3D Printed Watch Body for the TIMESQUARE DIY Watch Kit

Created by Justin Cooper

https://learn.adafruit.com/3d-printed-enclosure-for-the-timesquare-diy-watch-kit

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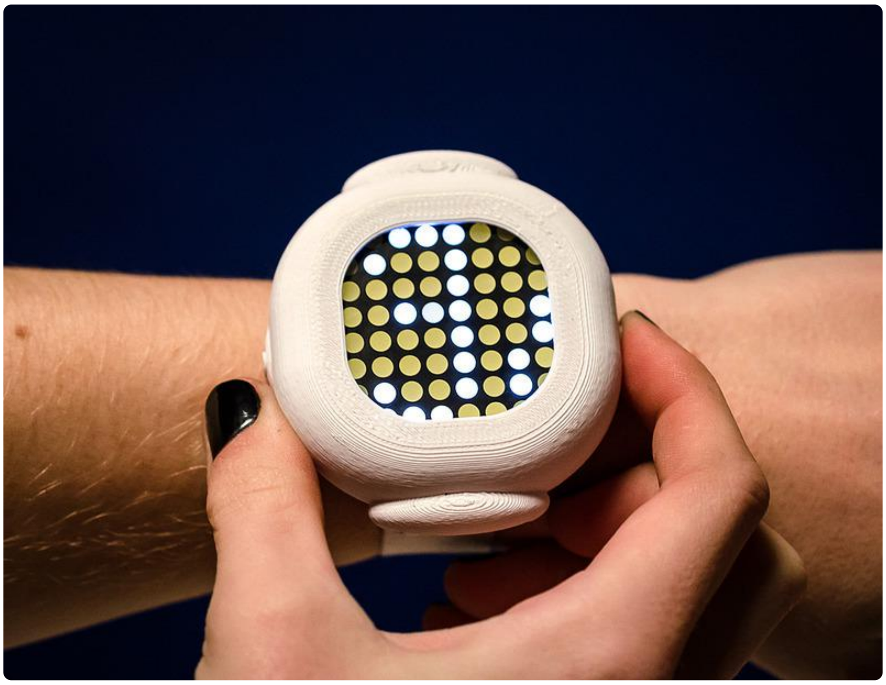
Overview



Love the TIMESQUARE DIY Watch kit (http://adafru.it/1106) and have a great idea for a custom watch body you would like to fabricate to house the electronic parts? The watch kit already ships with style to spare, but that's no reason to limit yourself to the included watch band when you can make one.

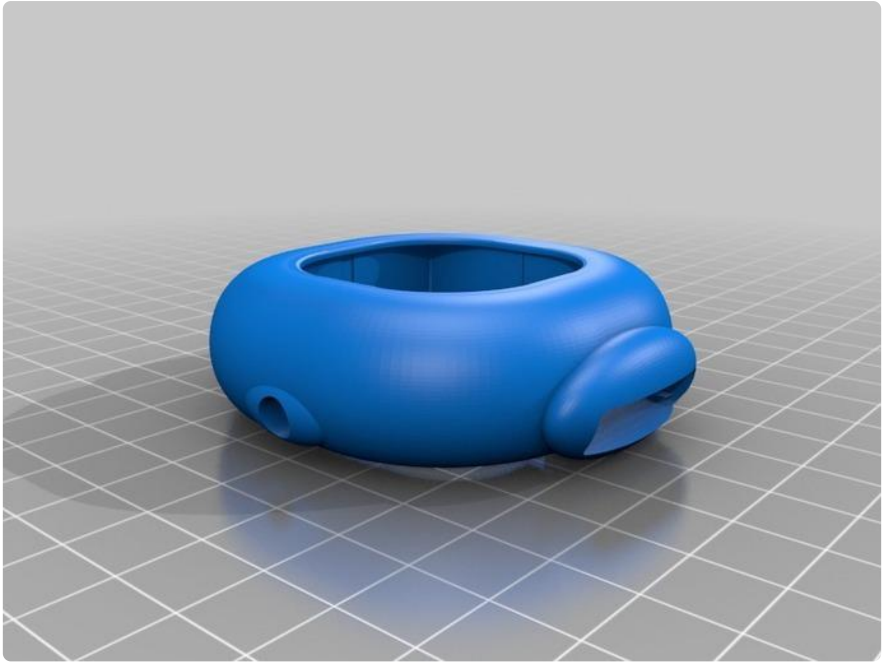
Here are the steps I took to create the "Circling the Square" TIMESQUARE Watch Body (). As I guide you through the steps I followed, I will share plenty of tips and tricks for how you can design your own!

Take advantage of the tools I created for this model kit to help you design faster! Check out this TIMESQUARE Sketch Guide (PDF) () that you can use to sketch out your ideas. Or download this TIMESQUARE Dummy (STL) () object to import into your modeling tool as a handy reference -- or as a boolean operations tool to punch an electronics cavity into another object you have designed!

Before You Get Started

Prepare the watch electronics first. Check out Ladyada's Learning System tutorial: TIMESQUARE Watch Kit ().

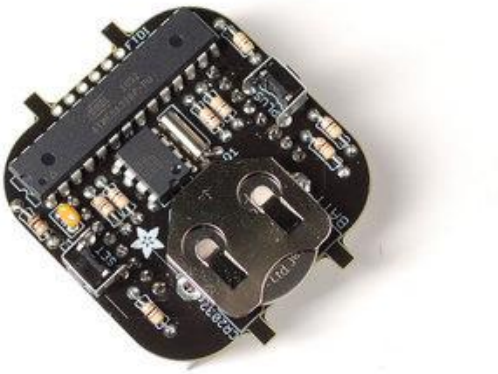
Print a test object from your design software. As a first stage to design, create and export a small file with easy to measure parts on x, y, and z axes. Print this as early in the process as possible and use digital calipers to measure how the physical object compares to the measurement settings in your digital design file.



Tools

You'll need:

Completed [TIMESQUARE DIY Watch (http://adafru.it/1106)](http://adafru.it/1106) electronics. Make sure to solder components close and tidy on the board to make inserting into enclosure easier.



Dependable digital calipers. We recommend the indestructable and ultra-precise [Mitutoyo - Absolute Digimatic Digital Calipers (http://adafru.it/294)](http://adafru.it/294), but you can get by with a less expensive set in a pinch.

3D CAD / Modeling software package. See below for tips on how to select your software.

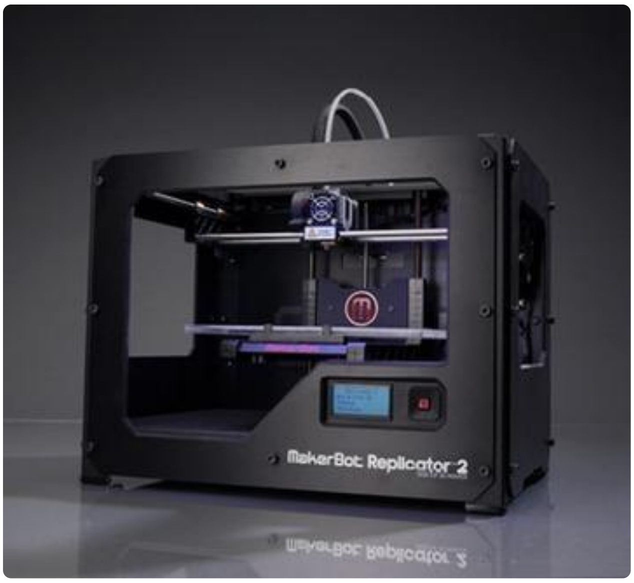
Desktop 3D printer or printing service. See below for tips on how to select your printer.

Optional tools:

Vector-based 2D modeling software. Create vector-based sketchs using the TIMESQUARE SketchGuide.pdf () in 2D illustration software and you can import your sketch layers right into your 3D modeling tool as reference guides.

Drafting tools: grid paper, straight edge, compass, protractor. Gaining physical drafting skills can be handy when building enclosures around irregular real world objects -- and a great way to get ideas for how to build your model from primitive solids.

Surface finishing tools: sandpaper, pliers, plastic polishing compound, solvents, and rotary tools. Your project might require nothing more than a little brush-up after the final print, but for some designers, when the final printed parts are ready, the project is only half complete.



Selecting 3D CAD / Modeling Software

For this project, I selected Rhino OSX () (work-in-progress) because it is a dependable, affordable solution for transforming my reference sketches into surfaces. Particularly useful are dimensional and object "snaps" (ways to lock elements to each other according to user-selected criteria) to ensure that I can build parts separately, joining them at a later stage in the design.

You might might have equal luck with another solution, from open source apps such as Blender (), Wings3D (), and OpenSCAD () to free options such as TinkerCAD () 123D Design (), and Sketchup () Other popular commercial modeling tools includes Solidworks, Maya, modo, AutoCAD, and 3DS Max.

Here are a few specs to consider when selecting a solid modeling tool for 3D printing:

- Dimensionally accurate. 2D vectors and 3D models can be imported and exported and will remain precisely the same all the way through a project.
- Multiple layers that can be shown, hidden, and locked. While versioning the design file itself is essential, the ability to break up the parts of your design into multiple layers allows you to keep around reference curves from earlier stages in the design to help you make adjustments later in the design process.
- Ability to create objects from points, curves, surfaces, and solids -- and explode them back into the faces, curves, and points they are made from.

- Grid and object snaps. Grid snaps are handy for making approximations early and late in the design process to adjust to the real world. Object snaps should be user configurable and aid the designer with establishing clear relationships between parts of a model: this line is a tangent to this curve, this surface is perpendicular to that surface, this point is the center of this circular object, etc..

- Ability to export manifold STL mesh models directly. While there are plenty of handy tools such as Meshlab () to import files from a variety of computer graphics formats (cloud data, obj, stl, etc.), having an export option to create from your design software directly what your 3D Printing software / CAM requires reduces the complexity of the process. (Luckily, formats like STL are very old and most CAD software supports it.)

