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Comparing Five Industrial 3D-Printing Methods:

MJF, SLS, FDM, SLA, and DLS

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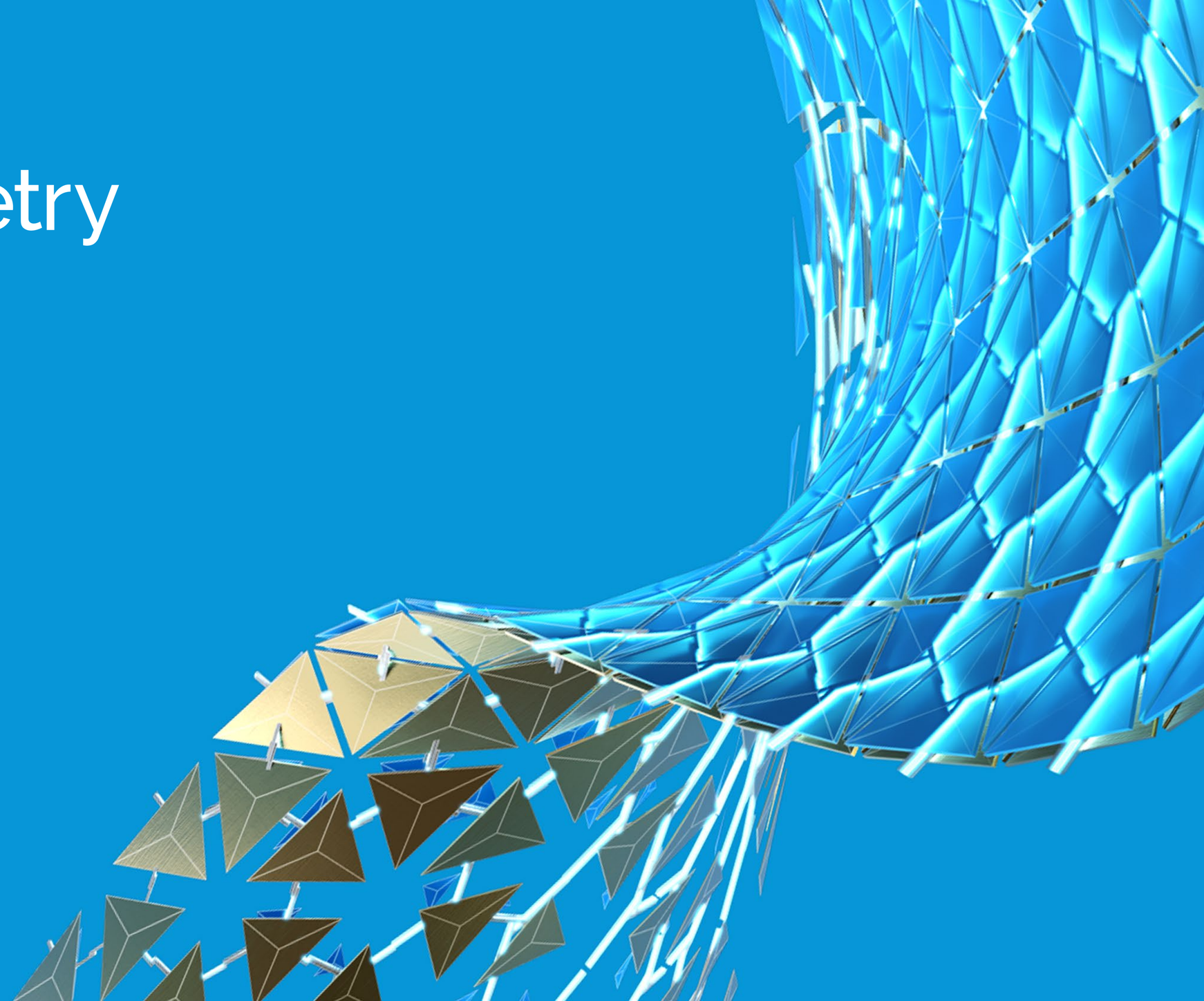
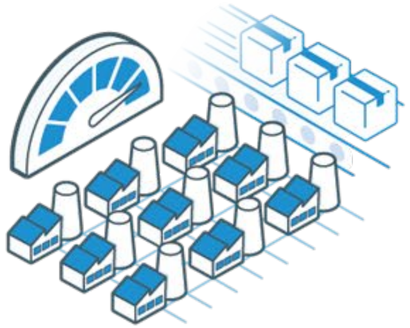
About the speaker

Greg Paulsen

Greg leads the Applications Engineering team a Xometry, which handles special case projects that require attention on material selection, design-for-manufacturing, or technical engineering resources. He has used his experience to create content and educate engineers about advanced manufacturing, 3D printing, design, and quality assurance. Greg plays a vital role in vetting new technologies and materials to add to Xometry's manufacturing portfolio.

About Xometry





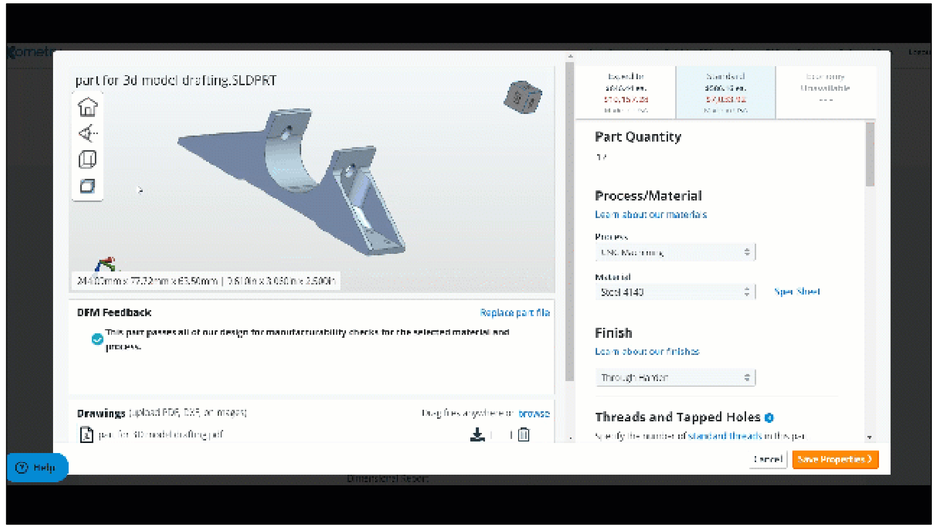
On-demand Access to Massive Global Network

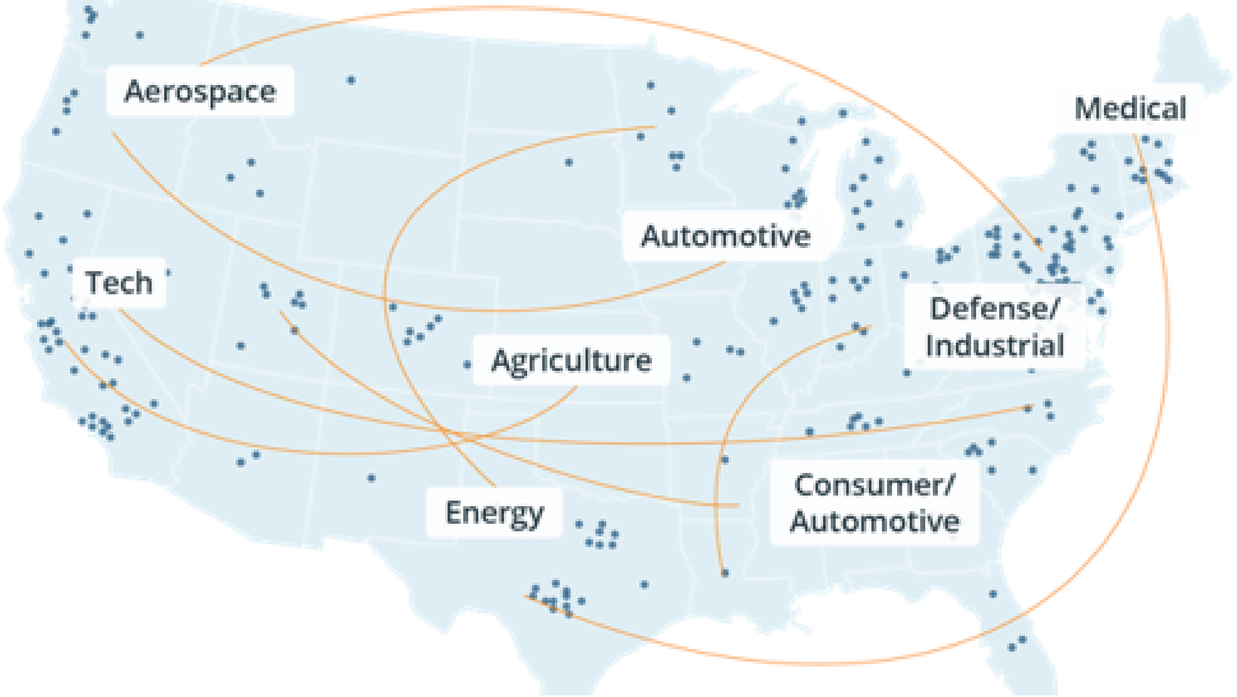
Instant Quoting & Fully Digital RFQ Process

Security, Certifications, & Quality Guaranteed

We make a TON of parts at Xometry

- Additive: SLS, FDM, PolyJet, SLA, Carbon DLS, DMLS, HP MJF, and more.
- Subtractive: 3+ Axis Milling, Turning, EDM, Sheet Metal, and more.
- Injection Molding and Casting
- Light Assemblies and Weldments
- Full Supply Chain Service





