Prototyping Overview
Prototyping
for Mechanical Parts
Started as prototyping vendor, then added:

- Industrial Design
- Product Engineering
- Product verification
- Breadboard models
- Computer Animations
- Graphic Design
<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Cost for Ball Tray</th>
<th>Delivery for Ball Tray</th>
<th>Tolerance</th>
<th>Layer height</th>
<th>Surface scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLA</td>
<td>Stereo Lithography Apparatus</td>
<td>liquid photopolymer</td>
<td>$300</td>
<td>2 days</td>
<td>+/-0.002</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>standard appearance models, casting masters</td>
<td>rigid</td>
<td>$300</td>
<td>2 days</td>
<td>+/-0.002</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td>flex resin more durable appearance models</td>
<td>flexible</td>
<td>$300</td>
<td>2 days</td>
<td>+/-0.002</td>
<td>0.005</td>
</tr>
<tr>
<td>SLS</td>
<td>Selective Laser Sintering</td>
<td>thermoplastic powder</td>
<td>$250</td>
<td>2 days</td>
<td>+/-0.007</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>Nylon living hinges, snap fits, functional models</td>
<td>nylon, polyamide</td>
<td>$250</td>
<td>2 days</td>
<td>+/-0.007</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>Glass Filled Nylon extremely durable</td>
<td>33% glass filled nylon, polyamide</td>
<td>$250</td>
<td>2 days</td>
<td>+/-0.007</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>Somos, elastomeric soft touch parts</td>
<td>like Santoprene nylon, polyamide</td>
<td>$200</td>
<td>2 days</td>
<td>+/-0.007</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>Castform investment cast masters</td>
<td>styrene/wax</td>
<td>$300</td>
<td>4 days</td>
<td>+/-0.007</td>
<td>0.004</td>
</tr>
<tr>
<td>FDM</td>
<td>Fuse Deposition Modeling</td>
<td>modeling filament</td>
<td>$250</td>
<td>2 days</td>
<td>+/-0.005</td>
<td>0.005 - 0.016</td>
</tr>
<tr>
<td></td>
<td>ABS replicate ABS thermoplastic</td>
<td>ABS replicate ABS thermoplastic</td>
<td>$250</td>
<td>2 days</td>
<td>+/-0.005</td>
<td>0.005 - 0.010</td>
</tr>
<tr>
<td></td>
<td>Polycarbonate replicate PolyCarb thermoplastic</td>
<td>Polycarbonate replicate PolyCarb thermoplastic</td>
<td>$250</td>
<td>2 days</td>
<td>+/-0.005</td>
<td>0.005 - 0.010</td>
</tr>
<tr>
<td></td>
<td>ZCorp form study models, colors available starch</td>
<td>$150</td>
<td>2 days</td>
<td>+/-0.005</td>
<td>0.003 - 0.010</td>
<td>3</td>
</tr>
</tbody>
</table>
Rapid Prototyping - SLS
<table>
<thead>
<tr>
<th>Other Prototyping Methods</th>
<th>Common uses</th>
<th>Benefits</th>
<th>Input/ Process</th>
<th>Delivery</th>
<th>Tolerance</th>
<th>Material characteristics</th>
<th>Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fabrication</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hand made models</td>
<td>form study models, wax models, breadboard models, LooksLike/WorksLike models</td>
<td>achieve geometry too complex for 3D CAD, multiple materials</td>
<td>napkin sketch to part drawings</td>
<td>complexity dependant</td>
<td>as needed</td>
<td>limitless</td>
<td>1-5</td>
</tr>
<tr>
<td><strong>Urethane Castings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silicone RTV Molds, cast urethane resins</td>
<td>sales samples, LL/WL models,</td>
<td>replicates production, fast, inexpensive, color</td>
<td>pattern/ cast silicone</td>
<td>1-2 weeks</td>
<td>+/- .001-.100 in/in</td>
<td>rigid, flexible, clear, hollow, insert and co-molding, production like materials</td>
<td>10 - &lt;50</td>
</tr>
<tr>
<td><strong>Thermoforming</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheet thermoplastics</td>
<td>wall thickness housings, blister packaging</td>
<td>quick, molds and produce many parts</td>
<td>pattern or mold</td>
<td>.5-2 weeks</td>
<td>+/- .010-.060</td>
<td>simple geometry, opaque and clear</td>
<td>prototype &amp; production</td>
</tr>
<tr>
<td><strong>Investment Casting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>metal cast process</td>
<td>engineering check models</td>
<td>production materials</td>
<td>pattern</td>
<td>2-4 weeks</td>
<td>material dependant</td>
<td>metals, zinc to titanium</td>
<td>prototype &amp; production</td>
</tr>
<tr>
<td><strong>CNC Machining</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer numeric controlled machining</td>
<td>engineering check models, strong parts</td>
<td>production materials</td>
<td>part drawings, 3D data</td>
<td>geometry dependant</td>
<td>limitless</td>
<td>all plastic and metals</td>
<td>prototype &amp; production</td>
</tr>
</tbody>
</table>
Wax Sculpting
Fabricated Model
Cast Urethane Samples
Vacuum Forming

