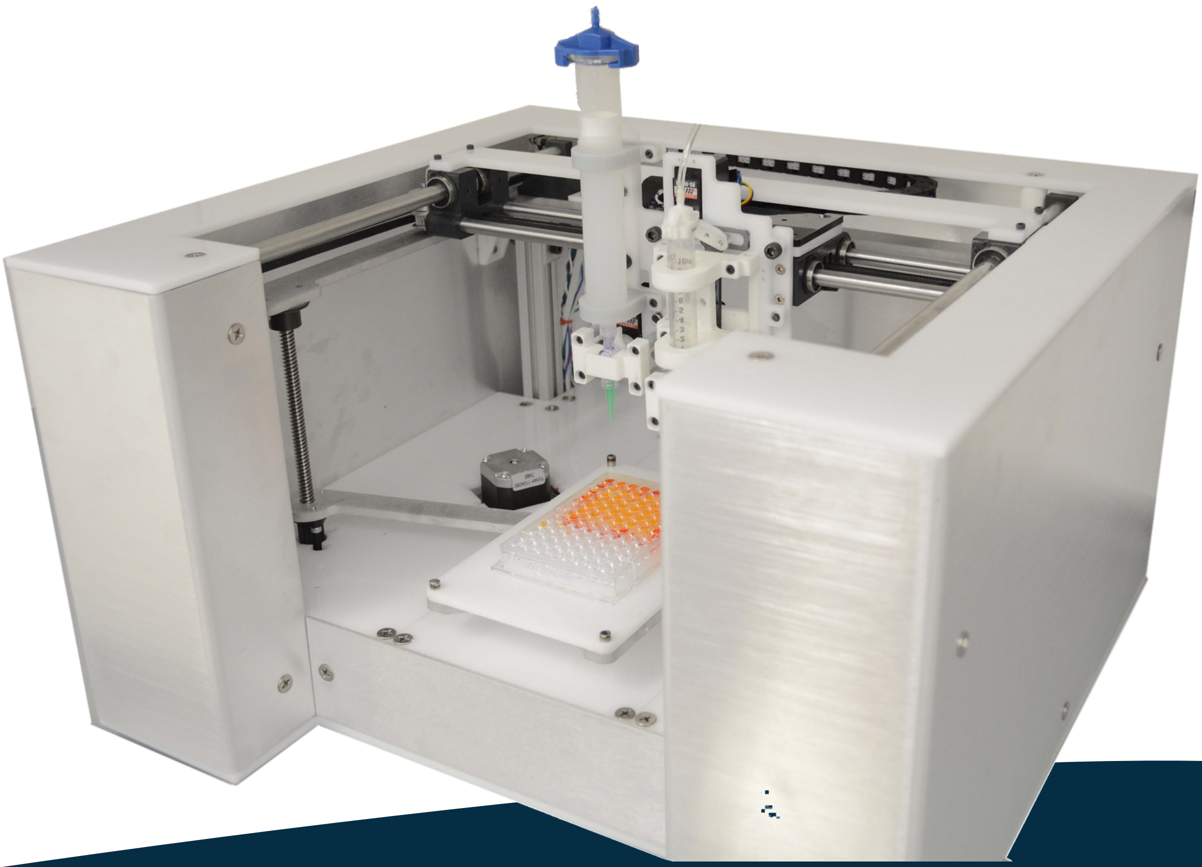

Seraph Scientist™

3D Printing Platform

USER GUIDE

3D Printing
solutions for
researchers
& professionals

526 Campus Rd. Suite 409C. Ithaca. NY 14853 | Fax : 815.301.9504 | Email: sales@seraphrobotics.com

Guide Edition 1.0 | Scientist v1.0

Please do not operate the equipment it unless you are able to ensure that it is safe. You are wholly and solely responsible for all safety inspection and safe operation of the equipment. Please take all necessary and proper precautions, such as safety goggle use, gloves, enclosures, UV shielding, etc. Improper use of the printer could result in INJURY OR DEATH.

2 February 2015

To Our Valued New Customers:

First, let me congratulate you on the decision to purchase the Scientist 3-D Printer from Seraph Robotics! You have taken the first step in a journey toward experiencing the very latest in 3-D printing technology. Building on the legacy of the Fab@Home 3-D printers developed at Cornell University, Seraph Robotics has taken 3-D printing research technology to the next level with the introduction of the Scientist.

You'll notice the fine craftsmanship that went into building your Scientist the moment you take it out of the box. The fully assembled printer encased in high-quality brushed aluminum represents the very highest standards in American manufacturing. With an ever-expanding array of tools and accessories, you will be able to enjoy the full advantages of a customizable 3-D printer built just for you that can survive the test of time and continue to meet your evolving demands with versatile software and well-built hardware.

Owning a Scientist places you in a league of professionals and academics committed to pushing the boundaries of 3-D printing with powerful tools for traditional and nontraditional material prototyping, as well as cutting-edge experiments and research. Whether your unit has been configured to produce high-quality rigid prototypes, soft or edible material objects, advanced material science experiments, pushing the boundaries of tissue printing in organ research, or to be used for the rapid production of 3-D cell cultures, you now have the equipment to achieve your goals with alacrity and precision.

On behalf of all of us that Seraph Robotics, I would like to wish you luck in your 3-D printing endeavors and hope that you enjoy using our hardware and software as you achieve your goals.

Sincerely,

Adam Tow

Adam Perry Tow, MBA
Co-Founder and CEO
Seraph Robotics, Inc.

526 Campus Rd, Suite 409C, Ithaca, NY 14853

sales@seraphrobotics.com | 815.301.9504 fax

19 June 2015

To Our Valued Users:

I would like to welcome you to the Seraph Robotics family and applaud your choice of the Scientist™ 3D Printer. You have made a decision which puts you in league with the most cutting edge academic and professional 3D printing researchers and developers on the planet. Whether you are doing simple printing in plastic filaments, novel multi-material printing, or bioprinting, the Scientist™ will be an invaluable asset to any academic or professional user, doing prototyping or R&D work.

Having worked as a 3D printing engineer both at Seraph and in the academy before, I am personally honored to have been a central part of developing and manufacturing this amazing technology. Each Scientist™ we make is truly a fine piece of machinery that far exceeds the standards for quality and reliability that preceded it. The work of calibrating new materials is made much simpler on this latest machine and software and the robustness of the hardware platform is something you will benefit from immensely.

I would like to wish you the best of luck as you calibrate your new materials and learn the in's-and-out's of the printing process. We hope that you will take advantage of the educational resources we have made available to make your first forays into the exciting world of 3D printing with the Scientist™ and we thank you for choosing Seraph Robotics.

Sincerely,

Jeffrey Lipton

Jeffrey I. S. Lipton, Ph.D.
Co-Founder and CTO
Seraph Robotics, Inc.

526 Campus Rd, Suite 409C, Ithaca, NY 14853

sales@seraphrobotics.com | 815.301.9504 fax

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your business is

greatly appreciated.

About Scientist ™

Flexible SOLUTIONS

For your research needs

that don't require engineering or computer science degrees to operate.

Advanced Technology

FOR HIGH PRECISION 3D PRINTING AND CUTTING EDGE RESEARCH

The Seraph Scientist™ expands the capabilities of the Fab@Home Model 3 Research Platform and allows professionals and researchers, both academic and private, to use our powerful technology to utilize or develop innovative techniques in additive manufacturing and three-dimensional printing. Whether you'd like to culture cells in 3d, print living organs, experiment in material science, or just print plastics, ceramics, or foods, the Scientist™ will allow professional research users the ability to easily push the limits of additive manufacturing technology. Combine new or existing materials, experiment with unique deposition patterns, or manufacture specialty, custom products, the Scientist™ Research Platform will give you the tools to develop your product or run your experiments. Our research platform will allow you to precisely control every aspect of your digital fabrication research – from materials, to depositions patterns and geometries.

ADVANCED FEATURES AND CONTROL

Manually create simple print jobs or write custom printer control software using our novel XDFL command language, a simple, intuitive and human-readable XML language for controlling 3D printers. XDFL allows precise control over the movement of the printer and the operation of its extrusion heads, affording the researcher machine-level control during experiments. Further, XDFL files are transferable and shareable among printers, making research protocols easy to document.

POWERFUL AND USER FRIENDLY TECH

The **fully assembled** Seraph Scientist™ Platform requires no engineering or programming experience. Like all our products, it's designed for the non-technical user, making it ideal for scientists and professionals whose expertise is in fields other than engineering (e.g. biology) and simplifying the research of engineers without sacrificing control.

Our system uses Standard STL files which most modern CAD programs can generate. Calibrate Materials and automatically process STL files into

CUSTOMIZATION COMES STANDARD

The Scientist™ platform allows you to select the number and type of tool head that's right for your project.

Use heated or cooled build trays to control the temperature of the build surface below ambient temperature and up to 150 degrees Celsius. Control the syringe temperature, using our heating or cooling cartridges.

Use our UV light source to cross-link your materials. Available in 365 nm and 385 nm wavelengths.

General Device Features Listing and Specifications

External Dimensions	54 cm width x 50 cm depth x 40 cm height
Printing Technologies	Syringe and/or Filament
Number of Tool/Material Bays	1,2, 3, or 4
Primary Fields of Use	Material Science, Tissue Engineering, 3D Cell Culture, Food Science, General Prototyping with software packages for each, as appropriate
Exemplary Materials	plastics, ceramics, silicones, food pastes, hydrogels, organic material, and novel research materials
Usability	Point and click software offers access to fundamental printing process at 'research level' without need for advanced coding or engineering knowledge. Unit is pre-assembled with no training required to operate. Uses standard wall outlet. Disposable and sterilized cartridges available, sterilizable work surface.
Positioning Accuracy	10 µm
Maximum travel speed	130 mm/s
Typical travel speed	80 mm/s
Build Dimensions (x/y/z)**	127mm, 200mm, 65mm
Reservoir volume	Nordson EFD or Becton Dickenson Syringes 3-55 mL
Minimum tip diameter	0.004"/ 0.1 mm / 32 gauge (or any lure lock tip)
Maximum tip diameter	0.06"/ 1.54 mm/ 14 gauge (or any lure lock tip)
File Types	STL and XDFL

*Specifications may vary based on your unit's specific configuration.

Tools and Accessories Listing and Specifications

Syringe Tools	Use 3-55mL Nordson EFD or 10ml Becton Dickenson syringes, needles, or taper tips to extrude material using pressure drive. 1,2, 3, or 4 syringe capacity tools available.
Plastic Filament Tool	traditional plastic 3d printing tool (1.75mm or 3mm filament options); Bowden Drive; 80 - 260C range
3D Cell Culture/Well Plating	use a specialized tool head and point-and-click software to easily run, design, or share complex cell culture protocols for automatic 3D cell culture in standard well plates without CAD or complex software/ procedures.
Heated build tray	External control (150 C max); useful in plastic printing, cell temperature regulation, and collagen crosslinking.
Syringe Head Heater	Regulate the syringe temperature (80 C max)
Cooled build tray	Peltier junction cooling system (-3.6 C min, 18.4C max)
Syringe Head Cooler	Regulate the syringe temperature (-3.6 C min, 18.4C max)
(UV) LED light tools	LED light source of selected source (e.g. 365 or 385nm), mountable in several configurations. Useful for hydrogel cross linking, among other uses. Illumination coordinated with printing process automatically or manually, depending on tool selected.
USB microscope tool	2 MP camera with 10-40x zoom; can be positioned to view work surface or tool head during printing. (May use multiple per printer.)

CUSTOM SOLUTIONS

Custom tools are available upon request for users needing specialized functionality. Help others cite your work by requesting that your custom tool is added to our standard accessories list, allowing others to easily build from your research.

Packing List

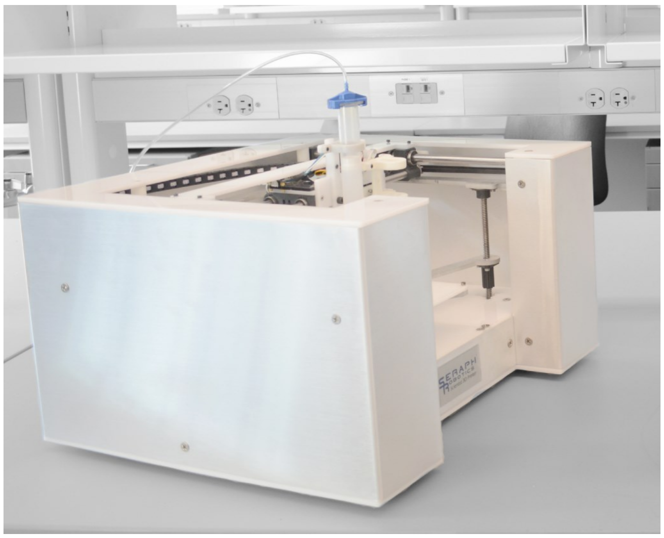
Item	Quantity
Scientist Base Unit	Per Order
Power Cable	One
Accessory Tower / Requested accessories	Per Order; may be in separate boxes
Pressure Lines	0-5 depending on order

What's not included

Item	Where to Find
USB Cable	Online or Local Retailer
Computer	Online or Local Retailer (PC Only)
Software	Visit web link provided to download
Syringes & Tips	Purchase from Nordson EFD/Becton Dickenson
Plastic Filament	Online or Local Retailer
Spare Parts	Contact us for more information

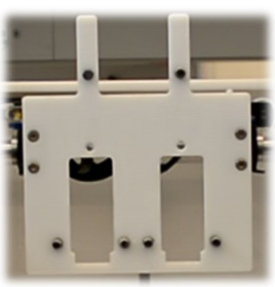
SERAPH ROBOTICS™

Each order is different, depending on the tools/ accessories you've ordered. You may also receive the items in multiple boxes/deliveries. Each order will contain the two items below in separate boxes.

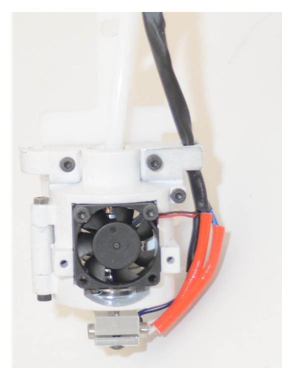


Scientist Printer Base Unit (w/o tool)

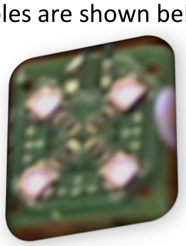
Accessory / Control Tower (bay configuration may vary) - large orders may contain two units.



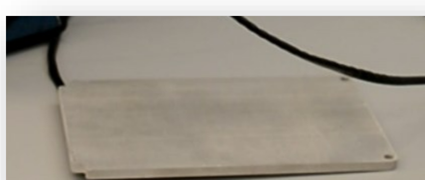
You will receive one or more carriages (left) and one or more tool head attachments (examples on the right).



Depending on your order, you may also receive additional accessories and their corresponding bays in the accessory tower. Some examples are shown below.



