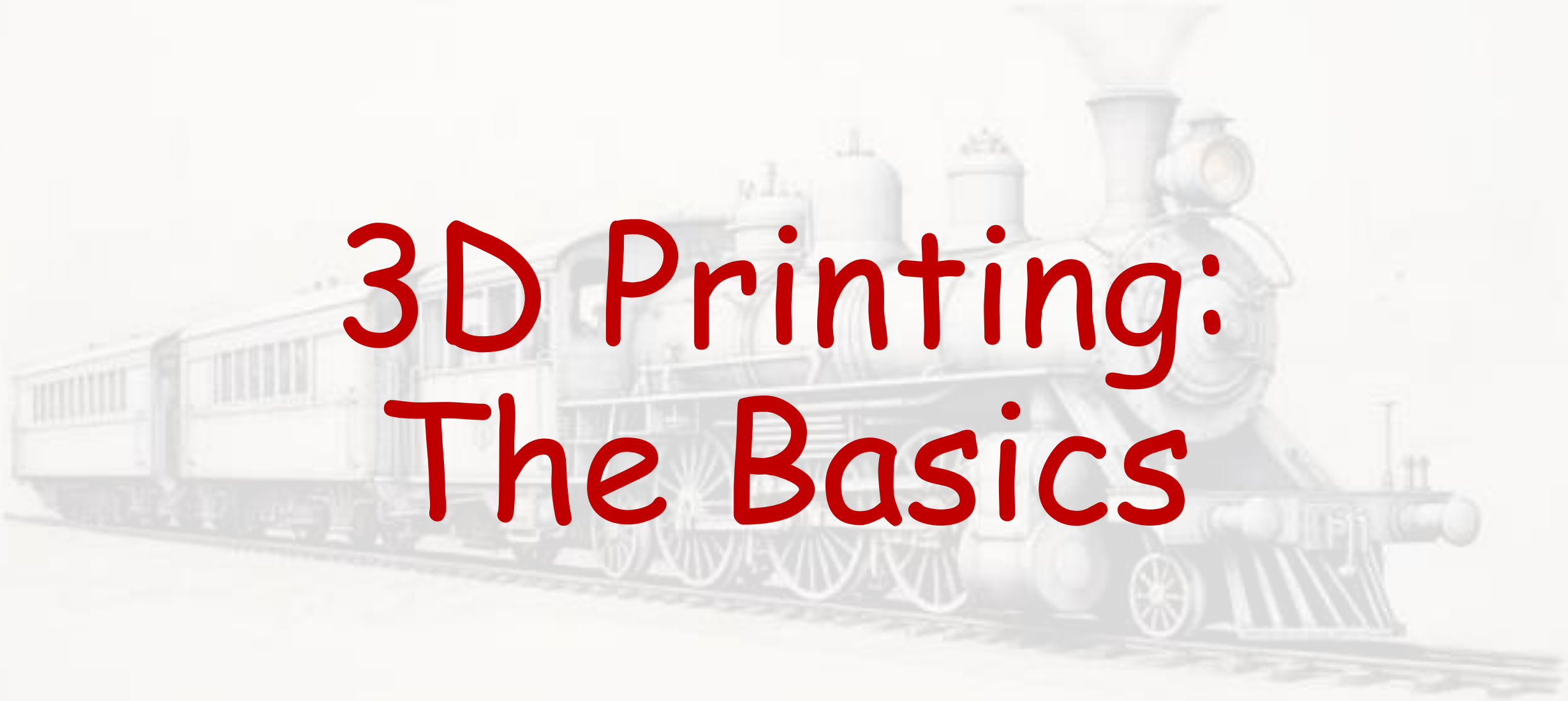


3D Printing: The Basics

Definitions

- 3D Model - The mathematical representation of any three-dimensional surface.
- 3D Printing Filament - The thermoplastic feedstock for FDM 3D printers. There are many types of filament available with different properties. Filament consists of one continuous slender plastic thread spooled into a reel.
- CAD – Computer-Aided Design. In our context this will refer to the software used to create our models.
- FDM - Fused deposition modeling, also known as fused filament fabrication (FFF).
- SLA – Stereolithography was the world's first 3D printing technology.
- Slicer – This is a software program that takes your 3D model and puts it in a format that your printer can understand.

What is 3D Printing?

3D printing, also known as additive manufacturing, creates physical three-dimensional items from computer aided design models. For hobbyists this is usually done with SLA (resin) or FDM (filament) printers.

So, How Does 3D Printing Work?

