3MF Test Specification

Specification & Reference Guide

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Status	Draft

Revisions:

Version	Changes	Date/Editor
1.0	Initial Release	JZ – 6/28/19
1.1	Added Beam Lattice Test Suite	JZ – 4/24/20
1.2	Change after review	JZ – 5/13/20
1.21	Fix Numbering Typos, added 4 test cases	JZ – 5/17/20
1.22	Misc tweaks to test cases	JZ – 6/20/20
1.23	Additional changes to beam lattice test cases	JZ – 7/3/20
1.24	Removed Test P_BXX_2005_02.3mf as it is a duplicate of a negative test case	JZ-7/9/20

1 Contents

2 Introduction

The 3D Manufacturing Format, or 3MF, describes the set of conventions for the use of XML and other widely available technologies to describe the content and appearance of one or more 3D models. It is written for developers who are building systems to process 3MF content.

A primary goal of this specification is to ensure the interoperability of independently created software and hardware systems that produce or consume 3MF content. This specification defines a set of test cases that can be used to validate 3MF consumer and producer implementations.

3 Terms and Acronyms

The following terms and abbreviations are used in this document:

Term	Description
3MF	3D Manufacturing Format
OPC	Open Packaging Conventions
DUT	Device Under Test

4 Scope

Execution of a 3MF test suite will provide a robust characterization of the Device Under Test's (DUT) behavior by providing a wide variety of both valid and invalid 3MF content based upon each of the conformance statements and schemas in the specifications that define 3MF. Collectively, running all the test cases developed as part of this test suite will provide the following test coverage:

- The DUT can successfully process 3MF files that include valid permutations of mandatory characteristics defined in the supported 3MF XML schemas
- The DUT can successfully process 3MF files that both include and exclude valid permutations of optional characteristics defined in the supported 3MF XML schemas
- The DUT can successfully process 3MF files that conform to valid permutations of the mandatory and optional OPC, Core, Material, Slice, and Production conformance requirements defined in 3MF technical specifications
- The DUT can gracefully handle invalid 3MF file content

Test cases are based on the following versions of the 3MF Specifications:

- *Office Open XML File Formats – Open Packaging Conventions – December 2012*
- *3MF Core Specification – Version 1.2.3*
- *3MF Materials and Properties Extension – Version 1.2.1*
- *3MF Production Specification – Version 1.1.2*
- *3MF Slice Specification – Version 1.0.2*
- *3MF Beam Lattice Extension – Version 1.0.4*

5 Test Suite Organization

Test cases defined in this specification many support one or more 3MF extensions and may belong to one or more test suites. The table below documents the six supported test suites.

Suite Name	Core	3MF Extensions			
		Slice	Production	Material	Beam Lattice
Test Suite 1	•	•	•		
Test Suite 2	•		•	•	
Test Suite 3	•				
Test Suite 4	•	•			
Test Suite 5	•		•		
Test Suite 6	•			•	
Test Suite 7	•				•

Note that Appendix C provides a mapping as to which test cases are contained in which test suites.

5.1 Test Case Numbering

Test Cases will use the following syntax for numbering: **U_VWX_YYYY_ZZ**

- U: P=positive, N=Negative
- V: S = Slice Used, B = Beam Lattice Used, X = Neither Beam or Slice used
- W: P = Production Used, X = Production not used
- X: M = Material Used, X = Material not used
- YYYY: Test case number
- ZZ: Test case iteration

Examples:

- **P_SPX_0123_02** – This is positive test case 123, iteration 02, that uses the Slice and Production Extensions
- **N_XXM_0234_04** – This is negative test case 234, iteration 04, that uses the Material Extension
- **P_BXX_0432_01** – This is a positive test case 432, iteration 01, that uses the Beam Lattice Extension.

Test case definitions in this document may use "???" placeholders for the 3MF extension labels, such as P_???_0123_02. Users should refer to Appendix C to determine the specific 3MF extension combinations supported for a test case.

5.2 Test Case Template

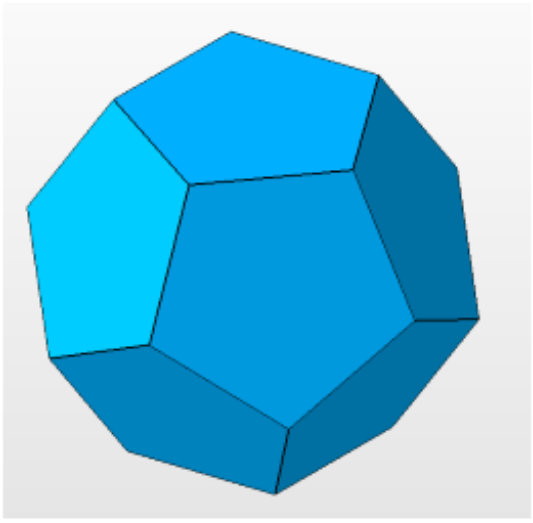
The following template will be used for test case definition. Note a general test scenario is followed by one or more iterations of a test case required to validate the conformance requirements targeted.

N_???_0123 Test Scenario Name

Test Scenario Description	3MF test files where the StartPart relationship defined in _rels/.rels does not point to the root 3d Model part
Pass/Fail Criteria	Printer rejects 3MF File
Test Case Iterations	**01 -** StartPart points at non-existent part **02 -** StartPart points at non-root model **03 -** StartPart points at Thumbnail **03 - Etc.**

Where practical, each 3MF test file will contain a 300 X 300-pixel thumbnail showing the expected result of rendering the 3MF file on a consumer as shown below. An example is shown below. These thumbnails are captured from a variety of applications and are not meant to be used as a definitive acceptance criterion. Note that shading and other lighting effects used by application may slightly alter the apparent colors.

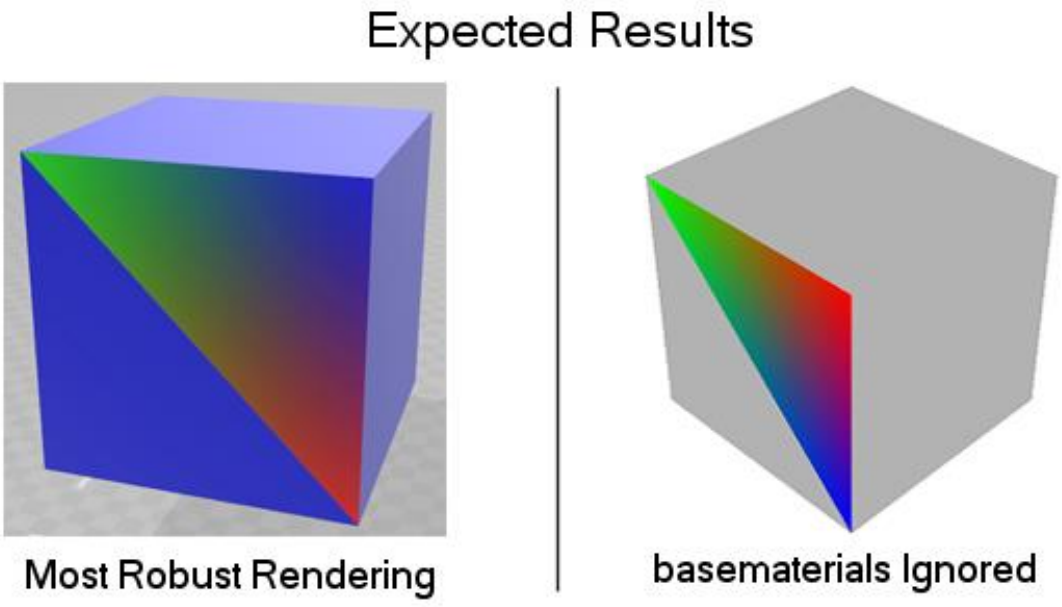
Expected Result



Note that the expected result thumbnails were captured using a variety of 3MF display rendering applications including 3D Builder, NetFabb, 3D Paint, QualtyLogic's 3MF previewer, MeshLab rendered PLY files, and other applications. Each of these applications

placed the 3D object in a different orientation and many objects needed to be rotated to show the intent of the test when capturing the thumbnails. Point being that users may need to rotate their 3MF images to get them in alignment with the thumbnail before comparing results and that thumbnail to thumbnail the orientations may differ.

Where the rendered 3MF file might differ between a display and printer, thumbnails of both renderings will be provided. The basematerials displaycolor attribute and the display properties which can be applied to resources only impact the appearance of the object on a display, not a printer. So, in these situations, the thumbnail labels "Most Robust Rendering" represents the appearance on a display and the rendering labels "basematerials Ignored" represents the appearance of the printer output assuming a neutral gray colored native material color.



5.3 basematerials name Attribute Mapping

Some printer implementations may require that the name attribute the basematerials base sub element be mapped to a physical material. The test cases use a standardized format for materials names: material_0, material_1, material_2, etc.

Implementations can simply map the same physical material to these names.

6 Test Case Definitions

6.1 Positive OPC Test Cases

6.1.1 P_???_0101 Content Type Variation

Test Scenario Description	Verify that content type mapping is case insensitive and that overrides do take precedence of the default extension definitions.
Pass/Fail Criteria	01 to 03 – Printer should process correctly
Test Case Iterations	**01 –** Create a content type where the case of the content type extension differs from the case used by the model part. The extension should be case insensitive. **02 –** Create a 3MF 3D model part with no extension, and use a content type override to define the content type of that part. **03 –** Define a content type override for a 3D model part whose case differs from the 3D model part name. The override should be case insensitive.
Requirement Reference	ECMA-375,4 Conformance ID: M2.9, M2.13, M1.2

6.1.2 P_???_0102 Content Type Overrides

Test Scenario Description	Various permutations of content type overrides
Pass/Fail Criteria	01 to 03 – Printer should process correctly
Test Case Iterations	**01 –** Create a test case where content types contains no default for ".model" but rather has an explicit override for each model part. Rename the extensions of the model parts to something other than ".model" **02 –** Create a test case where content types contains a default for ".model" and an override for the 3D model part. Rename the extensions of the model part reference in the override to something other than ".model" **03 –** Create a test file with a thumbnail. Leave the default mapping for ".model" as is. Rename the thumbnail extension to ".model" and define an override for the thumbnail mapped to the appropriate type for a thumbnail.
Requirement Reference	ECMA-375,4 Conformance ID: M2.4, M2.12, M2.9

6.1.3 P_???_0103 Unused Default Mapping

Test Scenario Description	Unused default content type mapping
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Include an unused default mapping (to Thumbnail) that is not used (i.e., no Thumbnail in package)
Requirement Reference	ECMA-375,4 Conformance ID: O2.5

6.1.4 P_???_0104 Model Part Root Names

Test Scenario Description	Various character mappings in part names
Pass/Fail Criteria	01 to 03 – Printer should process correctly
Test Case Iterations	**01 –** Create 3MF file with model part names that use alphanumeric characters from 0-9, a-z, A-Z, and the following unreserved characters: _ - ~ **02 –** Create 3MF file with model part names that use alphanumeric characters that include the following reserved characters: @ ! $ ( ) + , ; = **03** – Create 3MF file with model part root names that use a UTF-8 Unicode character from outside the standard ASCII character set, excluding symbols (use Windows charmap.exe)
Requirement Reference	ECMA-375,4 Conformance ID: M1.17, M3.2, O1.4, M2.12

6.1.5 P_???_0106 Thumbnail Image Size Range

Test Scenario Description	Various thumbnail image sizes
Pass/Fail Criteria	01 to 02 – Printer should process correctly
Test Case Iterations	**01–** Use a large jpg thumbnail image typical of a photo from a phone **02–** Use an extremely small (20 pixel) PNG Thumbnail image
Requirement Reference	ECMA-375,4 Conformance ID: M1.72

6.1.6 P_???_0107 TargetMode

Test Scenario Description	Valid relationship target mode permutations
Pass/Fail Criteria	01 to 02 – Printer should process correctly
Test Case Iterations	**01 –** Root 3MF file with relationship to a non-root model file that omits the TargetMode attribute **02 –** Root 3MF file with relationship to a non-root model file that uses a TargetMode = “Internal” attribute
Requirement Reference	ECMA-375,4 Conformance ID: O1.5

6.2 Negative OPC Test Cases

6.2.1 N_???_0202 Path Segment Period Ending

Test Scenario Description	Path segment that ends with a period
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Create a path segment that ends with a period. As the operating system will not allow subdirectories ending in a period and zip utilities also disallow periods at the end, the best this test case can do is use a period at the end of an existing referenced path in the XML
Requirement Reference	ECMA-375,4 Conformance ID: M1.9

6.2.2 N_???_0203 Path Segment Only Period

Test Scenario Description	Path segment with only a period
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Create a path segment with only a period. As the operating system will not allow subdirectories with just a period and zip utilities also disallow standalone periods, the best this test case can do is use a period as part of an existing referenced path in the XML
Requirement Reference	ECMA-375,4 Conformance ID: M1.10

6.2.3 N_???_0204 Relationships Part Content Type Parameter

Test Scenario Description	Add a parameter to the relationships part
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Add a parameter to the relationships part content type (i.e ?cow="Moo"). Printer should reject.
Requirement Reference	ECMA-375,4 Conformance ID: M1.22

