LOTAR

LONG TERM ARCHIVING AND RETRIEVAL

Introduction to –
Additive Manufacturing

aka – Additive Layer Manufacturing

aka – Rapid Prototyping

aka - Cloning Designs

aka – SteroLithography

aka – 3D Printing

aka – ……

Scott Summit — The Future of 3D Printing

1. Technology Overview
2. Hardware and Material
3. Applications
4. STL – Creation/Processing
5. Use Cases
6. Out of the Box

Technology Overview - Definitions

- **Additive Manufacturing** consists of a class of technologies that can automatically construct physical models from Computer-Aided Design files.
  - **Improve communication**
  - **Improve collaboration**
  - **Shorten design cycles**
  - **Stretch R&D dollars**
  - **Improve accuracy**
  - **Eliminate mistakes**
  - **Trigger innovation**
  - **Accelerate Production**
  - ……
  - **Save your Life?**

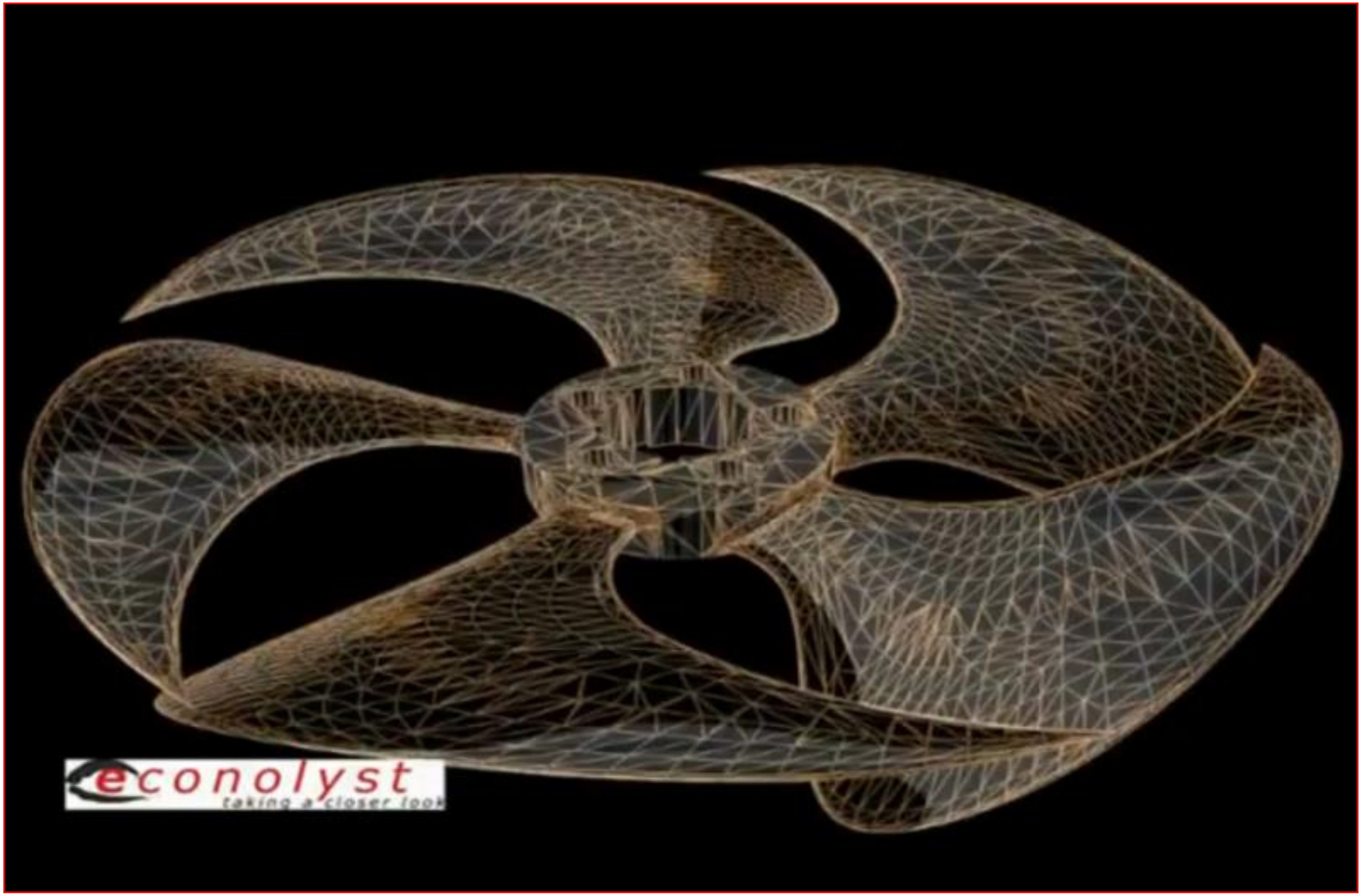
Technology Overview - Importance

- **Additive manufacturing** was named **number one in *Aviation Week & Space Technology*** magazine's May list of **"Top Technologies to Watch,"** is a rapidly growing manufacturing technology being touted for its cost savings and waste reduction. By 2015, the sale of additive manufacturing products and services worldwide is expected **to grow to $3.7 billion from $1.71 billion in 2011,** according to independent consultants Wohlers Associates.

Objective -

- Insight into being able to **recognize use cases** that would benefit from the use of Additive Manufacturing (ADDM)
- Insight into how to effectively initiate and **integrate** the use ADDM into a **standard engineering process**.
- Insight into the **benefits and limitations** found in each of the component disciplines found in the overall the use of ADDM.
- A perspective on **future directions** the use of ADDM might go

General Theory -



History -

- In the 60s Herbert Voelcker had thoughts of the possibilities of using computer aided machine control to run machines that build parts from CAD geometry.
- In the 70s he developed the mathematics to describe 3D aspects that resulted in the first algorithms for solid modeling
- in the 80s Carl Deckard came up with the idea of layer based manufacturing
- And while there are several people that have pioneered the Rapid Prototyping technology, the industry generally gives credit to Charles Hull -

History -

- The term "stereolithography" was coined by Charles W. Hull, in his US Patent 4,575,330, entitled "Apparatus for Production of Three-Dimensional Objects by Stereolithography" issued in 1986.

History -

- Stereolithography was ***originally*** defined as a method and apparatus for making solid objects by successively "printing" thin layers of the curable material, e.g., a UV-curable material, one on top of the other.

(Video)

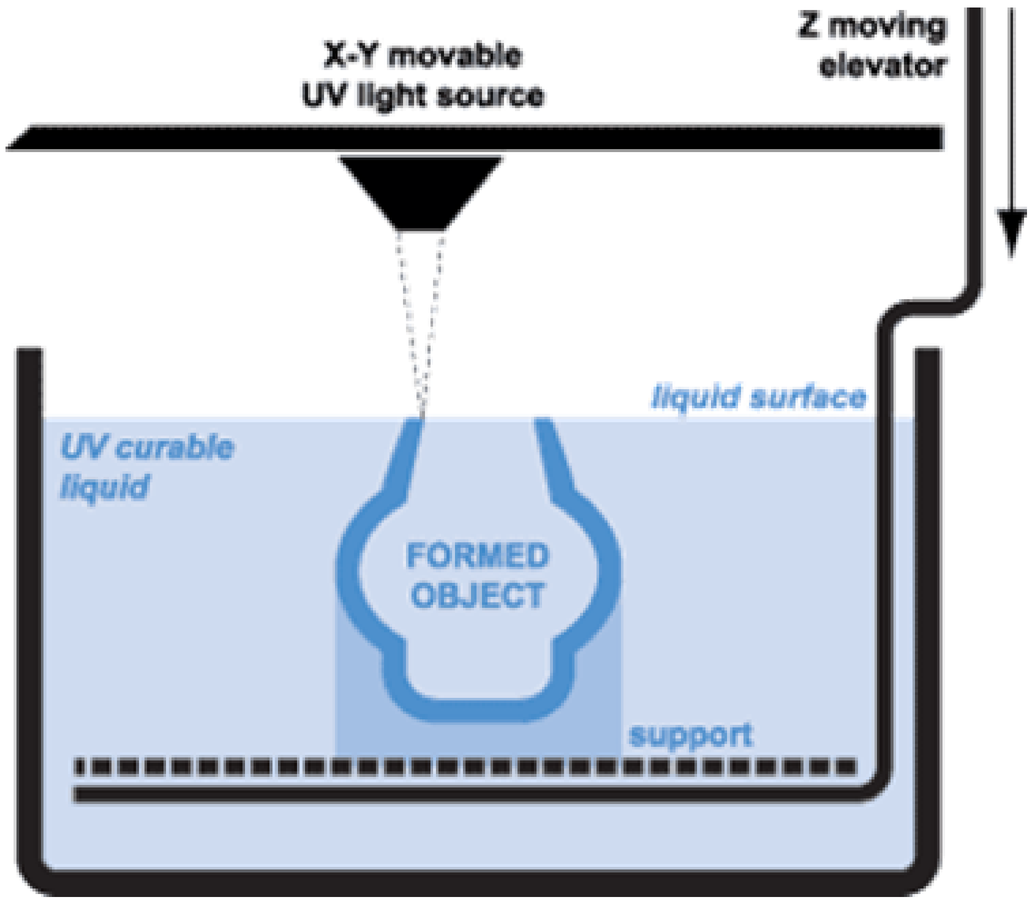
Processes - Stereolithography

Stereolithography (SLA) (Exerpted from Worldwide Guide to Rapid Prototyping)

Picture, ©Materialise, 2002

Stereolithography builds epoxy parts one layer at a time by tracing a laser beam on the surface of a vat of liquid photopolymer. The material solidifies wherever the laser beam strikes the surface of the liquid. After a layer is completed, the part is lowered a small distance into the vat, coating it with a fresh film of resin, and a second layer is traced right on top of the first. The layers are stacked sequentially to form a complete, three-dimensional object.

At this point in the process, parts are cleaned and post-cured.

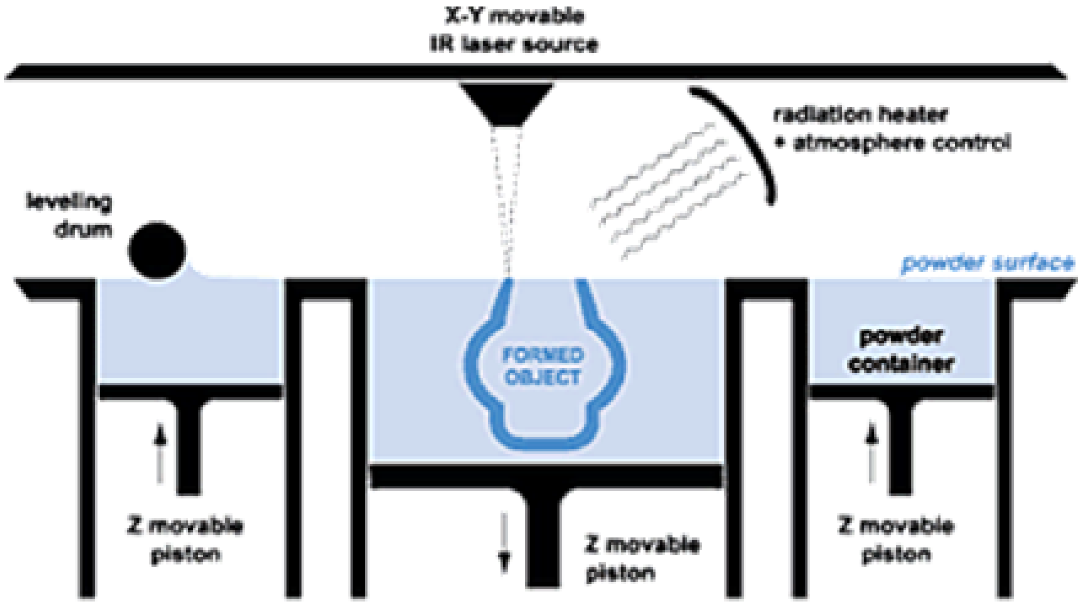


Processes - Laser Sintering

Selective Laser Sintering (SLS)

(Exerpted from Worldwide Guide to Rapid Prototyping)

