3D Printing For Costume Design and Technology

USITT – 2015 Conference
Cincinnati, OH
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Subtractive vs. Additive Manufacturing

-Most traditional manufacturing is subtractive- cutting pattern pieces from a bolt of fabric, carving an object from a block of wood, or cutting out a piece from metal.
-Additive manufacturing (also known as 3D printing) involves combining materials to create an object.

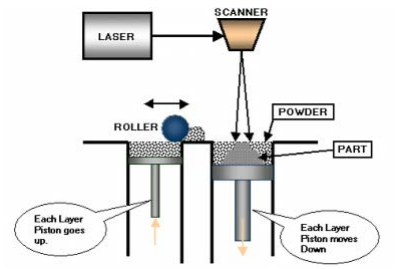
From Additive Prototyping to Additive Manufacturing

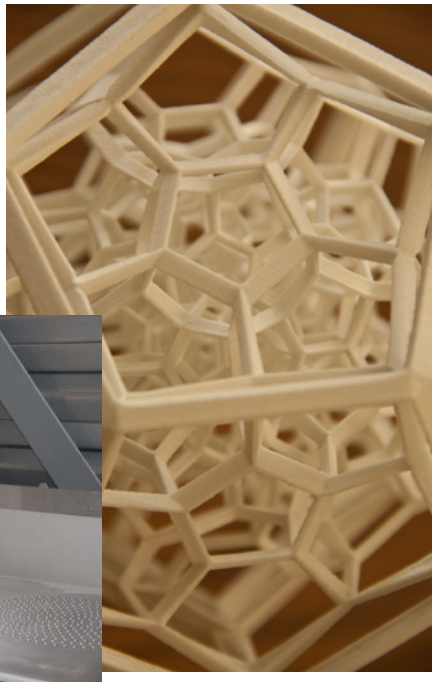
Was originally developed for use by engineers, architects and product designers as a method of rapid prototyping. It has evolved to include more substantial materials that make it a viable tool for rapid manufacturing, creating end use objects.

Selective Laser Sintering (SLS)

Carl Deckard invented Selective Laser Sintering (SLS) while studying in the The Department of Mechanical Engineering at University of Texas at Austin.

Selective Laser Sintering is the BINDING OF GRANULAR MATERIALS. It utilizes a laser to melt fine powders into 3D shapes. Common materials include nylon, metal, and elastomer polymers.

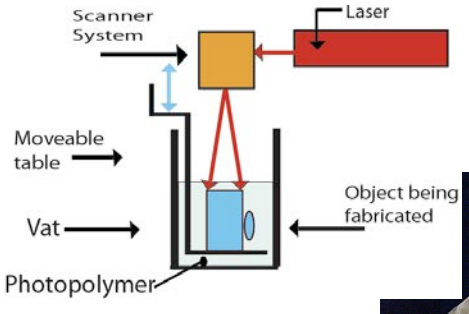


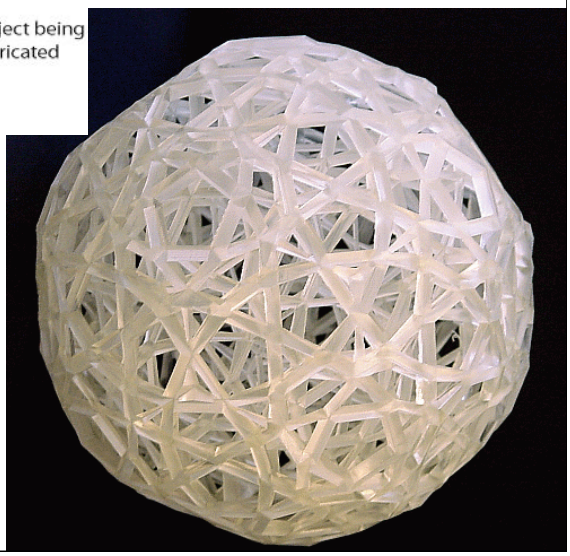


Stereolithography (SLA)

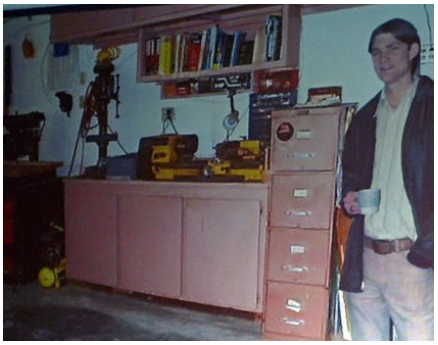
1984 - Chuck Hull invents Stereolithography while working nights and weekends for a small tech company.

Similar to SLS, but with liquid instead of powder. SLA utilizes a laser that cures photopolymer liquid in a vat that reacts with the ultraviolet light. Finished objects have a transparent property.

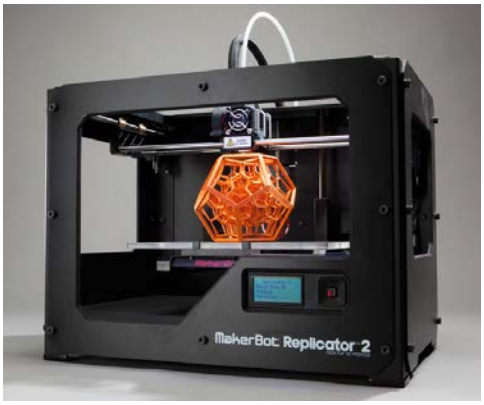




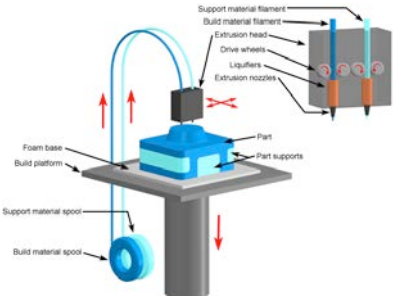
Fused Deposition Modeling (FDM)