6.2.4 N_???_0205 Duplicate Content Type

Test Scenario Description	Duplicate content type mappings
Pass/Fail Criteria	01 to 02 – Printer should generate error
Test Case Iterations	**01 –** Add duplicate default content type mappings for the ".model" extension **02 –** Add a duplicate override content type for a 2D model part
Requirement Reference	ECMA-375,4 Conformance ID: M2.5

6.2.5 N_???_0206 Empty Extension Content Type

Test Scenario Description	Content type with an empty extension
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	01-Create a content type with an empty extension (i.e. "")
Requirement Reference	ECMA-375,4 Conformance ID: M2.6

6.2.6 N_???_0207 Empty Partname String

Test Scenario Description	Override with an empty partname string
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Create a content type override with an empty partname string
Requirement Reference	ECMA-375,4 Conformance ID: M2.7

6.3 Positive 3MF Core Test Cases

6.3.1 P_???_0302 StartPart Location and Name

Test Scenario Description	Create a simple 3MF file, then reposition and rename the StartPart pointed to by the .rels file
Pass/Fail Criteria	01 to 03 – Successfully render object with no processing errors
Test Case Iterations	**01 –** Reposition StartPart at root of package. **02 –** Reposition the StartPart (3DModel.model) several sub folders deep **03 –** Rename the root model to something other than 3DModel.Model (maintain. model extension)
Requirement Reference	Link to Requirement in 3MF Specification

6.3.2 P_???_0304 Part Relationships

Test Scenario Description	Create a 3MF file that contains the appropriate relationship pointers to a Print Ticket, Thumbnail, and Core Properties Parts
Pass/Fail Criteria	02 – Printer should ignore extra thumbnail 03 – Printer should process the file correctly 04 – Printer should process the file correctly
Test Case Iterations	**02** – Include two package level thumbnails in the same OPC package **03** – Have a package level and object level thumbnail reference point to the same png file. **04 –** Change the ID of the StartPart relationship ID in the root .rels file to something other than “rel0”
Requirement Reference	Link to Requirement in 3MF Specification

6.3.3 P_???_0306 Units

Test Scenario Description	Create a simple 3MF file, then modify the 3D model files to support each of the supported enumerations for the unit attribute of the Model element
Pass/Fail Criteria	01 to 07 – Printer should process correctly
Test Case Iterations	Modify the build transform matrix of the 3D model file such that each of the images have the same size and positioning regardless of the unit used. **01 –** Micron **02 –** Millimeter **03 –** Centimeter **04 –** Inch **05 –** Foot **06 –** Meter **07 –** Unspecified (should default to millimeter)
Requirement Reference	Link to Requirement in 3MF Specification

6.3.4 P_???_0307 Metadata - Core

Test Scenario Description	Create a simple 3MF file, then add metadata elements from the core specification to the 3D model parts
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Include the metadata values defined in table 8-1 of the Core specification into the 3D model parts. Syntax for metadata is… <metadata name="title">this is a title</metadata>
Requirement Reference	Link to Requirement in 3MF Specification

6.3.5 P_???_0308 Metadata - Vendor

Test Scenario Description	Create a simple 3MF file, then add vendor specific metadata elements to the 3D model parts.
Pass/Fail Criteria	01 - Printer should process correctly, ignoring the vendor specific metadata values
Test Case Iterations	**01 –** Include the vendor specific metadata values defined to 3D model files xmlns:v="http://schemas.qualitylogic.com/vendorspecific" <metadata name="v:anyname">this is a test</metadata>
Requirement Reference	Link to Requirement in 3MF Specification

6.3.6 P_???_0309 Overlapping objects

Test Scenario Description	Create a 3MF file such that two objects are overlapping such that the positive full rule is applied by the printer
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Use 3D Builder to position the two instances of the test object such that the two objects overlap with empty space in the middle of the overlapping segments of the object. Make sure objects stay at least 30mm x 35mm x 30mm away from the origin of the print bed.
Requirement Reference	Link to Requirement in 3MF Specification

6.3.7 P_???_0310 Build Item

Test Scenario Description	Create a simple 3MF file with two objects, but with only one item referenced in a build item
Pass/Fail Criteria	01 – Printer should process correctly, although only the object in the build item should be rendered
Test Case Iterations	**01 –** Add both test objects to 3D builder, confirm two items are listed in the build element (modify if needed), then remove one item from the build object. The resulting test file should render a single object although it contains two objects
Requirement Reference	Link to Requirement in 3MF Specification

6.3.8 P_???_0311 Build Item Transform

Test Scenario Description	Create a simple 3MF file with one object, but two build items each referencing the same object, applying a different build item transform on one item
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Modify one build item transform matrix to position the two objects such that they are non-intersecting
Requirement Reference	Link to Requirement in 3MF Specification

6.3.9 P_???_0312 Base Material References

Test Scenario Description	Create a simple 3MF file with one object and add a basematerials to the 3dmodel file
Pass/Fail Criteria	01 – Printer should NOT render the colors, but should print the object in its native material color
Test Case Iterations	**01 –** Specify the color red in the object element via a reference to the basematerials definition. Include pid, p1, p2, p3 attributes for blue in one triangle. NOTE: Basematerials references are for display only and will not impact the printer rendered output.
Requirement Reference	Link to Requirement in 3MF Specification

6.3.10

6.3.11 P_???_0313 JPEG Thumbnail

Test Scenario Description	Create a simple 3MF file with a JPEG Thumbnail
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Create a 3MF with a jpeg thumbnail at the package level
Requirement Reference	Link to Requirement in 3MF Specification

6.3.12 P_???_0314 solidsupport, support, surface

Test Scenario Description	Create a 3MF document with two objects. Modify the object type attribute in the 3D object such that one object had a type of "model" and the other one of the following: "solidsupport", "support"
Pass/Fail Criteria	01 – Printer should process correctly, although rendering of support may be device dependent
Test Case Iterations	**01 –** model and solidsupport **02 –** model and support **03** – model and support where support only has 3 triangles **04** – model and surface **05** - model and solidsupport not inside component
Requirement Reference	Link to Requirement in 3MF Specification

6.3.13 P_???_0315 Name Attribute White Space

Test Scenario Description	White space in name attribute of object
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Modify the name attribute of the object element to include leading, trailing, and intermediate white space including the space character and tab
Requirement Reference	Link to Requirement in 3MF Specification

6.3.14 P_???_0316 Model Element Language Attribute

Test Scenario Description	Omit the lang attribute
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Omit the lang attribute from the model element
Requirement Reference	Link to Requirement in 3MF Specification

6.3.15 P_???_0317 Duplicates of Multiple Mesh Objects

Test Scenario Description	Duplicates of multiple mesh objects
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** A test case that use 3 different mesh objects defined in the same root model parts to build 24 objects, 8 of each via build item element on the build platform. Objects should be positions both adjacent in XY space, and stacked in the Z space.
Requirement Reference	Link to Requirement in 3MF Specification

6.3.16 P_???_0318 Positive Fill Rule

Test Scenario Description	Objects with patterns that trigger positive fill rule
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** This is a very limited test of the fill rule outlined in the core specification which defines the behavior when two features in the same mesh intersect. Define two mesh objects each with overlapping features. The first is a composite mesh object with a cube containing an embedded cylinder with 3 surfaces coplanar to the cube. The second is a composite mesh object with a cylinder intersecting a torus ring.
Requirement Reference	Link to Requirement in 3MF Specification

6.3.17 P_???_0319 Undetermined Language

Test Scenario Description	Undetermined language
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Define test file where model lang attribute is “und”.
Requirement Reference	Link to Requirement in 3MF Specification

6.3.18 P_???_0321 Negative Determinant

Test Scenario Description	Create mesh with negative determinant
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Create transform with negative determinant and a mesh with negative object volume
Requirement Reference	Link to Requirement in 3MF Specification

6.3.19 P_???_0322 JPEG APP1 Marker

Test Scenario Description	JPEG thumbnail Image with APP1 Marker
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** JPEG thumbnail Image and texture with APP1 Marker
Requirement Reference	Link to Requirement in 3MF Specification

6.3.20 P_???_0323 PNG Specification Support

Test Scenario Description	Various headers in PNG files
Pass/Fail Criteria	01 to 02 – Printer should process correctly
Test Case Iterations	**01** – PGN texture with tRNS and iCCP (include one or more in test case) **02** – PNG thumbnail with one of the MUST ignore items: sRGM, cHRM, gAMA, sBIT (include one or more in test case)
Requirement Reference	Link to Requirement in 3MF Specification

6.3.21 P_???_0324 Object Thumbnail Relationship

Test Scenario Description	Thumbnail relationship to non-root model
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Associate a thumbnail via relationship and object attribute with a non-root model file.
Requirement Reference	Link to Requirement in 3MF Specification

6.3.22 P_???_0325 Two Segment Model Part Name

Test Scenario Description	Two segment model part name
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Modify Content Types so that extension ".model" is ".part", then model balance of test file to use this extension placing parts in the default /3D folder
Requirement Reference	Link to Requirement in 3MF Specification

6.3.23 P_???_0326 Identity Singular Transform Matrix

Test Scenario Description	Object with Identity and singular matrix transform
Pass/Fail Criteria	01 to 03 – Printer should process correctly
Test Case Iterations	**01 –** Create a build item with no transform matrix **02 –** Create a build item with an identity transform matrix **03 –** Create a build item with a singular transform matrix
Requirement Reference	Link to Requirement in 3MF Specification

6.3.24 P_???_0327 Interlocking Objects

Test Scenario Description	3MF test file with interlocking objects
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Use build item transforms to create a set of 2 interlocking, but not overlapping objects.
Requirement Reference	Link to Requirement in 3MF Specification

6.3.25 P_???_0328 Overlapping Objects

Test Scenario Description	3MF test file with Overlapping objects
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Specify build item transform so that two objects overlap **02** – illustrate overlapping objects that have plains that are coplanar and show which material should have precedence (that last one rendered).
Requirement Reference	Link to Requirement in 3MF Specification

6.3.26 P_???_0329 Part Number Attribute

Test Scenario Description	Use of PartNumber attribute of Object
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Include a PartNumber attribute in object element in a test file
Requirement Reference	Link to Requirement in 3MF Specification

6.3.27 P_???_0330 Minimal Self-Intersections

Test Scenario Description	Mesh object with self-intersections
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Create a mesh object with self-intersections. Printer will most likely correct self-intersection triangles in mesh object.
Requirement Reference	Link to Requirement in 3MF Specification

6.3.28 P_???_0331 Non-Degeneracy

Test Scenario Description	Mesh object with zero area triangle
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Create a mesh image with a zero-area triangle. Printer will most likely ignore zero-area triangle in mesh object.
Requirement Reference	Link to Requirement in 3MF Specification

6.3.29 P_???_0333 Decimal Precision

Test Scenario Description	Various permutations of decimal precision
Pass/Fail Criteria	0 to 03 – Printer should process correctly
Test Case Iterations	**01 –** Use 3D vertex values with no decimal places to define mesh object **02 –** Use 3D vertex values with 10 decimal places to define mesh object **03 –** Use 3D vertex and unit of meter such that changes in very small decimal values impact the object shape in a meaningful way
Requirement Reference	Link to Requirement in 3MF Specification

6.3.30 P_???_0334 JPEG Image Markers

Test Scenario Description	Thumbnail JPEG images with different markers
Pass/Fail Criteria	01 to 02 – Printer should process correctly
Test Case Iterations	**01 –** Test case with JPEG Thumbnail that contains the APP0 marker. **02 –** Test case with JPEG Thumbnail that contains the APP2, APP13, and APP14 marker.
Requirement Reference	Link to Requirement in 3MF Specification

6.3.31 P_???_0335 Object Thumbnail Attribute

Test Scenario Description	Thumbnail JPEG images with different markers
Pass/Fail Criteria	01 to 04 – Printer should process correctly
Test Case Iterations	**01 –** Define a thumbnail from an object with mesh data using the thumbnail attribute. Use a PNG Thumbnail image. Make sure to include appropriate relationship pointers. **02 –** Define a thumbnail from an object with a component reference using the thumbnail attribute. Use a JPEG thumbnail image. Make sure to include appropriate relationship pointers. **03** – Use a thumbnail attribute on a model element in a root model, and if the production extension is supported, on a non-root model part **04** – Use a texture rather than thumbnail relationship type associated with thumbnails at the package, model, and object level
Requirement Reference	Link to Requirement in 3MF Specification

6.3.32 P_???_0336 Custom Part - Preserve

Test Scenario Description	Custom part with and without a root relationship mustPreserve type
Pass/Fail Criteria	01 to 02 – Printer should process correctly
Test Case Iterations	**01 –** Define a custom part with no mustPreserve root relationship **02 –** Define a custom part with a mustPreserve root relationship
Requirement Reference	Link to Requirement in 3MF Specification

6.3.33 P_???_0337 metadatagroup, preserve, type

Test Scenario Description	Test metadatagroup in build item and object. Use preserve and type attributes in metadata where it is allowed to appear
Pass/Fail Criteria	01 to 06 – Printer should process correctly
Test Case Iterations	**Use the table below to construct various iterations of metadata at the model, build item, and object level, conditionally using the preserve and type attribute.**
Requirement Reference	Link to Requirement in 3MF Specification