Selecting a 3D Printer:

I used a MakerBot Replicator 1 and Replicator 2 for this project, but every day, new affordable desktop 3D printers are released that offer the qualities you need to print electronics enclosures efficiently and inexpensively. As a reference to help you select one, consider the MAKE Ultimate Guide to 3D Printing (), to which I contributed.

Here are characteristics to consider when selecting a desktop 3D printer:

- Layer height. Often described as "resolution" or "z-axis resolution.

- Thread width. How wide is the filament extrusion coming out of the extruder nozzle? (Or in other methods of 3D printing, the grain size for powder printers and x-/y- axis resolution for laser and UV curing projects. This factor affects the size of "smallest discernable detail" which affects how thin walls and details can be on the surface of objects in terms of x-/y-axis.

- Layer-to-layer registration. When looking at a printed part, are there pronounced layer ridges or do flat/smooth parts only have layers upon close inspection? The more dependable desktop printers are designed to make sure registration is accurate to allow for smooth, organic curved surfaces.

- Repeatability. From job to job, do the calibration settings and dimensions of the results remain the same within a very narrow tolerance? The best way to learn this is to consult a longtime user of the machine. User-assembled kits tend to require user expertise with a painstaking process of establishing a baseline configuration -- but gaining this experience with your printer can allow for more control over print job settings.

- Print materials. Will the print material handle the heat, weight, torquing, pressure, seal, etc. that you require from your final piece? And most importantly, how will this material interact with the other elements you need to place up against it and to the process of gluing two parts of this material together?

For printing services, contact your local hackerspaces and university fab labs or visit the Shapeways () or Ponoko () services online to have your final models shipped to you.

Creating a 3D Model

Here are the steps I took to create the "Circling the Square" watch body.
Click any of the stage titles to head directly to that subtopic.

TIMESQUARE_DUMMY_4views.jpg

1. Create A Dummy Object
Take detailed measurements of the electronics parts to be inserted into the watch base and create an accurate 3D model that matches its real world counterpart when produced by the intended desktop 3D printer.

Techniques Learned:

- Research Available Measurements ("Cheat")
- Creating Orthographic Projections (The Six Views)
- Plan for Insertion of Parts
- Simplify Geometry to What Is Relevant
- Plan to Accomodate Mechanical Tolerances
- You Are Making Two (Three) Digital Dummies, Not Just One

CirclingTheSquareSketch.jpg

2. Sketching the Watch Body

Leaning on the accurate model produced for the dummy object, sketch out ideas for the watch body design and take notes how you design references the electronic parts.

Techniques Learned:

- Commit to a Design Concept

- Identify Where Your Design Interfaces wIth Dummy
- Trace Sketch with Vector Illustration Tool For Reference Markers for 3D Modeling.
- Break Down Complicated Shapes Into Primitive Solids

Screenshot_1_10_13_11_50_PM-2.jpg

3. Modeling the Faceplate

Import sketches for faceplate into 3D CAD tool and use reference measurements and notes where parts interface to model the first part of the watch body.

Techniques Learned:

- Create Reference "Cage"
- Triangulate Placement Using Orthographic Projections
- Use Many Layers (Duplicating, Locking, Hiding)
- Construct Complicated Shapes From Primitive Solids
- Build Details Using Points, Curves, Surfaces.
- Grouping vs Joining
- Boolean Operations - As Late As Possible
- Printing Test Parts; Insertion Test

Fullscreen_1_10_13_6_32_AM.jpg

4. Adding Buttons

Work with Faceplate test prints to determine placement of buttons and how they should interface with the enclosed electronics.

Techniques Learned:

- Trapped Button Caps
- Wireframe Routing Tip
- Creating Button Cage
- Creating Buttons and Button Cutting Tool
- Printing Button Tests

Screenshot_1_10_13_6_41_AM.jpg

5. Preparing for Wrist Straps

Create and implement a cutting tool for routing wrist straps / pocket watch fob. Create snap-fit strap bar for easier handling.

Techniques Learned:

- Build In Flexibility for Range of Sizes
- Overhangs and Support Material
- Snap-fit Planning

- Printing Strap Tests

Screenshot_1_11_13_12_39_AM.jpg

6. Modeling the Backplate

Model the backplate to closeup back of watch body, to insulate the electronics, and to accomodate wrist straps.

Techniques Learned:

- Scale and Offset
- Planning for Materials
- Accomodate Range of Wrist Sizes
- Printing Backplate Tests

A Few General Modeling Tips

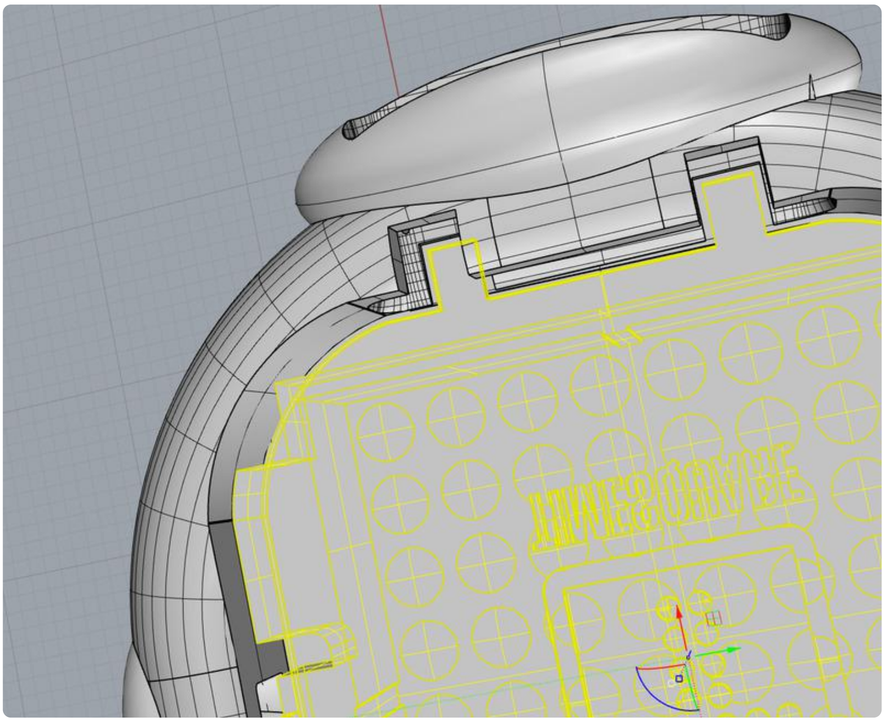
While I will mention many of these elsewhere in this guide, it is worth gathering here the general modeling tips you will return to again and again.

- Print a test object from your design software. As a first stage to design, create and export a small file with some easy to measure parts on x, y, and z axes. Print this as early in the process as possible and use digital calipers to measure how the physical object compares to the measurement settings in your digital design file.
- Use Many Layers. Get to know the layers in your application and develop a practice of duplicating all of the elements that you will use for joins,
- Create "Reference Layers." The simple points, curves, and surfaces that you use to produce solid parts by combining, lofting, slicing, and boolean operations are of crucial value later in the design process as a reference for how you created complex shapes. Create separate reference layers and copy and paste the elements you use as tools before running operations on them so that you can retrieve them later if something goes wrong and you need to roll back the clock.
- Build a Mechanical Tolerance Plan. Anytime you use a fabrication tool to produce a physical object from a digital design, there are slight differences between the "ideal" digital model and the accuracy of the machine used to create the printed object. When you create printed parts that interface with real world objects you need to plan to accomodate this by getting to know the technical specs for your machine and job settings -- and by printing frequently. See "Creating a Dummy Object ()" for a great practical example.
- Create "Reference Cages." You will find that you will create geometry separate from your design primarily as a reference for position, compare, or separate objects. A good "reference cage" includes both geometry to reference the "dummy object" and workplane and the workplane of the object being modeled.

(Here's a hint -- a reference cage for a cavity emphasizes the points and curves inset from boundary between cavity and dummy while a reference cage for an outer surface emphasizes the points and curves offset from the boundary of the object.)

- Learn the keyboard commands. You will rarely use all of the modeling tools from a CAD package within one project, just a small subset. Learning the keyboard commands won't just speed up the process of modeling, it will help keep you in more intuitive creative mindset than if you are constantly stopping to mouse over to a menu item.
- Print Often, Measure Once, Twice, Thrice! Take every opportunity to print your model, or parts of your model, available to you. You will learn quite a bit about your model by holding it physically in your hand. And if you use each opportunity to measure and compare your real world model to your digital one, you will make sure you detect faster whether any of your modeling operations has shifted your design off of the baseline you established creating the dummy object.
- Print Parts of your Model. To save time and print material, it is worth creating new layers with version of your project that are trimmed down to only the element you are currently working on, so that you can export and print those. Examples include how a button and button cavity will function.
- Adjust your model, not your job settings. While it is tempting to tweak your print job settings with lots of tiny scale and position changes in your CAM tool to just "make it work," those you share your printable model with after the design process will not benefit from what you learned about your model from printing it unless you go back into the design file and make adjustments there, upstream from your printable files.
- Fused Filament Fabrication prints shrink as they cool. And by a factor of about 1%-2%, depending on your plastic vendor. You will get the hang of this over time, but as long as you accomodate this when planning for engineering tolerances your design should remain accurate to the world.