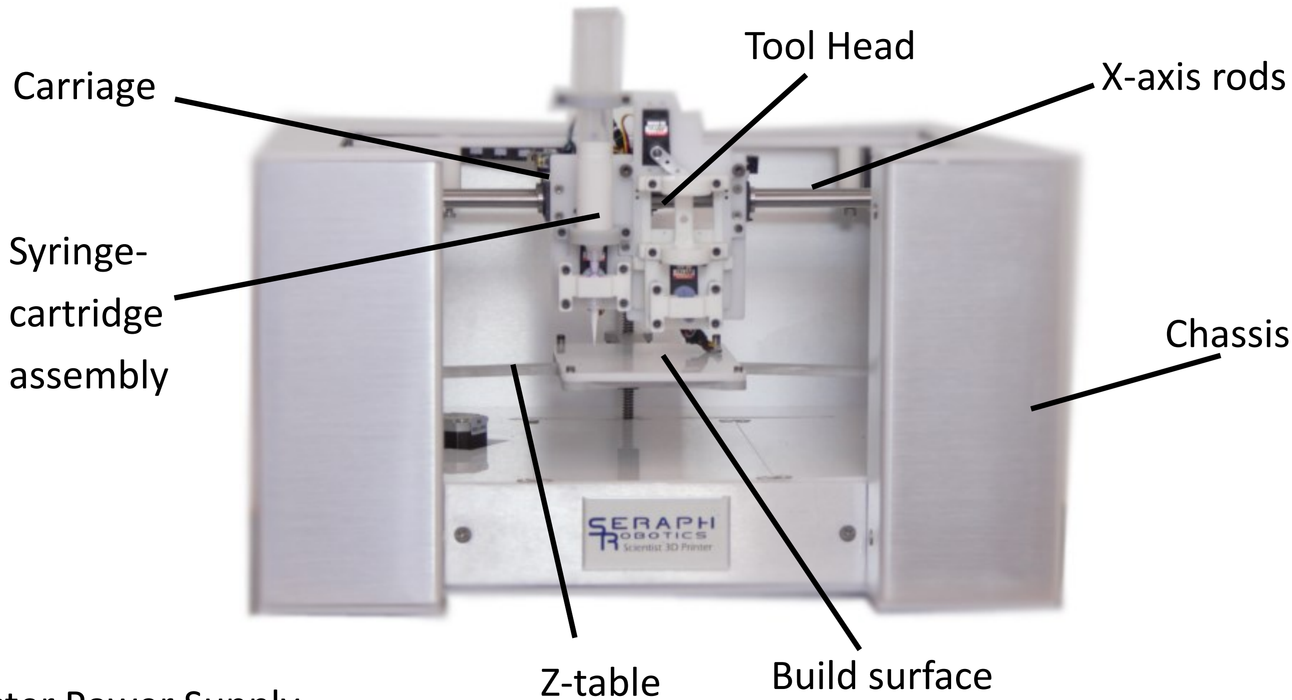
UV (LED) Tool

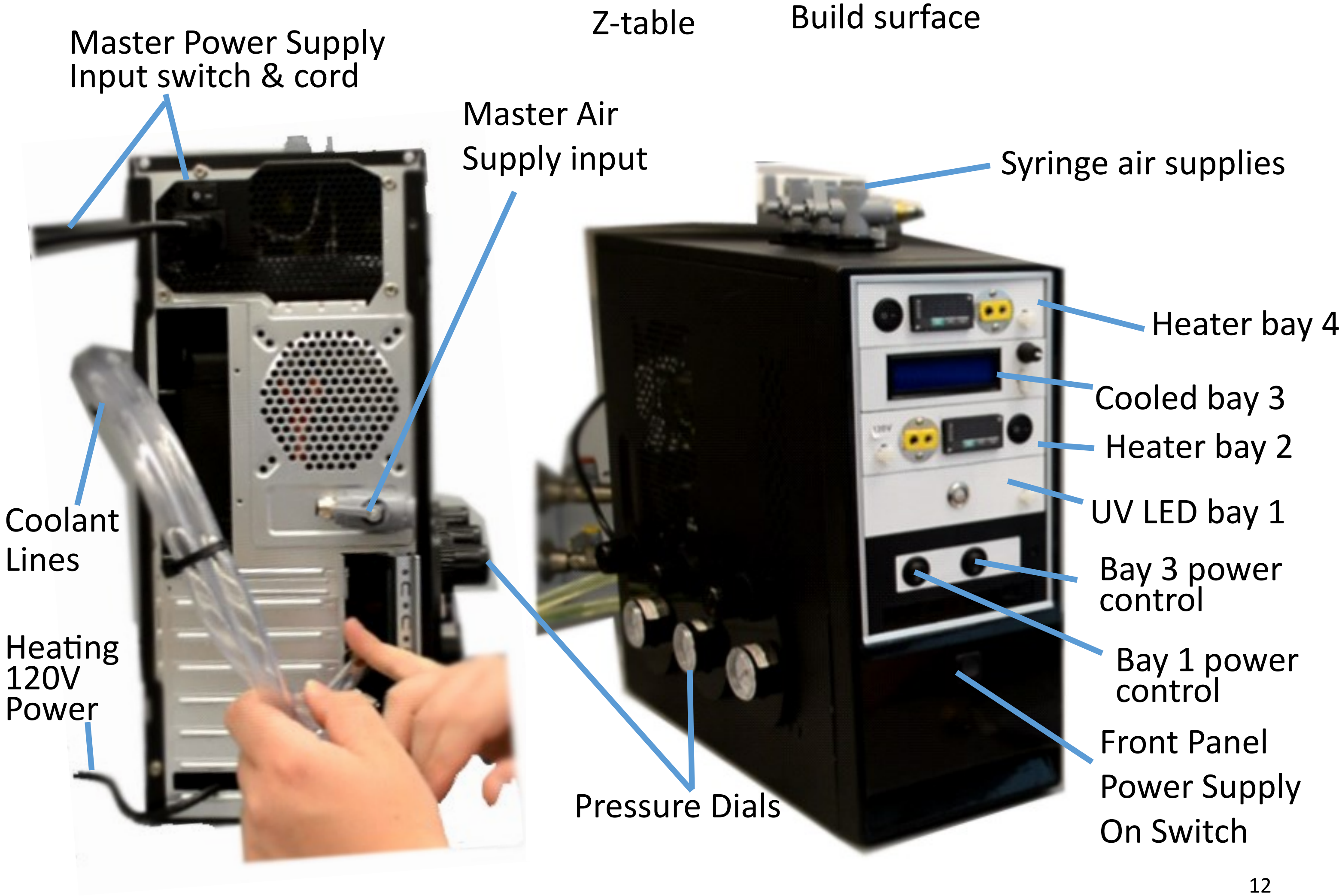


Heated build tray

USB Microscope

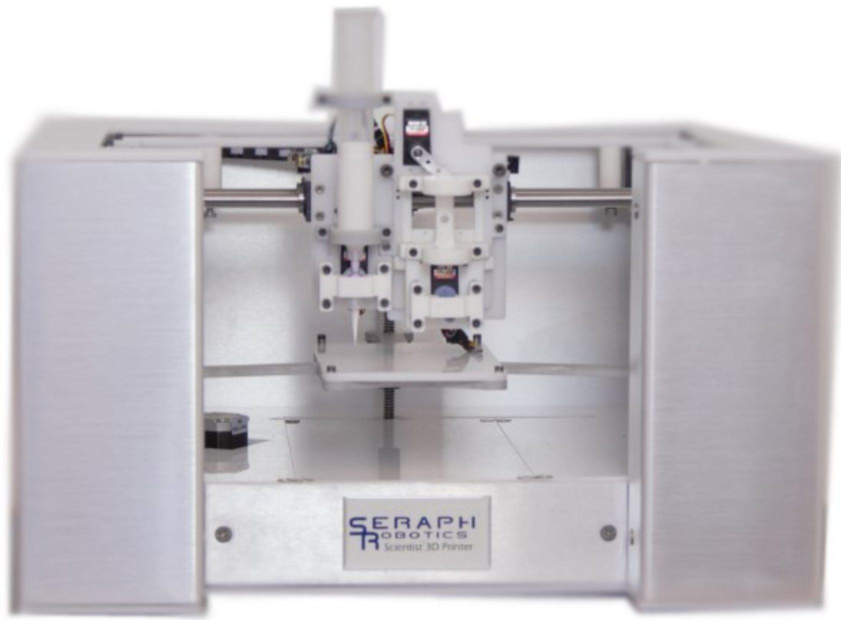
Basic Hardware Overview





Seraph Robotics™

Basic Hardware Overview



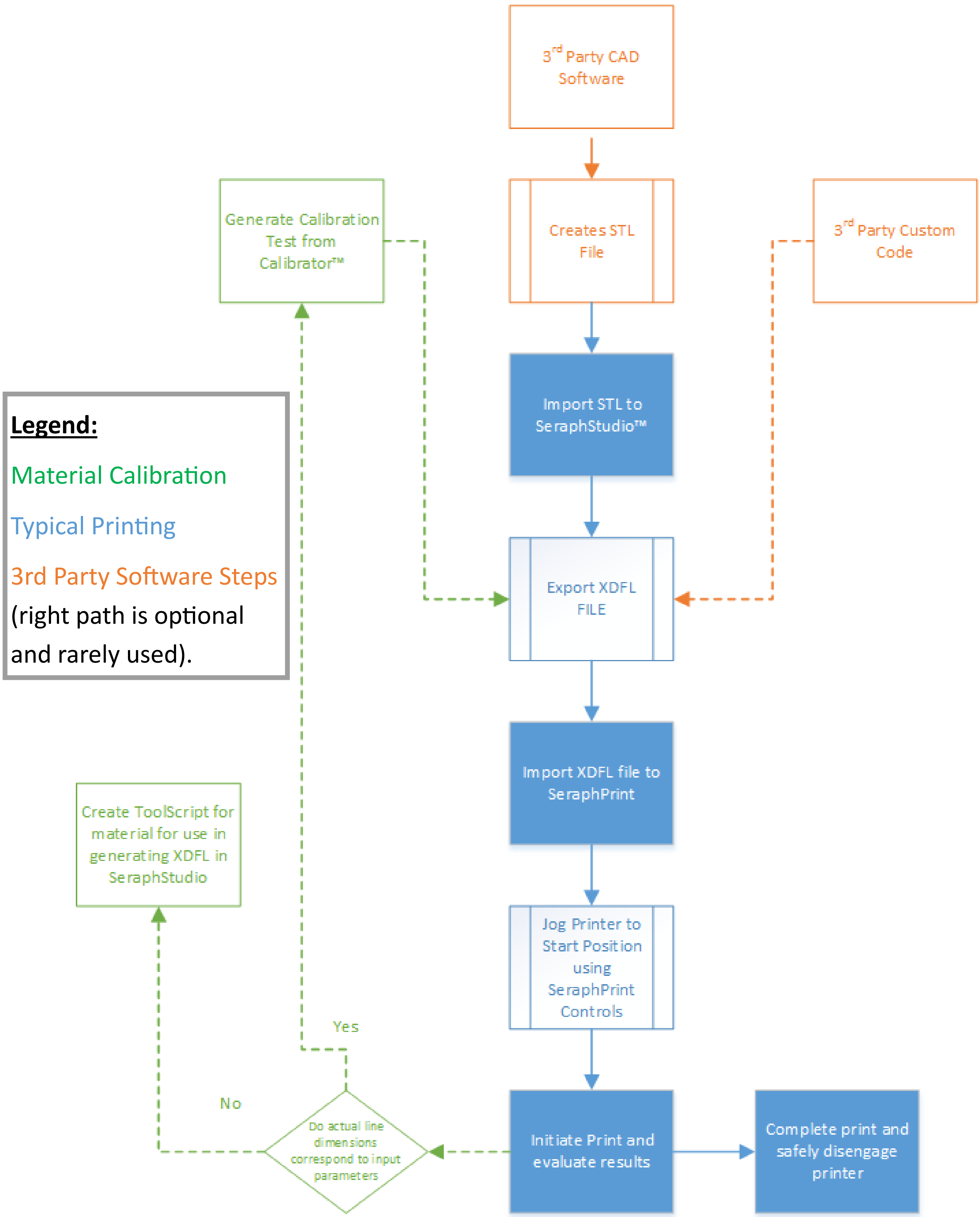
How the Printer Works

A Scientist 3-D printer works by moving the tool head around in the X-Y plane and moving the build tray down in the Z-direction with each successive layer. The printer control software, SeraphPrint™, works by interpreting a language called Extensible Digital Fabrication Language, or XDFL. XDFL consists of a series of commands: XYZ points and material identifications.

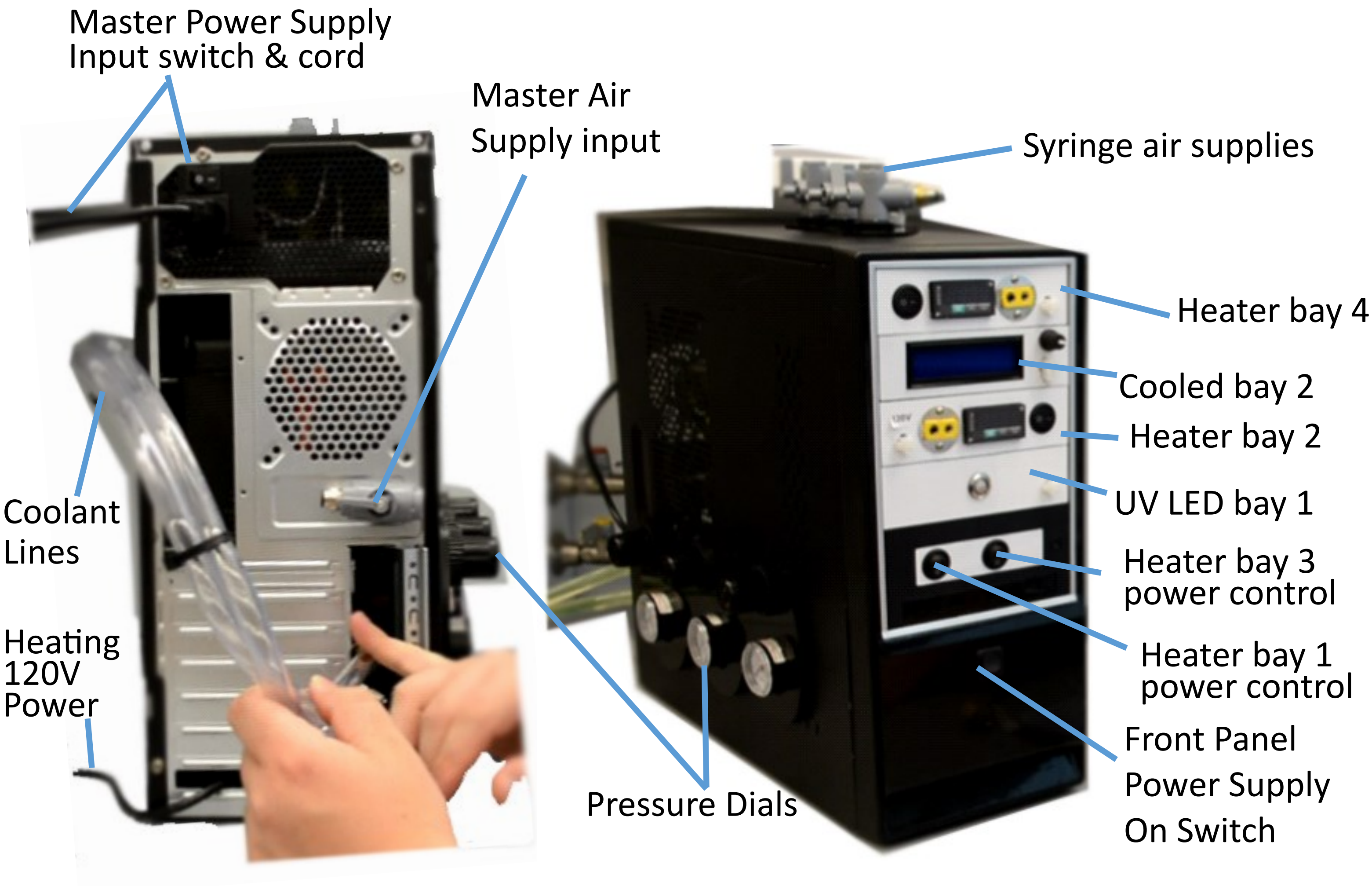
A third party Computer Aided Design (CAD) program creates a file called a stereolithography (STL) file. The print job-processing software, SeraphStudio™, takes an STL file of a three-dimensional object, slices it into layers, and draws paths to fill in each of those layers. Each layer is assigned a Z-height, according to the height of a single layer of the material used, (i.e. path height). Each XY path within a layer has a width corresponding to the material identification , much like the path height (layer height). The path width, height, and several other parameters are set in the Calibrator™ program which creates ToolScript™ files that instruct SeraphStudio on the geometric characteristics of the material you want to print with. (See Diagram on next page).

To begin a print job, move the build tray to a Z-height such that the tip just barely rests on the build tray and place the tip at the back corner. Load the XDFL file generated by SeraphStudio (Calibrator™, or your own code) into SeraphPrint™ and connect to the printer. The printer will begin drawing each 2D layer in the XY plane, complete the layer, move the Z-table down by one path (layer) height, and start the next path until you print the whole object out!

How the Printer Works



Basic Hardware Overview



How the Control / Accessory Tower Works

Most Scientist printers are configured to use a Control/Accessory Tower. The Control Tower is where you hook up the external air pressure source, i.e. lab output or portable compressor up to 100 PSI. Accessories are also typically operated from one or more towers.

The lab or compressor air supply is connected at the “Master Air Supply input.” Each syringe is connected via the “Syringe air supplies.” Pressure is connected when the switch is directed toward the hose (and away from the air release ports), which must always be uncovered for safety. Pressure can be adjusted for each syringe using the pressure dial directly beneath the syringe air supply with which you are working. Remember, each calibrated material has a particular pressure which the material should be run at to extrude the paths at the correct dimensions (i.e. the dimensions the computer is expecting based on calibrated ToolScript).

Does your unit look different?

Don’t panic!

You may not have ordered all of the accessories shown here! You may not even have a valved air pressure tool. Some configurations don’t use them, (e.g. the mechanical piston driven tools and filament tools don’t use air pressure, so you wouldn’t have received air pressure hook ups in your setup). We also often ship in separate boxes, so make sure you checked all the boxes.

If you want to order more tools or accessories, we can help! Email us at sales@seraphrobotics.com and we’ll get you set up.

QUICK START GUIDE

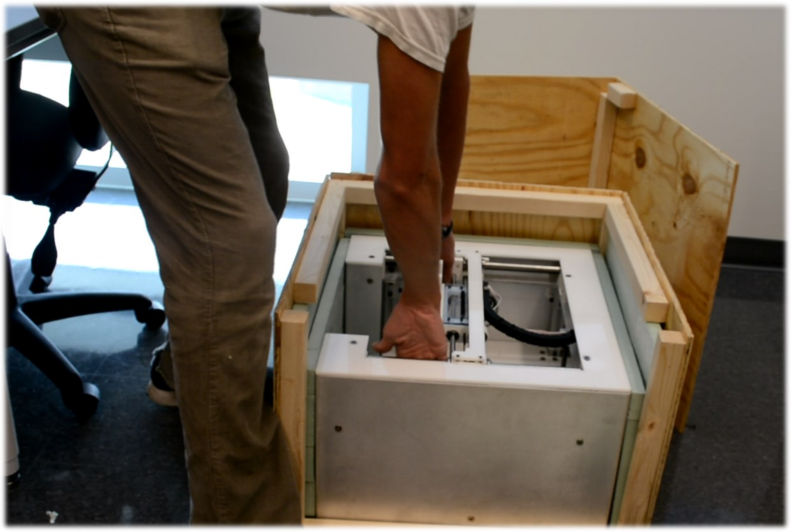
Unpacking the Printer

Step One

Carefully place box right -side up and unscrew the screws painted orange

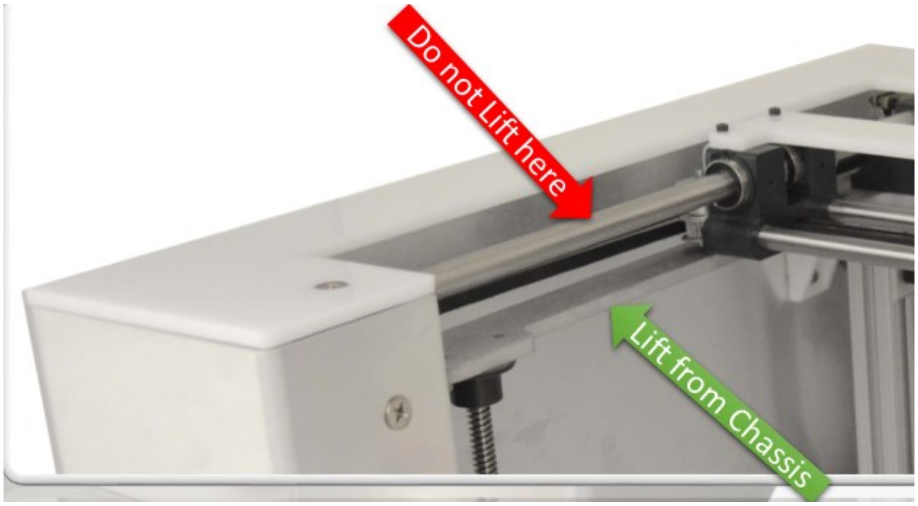
Step Two

Lift off front-side panel and remove foam padding. Check printer for loose parts and tighten, if needed.



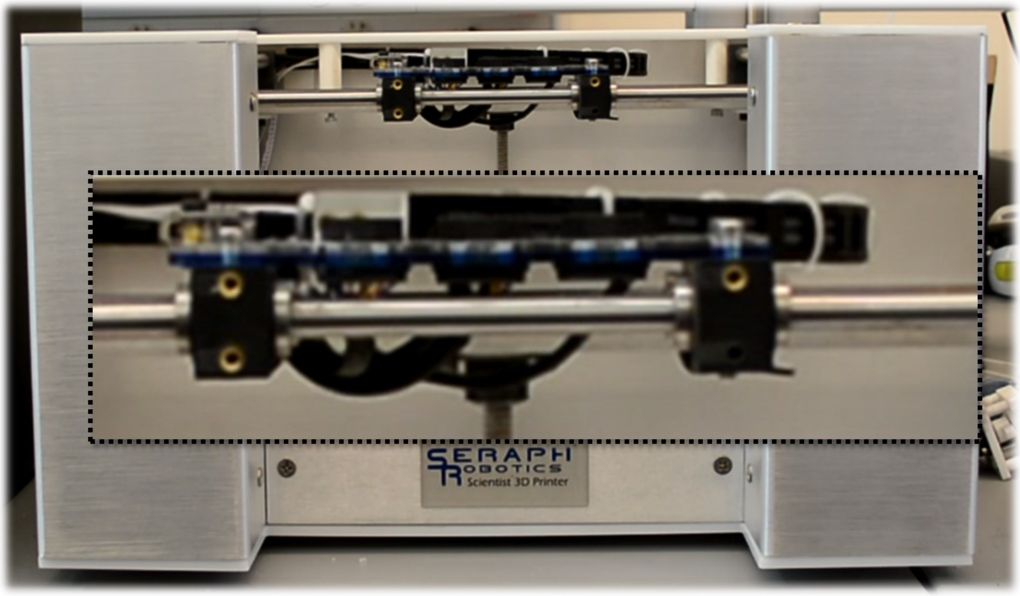
Step Three

Lift printer out of box from the chassis. **Do not lift from the shafts or you may damage the printer!** Place on a clean, dry area. Check that everything is in safe, working order.



QUICK START GUIDE

Installing Carriage & Tool Heads

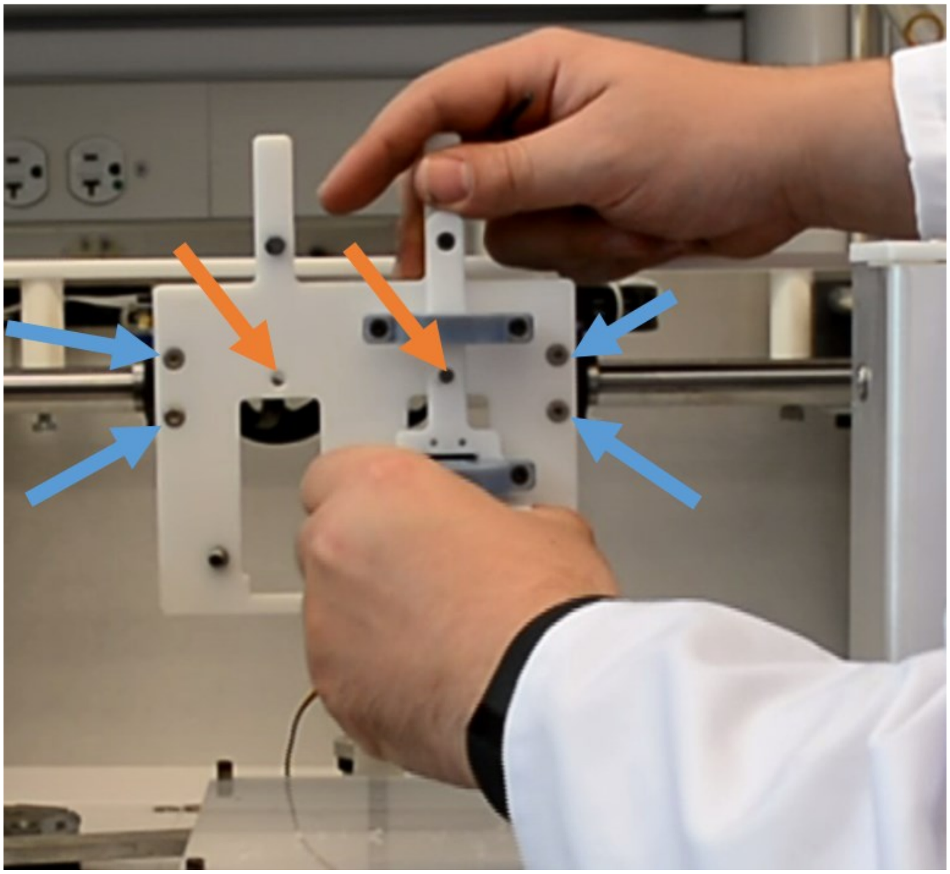


Step One

Unplug the printer and all accessories. Remove any pre-installed adapt-ers so that the four bolt holes for the carriage are exposed.

Step Two

For Dual Carriage Mount: Install the dual carriage on the printer by bolting on the blue arrows.



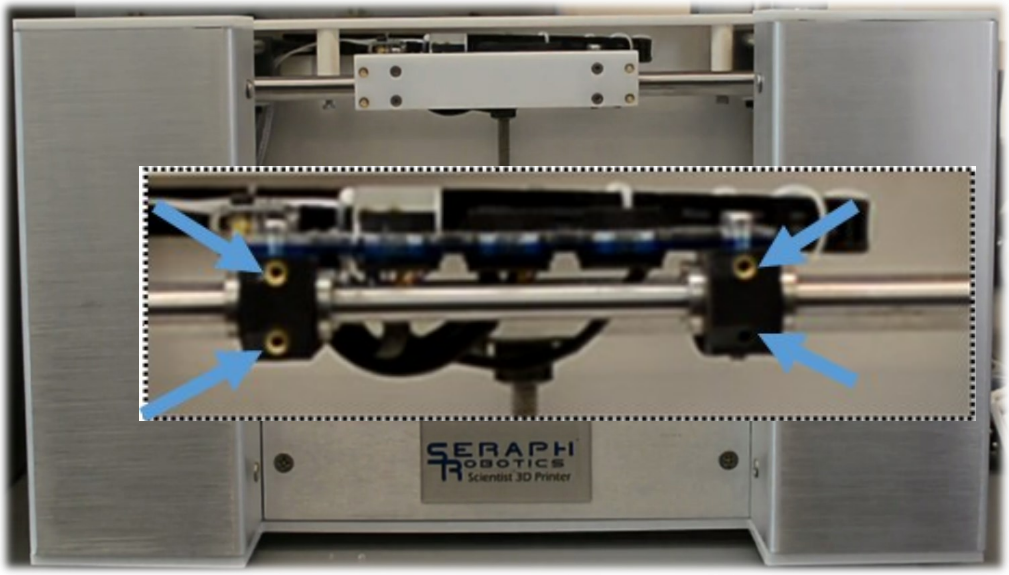
Step Three

Then insert the tool heads by bolting them onto the orange arrows, feeding the wire through the rectangular slot and plugging in around the top of the carriage.