Iteration	Model Metadata	Object metadatagroup	Build item metadatagroup	Preserve	Type	Other
01	Description			false		
	Title			true		
	Copyright				string	
	CreationDate				date	
	LicenseTerms			true	string	
	x:vendor1			false		
	x:vendor2			true		
	x:vendor3				string	
	x:vendor4				date	
	x:vendor5			true	integer	
02		x:vendor1				
		x:vendor2		false		
		x:vendor3		true		
		x:vendor4			string	
		x:vendor5			date	
		x:vendor6		true	integer	
03			x:vendor1			
			x:vendor2	false		
			x:vendor3	true		
			x:vendor4		string	
			x:vendor5		date	
			x:vendor6	true	integer	
04	x:vendor1			true	string	
		x:vendor2		true	string	
			x:vendor3	true	string	
05	Description			true	string	
		Title		true	string	s/ignore
			LicenseTerms	true	string	s/ignore
06	x:vendor1			true	string	
		x:vendor2		true	string	Non-root
			x:vendor1	true	string	

6.3.34 P_???_0338 Near Zero Volume

Test Scenario Description	Transform that result in near zero volume printable object
Pass/Fail Criteria	01 – Printer should not generate error
Test Case Iterations	**01 –** Create a simple test case, then change the build item transform so that the object has close to zero volume. Output may be device dependent.
Requirement Reference	Link to Requirement in 3MF Specification

6.3.35 P_???_0339 Not Required Extension

Test Scenario Description	Confirm printer will ignore content that is not from a required extension of not supported by the renderer
Pass/Fail Criteria	01 – Printer should not generate error
Test Case Iterations	**01 –** Create a simple test case with content from a namespace that is not required and is for 3MF core or extension namespaces. The renderer should ignore the content.
Requirement Reference	Link to Requirement in 3MF Specification

6.3.36 P_???_0340 Invalid Mesh, Valid Slicestack

Test Scenario Description	These are sliced test cases that have mesh with anomalies. The expectation is that the files will render correctly on a printer as the mesh is not needed for rendering. Note that in test case 01, 02, and 04 slice stacks have been inserted in the test file that does not match the mesh.
Pass/Fail Criteria	01 to 04 – Printer should not generate error
Test Case Iterations	**01** - Create negative volume mesh, but with valid slicestack **02** – Positive volume mesh with negative determinant transform, but with valid slicestack **03**-Reverse order of vertices such that normal face is pointing inward, but with valid slicestack **04 –** Create invalid mesh object with only 3 triangles. , but with valid slicestack
Requirement Reference	Link to Requirement in 3MF Specification

6.4 Negative 3MF Core Test Cases

6.4.1 N_???_0402 Invalid StartPart

Test Scenario Description	Create a simple 3MF file, then modify so that the relationship StartPart such that does not resolve to a valid model root file
Pass/Fail Criteria	01 to 04 - Printer error should be generated stating that the file cannot be processed
Test Case Iterations	**01 –** Use an incorrect folder name in the StartPart Target **02 –** Use an incorrect file name in the StartPath Target **03 –** Point the StartPart to a thumbnail or non-root file **04 –** Specify a StartPart relationship with a TargetMode=”External” and a URL Target (i.e. http://www...)
Requirement Reference	Link to Requirement in 3MF Specification

6.4.2 N_???_0403 External References

Test Scenario Description	Create a simple 3MF file, then modify so that there are external relationships in the root relationship file
Pass/Fail Criteria	01 – printer error
Test Case Iterations	**01 –** Specify a Thumbnail relationship in the root rels file with TargetMode=”External” and a root model URL Target (i.e. http://www...)
Requirement Reference	Link to Requirement in 3MF Specification

6.4.3 N_???_0404 Invalid Content Type

Test Scenario Description	Create a simple 3MF file, then modify to create invalid combinations of content types in the [Content.Types].xml file. Refer to Appendix C of Core Spec.
Pass/Fail Criteria	01 to 04 – Printer error should be generated stating that the file cannot be processed
Test Case Iterations	**01 –** In the [Content.Types].xml, modify the extension "model" to "item", such that a content type for "model" does not exist **02 –** In the [Content.Types].xml, modify the ContentType for "model" to "application/vnd.ms-package.xxxxx-3dmodel+xm", such that the content type for "model" is invalid **03 –** In the [Content.Types].xml, modify the ContentType for ".rels" to "application/vnd.openxmlformats-package.xxxxx-relationships+xml", such that the content type for ".rel" is invalid **04 –** In the [Content.Types].xml, modify the ContentType for "png" to "image/xxxpng", such that the content type for "png" is invalid
Requirement Reference	Link to Requirement in 3MF Specification- Could not find

6.4.4 N_???_0405 Invalid Relationships

Test Scenario Description	Create a simple 3MF file, then modify to create invalid relationship pointers. The test file will require a Thumbnail image.
Pass/Fail Criteria	01 to 05 – Printer Error
Test Case Iterations	**01 –** Add a Thumbnail to a 3MF file with invalid root relationship target to the Thumbnail part **02 –** Add an incorrect relationship "Type" attribute value in the root .rels file for the relationship that points to the StartPart **03 –** Add an incorrect relationship "Type" attribute value in the 3dmodel.model.rels file for the relationship that points to a non-root model file **04 –** Deleted **05 –** Add an incorrect relationship "Type" attribute value in root .rels part for the relationship that points to the Thumbnail
Requirement Reference	Link to Requirement in 3MF Specification

6.4.5 N_???_0406 Duplicate Relationship

Test Scenario Description	Create a simple 3MF file, then modify to create duplicate relationship pointers
Pass/Fail Criteria	01 to 02 – Printer Error
Test Case Iterations	**01 –** Modify the root .rels file so that there are identical instances of the start part pointer to the root model file, but using unique IDs (rel0 and rel1) **02 –** Modify the 3dmodel.model.rels file so that there are two instances of a pointer to the same non-root model file, but with unique IDs.
Requirement Reference	Link to Requirement in 3MF Specification

6.4.6 N_???_0407 Missing Relationship Target

Test Scenario Description	Create a simple 3MF file, then modify relationship pointers
Pass/Fail Criteria	01 to 02 – Printer Error
Test Case Iterations	**01 –** Modify the 3dmodel.model.rels file so that the relationship target part name for the non-root model part does not match the part name in the 3MF document. **02 –** Rename the 3dmodel.model.rels file so that it has a name that does not map to the 3dmodel.model part (i.e. wrongmodel.model.rels.)
Requirement Reference	Link to Requirement in 3MF Specification

6.4.7 N_???_0409 Use of Space Attribute

Test Scenario Description	Create a simple 3MF file, then modify XML encoding of root element to use the unsupported “space” attribute
Pass/Fail Criteria	01 – Printer Error
Test Case Iterations	**01 –** Modify the second line of the 3dmodel.model file to include the following attribute definition to the model element: xml:space="preserve"
Requirement Reference	Link to Requirement in 3MF Specification

6.4.8

6.4.9 N_???_0410 Invalid Metadata

Test Scenario Description	Create a simple 3MF file, then add unrecognized vendor specific metadata elements to the 3D and 2D model parts, as well as duplicate names in metadata
Pass/Fail Criteria	01 to 04 – Printer should generate error
Test Case Iterations	**01 –** Include the vendor specific metadata value to the 3D model part with no declared namespace prefix in the Model element <metadata name="x:anyname">this is a test</metadata> **02 –** Include the vendor specific metadata value to the 2D model part Use the following metadata value in both test cases 01 and 02: <metadata name="x:anyname">this is a test</metadata> **03 –** Include the same metadata name from Table 8-1 of the core specification twice in the 3D model part <metadata name="Title">this is a title</metadata> <metadata name="Title">this is another title</metadata> **04** - Include the same metadata name from Table 8-1 of the core specification twice in the 2D model part Use the following metadata values in both test cases 03 and 04: <metadata name="Title">this is a title</metadata> <metadata name="Title">this is another title</metadata>
Requirement Reference	Link to Requirement in 3MF Specification

6.4.10 N_???_0411 Non Unique Triangle Indices

Test Scenario Description	Create a simple 3MF file, then modify on triangle indices so that the vertex references are not unique
Pass/Fail Criteria	01 – Printer should generate error, although it is unclear if the printer will parse the 3D file in this level of detail.
Test Case Iterations	**01 –** Modify on triangle indices so that the vertex references are not unique
Requirement Reference	Link to Requirement in 3MF Specification

6.4.11

6.4.12 N_???_0412 Invalid Index Range

Test Scenario Description	Create a simple 3MF file that has out of range index references to vertex values
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01** – Modify a 3DModel triangle vertex attribute (v1, v2, or v3) so that it is +2 larger than the number of vertexes **02** – Modify a 2DModel polygon segment vertex attribute (v2) so that it is +2 larger than the number of vertexes **03 –** Modify a 2DModel polygon startv attribute (v2) so that it is +2 larger than the number of vertexes **04** – Add a test case where the vertices element is missing altogether from a slice stack, but polygons are defined with invalid vertex index references.
Requirement Reference	Link to Requirement in 3MF Specification

6.4.13 N_???_0413 Non-Unique ID Values

Test Scenario Description	Create a simple 3MF file that has non- unique values for relationships in the same. rels file and the resources group (object ID) of a part
Pass/Fail Criteria	01 and 02 – Printer should generate error
Test Case Iterations	**01 –** Create a 3MF file with two items in the build item path. Modify the 3dmodel.model.rels file to create duplicate IDs. **02 –** Create a 3MF file with two objects with the same ID values
Requirement Reference	Link to Requirement in 3MF Specification OPC

6.4.14 N_???_0415 Absolute Path Names

Test Scenario Description	Scenarios involving invalid paths
Pass/Fail Criteria	01 to 04 – Printer should generate error
Test Case Iterations	**01 –** Define a model part name with a leading period and reference that part in a component reference **02 –** Attempt to reference a non-root model part using a relative component path attribute **03 –** Attempt to reference a non-root model part using a relative build path attribute **04 –** Attempt to reference a non-root model part in path using the path only in the component path element, omitting the part name
Requirement Reference	Link to Requirement in 3MF Specification

6.4.15 N_???_0416 Negative Volume Mesh

Test Scenario Description	Object with negative volume mesh
Pass/Fail Criteria	01 and 02 – Printer should generate error
Test Case Iterations	**01** - Create negative volume mesh **02** – Positive volume mesh with negative determinant transform
Requirement Reference	Link to Requirement in 3MF Specification

6.4.16 N_???_417 Prior Object References

Test Scenario Description	Create a forward reference scenario in the root model file
Conformance Statement ID(s)	Core-M1.60, Core-M1.33
Base Test Object(s)	S11_cube_NA.3mf
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Create a forward reference by defining an object with a reference to a slicestackID before that slice stack appears in the XML stream
Requirement Reference	Link to Requirement in 3MF Specification

6.4.17 N_???_0418 Inward Facing Normal Face

Test Scenario Description	Mesh with inward facing normal face
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01**-Reverse order of vertices such that normal face is pointing inwards.
Requirement Reference	Link to Requirement in 3MF Specification

6.4.18 N_???_0419 CMYK Images

Test Scenario Description	JPEG thumbnail Image with CMYK
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** JPEG thumbnail Image with CMYK
Requirement Reference	Link to Requirement in 3MF Specification

6.4.19

6.4.20 N_???_0420 Data Type Definitions

Test Scenario Description	DTD declaration
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Include a DTD declaration as follows after the XML header: <!DOCTYPE note [<!ELEMENT note (to,from,heading,body)> <!ELEMENT to (#PCDATA)> <!ELEMENT from (#PCDATA)> <!ELEMENT heading (#PCDATA)> <!ELEMENT body (#PCDATA)>]>
Requirement Reference	Link to Requirement in 3MF Specification

6.4.21 N_???_0421 Transforms

Test Scenario Description	Various transforms that result in invalid printable objects
Pass/Fail Criteria	01 to 02 – Printer should generate error
Test Case Iterations	**01 –** Create a simple test case, then change the build item transform so that it is outside the printable area of the printer with a portion of the image in a negative quadrant
Requirement Reference	Link to Requirement in 3MF Specification

6.4.22 N_???_0422 Commas and German locale

Test Scenario Description	Specifying non en-US locale in model element
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01** –specify the lang attribute in all model elements (core model) to “de-de” and modify all decimal places as commas (,).
Requirement Reference	Link to Requirement in 3MF Specification

6.4.23

6.4.24 N_???_0424 Material in Object with Component

Test Scenario Description	Add basematerials reference to object with a component
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01** – Create an 3mf file with a colorgroup or basematerials defined, and specify a pid and pindex attribute in an object element that contains a component sub-element that point to other objects.
Requirement Reference	Link to Requirement in 3MF Specification

6.4.25 N_???_0426 Model with Less Than 4 Triangles

Test Scenario Description	Mesh object with only 3 triangles
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Create invalid mesh object with only 3 triangles
Requirement Reference	Link to Requirement in 3MF Specification

6.4.26 N_???_0427 Duplicate 3D Vertex and Non-Manifold Edge

Test Scenario Description	Mesh object with duplicate 3D Vertex and non-manifold edges
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Create a non-manifold mesh image and duplicate 3D vertex. Printer may ignore non-manifold mesh object and duplicate vertex.
Requirement Reference	Link to Requirement in 3MF Specification

6.4.27 N_???_0428 Required Extension

Test Scenario Description	Confirm printer will generate an error if a required extension is listed in the requiredextensions attribute of the model element that the renderer does not support
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Create a simple test case with content from a namespace that is required. The required extension should be a mock extension.
Requirement Reference	Link to Requirement in 3MF Specification

6.5 Positive 3MF Material Extension Test Cases

The Material Extension test cases will utilize the predefined colors, gradients, textures, and multiproperties defined in Appendix B. To the extent that specific colorgroups, textures, gradients, or multiproperties are not specified in the test case definition, the test case developer shall iterate through a random selection of the defined resources in Appendix B.