Xometry.com

Xometry US

- Serves U.S., Canada, Mexico, and more.
- Over 3,500 U.S.-based Manufacturing Partners
- Access to Asian Manufacturing Partners

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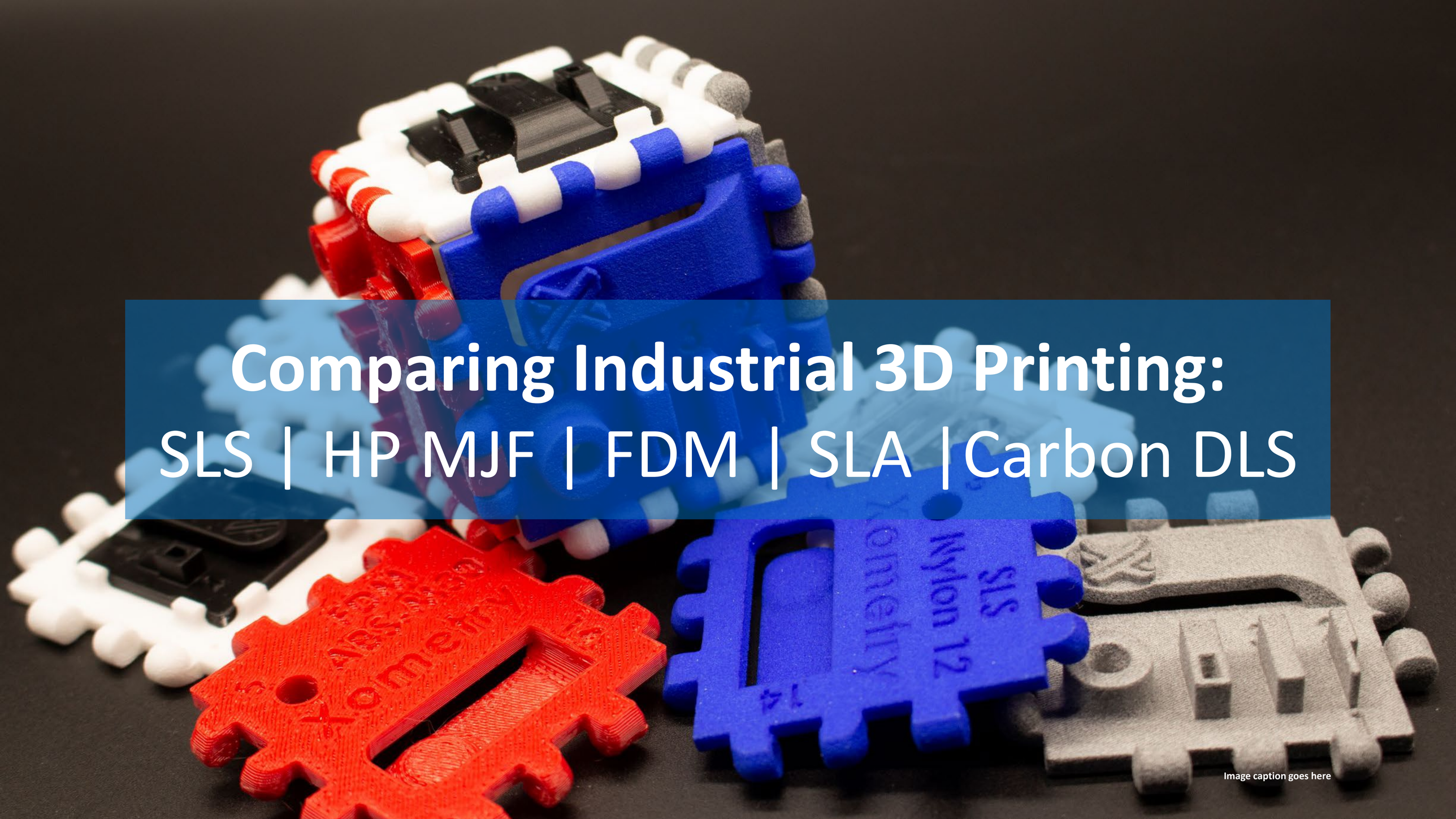
Xometry Europe

- Serves all of EU, UK, and Switzerland
- Over 2,000 European Manufacturing Partners
- Access to Asian Manufacturing Partners

Comparing Industrial 3D Printing:
SLS | HP MJF | FDM | SLA | Carbon DLS



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Common Themes in 3D Printing (Additive Manufacturing)

PRINTERS DICTATE THE TOLERANCES, NOT THE PRINT

- **NET SHAPE is the name of the game.**
  - Think in “global tolerances.”
- **CAD offsets are typically required on critical features.**

BEST USED WHEN PURPOSE-DESIGNED

- **Look for function, not cosmetics.**
- **Typically the prettier the prints, the less mechanical strength.**

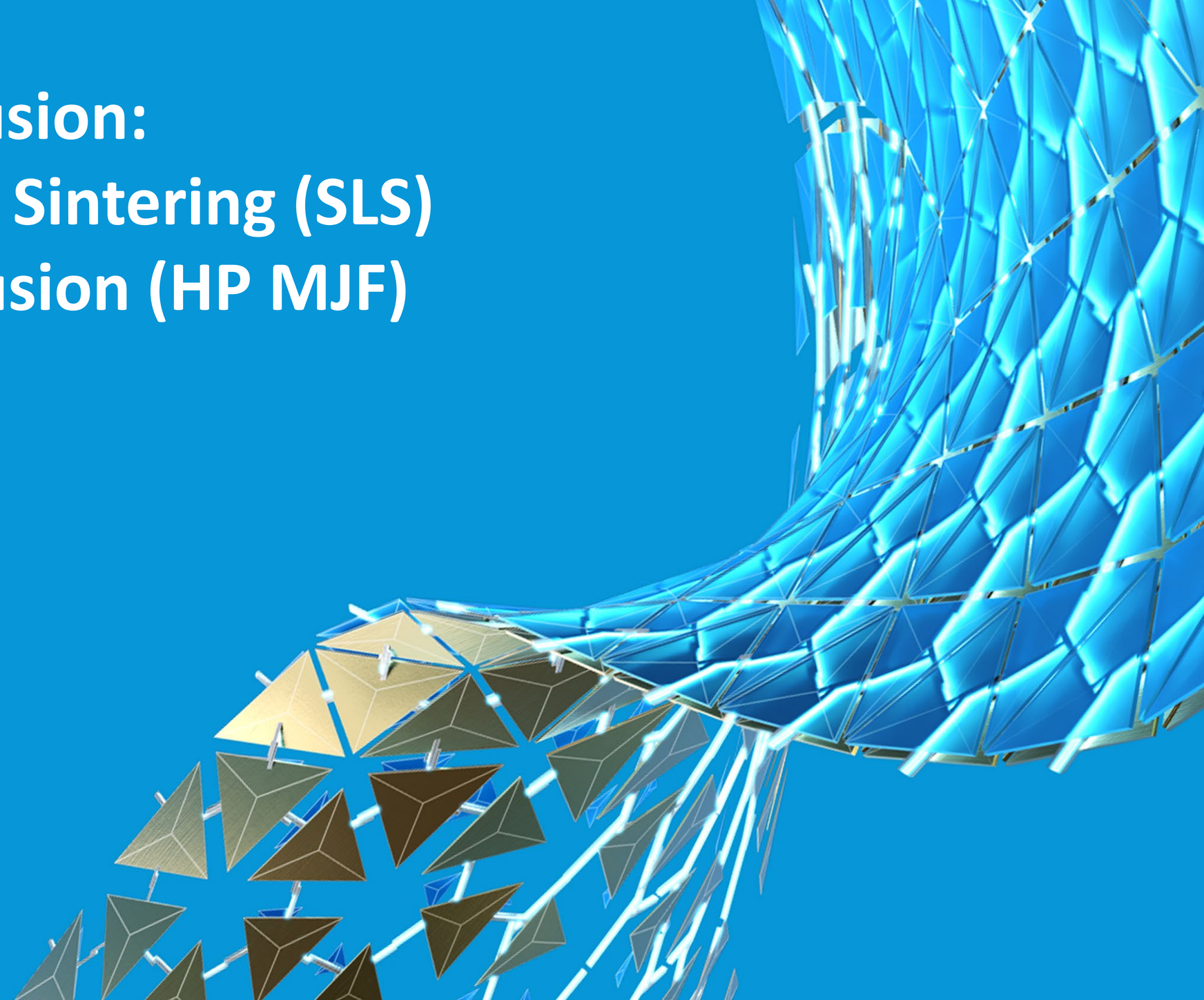
POWERFUL FOR PROTOTYPING

- **Typically faster and less expensive than traditional processes for one or low volumes.**