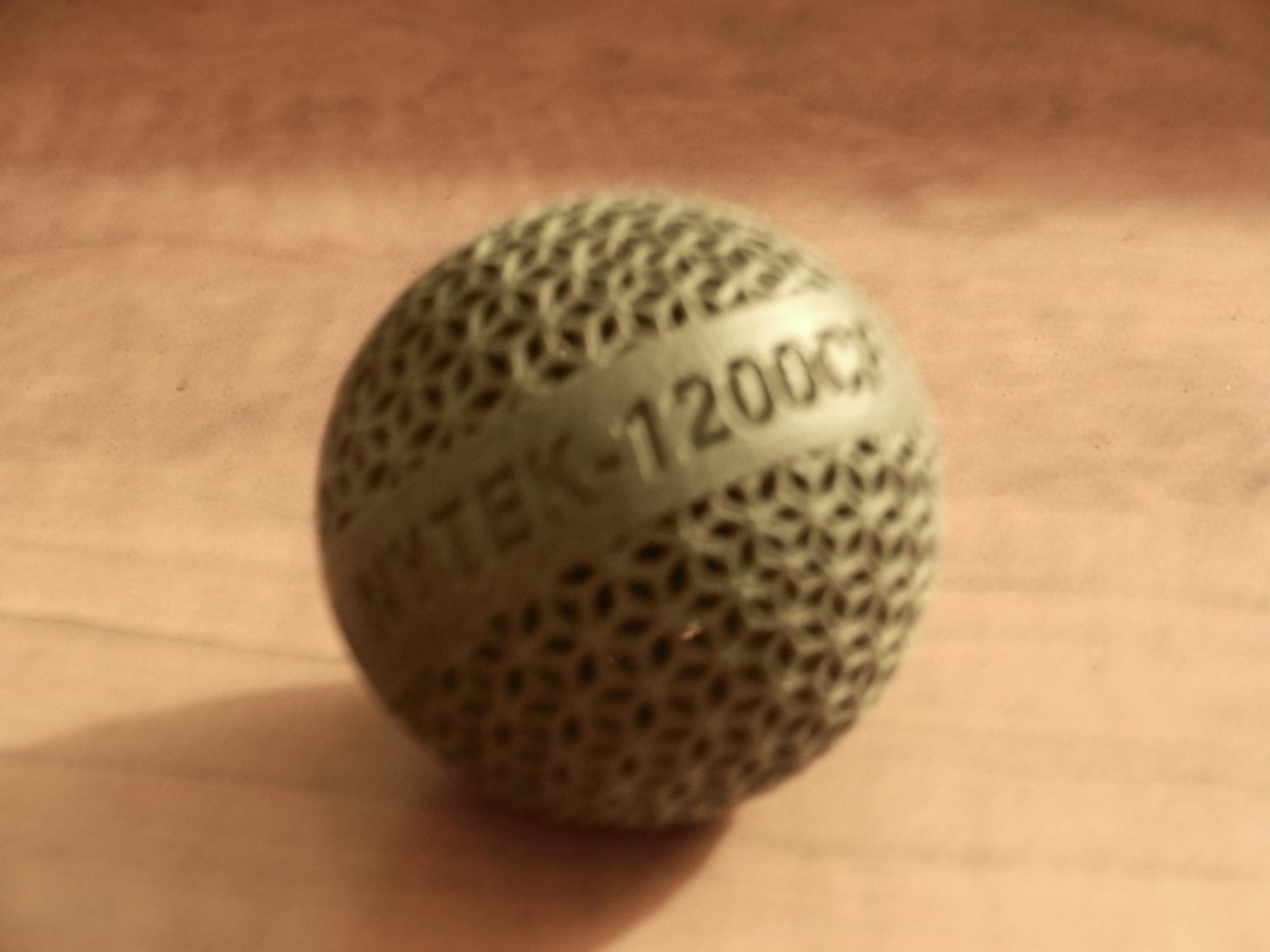
Picture, ©Materialise, 2002



Thermoplastic powder is spread by a roller over the surface of the part bed. The piston in the cylinder moves down one object layer thickness to accommodate each new layer of powder.

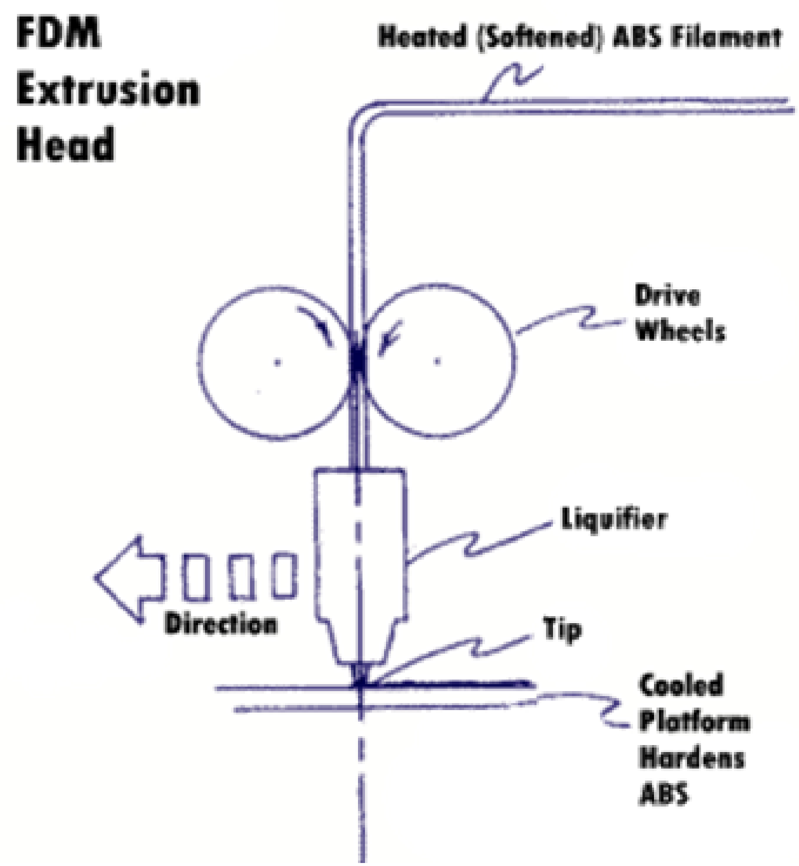
The powder delivery system is similar in function to the part bed. Here, a piston moves upward incrementally to supply a measured quantity of powder for each layer. The fabrication chamber is maintained at a temperature just below the melting point of the powder so that heat from the laser need only elevate the temperature slightly to cause sintering. This greatly speeds up the process.

A computer-directed infrared laser is then traced over the surface of the powder to selectively melt and bond a cross secion of the part to form one layer of the object. The process is repeated layer by layer until the entire object is fabricated.


1200CF

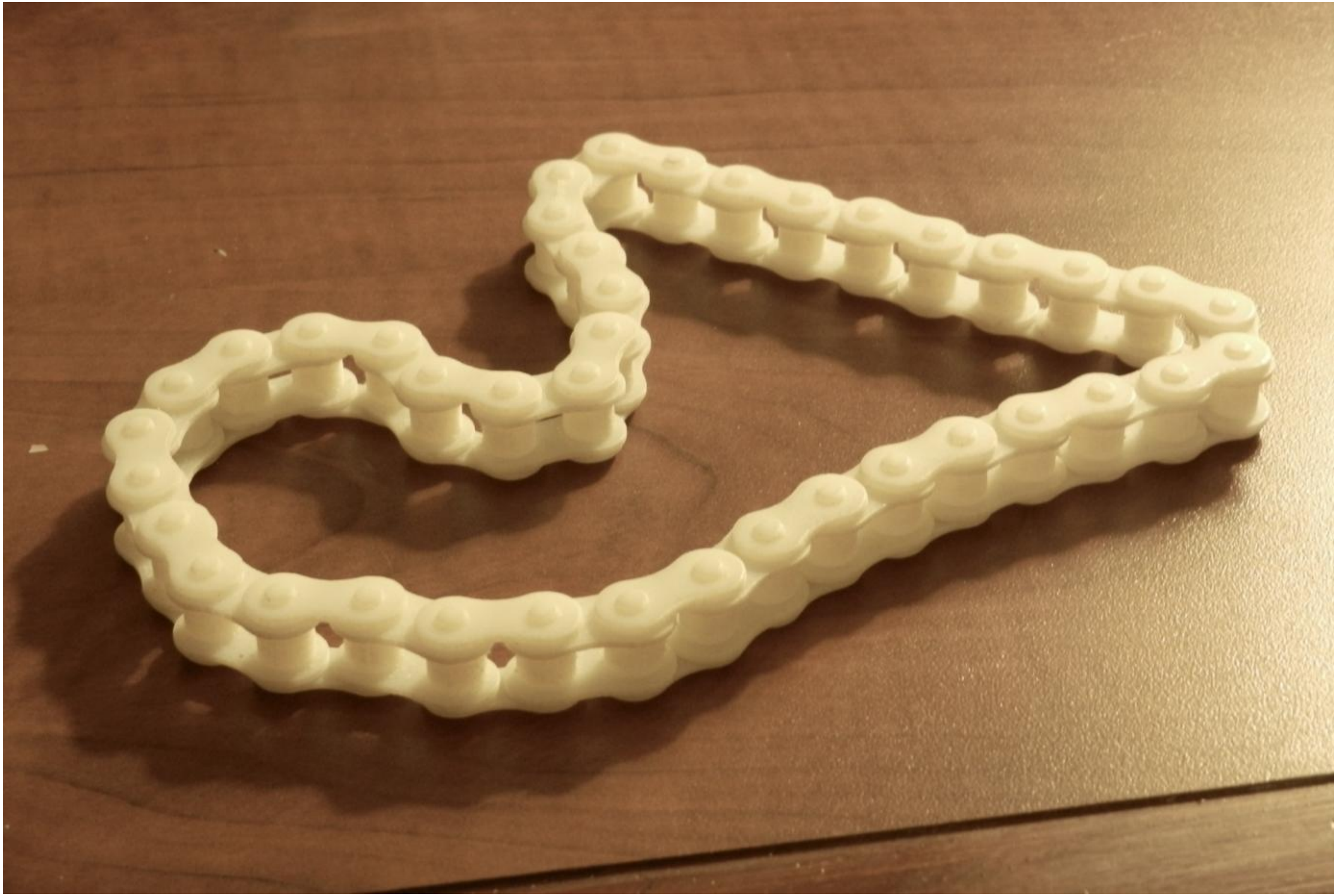
Processes – Fused Deposition

FDM is the second most widely used rapid prototyping technology, after stereolithography. A plastic filament is unwound from a coil and supplies material to an extrusion nozzle. The nozzle is heated to melt the plastic and has a mechanism which allows the flow of the melted plastic to be turned on and off. The nozzle is mounted to a mechanical stage which can be moved in both horizontal and vertical directions. The concept can best be described as a hot glue gun mounted in place of the cutter on a 3 axis NC mill.

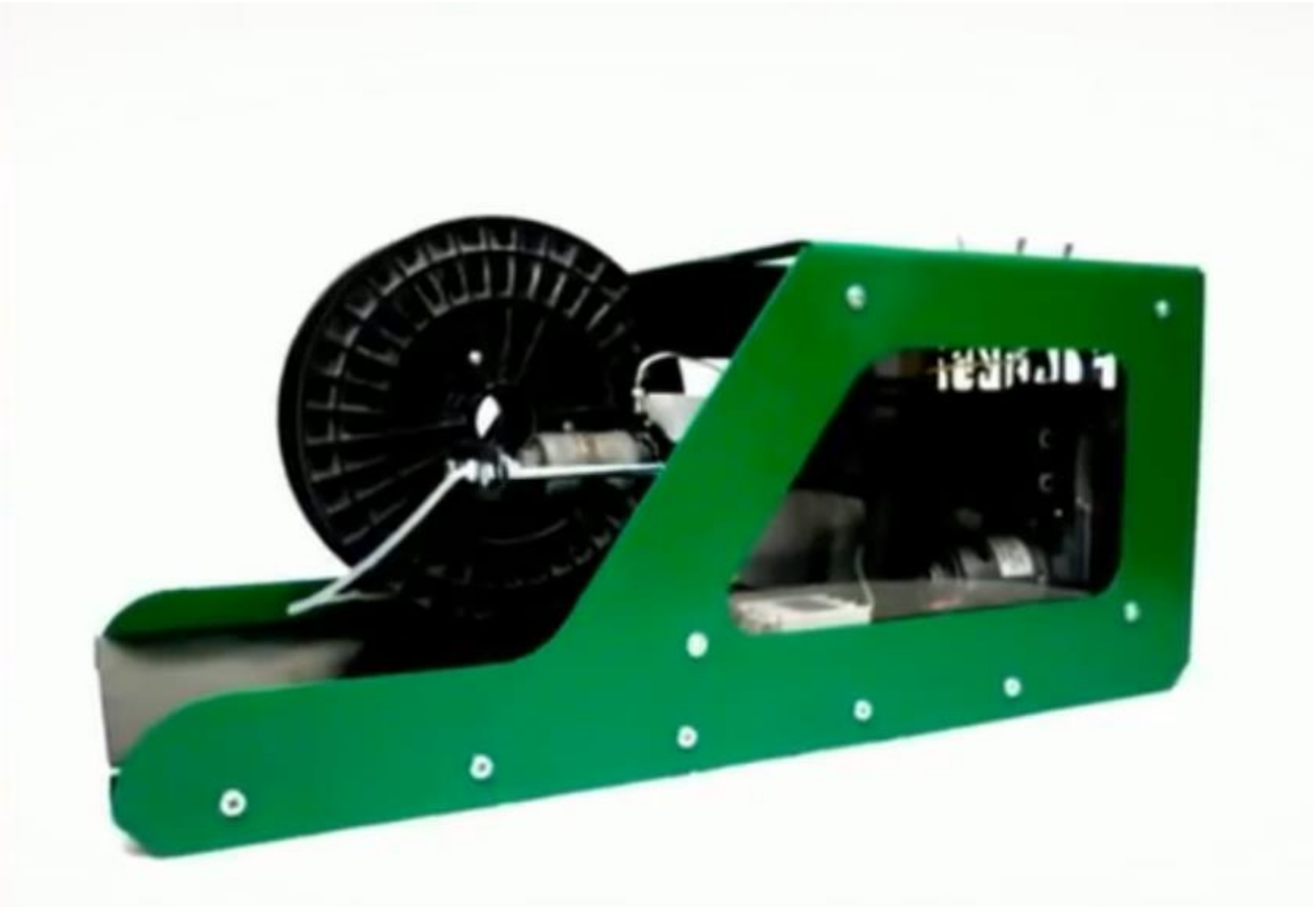


As the nozzle is moved over the table in the required geometry, it deposits a thin bead of extruded plastic to form each layer. The plastic hardens immediately after being squirted from the nozzle and bonds to the layer below. The entire system is contained within a chamber which is usually kept warm during the build process to prevent internal stresses from distorting the geometry.


