

# Scale Warship 3d Printing Talk Handout

## 1. Plastics

At the moment the majority of 3D Printers, especially the low cost systems, print using a technology called 'Fused filament fabrication (FFF)', these printers currently tend to print using one of the following materials:

### PLA Filament

**PLA (Polylactic Acid)** – PLA is probably the easiest material to work with when you first start 3D printing. It is an environmentally friendly material that is very safe to use, as it is a biodegradable thermoplastic that has been derived from renewable resources such as corn starch and sugar canes.

### ABS Filament

**ABS (Acrylonitrile butadiene styrene)** – ABS is considered to be the second easiest material to work with when you start 3D printing. It's very safe and strong, and widely used for things like car bumpers, and lego (the kids toy).

### PVA Filament

**PVA (Polyvinyl Alcohol Plastic)** – PVA plastic which is quite different to PVA Glue (please don't try putting PVA Glue into your 3D Printer, it definitely won't work). The popular Makerbot Replicator 2 printers use PVA plastic.

### PETG Filament

**PETG (Polyethylene terephthalate glycol)** PET-G is a strong, high clarity, odor neutral and easy to print filament for 3D printing. These characteristics, together with the high impact strength, excellent flexibility and practically no shrinkage make PET-G an excellent material which combines the advantages of both PLA and ABS. The filament is hydrophobic and therefore does not absorb water. In short, PET-G has many great features and is the perfect addition to any filament assortment.

## 2. Powders

The higher end printers, can use various powder based materials to create 3D objects, these materials can include:

- **Polyamide** – Which is a strong and flexible material that allows a high level of detail to be achieved. Polyamide objects are constructed from a white, very fine, granular powder.
- **Alumide** – Is a Polyamide-like material with a distinctive sandy and granular look, that is a rigid and strong material. Alumide objects are constructed from a blend of gray aluminum powder and polyamide, a very fine granular powder.
- **Multicolor** – A full color material with a sandy and granular appearance. Models made out of multicolor are constructed from a fine granular powder

## 3. Resins

Resins are also a material sometimes used in 3D Printing, although design freedom is limited due to the structure necessary to support the objects during the printing process. The following are examples of some resins that can be used:

- **High detail resin** – Objects made out of high detail resin are constructed from a photo polymeric liquid. This material is ideal for small and/or very finely-detailed visual models, where high detail is required.

- **Paintable resin** – Objects made out of paintable resin have a smooth surface and will look beautiful painted.
- **Transparent resin** – Objects made out of transparent resin are constructed from a hardened liquid. The material is strong, hard, stiff, water resistant by nature, and of course, transparent. Transparent resin is suited for models needing a good, smooth, quality surface with a transparent look.

## 4. Other Materials

Some metals and ceramics are also being used in 3D Printing, here are a few examples:

- **Titanium** – Is very light and the strongest 3D printing material available. Objects made from titanium are printed using titanium powder that is sintered together by a laser.
- **Stainless steel** – Object produced in stainless steel are 3D printed using a stainless steel powder that is infused with bronze material. Stainless steel is the cheapest form of metal printing, very strong and suitable for very large objects.
- **Bronze** – Objects produced in bronze are 3D printed in using a bronze powder that is infused with bronze. Bronze is an affordable and strong material for printing models in metal.
- **Brass, Silver, Gold** – Can also be used in 3D printing, although involves printing a wax mould which is then filled with the molten material.
- **Ceramics** – A 3D printing material that has a shiny appearance, is heat resistant, recyclable and food safe. Models made out of ceramics are constructed from alumina silica ceramic powder, then sealed with porcelain and silica and glazed. A perfect material for home decor items and tableware.

## 5. Methods of Printing

Additive Manufacturing (AM) is a term to describe set of technologies that create 3D objects by adding layer-upon-layer of material. Materials can vary from technology to technology. But there are some common features for all Addictive Manufacturing, such as usage of computer together with special 3D modelling software. First thing to start this process is to create CAD sketch. Then AM device reads data from CAD file and builds a structure layer by layer from printing material, which can be plastic, liquid, powder filaments or even sheet of paper.

The term Additive Manufacturing holds within such technologies like Rapid Prototyping (RP), Direct Digital Manufacturing (DDM), Layered Manufacturing and 3D Printing. There are different 3d printing methods that were developed to build 3D structures and objects. Some of them are very popular nowadays, others have been dominated by competitors.

This article is focused at the following 3d printing technologies or some may call them **types of 3D printers**:

- **Stereolithography(SLA)**

Stereolithography is a 3d printing method that can be used to implement your projects that involve 3D printing of objects. Although this method is the oldest one in history of 3D printing it's still being used nowadays. The process of printing involves a uniquely designed 3D printing machine called a stereolithograph apparatus (SLA), which converts liquid plastic into solid 3D objects. There is Standard Tessellation Language (STL) format that is commonly used for stereolithography, as well as for other additive manufacturing processes. The whole process consists of consequent printing of layer by layer hence STL file that printing machine uses should have the information for each layer.

- **Digital Light Processing(DLP)**

DLP as well as SLA works with photopolymers. But what makes SLA and DLP processes unlike is a different source of light. For DLP 3D amateurs generally use more conventional sources of lights such as arc lamps. The other important piece of process is a liquid crystal display panel, that is being applied to the whole surface of building material during single run of DLP process. The material to be used for printing is liquid plastic resin that is placed in the transparent resin container. The resin hardens quickly when affected by large amount of light. The printing speed is pretty impressive. The layer of hardened material can be created with such printer in few seconds. When the layer is finished, it's moved up and the next layer is started to be worked on.

- **Fused deposition modeling (FDM)**

Fused deposition modeling (FDM) technology was developed and implemented at first time by Scott Crump, Stratasy Ltd. founder, in 1980s. Other 3D printing companies have adopted similar technologies but under different names. A well-known nowadays company MakerBot coined a nearly identical technology known as Fused Filament Fabrication (FFF). 3D printing machines that use FDM Technology build objects layer by layer from the very bottom up by heating and extruding thermoplastic filament

- **Selective Laser Sintering (SLS)**

Selective Laser Sintering (SLS) is a technique that uses laser as power source to form solid 3D objects. This technique was developed by Carl Deckard, a student of Texas University, and his professor Joe Beaman in 1980s. The main difference between SLS and SLA is that it uses powdered material in the vat instead of liquid resin as stereolithography does.

- **Selective laser melting (SLM)**

Selective laser melting (SLM) is a technique that also uses 3D CAD data as a source and forms 3D object by means of a high-power laser beam that fuses and melts metallic powders together. In many sources SLM is considered to be a subcategory of selective laser sintering (SLS). But this is not so true as SLM process fully melts the metal material into solid 3D-dimensional part unlike selective laser sintering

- **Electronic Beam Melting (EBM)**

BM is another type of additive manufacturing for metal parts. It was originally coined by Arcam AB Inc. in the beginning of this century. The same as SLM, this 3d printing method is a powder bed fusion technique. While SLM uses high-power laser beam as its power source, EBM uses an electron beam instead, which is the main difference between these two methods. The rest of the processes is pretty similar.

- **Laminated object manufacturing (LOM)**

Laminated object manufacturing (LOM) is one more rapid prototyping system that was developed by the California-based company Helisys Inc.

During the LOM process, layers of adhesive-coated paper, plastic or metal laminates are fused together using heat and pressure and then cut to shape with a computer controlled laser or knife. Post-processing of 3D printed parts includes such steps as machining and drilling.