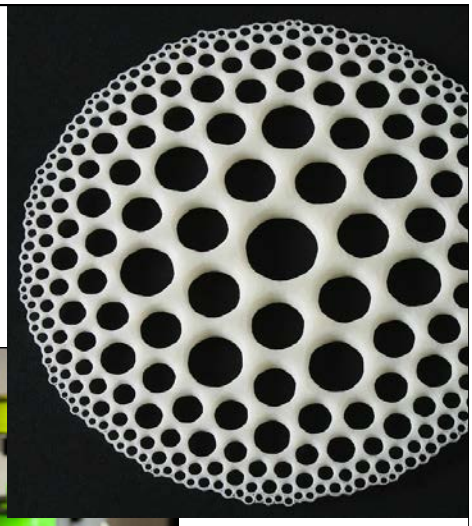


Scott Crump began developing Fused Deposition Modeling in 1989. He created the first working model in 1992. He is the co-Founder of Stratasys.



FDM works through EXSTRUSION DEPOSIT. Essentially a very fancy hot flue gun. Most common home/small business style 3D printer.

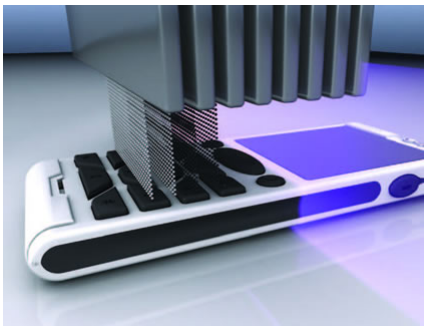


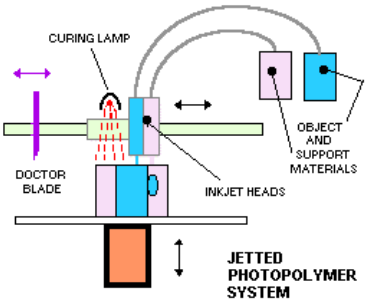


PolyJet

2000 – Objet patents
PolyJet Technology

Works as combination between Fused Deposition Modeling and Stereolithography. Jets, and then instantly UV-cures tiny droplets of liquid photopolymer. Fine layers allow it to print precise objects. Supports printed out of different material such as a gel can be easily washed off by water.





How far have we come in the world of 3D printed wearables?

3D Printed Garments

Drape Dress by Jiri Evenhuis and Janne Kyttanen – 1999

Janne Kyttanen for Freedom of Creation - 2005

"Crystalization" Top.
Iris van Herpen. 2010.

"Escapism" Dress.
Iris van Herpen. 2011

"Skeleton" Dress.
Iris van Herpen. 2011

"Cathedral" Dress.
Iris van Herpen. 2012.

Liquid Honey Dress.
Iris van Herpen. 2012.

Voltage Dress.
Iris van Herpen. 2013.

Dita's Gown.
Michael Schmidt
and
Francis Bitonti.
Spring 2013.

3D Printed Accessories

Shapeways – Print on Demand






pq Eyewear


Continuum Shoe

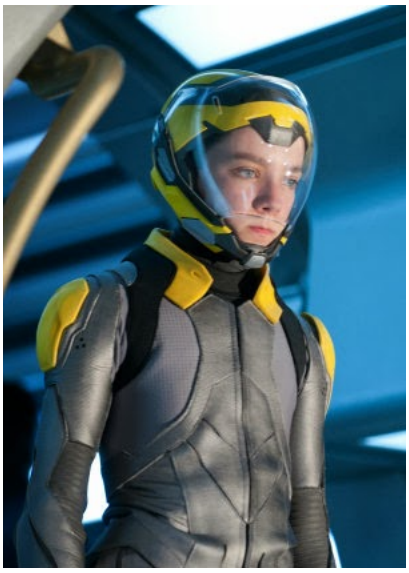
Shoes by Iris van Herpen.

3D Printing in Costume Design

Prometheus (2012) - Helmets

Costume Design by Janty Yates. Created by FB-FX.

Ender's Game (2013) - Helmets



Costume Design by Christine Clark.

Man of Steel (2013) – Boot Sole

Costume Design by Michael Wilkinson.

Victoria Secret – Corset and Wings

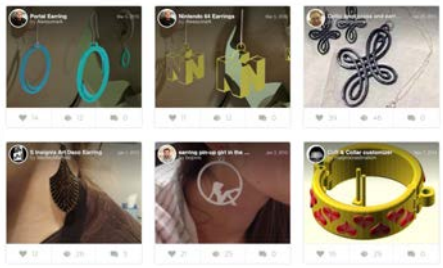
Getting Started 3D Printing

3 Ways to Obtain Printable Files

- Download
- Scan
- Design

DOWNLOAD

- FREE (Creative Commons License)
  - Thingiverse.com
  - 123Dapp.com
  - CubeHero.com