All 3D printing processes start with a 3D model. This model can be one of your own design, or one downloaded from one of the very many websites that provide them. These downloaded files can either be free or sold for a fee.

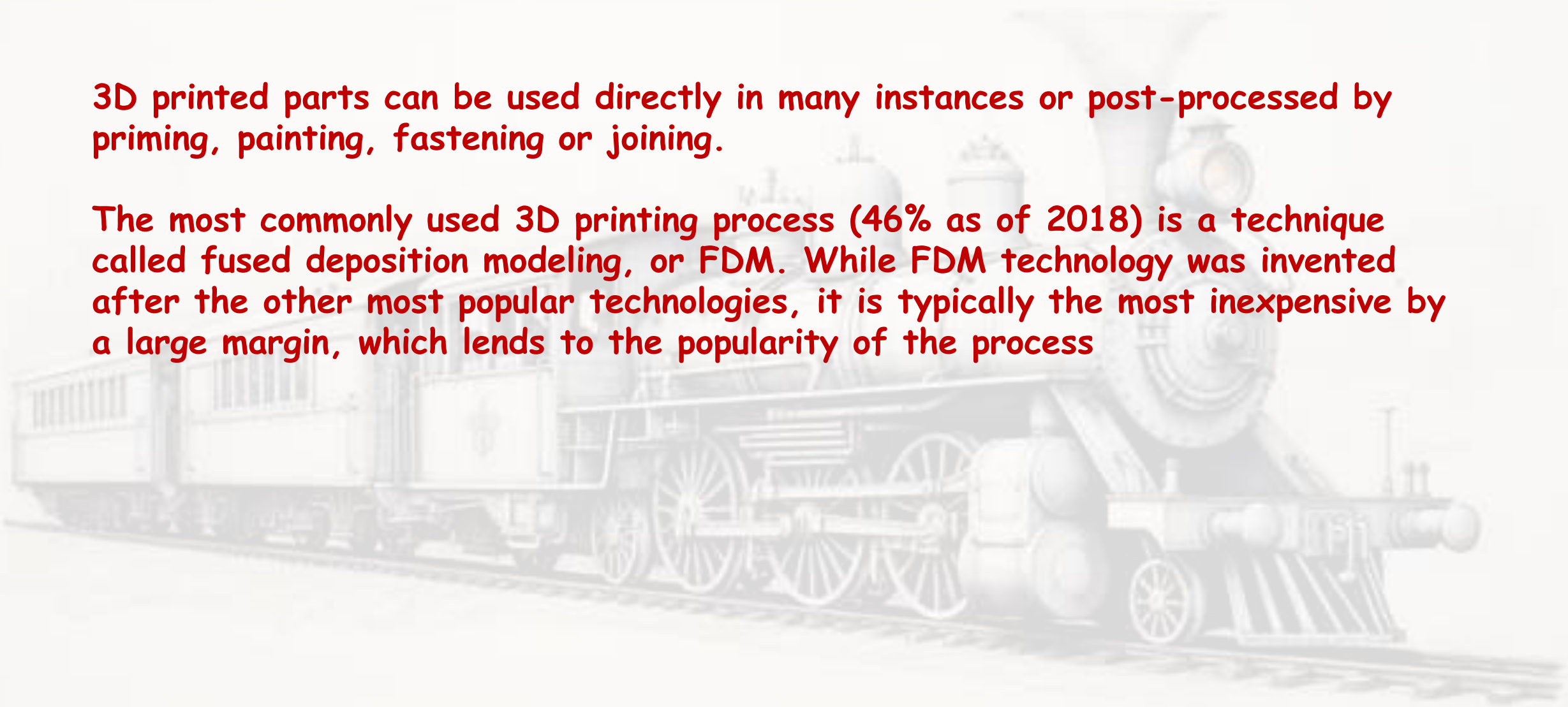
The model is then exported (or downloaded) as a file readable by your slicer to prepare it for printing, most commonly with a .stl or .obj suffix. Once you have your model file, you will need to import it into your slicer to specify print settings and slice the digital model into layers that represent horizontal cross-sections of the part.

Adjustable printing settings include orientation, support structures (if needed), layer height, and material. Once setup is complete, the software sends the instructions to the printer via Wi-Fi, memory card, or cable connection.

Depending on the technology and the material, the printed parts may require rinsing in isopropyl alcohol (IPA) to remove any uncured resin from their surface, post-curing to stabilize mechanical properties, or manual work to remove support structures.