GTES

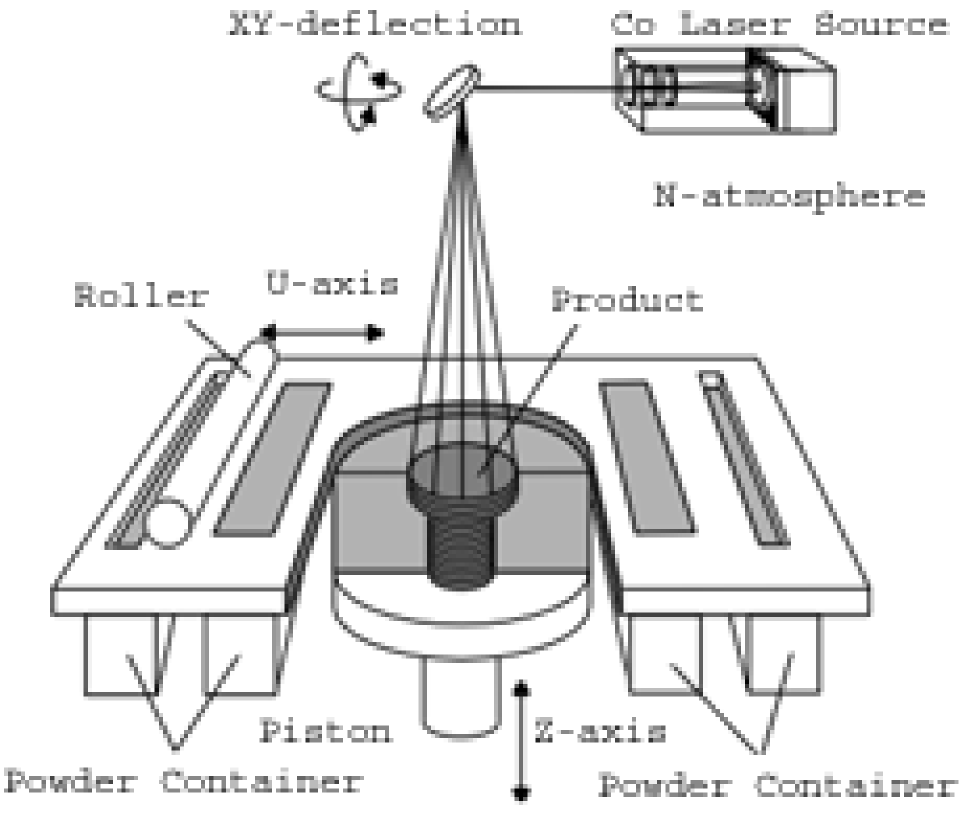



WELCOME TO THE
NEW ERA
LULZBOT AO-101
DESKTOP 3D PRINTER
GET STARTED NOW

Processes - Direct Metal Laser Sintering

DMLS on the M270 is also similar to SLS but metal powders are fused directly with a fiber laser. Complex metal parts with sharp detail down to .012 inch can be built from mild steel, a bronze/steel alloy, or 17-4 stainless steel. The M270 only has a 10 x 10 inch build platform but layer thickness is less than one thousandths of an inch so stair stepping seen in other processes is almost invisible.



Applications – Production

Technology Overview – 3D Printing

3D Printing on RPM's Z-Corporation Z810 is similar to SLS except the plaster powder is stuck together with binders delivered through ink-jet print heads on an XY plotter. The main advantages of 3DP are high speed and low cost with the added bonuses of a large build envelope and the capability to print in color. However, 3DP parts are fragile and don't have fine feature detail.

After printing, the parts are allowed to dry within the powder bed. Once removed, they are generally infused with cyanoacrylate (super glue) or epoxy to toughen them up.

Applications – Prototypes

Physical and Digital Prototyping belong TOGETHER –
By L. Stephen Wolfe, P.E.

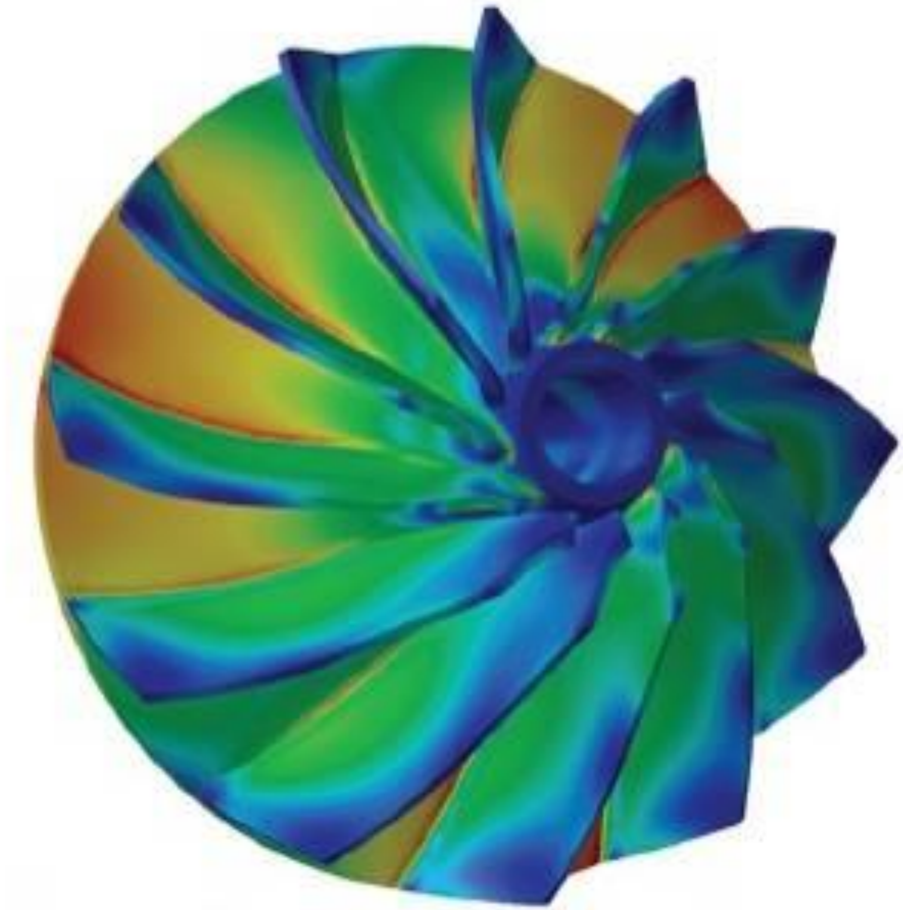
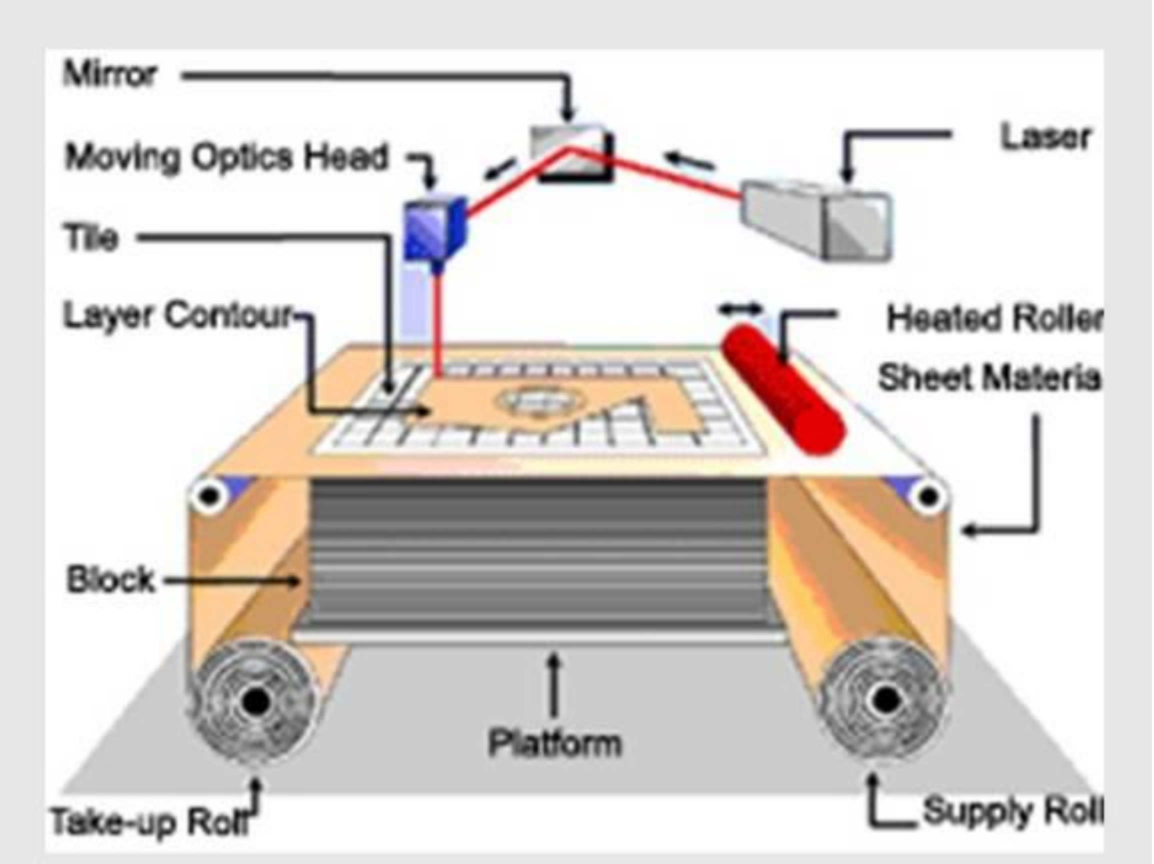


Figure 8. Plot of stresses produced by centripetal forces in a turbine impeller generated by Dassault Systèmes Abaqus software.

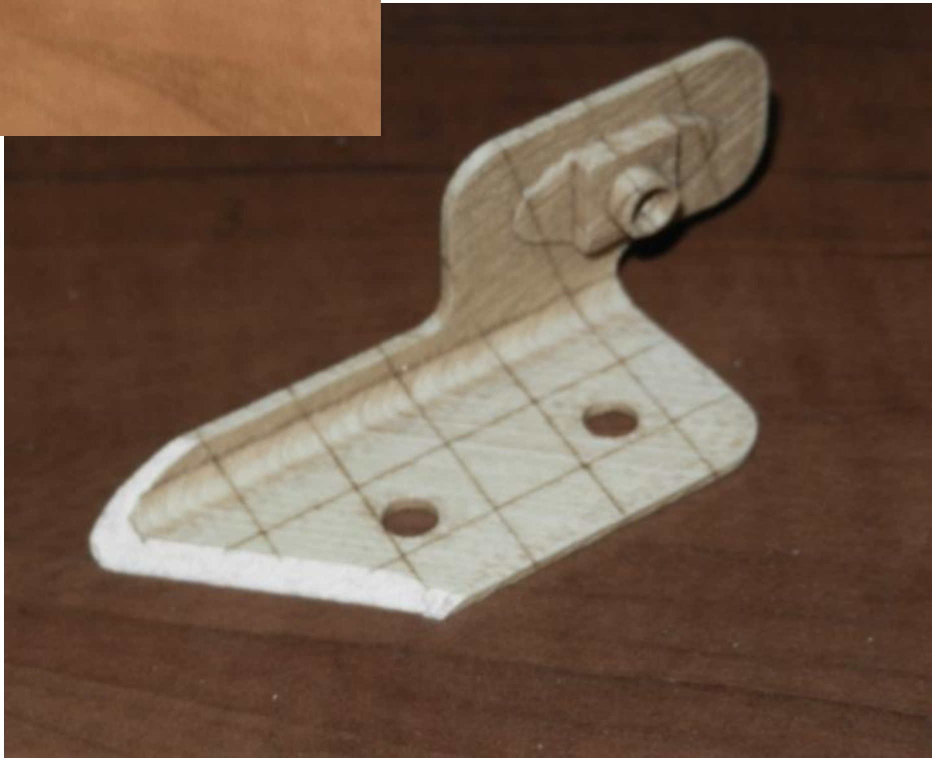
Technology Overview – Layer Object Manufacturing

A manufacturing process that uses a carbon-dioxide laser to create successive cross-sections of a three-dimensional object from layers of paper with a polyethylene coating on the backside.

A sheet of paper is fed through with the aid of small rollers. As the paper is fed through, a heated roller is used to melt the coating on the paper so that each new layer will adhere to the previous layer.



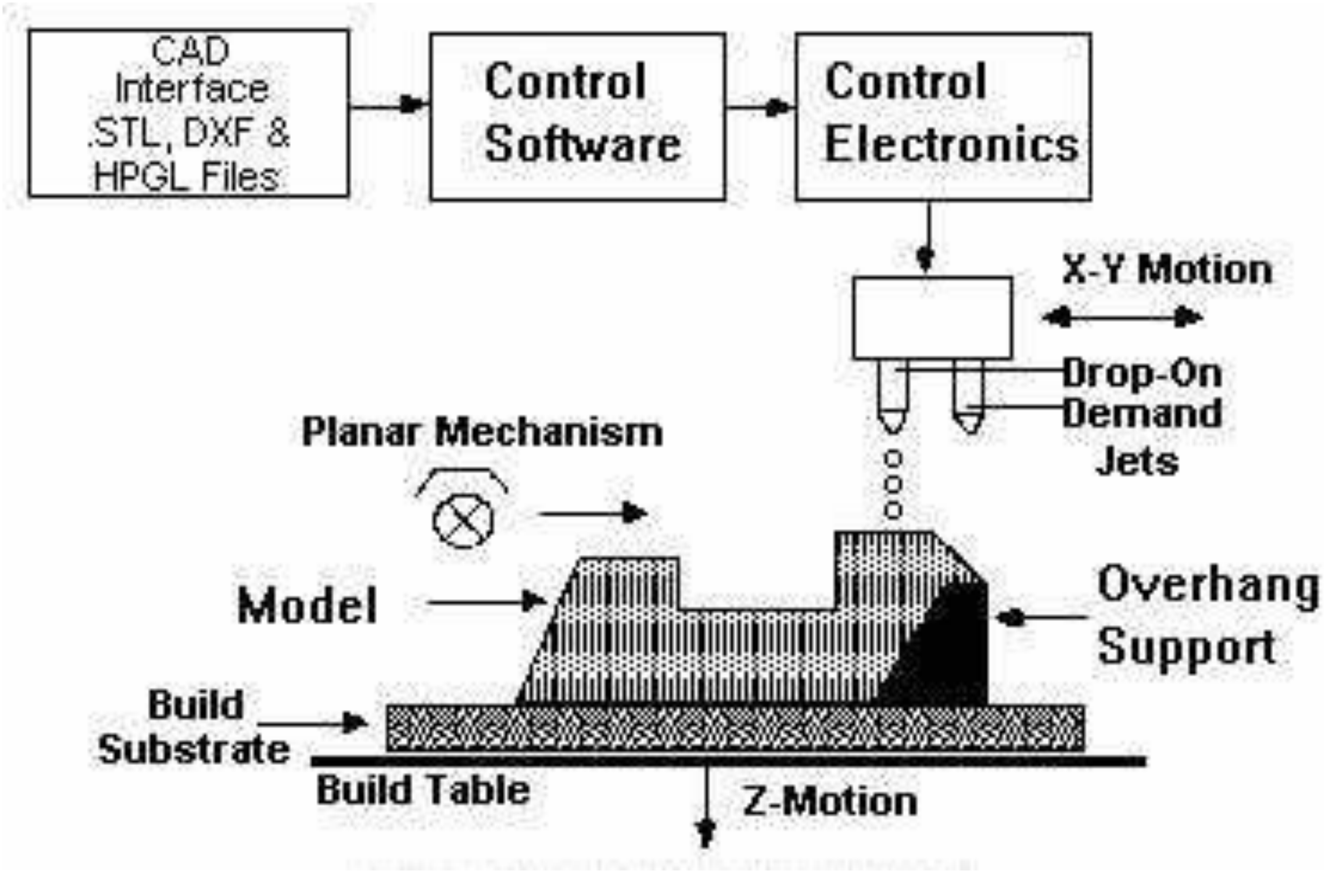
SOLIDO



Processes – Ballistic Particle Manufacturing

Ballistic Particle Manufacturing utilizes ink jet or droplet based manufacturing techniques, where it builds the models by firing micro-droplets of molten wax material from a moving nozzle or jet onto a stationary platform, the platform then lowers and the process is repeated for each layer of the model.

