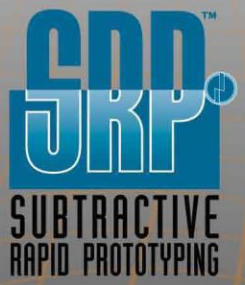
SUBTRACTIVE RAPID PROTOTYPING
&
ROLAND MDX-SERIES BUYER'S GUIDE

Version 1.2



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Chapter 1

About This Guide

This guide will attempt to answer all of the questions to help you make an informed decision about the purchase of a subtractive rapid prototyping system. It is our priority to help each client decide which machine would work best for there application, so we are available to help make a recommendation based on your specific application. If you have a question that is not answered in this document please contact me or one of the other application specialist at our company.

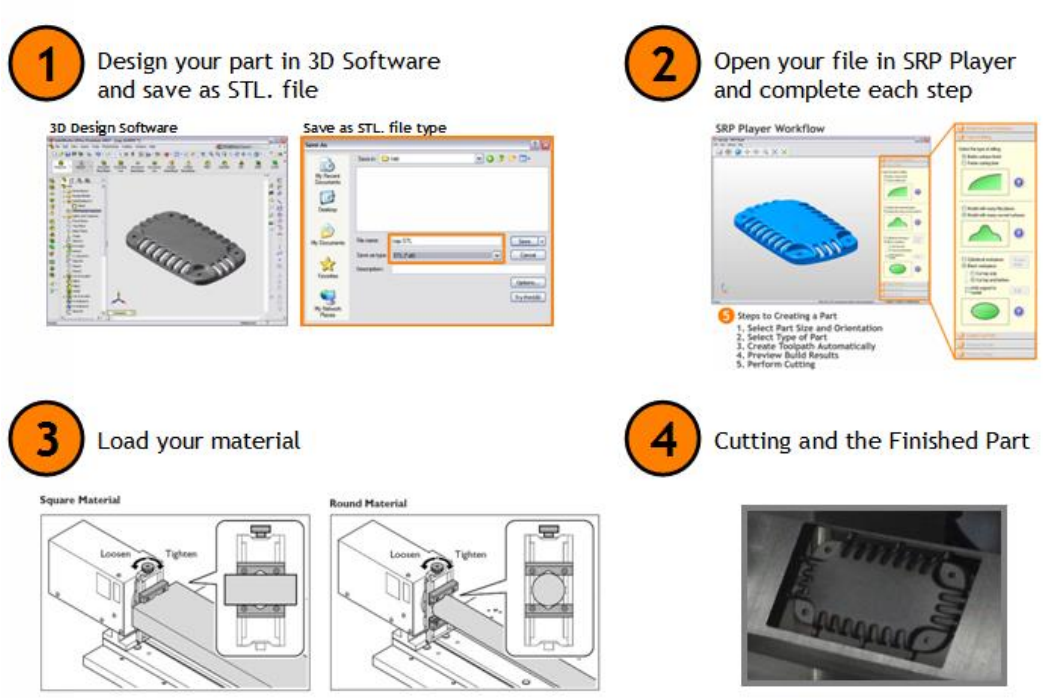
We would also like to take a minute to ask you to consider our company when planning to purchase a Roland product. We are dedicated to subtractive rapid prototyping and the Roland product line. We have spent countless hours trying to help inform and educate the industry and users to the advantages of subtractive rapid prototyping. We are ranked #1 for both sales and service for North America. Product Development, Inc. sells, supports, and trains the Roland MDX machines anywhere in the USA. We don't mention this to just brag about our success, we just want to show you that we are the most knowledgeable and dedicated company to help you be a success with the Roland Subtractive Rapid Prototyping products.

Thank You,
Thomas Buck
Product Development Inc

Chapter 2

What is Subtractive Rapid Prototyping?

Subtractive Rapid Prototyping is the process of making prototypes out of real materials. The MDX series machines are similar to a traditional CNC machine; one major difference is that they are optimized for rapid prototyping. The goal is to give the end user a similar experience to 3D printing a part. To accomplish this, the machine has a special fixture designed to make it easy to load real materials. Then the printing software guides the user through a series of questions that sets up and generates the cutting operations for the part. This allows the end user to make real parts out of real materials with very little knowledge of machining in just a few minutes.

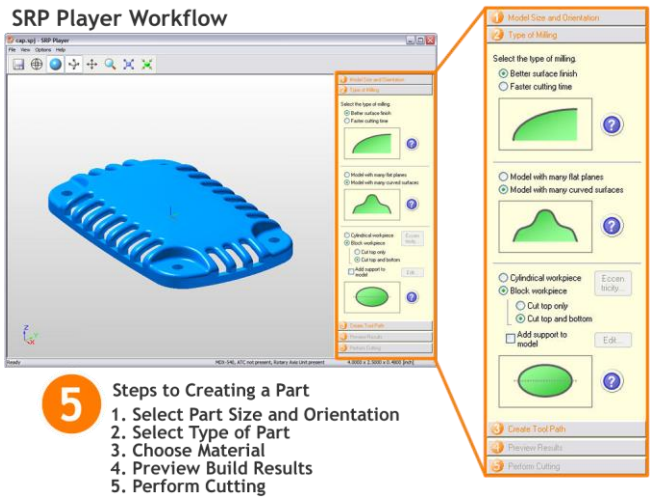


Chapter

3

Making a part
Step By Step Process

Before we begin the step by step process we wanted to show you an overview of the SRP Player software that comes with the machine. Below we break down each screen view so you will have a good understanding of the screens. The SRP Player software is important because it takes the workload off the user and places it on the software and machine. The user only spends a few minutes setting up a print or cutting job.



The software works by following along on the right side of the screen. Moving from top to bottom the end user answers questions and performs each step. When you get to the bottom you are done.