1. Create A Dummy Object



GOAL:

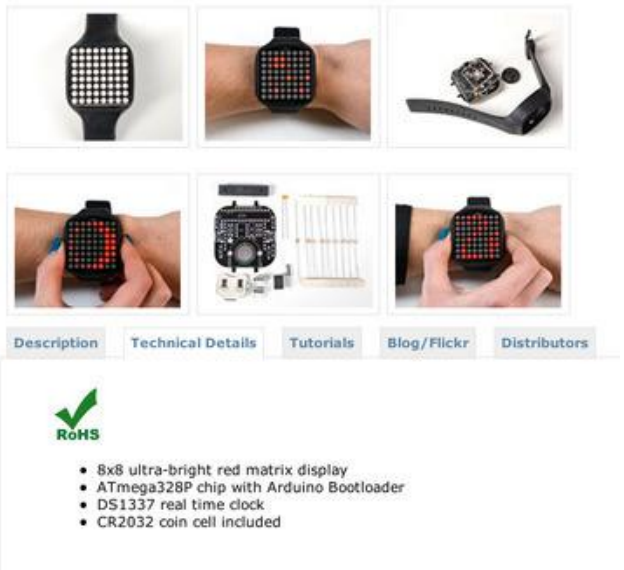
Take detailed measurements of the electronics parts to be inserted into the watch base and create an accurate 3D model that matches its real world counterpart when produced by the intended desktop 3D printer.

The first (often overlooked) stage for the design of a 3D enclosure, model, or bezel: measure your electronics and create a digital "dummy" object that is an accurate match for it's real world counterpart.

The creation of dummy objects is a long-standing tradition from the world of fashion, craft, and industry -- typically used to optimize how multiples of an object will be assembled. This process has added relevance to the digital designer within the wider open source / open hardware culture of today:

- Make use of the efforts of other people who have tackled these components before you.
- Share back digital models to help others print and tune your project for other, novel purposes.
- Why should anyone recreate the wheel when they can make a better functioning, better looking wheel by studying the wheels of others?

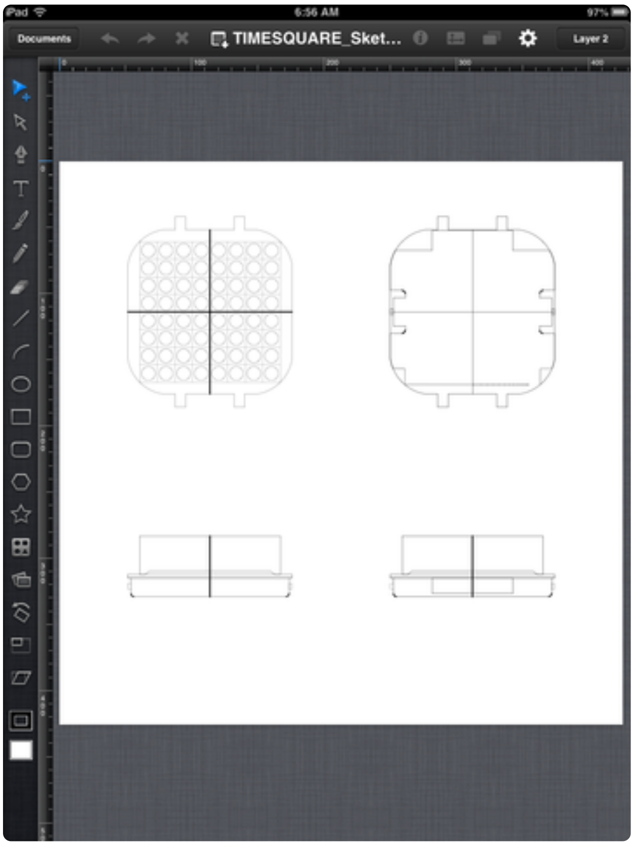
It is worth going through the process of re-making your physical objects in the digital world so that you can take the measurements you need to discover essential shape and position information to help you construct an artful, intentional design to interface with it!



Research Available Measurements ("Cheat")

Depending on the electronics components you want to enclose or mount, there may already be resources available online to help you speed up this stage. There are benefits to hunting for existing models: you can test and report back whether the model is accurate enough and you can meet designers who are also working with the components you selected -- an opportunity for exchanging models and getting feedback.

Great places to hunt for resources:
Product datasheets and tech specs.
Thingiverse and other object repositories.
Project pages for the PCBs -- including resources such as Fritzing.org where vector models are necessarily accurately scaled.
Electronics component suppliers.
And here's a great place to "cheat" for the TIMESQUARE project:
TIMESQUARE_SketchGuide.PDF () -- 2D Vector illustration
TIMESQURE_dummy.stl () -- 3D mesh model
When you are done with the process of measuring your components and making your dummy part(s) -- you should strongly consider including your dummy object with the community as well as your final model.



Creating Orthographic Projections (The Three Views)

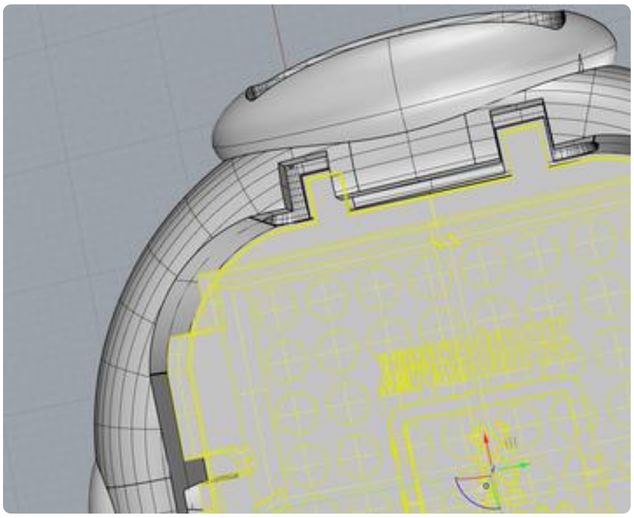
One handy time-tested approach to capturing accurate model data is to take measurements and sketch out the top front and right sides of the object as "orthogonal views" (ie eliminate the foreshortening).

If it is helpful, do all six views (think in terms of all of the faces of 6-sided dice).

Isometric projections can be helpful, particularly for recording references for how the elements match up. Performing them accurately is a real skill (or a keypress in expensive CAD software) but might not be necessary.

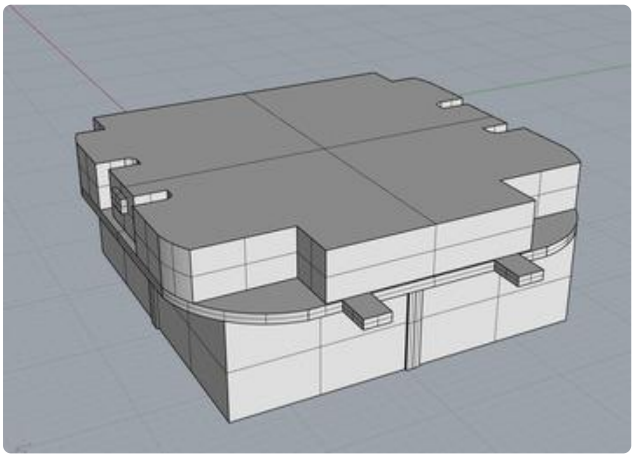
Record notes about where parts of these views match up to each other.

Plan in terms of the software's object snap options.



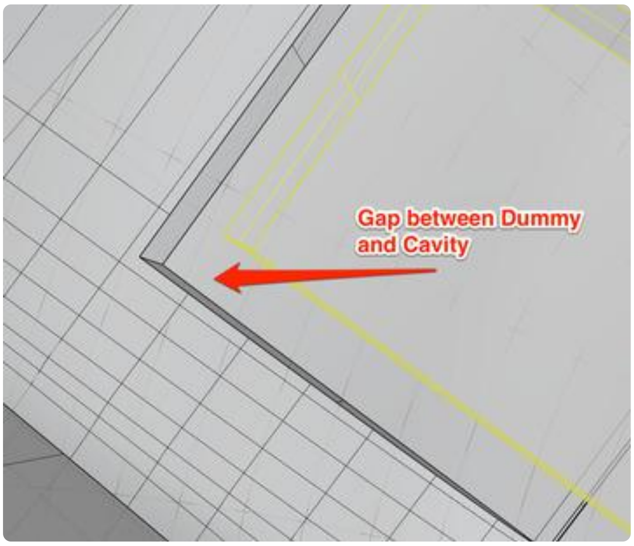
Plan for Insertion of Parts

A cavity for your electronics is no good if you can't place parts in there.



Simplify Geometry to What Is Relevant

Simplify geometry to what is significant for fit and mounting. Rendering all of the surface mount components will only increase the complexity of using your dummy as a boolean subtraction tool later -- account for a little bit of wiggle room and group a number of components together into a coarser block.

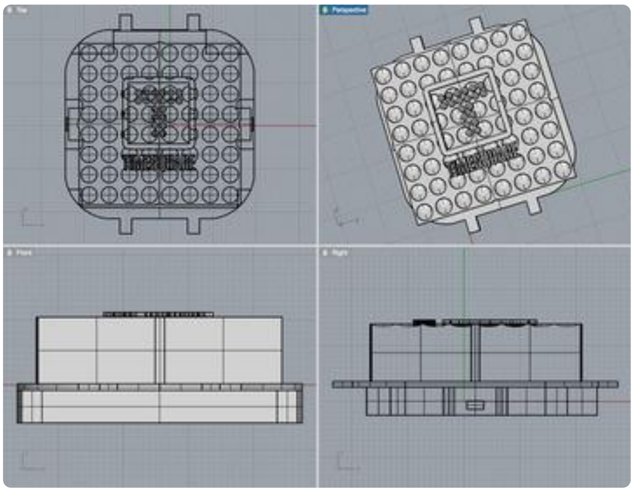


Plan to Accomodate Mechanical Tolerances

The amount of space between these two parts is known as the "enginneering tolerance" (http://en.wikipedia.org/wiki/Engineering_tolerance ()) and should be factored by the machine used to fabricate the part. Typically, this difference is determined by the thread width on x-/y-axes or the "resolution" on the z-axis, the factors that determine how accurately that element of the part can be produced.