Installing Carriage & Tool Heads

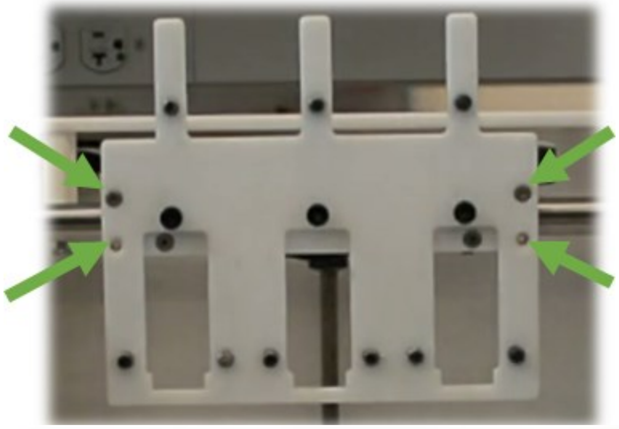
Step One

Unplug printer/accessories. For Triple Carriage Mount: Install the dual-to-triple carriage adapter on the printer by bolting on the blue arrows. (Shown installed on printer,) Disconnect if it is connected to the triple tool before mounting onto printer.



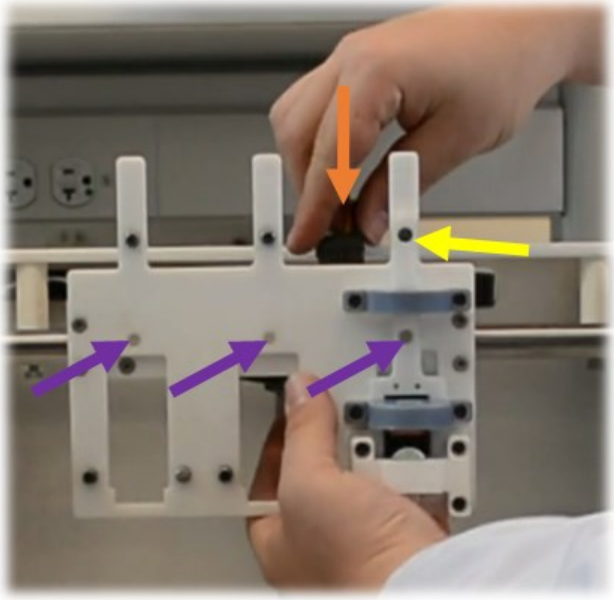
Step Two

Install the triple carriage on the adapter by bolting on the green arrows.



Step Three

Remove (purple) bolts. Then insert the tool heads by putting the wire through the rectangular slot, and pushing the head firmly and evenly in place on the carriage. The guide pin (yellow) should fit in the hole and the wire (orange) should plug in on top. Replace (purple) bolts.



Turining on the Printer

Step One

Locate the USB (left) and Power plugs (right)

Step Two

Plug in the USB to the printer and PC. Plug the power into the printer and wall outlet.

Step Three

Plug in tower power cords, turn on master power supply.

Step Four

Proceed to the cartridge/software guide to begin using the printer. View accessory instructions as necessary.

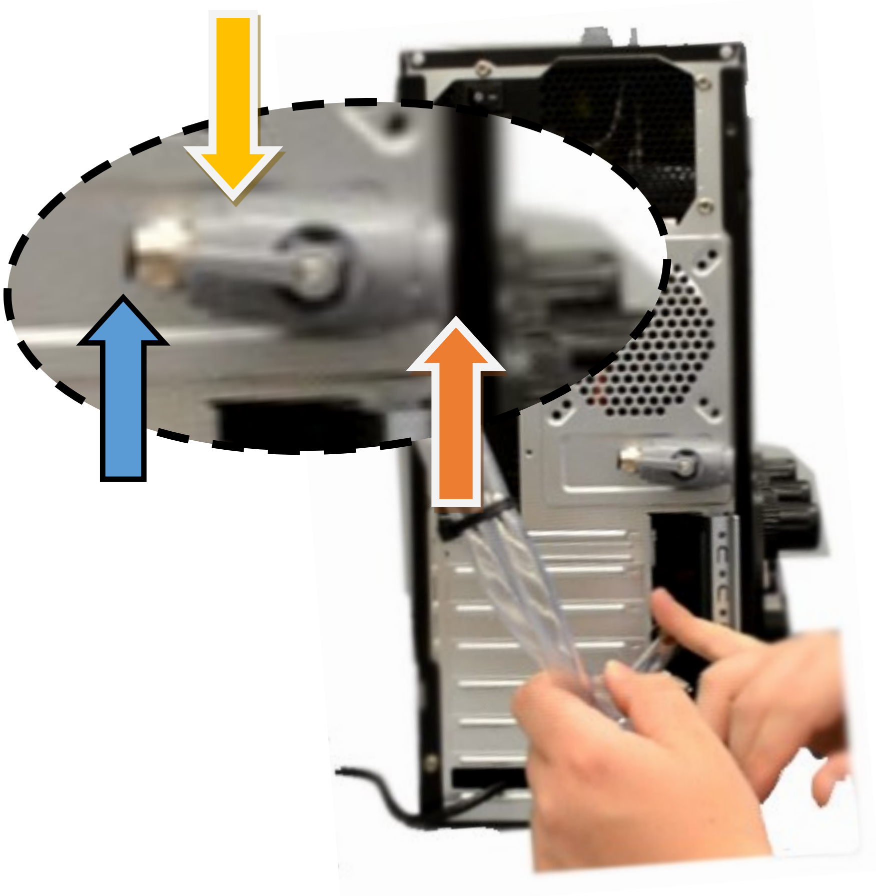
*Always do a safety evaluation before/ during use.

QUICK START GUIDE

Installing the Pressure Drive –Tower

Step One

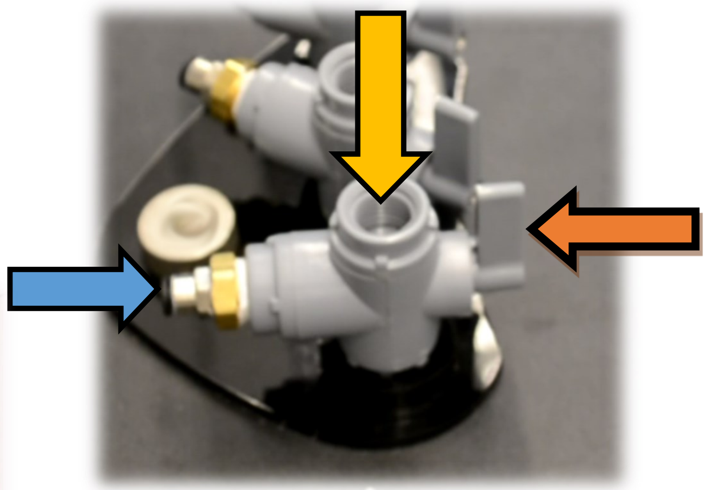
Connect your lab's pressure source (or compressor up to 100PSI) to the main pressure source push-to-connect port (blue arrow). The valve is turned to the "on" position (yellow arrow). The atmosphere out port must be open and unobstructed (orange arrow).



Insert the tube into the push-to-connect port, push it in, and tug gently to ensure it is secure. If you need to move the tower and release the connection, disconnect the tube. To release the tube, push inwards and then pull out to remove.

Step Two

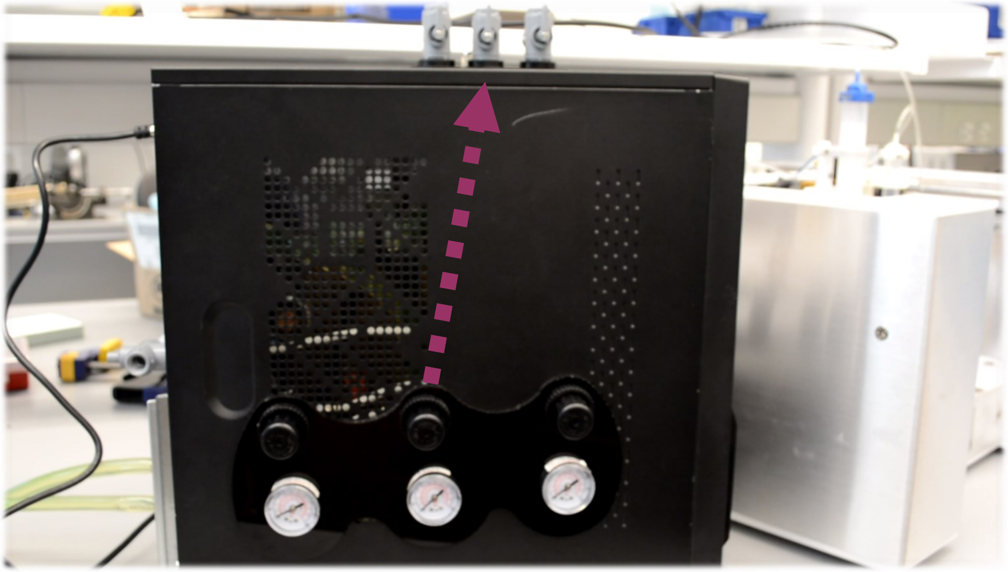
Repeat the steps above and connect the pressure lines to the "syringe air supplies" and to the syringe pressure caps (if not already connected).



Installing the Pressure Drive –Tower

Step Three

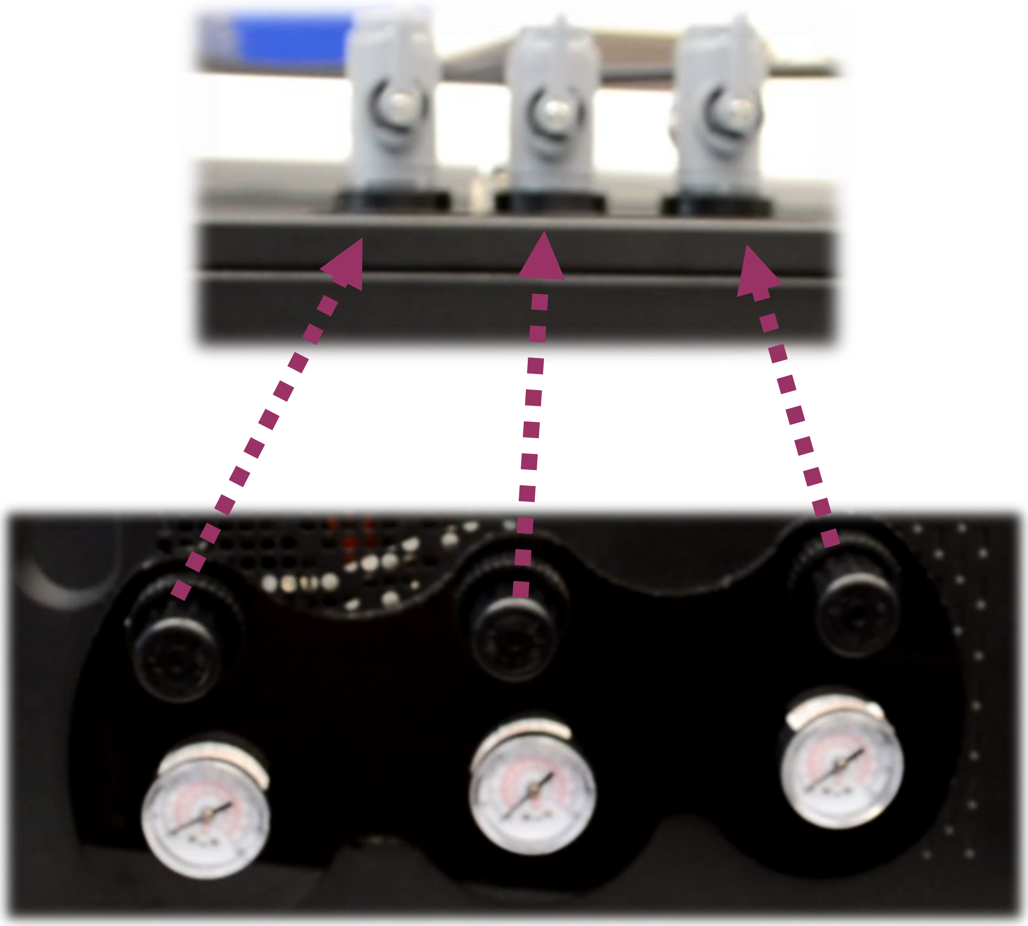
With the syringes connected and the material inside and primed, turn the main air valve on, as well as the syringe-specific air valves. Do this one at a time.



Step Four

Then pull on black pressure nob for the connected syringe. Twist to change the pressure reading on the dial to the desired pressure. To lock in the value, press the nob back into the tower until you hear the click.

*Always be sure to do a safety check before using the printer!



Preparing your Print: Cartridge Assembly

Step One

Nordson Syringes: Gather the appropriate plunger cap, syringe, valve and tip (left to right).

Step Two

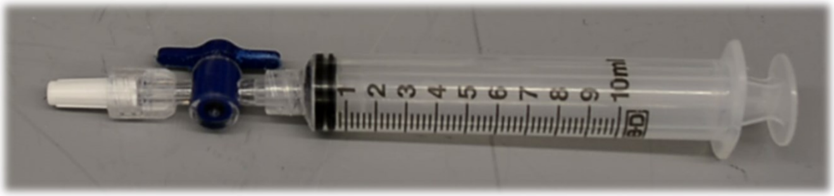
Load material into the syringe barrel from the back. Try to avoid introducing air bubbles, as they will degrade print quality.

Step Three

Push plunger into syringe and remove any air from barrel by pushing manually. Assemble items from step one, open valve and push until material comes out the tip.

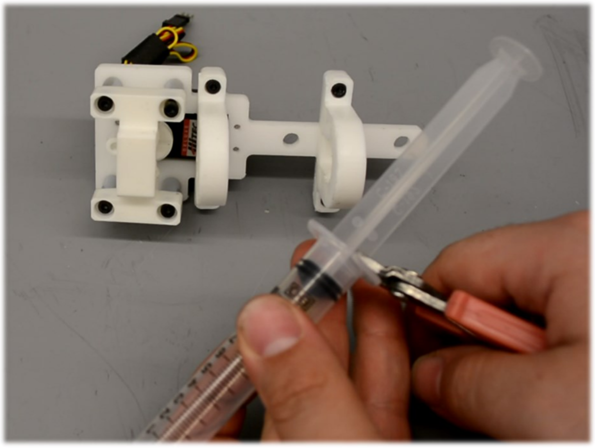
Preparing your Print: Cartridge Assembly

Becton Dickenson 10cc Syringes



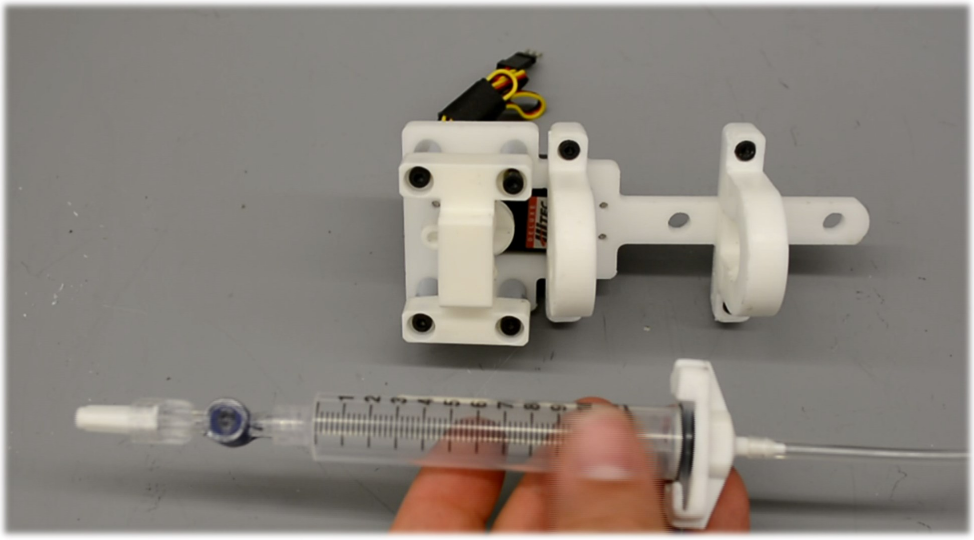
Step One

Gather the valve (cap installed), BD 10cc syringe (plunger all the way up) and tip.



Step Two

Pull back the syringe plunger and cut the plunger with pliers. Fill with material and manually prime.



Step Three

Install the pressure cap. This may require moderate force. To install, put cap onto syringe back, and twist the cap on so it holds the syringe snugly. Be sure the pressure line is securely connected to both the cap and the air supply.

List of compatible disposables and suppliers

*Each tool head is different. Please use the syringe barrel which corresponds to the tool head(s) you have on your printer.

Item	Where to Find
55cc Non-sterile Syringe	Nordson EFD
30cc Non-sterile Syringe	Nordson EFD
10cc Non-sterile Syringe	Nordson EFD
Taper Tips (assorted sizes)	Nordson EFD
10cc Becton Dickenson Syringe	Becton Dickenson
Replacement Pressure Cap	Nordson EFD or Seraph Robotics for BD Caps

*Please carefully monitor the pressure used and take necessary safety precautions when working with syringes under pressure to avoid serious injury or death. Seraph makes no representations or warranties about the suitability of these syringes for use in our printers. Please independently evaluate the risks and needed safety precautions.

Web addresses

Company	Website
Nordson EFD	http://www.nordson.com/en-us/divisions/efd/products/optimum-components/pages/
Becton Dickenson	http://www.bd.com/
Seraph Robotics	www.seraphrobotics.com
Distributor (Becton Dickenson)	http://www.coleparmer.com/Category/BD_Disposable_Sterilized_Syringes/15116