SIZE AND DETAIL LIMITATIONS VARY PER PLATFORM

- **Each process has its own platform size, detail resolution, and tolerances.**

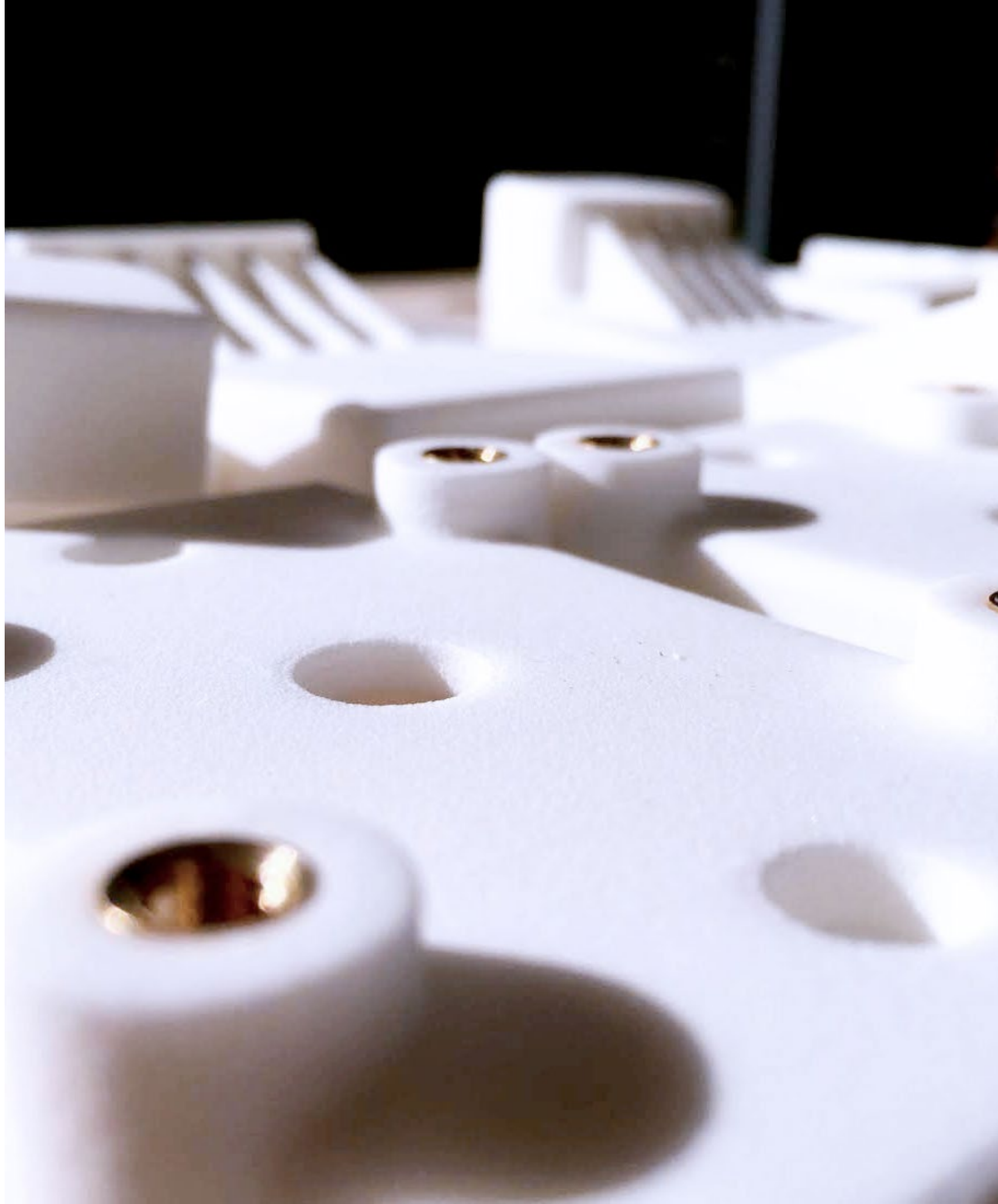
Powder Bed Fusion:
Selective Laser Sintering (SLS)
HP Multi Jet Fusion (HP MJF)



Selective Laser Sintering (SLS)

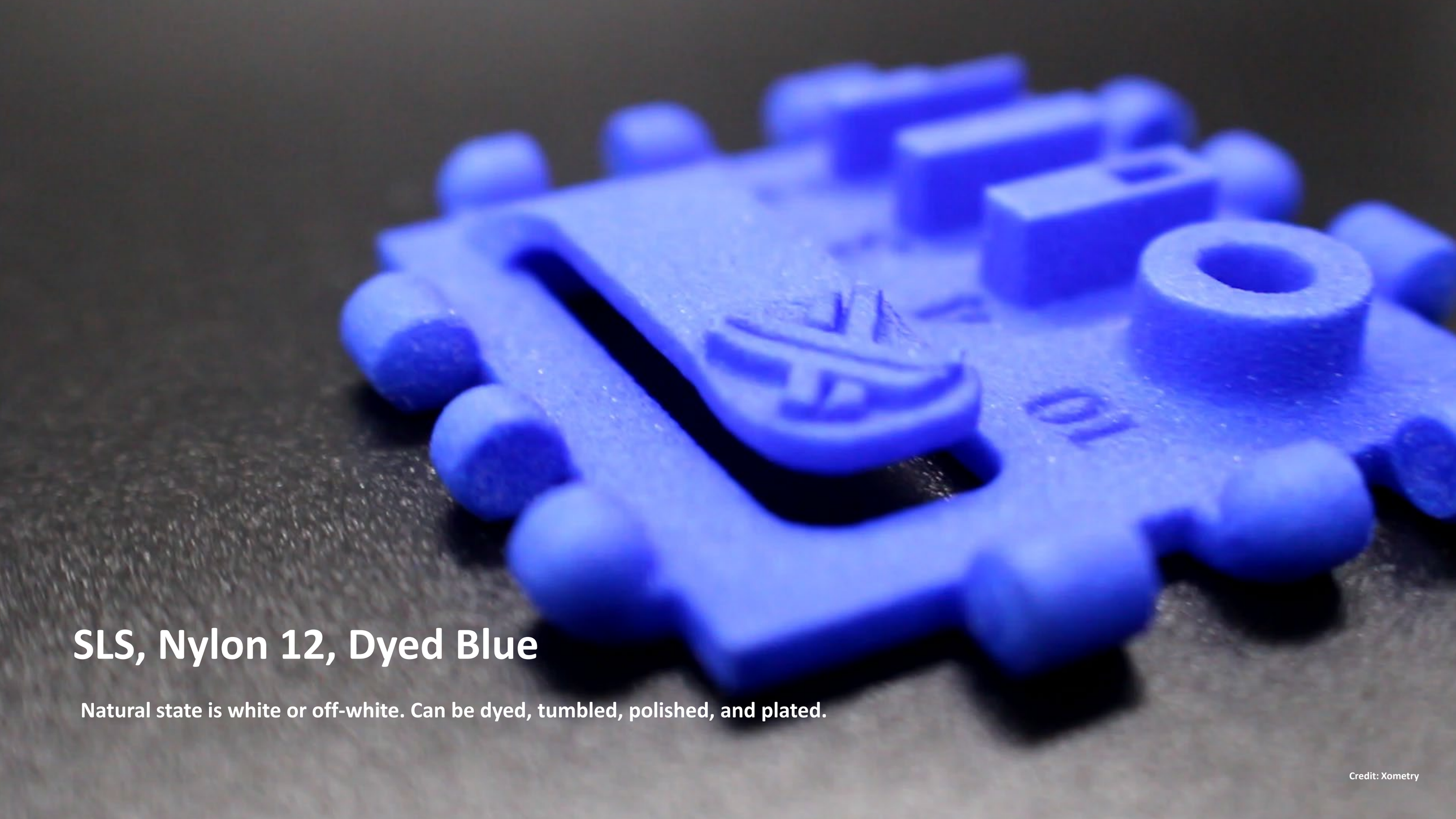
Key Information

- Known for high complexity in parts
- Uses nylon as a durable, flexible, and chemical resistant material
- Water-tight
- Tolerance of +/- 0.005″ or +/- 0.002″ per inch, whichever is greater
- Lower diversity in material/finishing options, has a textured or grainy surface
- Often chosen for internal components/non-cosmetic parts (jigs, fixtures)



SLS Time-lapse

Credit: Xometry



SLS, Nylon 12, Dyed Blue

Natural state is white or off-white. Can be dyed, tumbled, polished, and plated.

Credit: Xometry

HP Multi Jet Fusion (MJF)

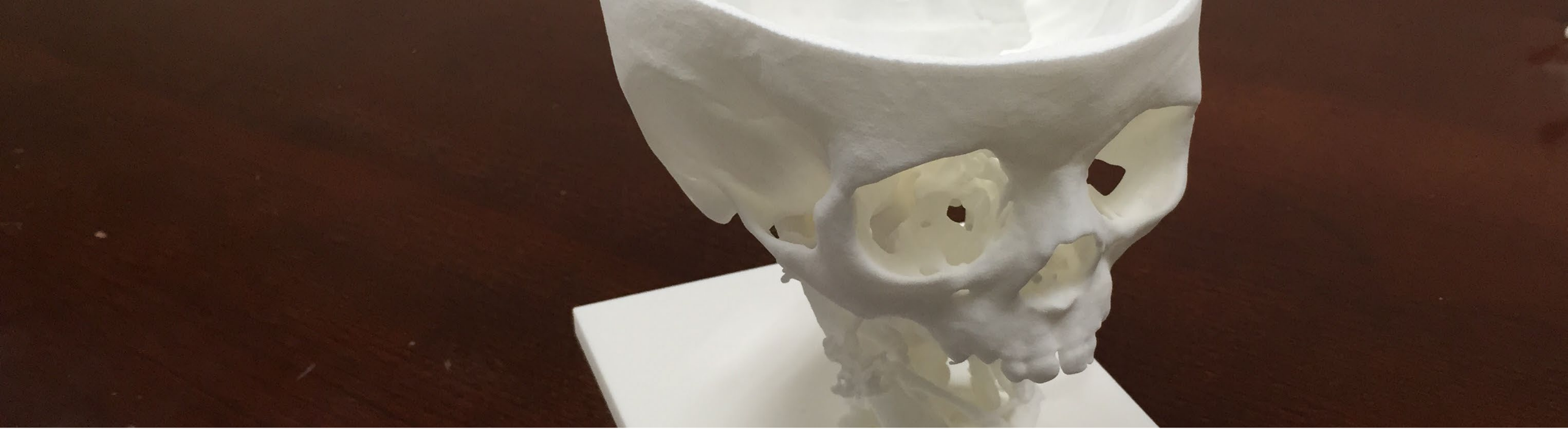
Key Information

- Known for high complexity in parts
- Slightly higher throughput than SLS
- Uses nylon as a durable, flexible, and chemical resistant material
- Water-tight
- Tolerance of +/- 0.012″ or +/- 0.002″ per inch, whichever is greater
- Lower diversity in material/finishing options, has a textured or grainy surface

MJF, Nylon 12, Standard

Natural state is light to dark gray. Commonly dyed black and can be tumbled, polished, and plated.