6.5.1 P_???_0501 Default Material Color

Test Scenario Description	Demonstrate use of object pid and pindex attributes as a default material color if a triangle does not have a material color specified
Pass/Fail Criteria	01 to 09 – Printer should process correctly
Test Case Iterations	**01** - Multiproperties as default object color. Apply colorgroup to at least one triangle to demonstrate that only triangles with undefined material color are impacted by the default. **02** - Texture as default object color. Apply colorgroup to at least one triangle to demonstrate that only triangles with undefined material color are impacted by the default. **03** - Colorgroup as default object color. Texture at least one triangle to demonstrate that only triangles with undefined material color are impacted by the default. **04** - No material color specified in object or triangles **05** - Deleted **06 -** Deleted. **07** – Texture as a default color where tex2coord pointed to by pindex is a u v value greater than 1 1 **08** – Multipropertes as a default color where tex2coord pointed to by pindex is a u v value greater than 1 1 **09** Texture with tilestyle of “none” as a default color where tex2coord pointed to by pindex is a u v value greater than 1 1 .
Requirement Reference	Link to Requirement in 3MF Specification

6.5.2 P_???_0502 Triangle P1, 2, 3 Usage

Test Scenario Description	Demonstrate that If p1 is not specified, then the default property is assigned to the triangle. If p2 or p3 is unspecified then p1 is used for the entire triangle.
Pass/Fail Criteria	01 to 05 – Printer should process correctly
Test Case Iterations	**01 -** Just p1 Specified **02** - Just p1 and p2 Specified **03** - Just p1 and p3 Specified **04** - p2 and p3 Specified, but not p1 – With default object color defined **05** - p1, p2, and p3 unspecified
Requirement Reference	Link to Requirement in 3MF Specification

6.5.3 P_???_0503 Ignoring Unsupported Materials

Test Scenario Description	Demonstrate that the printer ignores both basematerials and compositematerials
Pass/Fail Criteria	01 to 08– Printer should process correctly
Test Case Iterations	**01** - Use basematerials as object default. Also map colorgroup to one triangle **02** - Use compositematerials as object default. Also map colorgroup to one triangle **03** - Use basematerials as triangle PID/P1 with colorgroup as object default **04** - Use compositematerials as triangle PID/P1 with texture as object default **05** - Use basematerials as multiproperties pids component. Map multiproperties as object default. The multiproperties should also include a colorgroup which should get rendered. **06** - Use composite material as multiproperties pids component. Map multiproperties as object default. The multiproperties should also include a colorgroup which should get rendered. **07** - Use basematerials as multiproperties pids component. Map multiproperties as triangle PID/P1 with texture as object default. The multiproperties should also include a colorgroup which should get rendered. **08** - Use compositematerials as multiproperties pids component. Map multiproperties as triangle PID/P1 with colorgroup as object default. The multiproperties should also include a colorgroup which should get rendered.
Requirement Reference	Link to Requirement in 3MF Specification – Says N/A in the old mat spec

6.5.4 P_???_0504 Opaque first Layer

Test Scenario Description	Demonstrate that the first layer of material color applied to an object is opaque both when defined as an object default and as triangle specific
Pass/Fail Criteria	01 to 07 – Printer should process correctly
Test Case Iterations	**01 –** Use a colorgroup color with transparent alpha values to demonstrate the first layer applied to an object is opaque **02 –** Use a texture with transparent alpha values to demonstrate the first layer applied to an object is opaque **03 –** Use a colorgroup color with transparent alpha values to demonstrate the first layer of multiproperties is opaque. The second layer should also be partially transparent to illustrate the effect using a texture. **04 –** Use a texture with transparent alpha values to demonstrate the first layer of multiproperties is opaque. The second layer should also be partially transparent to illustrate the effect. **05** – Use a multiproperties with 3 materials/colors, with the 2nd and 3rd layer being partially opaque. Demonstrate that the 1st and 2nd layer are opaque once merged together. **06 -** Use a texture that uses tilestyle of "none" with uv values great than 1 with a transparent object default color **07** – Use a multiproperties with the first layer as basematerials and the second layer a transparent texture.
Requirement Reference	Link to Requirement in 3MF Specification couldn't find in any of the specs

6.5.5 P_???_0505 Pindices List

Test Scenario Description	Demonstrate the behavior when too few or too many items are listed in the pindices list.
Pass/Fail Criteria	01 to 03 – Printer should process correctly
Test Case Iterations	**01 -** In multiproperties have a pindices list that is one values shorter than the pids list. Demonstrate that an index value of zero is used for the omitted pindices value. For this test case have the omitted pids be colorgroup **02 -** In multiproperties have a pindices list that is one value shorter than the pids list. Demonstrate that an index value of zero is used for the omitted pindices value. For this test case have the omitted pids be texture **03** – Demonstrate in multiproperties that if pindices includes one extra value greater that the number of pids values, the printer should ignore the extra value
Requirement Reference	Link to Requirement in 3MF Specification

6.5.6 P_???_0506 Multiple Material Colors and Groups

Test Scenario Description	Utilities define multiple groups of material colors and utilize multiple colors from each group.
Pass/Fail Criteria	01 to 04 – Printer should process correctly
Test Case Iterations	**01** – Define and utilize multiple colorgroup references on an object, using multiple indexed items from each colorgroup **02** – Define and utilize multiple texture2dgroup references on an object, using multiple indexed items from texture2dgroup **03** - Define and utilize multiple multiproperties references on an object, using more than one material/color in each multiprop1erty **04** – On the same object use one each of the following: Colorgroup, texture, and multiproperties
Requirement Reference	Link to Requirement in 3MF Specification no conformance id

6.5.7 P_???_0507 Material Stress Tests

Test Scenario Description	Large numbers of material color components in a test file
Pass/Fail Criteria	01 to 09 – Printer should process correctly
Test Case Iterations	**01 –** Use 120 texture2d images mapped to 120 texture2groups. Paint one object with each of the defined textures **02 –** Use 100,000 text2coord mappings on one object **03 –** Use more than 1,000 colorgroups each with one color. Paint one object with each of the defined colorgroups. **04 –** Use more than 1,000 colors in one colorgroup to paint an object **05 –** Define 120 multiproperties each with three multi sub elements and two pids values. Paint one object with each of the multiproperties. **06 – Use** 2,500+ multi sub element indices in one multiproperties with two pids values. Paint one object with each of the defined multiproperties values. **07 –** A multiproperties listing 7 entries in pids and pindices. The same texture pids references can be interleaved. **08 -** Extremely small text2coord values (at the level of a pixel) **09 -** Extremely large text2coord values (such to cause 1000 tiles)
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.8 P_???_0508 Real World Textured Objects

Test Scenario Description	Paint textures on a variety of real world objects
Pass/Fail Criteria	01 to 14 – Printer should process correctly
Test Case Iterations	**The following table listing specific textures from Appendix B to specific real world objects in Appendix A:** 01 - brmarble.jpg - N22_ChessHorse_high 02 - droplets.png - M11_box_NA 03 - grmarble.jpg - M12_Extruder_Bowden_Adapterc_low 04 - oak.png - M11_Ventilated Build Platform_low 05 - pitissue.jpg - M12_role_drum_NA 06 - purmesh.png - N33_Duck_NA 07 - quads.jpg - M12_SW_Extruder-Hinged-Block_high 08 - photo_1.jpg - M11_stereographic_maze_lowres_NA 09 - photo_1.png_16 - M12_Tristruder_18mm_Probe_Mount_high 10 - photo_2.jpg - M21_flex_coupler_NA 11 - photo_3.png - N32_alligator_228_low 12 - photo_4.jpg - M22_FPV_Pod_Camera_Plate_NA 13 - photo_5.jpg - M22_FPV_Pod_Half_NA 14 - photo_6.png - N23_Deer_high
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.9 P_???_0509 Positive Ordering

Test Scenario Description	Demonstrate that colorgroup, texture2group, and multiproperties can be interleaved in resources as long as there are no forward references
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 – D**efine model part with the following ordering of materials in the resources element: colorgroup, texture2d, texture2dgroup, multiproperties, texture2d, colorgroup, texture2dgroup, multiproperties, object. There should be no forward references and all materials should be referenced in an object's triangles.
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.10 P_???_0510 Color Groups

Test Scenario Description	Description
Pass/Fail Criteria	01 to 04 – Printer should process correctly
Test Case Iterations	**01 -** Define one colorgroup with 10 colors, use all colors on one object **02 -** Define two colorgroups, each with 10 colors. Interleave use of colors from the two different colorgroups on the same object's triangles **03 -** Define one colorgroup with 10 colors, use each color as the default color on a separate object **04 -** Define two colorgroups, each with 4 colors. Interleave use of colors from the two different colorgroups as the default color on separate objects
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.11 P_???_0511 Color Values

Test Scenario Description	Demonstrate iterating through values for the color attribute of colorgroup
Pass/Fail Criteria	01 to 04 – Printer should process correctly
Test Case Iterations	**01** - Iterate through all 256 red channel values displaying each value in a triangle in the same object while omitting the alpha channel (#XX0000) **02** - Iterate through all 256 green channel values displaying each value in a triangle in the same object while omitting the alpha channel (#00XX00) **03** - Iterate through all 256 blue channel values displaying each value in a triangle in the same object while omitting the alpha channel (#0000XX) **04** - Iterate through all 256 RGB channel values concurrently with an opaque alpha channel value in a triangle in the same object (#XXXXXXFF)
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.12 **P_???_0512 Gradients**

Test Scenario Description	Demonstrate use various gradients using the standard gradient patterns defined in Appendix B
Pass/Fail Criteria	01 to 06 – Printer should process correctly
Test Case Iterations	**01 -** Use Gradient_1, Gragient_2, and Gradient_3 using a color value that omits alpha (#XXXXXX) **02 -** Use Gradient4, Gragient_5, and Gradient_6 using a color value that includes an opaque alpha (#XXXXXXFF) **03_**Use Gradient_7, Gragient_8, and Gradient_9 using a color value that includes a 50% transparent alpha (#XXXXXX9F) as part of a multiproperties definition where texture is the first layer and partially transparent gradient in the second layer **04-** Use a gradient as the 2nd layer in a multiproperties with a mixture of color values for p1, p2, and p3 that have no alpha channel (#XXXXXX) and a partially transparent color value (#XXXXXX2f) **06 –** Create gradient across all 6 sides of a cube such that the transition between triangles and faces of the cube appear seamless
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.13 **P_???_0513 Transparency**

Test Scenario Description	Use multiproperties to effect various alpha channel transparency behaviors
Pass/Fail Criteria	01 to 05 – Printer should process correctly
Test Case Iterations	**01** - Iterate through all 256 alpha channel values for color using a static RGB color for triangle attributes P1, P2, and P3 as the second layer of a multiproperties **02** - With a solid color as the first layer, use the alpha channel versions of the brmarble_A and droplets_A Small Texture Swatches (Appendix H) as the second layer in multiproperties **03** - With a Gradient_5 as the first layer, use the alpha channel versions of the grmarble_A and oak_A Small Texture Swatches (Appendix H) as the second layer in multiproperties **04** - With a brmarble.jpg texture as the first layer, use the alpha channel versions of the pitissue_A and purmesh_A Small Texture Swatches (Appendix H) as the second layer in multiproperties **05** – Multiproperties with second layer with tilestyle of “none” and UV values greater than 1 and a default color that is partially transparent.
Requirement Reference	Link to Requirement in 3MF Specification blank