- PAID
  - MakerBot Digital Store
  - CreateThis.com

SCAN

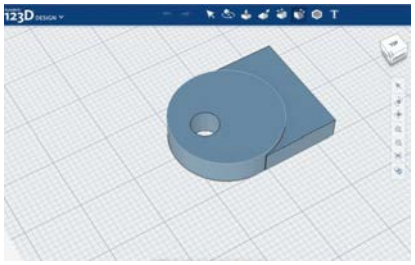
- Bed Scanners

- Hand-held Scanners

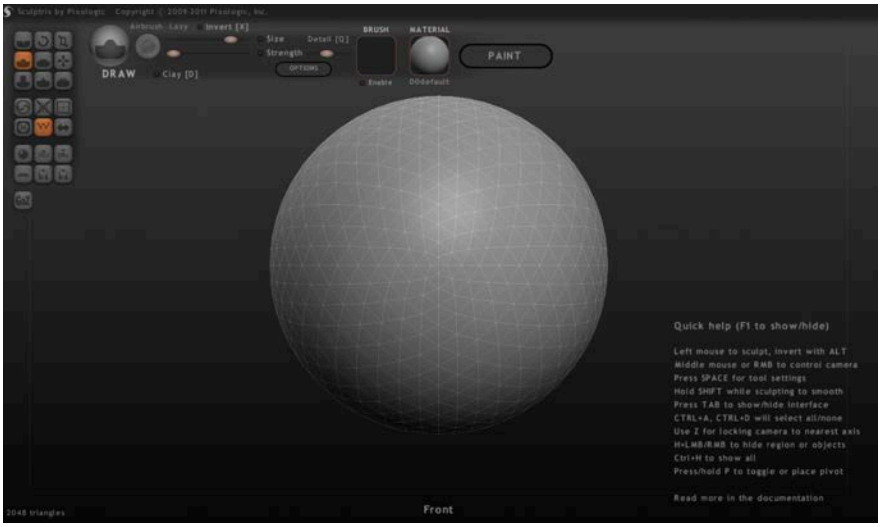
- Digital Camera/Photo Stitching Software

DESIGN

- FREE PROGRAMS
  - TinkerCad
  - **Sculptris**
  - **123D Design**
  - **MeshMixer**
  - Sketch-Up
- PAID PROGRAMS
  - Solidwork
  - Maya
  - Zbrush
  - Rhino

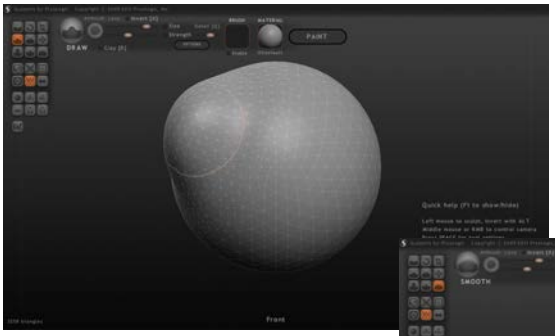


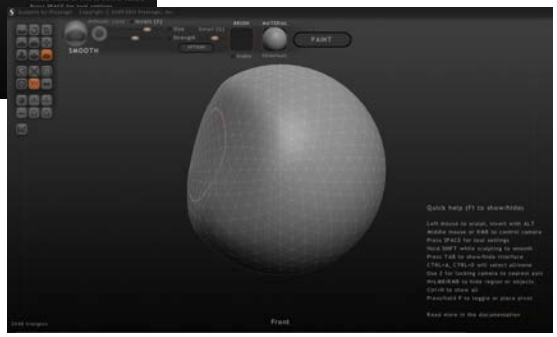
Sculptris



Start with digital “ball of clay.”

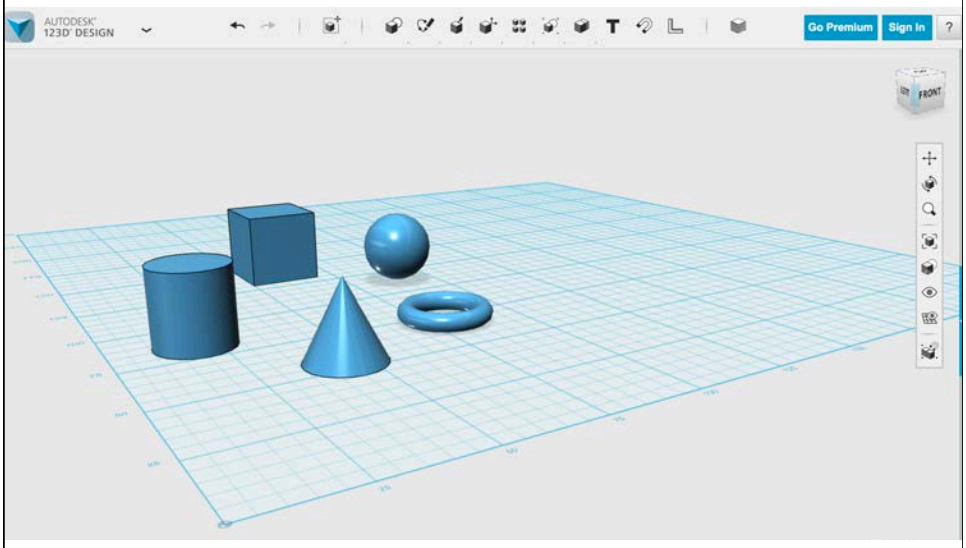
Sculptris





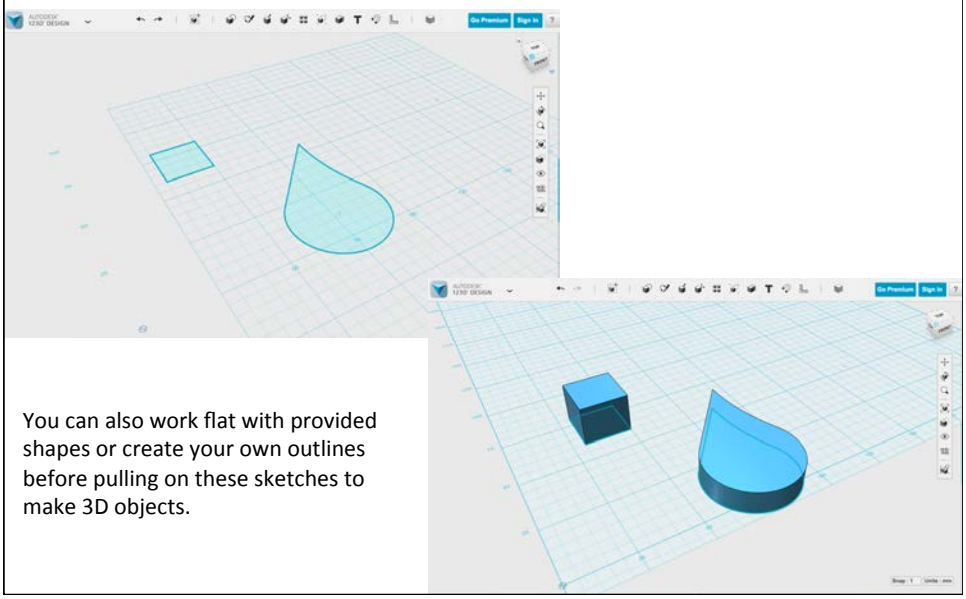
Use tools to push and pull the “clay.”
Great for creating organic shapes.