There are five steps in the software. We also add a step for loading the machine, so in the end there are 6 steps to creating the part.

Step 1

Open the file you saved from your CAD program.

You can open files from just about any 3D program. We have listed details about file compatibility in a chapter 4.

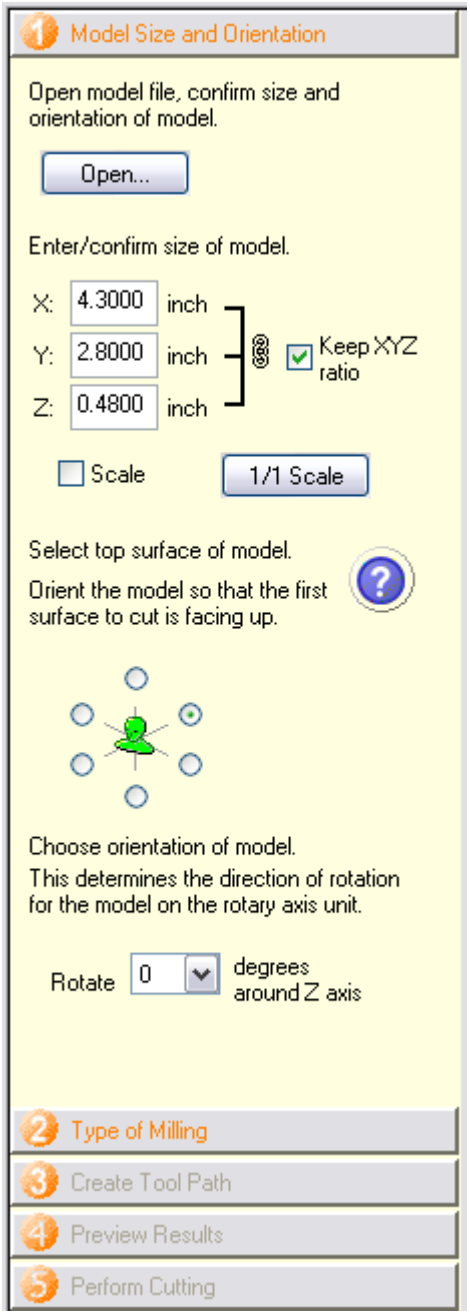
Confirm the size of your part

After you open the part you need to confirm the size or you can make adjustments to the model size for example maybe you want a ¼ scale model.

Make sure the part is oriented correctly; the way you want the machine to build it.

This determines what orientation you want the part built in. The blue question mark will give you some examples in case you need help.

As you click each of the directions the screen updates to match. So you can see the model on the screen in the orientation it will be built.



Step 2

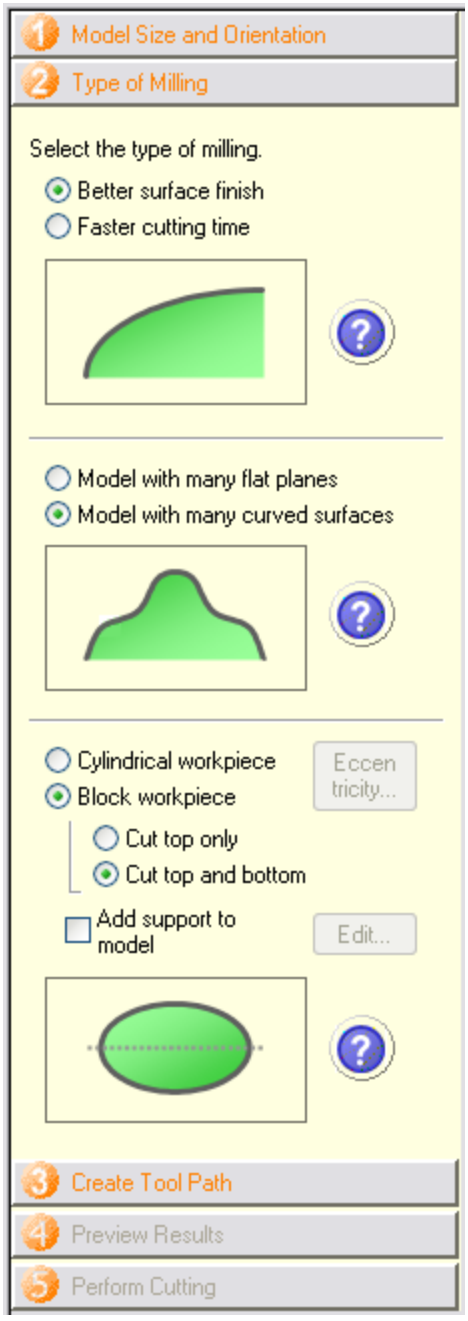
Answer a few questions about the type of part you want to create.

The print software uses this information to determine how to cut the part. By doing this, the software is taking the knowledge of a machinist and applying settings for the part.

If you are not sure what result you might get by selecting one or the other select the blue question mark and the software will explain the differences.

Select the kind of block you are going to use to cut the model from.

Here you will select if you are using a block or a cylindrical work piece. You will also tell the machine if you want to cut both sides of the model. The add supports button is to add supports if you would like to in this program we recommend adding these in your cad software because you have a lot more control, this just adds them automatically.



Step 3

Select the material you want to use to make your part.