6.5.14 **P_???_0514 Textures**

Test Scenario Description	Demonstrate the use of textures in a variety of ways. These test cases use a variety of texture patterns defines in Appendix B
Pass/Fail Criteria	01 to 12 – Printer should process correctly
Test Case Iterations	**01**-Create a cube where each side of the cube uses one of the jpg versions of the Small Texture Swatches **02**-Create a cube where each side of the cube uses one of the png versions of the Small Texture Swatches **03**-Create a cube where each side of the cube alternates use of jpg and PNG images from the Small Texture Swatches **04** - Create objects that are painted completely with the photo_1 Large Texture Images. The test file should have 4 objects, each utilizing jpg and png forms of the Photo_1 Image. **05** - Create objects that are painted completely with the photo_2 Large Texture Images. The test file should have 2 objects, each utilizing jpg and png forms of the Photo_2 Image. **06** - Create objects that are painted completely with the photo_3 Large Texture Images. The test file should have 2 objects, each utilizing jpg and png forms of the Photo_3 Image. **07** - Create objects that are painted completely with the photo_4 Large Texture Images. The test file should have 2 objects, each utilizing jpg and png forms of the Photo_4 Image. **08** - Create objects that are painted completely with the photo_5 Large Texture Images. The test file should have 2 objects, each utilizing jpg and png forms of the Photo_5 Image. **09** - Create objects that are painted completely with the photo_6 Large Texture Images. The test file should have 2 objects, each utilizing jpg and png forms of the Photo_6 Image. **10** - Define 7 texture2dgroups each using a different texture2d image from the Small Texture Swatches without alpha channel data. Use each texture2d group to paint at least 1 triangle on the same object **11** - Define 7 texture2dgroups each using a different texture2d image from the Small Texture Swatches with alpha channel data. Include each texture2d group as the second layer in a multiproperties, then paint at least 1 triangle on the same object with each multiproperties **12** – Map a texture with no area to a triangle. Repeat twice for two different triangles. One where p2, and p3 point to the same coordinate on the texture. And a second where p1, p2, and p3 point to the same coordinate. Coordinate points used shall point to distinctly different colors to illustrate the effect.
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.15 **P_???_0515 PNG Formats**

Test Scenario Description	Demonstrate each of the allowable basic png formats utilizing the Public Domain PngSuite shown in Appendix B
Pass/Fail Criteria	01 to 03 – Printer should process correctly
Test Case Iterations	**01 -** Positive - Use each of the png files defined in the Basic Format Public Domain PNG Suite (Appendix B) as a triangle texture on the same object **02** - Use each of the PNG files defined in the Public Domain PNG Suite (Appendix B) that have an alpha channel as the second layer of a multiproperties such that the alpha behavior of the png files is apparent. **03 –** All png images in the public test suite, including basic format tests.
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.16 **P_???_0516 Multiproperties**

Test Scenario Description	Demonstrate various combinations of colorgroup and texture as part of multiproperties. This test cases references a standard set of multiproperties combinations defined in Appendix B
Pass/Fail Criteria	01 to 08 – Printer should process correctly
Test Case Iterations	**01** - Define Multiproperties_1 and _2, and use each of them to paint on triangle on an object **02** - Define Multiproperties_3 and _4, and use each of them to paint on triangle on an object **03** - Define Multiproperties_5 and _6, and use each of them to paint on triangle on an object **04** - Define Multiproperties_7 and _8, and use each of them to paint on triangle on an object **05 -** Multiproperties with only one property defined in pids **06** - Use the same texture multiple times in a pids/pindex reference in multiproperties **07** - Demonstrate monochrome and color images with the default alpha channel blending using multiproperties **08** - Demonstrate monochrome and color images using the multiply blend method using multiproperties
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.17 **P_???_0517 Texture2D**

Test Scenario Description	Demonstrate various texture2D bounding box and tile style behaviors
Pass/Fail Criteria	01 to 35 – Printer should process correctly
Test Case Iterations	**01** - Demonstrate that the default tilestyleu and tilestylev attribute default is wrap **02** - Demonstrate that the default box attribute values are "0 0 1 1" **04** - Specify the tilestyleu attributes without the box or tilestylev attribute using a non-default value for tilestyleu (mirror or clamp) **05** - Specify the tilestylev attribute without the box or tilestyleu attribute using a non-default value for tilestylev (mirror or clamp) Note: Demonstrate various combinations of wrap, mirror, and clamp as part of color and image transparency. Default tex2coord greater than 1 to trigger tiling. **08** - Texture: u=wrap v=wrap **09** - Texture: u=mirror v=mirror **10** - Texture: u=clamp v=clamp **11** - Texture: u=wrap v=mirror **12** - Texture: u=mirror v=wrap **13** - Texture: u=clamp v=wrap **14** - Texture: u=wrap v=clamp **15** - Texture: u=mirror v=clamp **16** - Texture: u=clamp v=mirror **20** – Demonstrate clamp, mirror and wrap behavior on separate triangles of the same object using the photo_4.jpg, photo_5.png, and photo_5.jpeg images respectively **21** – Use negative text2cood values to texture a triangle with wrap and mirror. The origin tile will be flipped in both the u and v direction. **22** – Use negative v text2cood values to texture a triangle using a clamp and mirror tilestyle. **23** – Use wrap on all 6 sides of a cube **24** – Use mirror on all 6 sides of a cube **25** – Use clamp on all 6 sides of a cube **26** – Use a texture with an alpha channel with a tilestyle of mirror. Note: Demonstrate various combination of a tilestyle of “none” with wrap, mirror, and clamp as part of color and image transparency. Default tex2coord greater than 1 to trigger tiling and a default object color unless specified otherwise **27** - Texture: u=none v=none (negative uv to show all 4 sides) **28** - Texture: u=none v=none, basematerials as object default color , negative uv to show all 4 sides of coordinate space

	29 - Texture: u=none v=wrap **30** - Texture: u=wrap v=none **31** – Texture: u=mirror v=none **32** – Texture: u=none v=mirror **33** – Texture: u=clamp v=none **34** - Texture: u= none v=clamp **35** – Tilestyle of "none' on all 6 sides of a cube
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.18 **P_???_0518 Texture2dGroup**

Test Scenario Description	Demonstrate various mapping of text2coord attribute values of the texture2dgroup element
Pass/Fail Criteria	01 to 15 – Printer should process correctly
Test Case Iterations	**01** - text2coord u v values between 0 and 1 mapped to vertices such that the image aspect ratio is maintained **02** - text2coord u v values between 0 and .1 mapped to vertices such that the image aspect ratio is maintained **03** - text2coord u v values between 5 and 10 mapped to vertices such that the image aspect ratio is maintained and tiling is triggered **04** - text3coord u values such to create an obvious and exaggerated stretching of the image in the u axis **05** - text3coord v values such to create an obvious and exaggerated stretching of the image in the v axis **06** - text3coord u v values such to create an obvious and exaggerated stretching of the image in both the u v axis **07** - text3coord u values such to create an obvious and exaggerated stretching of the image in both the u v axis as well as tiling of at least 3 instances of the image in a triangle **08** - Use negative text2coord u and v values to map the texture to a triangle using the quad.jpg Small Texture Swatch with specified uv coordinate where the distance between vertex points is not greater than 1 (no tiling). Device UV coordinates: once with just u negative, once with just v negative, and once with both u and v negative. Use all the coordinates to map a texture to a single triangle. **09** - use negative text2coord u and v values to map the texture to triangles using the oakNumbers.png Small Texture Swatch with UV coordinate values between -1 and -3 (tiling). Use all the coordinates to map a texture to a single triangle. **10** – Repeat test case 09 with a tilestyle of mirror for u and v **11** - Repeat test case 09 with a tilestyle of clamp for u and v

	12 - Texture with mapped uv values all greater than 1. **13** - Repeat test case 08 with tilestyle of “none” **14** - Repeat test case 09 with tilestyle of “none” **15** - Repeat test case 12 with tilestyle of “none”
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.19 P_???_0519 “e” Notation

Test Scenario Description	Demonstrate the use of e notation rather than decimal values in one location to conform that implementation can handle that representation of a float
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Demonstrate the use of e notation with negative values on mesh vertex coordinate.
Requirement Reference	Link to Requirement in 3MF Specification N/E

6.5.20 P_???_0520 Overlapping Material Colors

Test Scenario Description	Demonstrate that the last voxel rendered takes precedence when two objects overlap in a coplanar fashion.
Pass/Fail Criteria	01 to 03 – Last color of last coplanar object rendered should have precedence
Test Case Iterations	**01** - 2 objects overlapping with gradient and textured surfaces coplanar both referenced from build items **02** - 2 cubes defined in same object mesh with overlapping gradient and textured surfaces coplanar (Note in Thumbnail master that the result may be device dependent where two layers are coplanar), although rules state that the last overlapping triangle rendered should have precedence. **03** - 2 cubes defined in separate objects with overlapping gradient and textured surfaces coplanar with each object referenced from components in the same object, with a single build item referenced to the assembly
Requirement Reference	Link to Requirement in 3MF Specification

6.5.21 **P_???_0521 Units of Measure**

Test Scenario Description	Demonstrate that units of measure declared in the model units attribute does not impact the appearance of textures.
Pass/Fail Criteria	01– Printer should process correctly
Test Case Iterations	**01 -** Display textured object (photo_4.jpg) in the same OPC package multiple times using separate model files, with each model file containing a different unit attribute value. Use the default (no units - millimeter), inch, and centimeters. Objects should be generated such that the object vertex values are the native units of measure with the object being the same size without the need for transform scaling.
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.22 **P_???_0522 Transform Impact**

Test Scenario Description	Illustrate the impact that transforms have on texture and gradient patterns. These test cases use the predefined gradients and textures defined in Appendix B.
Pass/Fail Criteria	01 to 02 – Printer should process correctly
Test Case Iterations	**01 -** Create an object with both gradient_5 and texture quads.jpg. Reference the same object from 4 build items, with each reference using a different transform matrix scaling **02 -** Create an object with both gradient_5 and texture quads.jpg. Reference the same object from one object with 4 component references, with each component reference using a different transform matrix for scaling and positioning.
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.23 **P_???_0523 OPC Package Location**

Test Scenario Description	Define objects with Colorgroups, textures, and multipropertiescan in different locations in the OPC package. Each object should utilize a solid color from colorgroups, a gradient from colorgroups, a texture, and multiproperties that uses both colorgroup as a base layer and a texture with an alpha channel.
Pass/Fail Criteria	01 to 04 – Printer should process correctly
Test Case Iterations	**01** - Root and non-root model parts in same package **02** - non-root model parts only, referenced by root build item **03** – non-root model parts only, referenced by component **04** – Use tilestyle combinations of wrap, mirror, clamp, and none on various sides of a single cube that whose object is in a non root model.
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.5.24

6.5.25 P_???_0524 Whitespace in Delimited Values

Test Scenario Description	Use multiple tab, space, CR, LF characters between space delimited attributes. The schema validation
Pass/Fail Criteria	01 to 02 – Printer should process correctly
Test Case Iterations	For each of the space delimited attributes noted in the test cases below, include multiple space characters, tab CR, and LF in one set of space delimited values. **01** – Include multiple whitespace characters in the following attributes: pids and pindices. **02** - Include multiple whitespace values in both a build item and component transform matrix.
Requirement Reference	Link to Requirement in 3MF Specification

6.5.26 P_???_0525 Permutations of Layers

Test Scenario Description	Iterate through a set of test cases, each using a unique combination of materials, alpha data, padding, tiling, gradients, and other characteristics. This is not intended to be an exhaustive list, but rather a reasonable sampling of the possibilities. Basic combinations of layers to include: • colorgroup + texture • texture + color group • colorgroup + texture + texture • texture + colorgroup + texture
Pass/Fail Criteria	01 to 59 – Printer should process correctly
Test Case Iterations	**The table on the following page details each test case and the layer characteristics using the following legend:** CG = Colorgroup TX = Texture MP = Multiproperties OP = Opaque TR = Transparent SC = Solid Color GC = Gradient Color GA = Gradient Alpha WR = Wrapped (presumes tex2coord uv > 1) MR = Mirrored (presumes tex2coord uv > 1) CL = Clamped (presumes tex2coord uv > 1) NO = None (presumes tex2coord uv > 1) – One or both tilestyles as none
Requirement Reference	Link to Requirement in 3MF Specification N/A

Test Iteration	Object Default	Layer 1	Layer 2	Layer 3
01	CG	CG_SC_OP	TX_TR	
02	CG	CG_SC_TR	TX_TR_WR	
03	CG	CG_GC_OP	TX_TR_MR	
04	CG	CG_SC_OP	TX_TR_CL	
05	Deleted			
06	MP	CG_SC_TR	TX_TR	
07	TX	CG_GC_OP	TX_TR_WR	
08	CG	CG_SC_TR	TX_TR_MR	
09	MP	CG_GC_OP	TX_TR_CL	
10	TX	CG_SC_OP	TX_OP	
11	TX	CG_SC_TR	TX_OP_WR	
12	CG	TX_OP	CG_SC_TR	
13	CG	TX_TR	CG_SC_TR	
14	CG	TX_OP_WR	CG_GC_TR	
15	CG	TX_OP_MR	CG_SC_GA	
16	CG	TX_OP_CL	CG_GC_GA	
17	CG	TX_OP	CG_SC_TR	
18	MP	TX_OP_WR	CG_GC_TR	
19	TX	TX_OP_MR	CG_SC_GA	
20	CG	TX_OP_CL	CG_GC_GA	
21	CG	CG_SC_OP	TX_TR	TX_TR_MR
22	CG	CG_SC_TR	TX_TR_WR	TX_TR_MR
23	CG	CG_GC_OP	TX_TR_MR	TX_TR_WR
24	CG	CG_SC_OP	TX_TR_CL	TX_TR
25	MP	CG_SC_TR	TX_TR	TX_TR_CL
26	TX	CG_GC_OP	TX_TR_WR	TX_TR
27	CG	CG_SC_TR	TX_TR_MR	TX_TR_CL
28	MP	CG_GC_OP	TX_TR_CL	TX_TR_MR
29	TX	CG_SC_OP	TX_OP	TX_TR_WR
30	TX	CG_SC_TR	TX_OP_WR	TX_TR
31	CG	TX_TR	CG_SC_TR	TX_TR_MR
32	CG	TX_OP_WR	CG_GC_TR	TX_TR_WR
33	CG	TX_OP_MR	CG_SC_GA	TX_TR
34	CG	TX_OP_CL	CG_GC_GA	TX_TR_CL
35	CG	TX_OP	CG_SC_TR	TX_TR_MR
36	MP	TX_OP_WR	CG_GC_TR	TX_TR_CL
37	TX	TX_OP_MR	CG_SC_GA	TX_TR_MR
38	CG	TX_OP_CL	CG_GC_GA	TX_TR_WR
39	CG	TX_TR	TX_OP_MR	
40	CG	TX_TR_WR	TX_TR_CL	
41	CG	CG_SC_TR	TX_TR_NO_OP	
42	TX	CG_GC_OP	TX_TR_NO_TR	
43	TX	CG_SC_TR	TX_OP_NO_TR	