123D Design



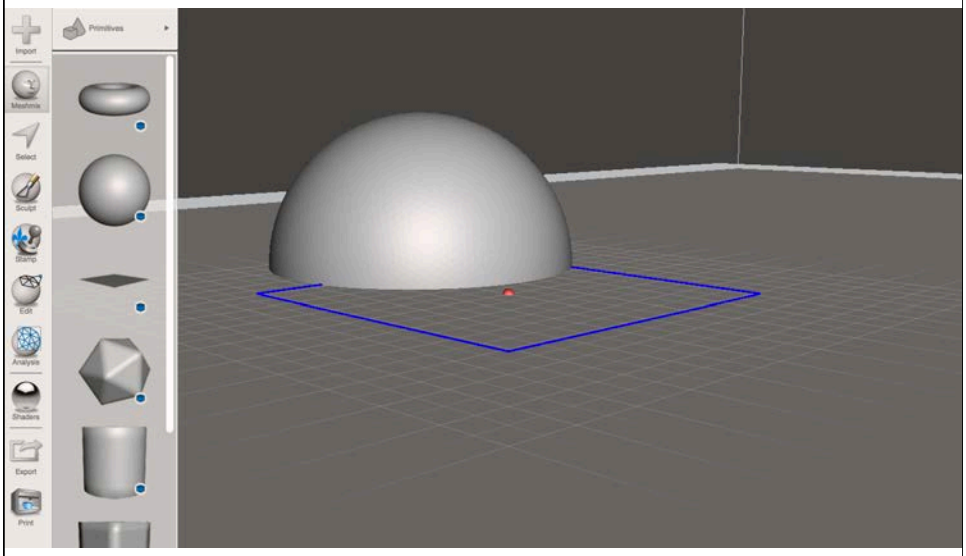
Work with a catalog of provided 3D primitives.

123D Design



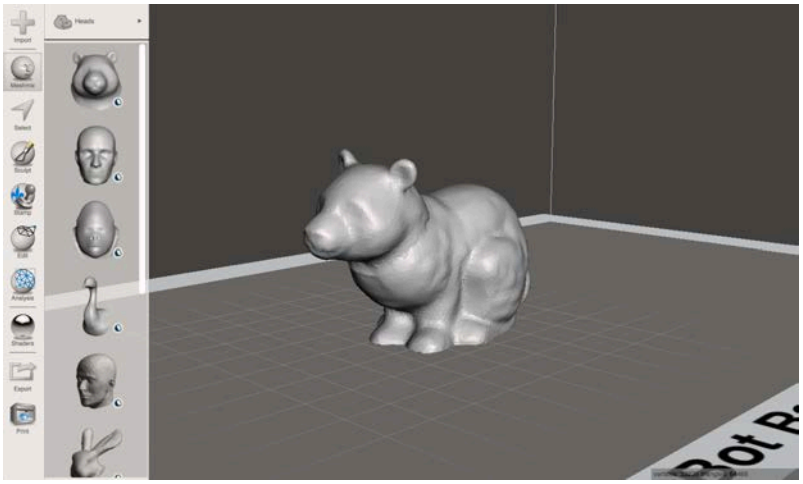
You can also work flat with provided shapes or create your own outlines before pulling on these sketches to make 3D objects.

Meshmixer



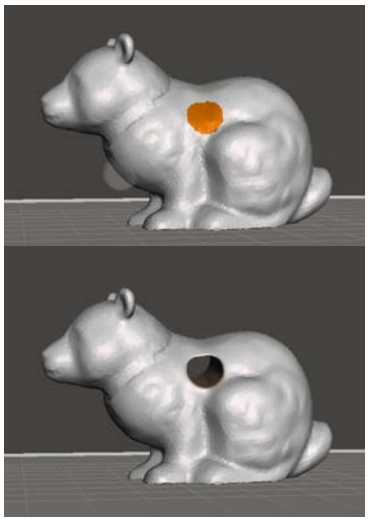
Combines many of the features of Sculptris and 123D Design, but provides more complex tools.

Meshmixer

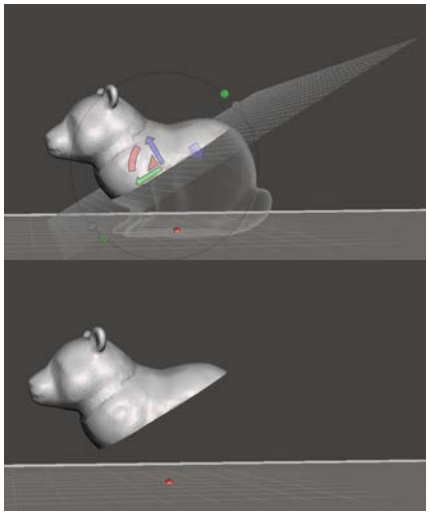


In addition to geometric primitives, you are provided complex animal and human body parts.