The Roland software is unique because, by selecting the material, it sets all of the important settings that would normally be set by a machinist. If the material you want to cut is not in the menu, then just select a similar. We have included a complete list of materials that the machine can cut in another section

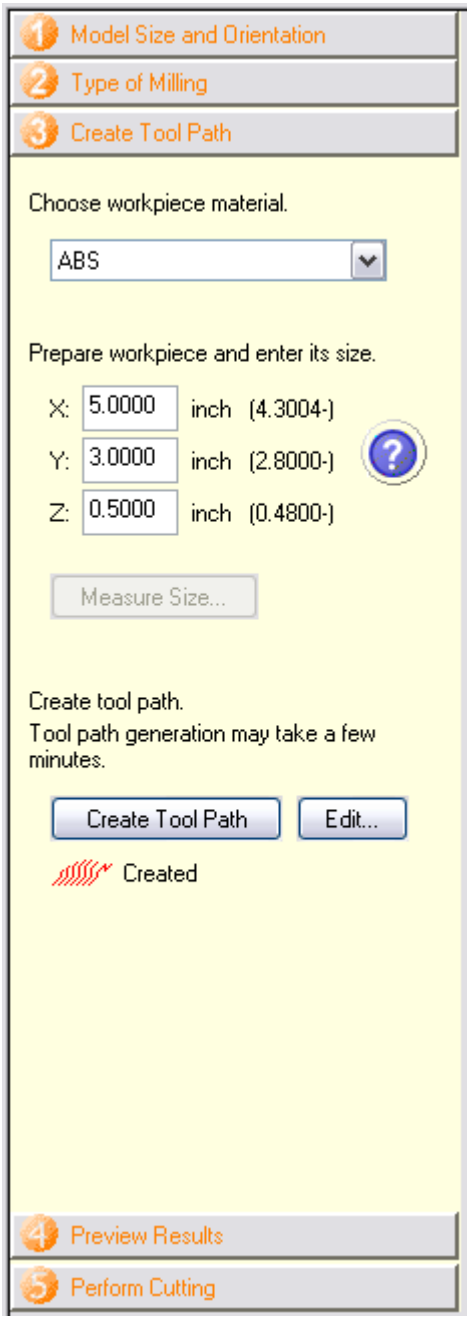
Enter the size of the material you are going to create the part from.

This can be anything you have lying around, and it does not have to be cut any special way. Just grab it, get the measurements, and type them in here.

This tells the machine where to start and stop cutting. For the end-user it means not having to worry about things like whether the material is too small or how to position the model. The screen even shows the material piece you entered so you can visually see the material.

Create tool path

Here we select the Create Tool Path button. This is where the software actually creates the cutting instructions for the machine so that it knows how to cut the part, when to flip the part if using a 4th axis, when to change tools, etc. But for the end-user, they just push the button.



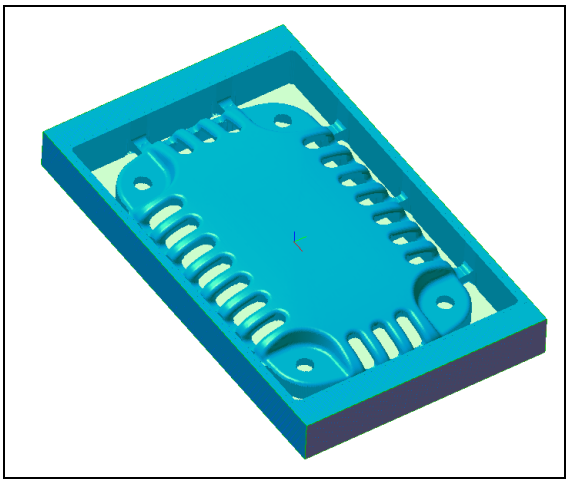
Step 4

Preview your cutting

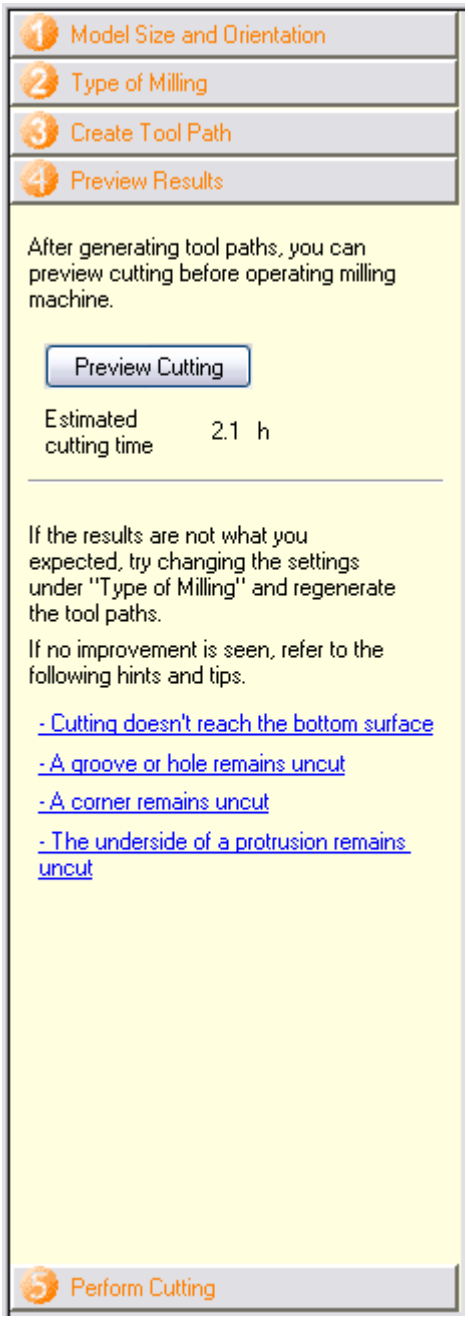
In this step, you can actually see what your part will look like before beginning the cut. This allows you to edit the settings to get a better surface finish, faster cutting time, or maybe even higher detail.

This step also tells you how long it will take to create your part. This helps so you know if it will be done in time for a meeting. If not, then you can adjust some settings to make it run faster.

In this view you can rotate the part in real time, so you can see all directions of the part. Here you can make sure the end result is what you want before performing the cutting.



