STANDARD SPECIFICATIONS FOR ADDITIVE MANUFACTURING FILE FORMAT (.AMF)

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NSF

.STL File Formats

- .STL file format has been the industry standard
- .STL contains information only about surface mesh
- No Provisions for;
  - Color
  - Texture
  - Material
  - Substructure
  - Additional properties

.AMF Format

- Key Considerations
  - Technology Independence
  - Simplicity
  - Scalability
  - Performance
  - Backward Compatibility
  - Future Compatibility

.AMF File Format

- General Structure
  - Object
  - Material
  - Texture
  - Constellation
  - Metadata

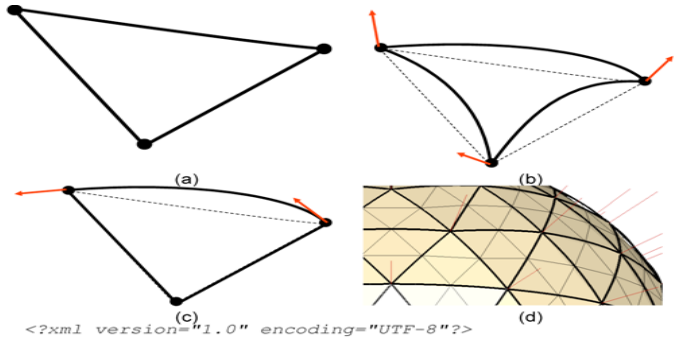
.AMF File Format

- Geometry Specification
  - Object
  - Vertices
  - Volume
  - Triangle

.AMF File Format

- Restrictions on Geometry
  - Every triangle shall have exactly three different vertices
  - Triangles may not intersect or overlap except at their common edges of common vertices
  - Volumes shall enclose a closed space with nonzero volume
  - Volumes may not overlap
  - Every vertex shall be referenced by at least three triangles
  - Every pair of vertices shall be referenced by zero or two triangles per volume
  - No two vertices can have identical coordinates
  - The outward direction of triangles that share an edge in the same volume must be consistent

AMF File Format




```
<?xml version="1.0" encoding="UTF-8"?>
<amf unit="millimeter">
  <object id="0">
    <mesh>
      <vertices>
        <vertex>
          <coordinates >
            ...
          </coordinates >
          <normal>
            <nx>0</nx>
            <ny>0.707</ny>
            <nz>0.707</nz>
          </normal>
        </vertex>
        ...
        <edge>
          <v1>0</v1>
          <dx1>0.577</dx1>
          <dy1>0.577</dy1>
          <dz1>0.577</dz1>
          <v2>1</v2>
          <dx2>0.707</dx2>
          <dy2>0</dy2>
          <dz2>0.707</dz2>
        </edge>
        ...
      </vertices>

      <volume materialid="0">
        <triangle>
          ...
        </triangle>
        ...
      </volume>
    </mesh>
  </object>
</amf>
```

(e)

a) Default (Flat) Triangle Patch, (b) Triangle Curved Using Vertex Normals, (c) Triangle Curved Using Edge Tangents, (d) Subdivision of a Curved Triangle Patch into Four Curved Subpatches, and (e) AMF File Containing Curved Geometry

Material Specification

- Mixed and graded materials and substructures
- Porous materials
- Stochastic materials
- Color specification
- Graded colors and texture mapping
- Transparency
- Texture
- Print
- Metadata

Material Specification

```
<?xml version="1.0" encoding="UTF-8"?>
<amf unit="millimeter">
  <material id="1">
    <metadata type="Name">StiffMaterial</metadata>
  </material>
  <material id="2">
    <metadata type="Name">FlexibleMaterial</metadata>
  </material>
  <material id="3">
    <metadata type="Name">MediumMaterial</metadata>
    <composite materialid="1">0.4</composite>
    <composite materialid="2">0.6</composite>
  </material>
  <material id="4">
    <metadata type="Name">VerticallyGraded</metadata>
    <composite materialid="1">z</composite>
    <composite materialid="2">10-z</composite>
  </material>
  <material id="5">
    <metadata type="Name">Checkerboard</metadata >
    <composite materialid="1">
          floor(x+y+z%1)+0.5) </composite>
    <composite materialid="2">
          1-floor(x+y+z%1)+0.5) </composite>
  </material>

  <object id="0">
    <mesh>
      <vertices>
        ...
      </vertices>
      <volume materialid="1">
        ...
      </volume>
      <volume materialid="2">
        ...
      </volume>
    </mesh>
  </object>
</amf>
```

NOTE—An AMF file containing five materials. Material 3 is a 40/60 %homogenous mixture of the first two materials. Material 4 is a vertically graded material and Material 5 has a periodic checkerboard substructure.

.AMF File Format

- Compression and Distribution
  - .amf file shall be stored in either plain text or compressed
  - Both the compressed and uncompressed version will have the .amf extension
- Tolerances, Textures and additional information
  - Prototyping
  - Modeling
  - Production parts
- Post Processing
  - Infusion

Color Specification

```
<?xml version="1.0"?>
<amf unit="millimeter">

  <material id="1">
    <metadata type="Name">StiffMaterial</metadata>
      <color>
        <r>0</r>
        <g>z</g>
        <b>1-z</b>
      </color>
  </material>

  <texture id="1" width="10" height="26" type="grayscale">
    TWFuIGlzIGRpc3RpbmdlaXNoZWQsIG5vdCB
    vbmx5IGJ5IGhpcyByZWFzb24sIGJ1dCBieS
    B0aGlzIHNpbmdlbGFyIHBhc3Npb24gZnJvb
    SBvdGhlciBhbmltYWxzLCB3aGljaCBpcyBh
    ...
  </texture>


  <object id="0">
    <mesh>
      <vertices>
        ...
      </vertices>
      <volume materialid="1">
        <color>
          <r>0.9</r>
          <g>0.9</g>
          <b>0.2</b>
          <a>0.8</a>
        </color>
        ...
        <triangle>
          <v1>0</v1>
          <v2>1</v2>
          <v3>3</v3>
          <color>
            <r>tex(1,x,y)</r>
            <g>tex(2,x,y)</g>
            <b>tex(3,x,y)</b>
            <a>0.1</a>
          </color>
        </triangle>
      </volume>
    </mesh>
  </object>
</amf>
```

Absolute color can be associated with a material, a volume, or a vertex. A vertex can also be associated with a coordinate in a color texture file.

File Size Comparison

Number of Triangles	Binary STL (uncompressed)	Binary STL (compressed)	AMF (uncompressed)	AMF (compressed)
1,016,388	49.6 Mb	25.3 Mb	205.9 Mb	12.2 Mb
100,536	4.9 Mb	2.3 Mb	20.1 Mb	1.2 Mb
10,592	518 K	249 K	2.1 Mb	129 K
1,036	51 K	20 K	203 K	12 K

Questions????