Meshmixer



Tools allow you to "drill" holes in objects. (Perfect for sewing and jewelry applications.)

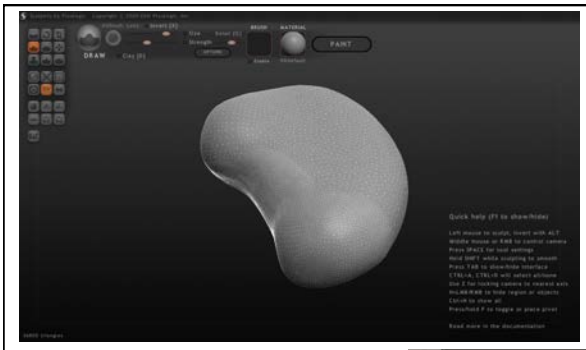


You can also do "plane cuts" of an object, among many other user friendly tools.

3D Printing Process Examples from the University Level

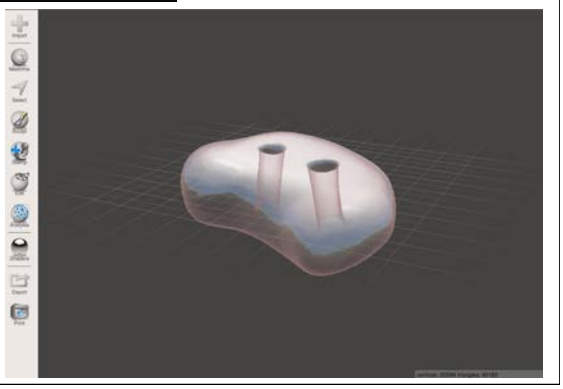
Into The Woods - Baylor University

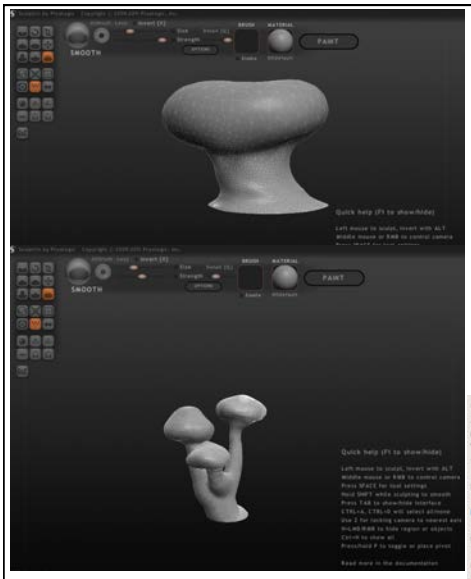
Costume design by Joe Kucharski



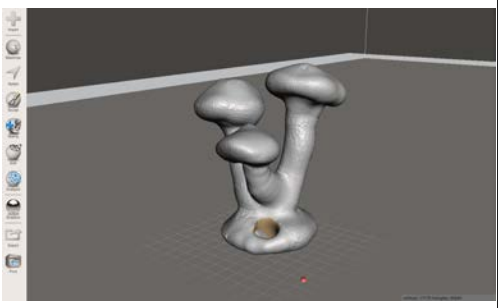
Sculpted bean in Sculptris.

"Drilled" sewing holes in Meshmixer.



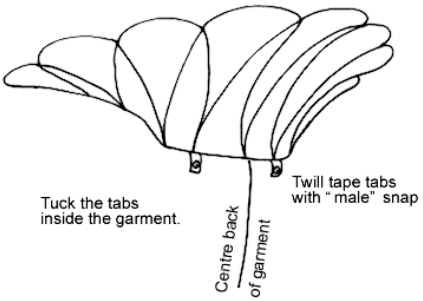


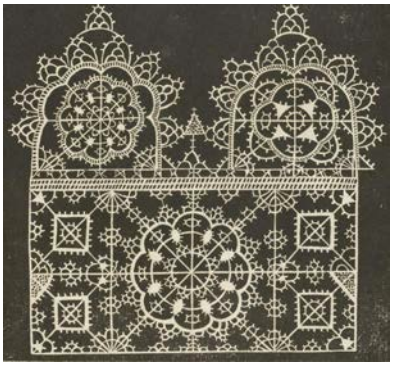
Sculpted mushrooms in Sculptris.



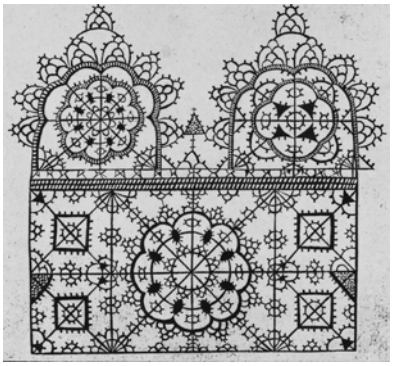
"Drilled" sewing holes in Meshmixer.