Bill Masters (the BPM inventor) first described BPM as a spit wad. “When you shoot a lot of wads,” he said, “they begin to take shape, and if you can control the direction of the wads and the motion of the device that's shooting them, you can produce any desired shape.”



Processes – Ballistic Particle Manufacturing or ???

Processes – Ballistic Particle Sterolithography (kind of)?

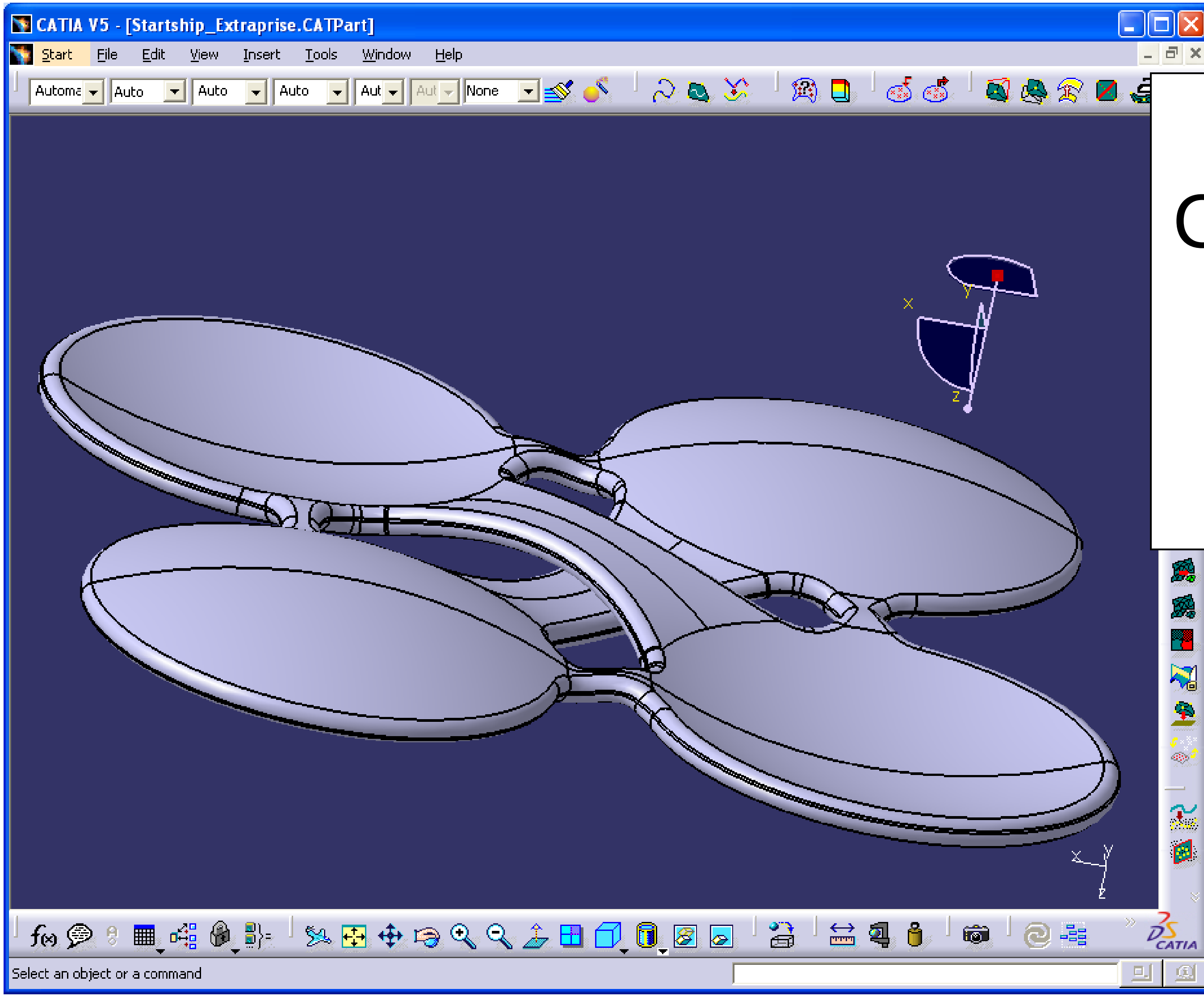
3D printing with ultra-clear materials
can be used to make highly
accurate medical models
that show detailed bone structures.
Source: Objet

Almost spooky - ?

Really spooky - ?