You Are Making Two (Three) Digital Dummies, Not Just One

The "first" dummy model is designed such that the machine that produces the model will fabricate a dimensionally accurate match for the electronics. (Keep in mind that most FFF desktop 3D printers produce objects that shrink by 1%-2% as they cool: the dummy model is designed to match its real-world counterpart after cooling/setting/etc.)



The "second" dummy is a "cutting tool" that has been resized to carve away the cavity required to insert the "first" dummy object.

It might be helpful to create a "third" dummy -- a virtual dummy positioned precisely between the object and and dummy cavity. Adjustments for this version could be made to suite any type of manufacturing no matter the threadwidth/kerf etc involved with manufacturing it by determining the engineering tolerances forced by the machine being used and creating new first and second dummies by adjusting the third dummy by the tolerance factor. Printing the third dummy wouldn't be helpful as it would tend to be too large to fit into cavities exported by the same design files.

Print your dummy object and check it with accurate calipers.

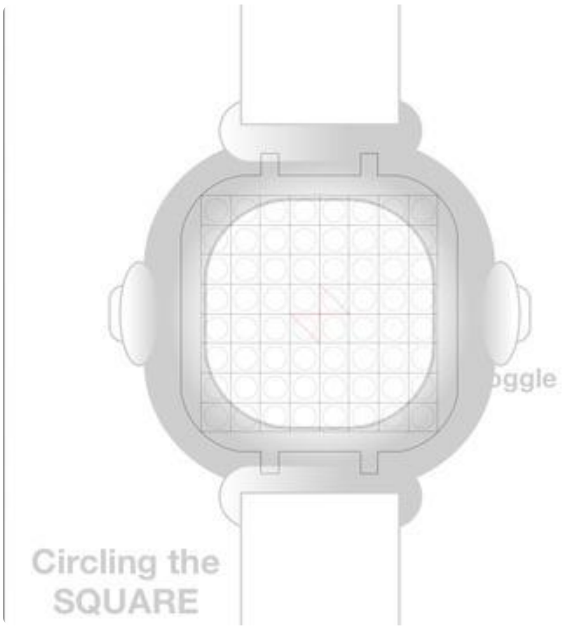
Does it match your model? Adjust until it does.

2. Sketching the Watch Body

GOALS:

Leaning on the accurate model produced for the dummy object, sketch out ideas for the watch body design and take notes how you design references the electronic parts.

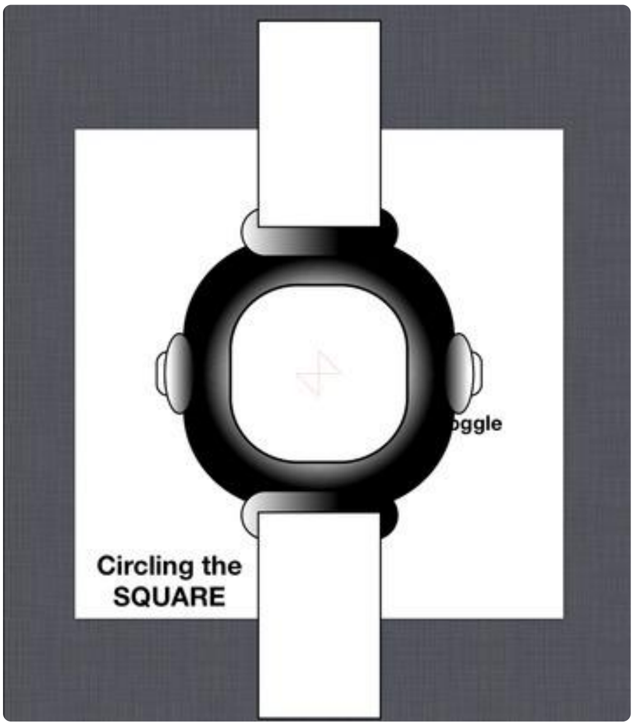
From hand draw notes to vector-based illustration ready to drop into your CAD application, any pathway you find to capture your ideas to aid you during the 3D modeling process is acceptable. However, when making a tight enclosure for electronics I find it is helpful to do your sketching at this stage in the order: after creating your "dummy" object.



Identify Where Your Design Interfaces wIth Dummy

Whether you will end up using a digital tool or a pencil and napkin to get down your ideas is up to you, but the most crucial information for you to consider at this stage is how your design will interface with your electronics.

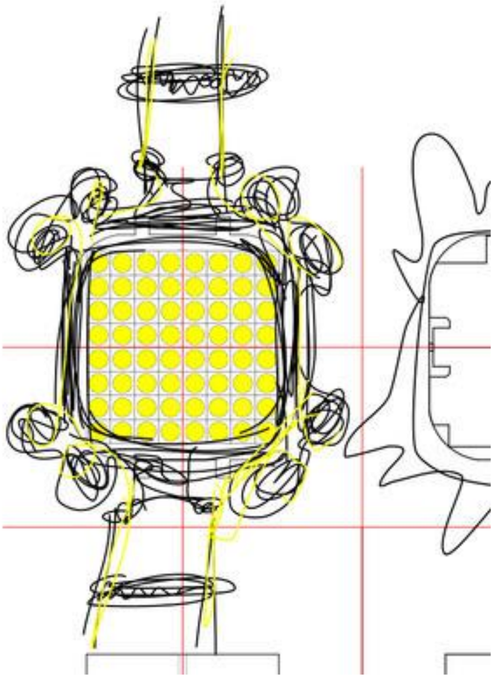
After I completed the dummy design stage, I had an extremely accurate vector model for the TIMESQUARE electronics -- necessary given that I wanted the electronics inserted into my design. I planned for the prongs off the top and bottom of the PCB to hold the watch in place -- meaning that measuring and modeling the PCB itself (for the outer ridge) was the most important information and became "sea level" in my design file. The buttons, likewise, were to be centered off the side of the PCB.



Commit to a Design Concept

This step is a matter of taste, but one that has stood me well over the years. When you are designing your project, commit to the one design element that is the center of why you are designing the project -- and stick with it. If you are familiar with games design, the concept "What is the X?" applies here.

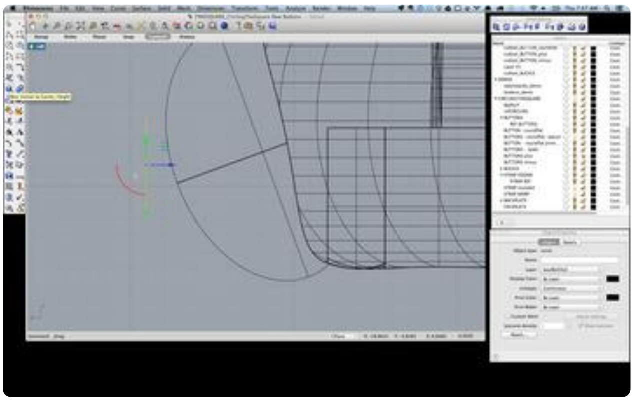
For Circling the Square, my essential design goal was to transform the edgy, rectilinear construction of TIMESQUARE into a "soft" rounded shape much like a that could also function as a pocket watch. Even when distracted by a host of unusual extrusion tools, I stuck to my guns and rejected the version of the faceplate that didn't match this goal.



Trace Sketch with Vector Illustration Tool For Reference Markers for 3D Modeling.

Working within digital tools for this stage is a pretty helpful hack. After using a pencil tool or similar to quickly work out ideas in a layer over the orthographical views, I created a new layer to trace with vector-based tools around the contours with careful, closed loops.

These layers can be imported into your 3D design software and used as references -- or even extruded into surfaces -- to help you create your 3D model!

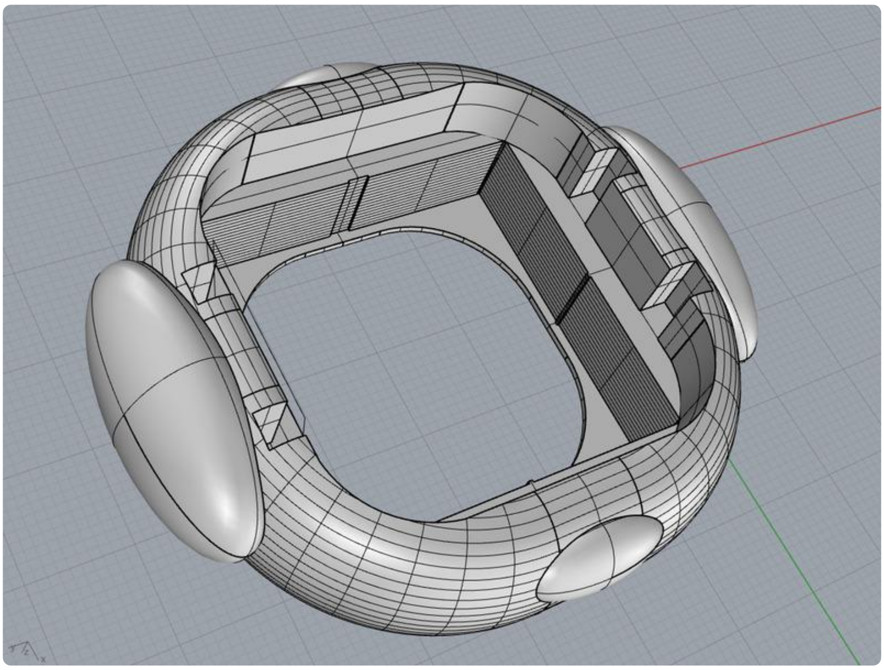


Break Down Complicated Shapes Into Primitive Solids

With the Circling the Square design, I created a few overfed ellipsoids and overlapped them, keeping the angle for much of the curved surface at a nice low angle that desktop 3D printers excel with.