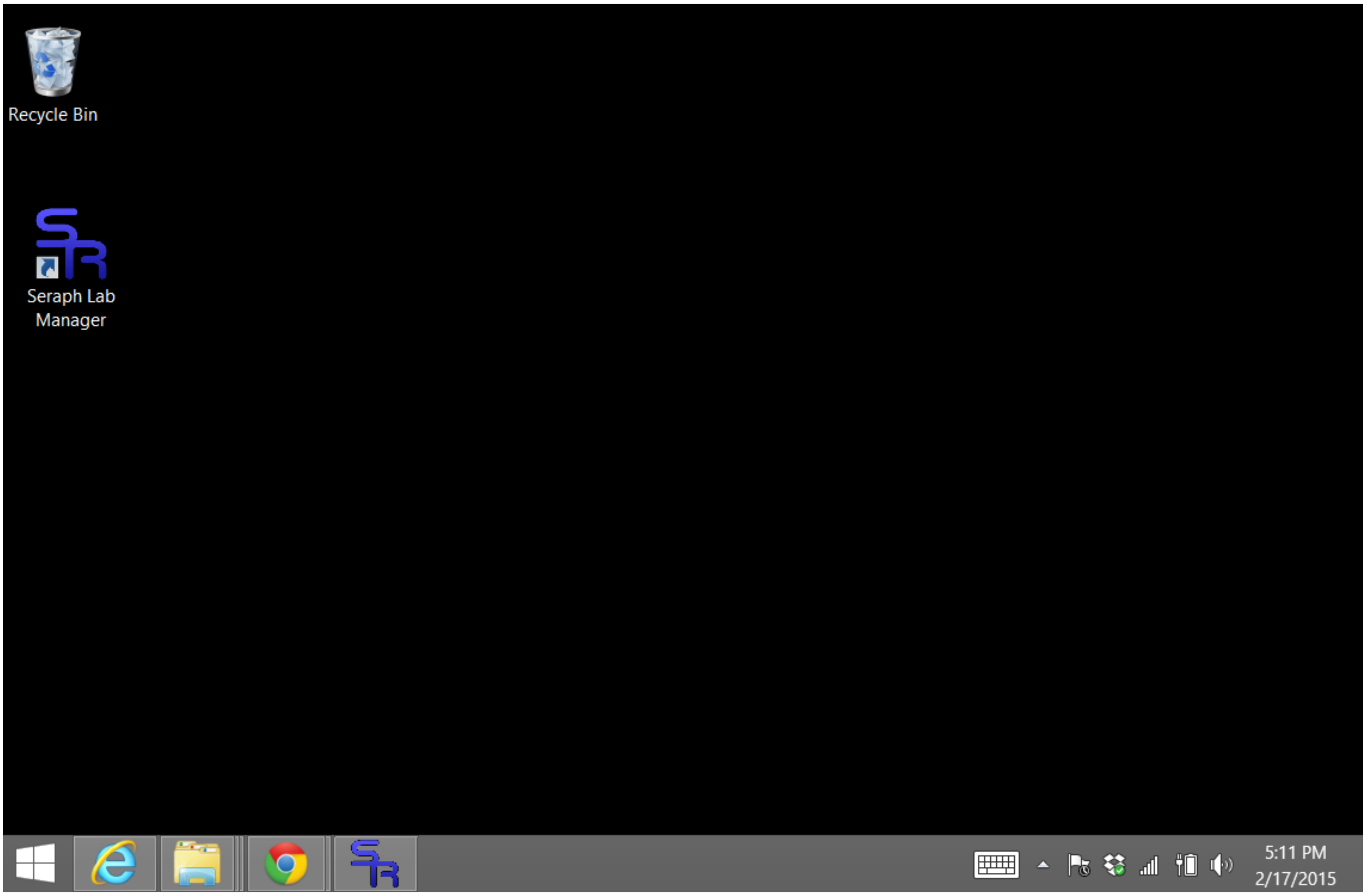
Software Guide

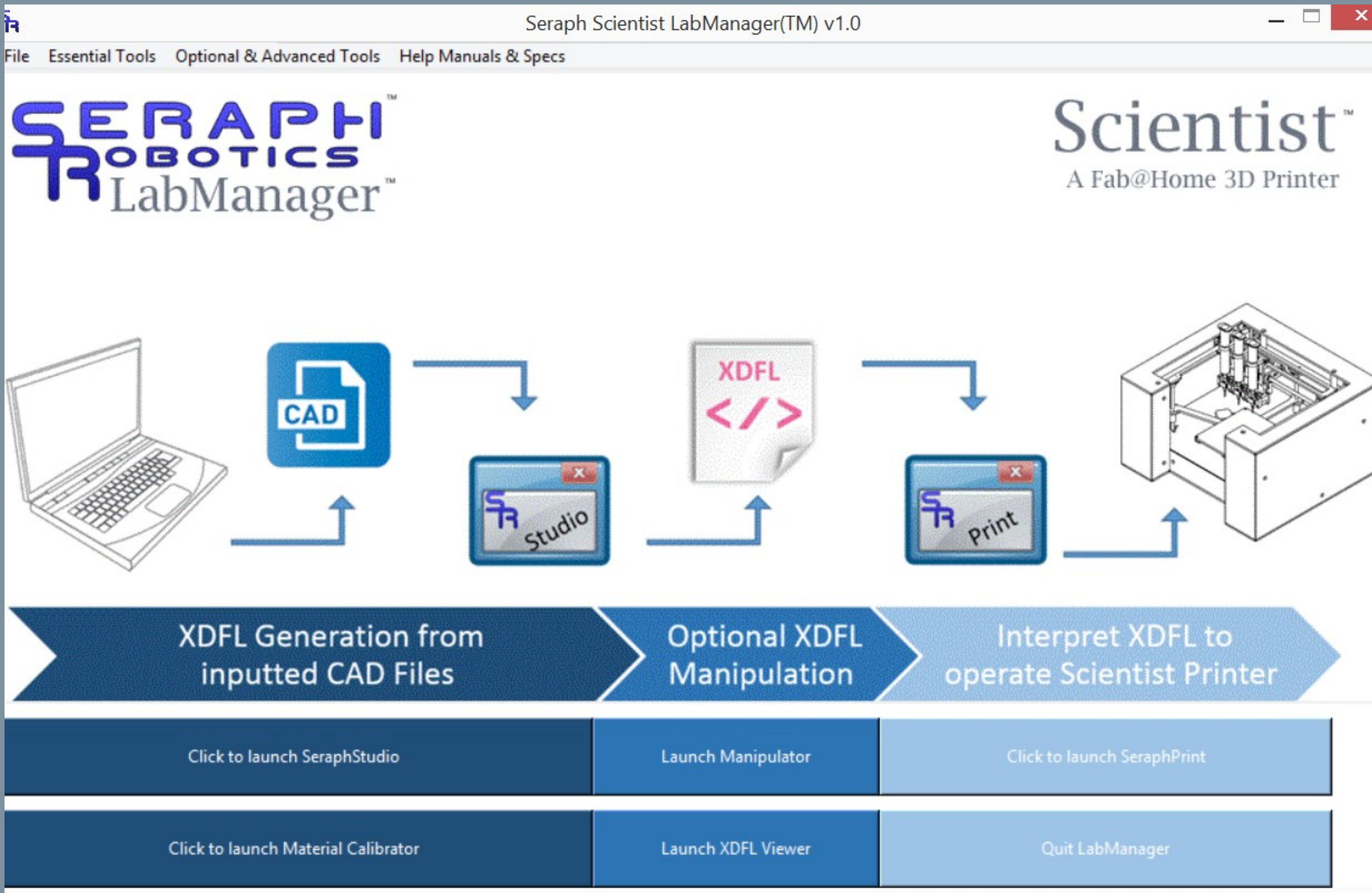
Installation Instructions

Visit the provided web link

Or scan this QR Code to download our software.

Double click the installer and then the SR icon to launch Lab Manager ™





With the Scientist™ , Seraph introduces Lab Manager™ , our centralized 3-D printing control suite. Use the Lab Manager flow chart to guide your 3-D printing experiments from computer concept to printed reality.

Begin by using the Calibrator ™ tool to calibrate your material and generate a "tool script" file unique to that material's settings.

Then, launch SeraphStudio ™ to import STL files for processing.

For most users, the easy-to-use, advanced features of **SeraphStudio**™ will provide all of the tools they need to conduct both simple and complex 3-D printing procedures. However, for more advanced users, Seraph introduces **Manipulator**™ which allows for the batch combination and editing of multiple processed STL files (XDFL files).

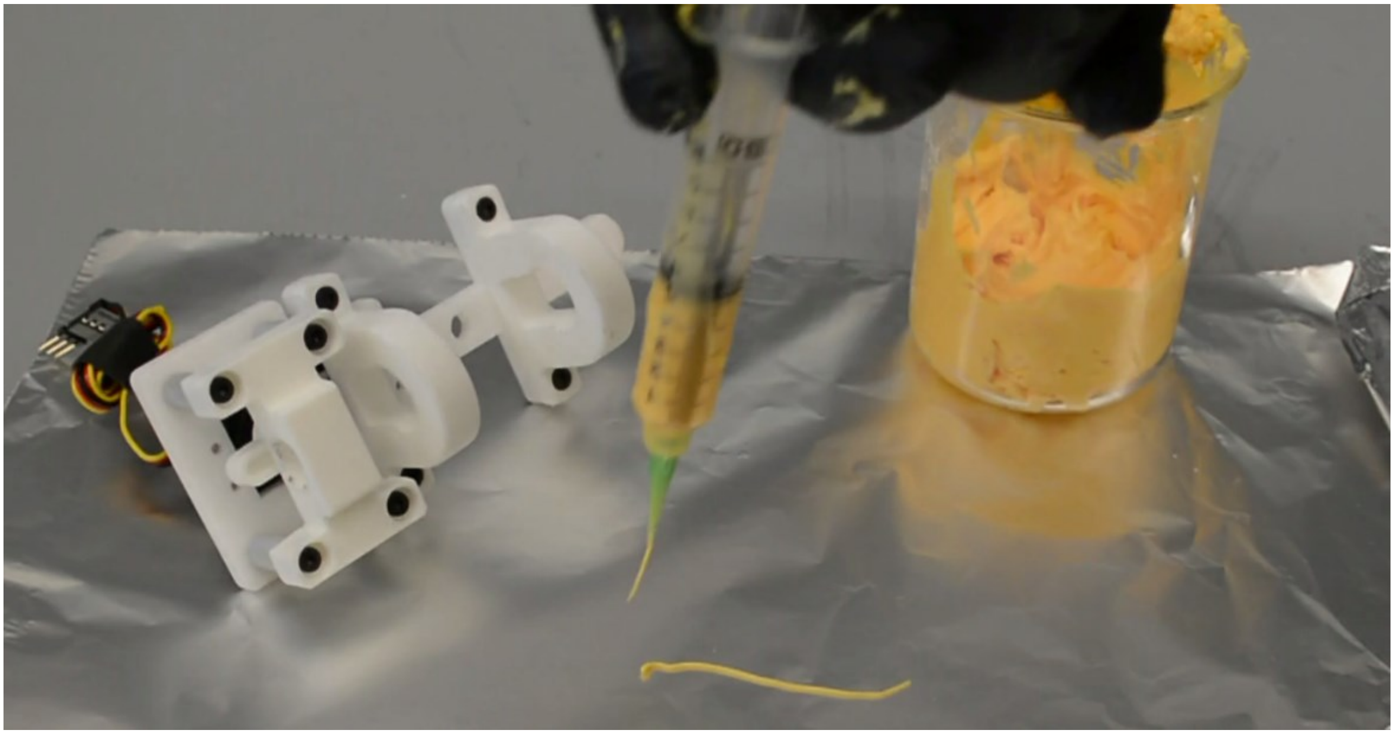
If you've created a complex printing job and would like to view a digital representation of the past the printer tool head will follow, launch the **XDFL Viewer** to scroll through the various layers in your print job.

Whether you create the print job file right from SeraphStudio or you further process it with Manipulator, launch **SeraphPrint** ™ to connect to the Scientist and load your print job.

Even though we think we've thought of nearly every possible tool you might wish to use to modify the XDFL printer instructions, the unique design of Seraph Print allows you to print any XDFL file, regardless of whether was originally generated in SeraphStudio. With this feature, advanced users can write their own XDFL manually or using custom software. We encourage users choosing this option to contact us to let us know what you've come up with!

Calibration Guide

Will it print?



If you can manually extrude the material, and it passes the test of:

1. Being extruded through the syringe
2. Creating lines that hold their shape and
3. can be stacked,

it is probably going to work. If it doesn't work right away, you may need to chemically or physically modify the material by adding an additive or by using temperature or UV accessories.

Theoretical Basis for Calibration and 3D Printer Operation.

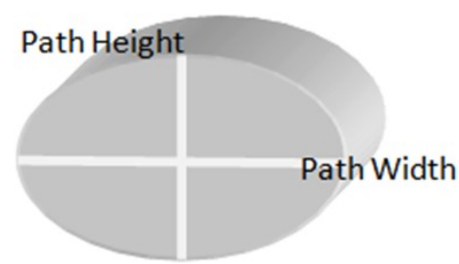
Calibrating a new material

All new materials will need to be calibrated for the size fo the nozzle used, the materials properties, and sometimes different environmental factors. It is important to keep in mind how the printer operates when calibrating a material. The printer lays down a bead that can thought of as having a height (PathHeight Ph) a width (PathWidth Pw) and a length D. This is done in a set time t.

Since $Volume = Width * Height * Distance * constant$ for extruded prisms. We can write an equation $Q = \frac{Vol}{t} = A_c * P_w * P_h * \frac{d}{t} = A_c * P_w * P_h * P_s$ where $P_s$is the path speed. Ideally the tool head would balance out this mass flow equation and deliver the exact amount of material as needed. However printed materials often have non-linear fluid properties and can be compressible. Therefore we need a “Compression Volume” term that can account for the need of the print head to charge up at the beginning of a deposition and decompress at the end. General the path width and height are measured imperially for a material flow rate and nozzle size. Often the dimensions are very close to the nozzle diameter. From there you can calculate the volume per unit length of material and get the Area Constant. Then you fix the path speed to match the flow rate you had established. This may require some iteration to get right. To add the calibration to Seraph Studio you will need the following steps:

$$\frac{Vol}{Sec} = PathWidth * PathHieght * AreaConstant * PathSpeed$$

$$Cross\ Section = AreaConstant * PathWidth * Path\ Height$$



Calibration

Valve Tool Instructions

The steps for calibration using Calibrator™ and the valve tool can be summarized in these steps:

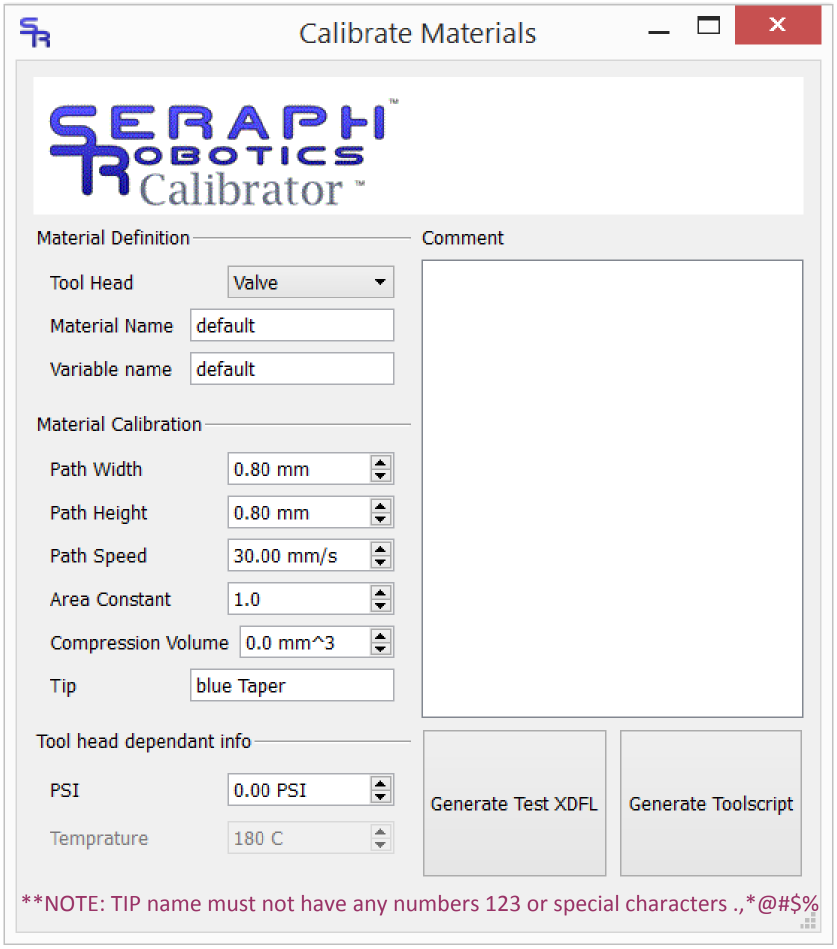
1. After successfully manually testing material, connect the syringe to the pressure source, but don't load into the printer. If you do load it into the printer, be sure to use the controls on SeraphPrint™ to open the valve. Otherwise, hold the syringe barrel and slowly increase pressure. After you've found a "sweet spot" pressure that seems to give a nice material flow out of the tip, record the PSI reading. This is an art, but not a terribly difficult one. Watch some of our demo videos if you want to get an idea of how good flow should look.

2. Launch LabManager™ and select Calibrator ™. Provide the material name (you can reuse the name in multiple calibrations and a unique "variable name' to identify this calibration.

3. Input your best guess for initial settings. You can manually extrude some lines of material and measure them with calipers to get starting path width/height.

4. The valve tool requires accurate path height and width to calibrate the print file appropriately. Choose a print speed that is appropriate. Start with 30mm/s and move up slowly, as needed. Area constant and compression volume should remain at their default 1.0 and 0.0 mm^3 values.

5. Generate a Test XDFL file and make sure to name it with the "filename.**xdfl**" syntax. Load into Seraph Print and the test file will extrude a line which you can measure again to more accurately configure the material.



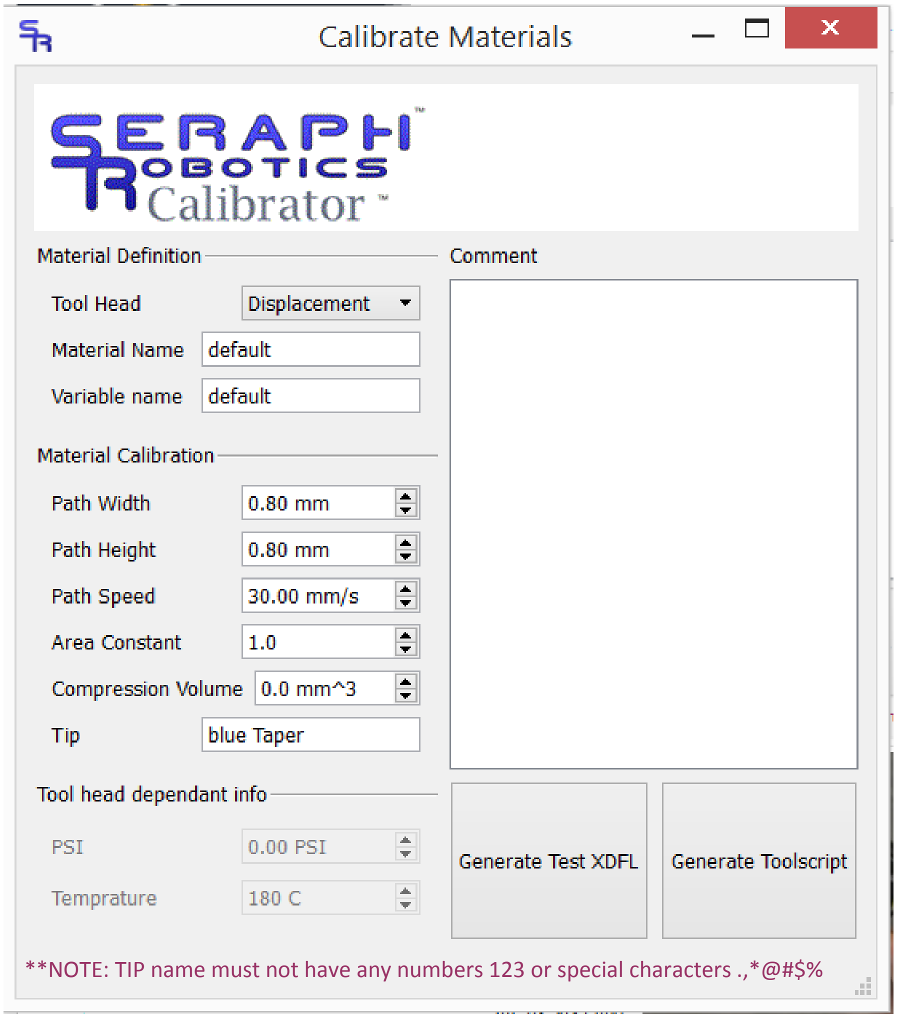
6. When you are happy with the correlation between the input values and printed values, click Generate ToolScript and save the tool script in the Seraph Studio system directory on your computer. Make sure the syntax is "filename.**xml**"

7. Load a Test Cube in SeraphStudio™ using the ToolScript to create the XDFL and send outputted XDFL to SeraphPrint™ to ensure you're happy with your results. (You may try a more complex print first, if you choose, but we don't recommend it. If the first couple layers of the test print go well, you can always cancel it. The idea is to try stacking the material with an easy print of a geometry that is known to print well, a cube being a great shape.)

****Always be aware of safety when working with pressurized items—you are always responsible for your own actions and we make no warranties or representations as to the suitability of 3rd party syringes for use with your materials or our printers.*****

Calibration

Displacement Tool Instructions



The steps for calibration using Calibrator™ and the displacement tool can be summarized in these steps:

1. After successfully manually testing material, install the syringe the printer. Be sure to use the controls on SeraphPrint™ to prime the tip.
2. Launch LabManager™ and select Calibrator ™. Provide the material name (you can reuse the name in multiple calibrations and a unique "variable name' to identify this calibration.
3. Input your best guess for initial settings. You can manually extrude some lines of material and measure them with calipers to get starting path width/height.
4. The displacement tool requires accurate **path height and width** to calibrate the print file appropriately. Choose a print speed that is appropriate. Start with 30mm/s and move up slowly, as needed. **Area constant** should remain at its default 1.0 , but can be used for quick adjustments to the flow equation, if desired. The and **compression volume** is the amount of "extra push" needed to compress the material to start its flow from standstill. The default value is 0.0 mm^3 , and can be adjusted up for viscous materials.
5. Generate a Test XDFL file and make sure to name it with the "filename**.xdfl**" syntax. Load into Seraph Print and the test file will extrude a line which you can measure again to more accurately configure the material.
6. When you are happy with the correlation between the input values and printed values, click Generate ToolScript and save the tool script in the Seraph Studio system directory on your computer. Make sure the syntax is "filename**.xml**"

7. Load a Test Cube in SeraphStudio™ using the ToolScript to create the XDFL and send outputted XDFL to SeraphPrint™ to ensure you're happy with your results. (You may try a more complex print first, if you choose, but we don't recommend it. If the first couple layers of the test print go well, you can always cancel it. The idea is to try stacking the material with an easy print of a geometry that is known to print well, a cube being a great shape.)

Calibration

Filament Tool Instructions

The steps for calibration using Calibrator™ and the plastic filament tool can be summarized in these steps:

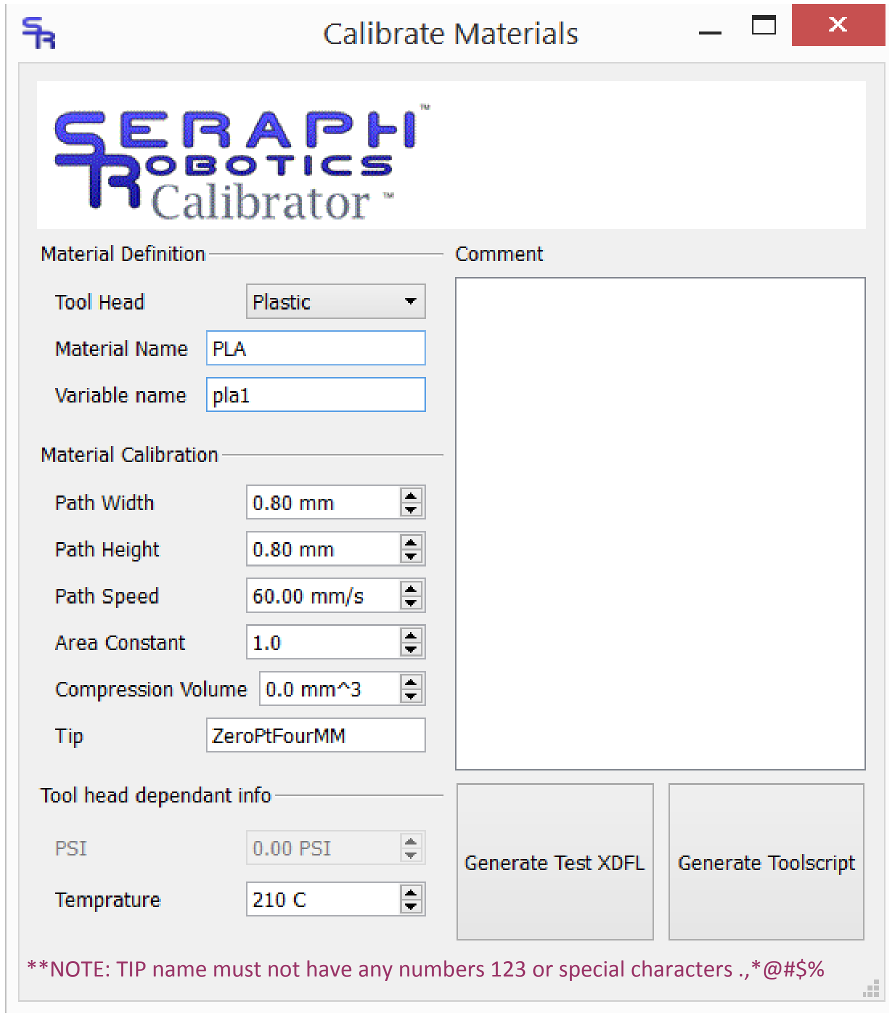
1. Load the filament into the tool according to the instructions in this document. Read those instructions before calibrating any materials with the steps below.

