The Printer Working Group

3D Printing BOF

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PWG F2F Meeting

Sunnyvale, CA

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# BOF Agenda

- Additional scoping/use cases
- 3D printing extensions for the Internet Printing Protocol (IPP)
- Next steps

- "3D Printing" is generally Additive Manufacturing (adding material to make a three dimensional object)
  - Subtractive Manufacturing (milling, grinding, etc.) is also applicable, and there are hybrid solutions that use both
- Useful web pages on 3D printing:
  - http://3dprintingindustry.com/3d-printing-basics-free-beginners-guide/
  - http://en.wikipedia.org/wiki/3D_printing
- Semantic Model:
  - http://www.pwg.org/sm
- Internet Printing Protocol (IPP):
  - http://www.pwg.org/ipp
- Past 3D Printing BOFs:
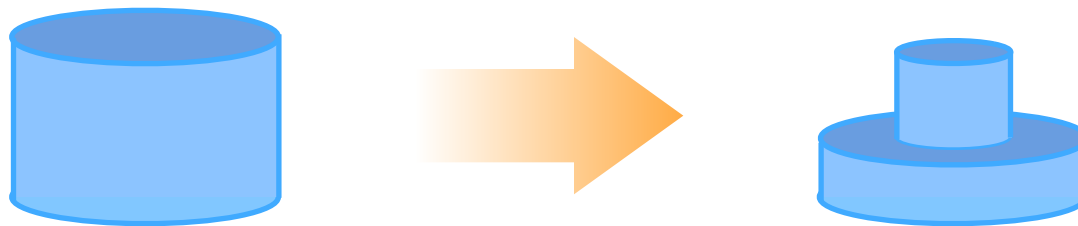 - http://www.pwg.org/bofs.html

- In Additive Manufacturing, material is added to form three-dimensional objects, typically in deposited horizontal layers:
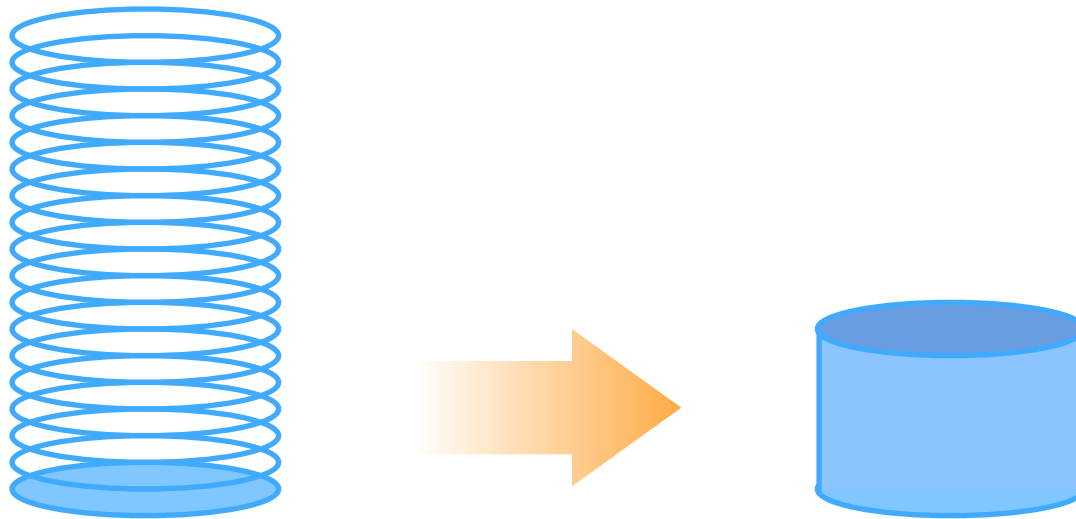
Subtractive Manufacturing

- In Subtractive Manufacturing, material is removed to form the final three-dimensional objects:

Scoping/Use Cases

- Scope thus far has been on direct printing from Client to Printer

- Cloud-based and paid printing solutions are becoming more widespread

  - Less reliance on low-level file formats, e.g., G-code, between Client and Cloud - User submits higher-level STL/DAE/AMF object files and specifies intent (materials, quality, etc.)
  - Cloud-based solutions typically also provide remote camera feeds, for printers with cameras
  - Paid printing solutions do not directly report status of output device

- What level of support do we want to provide for these?

IPP 3D Printing Extensions

- Current draft (white paper):
  - http://ftp.pwg.org/pub/pwg/BOFs/3d-printing/wd-apple-ipp3d-20150413-rev.pdf
- Issues:
  - Need a lot more definitions for materials
  - Need a way to associate materials in the job ticket to those in the document data (next slide), support materials, in-fill materials, etc.
  - What to do about paid printing solutions?
  - What to do for Cloud solutions
    - Particularly relaying camera video/stills

IPP 3D - Materials

- Existing file formats lack good material intent support:
  - AMF support a single named material per "volume" (a closed space, all or part of the printed object) with an RGB color value and some physical characteristics (but not the material type)
  - Collada (DAE) files support color and texture but not named materials
  - STL does not support a way to specify materials
- Multiple-material printers are becoming more common, but still largely experimental due to difficulty supplying document data expressing the material requirements
  - Multiple files, one per material, are often used for FDM printers but this does not scale
  - Users asking for the ability to use different materials for in-fill and supports, e.g., Red PLA on the outside, white/natural PLA on the inside, and dissolvable filament for the supports.

- Named/numbered material association in the document is fairly straight-forward
  - Match materials-col.material-name with AMF material name, for example
- Support material selection is already part of the white paper ('material-N')
- Could add an "infill-material (type2 keyword)" attribute to allow selection of different infill materials?

- Is what we have in the IPP Transaction-Based Printing Extensions sufficient?

IPP 3D - Cloud-Based Printing

- Is what we have in the IPP Shared Infrastructure Extensions (INFRA) sufficient?

- For cameras, simplest method is to have the Proxy upload (PUT) a snapshot from the camera video periodically and report the URL for the uploaded image
  - Implementations can be smart enough to only upload when the video frame changes significantly, or once per layer, etc.
  - Goal is to see progress and printing issues visually
  - Could limit updates to when a job is active

Next Steps

- Continue with 3D Printing BOFs, or do we feel that we are ready to work on a spec?

- Are there other people, companies, or organizations that we should invite to participate?