Pattern

Part
Investment Casting

1. Wax Pattern is created (positive)
2. Pattern is dipped in ceramic slurry and then fine sand
3. Assembly is de-waxed by applying heat
4. Molten metal is poured into shell
   • Creates metal parts that are difficult or impossible to machine
CNC Machining
<table>
<thead>
<tr>
<th>Prototype Tooling</th>
<th>Uses</th>
<th>Benefits</th>
<th>Input/ Process</th>
<th>Delivery</th>
<th>Tolerance</th>
<th>Material characteristics</th>
<th>Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>test production materials and part geometry</td>
<td>faster and less expensive than production tooling</td>
<td>2D, 3D data, Pattern/ CNC EDM, pantograph</td>
<td>1-10 weeks</td>
<td>+/- .002 in/in</td>
<td>medium temp thermoplastics</td>
<td>25K - &lt;50K</td>
</tr>
<tr>
<td>Pre-Hard Steel (P-20)</td>
<td>same as aluminum, longer tool life, more complex tools, wider range of materials</td>
<td>same as aluminum</td>
<td>2D, 3D data, Pattern/ CNC EDM, pantograph</td>
<td>1-10 weeks</td>
<td>production</td>
<td>all thermoplastics w/ glass</td>
<td>100K - &lt;250K</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Production Tooling</th>
<th>Uses</th>
<th>Benefits</th>
<th>Input/ Process</th>
<th>Delivery</th>
<th>Tolerance</th>
<th>Material characteristics</th>
<th>Quantities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardened Steel, Multi Cavity</td>
<td>all materials</td>
<td>large quantities, lower part cost</td>
<td>2D, 3D data, Pattern/ CNC EDM, pantograph</td>
<td>complexity dependant</td>
<td>production</td>
<td>all thermoplastics w/ glass</td>
<td>1M +</td>
</tr>
</tbody>
</table>
Prototype Tooling
Prototype Tooling
Aluminum or Pre-hardened Steel

- Process, machined, EDM
- Tool Life: 12 - 250,000
- Benefits:
  - Low volume production
  - High accuracy
  - Most Thermoplastics
- Delivery: 4-6 weeks
Types of Models

• Concept
  Functional, bread boards, form

• Looks like model
  Photography, presentations

• Looks like/ works like
  Sales samples, market testing

• Tooling patterns

• Engineering check models
  Confirm geometry, test production materials, prove function

Foam Study Model

Verification Model SLS

Clinical Trial Prototype,
  Autoclavable GE Ultem: CAM/CNC
Concept Models

• **Purpose:** Study scale, develop form, explore ergonomics

• **Input:** Sketches, verbal description, 3D data

• **Process and materials:**
  - Hand build, foam, insulation or urethane, foam core, clay, cannibalize existing products
  - Rapid prototyping, Z Corp, SLS, SLA
  - Machining, block, tube and sheet stock

• **Tolerances:** Not important

• **Quantity:** Usually ONE
Concept Model

Handmade foam model to explore form
Chosen for speed, 3D data not available
Concept Breadboard Model

Fabricated by hand

Chosen to accommodate many materials
Looks Like Model (LL Model)

- **Purpose**, aesthetic
  - Shows surface finish; color, clear parts, labels, tactile materials

Looks Like/ Work Like Model (LL/ WL)

- **Purpose**, same as above including functional requirements.
  - Draft included only as it effects the performance.
  - Cored for function only.
  - Materials used to replicate production material performance.
  - Includes batteries, electronics, springs, LEDs.

- **Process and materials.**
  - Rapid prototypes, SLS, SLA.
  - Castings/ urethane, silicone.
  - Machining/ stock plastic.

- **Tolerances**, tight as needed.
- **Quantity**, 1-12.
Looks Like/ Works Like

SLA master RTV Mold, Cast Urethane

Chosen for production like resins
LooksLike/ WorksLike

Urethane Casting from SLA master and RTV molds
Chosen to replication production parts in accuracy, color and texture
Tooling Pattern

Fabricated by hand

Chosen to accommodate highly complex geometry
Engineering Models

• Purpose, confirm geometry, test production materials, review function

• Input, 3D data, detailed part drawings

• Process and materials
  – Rapid prototyping/ SLS, FDM, SLA
  – CNC or machined/ production materials
  – Prototype molds/ production materials

• Tolerances, critical

• Quantity, usually ONE
Engineering Model

Rapid Prototype, SLA

Chosen for accuracy and speed
Engineering Model

Rapid Prototype, SLS Glass Filled Nylon

Chosen for durability to withstand testing
Prototype Molded Parts

Aluminum Prototype Injection Mold

Chosen to prove material adhesion and for market testing
Qualifying your prototyping needs

• What type of model do you need?
• What type of input do you have?
  – sketches, control drawings, 3D data
• Is the production material required?
• What are the tolerances?
• How many do you need?
• When do you need it?
• Are you working within a budget?
PD Efficiency

The right questions will improve PD efficiency

• Identify risk in your project
• Formulate questions, that if answered, will reduce/eliminate risk
• Use models/prototypes to get the answers
• Target individual questions at first.

Repeat as necessary.
Can use other tools to answer questions.