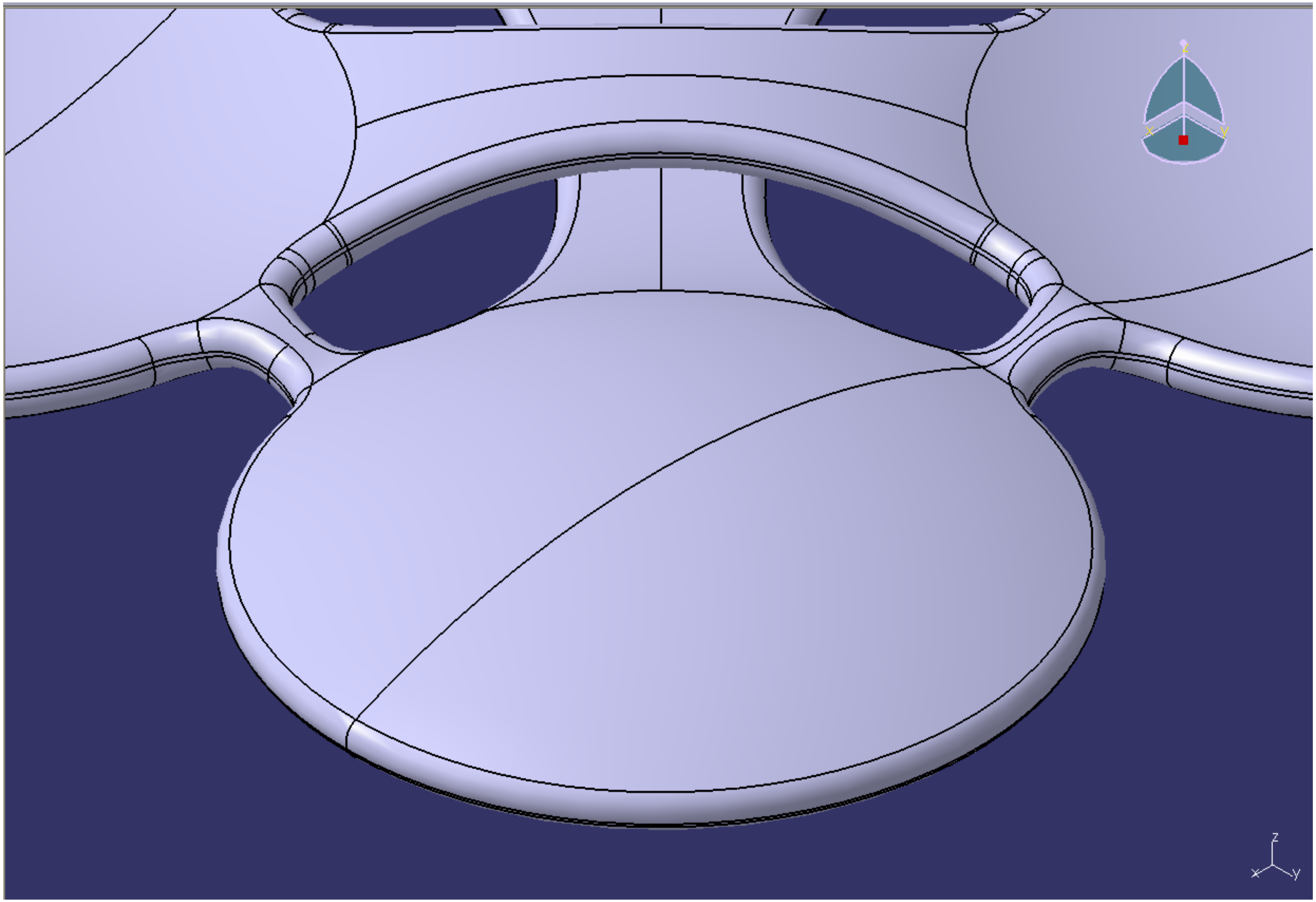
STL - Creation

STL Creation - CATIA

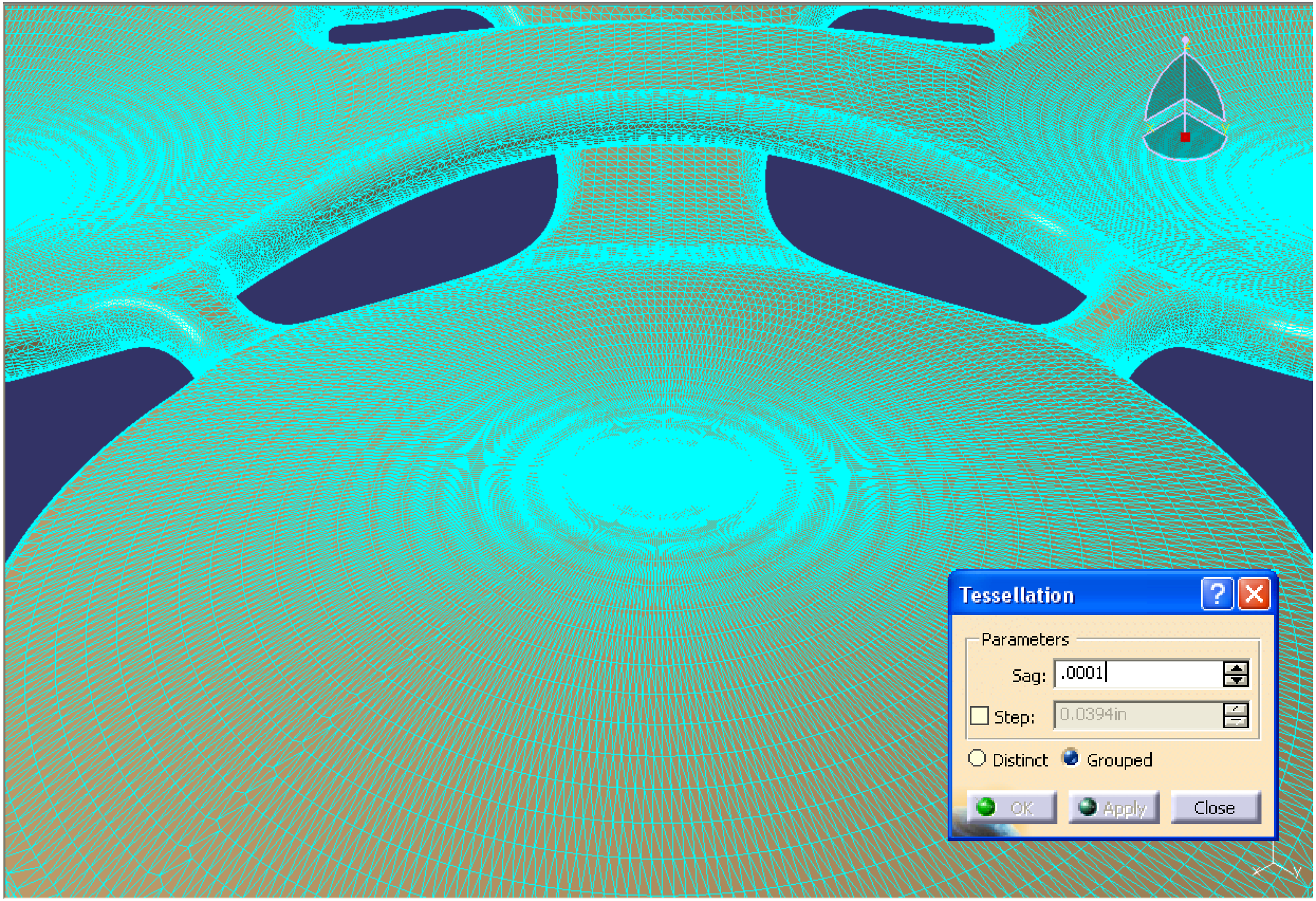


Create a CATIA solid of part to be generated using ADDM

Creation



STL Creation - Tessellation



Technology Overview - Considerations

Pre-Processing

Speed

Surface Finish

Color

Waste

Office Environment

Setup

Build Orientation

Accuracy

Flight Certified

Material Properties

Build Envelope

Post Build Processes

Support

Capital Cost

Material Cost

Envelope Utilization

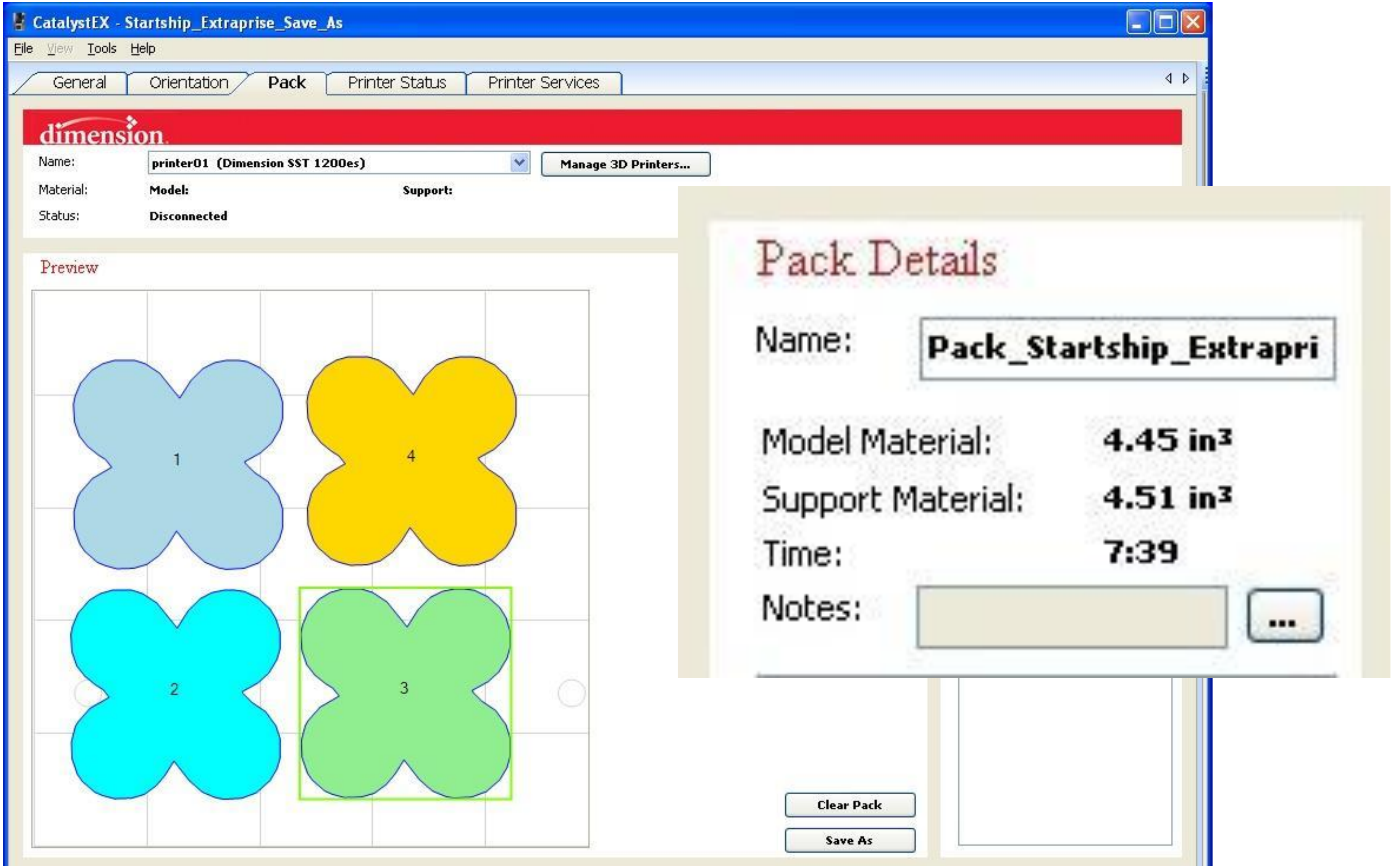
And on and on …

L. Stephen Wolfe, P.E. Whitepaper – Z-Corp

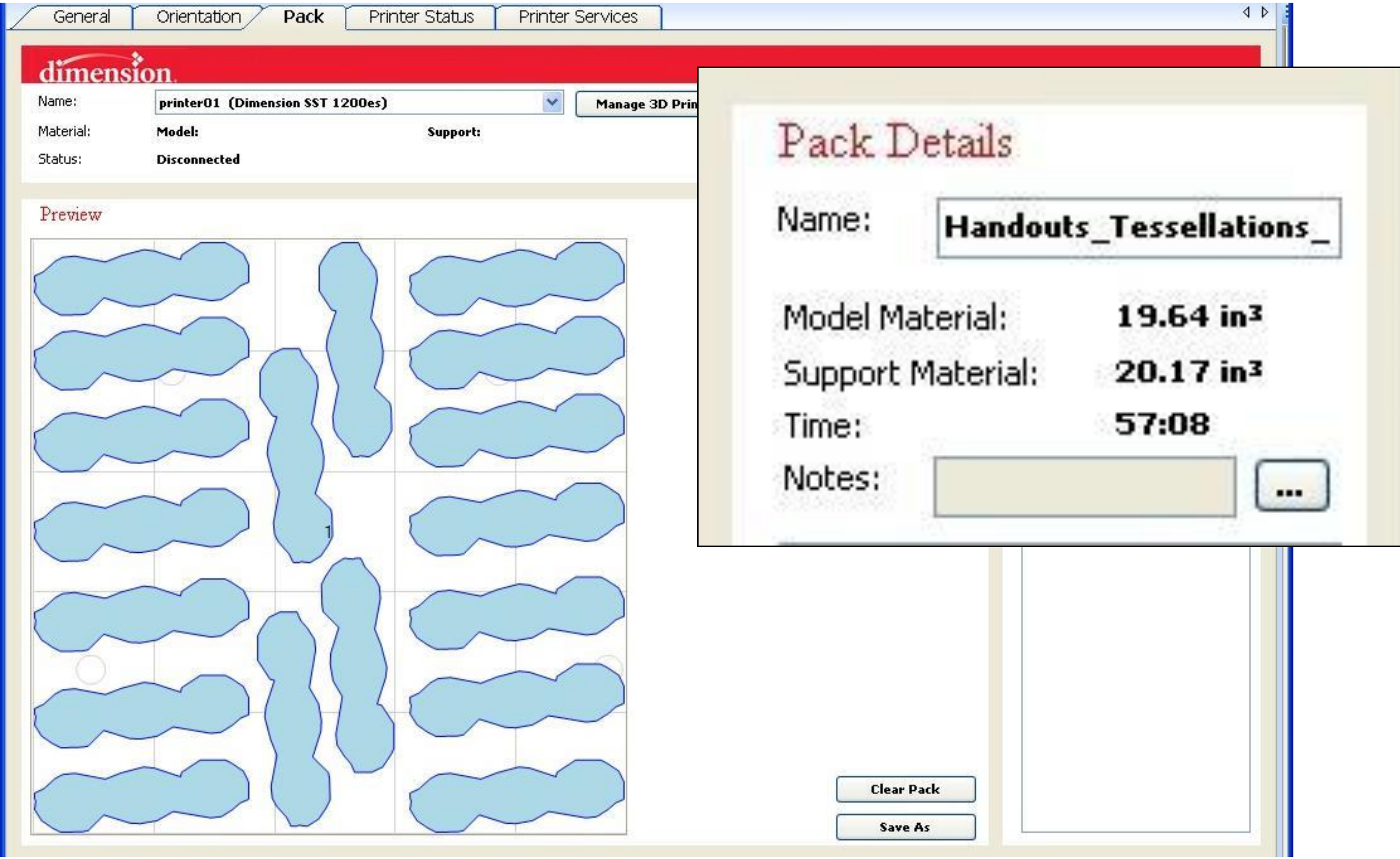
Technology Overview - Considerations

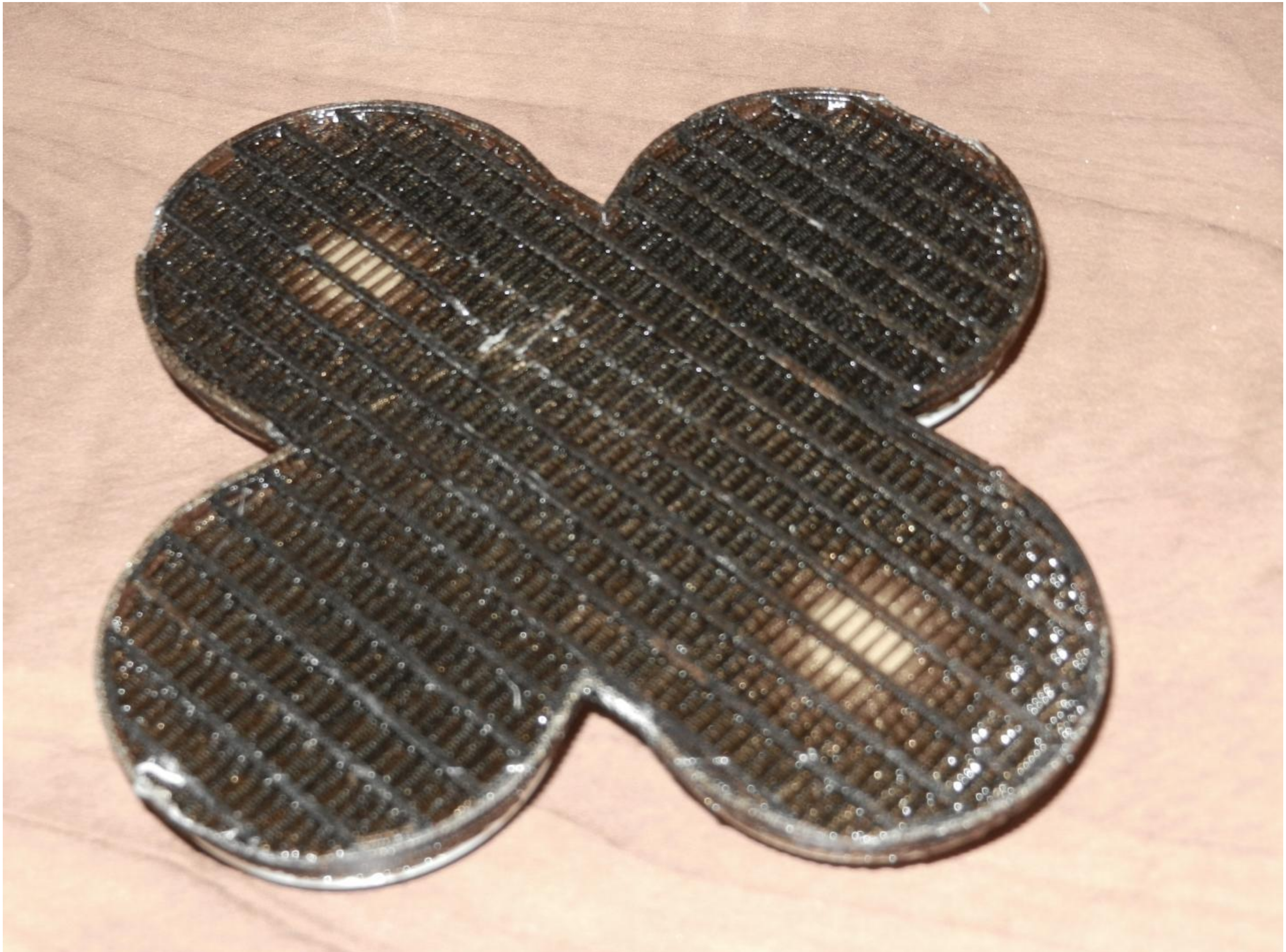
BUT – NOT COMPLEXITY THAT IS FREE

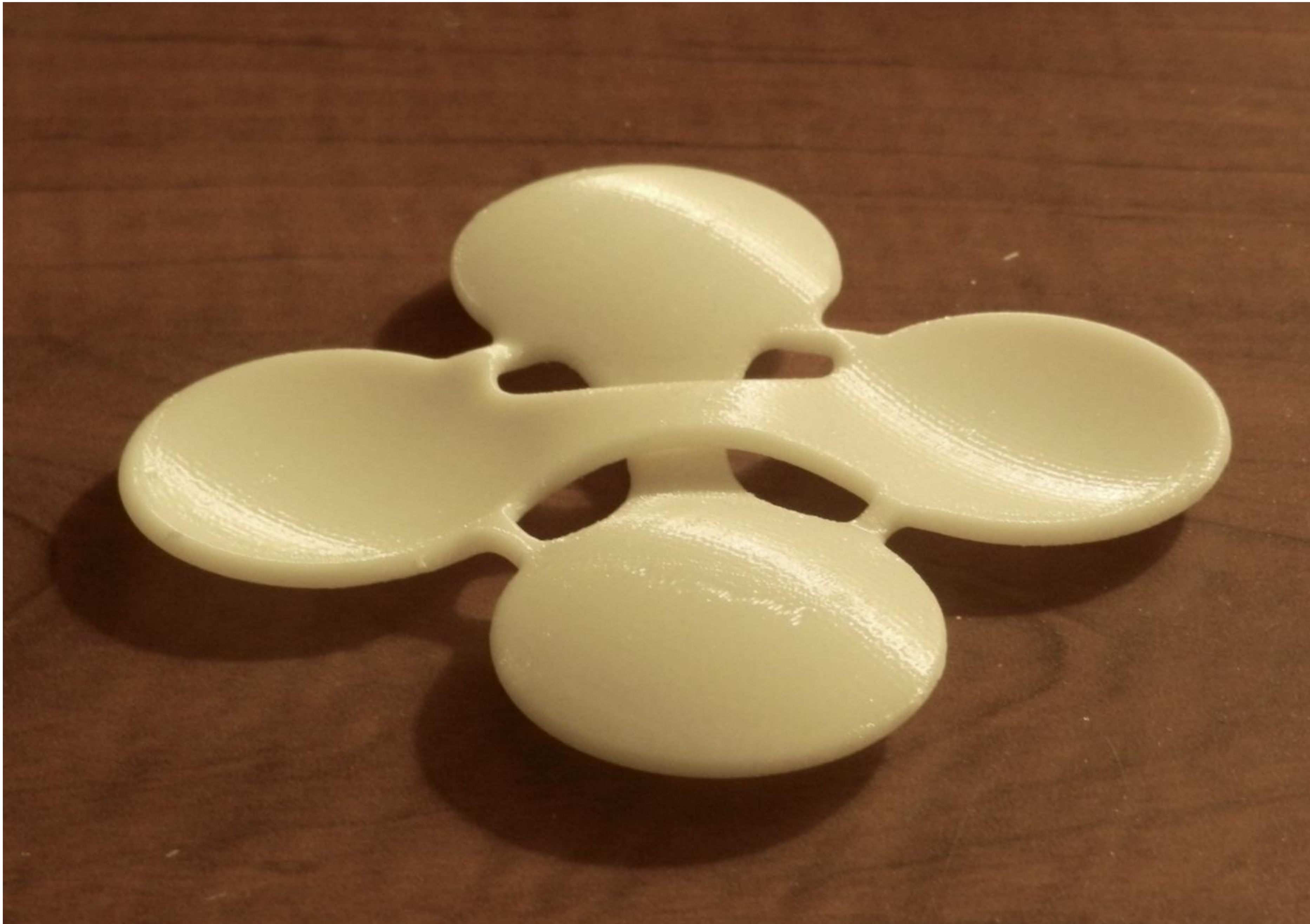
Sample - CATIA/Dimension CatalystEX Session