Preview of Cutting



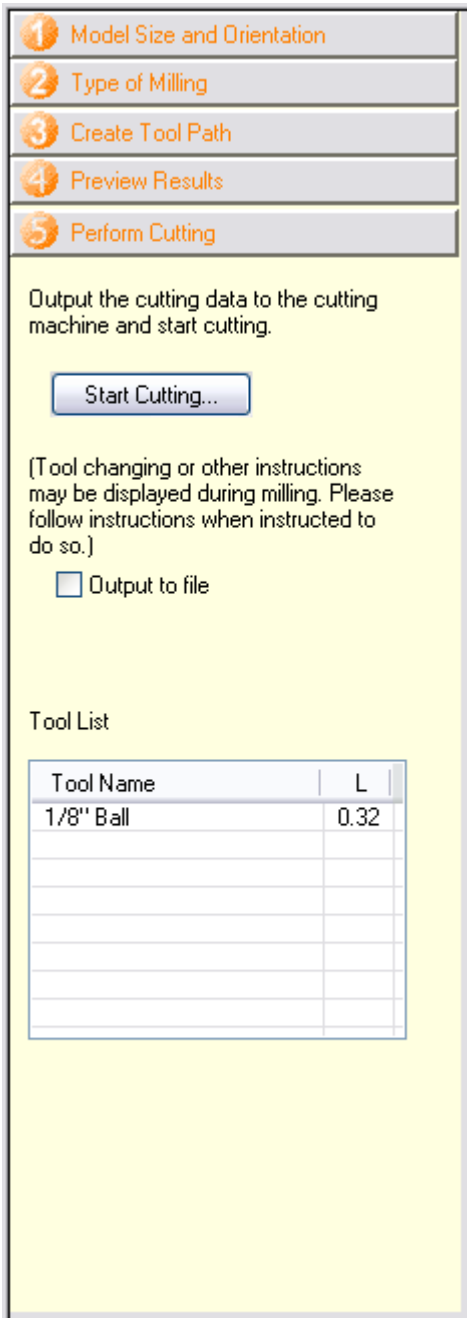
Step 5

Perform the cutting

Press the [Start Cutting] button to begin cutting. It keeps a progress report on the screen while your part is built. You do not have to stay with the machine. You can turn the lights out and go home, or go back to work and come back later.

Tool List

The tool list shows you what tools the machine will use to cut the part. If you have an automated tool changer the machine will change the tools automatically. If not then it will pause and prompt you to change the tool each time.

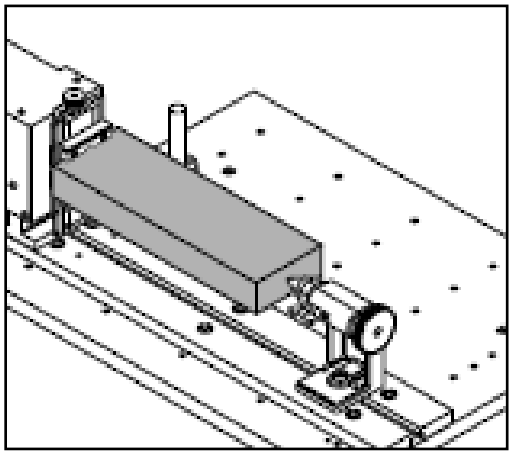


Step 6

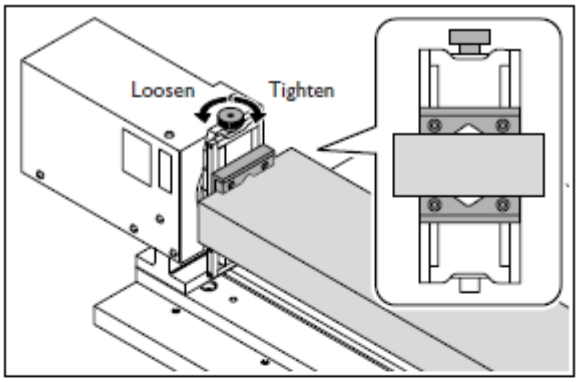
Loading the material

The MDX-40A and MDX-540 use a simple clamping system that allows you to quickly load material onto the machine for cutting. You simply tighten down the Chuck-tightening knob then slide the Core-support up to the material.

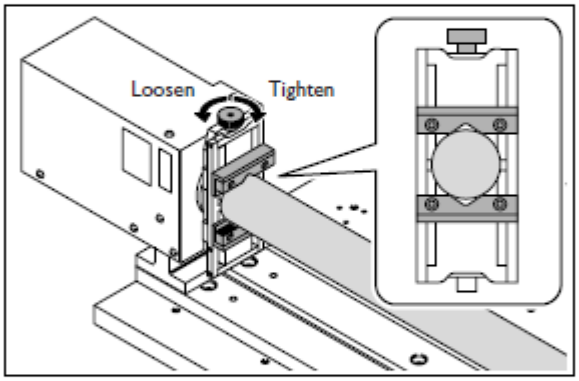
In traditional machining, trying to hold material in a position so that you can cut the part can be one of the hardest and most time consuming steps. Then there are things like the work piece zeros, fixtures, etc. On the Roland machine, you do not have to worry about any of this. The machine and software compensate for everything, so just load material and cut your part.

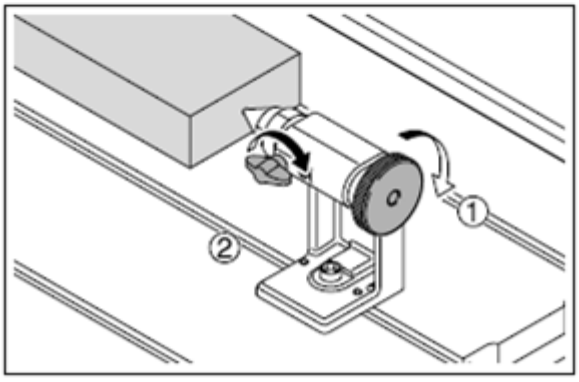


Square Material



Round Material





Chapter 4

Software Compatibility

What software programs do the MDX-machines work with?