Credit: Xometry



SLS and MJF Common Strengths

Freeform design (no supports)

Versatile material

Scalable

Fast

Cheap

SLS and MJF Common Considerations

Few materials choices

Few color choices

Surface roughness

Warp

Limited post processing

Choosing SLS vs MJF?

PART SIZE?

Rule of the fist

- Parts typically the size of your fist or smaller can be production-viable in both processes.
- SLS currently has larger platforms available.

THROUGHPUT?

Starts to matter after ~20 units

- Each build process can be interpreted as “overnight” but MJF can be slightly faster, meaning that in production it may save days or weeks on lead time.

COLOR?

Dyeing and finishing?

- SLS can be dyed colors, MJF sticks to gray/black with some exceptions. MJF color is developing quickly.

MJF parts “scratch black”

- Better for ruggedized components that will take a beating.

MATERIAL CHOICES?

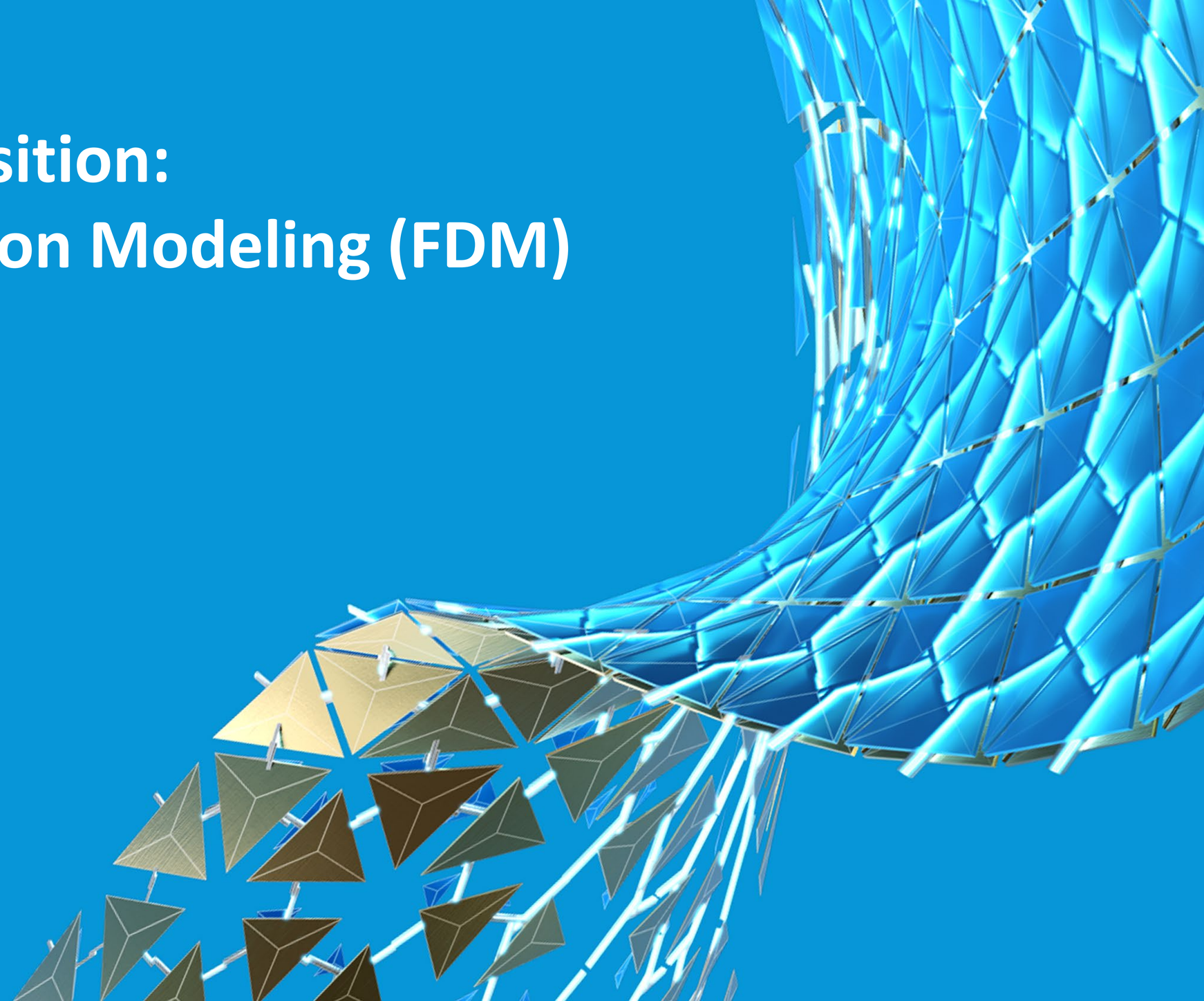
SLS is highly characterized

- Being around for 20+ years has its advantages in regards to adoption.

MJF is gaining momentum

- It is quickly gaining adoption by piggy-backing on SLS-related research for quicker qualification.

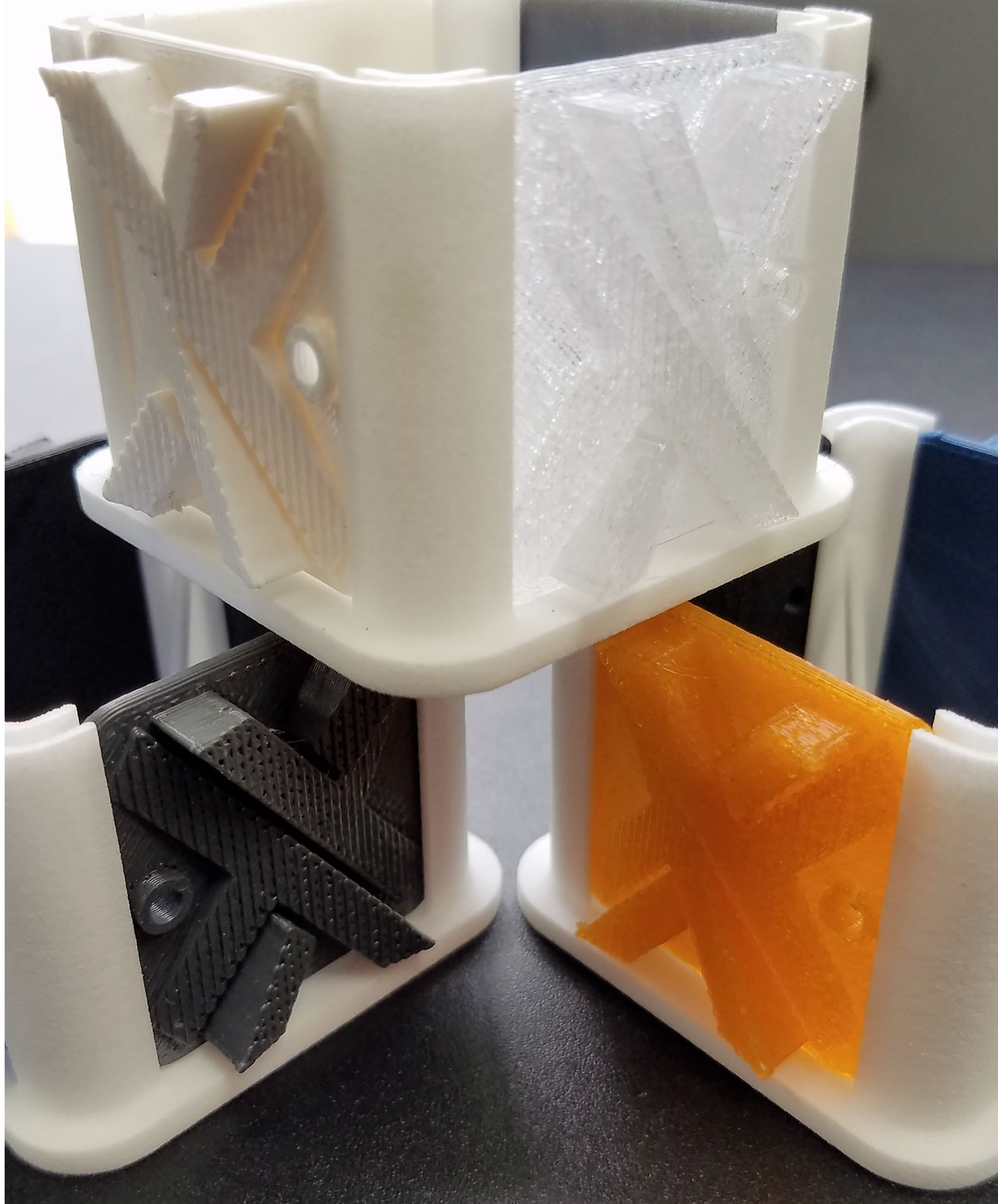
Material Deposition:
Fused Deposition Modeling (FDM)



