Which parts work best with Digital Light Synthesis™?
DLS Technical and Economic Fit

ALL PRODUCT COMPONENTS

Materials Specs

Printability

Value

DLS
DLS Sweet Spot
DLS Sweet Spot

- Part consolidation
- Unmoldable or complex geometries
- Small parts
- Textures
- Lattices
- Fine features
- Cosmetic surfaces
- Air and water up to 230°C
Part Consolidation

One of the strengths of additive manufacturing is the ability to consolidate assemblies into a single part. Carbon’s process gives engineers much more freedom to combine several features into a single part.

Assembly consolidation offers several advantages, including:

• Reducing points of failure
• Reducing or eliminating assembly time
• Reducing or eliminating hardware required to hold an assembly together
• Reducing or eliminating tooling
# Part Consolidation

<table>
<thead>
<tr>
<th>STRAIN RELIEF</th>
<th>Original</th>
<th>Designed for DLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parts</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Screws</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>O-ring seals</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Tooling</td>
<td>$9,000</td>
<td></td>
</tr>
</tbody>
</table>
Unmoldable or Very Challenging Geometry

DLS is not restricted by molds or toolpaths, so it has much more freedom to create complex or unusual forms. Carbon can build previously impossible parts and features.

- Lattices
- Complex undercuts
- Internal channels or channels of varying diameter
Injection Molding vs DLS
Small Parts

- Small parts are usually good parts.
  - Necessary for production applications
  - Many parts per build
  - Faster build times which enable more builds per day
  - Less resin use
  - Smaller parts are less likely to need sacrificial support structures, helping to reduce resin usage.

- Two fingers is a good starting point.
  - About 25 x 50 x 75 mm (1 x 2 x 3 inches)
  - Enables production volumes of 10–20 parts per build
Parts per Day: Effect of Height

<table>
<thead>
<tr>
<th>Part Height</th>
<th>20 mm</th>
<th>40 mm</th>
<th>80 mm</th>
<th>160 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Build Time</td>
<td>50 min</td>
<td>94 min</td>
<td>181 min</td>
<td>357 min</td>
</tr>
<tr>
<td>Parts/Day*</td>
<td>360 pcs</td>
<td>200 pcs</td>
<td>120 pcs</td>
<td>80 pcs</td>
</tr>
</tbody>
</table>

*Based on an 8-hour shift, including running an additional build at the end of the day so the machine runs overnight.
### Cost Comparison: Size Variation with Constant Height

<table>
<thead>
<tr>
<th>Part size</th>
<th>Qty per Build</th>
<th>Cost/Part (Qty 1000)</th>
<th>Material Cost (Bulk RPU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 x 10 x 20 mm</td>
<td>104 pcs</td>
<td>$0.57</td>
<td>$0.13</td>
</tr>
<tr>
<td>20 x 20 x 20 mm</td>
<td>40 pcs</td>
<td>$1.60</td>
<td>$0.50</td>
</tr>
<tr>
<td>30 x 30 x 20 mm</td>
<td>15 pcs</td>
<td>$4.03</td>
<td>$1.15</td>
</tr>
<tr>
<td>90 x 90 x 20 mm</td>
<td>2 pcs</td>
<td>$35.72</td>
<td>$10.27</td>
</tr>
</tbody>
</table>
Lattices

The latest CAD tools enable the production of parts that are wholly or partially made of **lattices**. Lattices have a high strength to weight ratio, so they can be used to make parts that are strong and light.

- Lattices can be designed for very specific conditions so that they can be stronger in one axis than another.
- When combined with our elastomers, lattices can be finely tuned to create durable cushions or pads.
- Traditionally massive fixtures and tooling such as molds can be lightweighted when combined with lattices.

**Version 1**: Massive mold designed for milling.

**Version 2**: Application of lattice dramatically reduces resin usage, creating lighter, cheaper part.
Textures

Superior feature sharpness and surface quality enables fine **textures** on a durable, additive part.