The MDX machines were built for rapid prototyping. So every effort was taken to make sure they were compatible with all the mainstream 3D design programs. Here is a list of many of the programs. Do not consider this list a complete list, if you have a program that is not on the list please contact our company and we will verify its compatibility.

3D Programs

- Ashlar Vellum
- Autodesk Inventor
- 3D Studio Max
- Alias Wavefront
- Catia
- Concepts 3D
- Form Z
- LightWave
- Maya
- Pro-Engineer
- Rhino 3D
- SolidEdge
- solidThinking
- SolidWorks
- Unigraphics

For 3D Any Program That Can (Save As) or (Export) To The Following Formats (DXF, STL, IGES, 3DM)

- STL File *.stl
- DXF File *.dxf
- IGES File *.igs or *.iges
- Rhino 3D *.3dm

(ADVANCED) 2D Programs for Doing 2D Cutting And Engraving

- AutoCAD
- Adobe Illustrator
- Corel Draw

(ADVANCED) For 2D Or Engraving Any Program That Can (Save As) Or (Export) To The Following Formats (DXF, STL, IGES, 3DM)

- DXF File *.dxf
- Adobe Illustrator File *.ai
- Rhino 3D *.3dm

Chapter

5

What kind of materials does the MDX systems use?

The MDX machines are different then other prototyping systems because they allow you to use a variety of materials. In a recent survey on 3D printers that focused on Rapid Prototyping use and what the readers wanted for the future. The number one request was better material properties (materials that match the production grade materials). This is important because when you make a prototype, using the right materials is the difference in having a prototype that will function like the final product or just a concept model that is good to hold in your hand.

Below, listed are some reasons why using the final production material in the prototyping stage is important.

Property	Reason for concern
Dimensional Accuracy	Make sure that parts really fit together correctly, and have the right amount of clearance when produced as a final product.
Dimensional Stability	Make sure that parts don't change there size, or flex to much that they will not fit correctly. Make sure that they do not shrink or grow when the parts are used in different environments.
Electrical Properties	Make sure that the material does not have any affect on the type of equipment you are building. Make sure the EMF shielding works as designed.
Environmental	Make sure that parts don't change there size and properties when the temperature changes, or when subjected to different environments
Feature Detail	Make sure that a feature is not to small or that it fails when built to its actual size in production material.
Functionality	Makes sure the part does not break or maybe you want it to break at a given stress level, the only way to know this for sure is to use the production materials.
Thermal Properties	Make sure the part does not melt when packaged so close to high temp electronics.

Better Price	What about making a design in multiple production grade materials and see if the lesser expensive performs good enough to use it instead of the more expensive material you might choose.
Mechanical Properties	Not knowing for sure how a design with a given material will really react in its environment, it is best to use the final production material in prototyping to eliminate any unknowns. Elongation, Compressive Strength, Fatigue Strength, Impact Strength, Tensile Strength, Rigidity, Flexibility, Friction, Electrical Insulation, Hardness, Temperature Range

Materials List

This list however is not a complete list of every material the machines can cut, if you want to cut a material that is not on this list please contact us and we will let you know if it can be used. Also some of the materials on the list require more advanced techniques for cutting, please be aware of the materials you are using for your own safety. We are available for assistance at anytime.

Material	SRM-20	MDX-40A	MDX-540
Aluminum	***	***	Y
ABS	Y	Y	Y
Acetal	Y	Y	Y
Acrylic	Y	Y	Y
Balsa Wood	Y	Y	Y
Bone-Human/Animal	Y	Y	Y
Brass	***	***	Y
Butyrate	Y	Y	Y
Carbon Fiber	Y	Y	Y
Ceramic	Y	Y	Y
Copper	***	***	Y
Chemical Wood (Soft)	Y	Y	Y
Chemical Wood	Y	Y	Y
Chemical Wood (Hard)	Y	Y	Y
Corian	Y	Y	Y
Cork	Y	Y	Y
Delrin	Y	Y	Y
Epoxy	Y	Y	Y

Fiberglass	Y	Y	Y
Foam Low Density	Y	Y	Y
Foam High Density	Y	Y	Y
Garolite	Y	Y	Y
Glass Mica Ceramics	Y	Y	Y
Graphite	Y	Y	Y
Modeling Boards	Y	Y	Y
Modeling Wax	Y	Y	Y
Nylon	Y	Y	Y
Nylon-Cast	Y	Y	Y
PC Board	Y	Y	Y
PEEK	Y	Y	Y
PET (Polyester)	Y	Y	Y
PETG	Y	Y	Y
Plaster	Y	Y	Y
Plexiglass	Y	Y	Y
Polyacetal	Y	Y	Y
Polycarbonate	Y	Y	Y
Polyetherimide (Ultem)	Y	Y	Y
Polyethylene (LDPE)	Y	Y	Y
Polyethylene (HDPE)	Y	Y	Y
Polyethylene (UHMW)	Y	Y	Y
Polyphenylene Oxide (Noryl)	Y	Y	Y
Polypropylene	Y	Y	Y
Polysulfone	Y	Y	Y
Precision Board	Y	Y	Y
PTFE	Y	Y	Y
PVC	Y	Y	Y
Renshape	Y	Y	Y
Resin Board	Y	Y	Y
Sanmodur SS	Y	Y	Y
Sea Shell	Y	Y	Y
Sign Foam	Y	Y	Y