Fused Deposition Modeling (FDM)

Key Information

- Known for printing big
- Has over 50 different materials like ABS, ASA, PC, PPSF, and ULTEM
- Many color options
- Does sweat the small details, has noticeable layer stepping
- Great for large custom fixtures

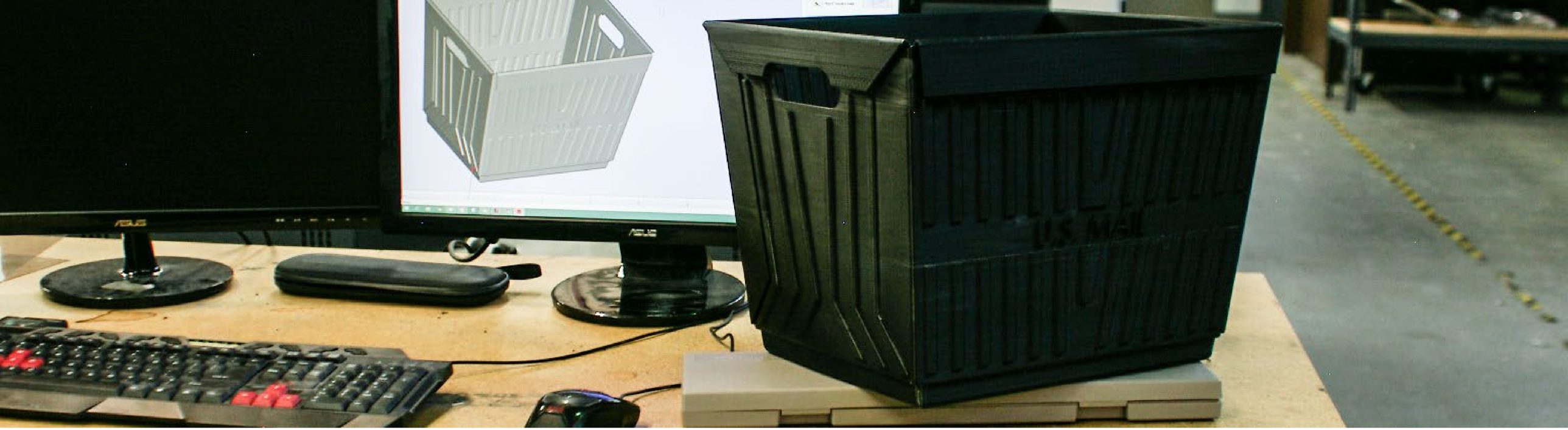


Credit: Xometry

FDM, ABS-M30 Red, Standard

Ran on Stratasys Fortus machines. 0.010” layer height.

Credit: Xometry

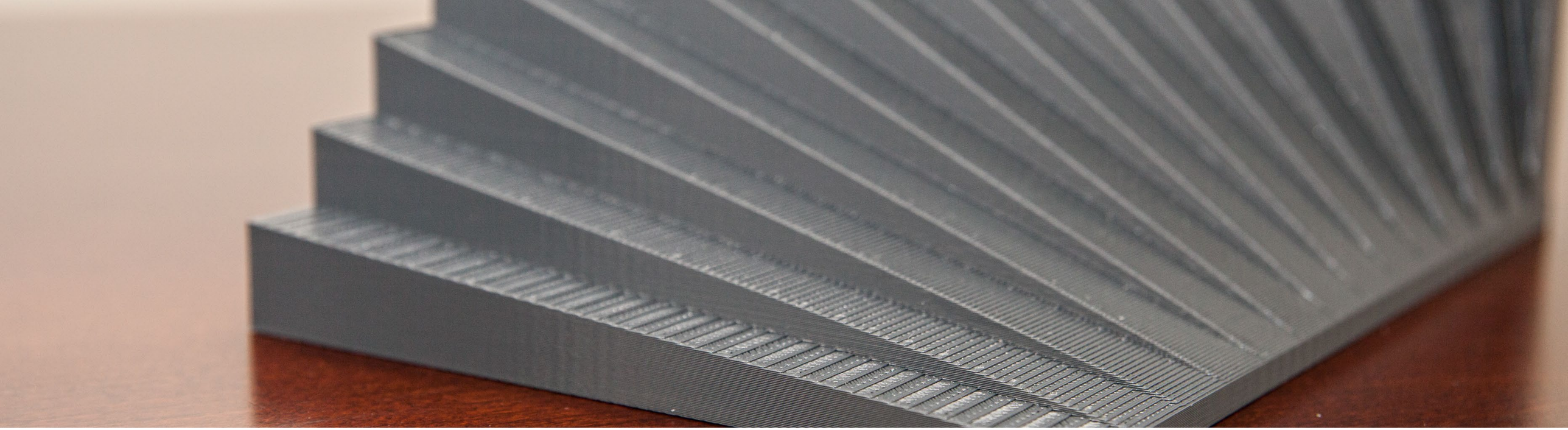


FDM Strengths

Large platform – up to 36” x 24” x 36”

