minimum bend distance of .2". What this means is that any cutout or lack of material that is within that proximity to a bend will be subject to stretching when we bend it, and can cause the part to not bend up within tolerance. The .2" is a controlled dimension of the smallest available bottom tooling for our brake press. Keep in mind with thicker gauge materials, we will need a wider bottom tool, which can increase the minimum bend distance. We typically see issues with this when it comes to flanges. If a flange has PEM nuts to fasten to another mating part, there is a minimum bend distance that you must follow, and the PEM nut itself also has a minimum center to edge distance it must follow in order to be properly inserted without risk of falling out, or bowing the material around it. These two constraints will typically determine your flange length size. Although we can break this rule in certain applications but it all comes down to a case by case basis.

    - Min flange Dimension

        - .200" for thicknesses up to .064"
        - .275" for thicknesses between .075" & .081"
        - .500" for thicknesses between .090" & .125"
        - Min flange dimension restriction also applies to cutouts close to a bend.
            - If a cutout ends up too close to a bend you can notch the bend radius. Read more about that in our blog post called "What to do when cutouts and other components need to be placed close to a bend."

- Dimensioning to a bend line has also been an issue in the past for us. Sometimes customers will send in files with critical dimensions that are constrained to a bend radius. The majority of the time when dealing with bends, we will need to update the bend radius and k factor to suit the tooling combination for that material. If we update the bend radius from .04" to .05", and there is a cutout dimensioned to that, it will shift position by .01"

- Depth of bent profiles that are thicker than .078" must follow the rule that the "Height must be at least 2" less than the Width" For thinner material, we can accept heights that are equal to the width.



- When milling parts, due to our cutting tools, all internal sharp corners will require a radius. This radius can increase or decrease with the thickness of the metal. These radii will be made clear during quoting stage but please take into account when designing parts.

End Mill Diameter	Maximum Cutting Depth
1/2"	1.5"
1/4"	3/4"
3/16"	5/8"
1/8"	1/2"
1/16"	1/4"
1/32"	1/4"

- The maximum machining envelope is as follows. X26" x Y16" x Z20". Any parts getting milled must stay within these dimensions.

- When parts require welding, special care needs to be taken when fitting with other parts. Some welding types will leave extra material ie. Inside corner seam and tack welds. This additional material must be accounted for when mating to other parts. If fully welding an outer seam, one edge should be cut back ½ material thickness to allow room for weld bead and good penetration of the weld.

- Spot welding only offer on ferrous materials. If you require an attachment method similar to spot welding on nonferrous (aluminum) materials, we can do a plug weld in place of this. For plug welding we require a hole a minimum of Ø.325" to fill.

- If parts require masking of powdercoat, please make it clear as to the location and size of the masked area, whether in the 3D file itself or a separate 2D drawing.

- Add clearance between mating parts. Typically .010" between mating parts. More clearance may be required depending on the complexity of the part.

METAL SELECTION

- Cold rolled steel is recommended for general purpose applications. It offers a good selection of cost and stiffness, and has long term durability in indoor applications when finished with powdercoat, unfinished it is not corrosion resistant. If unfinished parts are required, galvan neal, stainless steel or aluminum would be a better material selection.

- Galvanneal has a zinc-iron alloy coating on the steel surface which makes it much more durable in wet environments than cold rolled steel - but not as durable as stainless or aluminum. Galvanneal does not flake off its coating when formed and bent. It offers good paintability, weldability, corrosion resistance, and formability.

- Stainless steel offers that "special look" of brushed stainless (if brushed finish is requested), and can be powdercoated as well. It exhibits exceptional corrosion resistance whether bare or powdercoated. However, stainless steel can show surface corrosion when contaminated with traces of carbon steel or other corrosion susceptible materials. We use an environmental friendly, citric acid based passivation process that removes contamination.

- Aluminum is also corrosion resistant and has the advantage of minimum weight, but has a lower stiffness than steel so you need to use a thicker gauge. Protocase offers two alloys, 5052 Aluminum and 6061 thick sheet and barstock Aluminum. 5052's corrosion resistance includes salt water, it is optimal for sheet metal work as it is very bendable and easily welded and machined. 6061 is com monly used in extrusions but is not recommended for sheet metal work as it requires a very large bend radii to be able to bend it properly without cracking or damaging the material.

- Copper is mainly used for busbars. We stock copper alloy C110 1/8 hard, which has a very high conductivity along with exceptional formability which makes it ideally suited for electrical applications.

FINISHES

- If parts are not getting powdercoated, we have 4 options for surface finish:

No Finish	The material may contain swirl marks and small but visible scratches – good budget option
Grained Finish	More expensive but generally more appealing than No Finish
Media Blast Finish	Bead/Sand blast
Tumble Finish	Vibratory finish

- We offer a Clear Chemical Conversion coating on Aluminum only.
http://www.protocase.com/products/materials-components-finishes/chemconv.php

- We offer Passivation on Stainless Steel only.
http://www.protocase.com/products/materials-components-finishes/stainless-steel.php

- We offer Bright Electroless Tin for Copper only
http://www.protocase.com/products/materials-components-finishes/tin-plating.php

GENERAL TIPS

- Remember, staying with stocked hardware and material will help maximize your budget with Protocase. This includes, stocked sheet metal, PEM's, powdercoat colors, CNC tooling, etc.

- Getting all the "what if's" out of the way, and ensuring all specifications are correct before ordering will help your order run smoother and help avoid any unnecessary delays caused by back and forth.

- Once design is approved, it will be manufactured (typically within 2-3 days) and shipped to you. Shipping is included on all orders.

- Shipping typically has a transit time of 2 business days for North America -longer for international teams:

Country/Region	Approximate Shipping Time
India	7 Business Days
Egypt	4-5 Business Days
United Kindom	3-4 Business Days
South America	2-3 Business Days
Australia	3-5 Business Days
Europe	2-4 Business Days

When ordering, teams from outside North America should provide their account manager with a VAT number (an identifier used for value-added tax purposes).

We also encourage all teams to familiarize themselves with the customs regulations for their region. Ordering on time will allow for testing well before the competition starts, and will ensure your parts are able to be shipped directly to your university.

FAILURE LOGGING

Over the years, we have repeatedly observed problems or weaknesses at competition that could easily be avoided with routine rigorous testing. Make sure you are testing as early, and as often, as you can – well before the 2018 competition draws near.

Make sure all of your connectors are tight, and aren't susceptible to becoming undone during competition by brushing up against something, or going over rocky terrain.

For the first time ever, the 2018 competition will have a formal failure logging process (more info on that in the coming months).

For your own benefit before the competition, as well as to be familiar with the process before failure logging is required at the competition, make failure logging a regular part of your testing. The data you collect will make your work as strong as it can be! Document issues as they come up (with full descriptions) and try to determine the root cause of why the failure occurred.

ADDITIONAL RESOURCES

Our website has many technical resources and guidelines. Here are just a few in particular that you may find helpful:

- The Basics of Enclosure Design
- A Guide to Our Bend Radii & Minimum Bend Sizes
- FAQs
- Fabrication Tolerances
- Protocase Blog