New Project – In Process

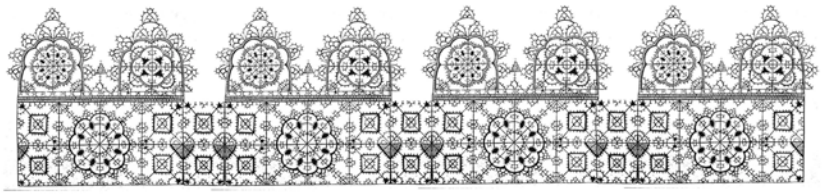




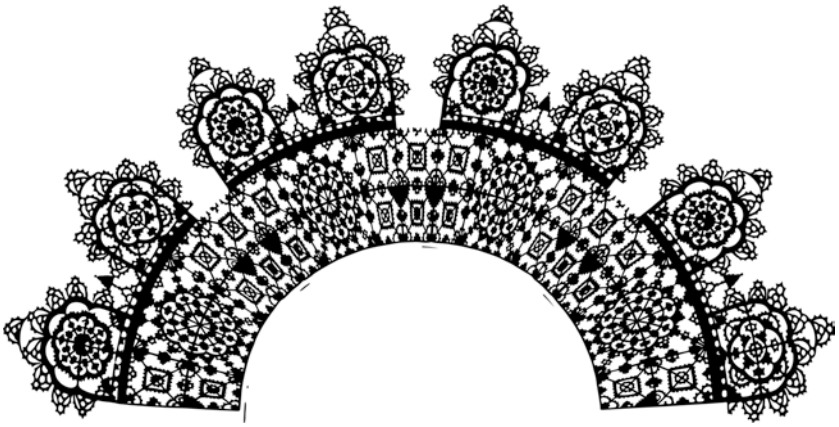
Digital scan of Renaissance lace.



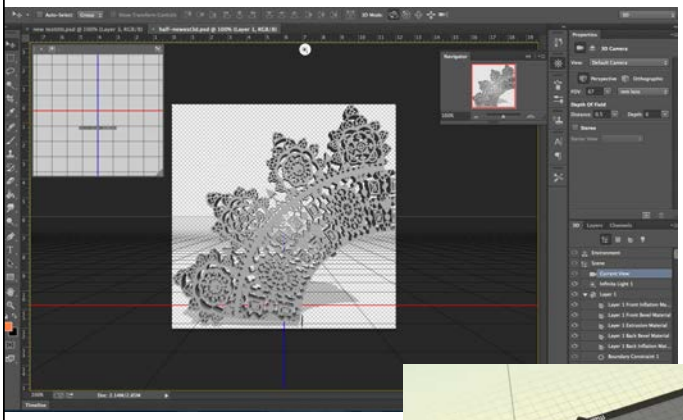
Photoshop - invert colors.



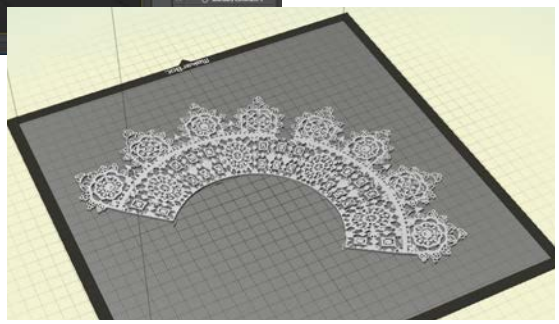
Photoshop - create a row.



Illustrator - trace, object envelope distort into an arch, and expand. Saved as .SVG file.



Photoshop - 3D extrusion of path.



Nobody Combines Spectacle and New Technology Quite Like Disney!

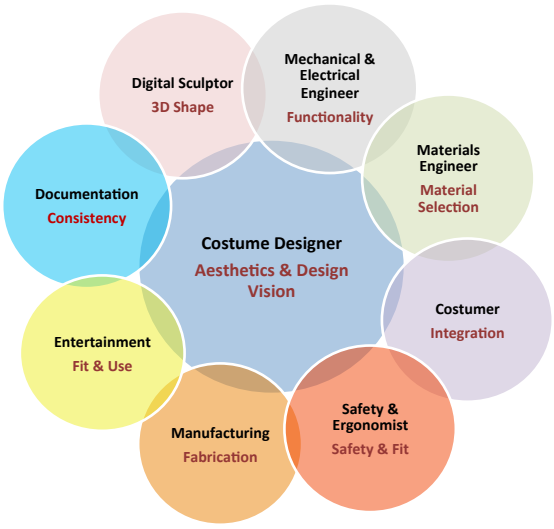
Joe Kucharski, editor of TyrannyOfStyle.com, interviewed costume designer Mirena Rada about her work with 3D printing for The Disney World Resort's Festival of Fantasy Parade.

DISNEY CREATIVE COSTUMING

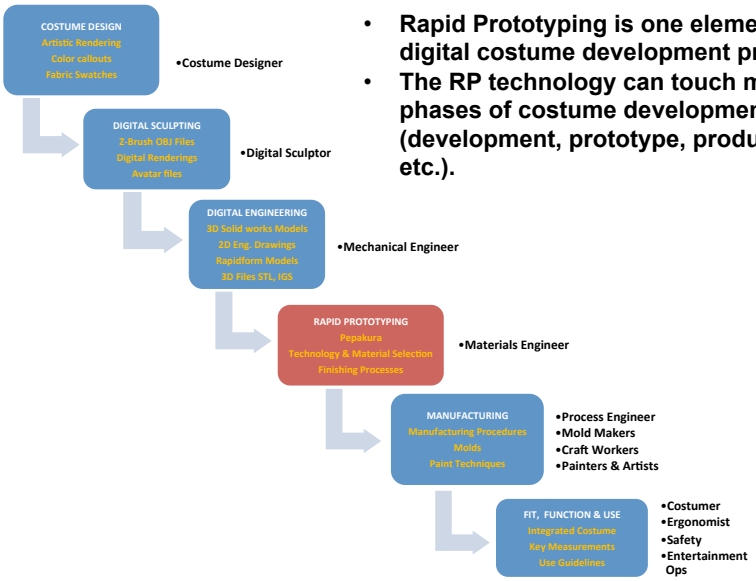
We are joined by Lisa Hanusiak, Process Engineer at The Walt Disney World Resort.