Styrenefoam	Y	Y	Y
Teflon	Y	Y	Y
Tooling Board	Y	Y	Y
Ultem	Y	Y	Y
UHMW	Y	Y	Y
Urethane	Y	Y	Y
Wax- Casting Blue	Y	Y	Y
Wax- Casting Green	Y	Y	Y
Wax- Casting Purple	Y	Y	Y
Wood Soft	Y	Y	Y
Wood Hard	Y	Y	Y

*** Aluminum/Brass/Copper-Light metal cutting on the MDX-40A/SRM-20. These machines are built strictly for an office environment so they are lighter duty. The cutting power is optimized for cutting plastics. So the machines can cut the light materials like aluminum, brass, and copper but they will cut at a much slower pace as compared to the MDX-540. The factory does not recommend the cutting of these materials as a general rule. So each individual needs to use there own discretion when cutting these materials. The work piece weight limits on these machines will also limit you to what size of material you can put on the machine and cut.

When you cut with smaller tools for really detailed parts you will not be as limited on the power curve, instead you are limited by your tool size, so even a full size milling machine can only cut a light metal at the same speeds as the MDX-40A and SRM-20, because by cutting faster you will break the tool, so in this respect, using the machine to cut light metals is slow but it would be slow on any machine. Tool examples in this regard would be for the MDX-40A 1/8” and smaller and for the SRM-20 1/16” and smaller.

Another option for those who want parts made of these materials is to cut out a wax pattern and send it to a casting company. They will cast it in the material of your choice, this is an inexpensive option.

Can the MDX machines cut Steel/Stainless Steel/ Titanium?

The MDX series machines were made for an office environment and with that in mind have no coolant system; We do not recommend cutting these materials at all. The reason is that when cutting these materials the tool and the material it is cutting builds

up extreme heat. Normally you would have coolant flowing on the tool while it is cutting these materials and this keeps everything cooled down to a reasonable temperature.

Without the cooling the tool will break or from the heat it will dull the tool very quickly.

As mentioned above another good option for these kinds of metals is to cut out the part you want in wax and send it to a casting company and they will cast it in the material of your choice, this is an inexpensive option.

Yes other customers have added cooling systems to the machine, both drip and air coolers. The design of the MDX machines will not allow for a flood type system. So we recommend either misting or airgun if you are planning to add cooling to the machine to cut harder materials.

What do I have to do to change materials on the MDX machines?

To change the materials you simply load the material you want to make your next part out of. There is no requirement to purge a system, no retooling time, simply put in the material you want to use. In the print software simply select the material you now want to cut. It is that simple.

Do I need different tools?

For the materials that are preloaded into the SRP Player software you can use the same tools to cut all these materials. There is however specialty tools if you plan to cut a single material all the time. They can cut faster and give you a better surface finish.

Chapter

6

Build Times

In this chapter the focus is to answer the most asked questions we get from potential clients. Questions like, (How long does it take to make my part in plastic?) or (How long does it take to make my part in wax?) Since both of those questions are specific to the part itself and the materials it will be made in, we decided to give you some real world examples to compare. In the following pages you will see 8 example parts, with a little background info on each part and why it was chosen as an example. We included for each part the cost of materials so you have some idea what the recurring costs are to make your parts. If you have a part that you would like a time estimate on please contact myself or one of our applications engineers and we will get that specific information for you.

Inflation Valve Cap

This cap is used on an inflation valve for a life raft. It fits over the valve and protects the moving parts yet allows air to flow through. This part shows the high quality surface finish that can be achieved right off the machine. This part does not require any further post processing like sanding or finishing. In our demonstration video we make this part out of black plastic. Below are the times and costs for prototyping this part in multiple materials. The customer who produces this part makes the final part out of PVC. The client was able to make this part out of PVC and the rest of the parts for the inflation valve. The assembly was then tested in a salt water environment to see how it would perform. Normally the client would have to make prototype molds with many revisions before finalizing the design. Since they were able to produce the model in the production grade materials on the Roland MDX machines they could bypass the prototype molding process. This saved them about 3 months on the design and testing of the product.

Model Size 3.5” x 2.5” x 0.5”				
Material	Cost	MDX-540	MDX-40A	SRM-20
Modeling Foam	$2	36 min	60 min	78 min
Wax	$8	78 min	108 min	126 min
ABS / Plastic	$5	156 min	336 min	360 min
Acrylic / Clear	$5	276 min	336 min	462 min
Aluminum	$10	720 min	*	*

* Aluminum is not recommended for the MDX-40A or SRM-20 see notes in materials

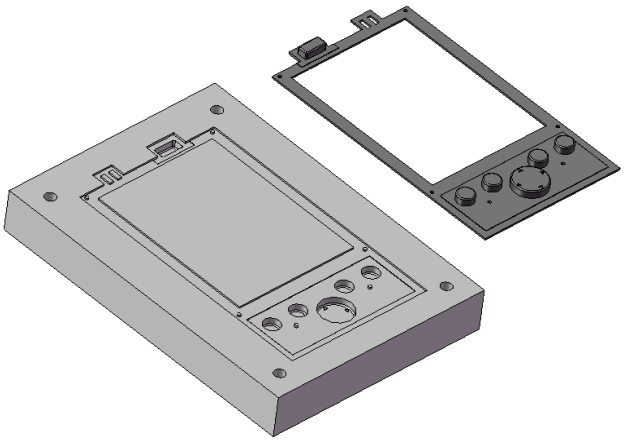
Gear for Robotics Kit

This gear is a part used on the VEX Robotics design system. If you are unfamiliar with the VEX Robotics System it is used in schools all over the nation and by consumers for building prototype robots. This gear was made on the MDX machines then taken right off the machine and fitted on the shaft of a drive train for the robot. The MDX machines are used to make other parts for the robotics platform. Any part the designer can come up with he can then make in a few hours and add to his robot. The gear just happens to be one of the parts that we are asked most often about. This is also a good model to show the tight tolerances achievable with the Roland MDX machines. You can make two gears that can be used together and will interact with each other like off the shelf gears. In prototyping or short run production it is important to make sure parts fit together correctly especially before making thousands of parts and find out that you have a tolerance issue. When the MDX machines are done making a part you are not required to do any type of post processing which changes the dimensions of the part. Below you can see the times and costs for producing this gear in different materials. The final gears are made of Delrin.

