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Standard specification for additive manufacturing file format (AMF) Version 1.1

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**Standard specification for additive
manufacturing file format (AMF)
Version 1.1**

*Spécification normalisée pour le format de fichier pour la
fabrication additive (AMF) Version 1.1*



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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives.

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ISO/ASTM 52915 was prepared by ASTM International (as ASTM F2915) and was adopted, under a special “fast-track procedure”, by Technical Committee ISO/TC 261, *Additive manufacturing*, in parallel with its approval by the ISO member bodies. This has been done under a Partner Standards Development Organization (PSDO) Cooperation Agreement between ISO/TC 261, *Additive manufacturing*, and ASTM International Committee F42, *Additive Manufacturing Technologies*. ASTM F2915 was developed by ASTM Subcommittee F42.04, *Design*.

This first edition of ISO/ASTM 52915 cancels and replaces ASTM F2915-12.



Standard Specification for Additive Manufacturing File Format (AMF) Version 1.1¹

This standard is issued under the fixed designation ISO/ASTM 52915; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision.

1. Scope

1.1 This specification describes a framework for an interchange format to address the current and future needs of additive manufacturing technology. For the last three decades, the STL file format has been the industry standard for transferring information between design programs and additive manufacturing equipment. An STL file contains information only about a surface mesh and has no provisions for representing color, texture, material, substructure, and other properties of the fabricated target object. As additive manufacturing technology is quickly evolving from producing primarily single-material, homogenous shapes to producing multimaterial geometries in full color with functionally graded materials and microstructures, there is a growing need for a standard interchange file format that can support these features.

1.2 The additive manufacturing file (AMF) may be prepared, displayed, and transmitted on paper or electronically, provided the information required by this specification is included. When prepared in a structured electronic format, strict adherence to an extensible markup language (XML)(1)² schema is required to support standards-compliant interoperability. The adjunct to this specification contains a W3C XML schema and **Annex A1** contains an implementation guide for such representation.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This standard also does not purport to address any copyright and intellectual property concerns, if any, associated with its use. It is the responsibility of the user of this standard to meet any intellectual property regulations on the use of information encoded in this file format.*

2. Terminology

2.1 Definitions of Terms Specific to This Standard:

¹ This specification is under the jurisdiction of ASTM Committee F42 on Additive Manufacturing Technologies and is the direct responsibility of Subcommittee F42.04 on Design, and is also under the jurisdiction of ISO/TC 261.

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² The boldface numbers in parentheses refer to the list of references at the end of this standard.

2.1.1 This section provides definitions of terms specific to this standard—these terms also include the common terms seen in many documents related to extensible markup language (XML) and additive manufacturing. See also **Annex A1** for definitions of additional terms specific to this specification.

2.1.2 *attribute, n*—characteristic of data, representing one or more aspects, descriptors, or elements of the data.

2.1.2.1 *Discussion*—In object-oriented systems, attributes are characteristics of objects. In XML, attributes are characteristics of elements.

2.1.3 *comments, n*—all text comments associated with any data within the additive manufacturing file (AMF) not containing core relevant, technical, or administrative data and not containing pointers to references external to the AMF.

2.1.4 *domain-specific applications, n*—additional, optional sets of AMF data elements specific to such areas as novel additive manufacturing processes, enterprise workflow, and supply chain management.

2.1.4.1 *Discussion*—Data sets for optional AMF domain-specific applications will be developed and balloted separately from this specification.

2.1.5 *extensible markup language, XML, n*—standard from the WorldWideWeb Consortium (W3C) that provides for tagging of information content within documents offering a means for representation of content in a format that is both human and machine readable.

2.1.5.1 *Discussion*—Through the use of customizable style sheets and schemas, information can be represented in a uniform way, allowing for interchange of both content (data) and format (metadata).

2.1.6 *STL (file format), n*—file format native to the stereolithography computer-aided drafting (CAD) software that is supported by many software packages; it is widely used for rapid prototyping and computer-aided manufacturing.

2.1.6.1 *Discussion*—STL files describe only the surface geometry of a three-dimensional object as a tessellation of triangles without any representation of color, texture, or other common CAD model attributes. The STL format specifies both the American Standard Code for Information Interchange (ASCII) and binary representations.