MULT-DISCIPLINE COSTUME DIGITAL DEVELOPMENT TEAMS
Team Members & Member Roles

- **Each team member has an area of expertise.**
- **There is a huge amount of overlap between team member roles.**
- **All team members are involved from cradle to grave.**
- **Team members come from a variety of organizational units and backgrounds.**
- **Entire team facilitates the realization of the costume designers creative intent.**



DIGITAL DEVELOPMENT OF COSTUME ELEMENTS
Process Stages, Outputs and Owners



- **Rapid Prototyping is one element of the digital costume development process.**
- **The RP technology can touch multiple phases of costume development (development, prototype, production, etc.).**

USES OF RAPID PROTOTYPING (RP) TECHNOLOGIES FOR COSTUMING

Prototypes
- Scale
- Appearance
- Fit
- Functionality
- Manufacturability

Models for Molds
- Silicone Molds for high detail
- Composite Molds for lower detail

Production Molds
- Lower Volume Production Molds
- Prototype Soluble One Time Use Mold

Manufacturing Aids
- Trim Fixtures
- Bonding Fixtures
- Drill Fixtures

Additive Manufacturing
- Fully Functional Elements
- Head Pieces, Accessories

RP PROTOTYPES

RP prototypes are a great way to try out concepts before building molds
- Scale – Is the size correct for the overall costume?
- Fit - How does it fit the performer and how is it adapted to the costume?
- Finishing - Do the aesthetics and finishes look as intended?
- Functionality – Is the costume element functional for its intended use?
- RP Shell made of Accura Clear Vue SLA
- RP prototype crown made of Accura 25 SLA

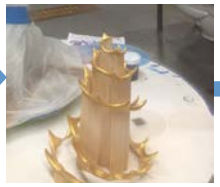
Costume Design

Digital Sculpt

RP Clear shell

Laminating Angelina fibers and shear dress fabric, then fiberglass

RP Crown in machine with support material



Prime and paint crown

Costume Designer – Mirena Rada, Digital Sculptor – Robert King

RP PROTOTYPES

Final costume review

Joining, trimming & smoothing

Airbrushing & clear coating

Prime and paint crown

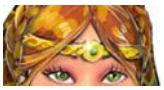
Bonding pearls & crystals

Finished Sea Shell Head Piece

Costume Designer – Mirena Rada, Digital Sculptor – Robert King

RP MODELS FOR HIGHLAND DANCER

Costume Design



Costume elements digitally modeled

- Festival of Fantasy Highland Dancer
  - Male pins
  - Female disks
  - Female head bands
- All RP models made of Objet Vero White
- Production pieces cast out of urethane

Digital renderings of sculpts

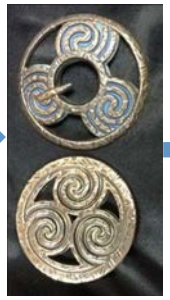
RP Model for casting silicone molds

Costume Designer – Mirena Rada, Digital Sculptor – Heidi Fleming

RP MODELS FOR HIGHLAND DANCER

Cast silicone mold

Casting the production pieces



Finished pieces

In Parade

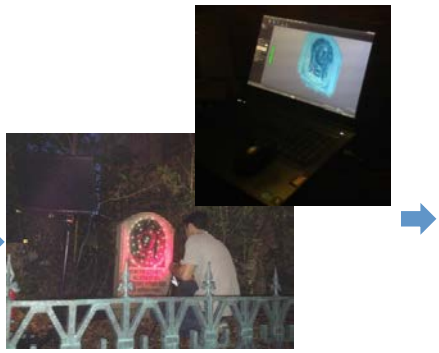
Costume Designer – Mirena Rada, Digital Sculptor – Heidi Fleming

RP MODELS FOR MADAME LEOTA CAMEO

Haunted Mansion merchandise location costume
- Face – Scanned from tombstone at Haunted Mansion attractior
- Base & Border Sculpted in Z-Brush
- All RP models made of Objet Vero White
- Base cast of metal
- Oval & face cast out of pigmented urethane

Costume Design

A Disney legend



Scanning the facial sculpt

Costume Designer – Donna Bailey, Digital Sculptor – Heidi Fleming

RP MODELS FOR MADAME LEOTA CAMEO

Digitally sculpted cameo

Sculpted elements were individual RP pieces to be cast separately

RP model sent for casting production molds

Finished cameo

On operational costume

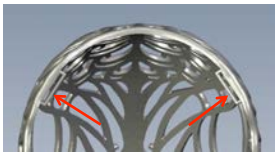
Costume Designer – Donna Bailey, Digital Sculptor – Heidi Fleming

ADDITIVE MANUFACTURING OF THE RAVEN MASK

- Festival of Fantasy parade Raven mask
- Carbon fiber filled nylon ALM 601-CF SLS
- Finished with Modern Masters Shimmer series of paint.
- AM raven masks have been in parade for over a year.

Costume Design

Digital sculpt and rendering



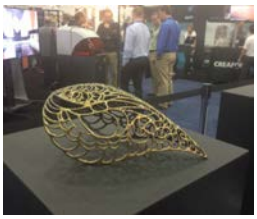
Digital Engineering

Preliminary in Pepakura scale check

Costume Designer – Mirena Rada, Digital Sculptor – Robert King

ADDITIVE MANUFACTURING OF THE RAVEN MASK

RP Raven mask



Raven Mask at the
2014 RAPID Contemporary Art Gallery

Mask attachment check

Paint finishing

Raven in parade

Costume Designer – Mirena Rada, Digital Sculptor – Robert King

ADDITIVE MANUFACTURING OF DWARF PICK AXE TOOLING

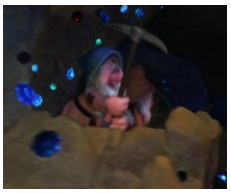
- Animatronic dwarf pick axe mold
- Accura 25 SLA mold reinforced with fiberglass
- Used for composite layup of the pick axe

Digital 3 Piece Mold Design

De-molding a pick axe from RP mold

Raw pick axe, rigid carbon fiber middle, soft urethane tips

Painted & finished pick axe

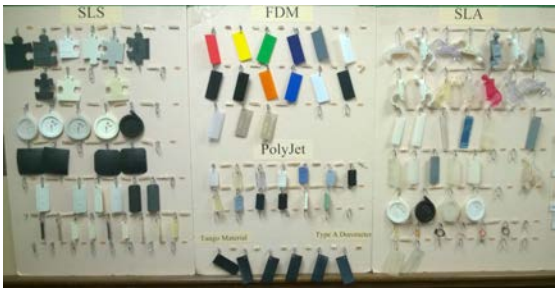


Pick axe in attraction

Mechanical Engineer – Mike McCormick

How to select the right material and technology?