Model Size 1.63” x 1.63” x 0.375”				
Material	Cost	MDX-540	MDX-40A	SRM-20
Modeling Foam	$2	24 min	42 min	48 min
Wax	$5	54 min	84 min	96 min
ABS / Plastic	$5	84 min	162 min	196 min
Acrylic / Clear	$4	126 min	174 min	246 min
Aluminum	$10	294 min	*	*

* Aluminum is not recommended for the MDX-40A or SRM-20 see notes in materials

Key Pad Mold



This keypad is used on a handheld device that is based on the Pocket PC. The main electronics platform from the Pocket PC was embedded into a new housing and some additional inputs like a barcode scanner and imaging system were added to the final device. The original touchpad that came on the Pocket PC would not work on the new housing so it was redesigned. Since the device that was being built was for a very narrow market. The client needed to find a way to create the keypad along with the housing components without having to spend the money on injection molds and production setups. Their monthly production might only be 25 units. The mold you see here was used to create the keypad, it is a simple process after creating both sides of the mold you then pour silicone into the mold, then let it set for a while and open the mold and you have a rubber or silicone keypad. It is an easy an inexpensive process. There are many sources to purchase the silicone and urethanes from and by adding dye that they also sell you can create keypads or overmoldings in a variety of durometers and colors. Below you can see the times and costs for producing this mold in different materials. The final mold was made of UHMW because of it mold release characteristics. We can supply you with any information needed on where to purchase the silicone and urethanes.

Model Size 6.1” x 4.5” x 0.75”				
Material	Cost	MDX-540	MDX-40A	SRM-20
Modeling Foam	$3	30 min	48 min	54 min
Wax	$8	48 min	60 min	72 min
ABS/ Plastic	$12	78 min	108 min	114 min
Acrylic / Clear	$8	108 min	108 min	114 min
Aluminum	$20	198 min	*	*

* Aluminum is not recommended for the MDX-40A or SRM-20 see notes in materials

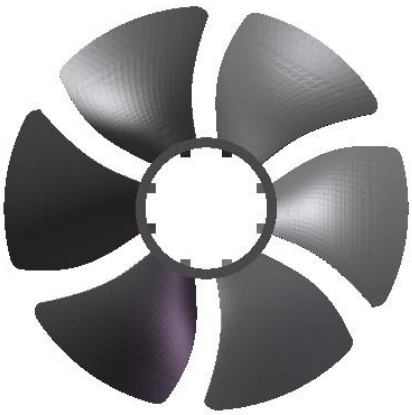
Remote Control Concept Model

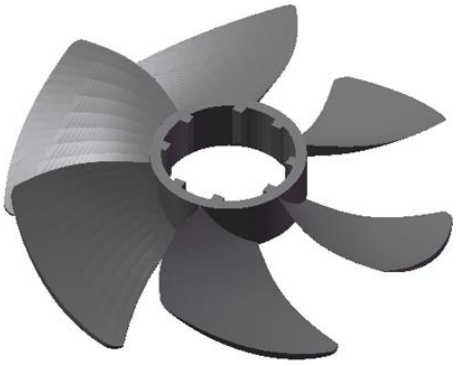
This remote control might look familiar to you. It is used by a name brand electronics manufacturer. This model was used for ergonomics studies. The industrial designer will create multiple designs and cut them out so they can see them, touch them, and feel them. Although the cad software shows a model really clearly on the screen and you can rotate it around and around there is nothing like putting your hands on a design. With the MDX machines you can make these type of models really quickly out of modeling foam. This gives you the ability to put your hands on your designs really quickly. Then after you get more set on a design you like you can make it in a real material like plastic and aluminum, to see how it feels in the actual material. Then make all the components, put it together and see how you like it, all from one machine. Below you can see the times and costs for producing this concept model in different materials. The final concept model was made of modeling foam.

Model Size 5.5” x 2.5” x 0.75”				
Material	Cost	MDX-540	MDX-40A	SRM-20
Modeling Foam	$3	24 min	78 min	96 min
Wax	$8	54 min	132 min	150 min
ABS / Plastic	$10	162 min	342 min	462 min
Acrylic / Clear	$8	300 min	462 min	636 min
Aluminum	$15	582 min	*	*