2. Launch LabManager™ and select Calibrator ™. Provide the material name (you can reuse the name in multiple calibrations and a unique "variable name' to identify this calibration.

3. Input your best guess for initial settings.

4. The filament tool requires accurate path height and width to calibrate the print file appropriately. A guideline is that a 0.4mm tip would have a starting guess of a 0.4mm path width and a 0.2mm path height. Choose a print speed that is appropriate. Start with 60mm/s and move up slowly, as needed. Area constant and compression volume should remain at their default 1.0 and 0.0 mm^3 values. It is critical that you input a **temperature.** Each material is different and you may need to tweak this value. A guide is that PLA usually prints at 180-210C, ABS prints around 230C and Nylon prints around 270C. Please note that temperatures above 280C may damage the tool head or melt it. Always supervise printer and do safety checks!

5. Generate a Test XDFL file and make sure to name it with the "filename**.xdfl**" syntax. Load into Seraph Print and the test file will extrude a line which you can measure again to more accurately configure the material.

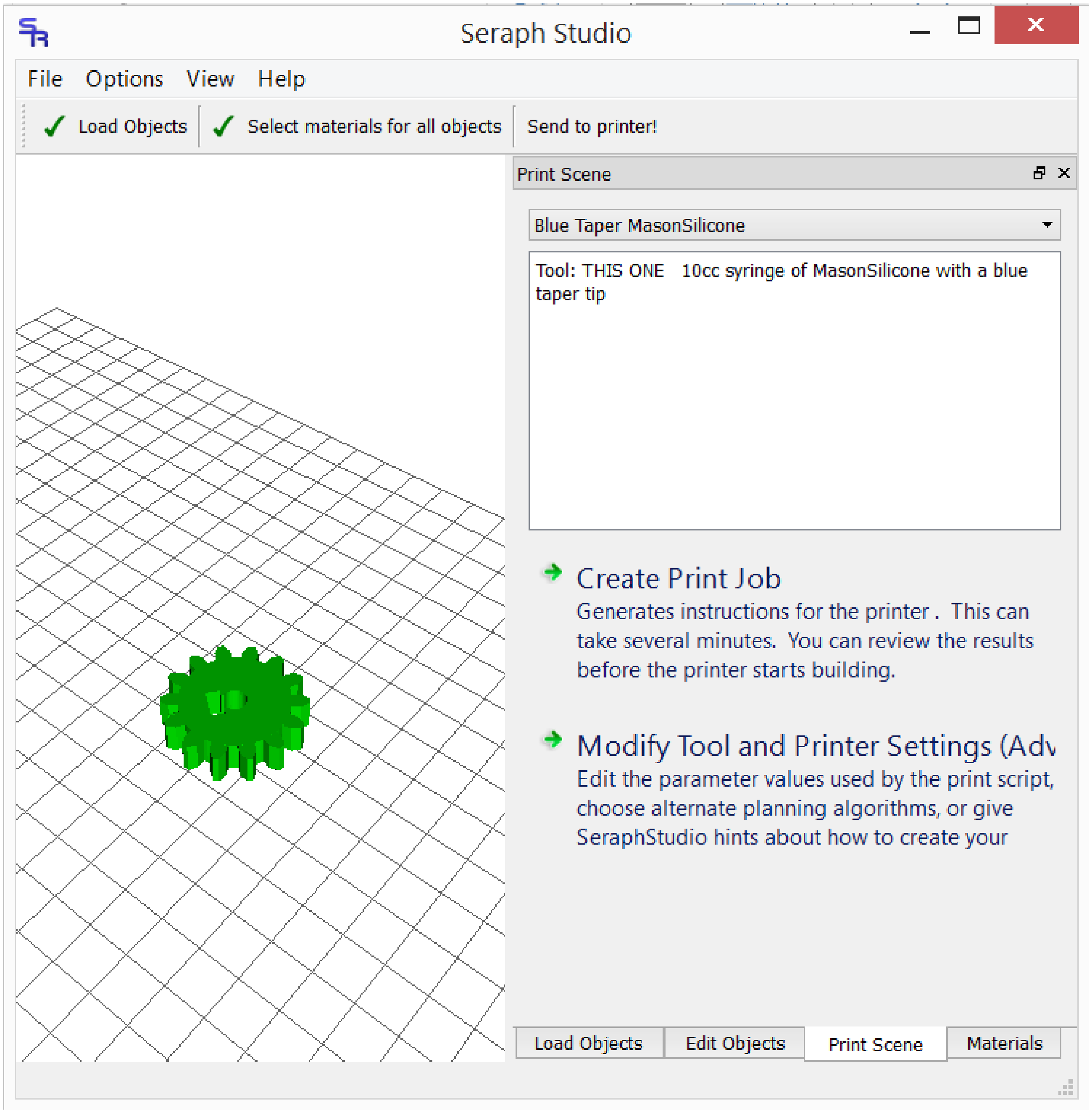


6. When you are happy with the correlation between the input values and printed values, click Generate ToolScript and save the tool script in the Seraph Studio system directory on your computer. Make sure the syntax is "filename**.xml**"

7. Load a Test Cube in SeraphStudio™ using the ToolScript to create the XDFL and send outputted XDFL to SeraphPrint™ to ensure you're happy with your results. (You may try a more complex print first, if you choose, but we don't recommend it. If the first couple layers of the test print go well, you can always cancel it. The idea is to try stacking the material with an easy print of a geometry that is known to print well, a cube being a great shape.)

****Always be aware of safety when working with heated items—you are always responsible for your own actions and for inspecting the printer for safety*****

Calibration Guide

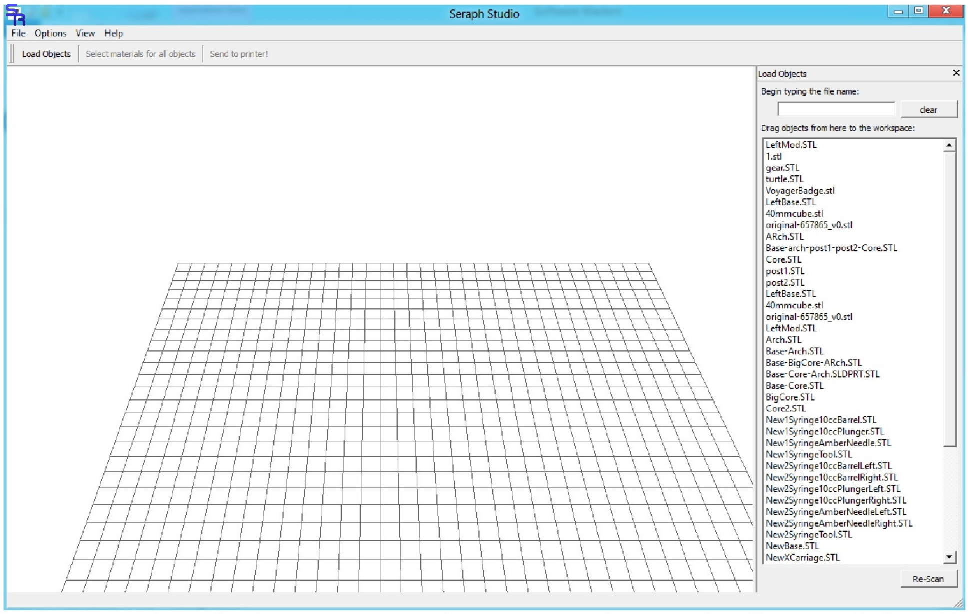


The tip name, comments, and PSI settings you input in calibrator will appear in Seraph Studio when you load the print scene of a calibrated material for which you have generated and used a toolscript.xml file saved in the appropriate directory.

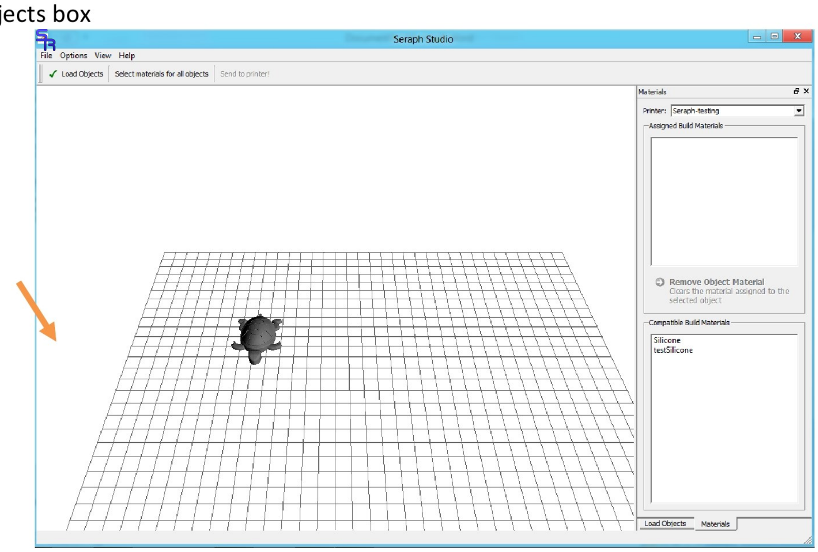
Use Seraph Studio to Process STL files created in your CAD software of choice into XDFL files, specialized files containing instructions for the 3D Printer. (See XDFL Guide to understand how XDFL works and how you can by pass SeraphStudio to write your own XDFL code to control the Scientist, if you wish.)

SeraphStudio

Load Objects

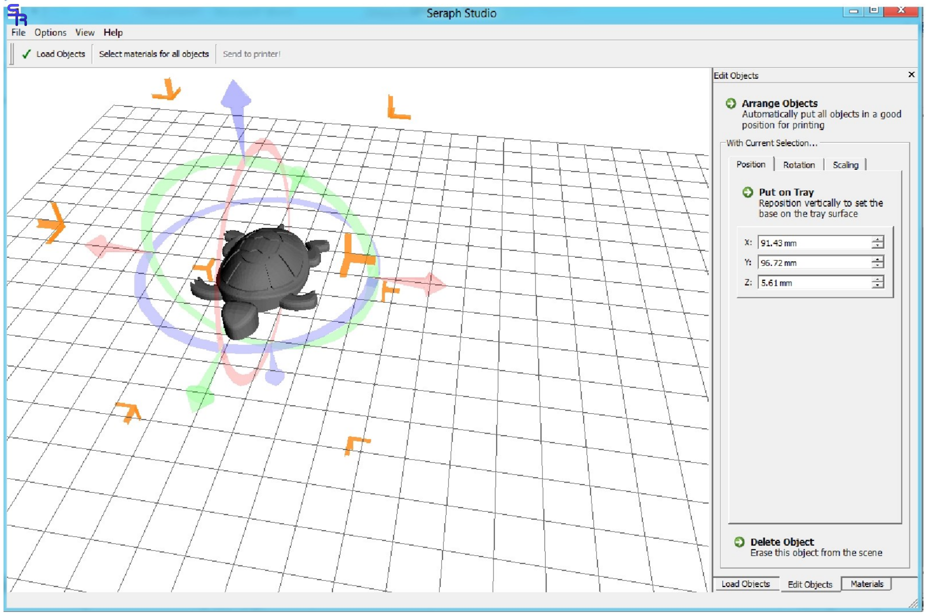


Upon opening Seraph Studio the program searches your User directory for all STLS and places them in the load objects box



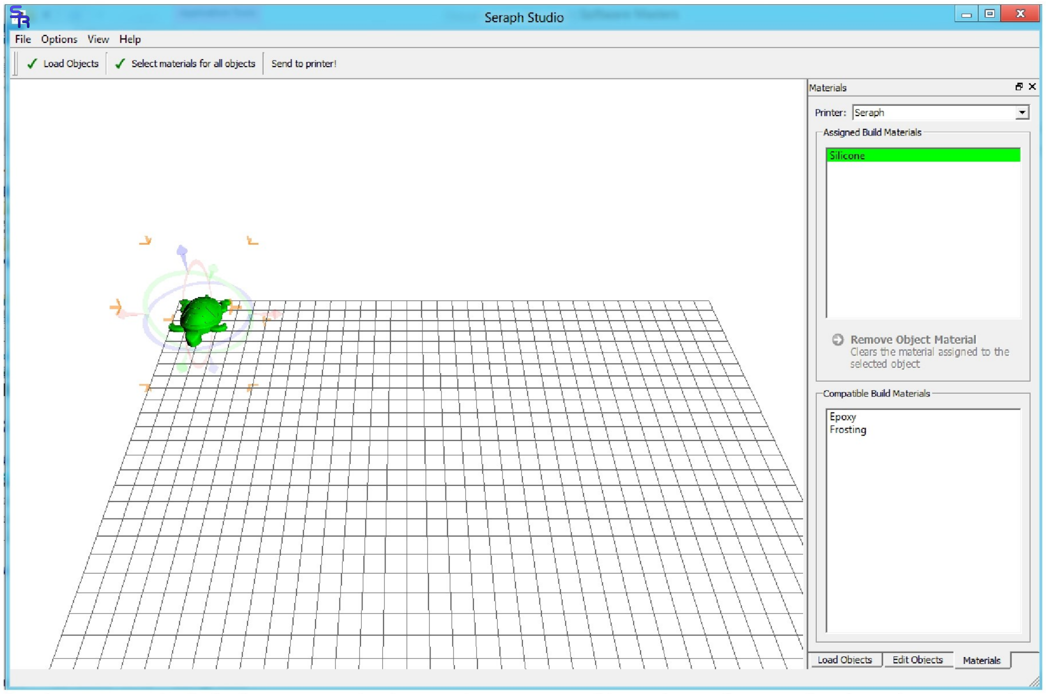
Drag and drop the design into the scene it will appear along with the graphic controls. Dragging and object into the scene will cause the program to switch to the “select material” state, and the materials list will appear. The arrow points to the origin of the scene. You can zoom by holding down the right click button and moving the mouse forward and backward. To rotate views, right click and move the mouse left and right

Edit Objects



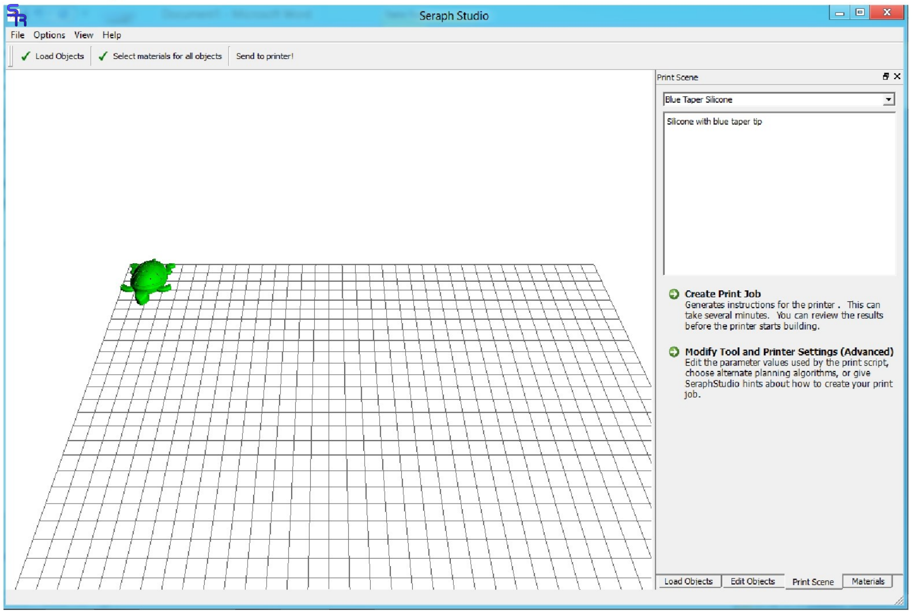
The rings on the visual control allow you to rotate the object by 90 degree increments. The arrows allow you to move the object; the corner markers allow you to scale the object. When you grab the object it will bring the edit objects tab up.

Select Materials

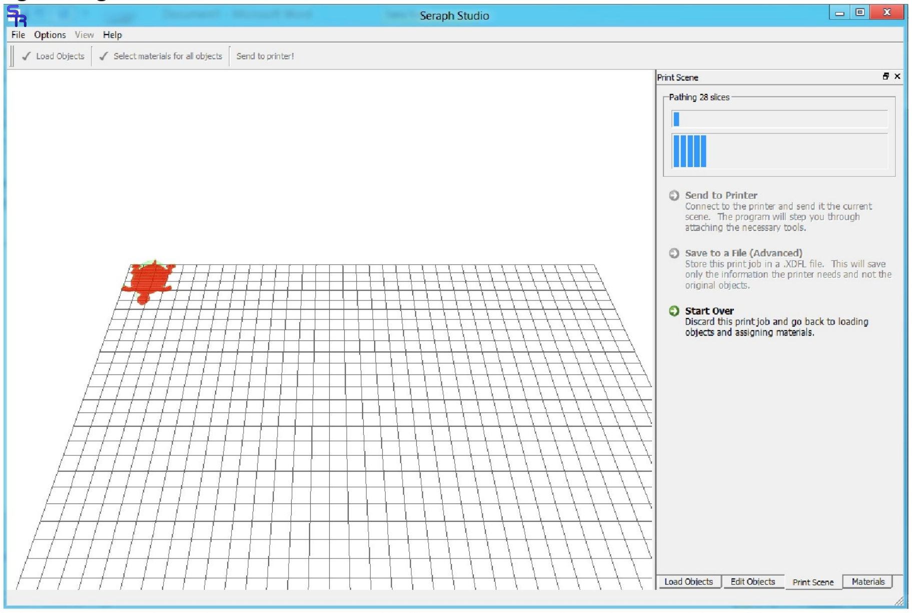


To load a material, click the material tab or Select Material breadcrumb. Use the dropdown to select the type of tool head and printer you're using to filter the material options. Drag and drop the material to the object. This will cause the object to colorize. It will also allow you to see what other materials can be printed with the selected material.

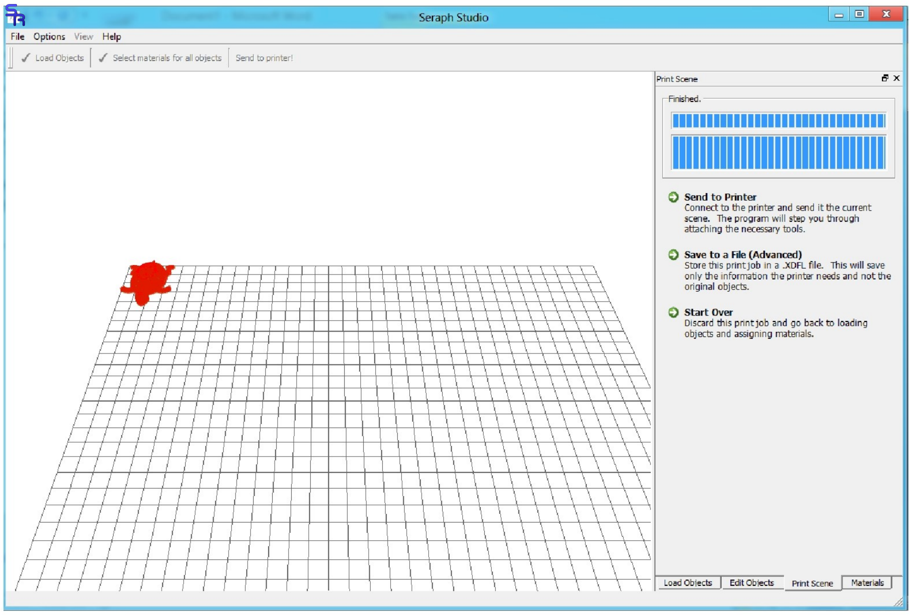
Generate Print Job



Hit Send To printer to bring up the bring screen tab. This will allow you to set the resolution and other settings by selecting the script form the drop down menu. You can then create the print job or modify the pathing setting.



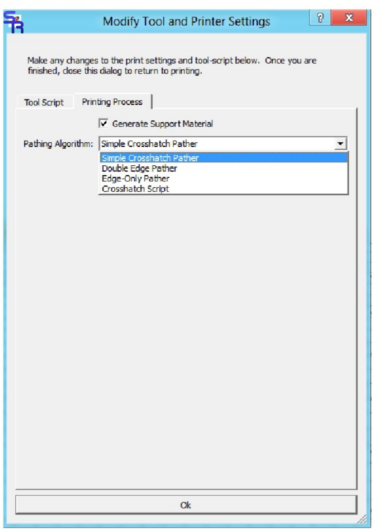
When the hit create print job, the system will slice and path the object. This will cause it to path the object. Paths show up as red lines.

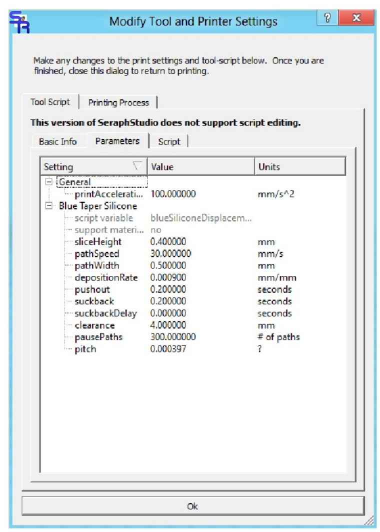


Once pathed, you can either send it to the printer, or save to a file. We recommend saving the print for later. If you don't see the save to file option, please enable advanced features under options Congrats, you have made your first print job.

Once saved you will need to use SeraphPrint to control the printer.