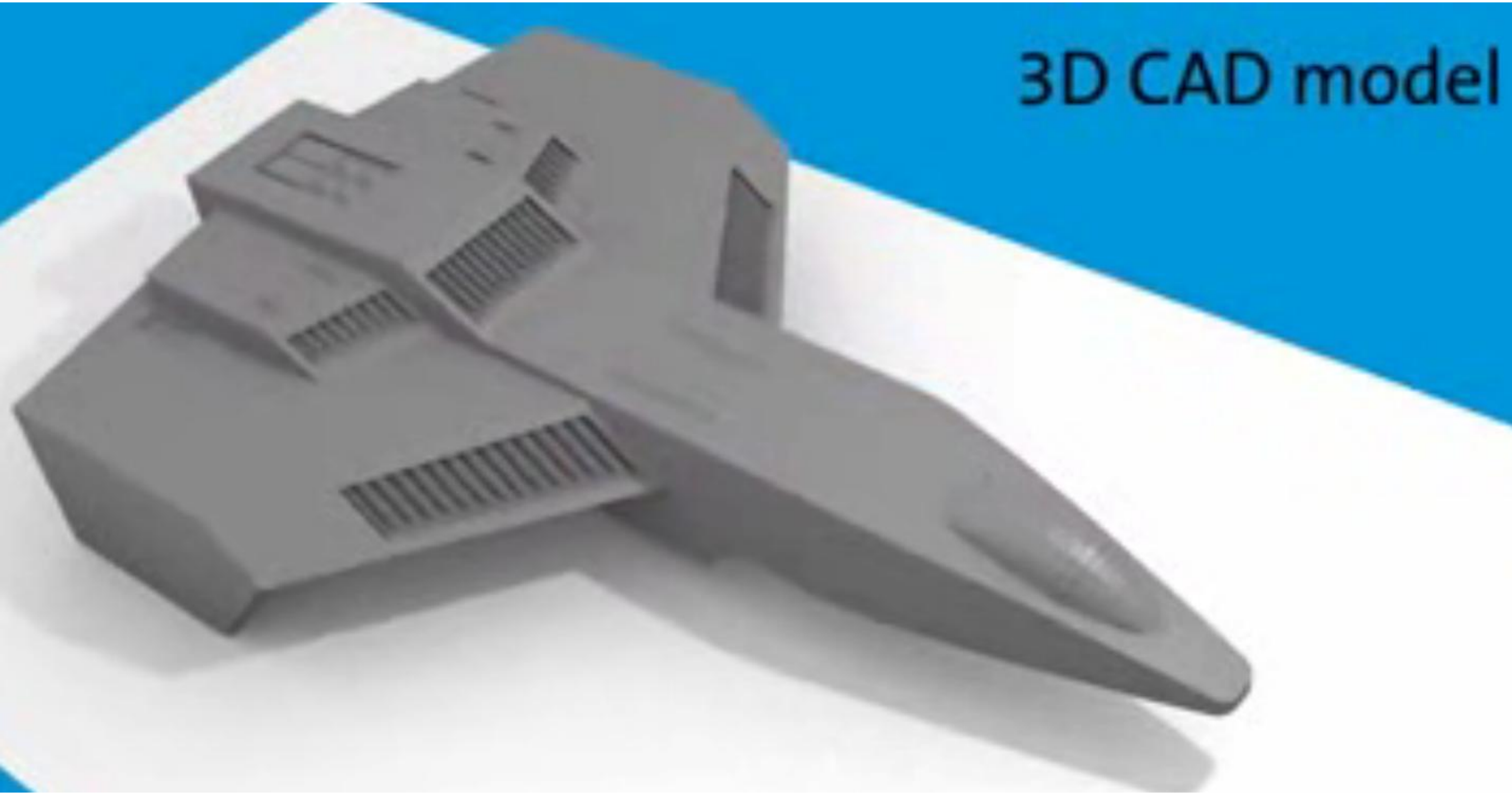


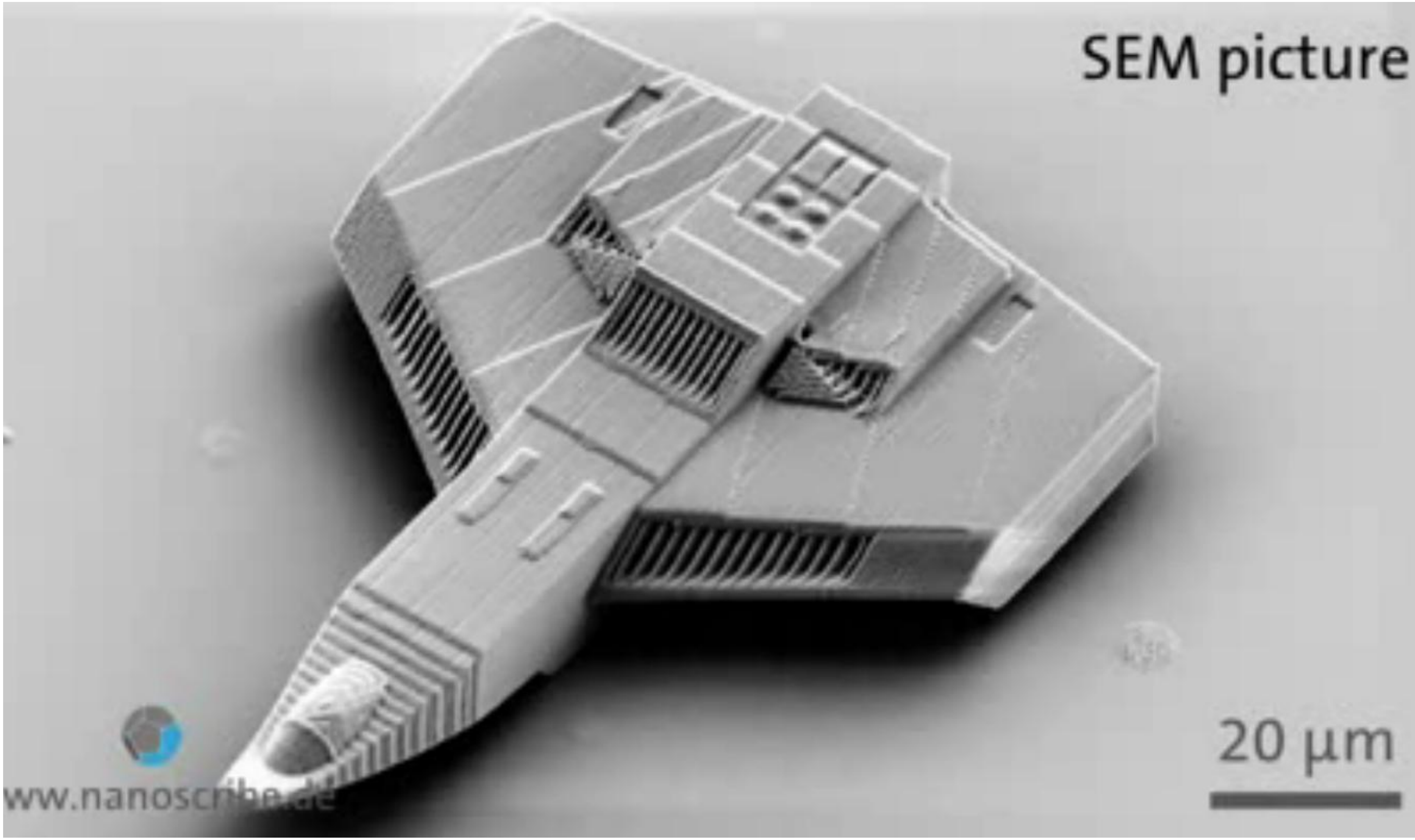
Sample - CATIA/Dimension CatalystEX Session








3D CAD model


SEM picture
20 µm
www.nanoscribe.de

Applications – Large Scale?

Applications - Production

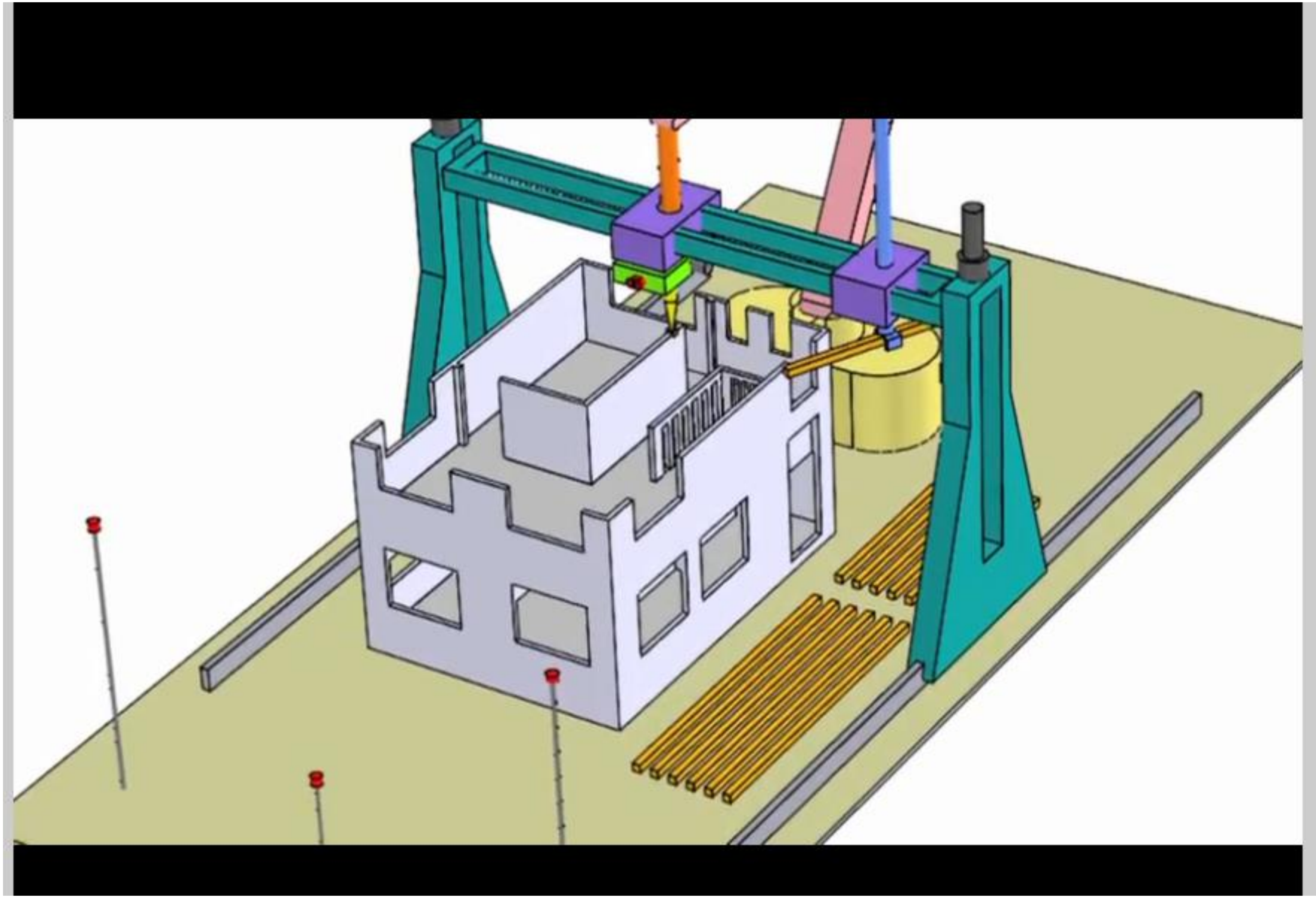
A prototype one-sixth the size of the final Urbee vehicle was produced solely using 3-D printing technology from Stratasys.

