ABOUT 3MF FILE FORMAT FOR 3D PRINTING

prof.PhD.eng. Cătălin IANCU
Faculty of Engineering, "C-tin Brâncuşi" Univ. of Tg-Jiu,
ciancu@utgjiu.ro

Abstract: *In this paperwork is presented a documentary research regarding 3MF file format for 3D printing, the situation existing in the end of 2018 and early 2019, in comparison with other used file formats for this purpose, like STL, OBJ and AMF. There are presented also some characteristics of 3MF format, some limitation and the future perspective of this file format.*

Keywords: 3D printing, 3MF, STL, OBJ, AMF.

1. INTRODUCTION

In [1] has been presented the situation existing in the end of 2018, regarding the four most common 3D printing file formats (STL, OBJ, AMF and 3MF), their features and future perspective. This situation was compared with one existing in 2010, presented in [2], regarding 3D printing using STL file format, as a most common and well known format and therefore supported by most software and hardware for 3D printing. In [2] has been concluded also that "… 3D printing and 3D printers have become financially accessible to small and medium sized business, thereby taking prototyping out of the heavy industry and into the office environment. The technology of rapid prototyping also finds use from industrial design to dental and medical industries".

It's a common fact that the most used file format for 3D printing is STL, native to the stereolithography CAD software created by 3D Systems Inc. since 1987. In [2] have been presented in detail the features and characteristics of STL file format. Also the STL file format has a few inherent problems [2]: file size is excessive, file security is limited, and it can't detect or fix errors (especially unintended holes) in the part to be built. In [3] AND [4] was stated that STL files used to transfer data from CAD package to 3D printers have a series of limitations and therefore new formats will replace it.

These new formats are OBJ (along with a MTL file), AMF (Additive Manufacturing File), which is practically called "STL 2.0", and the 3MF (3D Manufacturing Format), the last one having the biggest chances to replace STL.

3MF was developed in 2015, by Microsoft along with **3MF Consortium**, see figure 1.

Figure 1. Logo of 3MF Consortium

Microsoft developed the 3MF format first for its operating system, WINDOWS, and then for its proprietary application 3D Builder, intending to 3D printing direct from operating system [5], figure 2.

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Figure 2. 3MF file open in Microsoft 3D Builder

The 3MF Consortium is an association that will govern further development and progress of the 3MF format. In this Consortium are included all the big names in 3D printing as founding members: Autodesk, Dassault Systems, PTC, Stratasys, Ultimaker, Materialize, Shapeways, 3D Systems, Siemens, HP, GE, and many more.

2. FEATURES OF 3MF FORMAT [6]

3MF file format for 3D printing is an open source XML-based format.

The 3MF Consortium established that the benefits of human readability for ease of development is more important than the performance gain from going to a binary format.

It features geometry representation similar to STL (triangular meshes), but in a more compact and small size format than AMF 3D printer file format. As an example of its space-saving features, multiple identical objects can be placed referencing the same mesh (figure 3).

Figure 3. Multiple objects can be placed without additional space in the 3MF file format

According to the 3MF Consortium, the core properties of the 3MF file format are the following:
 - *Completeness*: All of the necessary model, material and property information is contained in a single archive.
 - *Human readability*: Common structures, such as ZIP and XML, are used to ease development.
 - *Simplicity*: The specification is short and clear, making development easy and validation fast.
- *Extensibility*: Leveraging XML namespaces allows for both public and private extensions while maintaining compatibility.
 - *Clarity*: Clear language and conformance tests ensure a file is always consistent from digital

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to physical.

 - *Accessibility*: Access to and implementation of the 3MF specification is and will always be free of royalties, patents and licensing.

Today, 1 operating system, 5 service platforms, and 19 software applications support the development and implementation of 3MF.

3MF file format ensures that the files are completely with no gaps or overlapping triangles avoiding problems common in other formats standardized for animation and VR rather than 3D printing. The most important thing in 3D printing is having a ready-to-print file which requires no adjustment or fixing, and 3MF seems capable of doing this.

A 3MF file always contains a 3D model, which includes a description of one or more 3D objects. The 3D model may also include texture information for each 3D object and a "print ticket" that contains recommended print options. The 3MF file may also store a .JPG or .PNG thumbnail image, digital signatures, core properties, and other metadata.

So as metadata in a 3MF file, besides the 3D model, are stored extensions for: *3MF Materials and Properties*, *3MF Slice*, *3MF Production*, and *3MF Beam Lattice*.
Further is presented an example of simple encoding of 3MF metadata [6]:

```
<?xml version="1.0" encoding="UTF-8"?>
<model unit="millimeter" xml:lang="en-us"
xmlns:m="http://schemas.microsoft.com/3dmanufacturing/material/2015/02"
xmlns="http://schemas.microsoft.com/3dmanufacturing/core/2015/02"
xmlns:vendor1="http://www.vendorwwebsite.com/3mf/vendor13mfextension/2017/01">
        <metadata name="Copyright"> Microsoft Corporation 2015</metadata>
        <metadata name="Application">Microsoft 3D Builder</metadata>
        <metadata name="LicenseTerms">All rights reserved</metadata>
        <metadata name="Title">Cube</metadata>
        <metadata name="Designer">Microsoft Corporation</metadata>
        <metadata name="CreationDate">2015-10-07</metadata>
        <metadata name="ChangeHistory">2015-10-07 Initial model</metadata>
        <metadata name="ModificationDate">2016-03-27</metadata>
        <metadata name="Description">Cube</metadata>
      <metadata name="vendor1:CustomMetadata1" preserve="1">CE8A91FB-C44E-4F00-B634-
BAA411465F6A</metadata>
<resources>
<basematerials id="1">
<base name="Green" displaycolor="#21BB4CFF" />
</basematerials>
<object id="2" type="model" pid="1" pindex="0">
<metadatagroup>
<metadata name="vendor1:CustomMetadata2" preserve="true" type="xs:string">03DAE6E4-24FF-4B20-97A1-
7487AB9C1CB0</metadata>
</metadatagroup>
<mesh>
<vertices>
        <vertex x="0" y="42.998" z="39.998" />
        …………………………………………..
</vertices>
<triangles>
        <triangle v1="0" v2="1" v3="2" />
………………………………….
</triangles>
        </mesh>
        </object>
```

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```
<object id="3" type="model">
<components>
<component objectid="2" />
</components>
</object>
</resources>
        <build>
<item objectid="3" transform="1 0 0 0 1 0 0 0 1 -19.999 -62.998 0" >
<metadatagroup>
<metadata name="vendor1:CustomMetadata3" type="xs:boolean">1</metadata>
</metadatagroup>
        </item>
        </build>
</model>
```

3. CONCLUSIONS [7], [8]

As is stated in [8], theoretically can be used any 3D file format for 3D printing. In the end of 2018 and early 2019, STL, OBJ, AMF, and 3MF are the most important 3D printer file formats. They all have their own strengths, weaknesses and have varying levels of compatibility with 3D printing software and hardware. STL is still the predominant format, OBJ have little spreading, while formats like AMF and 3MF are trying to provide a more capable STL for modern 3D printing.

Meanwhile, based on the fact that 3MF is open source can be adopted by any company willing to do so, without needing to become part of the 3MF Consortium.

As more 3D printing equipment supports color, texture, multiple materials and other developments, 3MF will play a key role in simplifying the process of 3D printing for everyone.

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