ADV features

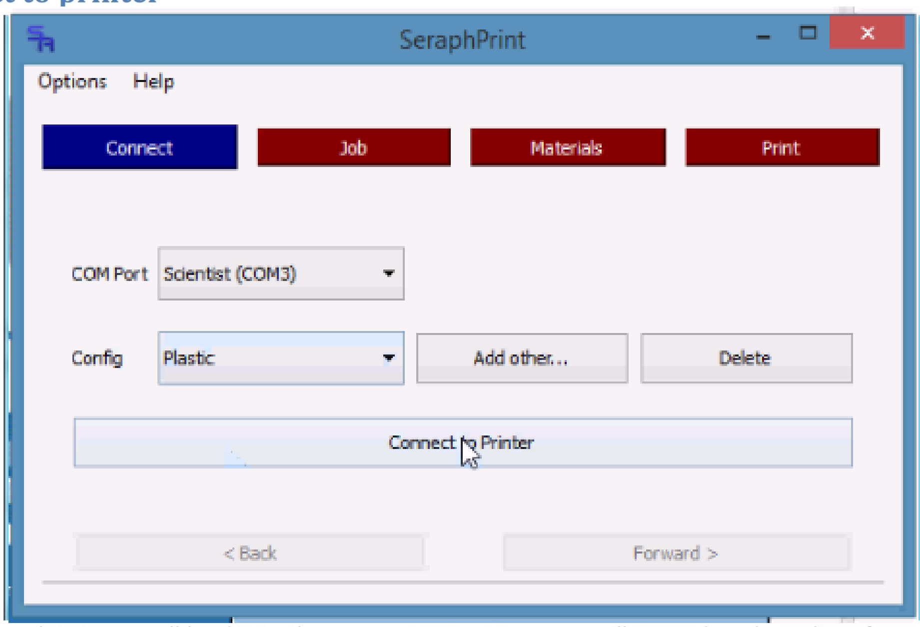




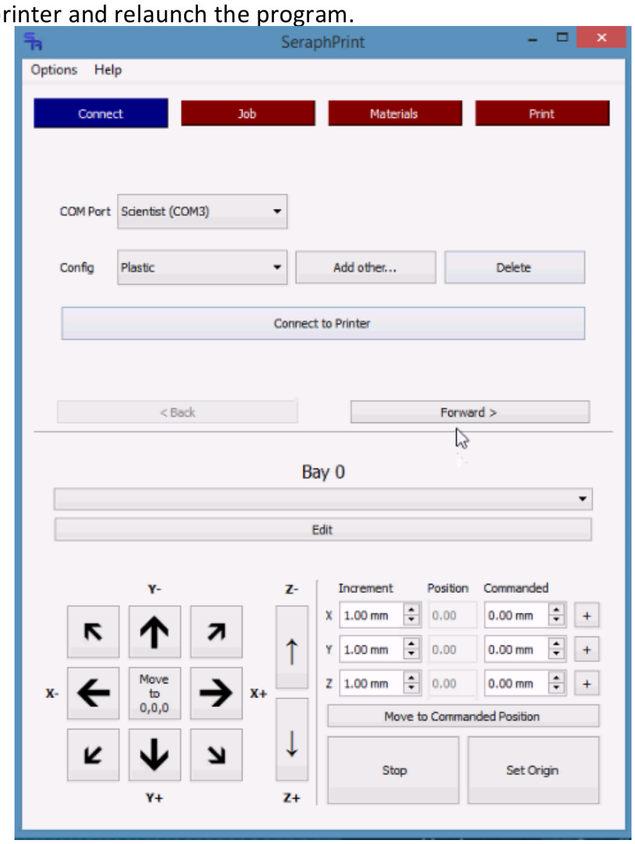
The modify tool and printer settings allows you to select the pather used and if support material is generated. The edge pathers create outlines of the object. Simple Crosshatch script generates an object with double walls and a crosshatch. The crosshatch script only uses a crosshatch to fill the object. You can also review the settings of the toolscript.

Seraph Print

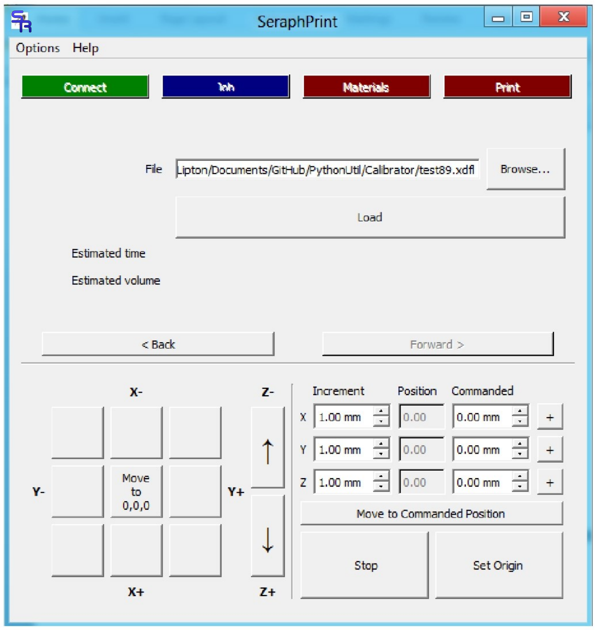
Connect to printer



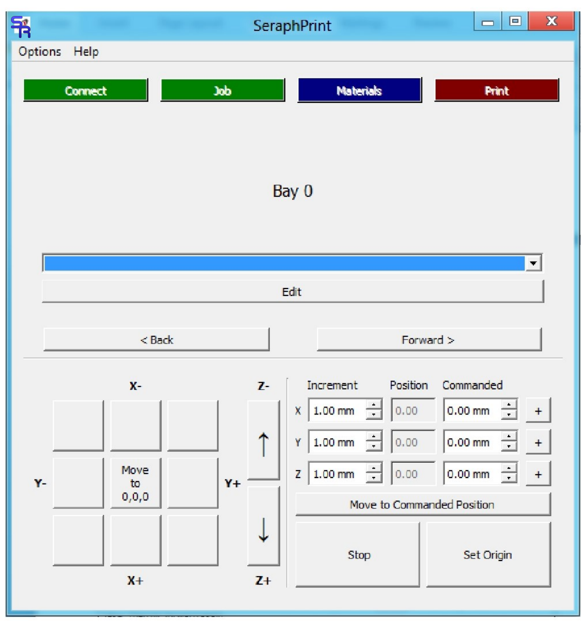
Open Seraph Print. It will load into the connect state, Here you will see a dropdown list of ever available machine. The comport of the machine will be listed. You will need to have the FTDI VCP drivers installed for your operating system. The list of previously added configs will also be available. If you don't see any configs, hit add other to find a printer config file. If you cant see a comport, make sure that the hub is plugged in an turned on, and that the drivers are installed. Once you have selected the machine and config, hit connect to printer. Should it fail to respond after 3 seconds. Cycle the power of the printer and relaunch the program.



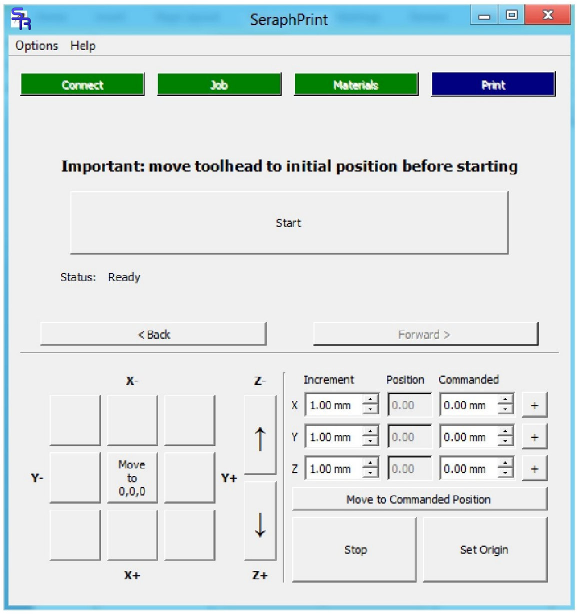
Once connected, the machine interface should appear. You can use the arrows plus up page and down page to jog the head. You can adjust the jog increment, and hit the plus arrow to adjust the speed



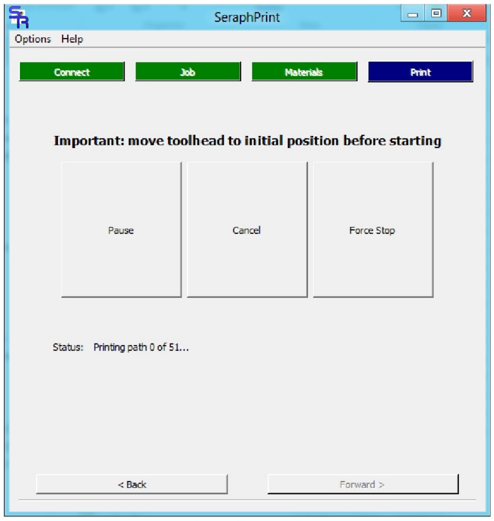
Hit forward and you are brought to the load file stage. You can load the last file by hitting load, or you can browse for the print file. Once loaded you will be given and estimate on how long the print should take. Then hit forward again.



In the materials stagem you can select which print material In the job is in which bay. You can jog the bay motor by hitting edit and using the popup dialog. Once the material is loaded hit forward



Before you start to print, job the print head so that the tip of the bay just touches the build surface. Once there, hit Set Origin. This will set that location as 0,0,0 for the print job. Hit start and the print will begin



Once the print is started you can pause, cancel or forcible stop the print. IF you forcibly stop the print, the program will crash and the machine will freeze. Only use this for emergencies. Pausing will cause the machine to finish the current path and then wait for your instruction to resume. Canceling will finish the path and quit printing, returning you to the load file stage.

XDFL User Guide

eXtensible Digital Fabrication Language

Overview

XDFL is the command language for the Fab@Home system. It is designed to allow for quick modification of calibrations. XDFL is generated from STL files by the SeraphStudio^{TM} program. The SeraphStudio program uses information contained in tool script files to process the geometry into the XDFL. The SeraphPrint^{tm} system converts the XDFL commands into motions the machine will execute. The code that converts the commands into movements in contained in the printer configuration files. Each bay for each tool head contains a JavaScript file that tells the system how to respond to XDFL commands. The XML structure allows the system to be edited by hand and by computer programs. Almost all programming languages have readily accessible libraries for reading and writing XML documents. The SeraphPrint program is case insensitive so it is possible to use any case when developing an XDFL file.

```
<!--?xml version="1.0" encoding="UTF-8" standalone="yes"?-->
<xdfl>
    <palette>
        <material>
            <id> </id>
            <name> </name>
            <pathwidth> </pathwidth>
            <pathheight> </pathheight>
            <pathspeed> </pathspeed>
            <areaconstant> </areaconstant>
            <compression> </compression>
            <pathwidth> </pathwidth>
        </material>
    </palette>
    <commands>
            <path>
                <materialid> </materialid>
                <point> </point>
                    <x> </x>
                    <y> </y>
                    <z> </z>
            </path>
    </commands>
</xdfl>
```

Structure

The first line in an XDFL file is an XML declaration. It sets the XML version and encoding standard for the characters. The seconds line in the root tag of the file. The root tag is always “xdfl”. The xdfl tag has two children, the “pallete” tag and “commands” tag. The pallet contains the calibration information for each material. The commands contain the deposition paths and the non-deposition paths for a print job. The system will execute the commands in order, so positioning of the commands matters for the file.

```
<?xml version="1.0" encoding="UTF-8" standalone="yes" ?>
<xdfl>
<Palette>
        <material >
                <name>silicone</name>
                <id>1<id>
                <PathWidth>2</PathWidth>
                <PathHeight> 4</PathHeight>
                <PathSpeed > 3</PathSpeed>
                <AreaConstant > 1</AreaConstant>
                <CompressionVolume>10</CompressionVolume>
                <property>
                        <name>conductivity</name>
                        <value units = "siemens">1</value>
                </property>
        </material>
</Palette>
<commands>
        <Path>
                <materialID>1</materialID>
                <Point >
                        <x>1</x>
                        <y>2</y>
                        <z>3</z>
                </Point>
                <Point  >
                        <x>2</x>
                        <y>2</y>
                        <z>3</z>
                </Point>
                .......
        </Path>
        <path>
                ......
        </path>
</commands>
</xdfl>
```

Figure 1: The Layout of a XDFL File.

Pallet

The Pallet contains all of the information needed for each material to ensure the machine can extrude the material. The opening tag is a “palletE” tag. Each material calibration is given its own tag “material” This tag contains and id tag and a name tag. The name lists the materials name for use by human identification. The id tag contains a locally unique ID for the calibration. The paths will reference the id number.

The system operates on the basis of balancing the volumetric flow of material from a tool head. Each path has a height, width and cross sectional area. These paths are traversed at set speeds. This leads to a required volumetric flow rate (Q). The SeraphPrint system extrudes material from the tool head to match the material required for the path. Since no tool head is without the need for priming, and some materials are compressible, the material also need to list a compression volume. This is the volume the system will “extrude” before a path and suckback after a path. The system uses mm for distance, seconds for time, and mm^3 for volumes

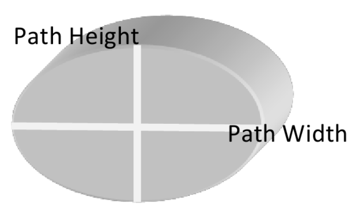
As a result of these requirements, each material must have the following tags:

- name
- id
- PathWidth
- PathHeight
- PathSpeed
- AreaConstant
- CompressionVolume

$$\frac{Vol}{Sec} = PathWidth * PathHieght * AreaConstant * PathSpeed$$

$$Cross\ Section = AreaConstant * PathWidth * Path\ Height$$

(a)



(b)

Figure 2: The equations governing XDFL path flow rates (a), and a diagram of a given path (b)

Commands

The commands section is a list of paths the system will move along and voxels that the system will deposit. Paths are the most common form of deposition and the only form generated by SeraphStudio.

Paths

These paths are executed in the order in which they appear in the file. There are two types of paths, deposition paths, and movement paths. Both paths contain a series of points that define the line segments the machine will move along. Each point contains a tag of x,y and z which defines the location in space of the point. Deposition paths contain a “materialid” tag that has an integer which references the id of a material in the pallet. This reference defines the speed along which the path will be moved and tells the system to extrude material. Movement paths contain a “speed” tag that defines how quickly the system will move along the path. Movement paths are often used to create a movement clearance to prevent the tool head from intersecting the printed object when moving from section to section.

```
<path>
  <speed>30</speed>
  <point>
    <x>0.0</x>
    <y>0.0</y>
    <z>0.0</z>
  </point>
  <point>
    <x>0.0</x>
    <y>0.0</y>
    <z>10.0</z>
  </point>
  <point>
    <x>10.0</x>
    <y>10.0</y>
    <z>10.0</z>
  </point>
  <point>
    <x>10.0</x>
    <y>10.0</y>
    <z>1.0</z>
  </point>
</path>
```

(a)

```
<path>
  <materialID>1</materialID>
  <point>
    <x>0.0</x>
    <y>0.0</y>
    <z>1.0</z>
  </point>
  <point>
    <x>0.0</x>
    <y>10.0</y>
    <z>1.0</z>
  </point>
  <point>
    <x>10.0</x>
    <y>10.0</y>
    <z>1.0</z>
  </point>
  <point>
    <x>10.0</x>
    <y>0.0</y>
    <z>1.0</z>
  </point>
  <point>
    <x>0.0</x>
    <y>0.0</y>
    <z>1.0</z>
  </point>
</path>
```

(b)

Figure 3: The paths are the children of the commands tag. There are two types. A movement path (a) and a deposition path (b)

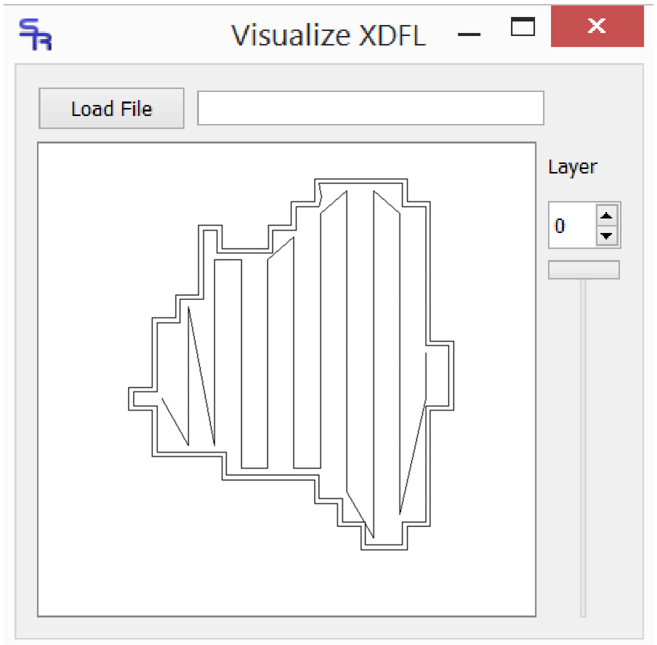
Voxels

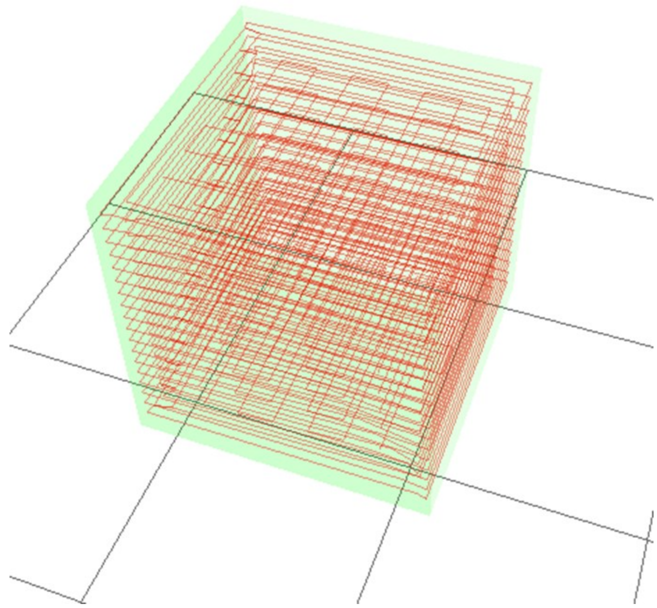
Voxels extrude a single material at a point. They are children of the commands node and list the location, volume and material to be extruded.

```
<voxel>
        <materialID>1</materialID>
        <volume units = "mm^3">20</volume>
        <x>0</x>
        <y>0</y>
        <z>1</z>
</voxel>
```

Figure 4: a Voxel tag that extrudes 20 mm^3 of material at 0,0,1

Visualize XDFL Paths





Use the visualizer to load an XDFL file and scroll through its layers. Within each layer, the individual paths the printer will follow are shown. This tool will help you design printing experiments as well as verify the pathing of a processed STL file or custom XDFL file to ensure there are no errors.

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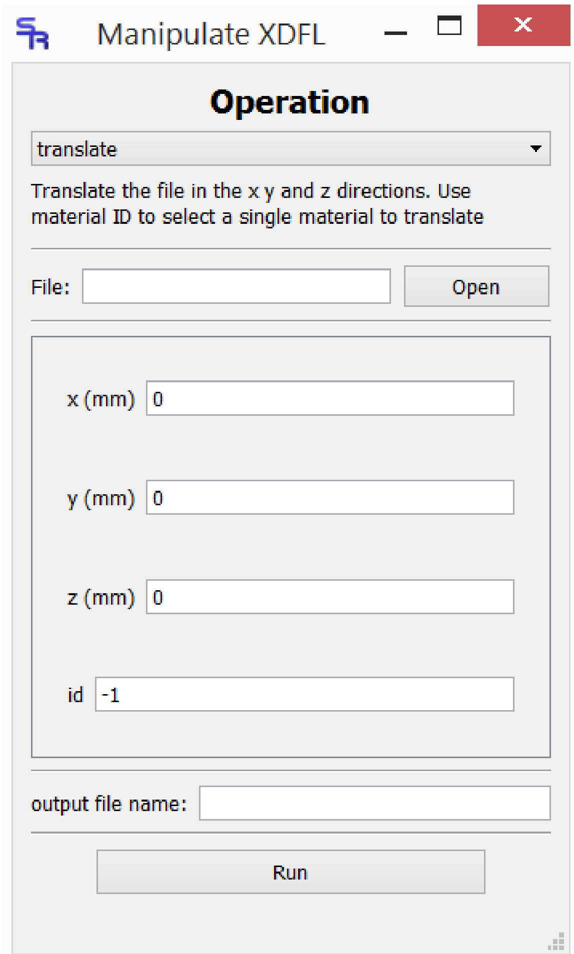
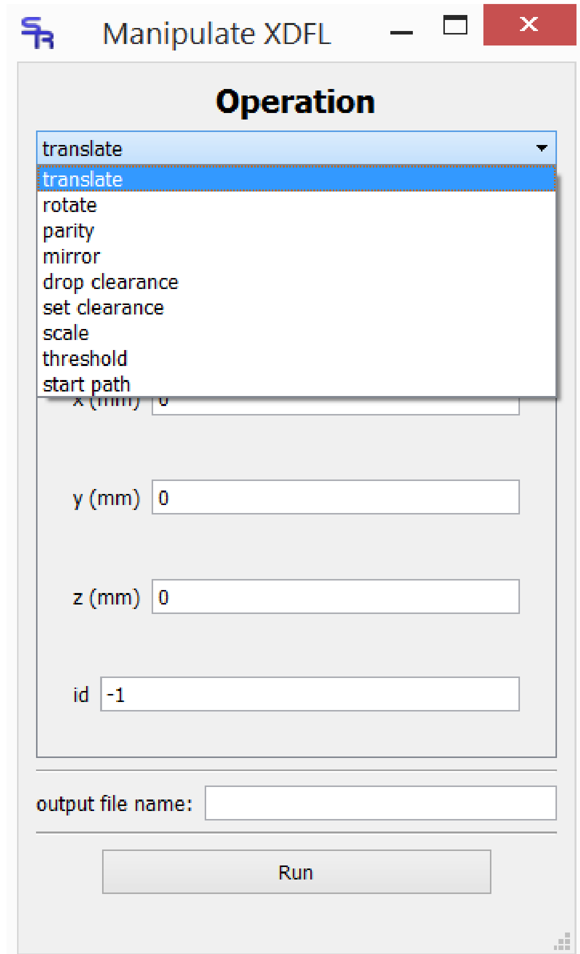
Advanced XDFL Manipulation with Manipulator™





Use the Manipulator™ to translate, rotate, parity transform, mirror, drop/set clearance paths, scale, threshold, or reset start path of an XDFL file. Use the dropdown menu to see a brief description of each function. When you select a function, the necessary parameters will appear below it. Fill out the settings, type a name for the output file, and click run to create a new XDFL file in the directory containing the original file.