Higher variety of thermoplastics

Very accessible



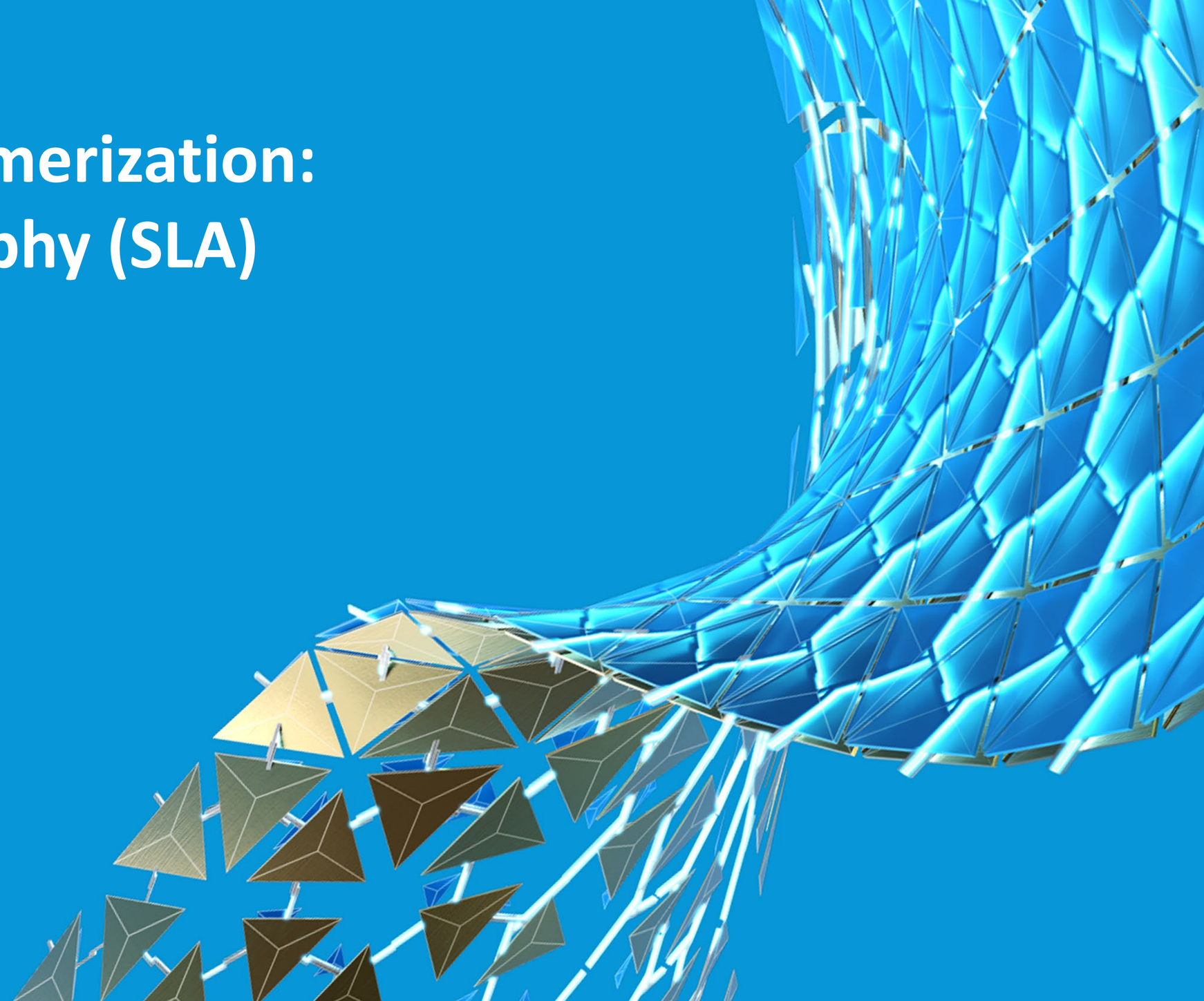
FDM Considerations

Sweats the small details

Significant layer stepping

Limited scalability

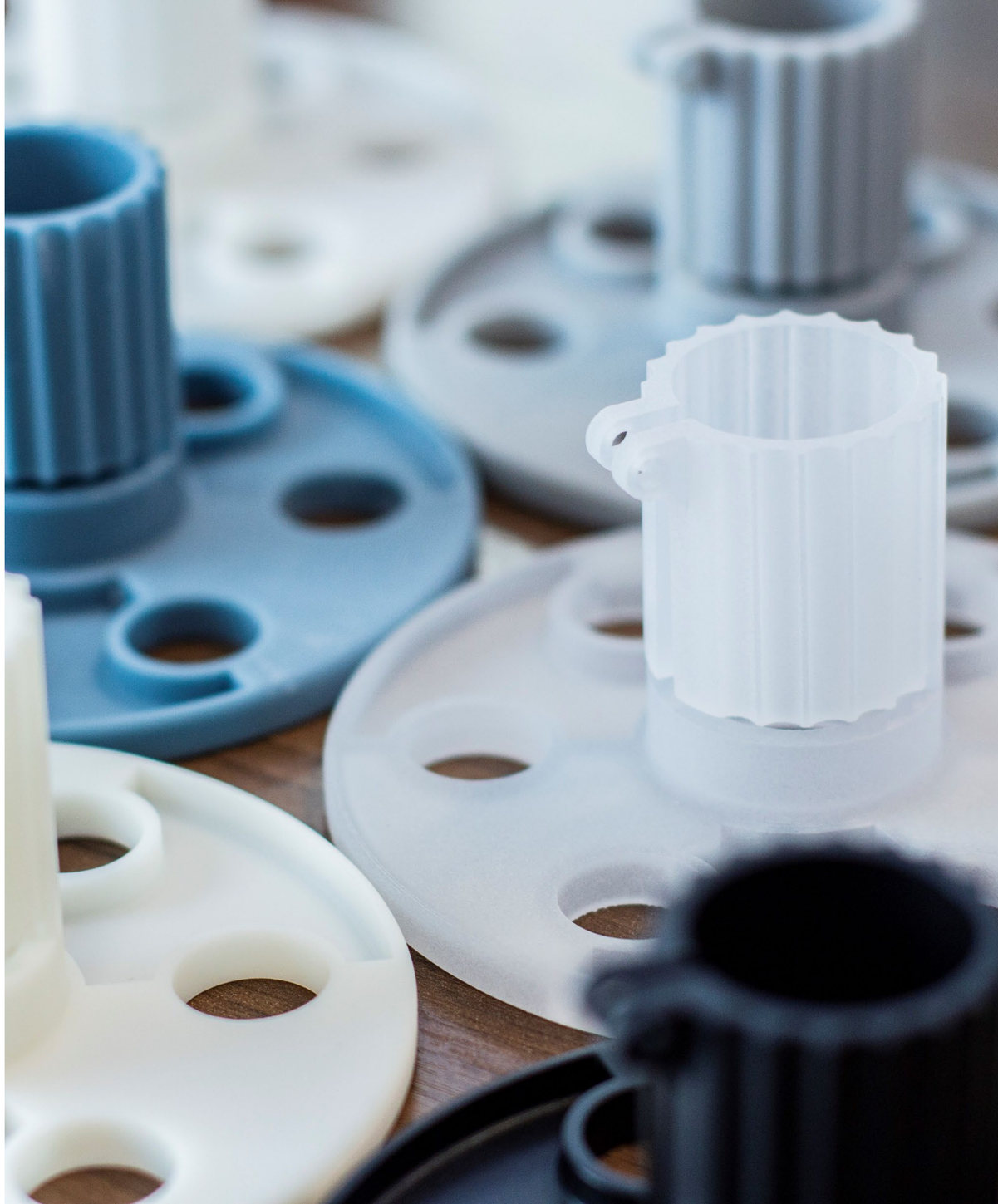
Vat Photopolymerization: Stereolithography (SLA)



Stereolithography

Key Information

- Engineered resins to “act like” plastics
- High variety of materials
- Best surface smoothness from direct print
- Best detail resolution
- Tolerances:
  - XY plane: +/- 0.005” for the first inch, plus +/- 0.002” for every inch thereafter. Z plane: +/- 0.010” for the first inch, plus +/- 0.002” for every inch thereafter.
- Typically used in prototyping phase



SLA

Credit: Xometry

SLA, Accura ClearVue, Natural

Translucent clear material. Can be post processed by sanding or gloss painting for greater transparency.