44	CG	CG_SC_TR	TX_TR_NO_OP	
45	CG	TX_OP_NO_OP	CG_GC_TR	
46	MP	TX_OP_NO_TR	CG_GC_TR	
47	CG	CG_SC_TR	TX_TR_NO_TR	TX_TR_MR
48	CG	CG_GC_OP	TX_TR_MR	TX_TR_NO_TR
49	TX	CG_GC_OP	TX_TR_NO_TR	TX_TR
50	basematerials	CG_SC_OP	TX_TR_NO (no default)	TX_TR_NO(no default)
51	TX	CG_SC_TR	TX_OP_NO_TR	TX_TR
52	CG	TX_OP_NO_TR	CG_GC_TR	TX_TR_NO_TR
53	basematerials	TX_OP_NO (no default)	CG_GC_TR	TX_TR_CL
54	CG	TX_OP_CL	CG_GC_GA	TX_TR_NO_TR
55	CG	CG_GC_OP	TX_TR_WR	TX_TR_NO_TR
56	CG	basematerials	TX_TR_NO	TX_TR_NO (Mix Blend)
57	CG	basematerials	TX_TR_NO	TX_TR_NO (Mult Blend
58	CG	basematerials	TX_TR_NO	CG_GC_TR (Mix Blend)
59	CG	basematerials	CG_GC_TR	TX_TR_NO (Mult Blend)

6.5.27 **P_???_0526 Filters**

Test Scenario Description	Test the various valid enumerations for the texture2d elements filter attribute
Pass/Fail Criteria	01 to 09 – Printer should process correctly
Test Case Iterations	Use the table below to render adjacent triangles using various filter and scaling combinations. The image selected and the scaling factors should be selected to make the interpolation method used as obvious as possible. Each test iteration has two scenarios with each presented on the upper or lower horizontal surface of a rectangular object. Most test cases will use a jpg image.
Requirement Reference	Link to Requirement in 3MF Specification

Iteration	TextureGroup	Multi	Downscale	Upscale	No Filter Attribute	Auto	Linear	Nearest
01	X (B)			X	X			
	X (T)			X		X		
02	X (B)			X		X		
	X (T)			X			X	
03	X (B)			X		X		
	X (T)			X				X
04	X (B)			X			X	
	X (T)			X				X
05	X (B)		X		X			
	X (T)		X			X		
06	X (B)		X				X	
	X (T)		X					X
07		X (B)	X				X	
		X (T)		X				X
08		X (B)		X		X		
		X (T)		X			X	
09 (1)	X	X	X	X	X	X	X	X

1)A single object that uses a variety of filter configurations using png images

6.5.28 P_???_0529 Display Properties

Test Scenario Description	Include an example of each supported display property. The printer should ignore the display property and render the mesh without influence from the display property values.
Pass/Fail Criteria	01– 05 Printer should process correctly
Test Case Iterations	**01 –** colorGroup displaypropertyid mapped to pbspeculardisplayproperties **02 –** colorGroup displaypropertyid mapped to pbmetallicdisplayproperties **03 –** texture2dgroup displaypropertyid mapped to pbmetallictexturedisplayproperties **04 –** texture2dgroup displaypropertyid mapped to pbspeculartexturedisplayproperties **05 –** basematerials displaypropertyid mapped to translucentdisplayproperties 06 - basematerials displaypropertyid mapped to translucentdisplayproperties with multiproperties “stamp” over transparacy.
Requirement Reference	Link to Requirement in 3MF Specification TBD

6.5.29 P_???_0530 Blend Method

Test Scenario Description	Exercise blendmethods in a variety of permutations of colorgroup, texture, any tylestyle enumerations. Note that the default “mix” behavior is tested extensively elsewhere, so the focus of this testing will be on the use of multiply either independently or in combination with mix.
Pass/Fail Criteria	01 to 08–Printer should process correctly
Test Case Iterations	**See tables below.**
Requirement Reference	Link to Requirement in 3MF Specification TBD

Characteristics combinations uses in test case definitions below.

ID	Blend Method When ID used as layer 2 or above		Solid Color	Gradient Color	Texture	Wrap	Mirror	Clamp	None
	Mix With layer below	**Multiply** With layer below							
A	x		x						
B	x			x					
C		X	x						
D		X		x					
E	x				x	x			
F	x				x		x		
G	x				x			x	
H	x				x				x
I		X			x	x			
J		X			x		x		
K		X			x			x	
L		X			x				x

Test Iteration	Layer 1	Layer 2	Layer 3	Comment
01	I	C		Multiply solid color with texture
02	B	J		Multiply texture with gradient color
03	K	A	L	Mix solid color with texture, then multiply texture
04	B	L	I	Multiply texture with gradient, multiply texture
05	J	A	K	Mix solid color with texture, multiply texture
06	L	D	H	Multiply gradient with texture, then Mix texture
07	Base	J	I	basematerials as 1st layer. Multiply texture with texture
08	A	K	L	Multiply texture with solid color, multiply texture basematerials as default object color
09	A	A Red 50% alpha		Test case to illustrate impact of not converting to linear RBG space prior to alpha blending. If the render to not covert to linear space the image will darker in general.

6.6 Negative Material Extension Test Cases

6.6.1 N_???_0601 No Default Color

Test Scenario Description	Define a material color on a triangle without the required default material color specified on the object
Pass/Fail Criteria	01 to 02 – Printer should generate an error
Test Case Iterations	**01 –** Triangle with material color, root model object with no default material color **02** – Triangle with material color, non- root model object with no default material color
Requirement Reference	Link to Requirement in 3MF Specification

6.6.2 N_???_0602 Duplicate IDs

Test Scenario Description	Duplicate material color IDs in model file.
Pass/Fail Criteria	01 to 04 – Printer should generate an error
Test Case Iterations	**01 –** Duplicate colorgroup ID attribute values **02 –** Duplicate texture2dgroup ID attribute values **03** – Duplicate texture2d ID attribute values **04** – Duplicate multiproperties ID attribute values
Requirement Reference	Link to Requirement in 3MF Specification

6.6.3 N_???_0604 Multiproperties pids References

Test Scenario Description	Verify that the printer rejects multiple colorgroup references multiproperties and ignores the use of another multiproperties as part of a multiproperties pids reference
Pass/Fail Criteria	01 to 03 – Printer should generate an error
Test Case Iterations	**01** – Include two colorgroup references in multiproperties pids **02 –** Include references to another multiproperties group in multiproperties pids **03–** basematerials as layer 2 of multiproperties 03 – Basematerials as bot layer 1 and 2 of multiproperies
Requirement Reference	Link to Requirement in 3MF Specification Could not find

6.6.4

6.6.5 N_???_0605 Invalid Texture Relationship Mapping

Test Scenario Description	Description
Pass/Fail Criteria	01 to 02 – Printer should generate an error
Test Case Iterations	**01 –** Define a texture relationship in a .rels file that uses in incorrect type (use a "model" relationship type) in a test file that uses a texture **02 –** Omit a relationship in .rels to a texture file used in a test case
Requirement Reference	Link to Requirement in 3MF Specification

6.6.6 N_???_0606 Material Forward Reference

Test Scenario Description	Define forward references for material color resources where a prerequisite component has not yet been defined when referenced.
Pass/Fail Criteria	01 to 03 – Printer should generate an error
Test Case Iterations	**01 -** Texture2dgroup in resources before referenced texture2d **02 -** Multiproperties in resources before referenced texture2dgroup **03 -** Multiproperties in resources before referenced colorgroup
Requirement Reference	Link to Requirement in 3MF Specification could not find

6.6.7 N_???_0607 Out of Order Resources

Test Scenario Description	Demonstrate that the object element(s) must appear at the end of the list of resources defined in a model part.
Pass/Fail Criteria	01 – Printer should generate an error
Test Case Iterations	**01 –** Define model part with the following ordering of materials in the resources element: colorgroup, texture2d, texture2dgroup, multiproperties, object (This is invalid), texture2d, colorgroup, texture2dgroup, multiproperties, object. There should be no forward references and all materials should be referenced in an object's triangles. Note that this text case can be modeled after the "Positive Ordering" test case in the positive material test cases.
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.6.8

6.6.9 N_???_0608 Out of Range Color

Test Scenario Description	Use invalid color value
Pass/Fail Criteria	01 – Printer should generate an error
Test Case Iterations	**01 –** Use a value outside hex range in color (#FFHFFF) for a color defined in a colorgroup
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.6.10 N_???_0609 Incorrect Material IDs and Indexes

Test Scenario Description	Demonstrate various incorrect ID references
Pass/Fail Criteria	01 to 11 – Printer should generate an error
Test Case Iterations	**01** - Incorrect multiproperties pids reference **02** - Incorrect texture2dgroup reference to texture2d (textid) **03** - Incorrect (max+1) index to color in multiproperties(pindices) **04** - Incorrect (max+1) index to texture in multiproperties (pindices) **05** - Incorrect (max+1) triangle p1 index to a colorgroup **06** - Incorrect (max+1) triangle p2 index to a texture **07** - Incorrect (max+1) triangle p3 index to a multiproperties **08** - Incorrect (max+1) object pindex index to a colorgroup **09** - Incorrect (max+1) object pindex index to a texture **10** - Incorrect (max+1) object pindex index to multiproperties **11** - Incorrect object pid reference
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.6.11 N_???_0610 Misc Path and ContentType

Test Scenario Description	Miscellaneous invalid values
Pass/Fail Criteria	01 to 03 – Printer should generate an error
Test Case Iterations	**01 –** invalid path to texture file from texture2d **02 –**Invalid texture2d ContentType attribute value (other than image/jpeg or image/png) **03 –**Invalid [content_Types].xml ContentType attribute value (other than image/jpeg or image/png)
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.7 Positive Production Extension Test Cases

The table below maps the possible permutations of parts and XML objects required to traverse from the StartPart object to the slices. Each set of relationships is defined by a letter, with the green highlight showing the target of the relationship. Test cases will be defined by listing a sequence of relationship letters together, such as "A, F, R, J". This table will be used to define test cases in subsequent sections.

Table 1.1

Relationships																								
Root Model Build Item – objectid Only (local)	A	B	C													Q	R							
Root Model Build Item – objectid + Path (remote)				D	E													S						
Root Model Object – w/o slicestackid Attr Component -> objectid of local mesh object	A					F																		
Root Model Object – w/o slicestackid Attr Component -> remote objectid + path of remote mesh object		B					G	H																
Root Model Object – with slicestackid Attr Component -> objectid of local mesh object																Q			T	U				
Root Model Object – with slicestackid Attr Component -> remote objectid + path of remote mesh object																	R						X	Y
Root Model Object – with slicestackid Attr Local mesh			C			F			I	J														
Root Model Object – w/o slicestackid Attr Local mesh																			T					
Root Model Slice Stack – Local Slices (ID)									I															Y
Root Model Slice Stack – Remote Sliceref (slicestackid + slicepath)										J	K													
Non-Root Model Object – w/o slicestackid Component -> objectid of local mesh object				D			G					M												
Non-Root Model Object – with slicestackid Component -> objectid of local mesh object																		S			V	W		
Non-Root Model Object – with slicestackid Local mesh					E			H				M	N	O										
Non-Root Model Object – w/o slicestackid Local mesh																					V		X	
Non-Root Model Slice Stack – Local Slices (ID)											K		N							U		W		
Non-Root Model Slice Stack – Remote Sliceref (slicestackid + slicepath)														O	P									
Another Non-Root Model Slice Stack – Local Slices (ID)															P									

6.7.1 PP_701 Object and Slice Mapping

Test Scenario Description	Construct sliced 3MF test files that iterate through the possible mapping relationships between Build Items, Objects, Components, and Slice Stacks. This will require slicing a number of individual 3MF files, then concatenating the data together in a single 3MF file.
Conformance Statement ID(s)	Prod-O1.3, Slice-M1.17, Slice-O1.1, Slice-O1.2, Prod-O1.2
Base Test Object(s)	S11_cube_NA.3mf S11_octahedron_NA.3mf S11_hex_pyramid_NA.3mf S12_cylinder_low.3mf
Pass/Fail Criteria	01 to 14 – Printer should process correctly
Test Case Iterations	**01 –** Create a 3MF file with relationships “A, F, I” from table 1.1 **02 –** Create a 3MF file with relationships “A, F, J, K” from table 1.1 **03 –** Deleted **04 –** Create a 3MF file with relationships “B, G, M, N” from table 1.1 **05 –** Create a 3MF file with relationships “B, G, M, O, P” from table 1.1 **06 –** Create a 3MF file with relationships “B, H, N” from table 1.1 **07 –** Create a 3MF file with relationships “B, H, O, P” from table 1.1 **08 –** Create a 3MF file with relationships “C, I” from table 1.1 **09 –** Create a 3MF file with relationships “C, J, K” from table 1.1 **10 –** Deleted **11 –** Create a 3MF file with relationships “D, M, N” from table 1.1 **12 –** Create a 3MF file with relationships “D, M, O, P” from table 1.1 **13 –** Create a 3MF file with relationships “E, N” from table 1.1 **14 –** Create a 3MF file with relationships “E, O, P” from table 1.1
Requirement Reference	Link to Requirement in 3MF Specification

The table below maps the possible permutations of parts and XML objects required to traverse from the StartPart object to various mesh representations in the OPC file. Each set of relationships is defined by a letter, with the green highlight showing the target of the relationship. Test cases will be defined by listing a sequence of relationship letters together, such as "A, F, R, J". This table will be used to define test cases in subsequent sections.