Translate	Translate the file in the x y and z directions. Use material ID to select a single material to translate
Rotate	Rotate the file about an axis
Parity	Perform a parity transform on the file (x->y, y->x)
mirror	Mirror the file about an axis
Drop clearance	Remove all clearance paths from the file
Set clearance	Set the amount the head will move up between paths and the speed of the movement between paths
scale	Scale the file by a percentage along the x y and z dimensions
Threshold	Remove all paths bellow 0 height
Start path	Remove all paths up until and including the path number specified

Advanced XDFL Manipulation with Manipulator™

Overview

The Manipulation tool for XDFL is designed to let you edit your print jobs and to customize your printing process. The tool has several functions that can change your XDFL print job. The print job is loaded by typing in the file location and name into the line underneath the explaining text or by hitting the open button. Each function has a set of arguments (inputs) that are needed to perform their task. They are loaded into the box beneath the input file name. Each argument is given a default value. You can edit some or all of the arguments. The output of the function is sent to the output file. By default, the input file is overwritten by the function, but you can specify a new file to be written.

The rest of this document will be used to describe the different functions and how to use them. The functions are broken into three groups, geometric, clearance, and edits. Geometric functions change the location and orientation of print jobs. Clearance functions change the behavior of the printer between extrusion paths. Edit functions truncate a print job or merge print jobs together.

Functions

Geometric

Geometric functions change the location and orientation of print jobs. The printer uses X Y and Z coordinates. The XDFL file coordinate will be the coordinates referenced for the entire print job. The Printer bays will moved in order to align the extrusion heads for the correct material to the locations in the print job.

Translate

Function

The Translate tool moves the paths of one or all of the materials in a print to move the object on the build surface. If you use a material ID only that material is shifted, none of the clearance paths and none of the other extrusion paths are shifted to match it. You can used the clearance function to update the clearance paths to match the ends of extrusion paths after shifting one material.

Arguments

Name	Units	Default	Description
X	mm	0	The amount in mm to shift the print job in the X direction
Y	mm	0	The amount in mm to shift the print job in the Y direction
Z	mm	0	The amount in mm to shift the print job in the Z direction
Id		-1	The ID of the material to shift, use -1 to shift all materials and the clearance paths, use 0 to shift the non-extrusion paths

Example

Lets sat you have a multi-material print and you placed one of the STLs in the wrong location, you can use this tool to make a correction. After your first attempt printing, if you measured that you were off by 5mm in the y direction on the STL for material two, you can enter 5 for Y and 2 for ID. Then when you are done use the clearance function to update the clearances.

Rotate

Function

The rotate function turns the entire print job about the X Y or Z axis This function can put parts below the XY plane (the build surface), make sure to shift your prints up to prevent the tool head from crashing into the build plate if you rotate it about the X or Y plane.

Arguments

Name	**Units**	**Default**	**Description**
Angle	Degrees	0	The angle to rotate the print around an axis
Axis		z	The axis to rotate around X Y or Z

Example

Lets say you made a print job that is too long for the X axis but can fit on the printer if your rotated it. Use the tool to rotate the print 90 degrees around the Z axis

Parity

Function

The parity function performs a parity transform. Parity transforms turn right hands into left hands. This is similar to mirroring the print through the build tray and rotating up to original position on the build surface.

Arguments

None

Example

Lets say you want to turn and left ear into a right ear, use the parity function to make a new print job.

Mirror

Function

This mirrors the print job through a plane. The planes are defined by the axis that is perpendicular to them. IE the Z axis is perpendicular to the XY plane (build surface). If you mirror about it, it will put the print jobs below the build surface.

Arguments

Name	Units	Default	Description
Axis		z	The axis to rotate around X Y or Z

Example

Let's say you want to print an object upside down. Use the mirror tool to mirror about the Z axis and then use the translate tool to shift the print up back above the build surface.

Scale

Function

This function will scale the print in the X Y and/or Z directions. It will not fill in areas, it will only change the spacing of the points in the paths. 1 is equivalent to 100%. This tool is rarely used, but it can be used to make solid objects into sparse filled scaffolds.

Arguments

Name	Units	Default	Description
X	-	1	The amount to scale the print job in the X direction
Y	-	1	The amount to shift the print job in the Y direction
Z	-	1	The amount to shift the print job in the Z direction

Example

lets say you want to make a sparse scaffold. Take a print with solid infil and scale it in the x and y directions.

Clearance

Clearance paths are the non-extruding movements between extrusion paths. These paths lower the build tray, and then move the head to the XY position of the start of the next path, and then move the tray back up.

Drop clearance

Function

This function removes all of the clearance paths from a print. This will cause the head to move in a straight line between the end of one path and the beginning of the next path. You will want to drop clearance to make a print faster or if you plan on making a series of edits to the XDFL and setting the clearance at the end.

Arguments

There are no arguments for the function other than input and output file name

Name	Units	Default	Description
-	-	-	-

Example

Lets say you a printing with plastic with a single plastic material, removing clearance paths can speed up the print process. You would not want to remove clearance paths when using two materials with different heights which might cause the materials to drag into each other.

Set clearance

Function

This function sets the clearance paths between all paths in the print process. You can set the Z movement amount to ensure either a breaking of the strand from the tip or to avoid dragging the tip into another region of material.

Arguments

Name	Units	Default	Description
clearance	mm	0.1	The amount to drop the tray before moving in XY
speed	Mm/s	10	The speed along the print pass

Example

Let’s say you have a print with a single material that needs a movement to break its connection between the path and the nozzle. Set a 0.1mm clearance and 50mm/s speed to ensure that the head jerks away from the path and breaks the material connection.

Let's say you have a two material print where one material has a 1mm path height and the other has a 2mm path height, setting a 1.1mm clearance will ensure that the nozzles do not crash into printed materials.

Edits

Threshold

Function

This function removes all paths bellow the build surface (XY plane) from the print to prevent the head from crashing to the build surface. This function is needed because there is nothing to stop you from putting an object bellow the build surface using one of the other manipulation functions.

Arguments

There are no arguments for the function other than input and output file name

Name	**Units**	**Default**	**Description**
-	-	-	-

Example

Let's say you have rotated a print using the X axis and it now has the first 5 paths bellow the build surface, but these paths are un needed to print the object, this function can remove those paths.

Start path

Function

This is a debugging function useful for resuming a print from a specific path number if your print fails and you want to recover the print from a specific path. This function removed all paths before this specified number from the print job.

Arguments

Name	**Units**	**Default**	**Description**
Path number	-	1	The number of the path to start the print from

Example

Let's say a 5 hour print fails are path 190 because you ran out of material or the tip clogged. Write down the number of the path it is on in Seraph Print, cancel the print. Move the print to X=0 Y=0 and the current layer height. Then use this tool to make a new print job from that path, and run this new print job.

Merge (for Multi-Material Printing)

Function

This function merges multiple XDFL files together to make a new multi-material XDFL file. All of the materials are kept, even if they are unused in the file. The system assumes that both files are aligned to the same origin. The merged file will be sorted by layer height to make the print order for the layers.

Arguments

There are multiple arguments of the same name, you only need to fill a value for as many files as you are merging together.

Name	Units	Default	Description
File name	-	-	The location of the file to merge

Example

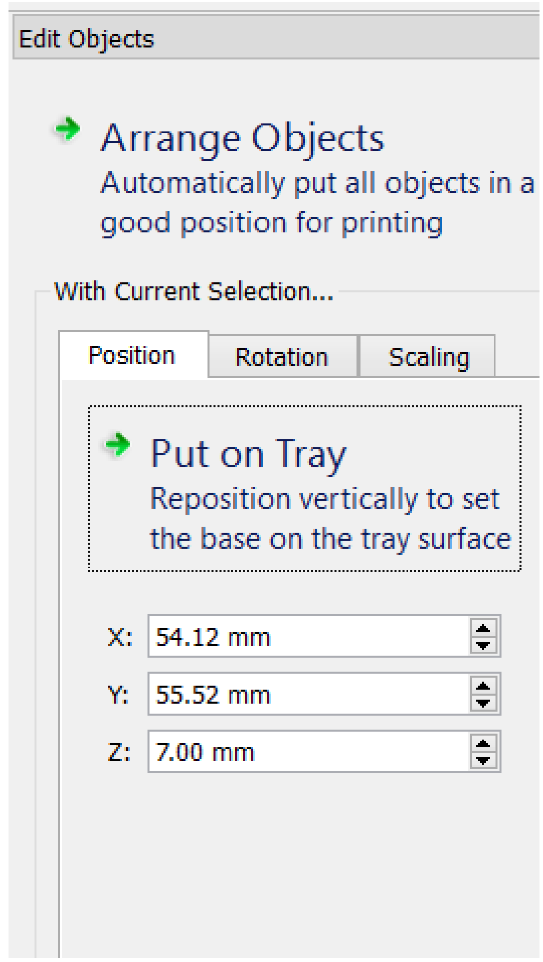
Let's say you want to make a combination of two materials, but don't have a toolscript for the combination. You can align the STLs in seraph studio and record their XYZ positions form the menu on the right. Then remove the STLs for material 2 and path material 1 and save an XDFL file. Then remove the STLs and place the STLs using the corrdinate you recorded before and make a new XDFL file for material 2 and save it. Then merge the two files together into a new file using this tool.

Let's say you have an STL file and a set of paths you generated from code in matlab. You can use the XDFL from the STL file and the XDFL written in matlab code to make a new print job. Use this tool to merge the two sets of paths together.

Multi-Material Printing Guide

Let's say that you want to print a multi-material object. The simplest way to do this using Seraph software is to create two separate XDFL files and merge them.

The first file would contain the geometry of all areas of the print using material number one, and the second file would contain geometry of the print using all areas of material number two. Of course, it is possible to extend this prototypical case and use more than two STL files to accommodate two or more materials in this fashion.

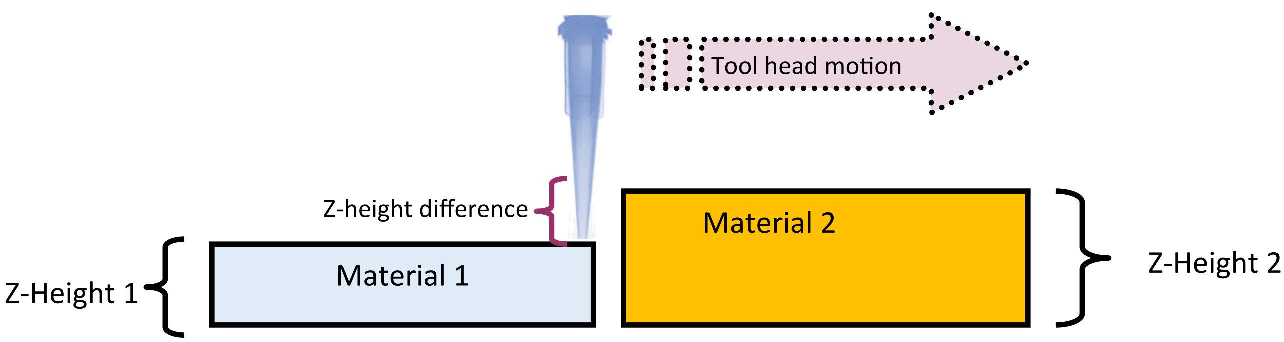


The process begins by selecting the first material's STL file and placing it on the build surface using Seraph Studio. The user should make note of the X, Y, and Z positions of the first STL object and create an XDFL file.

Using this information, the user should then clear the build surface on Seraph Studio and on to an empty virtual build surface, import the second material STL object. Then, place the second STL object in the appropriate position relative to the first, using the "Edit" tab on the program to manually input the correctly offset XYZ position. A second XDFL file should then be created containing only the information regarding the pathing instructions for the second STL file. The user should now have two XDFL files, each containing the respective paths for their object and material.

With the to appropriately positioned XDFL files created, the user must now launch the "Manipulator" from Lab Manager and select the "Merge" tool. This tool will merge the two separate XDFL files into a single XDFL file containing all of the instructions for the printer to simultaneously print both materials. Unlike printing these two XDFL files in succession, using the merge tool will sort their XDFL commands by layer, allowing a successful print comprised of multiple materials per layer.

Please refer to the instructions in the section discussing the Manipulator Tool for more detailed information on the Merge tool. Also note that for your print to be successful the z-heights of the two or more materials should be the same or nearly the same to ensure that one syringe does not interfere with printed material of another. See diagram below, which illustrates how a big z-height (path/layer height) difference is problematic because the tool will crash. To avoid this problem, tell the Merge program a “clearance height” and it will lift the head by that amount between materials to avoid crashing. This will allow you to circumvent the problem described below.



ACCESSORIES

USER GUIDE

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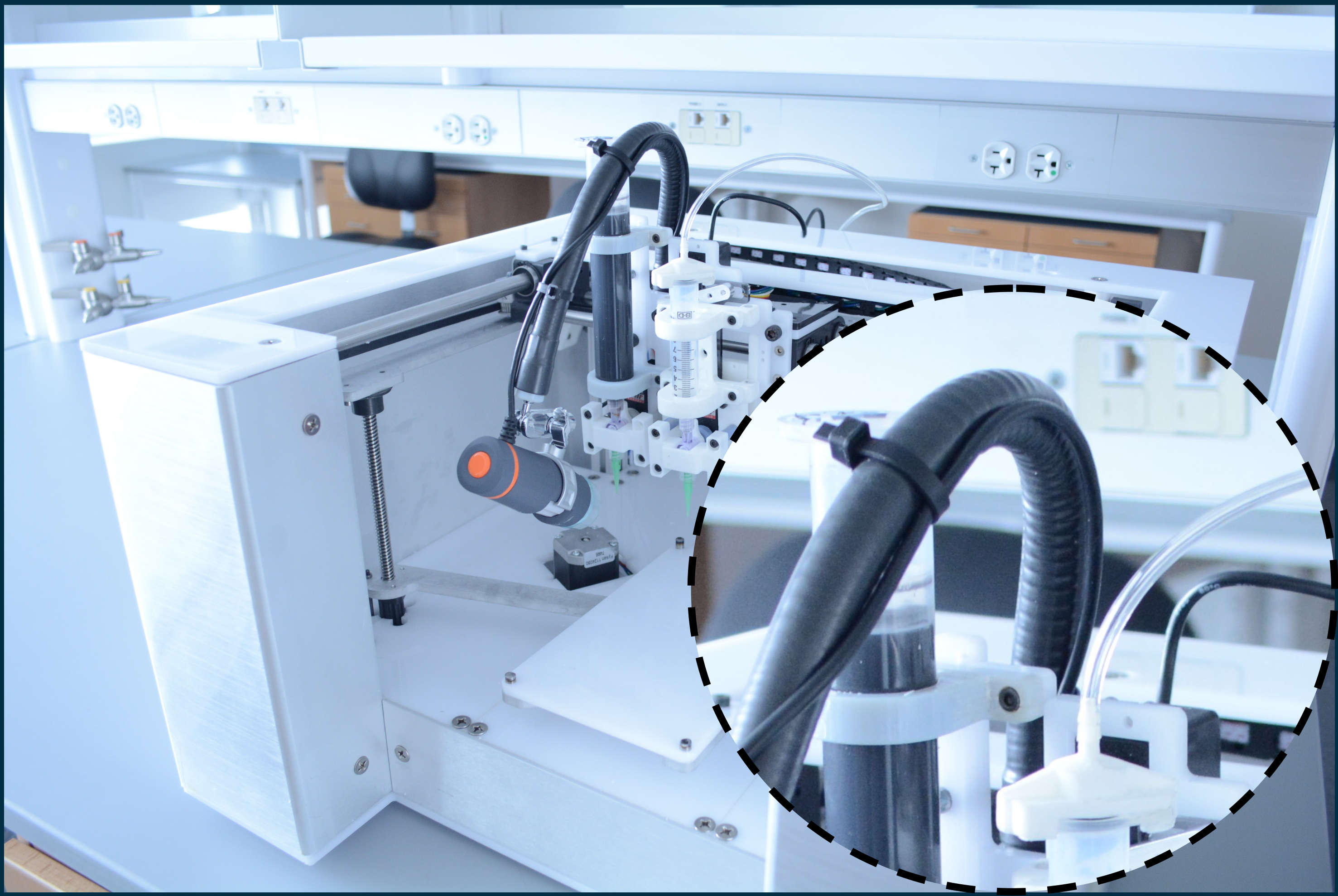
USB Microscope Tool



The updated USB microscope tool allows you to visualize the build surface or tool head with a positionable scope using your choice of camera software. To install, bolt onto the carriage as shown (on the next page) and angle camera as desired. Connect USB to PC and open 3rd party camera app of your choice.

USB Microscope Tool—Installation

Step One

To install the USB Microscope tool, remove the carriage and plates.

Step Two

Then unthread the bottom nut (purple arrow) from the end of the threaded rod.

Step Three

Straighten the gooseneck , unthread the bottom nut, grip the bottom of the shaft, and place it in the hole on the carriage. Place the unthreaded the bottom nut below the hole and entrap the threaded rod with the top and bottom nut. You may need to use pliers to hold the bottom nut in place as you twist in the shaft.

Step Four

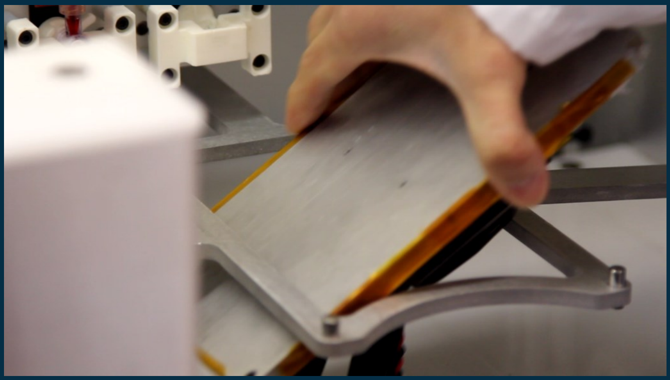
Reinstall the carriage and tools.

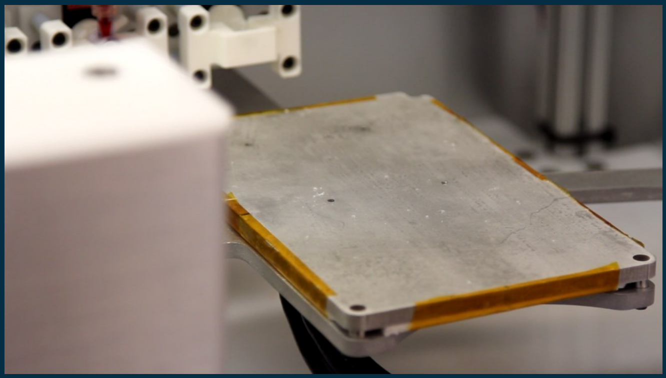
Step Five

When you are ready to position the microscope, grip the shaft at the base and bend the end while holding the shaft at the base to avoid torqueing the chassis.

Cooled Build Tray

Cool the build surface down to –3.6 C





Installation Instructions:

1. Remove the existing tray
2. Turn the tray sideways to fit it through the z-table slot
3. Rotate back to the correct position and align with the pins
4. Connect power cable and cooling cables to accessory tower.
5. Power on the heater and adjust the dial
6. When Set Temp = Temp, you may begin printing. You may need to place printer in a cold environment to reach desired setting.

Heated Build Tray

Caution: Do NOT touch when HOT to avoid burns!

1) **Install the tray** by the sliding it underneath the Z table at 90° to its final position pulling it through the rectangular hole, and turning it another 90° to its proper orientation, and resting it on the appropriate pegs. The cord should exit the tray through the rectangular hole in the Z-table. (See cooling tray for reference.)

2) **Connect to Accessory Tower.** Grab the thermocouple by the yellow plastic connector and plug it into the appropriate bay on the accessories tower, and connect the white power supply connector alongside it. Do not connect or disconnect by pulling on the wires, as they are 120 V connections. (Never touch exposed wire when the unit is plugged in!)

3) **To use the heater,** turn on the accessory tower power supply and then turn on the heating bay power supply.

4) **Press "set"** and use the arrow keys to set the desired temperature. Press "set" again, to confirm selection.