- What is its intended use, i.e. prototype tooling, mold model or an end use item?
- What is the use environment, i.e. heat, stress, shop production, etc.?
- Is high resolution required, i.e. for high detail jewelry, accessories, etc.?
- What material properties are important, i.e. strength, stiffness, impact, wear, flexibility, heat tolerance, UV resistant, etc.?
- Is the color important?
- Is weight important?



My office wall of RP material samples

SELECTIVE LASER SINTERING (SLS)

- **Fibers & Particulates Can Be Mixed In**
- **Higher Cost**
- **Highest Performance**
- **Rigid to Flexible Available**
- **Highest Temperature**
- **Most Durable**
- **Can Take a Dye**
- **Lower Resolution than SLA**
- **Most industrial RP process**
- **Powders can be explosive in air**

STEREOLITHOGRAPHY (SLA/POLYJET)

- **UV Cure**
- **Highest Resolution (Objet Polyjet)**
- **Multi-Durometer Builds**
- **Lower Cost (SLA)**
- **Largest Builds Available**
- **Some Flexible (Objet Polyjet)**
- **Multi-durometer printing (Objet Polyjet)**
- **Color Printing**
- **Clear**
- **Tend to be more brittle**
- **Liquid resins to be stored and disposed of**

FUSED DEPOSITION MODELING (FDM)

- **Most accessible to users**
- **One of the least expensive**
- **Good properties in wire direction**
- **Lowest resolution**
- **Need to fuse wires for durability**
- **Resolution improving**

SELECTIVE LASER SINTERING (SLS) FINISHING PROCESS

SLS surface finish tends to be porous and rough, but surface quality is improving

Bead Blast	•Upon removal from powder cake, the part is given a bead blast to remove any excess powder clinging to the part.
Apply Sealer	•The SLS materials are slightly porous, so a sealer is typically applied to densify the material.
Sand Smooth	•After sealing, the surface tends to be a bit rough, so if cosmetic appearance is important the surface can be smoothed with sandpaper. If this is a structural part, then no further finishing is necessary.
Apply Primer	•If requiring a painted finish, the part will be primed with a two part epoxy primer.
Apply Paint	•If cosmetic appearance is important, sand with a fine grit sandpaper and then apply a paint.
Clear Coat	•To achieve the desired sheen and to protect the paint finish, apply a clear coat

STEREOLITHOGRAPHY (SLA/POLYJET) FINISHING PROCESS

SLA & Polyjet surface finishes are high resolution with the Polyjet and Envisiontec having the highest resolution.

Sand Smooth	•After removal of support material, sand smooth with fine grit sandpaper.
Apply Primer	•If model for a mold, use a high gloss two part epoxy primer compatible with the mold resin. •If this is to be a painted part, apply a two part epoxy primer. If model for a mold, use a high gloss two part epoxy primer compatible with the mold resin. •If this is to be a painted part, apply a two part epoxy primer.
Sand Smooth	•If this is a cosmetic part, sand with fine grit sandpaper and then apply a decorative paint.
Apply Clear Coat	•For finished part, to achieve the desired sheen and to protect the paint finish, apply a clear coat.

FUSED DEPOSITION MODELING (FDM) FINISHING PROCESS

- **FDM surface finish tends to appear as wires in layers, but surface quality is improving.**
- **In order to have much strength in the direction across the wires, they must be fused.**

Remove Support	•Upon removal from the build chamber, break away most of the support material. •If support remains, use support dissolving solution bath.
Seal Part	•If using ABS material, the part can be solvent smoothed and sealed with acetone. •Solvent smoothing and sealing can be done in a solvent vapor chamber, but this tends to treat details indiscriminately. •Solvent smoothing can be done by hand to treat details with extra caution. •If building with Ultem or solvent resistant material, seal with epoxy.
Sand Smooth	•After sealing, sand the part smooth with sandpaper.
Apply Primer	•If requiring a painted finish, the part will be primed with a two part epoxy primer.
Apply Paint	•If cosmetic appearance is important, sand with a fine grit sandpaper and then apply a paint.
Clear Coat	•To achieve the desired sheen and to protect the paint finish, apply a clear coat.

SUMMARY

- **RP (or Additive Manufacturing AM) works well in conjunction with other digital technologies, i.e. scanning, sculpting, pattern making and engineering.**
- **I have many partners in the digital process (i.e. sculptors, rendering artists, engineers, mold makers, finishing artists, etc.) that help make this process work successfully.**
- **A huge variety of the RP technologies and materials can be very useful to the costume development process.**
- **Using only one technology and one material would be analogous to telling a mechanic they could only use one tool from their tool box, or an artist that they could only use one color from their color palette.**
- **Not all RP technologies are represented here, but only the ones we most frequently use in costuming.**
- **Each costume element is unique is developed in a unique way.**
- **Each costume application lends itself to a particular RP material & technology.**
- **We have developed processes that work well for us, but explore how this technology works best for your process.**
- **There are hundreds of RP materials coming on the market and while sometimes overwhelming, it can also be a Wonderland of possibilities.**