3D printed parts can be used directly in many instances or post-processed by priming, painting, fastening or joining.

The most commonly used 3D printing process (46% as of 2018) is a technique called fused deposition modeling, or FDM. While FDM technology was invented after the other most popular technologies, it is typically the most inexpensive by a large margin, which lends to the popularity of the process



3D Printer Types

- **FDM** - The filament is fed into the FDM 3D printer. The thermoplastic filament is heated past its melting temperature inside the hotend. The filament is extruded and deposited by an extrusion head onto a build platform where it cools. The process is continuous, building up layers to create the model.

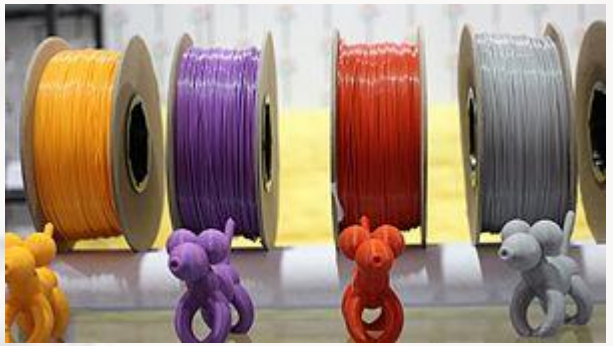
- **SLA** - This was the world's first 3D printing technology, invented in the 1980s, and is still one of the most popular technologies for highly detailed miniatures. SLA 3D printers use ultraviolet light or a laser to cure liquid resin into hardened plastic layer by layer.

3D Printer Makers

There is a 3D printer out there for just about every budget and skill level. Here is a list of some of the more popular manufacturers:

Creality	Filament and Resin
Elegoo	Filament and Resin
AnyCubic	Filament and Resin
Bambu Labs	Filament ONLY
Ultimaker	Filament ONLY
MakerBot	Filament ONLY
Prusa Research	Filament and Resin

Most common filament types



- ABS - Acrylonitrile Butadiene Styrene. A staple in the manufacturing of items such as LEGO bricks, it requires higher temperatures to print correctly and a heated bed to prevent warping. Ventilation is also crucial due to the fumes during printing.
- ASA - Acrylonitrile styrene acrylate. A thermoplastic developed as an alternative to ABS, that has improved weather resistance
- PLA - Polylactic Acid. It prints at lower temperatures and doesn't emit harmful fumes, making it a favorite for use. Its final product boasts a matte or glossy finish, available in an array of colors, perfect for decorative pieces.
- PETG - Polyethylene Terephthalate Glycol. It is the middle ground between PLA and ABS, offering durability and while being easier to print than ABS. It offers resistance to chemicals and moisture, making it suitable for practical containers or mechanical parts.
- TPU - Thermoplastic Polyurethane. Brings flexibility to printed objects, perfect for phone cases or wearable gadgets.

SLA Resins

The liquid materials used for SLA printing are commonly referred to as "resins" and are thermoset polymers. A wide variety of resins are commercially available. Material properties vary according to the resin formulation. They can be soft or hard, or imbued with mechanical properties like high heat deflection temperature or impact resistance similar to the properties of the various filaments for FDM printers.

Ok, I have my printer and materials, now what?

- First you have to decide if you want to:
  - design and print your own models;
  - download and print already created models, or;
  - some combination of both.
- Then you will need to slice the model in your slicer software.
- Next you will need to get the sliced file to your printer through a cable, memory card or WiFi connection.
- Sit back and watch the magic happen (if you have a LOT of free time!).
- Once printing is finished, perform any post-printing processing (if needed).

Designing your own models

There are a number of different CAD and programs to use to design your models with, both paid and free. Some of the more popular ones are:

- Tinkercad
- Blender
- SketchUp
- FreeCAD
- OpenSCAD
- Fusion 360

Downloading models

There are literally dozens of websites that host model files for downloading, here are a few:

- https://www.thingiverse.com/
- https://www.printables.com/
- https://thangs.com/
- https://makerworld.com/
- https://cults3d.com/
- https://www.yeggi.com/
- https://www.myminifactory.com/
- https://www.cgtrader.com/

Slicing your files

Most 3D printers will come with a native slicing software. However, once you get familiar with the process, you may find that you would like a slicer with more features, is easier to use, etc. Here are some you might be interested in:

- Cura - https://ultimaker.com/software/ultimaker-cura/
- Slic3r - https://slic3r.org/
- Bambu Studio - https://bambulab.com/en/download/studio
- Orca Slicer - https://orca-slicer.com/

FINALLY, get to printing!