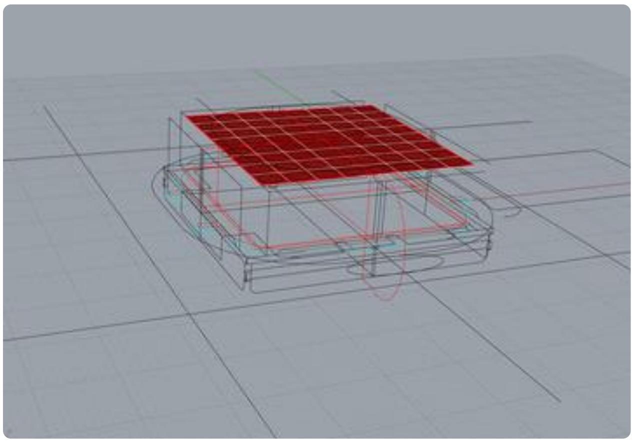
You can building organic shapes from simple primitives, curves, lofting, and rails keeps the complexity of the model comparatively low, allowing for better control over adjustments. By breaking complex shapes into systems of cylinders, spheres, cubes, and pyramids you will help yourself find a way for these elements to be quickly constructed in the modeling phase.

3. Modeling the Faceplate



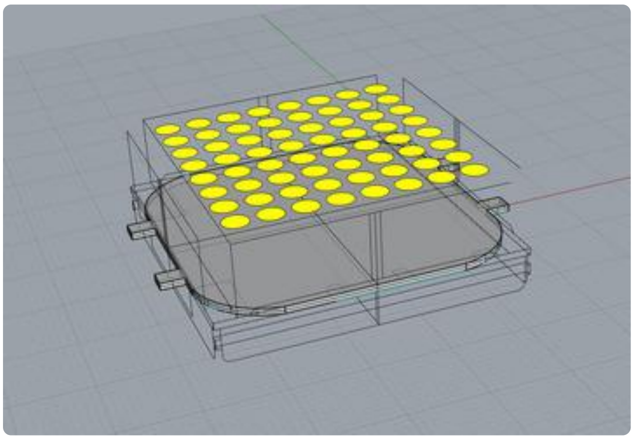
GOALS:

Import sketches for faceplate into 3D CAD tool and use reference measurements and notes where parts interface to model the first part of the watch body.



Create Reference "Cage"

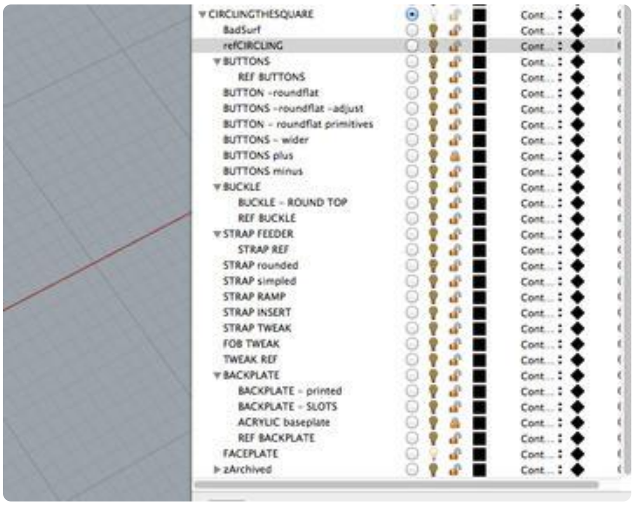
You will find that you will create geometry separate from your design primarily as a reference for position, compare, or separate objects. A good "reference cage" includes both geometry to reference the "dummy object" and workplane and the workplane of the object being modeled. (Here's a hint -- a reference cage for a cavity emphasizes the points and curves inset from boundary between cavity and dummy while a reference cage for an outer surface emphasizes the points and curves offset from the boundary of the object.)



Triangulate Placement Using Orthographic Projections

By connecting perpendicular lines across between two orthographic projections and then extending a perpendicular line from a third projection to where crosses the first line, it is possible to locate reference points from your design precisely in 3D dimensional space.

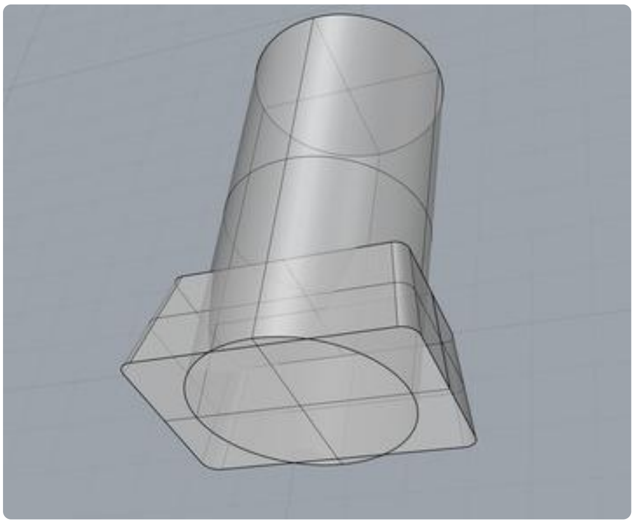
Use Many Layers (Duplicating, Locking, Hiding)



Get to know the layers in your application and develop a practice of duplicating all of the elements that you will use for joins, surfacing, extruding, boolean operations, or positioning.

"Reference Layers" are extra layers that contain only the points, curves, and surfaces that you use to produce solid parts by combining, lofting, slicing, and boolean operations are of crucial value later in the design process as a reference for how you created complex shapes. Create separate reference layers and copy and paste the elements you use as tools before running operations on them so that you can retrieve them later if something goes wrong and you need to roll back the clock.

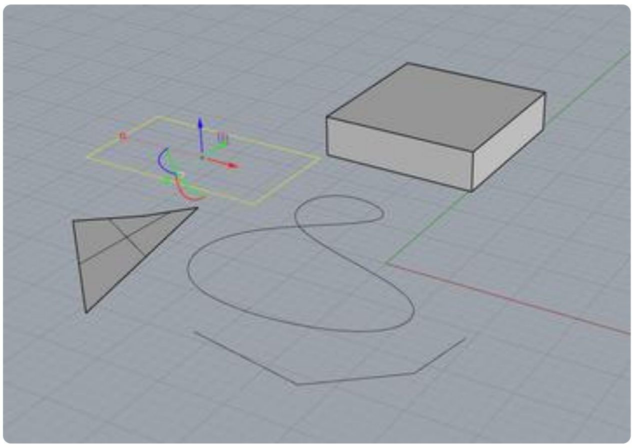
Construct Complicated Shapes From Primitive Solids



Building organic shapes from simple primitives, curves, lofting, and rails keeps the complexity of the model comparatively low, allowing for better control over adjustments. The best place to start is at the sketching phase, to locate the primitive solids that get close to solving most of the construction issues. These elements can be quickly constructed in the modeling phase, getting you most of the way to the intended version with fewer control points required.

Many Solid CAD packages have a series of tools to fillet, chamfer, and bevel edges and corners, which can go far to tuning up the results of these first quick constructions.

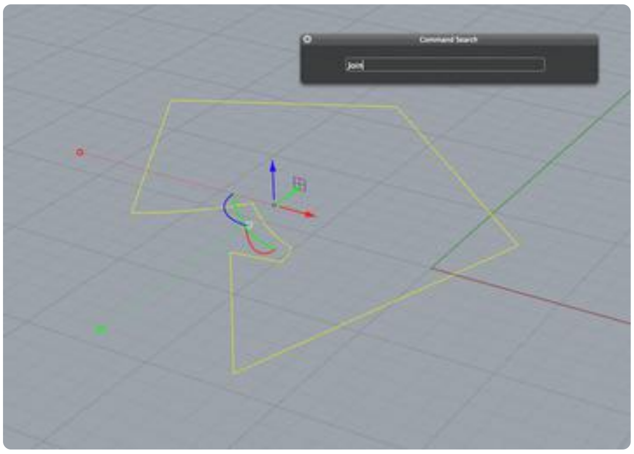
Build Details Using Points, Curves, Surfaces



Almost all CAD tools offer the ability to construct solids based on points/vertexes, lines/curves, planes/surfaces. Where they differ tends to be in the manner of control and adjustment.

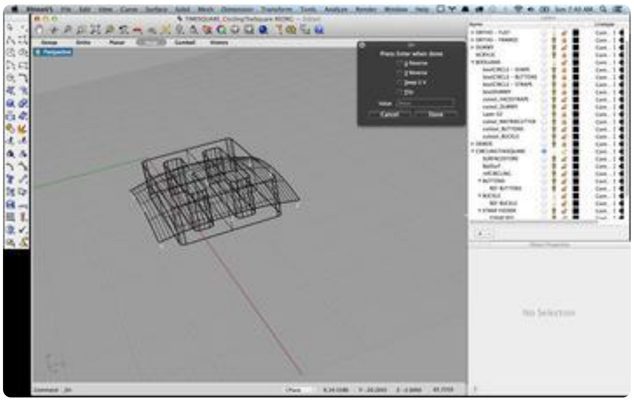
Whichever tool you select, consider first how you can move from each of these construction tools towards solids and back towards more primitive elements to allow for precise editing throughout the entire process.

Grouping vs Joining



While the precise name for these two features differs from package to package, "grouping" and "joining" are the most common names for these related but dissimilar way to bring together elements. Grouping means to collect an assortment of selected items so that they can be manipulated as one entity, handy for a host of transforms such as scale, rotate, move, copy, and hide. Groups can also sometimes be assigned to special colors, beyond the color associated with the layer. Joining means to process the sub-entities into a new conglomerate entity: example, lots of little lines becoming a closed outline. While this kind of operation can be essential to perform transforms such as various "Extrude" commands or "Create Surface from Curves," it might not be easy to revert to the many elements you used to created the joined element. When in doubt, group all of the elements in question, duplicate them a reference layer, and then perform the join command on the original set of the element.