* Aluminum is not recommended for the MDX-40A or SRM-20 see notes in materials

Spindle Fan



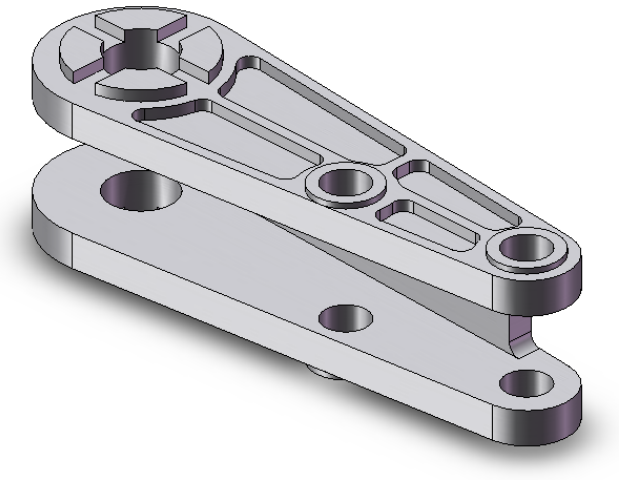


This fan is used on the Roland MDX-40 to blow away chips from the work area while the machine is cutting. This part shows the ability for the machine to produce a final working part. Although the curvature and surface finish on this part are impressive the thing most people don't realize is the thickness of the blades. These blades are only .032" thick, which is the most impressive feature of this part. Since 3d printers build layer by layer some times the layers are too thick to create features. If they are able to create the feature they are very fragile from the layering process. This part was taken off the MDX-40 after being built and put onto the MDX-40's own spindle rotating at 12,000 rpm and continues to work 4 years later. Below you can see the times and costs for producing this fan in different materials. The final fan was made of Delrin. And yes we have the file available for download in our customer learning center.

Model Size 2" x 2" x 0.375"				
Material	Cost	MDX-540	MDX-40A	SRM-20
Modeling Foam	$2	30 min	54 min	66 min
Wax	$5	72 min	96 min	115 min
ABS / Plastic	$5	102 min	162 min	186 min
Acrylic / Clear	$4	150 min	186 min	312 min
Aluminum	$8	324 min	*	*

* Aluminum is not recommended for the MDX-40A or SRM-20 see notes in materials

Optical Steering Bracket



This is part used on a optical platform that is mounted inside of an aircraft. The part holds a set of optics that is repositioned using an electronic solenoid. The client uses the MDX machines to make all the different parts and components on the optics platform. Before they used the Roland machines they would send the parts out to an outside machine shop and have them made. The procurement process alone took them 1 week because they were required to have 3 quotes on every piece they were making. Then the time it took them to get it back would take them another 2 weeks so for each part they sent out it was a 3 week turnaround. Using the Roland system they are able to make the components in house in a single day. This part is unique because it shows the ability to make a part with an undercut. What the machine does is cut from the top and bottom, then rotate 90 degrees and cut the center area out. With the 4th axis unit the machine can rotate to any angle and cut the part. This helps achieve undercuts and areas on parts that you might not be able to reach otherwise. This is all automated so it does not require you to do anything. The MDX-15/20 does not have the 4th axis so this would require a very detailed fixturing system to flip the part and cut from 3 directions. This is possible but requires an advanced technique. Below you can see the times and costs for producing this part in different materials. The final part was made of aluminum.

Model Size 3.5” x 1.3” x 1”				
Material	Cost	MDX-540	MDX-40A	SRM-20
Modeling Foam	$2	18 min	60 min	**
Wax	$5	42 min	102 min	**
ABS / Plastic	$5	138 min	414 min	**
Acrylic / Clear	$6	264 min	414 min	**
Aluminum	$8	780 min	*	*

* Aluminum is not recommended for the MDX-40A or SRM-20 see notes in materials
** This part requires a 4th axis unit or an advanced set up for the SRM-20

Electronic Device Housing

This electronic device is manufactured by a medical company. This version of the model was not the final version but was used in the final design process to check for fit form and function. When further along in the design process you need more then just a concept model to hold in your hand. You need a model that you can make final decisions with. On this model both the front and back of the housing were created and all components. During assembly the client could check how everything was going to assemble, check to see if there are any interference and wiring problems. This device is used by consumers for monitoring vital statistics so the client wanted to make sure the final product was going to be able to withstand being dropped multiple times. Since the prototypes material matches the actual production grade material they know if the prototype can withstand this and other rigorous testing, then the final product will be able to also. There is no other prototyping system that can give you the absolute assurance that the product you are testing and the final part will behave the same under these kinds of testing. Below you can see the times and costs for producing this part in different materials. The final part was made of ABS plastic

Model Size 4.6” x 2.9” x 1”				
Material	Cost	MDX-540	MDX-40A	SRM-20
Modeling Foam	$3	36 min	108 min	174 min
Wax	$8	84 min	192 min	276 min
ABS / Plastic	$12	246 min	696 min	936 min
Acrylic / Clear	$8	450 min	696 min	1260 min
Aluminum	$12	975 min	*	*

* Aluminum is not recommended for the MDX-40A and SRM-20 see notes in materials

Bottle Design

This bottle is manufactured by a large packaging company. They need to create models of new bottle designs to give there potential customers. Before using the Roland machine they sent the customer the cad file. After the client approved the cad file they would build a prototype mold and run a few bottles so the client could see what the finished product looked like. Using the Roland machine they are able to create a model in clear acrylic and with a little polishing the model looks clear as glass. So now they can give the client a bottle design without having to go through the process of making a mold and taking a production blow molding machine off line to make a sample. Using the Roland GX-24 and an inkjet printer they are able to create labels and place them on the bottle to give the client what looks like a finished product. What once took weeks and even months to design and get approval for, now can happen in just days. They even have the potential with the machine to make there prototype blow molds when they need to make more then a single sample. Below you can see the times and costs for producing this part in different materials. The final part was made of Acrylic.

Model Size 5.5” long x 1.75” diameter				
Material	Cost	MDX-540	MDX-40A	SRM-20
Modeling Foam	$2	42 min	126 min	**
Wax	$8	102 min	246 min	**
ABS / Plastic	$10	276 min	942 min	**
Acrylic / Clear	$10	456 min	942 min	**
Aluminum	$16	1206 min	*	*

* Aluminum is not recommended for the MDX-40A and SRM-20 see notes in materials
** This part requires a 4th axis unit or an advanced set up for the SRM-20

We are currently working on the next chapter and will be finished with it soon, if you have any further questions please contact myself or one of the applications engineers at our company. We would be happy to help you.

Thank You,
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