3. Key Considerations

3.1 There is a natural tradeoff between the generality of a file format and its usefulness for a specific purpose. Thus,



features designed to meet the needs of one community may hinder the usefulness of a file format for other uses. To be successful across the field of additive manufacturing, this file format is designed to address the following concerns:

3.1.1 *Technology Independence*—The file format shall describe an object in a general way such that any machine can build it to the best of its ability. It is resolution and layer-thickness independent and does not contain information specific to any one manufacturing process or technique. This does not negate the inclusion of properties that only certain advanced machines support (for example, color, multiple materials, and so forth), but these are defined in such a way as to avoid exclusivity.

3.1.2 *Simplicity*—The AMF file format is easy to implement and understand. The format can be read and debugged in a simple ASCII text viewer to encourage understanding and adoption. No identical information is stored in multiple places.

3.1.3 *Scalability*—The file format scales well with increase in part complexity and size and with the improving resolution and accuracy of manufacturing equipment. This includes being able to handle large arrays of identical objects, complex repeated internal features (for example, meshes), smooth curved surfaces with fine printing resolution, and multiple components arranged in an optimal packing for printing.

3.1.4 *Performance*—The file format should enable reasonable duration (interactive time) for read-and-write operations and reasonable file sizes for a typical large object. Detailed performance data are provided in [Appendix X1](#).

3.1.5 *Backwards Compatibility*—Any existing STL file can be converted directly into a valid AMF file without any loss of information and without requiring any additional information. AMF files are also easily converted back to STL for use on legacy systems, although advanced features will be lost. This format maintains the triangle-mesh geometry representation to take advantage of existing optimized slicing algorithm and code infrastructure already in existence.

3.1.6 *Future Compatibility*—To remain useful in a rapidly changing industry, this file format is easily extensible while remaining compatible with earlier versions and technologies. This allows new features to be added as advances in technology warrant, while still working flawlessly for simple homogeneous geometries on the oldest hardware.

4. Structure of This Specification

4.1 Information specified throughout this specification is stored in XML format. XML is an ASCII text file comprising a list of elements and attributes. Using this widely accepted data format opens the door to a rich host of tools for creating, viewing, manipulating, parsing, and storing AMF files. XML is human readable, which makes debugging errors in the file possible. XML can be compressed or encrypted or both if desired in a post-processing step using highly optimized standardized routines.

4.2 Another significant advantage of XML is its inherent flexibility. Missing or additional parameters do not present a problem for a parser as long as the document conforms to the XML standard. Practically, this allows new features to be

added without needing to update old versions of the parser, such as in legacy software.

4.3 *Precision*—This file format is agnostic as to the precision of the representation of numeric values. It is the responsibility of the generating program to write as many or as few digits as are necessary for proper representation of the target object. However, a parsing program should read and process real numbers in double precision (64 bit).

4.4 *Future Amendments and Additions*—Additional XML elements can be added provisionally to any AMF file for any purpose but will not be considered part of this specification. An unofficial AMF element can be ignored by any reader and does not need to be stored or reproduced on output. An element becomes official only when it is formally accepted into this specification.

5. General Structure

5.1 The AMF file begins with the XML declaration line specifying the XML version and encoding, for example:

```
<?xml version="1.0" encoding="UTF-8"?>
```

5.2 Blank lines and standard XML comments can be interspersed in the file and will be ignored by any interpreter, for example:

```
<!-- ignore this comment -->
```

5.3 The remainder of the file is enclosed between an opening `</amf>` element and a closing `</amf>` element. These elements are necessary to denote the file type, as well as to fulfill the requirement that all XML files have a single-root element. The version of the AMF standard as well as all standard XML namespace declarations can be used, such as the `lang` attribute designed to identify the human language used. The unit system can also be specified (mm, inch, ft, meters, or micrometers). In absence of a unit specification, millimeters are assumed.

```
<amf unit="millimeter" version="1.0" xml:lang="en">
```

5.4 Within the AMF brackets, there are five top level elements:

5.4.1 `<object>` —The object element defines a volume or volumes of material, each of which are associated with a material identification (ID) for printing. At least one object element shall be present in the file. Additional objects are optional.

5.4.2 `<material>` —The optional material element defines one or more materials for printing with an associated material ID. If no material element is included, a single default material is assumed.

5.4.3 `<texture>` —The optional texture element defines one or more images or textures for color or texture mapping each with an associated texture ID.

5.4.4 `<constellation>` —The optional constellation element hierarchically combines objects and other constellations into a relative pattern for printing. If no constellation elements are specified, each object element will be imported with no relative position data. The parsing program can determine the relative positioning of the objects if more than one object is specified in the file.