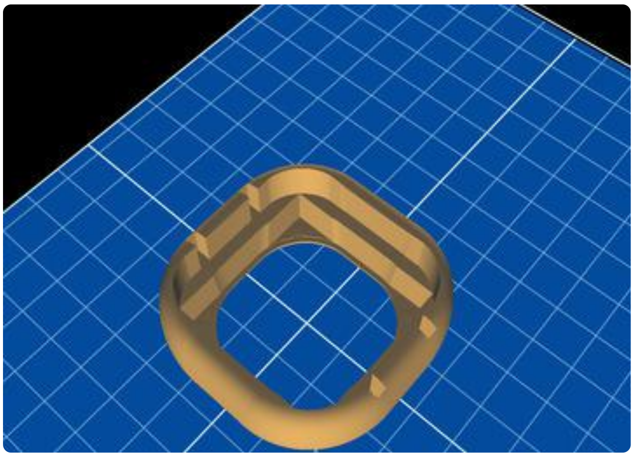
Boolean Operations - As Late As Possible



One of the best way to combine your primitives into more elaborate shapes is to apply boolean addition/union and subtraction/difference to clusters objects. However, as you perform boolean operation after boolean operation, you forever alter the system of control points that can be accessed to make changes to the form.

To protect against making mistakes that force you to rebuild a model again from scratch, it is important to duplicate and preserve the pre-boolean shapes in other layers. Typically, I will continue to add solids into a group until I am certain I am ready to union/difference them, at which point I'll duplicate the set to store them for later, and perform the boolean operations systematically in one go. It is helpful to check to make sure the resulting model is manifold after performing lots of number crunching -- Rhino OSX has a Volume check under the analysis tool that will tell you if your volume is water-tight as well as its size. Blender has a check for manifold option as well.

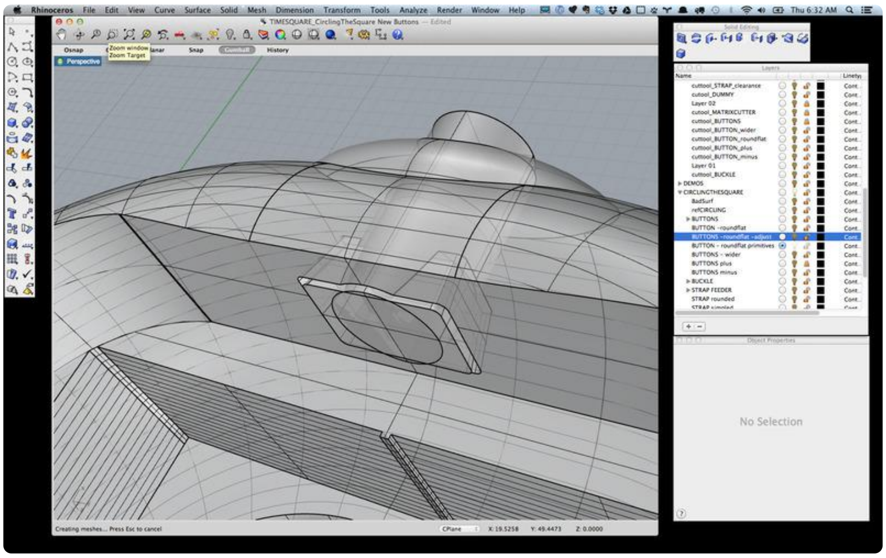
Printing Test Parts / Insertion Test



As early as possible, it is important to start testing your design in the real world. That is, in fact, the best reason to have a desktop 3D printer!

I didn't like the outer contour of this version of the watch, but I closed it up quickly so I could print a model to test for fit when inserting the electronics. I discovered immediately that my factor for tolerances was too low -- too tight a fit -- and I made changes to both the cavity side and outer shell side to match the new measurements.

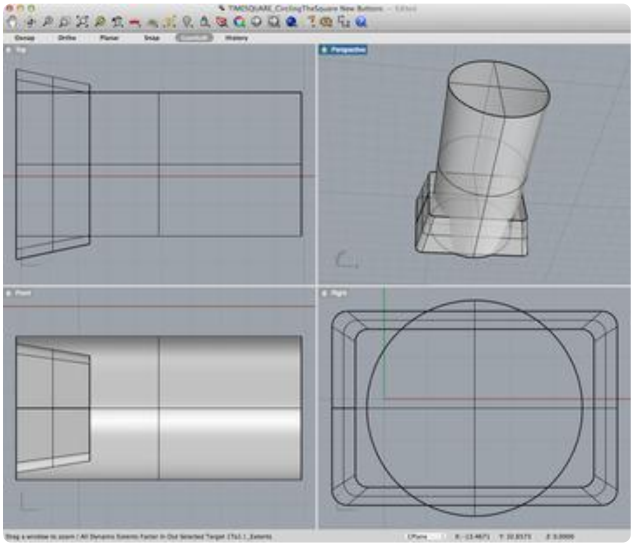
4. Adding Buttons



GOALS:

Work with Faceplate test prints to determine placement of buttons and how they should interface with the enclosed electronics.

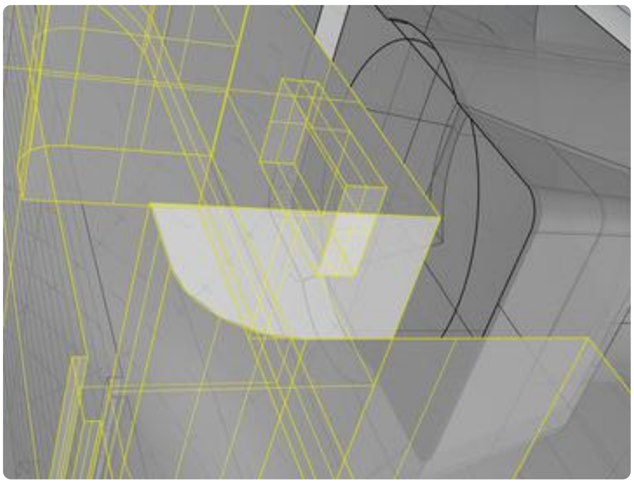
Trapped Button Caps



In order to offer access to the buttons soldered to the TIMESQUARE PCB, I decided to build printed "caps" to extend the button press beyond the watch body. To keep the mechanical complexity low, I added a base to the button that would prevent it from falling out of the narrow button cavity, and scaled it down to compensate for more than the usual tolerance factor so that the button cap would sit in its cavity loose enough to move, but not enough to rattle.

Previous attempts to construct the buttons were too fragile, both in terms of the width of the shaft (shifting from 3.5mm to 5mm) and infill density (rotated the direction of infill and printed at 100% infill). I came to the result that worked through trial and error, taking notes each print as to the ideal height of the shaft, width for base, and shape of the grooves around the base to prevent rattling.

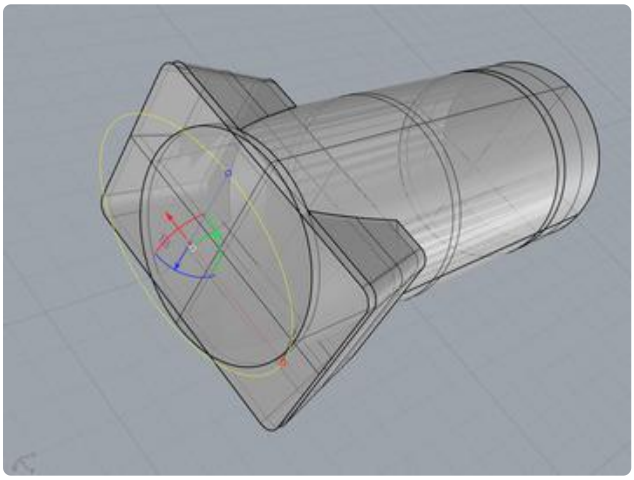
Wireframe Routing Tip



One challenge for the base of the button was how to make sure the button functions well when pressed from any angle without either hitting the edge of the PCB (preventing the printed button cap from hitting the button on the board) or rattling.

To help me solve this problem, I activated the layer that had the dummy cutting tool (ie larger than the printable dummy part) and to start the button cage and used the button that I had modeled on the dummy to help me find an angle satisfying my conditions.

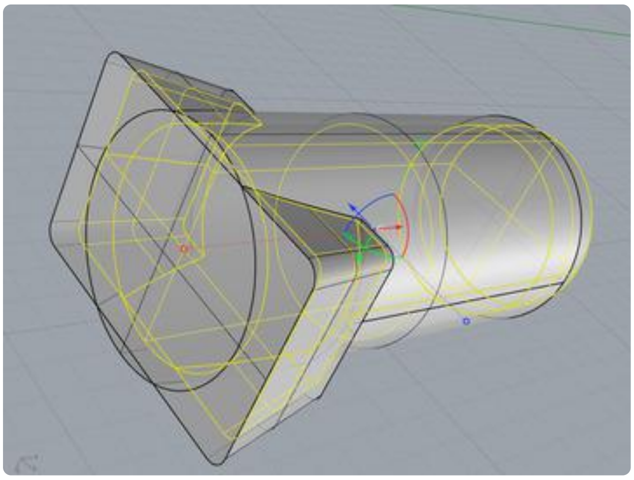
Creating Button Cage



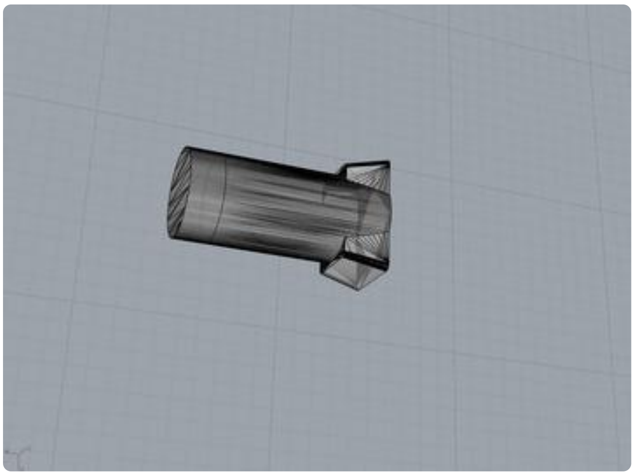
In the previous step, I used the dummy cutting tool model from a reference layer to calculate the furthest distance that the button might be expected to extend, with tolerance factors included. I created an ellipse at the angle I wanted for striking the button on the PCB, with enough range around the button the ensure good contact.