Credit: Xometry

SLA Strengths

Very high accuracy to-CAD

Fit check models

“Show off” models

Easier to post-finish

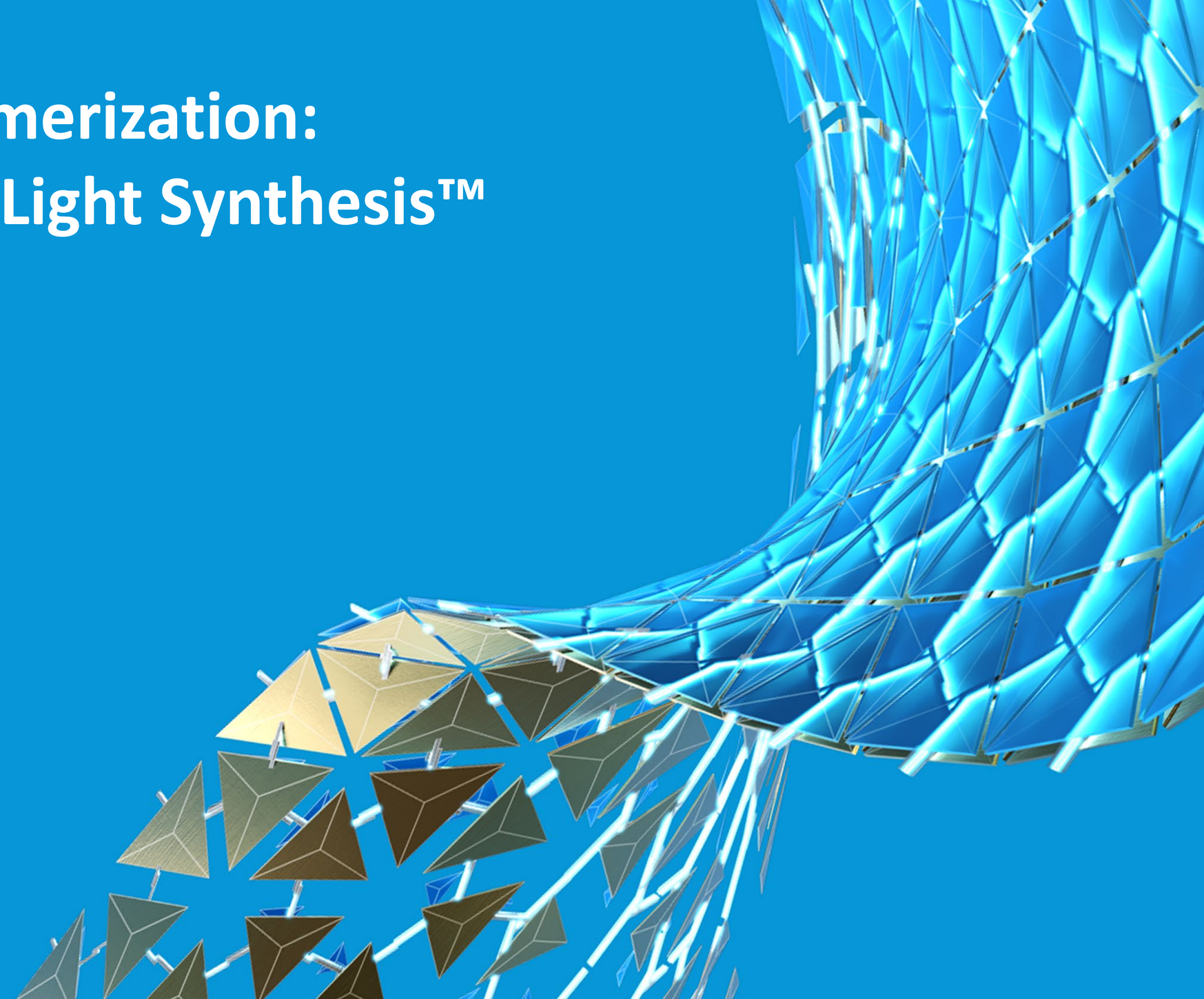
SLA Considerations

More fragile than thermoplastics

Low heat deflection temperature

UV degradation over time

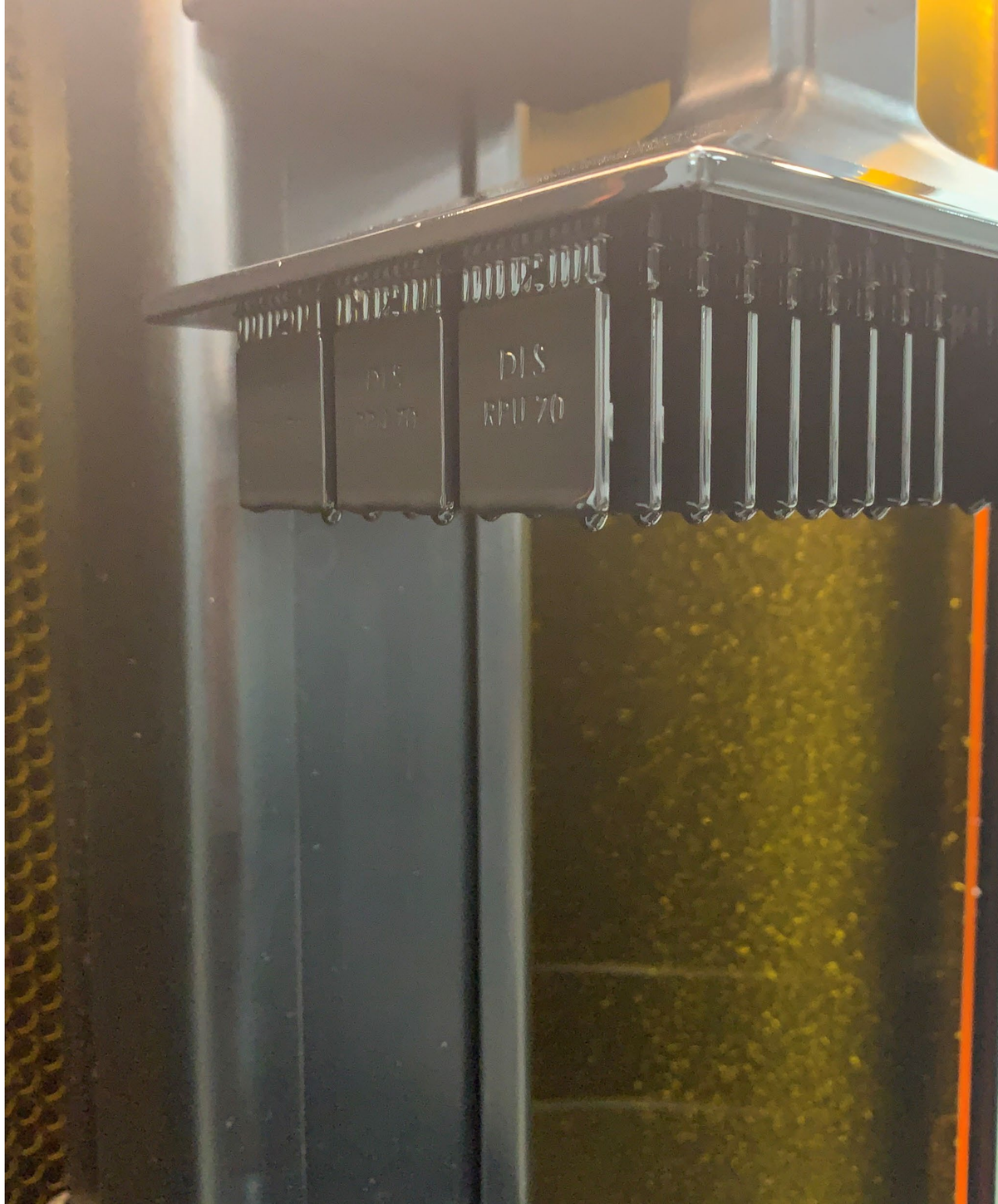
Vat Photopolymerization: Carbon Digital Light Synthesis™ (DLS™)



Carbon DLS™

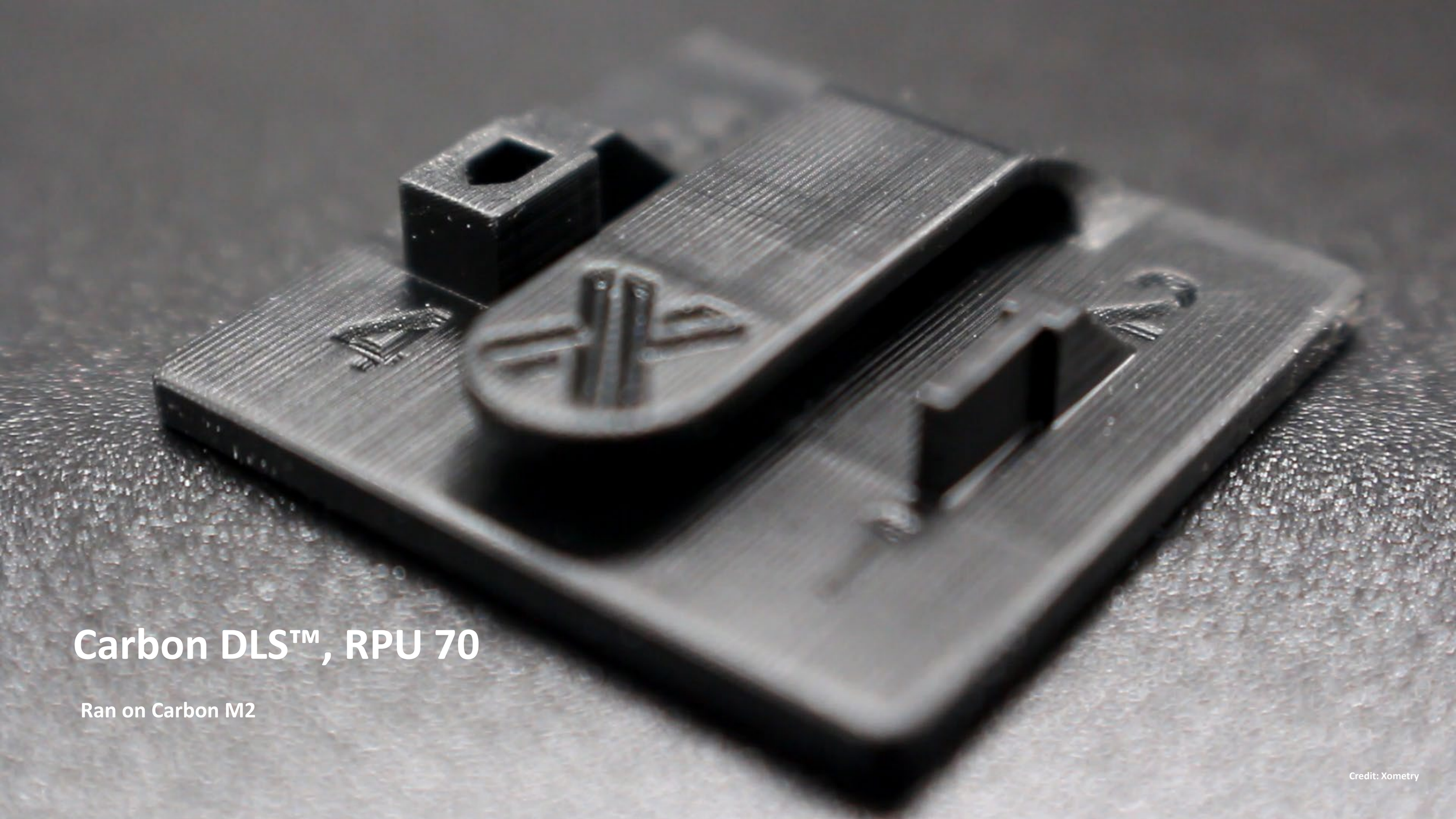
Key Information

- Best combination of mechanical performance and surface finish
- Several resins ranging from highly stiff, to ductile, to elastomers
- Isotropic printing
- Tolerances of +/- 0.005” for the first inch is typical, plus +/- 0.002” for every inch thereafter.
- Can scale better than most photopolymers
- Limited build area (two fingers is optimal size)