Table 1.2

Relationships									
Root Model Build Item – objectid Only (local)	A	B	C						
Root Model Build Item – objectid + Path (remote)				D	E				
Root Model Object – Component -> objectid of local mesh object	A					F			
Root Model Object – Component -> remote objectid + path of remote mesh object		B					G	H	
Root Model Object – Local mesh			C			F			
Non-Root Model Object - Component -> objectid of local mesh object				D			G		M
Non-Root Model Object – Local mesh					E			H	M

6.7.2 P_???_0702 Object Mapping

Test Scenario Description	Construct 3MF test files that iterate through the possible mapping relationships between Build Items, Objects, and Components.
Pass/Fail Criteria	01 to 06 – Printer should process correctly
Test Case Iterations	**01 –** Create a 3MF file with relationships "A, F" from table 1.2 (root build item -> root object w/component -> root object w/mesh) **02 –** Create a 3MF file with relationships "B, G, M" from table 1.2 (root build item -> root object w/component ->non-root object w/component -> non-root object w/mesh) **03 –** Create a 3MF file with relationships "B, H from table 1.2 (root build item -> root object w/component -> non-root object w/mesh) **04 –** Create a 3MF file with relationships "C" from table 1.2 (root build item -> root object w/mesh) **05 –** Create a 3MF file with relationships "D, M" from table 1.2 (root build item -> non-root object w/component -> non-root object w/mesh) **06 –** Create a 3MF file with relationships "E" from table 1.2 (root build item -> non-root object w/mesh)
Requirement Reference	Link to Requirement in 3MF Specification

6.7.3 **P_???_0703 Object Mapping 2**

Test Scenario Description	Construct 3MF test files that iterate through the possible mapping relationships between Build Items, Objects, and Components.
Pass/Fail Criteria	01 to 12 – Printer should process correctly
Test Case Iterations	**01 –** Create a 3MF file with two build items which point directly to root part mesh objects. Modify build item transform so they don't overlap. **02 –** Create a 3MF file with two build items which point at two objects that define components, which in turn point at locally defined mesh objects. Modify build item transform so they don't overlap. **03 –** Create a 3MF file with two build items which point at two objects that define components, which in turn point at remote parts with mesh objects and via the component path element. Modify build item transform so they don't overlap. 04 **–** Create a 3MF file with build items including one each of the following objects: Local mesh, local mesh via Object component, remote mesh via Object component. Modify build item transform so they don't overlap. **05 –** Create 3MF file with two build items pointed at the same local mesh object. Modify build item transform so they don't overlap. **06 –** Create a 3MF file with two build items pointed to the same remote part mesh object, modify build item transform so they don't overlap. **07 –** Create a 3MF file with an object with two components that contain objectid references to two local root part mesh objects. Modify component so they don't overlap. **08 –** Create a 3MF file with an object that points to another object with two components that contain objectid references to locally defined mesh objects. Modify component transform so they don't overlap. **09 –** Create a 3MF file with an object with two components which point at remote parts with mesh objects via the component path element. Modify component transform so they don't overlap. **10 –** Create a 3MF file with an object with three components that includes one each of the following objects: Local mesh, local mesh via another Object component, remote mesh via path. Modify component transform so they don't overlap. **11 –** Create 3MF file with an object with two components pointed at the same local mesh object. Modify build item transform so they don't overlap. **12 –** Create a 3MF file with an object with two components pointed to the same remote part mesh object via path. Modify build item transform so they don't overlap. Include model level metadata in non-root model file.
Requirement Reference	Link to Requirement in 3MF Specification could not find

6.7.4 PP_704 Object and Slice Mapping

Test Scenario Description	Construct sliced 3MF test files that iterate through the possible mapping relationships between Build Items, Objects, Components, and Slice Stacks. This will require slicing a number of individual 3MF files, the concatenating the data together in a single 3MF file.
Conformance Statement ID(s)	Prod-O1.3, Slice-M1.17, Slice-O1.1, Slice-O1.2, Prod-O1.2
Base Test Object(s)	S11_cube_NA.3mf S11_octahedron_NA.3mf S11_hex_pyramid_NA.3mf S12_cylinder_low.3mf
Pass/Fail Criteria	01 to 04 – Printer should process correctly
Test Case Iterations	**01 –** Create a 3MF file with a slicestack that contains two Sliceref slicepath objects pointing to remote slice stacks. The composite of the slice stacks should comprise one object. The following test cases define the slicestackID in an object with component references. The downstream 3D objectID references will not contain a slicestackID. Note that the letters in parenthesis indicate that there is a reference from the object to both the slicestack and the 3D mesh object. **02–** Create a 3MF file with relationships “Q, (TU)” from table 1.1 **03 –** Create a 3MF file with relationships “R, (XY)” from table 1.1 **04** – Create a 3MF file with relationships “S, (VW)” from table 1.1
Requirement Reference	Link to Requirement in 3MF Specification

6.7.5 P_???_0705 Duplicates of Separate Parts

Test Scenario Description	Multiple part build using production extensions
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** A test case that use 3 different mesh objects defined in separate parts to build 30 objects, 10 of each via build item element on the build platform. Objects should be positioned both adjacent in XY space, and Stacked in the Z space.
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.7.6 P_???_0706 Build Item Non-Root Model

Test Scenario Description	Build item in a non-root model file
Pass/Fail Criteria	01 – Printer should ignore
Test Case Iterations	**01 –** File with a build item in a non-root model file. Printer should ignore.
Requirement Reference	Link to Requirement in 3MF Specification

6.8 Negative Production Extension Test Cases

6.8.1 N_???_0801 Incorrect Mapping of IDs and Paths

Test Scenario Description	Construct 3MF test files that have incorrect mapping relationships between Build Items, Objects, and Components. The files generated in test case P_???_0701_01 through P_???_0701_18 will be used as a resource for these test cases. Test case developers can select a test case from this group that has the targeted mapping modified as defined below.
Pass/Fail Criteria	01 to 09 – Printer should generate an error
Test Case Iterations	**01 –** Modify existing test case to create an incorrect objectid mapping using relationship “A” defined in table 1.2 in section 5.7 **02 –** Modify existing test case to create an incorrect objectid mapping using relationship “E” defined in table 1.2 in section 5.7 **03 –** Modify existing test case to create an incorrect path mapping using relationship “E” defined in table 1.2 in section 5.7 **04 –** Modify existing test case to create an incorrect objectid mapping using relationship “F” defined in table 1.2 in section 5.7 **05 –** Modify existing test case to create an incorrect objectid mapping using relationship “H” defined in table 1.2 in section 5.7 **06 –** Modify existing test case to create an incorrect path mapping using relationship “H” defined in table 1.2 in section 5.7 **07 –** Modify existing test case to create an incorrect slicestackid mapping using relationship “I” defined in table 1.1 in section 5.7 **08 –** Modify existing test case to create an incorrect slicestackid mapping using relationship “K” defined in table 1.1 in section 5.7 **09 –** Modify existing test case to create an incorrect slicepath mapping using relationship “K” defined in table 1.1 in section 5.7
Requirement Reference	Link to Requirement in 3MF Specification could not find

6.8.2 **N_???_0802 UUIDs**

Test Scenario Description	Create a 3MF document file with missing UUID values or duplicate UUIDs.
Pass/Fail Criteria	01 to 05 – Printer should generate an error
Test Case Iterations	**01 –** Missing UUID in Build item **02 –** Missing UUID in object with local mesh **03 –** Missing UUID in component **04 –** Duplicate UUID between two objects **05 –** Missing UUID in Build element
Requirement Reference	Link to Requirement in 3MF Specification

6.8.3 **N_???_0803 Restricted Mappings**

Test Scenario Description	The conformance rules restrict the use of path on the component element of non-root model parts.
Pass/Fail Criteria	01– Printer should generate an error
Test Case Iterations	**01 –** Create a 3MF file that contains three 3D model parts. The root model has an object component reference to the second, and the second has an object component reference to the third.
Requirement Reference	Link to Requirement in 3MF Specification

6.9 Miscellaneous 3MF Test Cases

6.9.1 P_???_0901 Test Synthetic Low Res

Test Scenario Description	Generate 3MF files for each of the Synthetic low res and NA Test objects defined in Appendix A
Pass/Fail Criteria	01 to 12 – Printer should process correctly
Test Case Iterations	**01 –** S11_Cube **02 –** S11_Cube_Fillet_Low **03 –** S11_Dodecahedron_NA **04 –** S11_Hex_Pyramid_NA **05 –** S11_Octahedron_NA **06 –** S11_Pentagon_Prism_NA **07 –** S11_Rectangle_Pyramid_NA **08 –** S11_Cone_Low **09 –** S11_Cylinder_Low **10 –** S11_Ellipsoid_Low **11 –** S12_Sphere_Low **12 –** S12_Torus_Low
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.9.2 P_???_0902 Synthetic High Res

Test Scenario Description	Generate 3MF files for each of the Synthetic high res Test objects defined in Appendix A
	N/A
Pass/Fail Criteria	01 to 06 – Printer should process correctly
Test Case Iterations	**01 –** S11_Cube_Fillet_High **02 –** S12_Cone_High **03 –** S12_Cylinder_High **04 –** S12_Ellipsoid_High **05 –** S12_Sphere_High **06 –** S12_Torus_High
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.9.3 P_???_0903 Natural Low Res and NA

Test Scenario Description	Generate 3MF files for each of the Natural low res and NA Test objects defined in Appendix A
Pass/Fail Criteria	01 to 06 – Printer should process correctly
Test Case Iterations	**01 –** N22_ChessHorse_Low **02 –** N23_Deer_Low **03 –** N32_Alligator_228_Low **04 –** N32_Shell_Low **06-** N33_Duck_NA
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.9.4 P_???_0904 Natural High Res

Test Scenario Description	Generate 3MF files for each of the Natural high res Test objects defined in Appendix A
Pass/Fail Criteria	01 to 04 – Printer should process correctly
Test Case Iterations	**01 –** N22_ChessHorse_High **02 –** N23_Deer_High **03 –** N32_Alligator_228_High **04 –** N32_Shell_High
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.9.5 P_???_0905 Real World Low Res and NA

Test Scenario Description	Generate 3MF files for each of the Real World low res and NA Test objects defined in Appendix A
Pass/Fail Criteria	01 to 13 – Printer should process correctly
Test Case Iterations	**01 –** M11_Box_NA **02 –** M11_Snorkel_Low **03 –** M11_Stereographic_Maze_Low **04 –** M11_Ventilated Build Platform_low **05 –** M12_Extruder_Bowden_Adapterc_low **06 –** M12_role_drum_NA **07 –** M12_SW_Extruder-Hinged-Block_low **08 –** M12_Tristruder_18mm_Probe_MouN_???_0low **09 –** M21_flex_coupler_NA **10 –** M21_headphone_rest_low **12 –** M21_stereographic_flat_math2_low **13 –** M22_FPV_Pod_Half_NA
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.9.6 **P_???_0906 Real World High Res**

Test Scenario Description	Generate 3MF files for each of the Real World high res Test objects defined in Appendix A
Pass/Fail Criteria	01 to 06 – Printer should process correctly
Test Case Iterations	**01 –** M11_Snorkle_high **02 –** M11_Ventilated Build Platform_high **03 –** M12_Extruder_Bowden_Adapterc_high **04 –** M12_SW_Extruder-Hinged-Block_high **05 –** M12_Tristruder_18mm_Probe_MouN_???_0high **06 –** M21_headphone_rest_high
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.9.7 **P_???_0907 Assembly Low Res and NA**