Even though I wouldn't be using this closed curve to create a solid, I kept this ellipse throughout the design process as a reference point (and reference angle) to start when create the series of buttons I tried before selecting this simple shape -- building the buttons from the center of the ellipse and making sure that they satisfied the button's mechanical needs.

Creating Buttons and Button Cutting Tool



The yellow highlighted item ghosted within the larger outer button demonstrates the scale difference between the button cutting tool (the larger button) and highlighted button (for export for printing). Because these items are so small in terms of the roughly 0.5mm threadwidth of this machine, it was essential to keep the models handy for the cavity in a pre-boolean state so that the shape of the cavity and the shape of the button cap could be adjusted.



Printing Button Tests

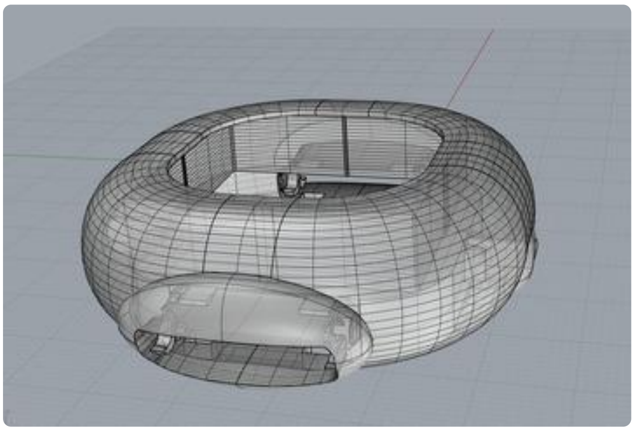
For any part of a project that will be handled by a user, it is important to print lots of tests and record feedback for each version.

Within Rhino OSX I was able to generate mesh objects for testing the buttons. I collected each of the mesh results in row in a reference layer so that if the one-before-the-last-one proved to be the best, I had it ready.

5. Preparing for Wrist Straps

5. Preparing for Wrist Straps ()

Create and implement a cutting tool for routing wrist straps / pocket watch fob. Create snap-fit strap bar for easier handling.

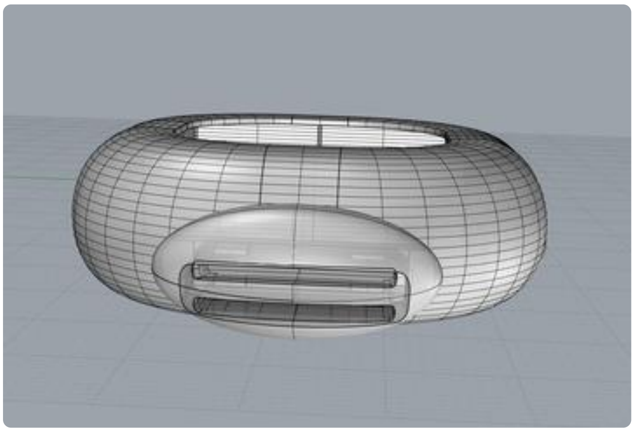


Build In Flexibility for Range of Sizes

Make sure to consider a range of materials and uses when selecting an option for wrist straps for your TIMESQUARE watch body project so that those you share your design with can easily source their own strap.

In the case of Circling the Square, I made sure that the opening could accomodate 3/4" straps as well as the 20mm straps I designed the watch around.

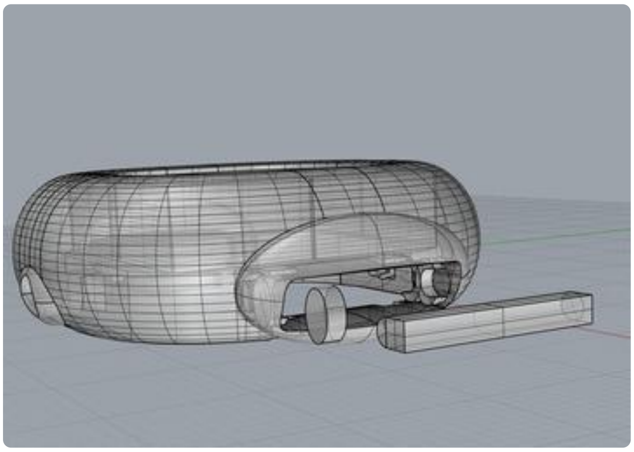
Overhangs and Support Material



While many of the CAM slicing tools (such as Slic3r, Skeinforge, and Cura) off support material printing even for single nozzle desktop printers, printed in the same material, narrow openings such as the one pictured proved too difficult to remove the support material, and the opening was too tight when support settings were not used.

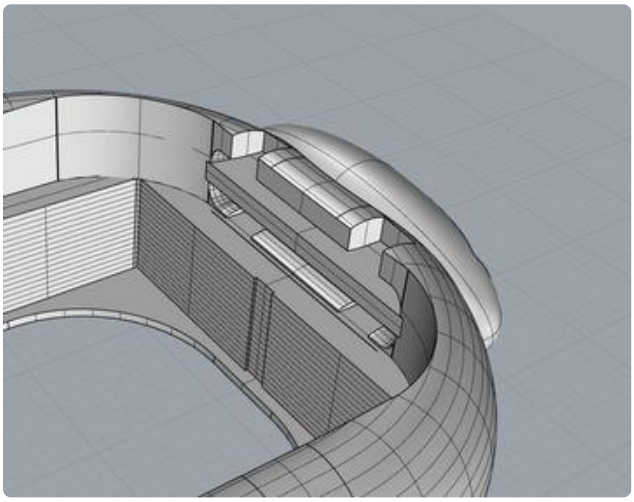
Planning for support lead to a better, more flexible solution for the watch band -- snap-fit parts that work for pocket watch configuration as well.

Snap-fit Planning



In the interest of making use of support material printed in the same material as the watch body, I found I need to make a larger opening for the strap to loop out of the body. I modeled a snap-fit bar, to be held in place by the loop of the strap. A shorter bar of the same footprint can be inserted inside of the body of the watch for the use of a pocket watch fob.

In view in this shot are the bar, a copy of the disk I used to make the snap-fit slot, and the version of the watch body prepared for this solution.



Printing Strap Tests

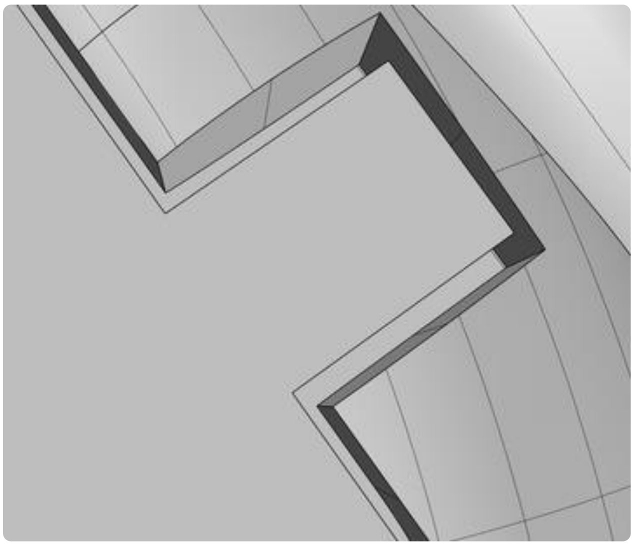
Working on an earlier attempt to route straps out around the outside of the case, I came up with this solution. Because I was focused on the part of the model OUTSIDE of the body, I didn't notice the serious mistake that might be clear to some of you in the middle of the frame: the plate that I shifted around now prevents one from inserting the electronics -- the notches of the PCB stop at the top of the strap bar.

While after the fact I felt this should have been obvious, printing out a test model made the issue immediately clear -- and this print further proved that the narrow horizontal slits were too small for support.

6. Modeling the Backplate

GOALS

Model the backplate to closeup back of watch body, to insulate the electronics, and to accomodate wrist straps.



Scale and Offset

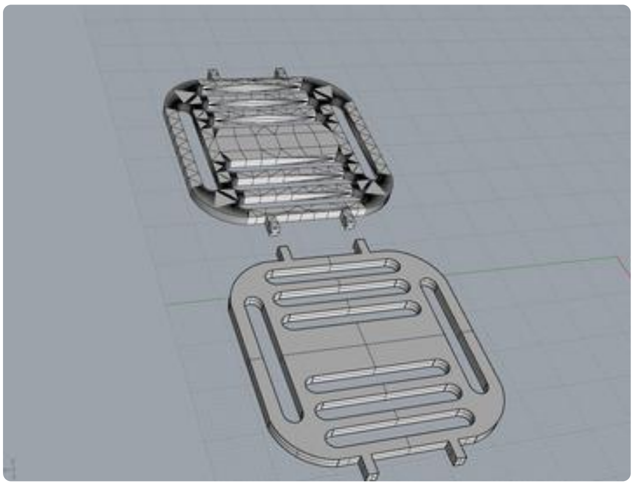
Factoring the gap between faceplate and backplate is a special case. Rather than selecting the same tolerance factor (around 0.5mm) that I determined for other fit places, used the Offset tool (rather than scale) shrink the faceplate by 1mm for a slightly looser fit.

In CAD tools, Scale shrinks the object across all three dimensions (though many tools permit scaling each axis separately). Scale was a good choice for making the button caps smaller all the way around.

Offset takes a curve and extends it (or reduces it) by a user assigned factor. Offset was a better choice for the backplate because scaling would cause the two prongs to move closer to each other, so the backplate would not have fit.

