In-Space Rapid Manufacturing

Ken Cooper
MSFC
# MSFC Rapid Prototyping

<table>
<thead>
<tr>
<th>RP Process</th>
<th>Build Technique</th>
<th>Build Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laminated Object Manufacturing (LOM)</td>
<td>Materials are Sheet-Fed and Automatically Laminated Together</td>
<td>Paper (wood), Plastic *Composite</td>
</tr>
<tr>
<td>Stereolithography</td>
<td>Laser-cured Resin</td>
<td>Epoxy 5170</td>
</tr>
<tr>
<td>Selective Laser Sintering</td>
<td>Laser-sintered powders</td>
<td>polycarbonate, sand, nylon, rubber, wax</td>
</tr>
<tr>
<td>3D Printing</td>
<td>Ink-jet technology</td>
<td>wax</td>
</tr>
<tr>
<td>Fused Deposition Modeling (FDM)</td>
<td>Melt Extrusion, or &quot;Hot Glue Gun&quot; Technology</td>
<td>wax, ABS plastic, *Ceramics, *Metals</td>
</tr>
</tbody>
</table>

* Under Development
In-Space Mfg. Objectives

- Develop and demonstrate capability to directly fabricate components in space using rapid prototyping technology
  - Ceramics (Alumina, Silicon Nitride, Zirconia)
  - Metallics (Stainless, Inconel, etc.)
  - High strength/temperature plastics (PEEK)
  - ABS Plastic (Starting Point)

- Perform materials science experiments on rapid prototyping candidate materials in microgravity.
Applications/ Advantages

• Space Station:
  – Reduce spares inventory (part CAD files stored on disk)
  – Replace broken parts on demand

• Build variations of designs for other on-board experiments.

• Determine the effects of microgravity on materials properties and rapid prototyping manufacturing methodologies.
Approach

- The FDM and LOM systems exhibit the best capability for operation in microgravity.
- Purchase FDM 1600 ($35K) and modify for flight.
- MSFC and JSC work jointly to modify FDM apparatus, and apply for KC-135 flight tests to prove concept with ABS material. Next goal is to fly on STS.
- Current materials development through MSFC and SBIR/STTR contracts include ceramics & metalics using FDM and LOM, which will lead to installation of rapid prototyping system(s) on Space Station.
Summary

- In-space manufacturing using FDM or LOM rapid prototyping technology offers significant benefits/research opportunities for Space Station and future exploration initiatives.
- MSFC, as the agency leader in rapid prototyping technology, should extend this leadership role to in-space manufacturing.
- Request support/approval to solidify roles and responsibilities with JSC, finalize plans, and proceed with equipment procurement.