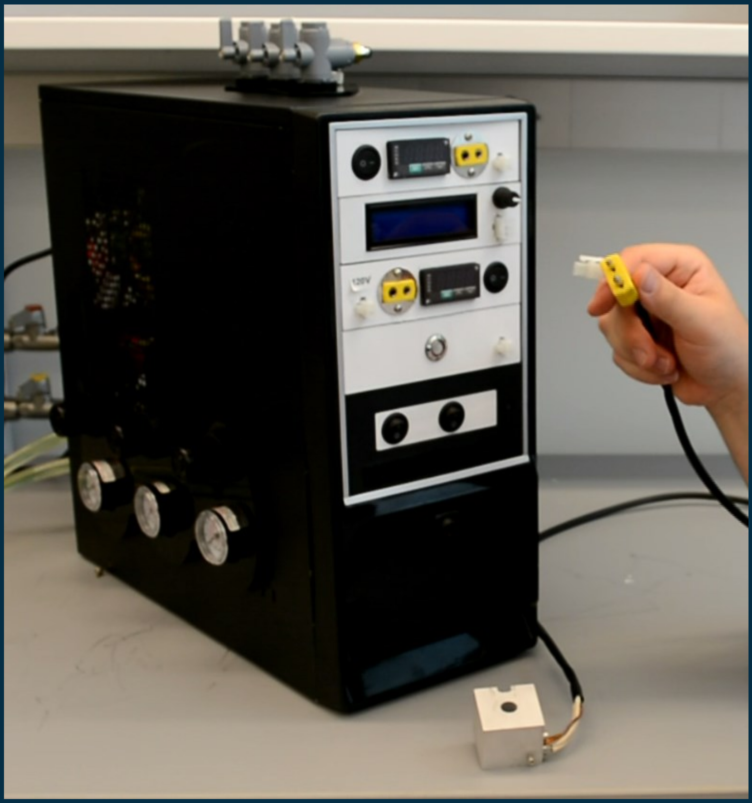
5) **The current temperature will appear** on the display and rise to your selected temperature. The green light on the controls indicates that the heater is active.

6) **Begin Use.** When the temperature reaches your desired temperature, proceed cautiously with your experiments.

7). **When done** you may select a new lower desired temperature or shut off the device power. Be sure to allow the tray to cool to room temperature before touching it to avoid burns! Ensure you have proper procedures in place to prevent others from touching printer while any hazardous parts (e.g. heating, UV, or toxic chemicals)

Syringe Heater

Caution: Do NOT touch when HOT to avoid burns!



The syringe cooler allows you to cool the syringe to as hot as 100 degrees Celsius , but temperatures above 70-80C may melt plastic syringes!

The syringe heater allows you to heat the block to as hot as 100 degrees Celsius , but temperatures above 70-80C may melt plastic syringes!

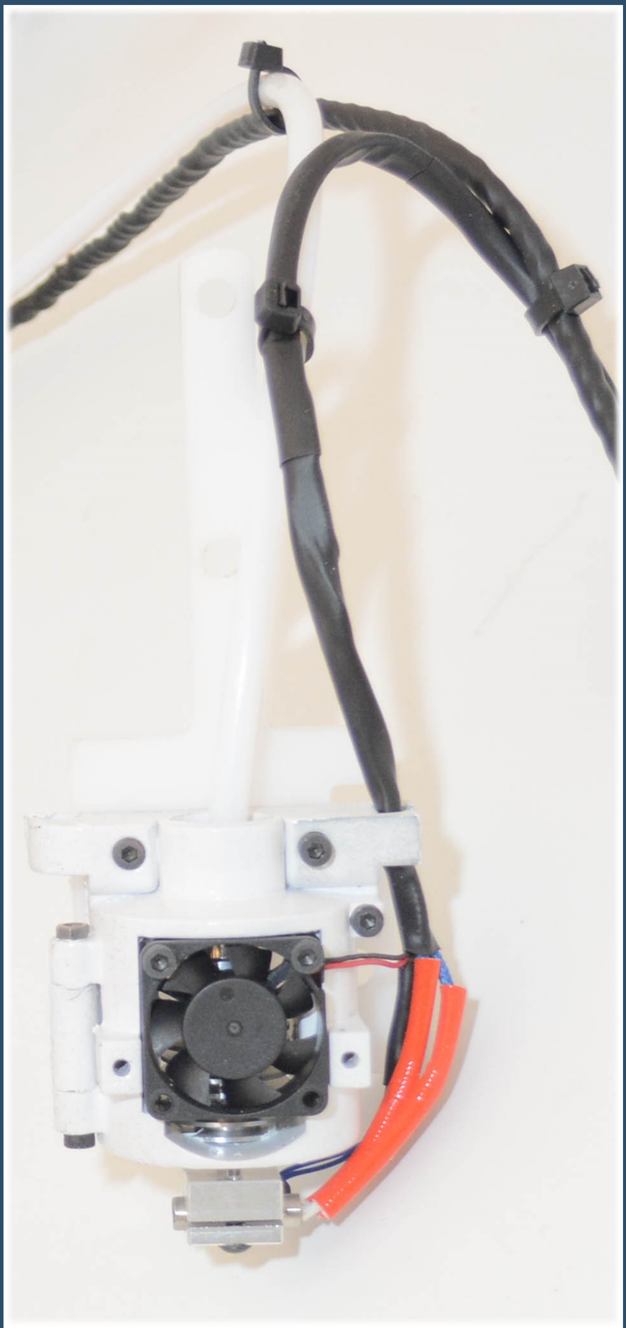
Installation Instructions

1. Insert syringe cartridge assembly into printer, lock valve/tip and then unscrew and remove syringe barrel.
2. Place heater block between retaining rings on tool head and reinsert syringe through rings and heater block.
3. Connect heater power/thermocouple
4. Be careful of hot surfaces.
5. Turn on accessory tower/bay
6. Push “Set” and use arrows to set temperature. Push “set” again to confirm selection.
7. Wait for display to show desired temperature has been reached.
8. Begin printing
9. When done, change set temperature to room temperature and wait for device to cool. Shut off switches and disconnect. Cautiously remove heater ensuring it is safe to touch. Always have proper safety procedures in place to ensure no one touches a hot heater before, during, and after printing.

Standard BioLab UV tool

The standard BioLab UV tool comes in either 385nm (or 365nm) wavelengths. The user is responsible for appropriate safety precautions while using this tool. To use, simply plug in as shown, affix the UV board to the printer or tool head in the desired position using your own rigging. To turn on/off the light, push the button power button for the appropriate bay and on the control tower and then use the silver button to directly control the light.

Plastic Filament Tool



The plastic filament tool allows users to print ABS/PLA filament (or custom filaments).

The tool can be configured for use with 1.75mm or 3mm filaments, as well as a variety of tips ranging in size from 0.2mm to 0.8mm.

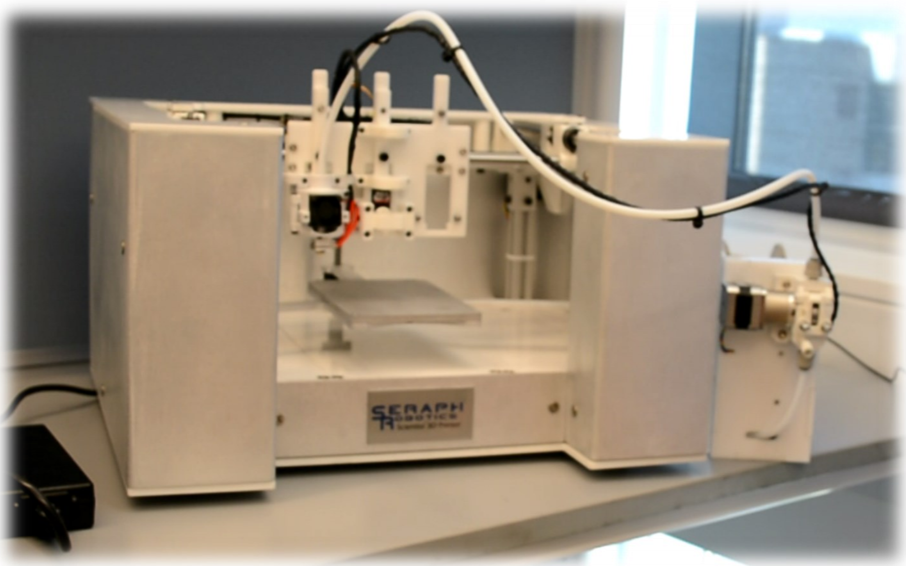
Use standard ABS/PLA filaments for traditional 3D Printing experience.

Or experiment with novel materials by creating and testing your own filaments for extrusion on the system.

As with all extrusion tools, please ensure you are using the appropriate printer config file in Seraph Studio.

FILAMENT EXTRUSION TOOL

USER GUIDE



Recommended Materials: ABS/PLA filament

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Plastic Printing Guide

Step One

To install the Plastic Tool, place it in one of the two left-most bays on a single, dual, or triple tool carriage

Step Two

Install a second tool if bay 1 & 2 are not both already occupied. You do not need a syringe loaded, but do need the electrical connection connected for the plastic tool to function.

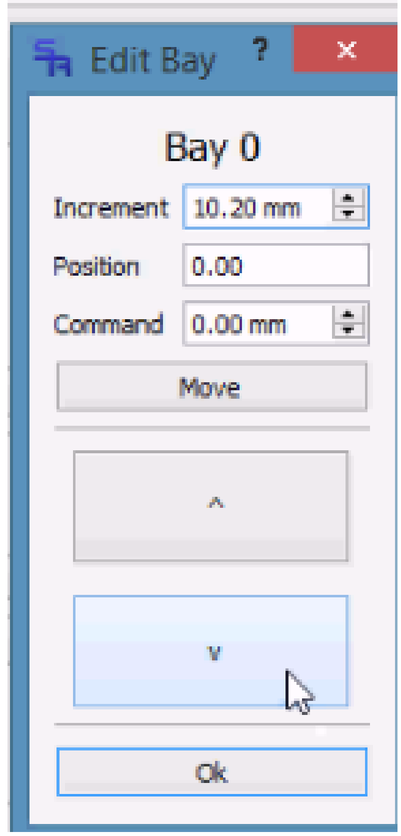
Step Three

Plug in and power on the printer and plastic tool and load the appropriate XDFL and Config file in Seraph Print for a plastic print job. Be careful of high temperatures.

Step Four

Proceed through the screens. You can jog the printer to verify it is properly connected. Then select "plastic" tool in the appropriate bay (0=left, 1=middle, etc.) and the head will begin to heat. Then, send one or two additional small jog commands to move the tool head (without crashing it), and wait for the jog controls to become responsive. (In other words, it won't move at first.) Wait! Do not send more jog commands to avoid crashing. When the jog controls are responsive and the printer moves, you know the heat-up command completed and tool is at temperature. This can take several minutes, so be patient and do not touch the hot head.

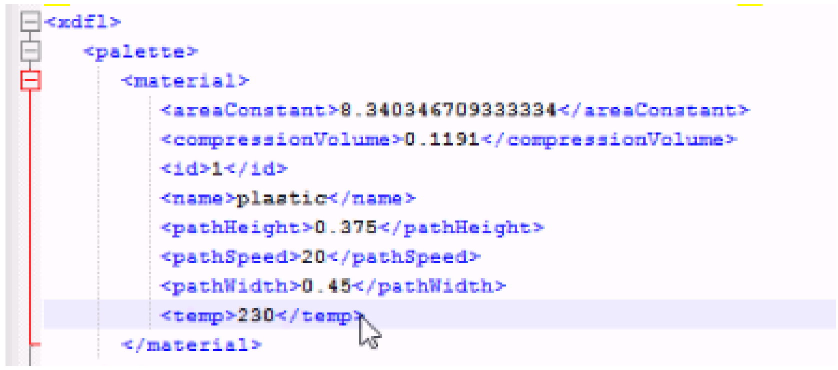
Step Five



You can now click "edit bay" to move the filament forward or backward through the head from the reel. Use approx. 10mm increments for quick priming of a loaded tool, and 100mm increments for advancing the reel that is not already loaded (i.e. as in a new reel). You want to extrude a few drops from the end of the printer before starting the job to prime the system. Remove excess with pliers. Please note, that this is the same procedure you'll use to remove filament reels. If necessary, you may wish to increate the temperature value in the XDFL (or calibration) to make removal easier. If the head is not hot and the plastic not liquefied at the tool, it will stick. Remember, if you just want to prime or remove filament, then it doesn't matter which XDFL file you load into SeraphPrint to gain access to the controls. The only parameter that matters is temperature, so your head is at the right temperature for your desired operation (i.e. printing or removing filament).

Down arrow = extrude

Up arrow = retract



Step Six

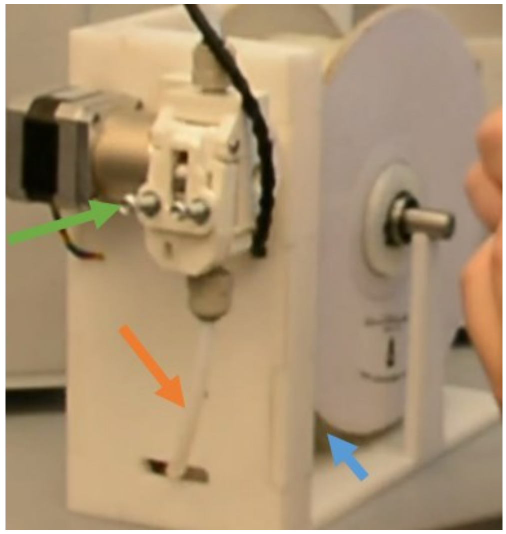
With the heated and primed head, you can jog the printer to the appropriate start position and follow normal printing procedure.

Plastic Printing Guide

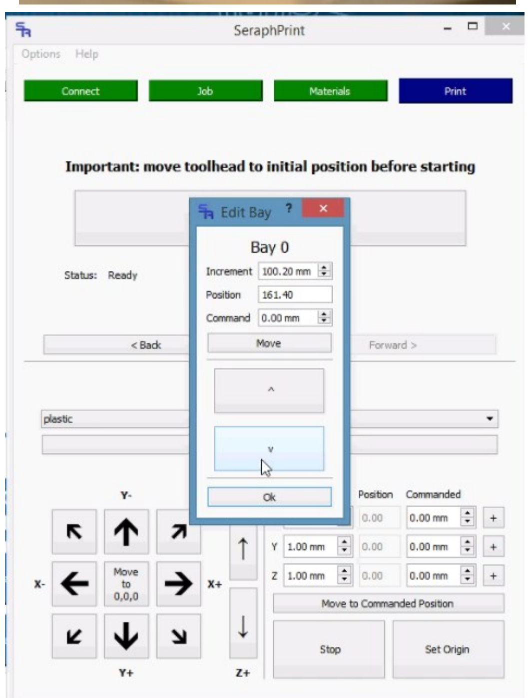
Loading a new Filament

1. Install the bearings in the filament reel

2. Thread the filament (blue arrow) through the plastic guide shaft (orange arrow). You can remove the shaft or reel to do this.
3. Attach guide shaft to reel feeder mechanism
4. Unscrew filament catch and push filament into drive mechanism (green arrow)



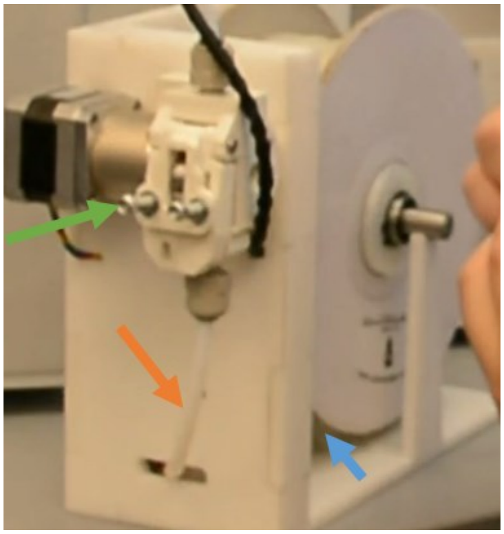
5. Visually confirm filament in drive mechanism and retighten bolt
6. Load a test filament XDFL file to SR Studio, select printer tool in appropriate bay and heat up tool (be careful not to burn yourself)
7. Send a jog movement command and wait until printer can perform it
8. When it does, you're at temperature. Do NOT send extraneous commands or when the printer head is hot it will probably crash trying to perform the backlog of commands.



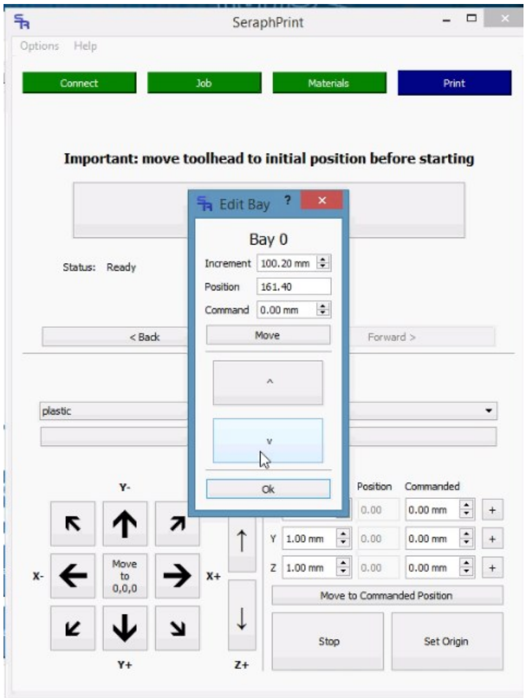
9. Then use the printer commands to advance the filament in 100mm increments until it reaches the head. Then use 10mm increments to complete the priming.
10. When material is extruded smoothly, use pliers to pull off the excess and you can proceed to normal printing procedure.

Plastic Printing Guide

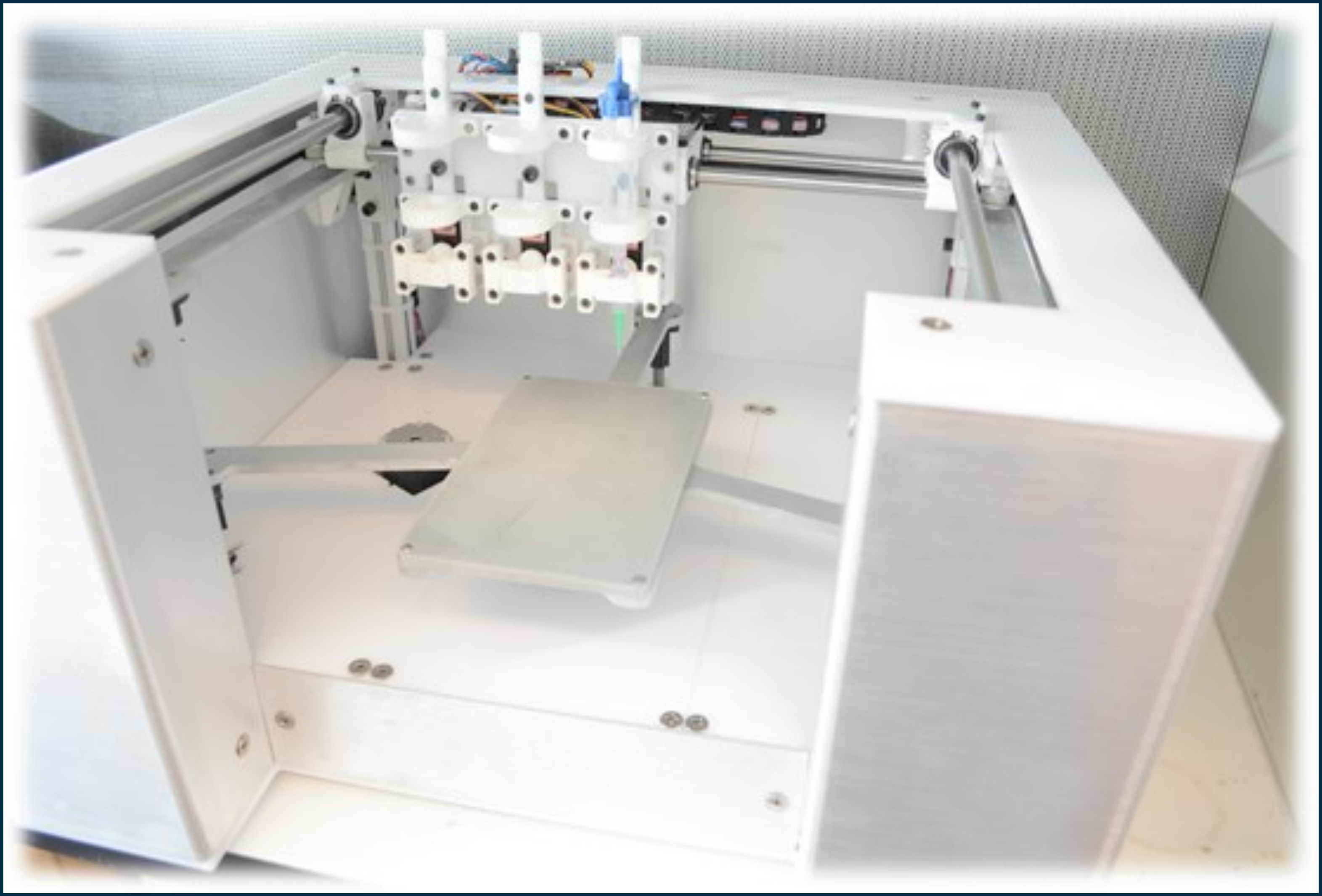
Unloading a Filament



1. Load a test filament XDFL file to SR Studio, select printer tool in appropriate bay and heat up tool (be careful not to burn yourself). Your test XDFL should have a temperature > or = to ideal extrusion temperature. Higher temperatures will help melt plastics to make them easier to pull out of the tool. Use this trick to trouble shoot.
2. Send a jog movement command and wait until printer can perform it
3. When it does, you're at temperature. Do NOT send extraneous commands or when the printer head is hot it will probably crash trying to perform the backlog of commands.
4. Then use the printer commands to retract the filament in 100mm increments at least until it crosses the head.
5. Once it is clear of the tool head, you can unscrew the drive mechanism clamp and manually pull the filament out.
6. You may wish to discard the filament that was in the tube as it is often weakened by the process.
7. If high temperature and pulling with pliers doesn't work, you may need to use hand tools to help pull the filament loose from the head. We recommend using high temperature to melt plastic and break connection that way.



Service, Support & Troubleshooting



Troubleshooting | Technical Consulting

The customers' section of the website may have additional updates to this document and other resources for you.

If you have a defective unit, please contact us immediately after purchase. If you require technical assistance of any other kind, contact sales@seraphrobotics.com to schedule paid tech support provided based on availability.

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