Ok you finally made it to the actual printing part. Now, you can sit and watch the entire printing process (if you don't have any paint to watch drying or grass growing), but overall, you will be better off just watching to make sure the print starts correctly and then checking on it occasionally until it finishes.

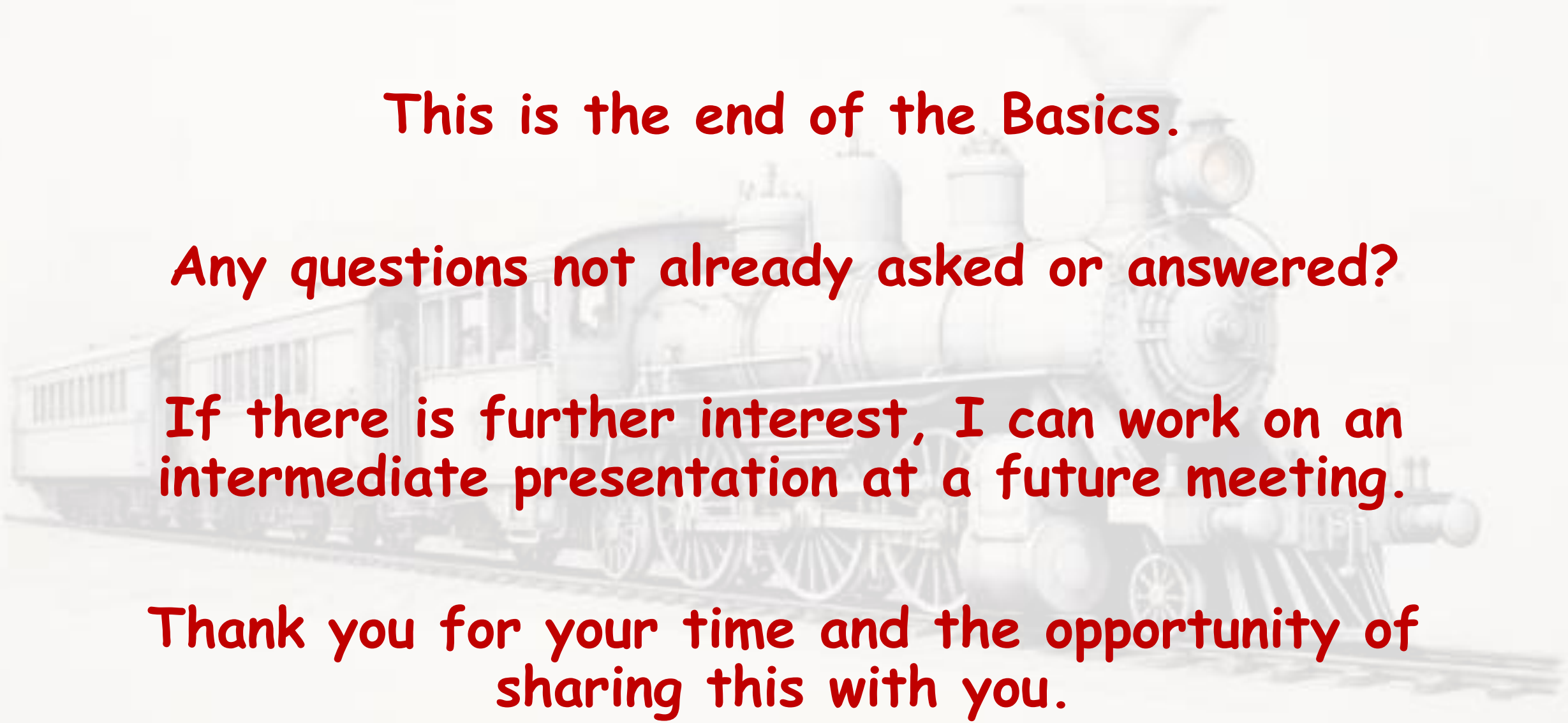
Depending on what you are printing, print times can range from just a few minutes to a multi-day affair

Printing is done

Once your print finishes it may or may not be ready to go. This is where you have to decide if there is any post-print processing you need to do.

With FDM printers this can be none at all, minimal or extensive.

With SLA printers you will ALWAYS have some processing to do. At a minimum you will need to wash your print to remove excess resin and to cure it.



This is the end of the Basics.

Any questions not already asked or answered?

If there is further interest, I can work on an intermediate presentation at a future meeting.

Thank you for your time and the opportunity of sharing this with you.