Planning for Materials

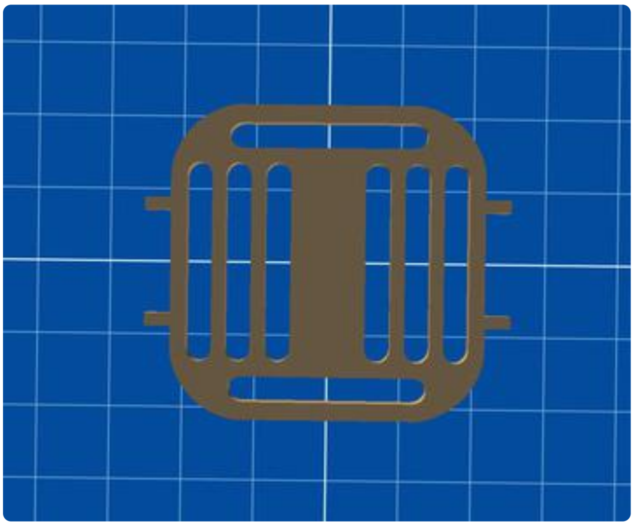
When you are creating a 3D model that you want to share as files for people to download to print on their own desktop printers, it is important to consider sourcing considerations for people who might want to try your project. I made sure that my project would fit straps of 20mm and 3/4", both of which are pretty common sizes you could find anywhere in the world. Because I wanted this project to be easy to get parts for, I made sure to leave the slits on the backplate a little looser and spread out so that people can try things such as neoprene or even woven bands.



Accomodate Range of Wrist Sizes

Likewise, I wanted to make sure that anyone who wants to print this watch can wear it, hang it, stick it in a pocket -- anything they'd like to do with it. So I worked out a logic of slits on the backplate that works for narrow wrists (thread the strap out of the innermost slits on either side so that the watch hugs tightly to a slighter wrist) or even go really maximum and route the strap out of sides of the watch so you can mount it on your thigh or backpack.

Printing Backplate Tests

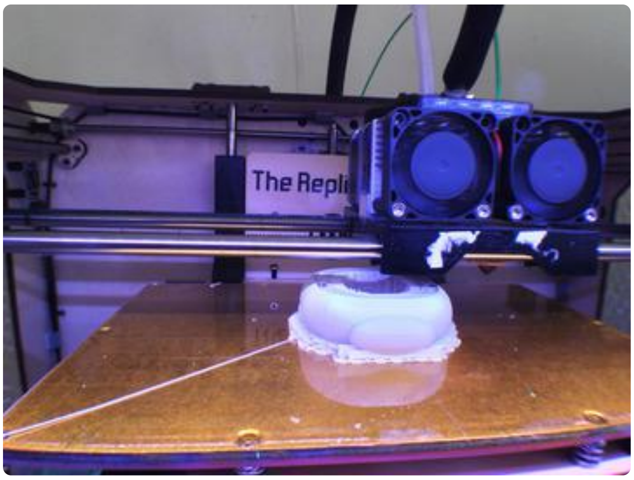


I printed the backplate a number of times to try to figure out a good height that would suit a range of results depending on TIMESQUARE owners' soldering skils -- the height I chose is also similar to 1/16mm acrylic for those who want to laser cut this part.

The important thing with this part is what we already went over above -- you need to keep the scale the same and use offset/inset commands in your design tool to grow or shrink your backplate to marry it to the other 3D printed parts you designed.

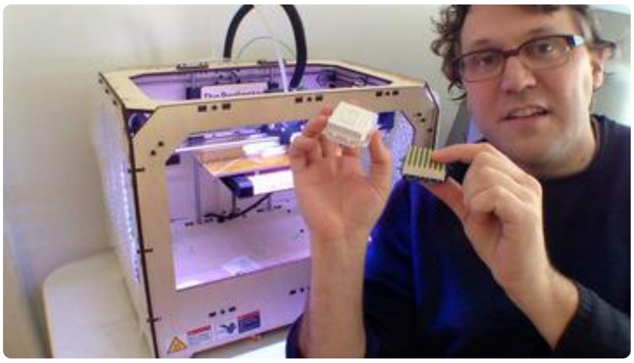
Printing and Proofing Your Models

Print Often, Learn through Printing



Take every opportunity to print your model, or parts of your model, available to you. You will learn quite a bit about your model by holding it physically in your hand. And if you use each opportunity to measure and compare your real world model to your digital one, you will make sure you detect faster whether any of your modeling operations has shifted your design off of the baseline you established creating the dummy object.

Collect the various drafts you have attempted during the design stage to have handy for testing finishing techniques.



Clean up and Fit Testing

Clear away support material and/or "dropped loops" from the electronics cavity.

Insert at the intended angle.

What to do when your electronics do not fit.

Measure the watch body and compare the measurements to the digital model.

Compensate for cooling / shrinking 1-2%.

Adjusting Your Design

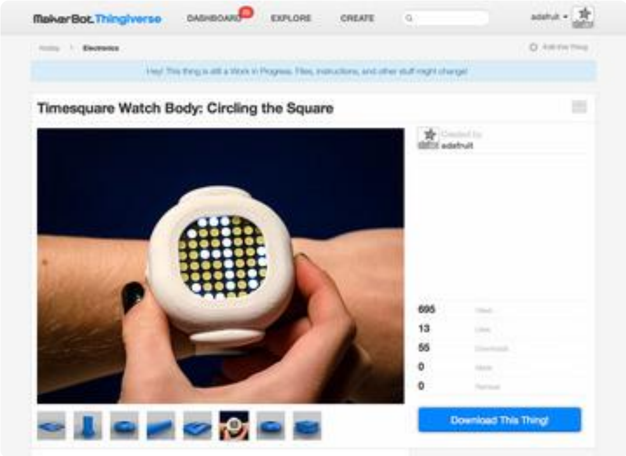
Taking notes on scale changes when printing.

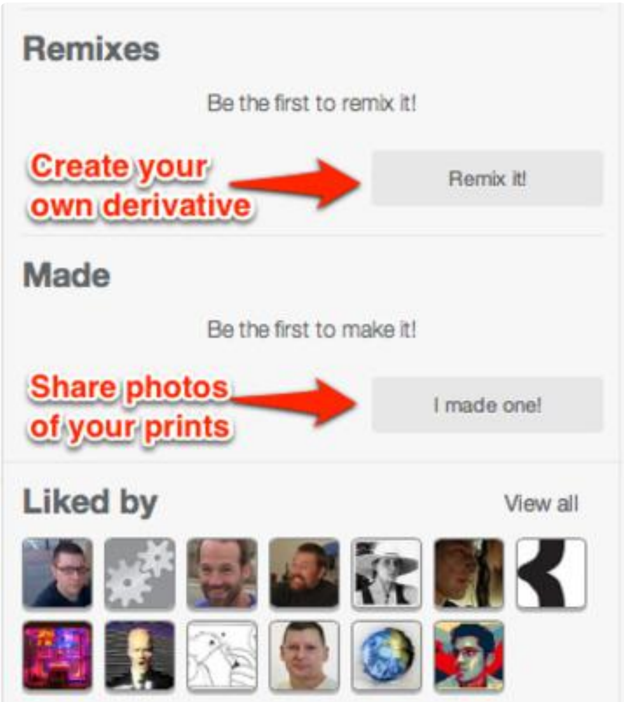
Adjusting scale and tolerances.

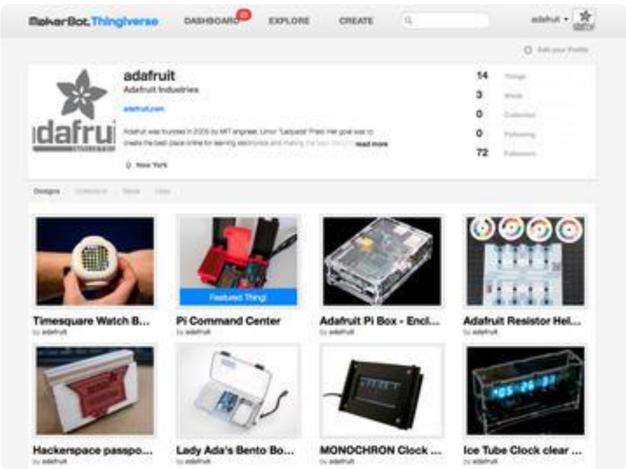
Surface Finishing Techniques

- Sanding
- Dremel polishing - Abrasive buffs rather than sanding discs or grinders.
- Plastic polishing compound
- Heat - annealing the surface
- Solvents

Sharing Your Design







Thingiverse

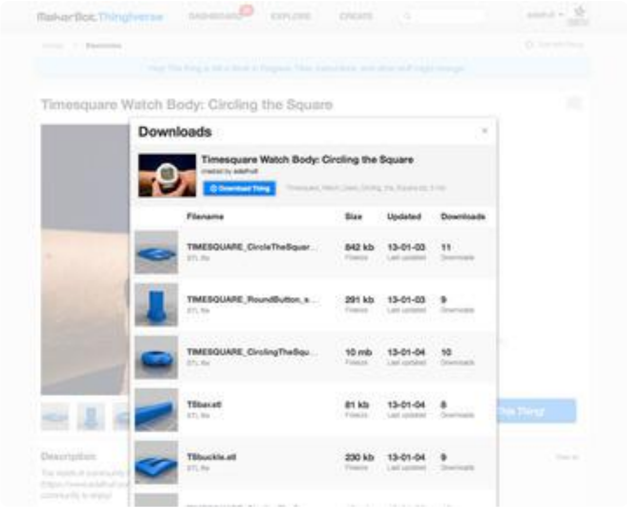
This is one of the best places to share your 3D printed work, published with Creative Commons licenses, within a responsive community.

Did you print out a copy of the "Circling the Square" watch body?

Share a photo of your project using the "I Made One!" button!

Did you use these resources to create your own watch body design?

Share your derivative by selecting the option "Remix it!" and sharing your own design using a Creative Commons license!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