DLS

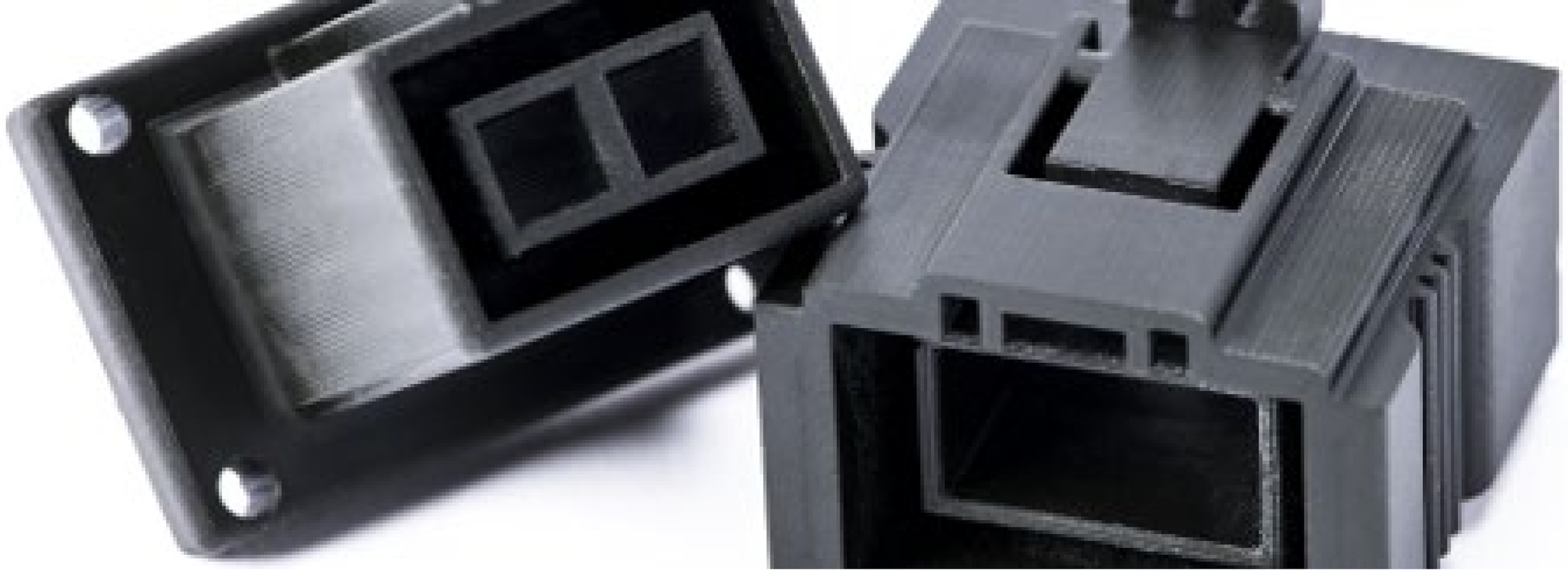
Credit: Xometry



Carbon DLS™, RPU 70

Ran on Carbon M2

Credit: Xometry



DLS™ Strengths

Great mix of properties and surface finish

Isotropic mechanics

Urethane-base makes them tough

Fully dense / watertight

Promise of scaling

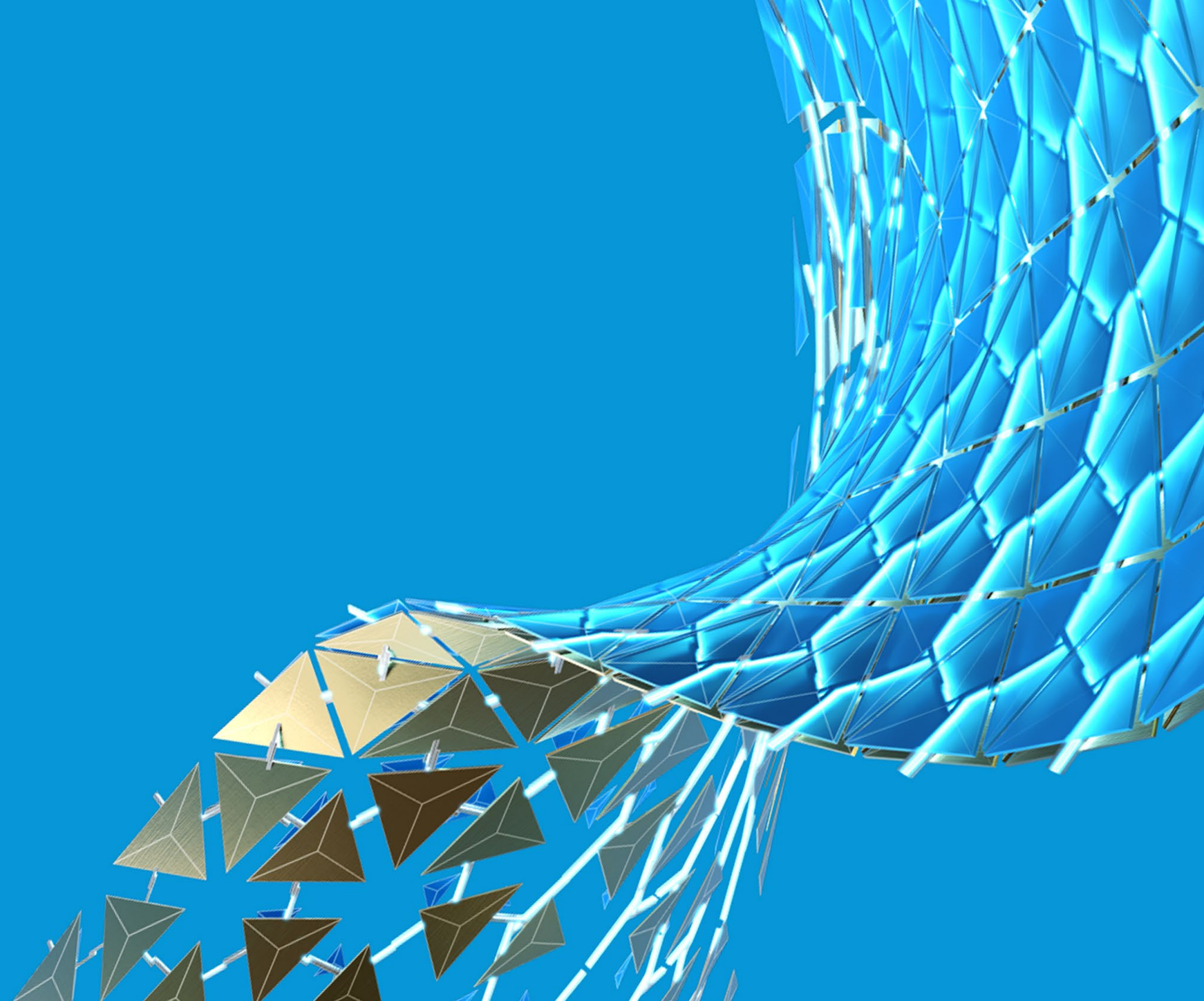
DLS Considerations

Higher up-front costs

Typically requires part tuning for production

Small build size

Let’s Recap!



When to choose what process and why?

MJF AND SLS

- **The 90% tool - getting you a general purpose, useful outcome**
- **Cheap and scalable**
- **No supports = most design freedom**
- **MJF may price slightly better than SLS in quantity**
- **SLS materials are characterized well due to decades of use, but MJF is catching up!**

SLA

- **Smoothest surface finish of all processes**
- **Great detail resolution**
- **Parts are not as durable as SLS, FDM, or DLS**
- **Clear parts are available with light post processing**

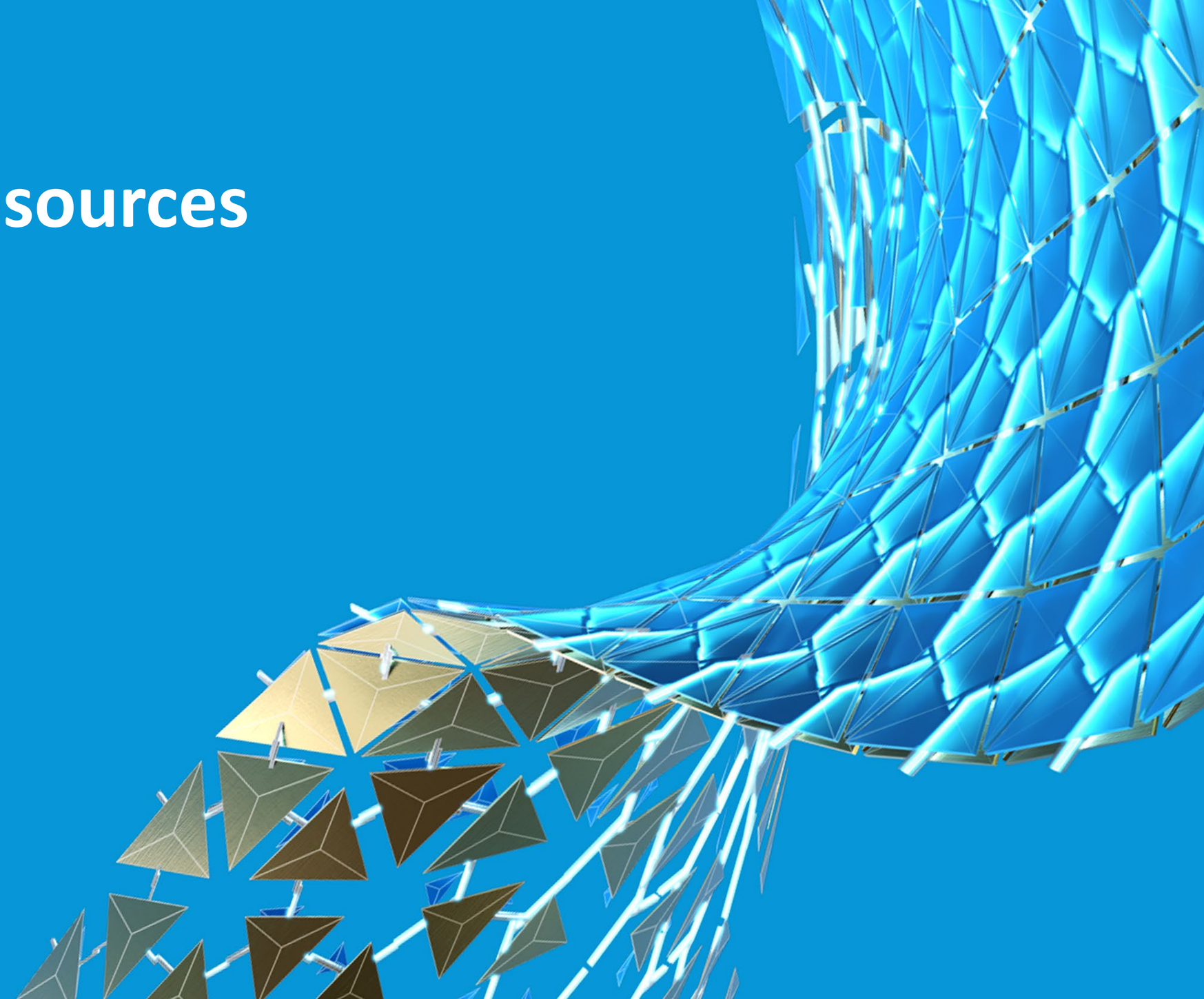
FDM

- **Higher variety of real thermoplastics**
- **Great for bulkier designs--think designing for machining**
- **Big or broad parts**

DLS

- **Awesome material properties + surface finish balance**
- **Good for rigid and elastomers**
- **Small build is best for narrow parts under 3”**
- **High setup favors minimum lot sizes**
- **Great sub for urethane casting on smaller parts**

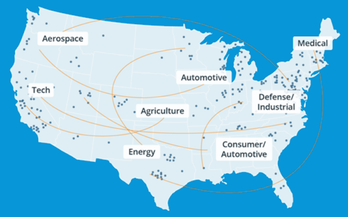
Xometry Resources



Xometry.com Resources

- **Instant online pricing and lead times**
  - 8 industrial 3D printing processes
  - CNC machining
  - Sheet metal
  - Urethane Casting
  - Injection Molding
  - Accepts STP, IPT, SLDPRT, STL, PRT, and more.
- **Free Design Guides**
- **Webinars and Engineering Challenge Videos**
- **Chat with an engineer**

Questions? Email me!



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Thank you!