Urbee to Be First 3-D Printed Car

Using 3-D Printing Tech, British Airbus Engineers Aim to Print Out an Entire Aircraft Wing

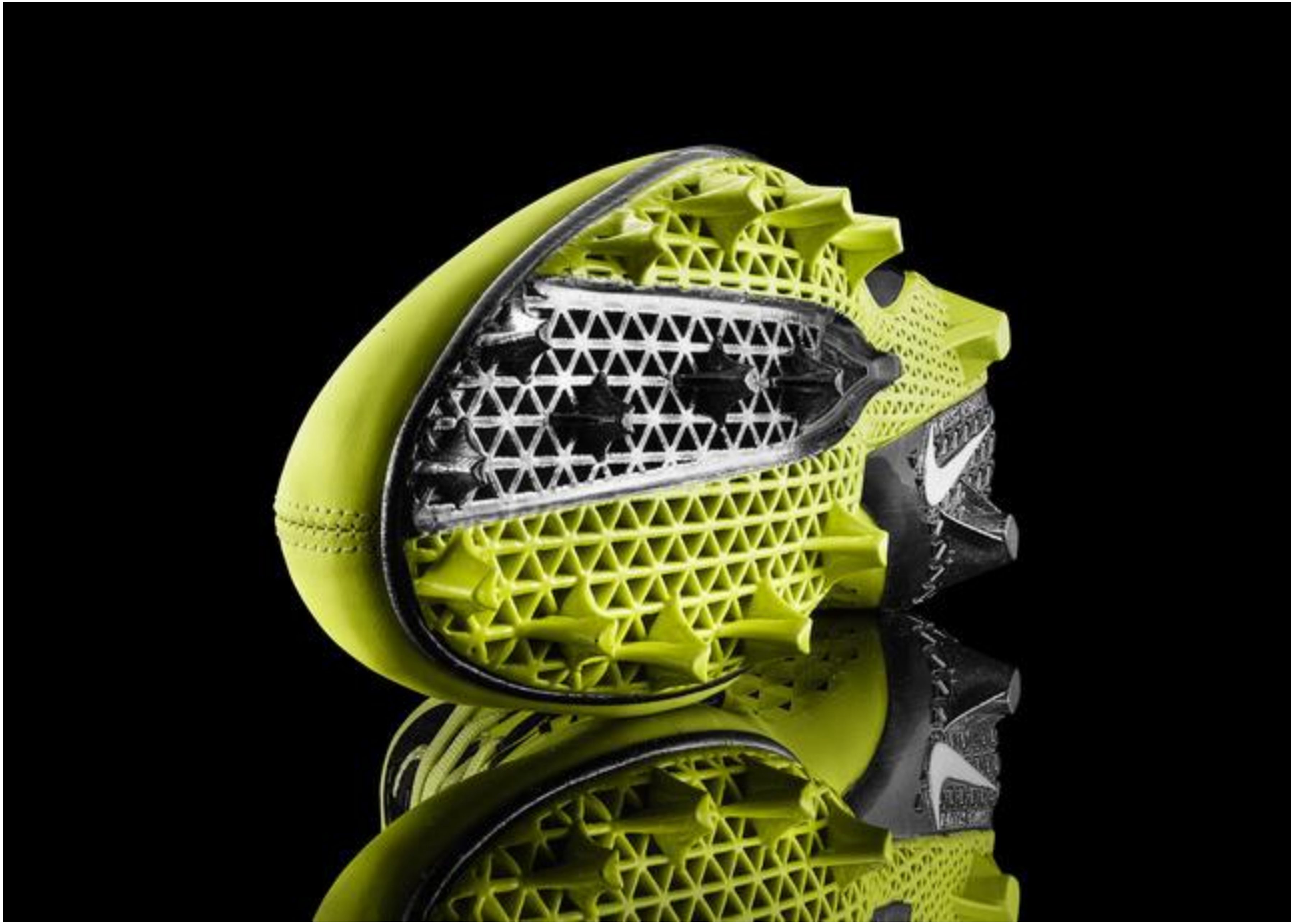
If you can print an airplane, what can't you print?

By Clay Dillow Posted 02.14.2011 at 5:16 pm 11 Comments



Applications – Sales and Marketing

Figure 7. Prototypes of Timberland Company footwear made on Z Corporation's color ZPrinter appear remarkably lifelike.



Applications – Clothing?

Applications – Clothing?

3D Printed Bikini by Continuum & Shapeways

http://www.shapeways.com/blog/archives/875-N12-3D-Printed-Bikini-Technical-Update.html

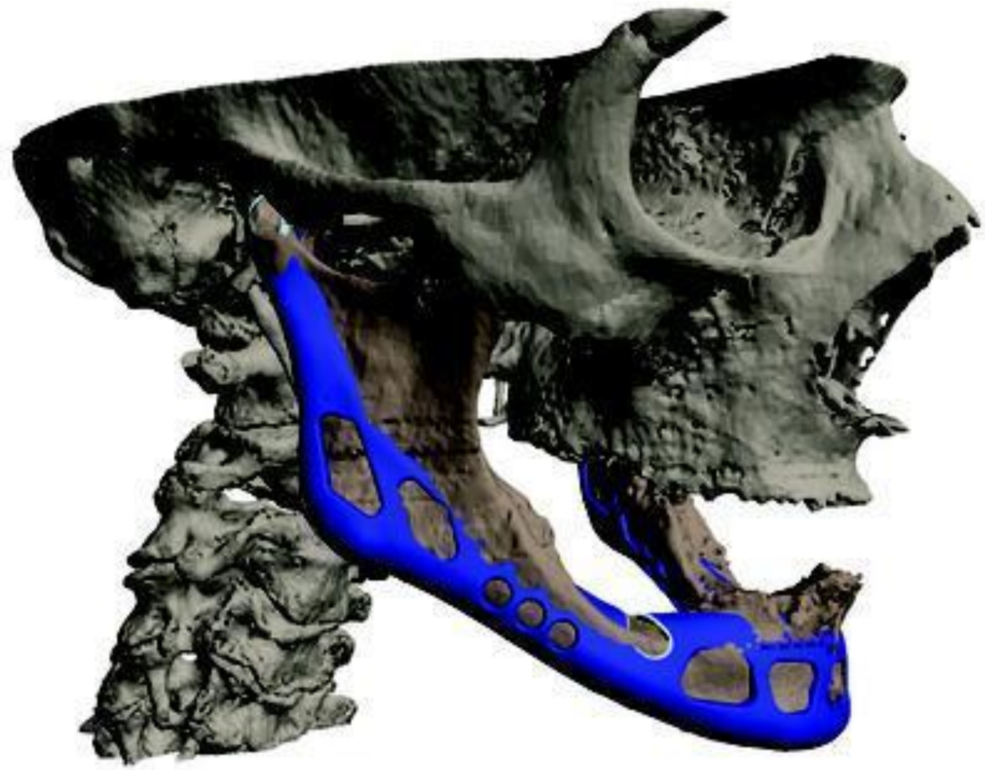
Selective Laser Sintered Nylon - SLS

$150.00

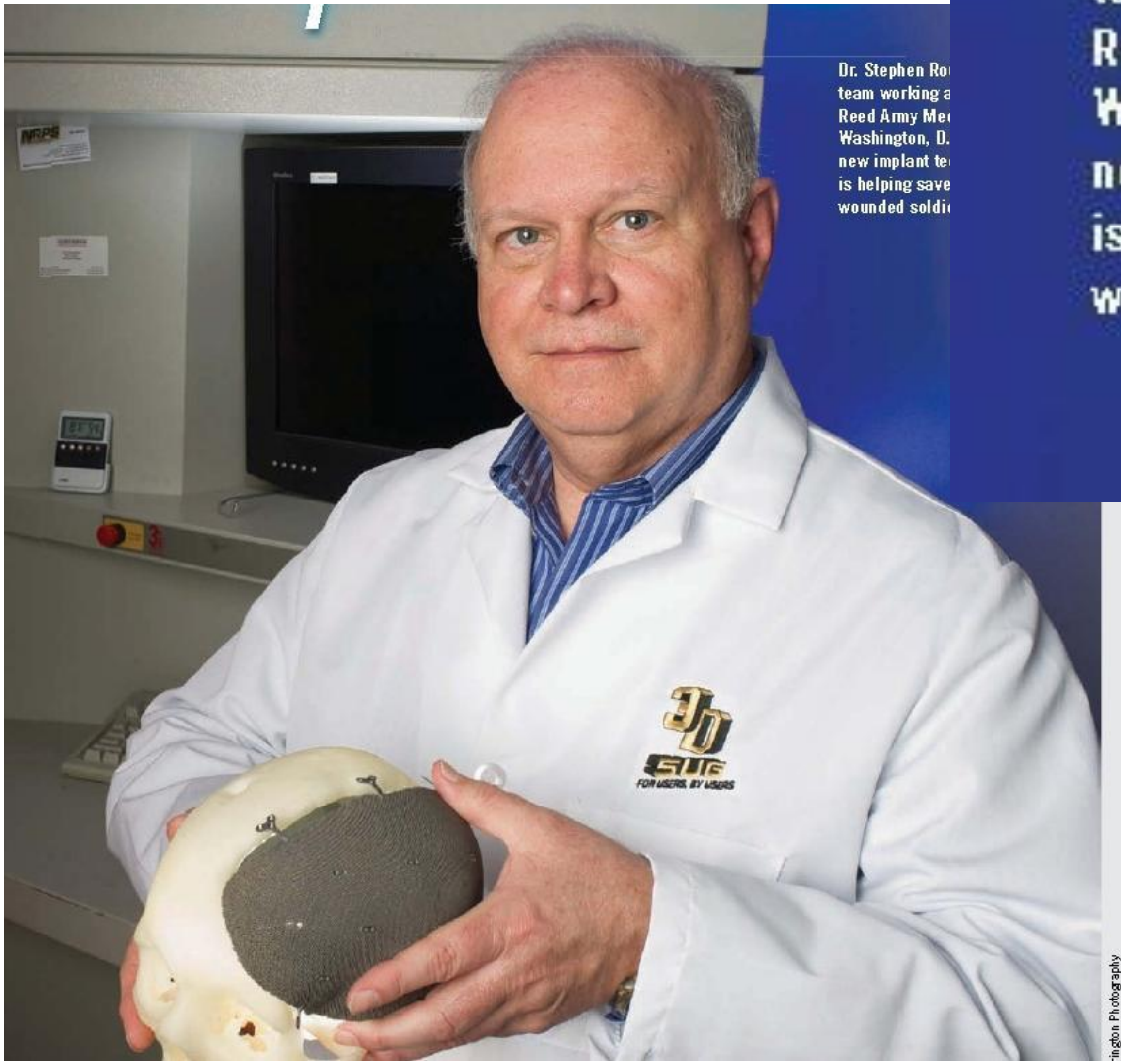
http://www.shapeways.com/n12_bikini

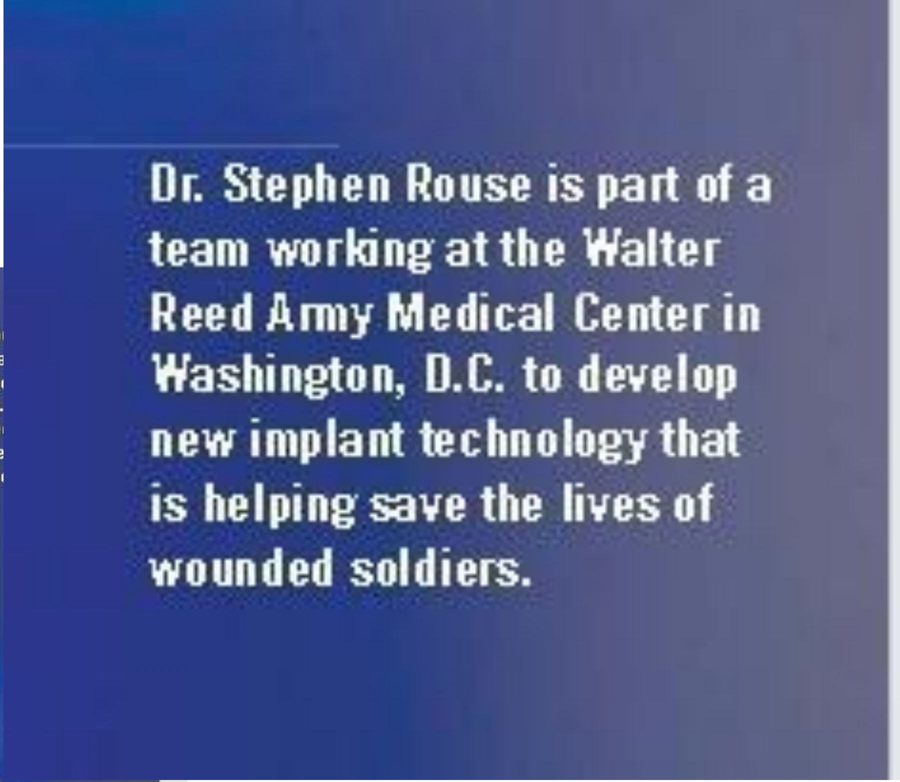
Applications – Medical

3D Printed Jaw Used in Transplant
2/27/2012
A team of doctors in The Netherlands performed successful jaw transplant surgery recently that showcases just how far the power and potential of 3D printing has come as key asset in medical applications, particularly the design and development of custom prosthesis.
An 83-year-old woman suffering from a chronic bone infection received a lower jaw transplant of a 3D-printed jaw made out of titanium powder as opposed to undergoing reconstructive surgery, which the medical team deemed too risky because of her age. Using a 3D model of the patient's lower mandible, the medical team, in partnership with metal additive manufacturing provider LayerWise, constructed and 3D-printed a metal jaw implant structure that incorporates articulated joints and dedicated features, becoming one of the first complete patient-specific implants, according to officials.