- Create and apply textures in CAD, eliminating the need for expensive processes on tooling.
- Digital workflow opens up almost limitless possibilities for textures.
  - Functional: Non-slip grips
  - Cosmetic: Product differentiation
Fine Features

DLS excels at creating fine, sharp features.

• Embossed or engraved text
• Logos
• Clips
• Tabs
• Holes
• Vents
• Channels
• Threading
Cosmetic Surfaces

Parts printed with DLS can have remarkably smooth surfaces that approach injection molded quality.

• Better surface quality than SLS or FDM processes
Air and Water Up to 230°C

Carbon materials work well for air and water applications up to 230°C.

• Air ducts
• Complex water handling
DLS Challenges
DLS Challenges

• Locked designs
• Large parts
• Massive parts
• Accuracy requirements
• Parts that are easily made with other processes
• Flame and chemical resistance
Locked Designs

Designing parts for DLS is critical for achieving success. Just like injection molding, CNC milling, or laser cladding, DLS is a manufacturing process that presents opportunities and challenges for designers. Taking these particular conditions into account is critical for success.

- Failure to design for DLS and expecting success is similar to designing a part for milling and expecting success when trying to produce that same part using injection molding.
- Virtually all parts can be improved functionally and economically by optimizing the design for DLS.
Large Parts

Large parts require longer print times, use more resin, require more supports, require more iteration, and yield fewer parts per build.
Massive Parts

Blocky, heavy parts do not take full advantage of the many benefits of DLS and additive manufacturing.
Accuracy Requirements

Parts that have accuracy requirements tighter than +/- 250 microns (0.010 inch) are more challenging for DLS.

• Higher degrees of accuracy are certainly attainable, but require more iteration.
  • Dental and hearing aid applications have been validated at +/- 50 microns (0.002 inch).
Parts That Are Easily Made with Other Processes

• Simple geometries such as straight pipes, blocks, plates, or extrusions are easily produced with existing manufacturing technologies. DLS offers no clear value.

• Parts that are a good fit for thermoforming are typically not a good fit for DLS due to inexpensive raw materials and tooling.
Flame and Chemical Resistance

Applications that require high flame or chemical resistance are not a good fit for DLS at this time.

- Carbon is working to develop materials that offer flame and chemical resistance.
- RPU 70 has received a UL 94 HB flame resistance classification.
Vacuum Teardown
Part Consideration
DLS SWEET SPOT

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DLS CHALLENGES

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- Parts that are easily made with other processes
- Flame and chemical resistance
Challenging Fit
Low Impact – Low Feasibility

This clear housing component presents some challenges for DLS. The impact gains are low due to minimal to no gains in part consolidation. Feasibility is low due to part size and clear material specs.

DLS Challenges

- Locked designs
- Large parts
- Massive parts
- Accuracy requirements
- Flame and chemical resistance
- Parts that are easily made with other processes
Challenging Fit
Mid Impact – Low Feasibility

While there is impact potential with fine features and cosmetic surfaces, the large size of these housing components presents feasibility challenges.

DLS Challenges

- Locked designs
- Large parts
- Massive parts
- Accuracy requirements
- Flame and chemical resistance
- Parts that are easily made with other processes
Challenging Fit
Low Impact – Mid Feasibility

This component is adaptable to DLS technology but does not have significant gains in impact because it can be easily produced using existing technologies.

DLS Challenges

- Locked designs
- Large parts
- Massive parts
- Accuracy requirements
- Flame and chemical resistance
- Parts that are easily made with other processes
Potential Fit
High Impact – High Feasibility

This small filter is molded with an additional screen component. Fine feature geometries can be printed as one piece. Cosmetic markings from injection molding can be avoided with DLS.

DLS Strengths

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Potential Fit
Mid Impact – High Feasibility

This two-part housing could be one part. If parts do not require separate tooling, consolidation is possible.

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Potential Fit
High Impact – Mid Feasibility

Brush assemblies are complex and expensive, so there is a very high impact potential using rigid and elastomer materials. A DLS solution requires research and development, placing feasibility in the mid-range.

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