Applications – Medical



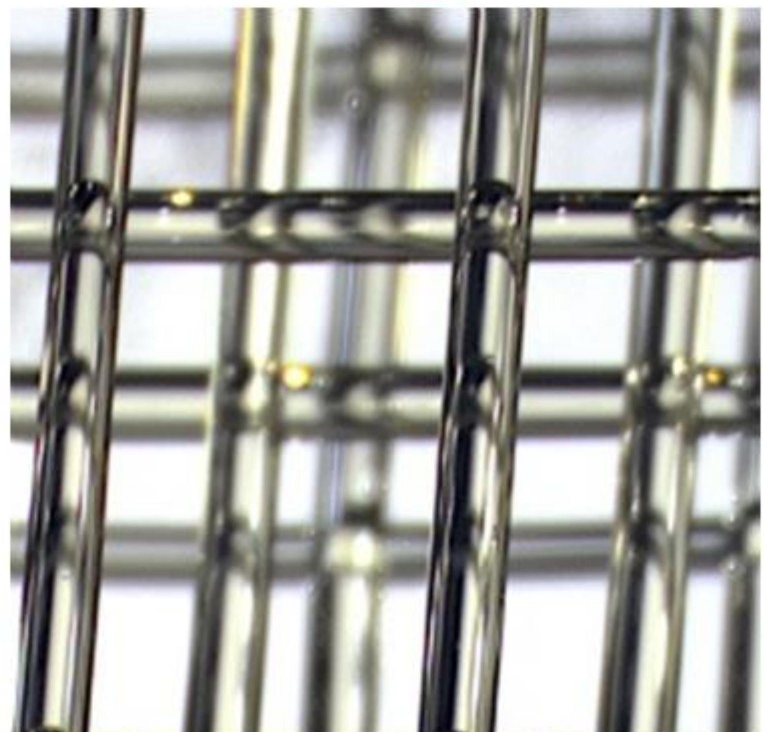


Applications – Medical

Penn Researchers Improve Living Tissues With 3D Printed Vascular Networks Made From Sugar

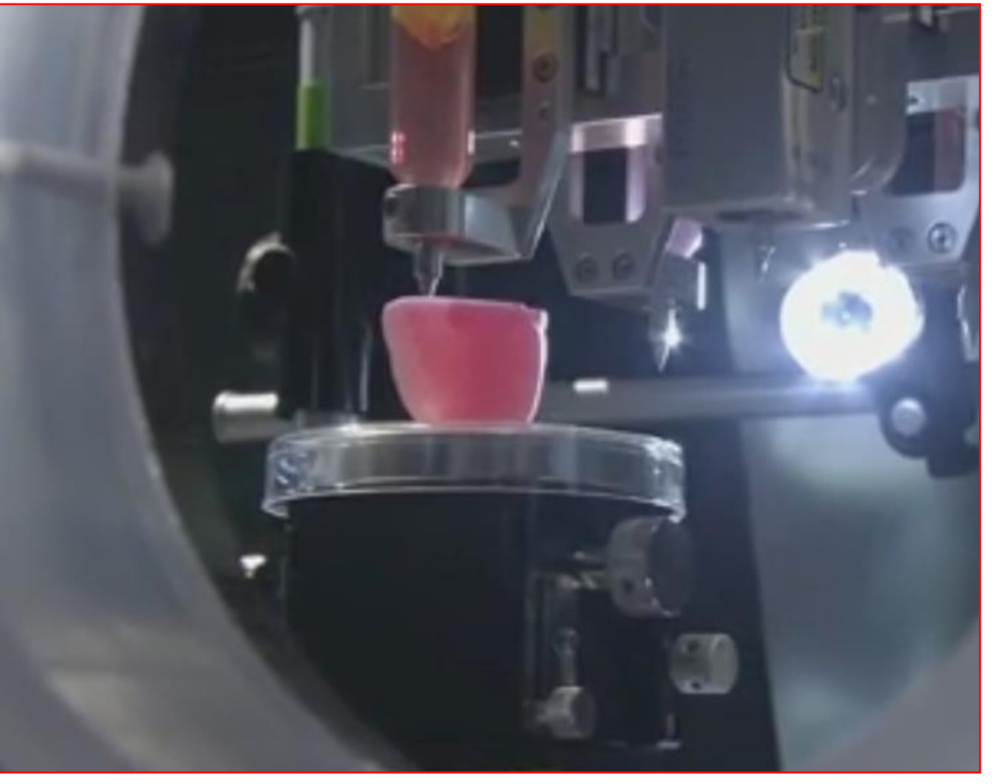
July 1, 2012

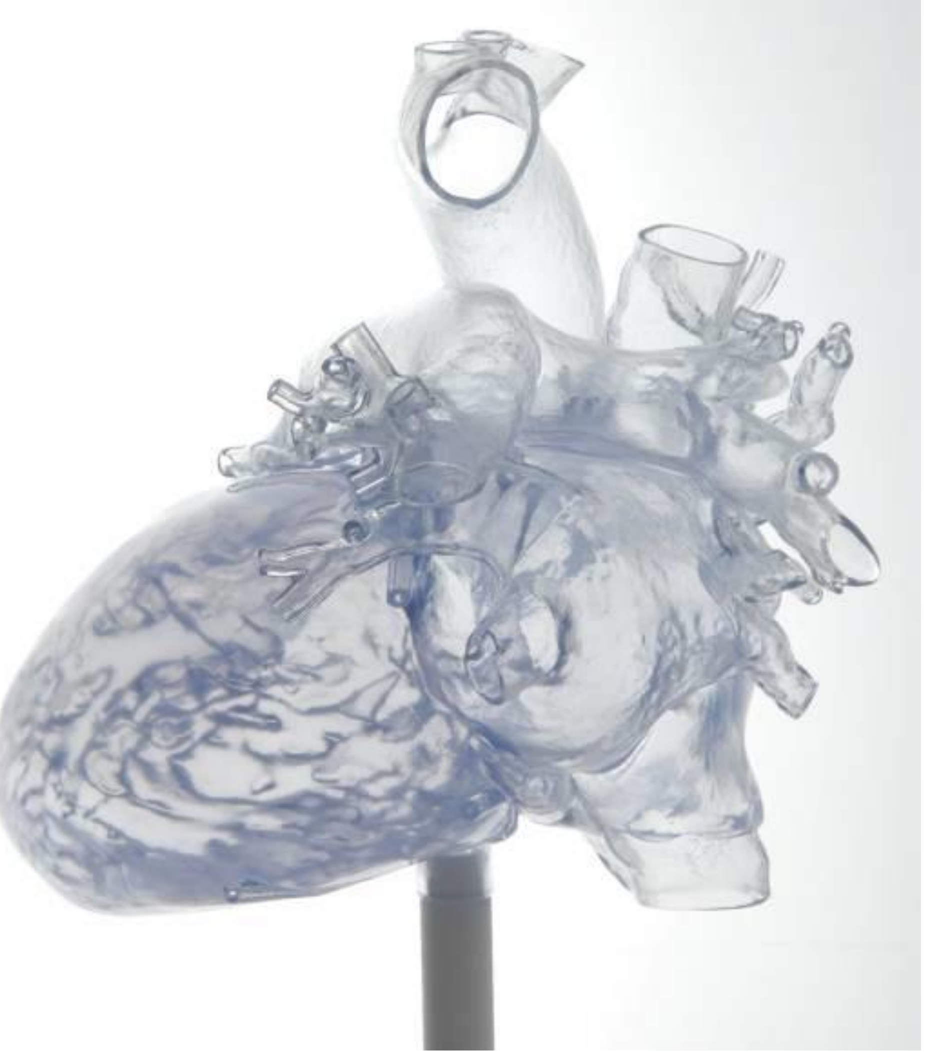
PRINT EMAIL SHARE



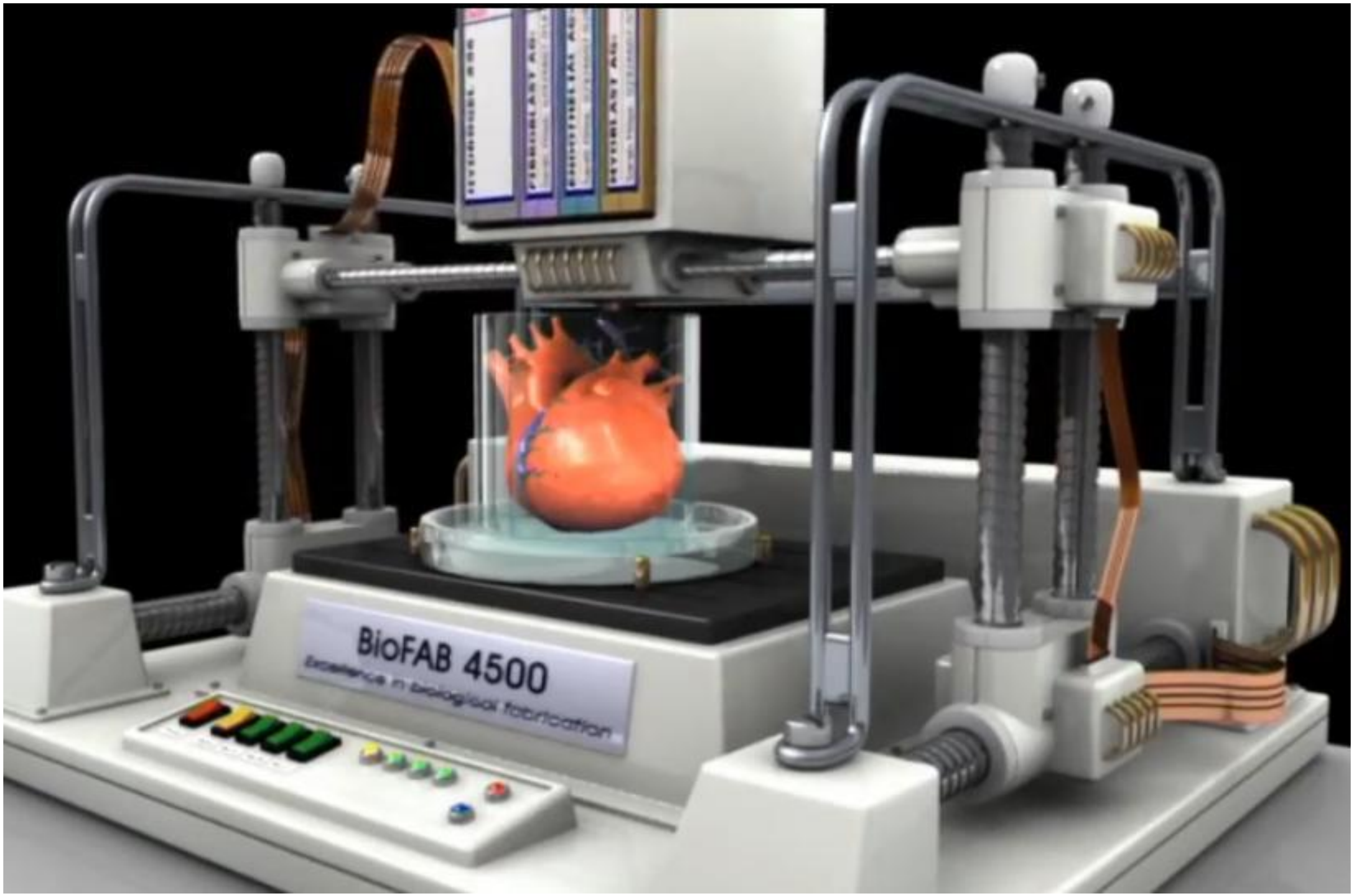
PHILADELPHIA — Researchers are hopeful that new advances in tissue engineering and regenerative medicine could one day make a replacement liver from a patient's own cells, or animal muscle tissue that could be cut into steaks without ever being inside a cow. Bioengineers can already make 2D structures out of many kinds of tissue, but one of the major roadblocks to making the jump to 3D is keeping the cells within large structures from suffocating; organs have complicated 3D blood vessel networks that are still impossible to recreate in the laboratory.

Applications – Medical





Applications – Medical

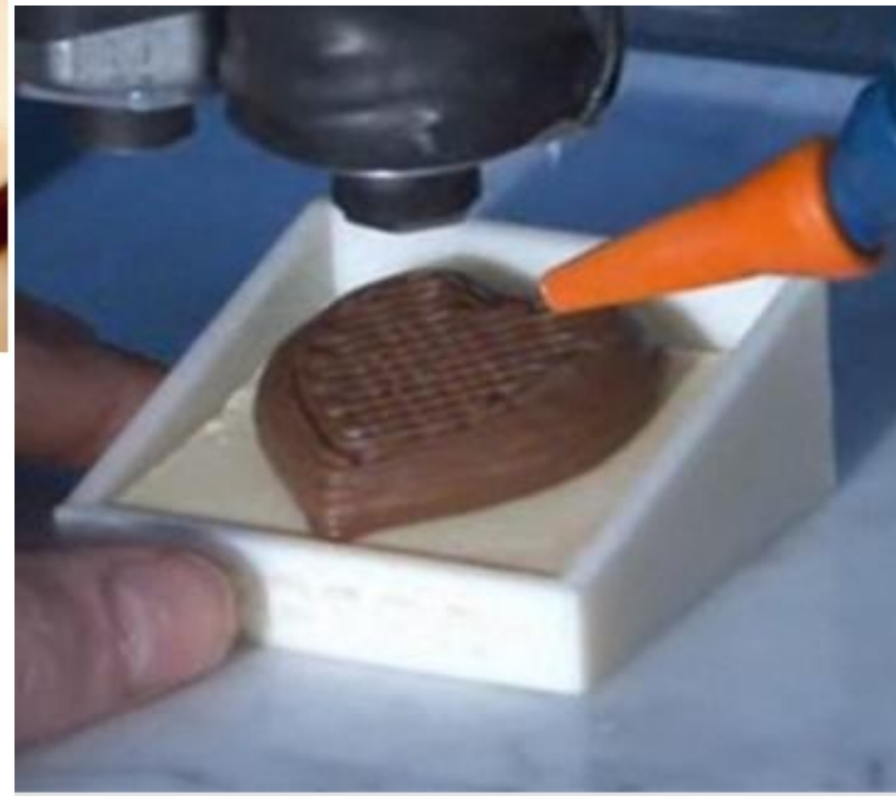


The EOS direct laser sintering process can be used to produce a wide variety of objects, such as this customizable titanium necklace.
Source: Future Factories

The titanium heel of this high-fashion sandal was made with DLS.
Source: Kerrie Luft

Applications – FOOD??

Examples of chocolates created by the 3D chocolate printer (Photo: EPSRC)



Peter Thiel Backs Start-up Making 3D Printed Meat

Inc.

Text Size - +

Published: Friday, 17 Aug 2012 | 2:57 PM ET

By: Abigail Tracy, INC

Lauren Burke | Digital Vision | Getty Images

Breakout Labs, eccentric billionaire Peter Thiel's biotech foundation, announced an eyebrow-raising investment in a start-up that makes 3D printed meat (yes, really).