Test Scenario Description	Generate 3MF files for each of the xx Assembly and NA Test objects defined in Appendix A
Pass/Fail Criteria	01 to 04 – Printer should process correctly
Test Case Iterations	**01 –** chainassembly_low **02 –** octohedron5_NA **03 –** raindrop_low **04 –** randomplacemeN_???_0NA
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.9.8 P_???_0909 Stress Tests

Test Scenario Description	Generate 3MF that may stress the resource or implementation boundaries of the printer
Pass/Fail Criteria	01 to 08 – Printer should process correctly
Test Case Iterations	**01 –** Create a small cube (8x8x8mm) object. Replicate both the object 1000 times within the root model part. Create a thumbnail for each object and reference in the object element and the root model .rels part. This test will exercise the following stress points: • Number of items in a relationship file (1000) • Number of object elements in a resource element (1000) • Number of build items in a build element (1000) **02** – Create a sliced 3D part that utilizes most of the allowable x axis build space, with a slice thickness of 80 microns. Divide the slicestack part into 1000 separate part slices and add the appropriate slicesref pointers to each of the parts to a single slicestack. This test will exercise the following stress points: **03**– Create a 3D part and use 180-character long string that contains Cyrillic and Kanjii characters in metadata content, and the max value of 2147483647 in the following places in the XML: • ID attribute value for an object • Partnumber attribute value object element **04** – create a 3D part with characteristics likely to require more than 10,000 vectors in a single polygon to render a single layer. Use 5,000 small cylinders arranged as 100 spokes, each consisting of 50 slightly overlapping adjacent cylinders. **05** – Create a 3D part that when slices will produce will produce 10,000 polygons for a single slice **06** – create a 3D part with characteristics likely to require more than 10,000 separate polygons to render a single layer. Use a matrix of 10,000 small non overlapping rectangular objects **07** – Leverage the test case defined in 01 above and place each of the 1000 objects in a separate non-root model file. Reference these objects from the build items using the path attribute **08** – Leverage the test case define in 01 above and place each of the 1000 objects in a separate non-root model file. Reference these objects from the component path attributes, then have the build items point to the object containing the components.
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.9.9 P_???_0910 Transform Matrices

Test Scenario Description	Modify the allowable transform matrix elements for a 3MF file
Pass/Fail Criteria	01 to 06 – Printer should process correctly
	01 – Render the same object multiple times using each of the various build item transforms. For tests with no slice stack, elements to modify include m00, m01, m02, m10, m11, m12, m20, m21m m22 m30, m31, and m32 in a build item transform. For tests that include slice stack data, modify m00, m01, m10, m11, m30, m31, and m32 **02 –** Render the same object multiple times using each of the various component item transforms. For tests with no slice stack, elements to modify include Modify m00, m01, m02, m10 m11, m12, m20, m21m m22 m30, m31, and m32 in a component item transform. For tests that include slice stack data, modify m00, m01, m10, m11, m30, m31, and m32 **03** – Use all 12 transform matrix elements (7 elements for tests with slice stack data) in a single build item transform such the impact of each element is obvious **04** – Use all 12 transform matrix elements (7 elements for tests with slice stack data) in a single component transform such the impact of each element is obvious **05** – Create a file with a build item pointing to an object with components, then an object with mesh. Modify the transforms in the build item and each of the object components to create a cascading effect using all 12 transform elements (7 elements for tests with slice stack data) in both the build item and component transforms. **06 –** Create a file where the transform attribute is used in a non-root model component element
Requirement Reference	Link to Requirement in 3MF Specification Blank

6.9.10 P_???_0911 Maze Geometry

Test Scenario Description	A 3MF file that will result in a more complex geometry
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Create an object that represents a complex maze involving a large number of vector variations
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.9.11 P_???_0912 XY Axis Positioning

Test Scenario Description	Objects around perimeter of print bed
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Create 3MF file with a number of object positioned around the periphery of the allowable XY axis
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.9.12 P_???_0913 Overlapping Objects

Test Scenario Description	Create 3mF parts that are overlapping
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Create 3MF file with a number of partially overlapping objects that coexist in the same XY plane.
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.9.13 P_???_0914 namespace prefixes

Test Scenario Description	Modify namespace prefixes of extensions so they are something other than “m” and ‘p” for material and production
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Modify a simple 3MF file such that the namespace prefix used for the material and production extensions is something other than “m” or “p” by modifying the xmlns declarations in the model element. Also update the prefixes used in requiredextensions to match the new prefixes
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.9.14 P_???_0915 Object Pointers

Test Scenario Description	A 3MF test job with various object relationships
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Create a 3MF file that uses Build item path references to two separate parts containing mesh objects.
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.10 Positive 3MF Slice Extension Test Cases

6.10.1 P_???_1501 Meshresolution Attribute

Test Scenario Description	Valid enumerations of meshresolution
Pass/Fail Criteria	01 to 03 – Printer should process correctly
Test Case Iterations	**01 –** Use fullres meshresolution attribute **02 –** Use lowres meshresolution attribute **03** – Omit meshresolution from the model element
Requirement Reference	Link to Requirement in 3MF Specification

6.10.2 P_???_1502 Transform Matrices

Test Scenario Description	Modify the allowable transform matrix elements for a sliced 3MF file (i.e. planar transformation)
Pass/Fail Criteria	01 to 06 – Printer should process correctly
Test Case Iterations	**01 –** Modify M0, M11, M30, M31, and M32 in a build item transform **02 –** Modify M0, M11, M30, M31, and M32 in a component transform **03 –** Modify M0, M01, M10, M11, and M32 in a build item transform **04 –** Modify M0, M01, M10, M11, and M32 in a component transform **05** – Create a sliced file with a build item pointing to an object with components, then an object with mesh. Add or modify the transforms in the build item and each of the object components to create a cascading effect using transform elements M0, M01, M10, M11, M30, M31, and M32.
Requirement Reference	Link to Requirement in 3MF Specification Blank

6.10.3 P_???_1503 Slice Increments

Test Scenario Description	Vary Z-axis slice increments
Pass/Fail Criteria	01 to 03 – Printer should process correctly
Test Case Iterations	**01 –** Generate 3MF file with small slice increments (10 microns) **02 –** Generate 3MF file with large slice increments (2mm) **03 –** Generate 3MF file with discontinuous slice increments between 80 and 500 microns
Requirement Reference	Link to Requirement in 3MF Specification

6.10.4 P_???_1504 Multiple Slicestack References, Mismatched Ztop and Zbottom

Test Scenario Description	Multiple sliceref's in a single slicestack
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Create scenario where there are two Sliceref slicestack references, with a mismatch between the last ztop and the second Sliceref zbottom.
Requirement Reference	Link to Requirement in 3MF Specification

6.10.5 P_???_1505 Polygon Definition with Positive Fill Rule

Test Scenario Description	Polygon positive fill rule permutations
Pass/Fail Criteria	01 to 03 – Printer should process correctly
Test Case Iterations	Test case with Polygon definition requiring application of the positive fill rule. Scenario should include each of the positive file rule example shown in section 4.1.1 of the core specification. **01 –** Example 1 **02 –** Example 2 **03 –** Example 3
Requirement Reference	Link to Requirement in 3MF Specification

6.10.6 P_???_1506 Ignore Object Level Material Mapping

Test Scenario Description	Scenario that uses basematerials references in polygon segment references. Printer should ignore.
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Create a slice stack that uses the segment p1, p2, and pid. Define two basematerials and multiple colors within each base materials. Use the attributes on several segments to override the object level material mapping. Printer should ignore attributes.
Requirement Reference	Link to Requirement in 3MF Specification

6.10.7 P_???_1507 Multiple Polygons Representing a Slice

Test Scenario Description	3MF object where the sliced data has multiple polygons in a single slice layer.
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Multiple polygons representing a slice
Requirement Reference	Link to Requirement in 3MF Specification

6.10.8 P_???_1508 Collapsing Proximal Vertices

Test Scenario Description	Identical and near identical vertices used in a polygon definition
Pass/Fail Criteria	01 to 02 – Printer should process correctly
Test Case Iterations	**01 –** Create a series of 2D vertices that are almost identical, then use those vertices in the polygon segment definition **02 –** Create a series of 2D vertices that are identical, then use those vertices in the polygon segment definition
Requirement Reference	Link to Requirement in 3MF Specification

6.10.9 P_???_1509 Small of number of vertices and polygons

Test Scenario Description	Variations in number of vertices and polygons
Pass/Fail Criteria	01 to 04 – Printer should process correctly
Test Case Iterations	**01 –** Slicestack layers with 3 segments elements per polygon **02 –** Slicestack layer with approximately 400 segments elements per polygon **03 –** Slicestack layer with 1 polygon **04 –** Slicestack layer with approximately 100 polygons
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.10.10 P_???_1510 Complex 2D Geometries

Test Scenario Description	A 3MF file that will result in a more complex sliced 2D geometry
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Slice an object that represents a complex maze involving a large number of 2D vector variations
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.10.11 P_???_1511 Z-Axis Offsets

Test Scenario Description	3MF files with varying slice thicknesses
Pass/Fail Criteria	01 to 06 – Printer should process correctly
Test Case Iterations	**01 –** Slice an object at 100 microns **02 –** Slice an object at 200 microns **03 –** Slice an object at 300 microns **04 –** Slice an object at 400 microns **05 –** Slice an object at 500 microns **06 –** Object sliced with 20% segments of slicestack at 100, 200, 300, 400, and 500 microns
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.10.12 P_???_1512 XY Axis Positioning

Test Scenario Description	Objects around perimeter of print bed
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Create 3MF file with a number of object positioned around the periphery of the allowable XY axis
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.10.13 P_???_1513 Multiple Slice Stacks

Test Scenario Description	Create sliced 3mF files that contain multiple slice stacks
Pass/Fail Criteria	01 to 03 – Printer should process correctly
Test Case Iterations	**01 –** Create 3MF file with a number of non-overlapping objects that coexist in the same XY plane. Independent slice stacks for each object should be in root model part. **02 –** Create 3MF file with a number of non-overlapping objects that coexist in the same XY plane. Independent slice stacks for each object should exist in separate slice stack parts, each pointed to using a sliceref element in the root model part. **03 –** Create 3MF file with a number of partially overlapping objects that coexist in the same XY plane. Independent slice stacks for each object should exist in separate slice stack parts, each pointed to using a sliceref element in the root model part.
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.10.14 P_???_1514 Duplicate IDs

Test Scenario Description	Duplicate slicestack ID values
Pass/Fail Criteria	01 to 02– Printer should process correctly
Test Case Iterations	**01 –** Duplicate slicestack IDs split between a root model file and a non-root model file **02** – Create a sliced 3MF package where two mesh objects that reside as separate parts use the same ID
Requirement Reference	Link to Requirement in 3MF Specification

6.10.15

6.10.16 P_???_1515 namespace prefixes

Test Scenario Description	Modify namespace prefixes of extensions so they are something other than “s” and ‘p” for production and slice
Pass/Fail Criteria	01 – Printer should process correctly
Test Case Iterations	**01 –** Modify a simple slice file such that the namespace prefix used for the slice and production extensions is something other than “s” or “p” by modifying the xmlns declarations in the model element. Also update the prefixes used in requiredextensions to match the new prefixes
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.10.17 P_???_1516 Slicestack Object Pointers

Test Scenario Description	A 3MF test job with various slicestack to object relationships
Pass/Fail Criteria	01 to 02– Printer should process correctly
Test Case Iterations	**01 –** Create a sliced 3MF file that uses Build item path references to two separate parts containing mesh objects. Those two mesh object parts should point to a single model file containing two separate slicestacks in the same file, with each object pointed at a separate stack **02 –** Create a sliced 3MF file that uses Build item path references to two separate parts containing mesh objects. Those two mesh object parts should point to a single model file containing one slicestack in the file, with each object pointed at the same slicestack. Modify build item transform so objects do not overlap
Requirement Reference	Link to Requirement in 3MF Specification N/A

6.10.18 P_???_1517 Polygon Slice

Test Scenario Description	Odd polygon definition
Pass/Fail Criteria	01 t0 02– Printer should ignore
Test Case Iterations	**01 –** Closed no area (Overlapping 2 segments) **02** – No polygons
Requirement Reference	Link to Requirement in 3MF Specification

6.10.19 P_???_1518 Slicestack Precedence

Test Scenario Description	A object could contain a reference slicestack and that same object could be part of a component that also contains a slicestack reference. The component slicestack that prevails must be the one at the component level
Pass/Fail Criteria	01 – Printer should print component defined slicestack
Test Case Iterations	**01 –** Map two different slicestacks to the same object. One directly the other via a component reference. Have the mesh output reflect the slicestack precedence of using the component slicestack
Requirement Reference	Link to Requirement in 3MF Specification

6.11 Negative Slice Extension Test Cases

6.11.1 N_???_1601 Transform Matrices

Test Scenario Description	Invalid values in transform matrix
Pass/Fail Criteria	01 to 05 – Printer should generate error
Test Case Iterations	**01 –** Use a non-zero value in a transform for M02 in a build Item transform **02 –** Use a non-zero value in a transform for M12 in a build Item transform **03 –** Use a non-zero value in a transform for M20 in a build Item transform **04 –** Use a non-zero value in a transform for M21 in a component transform **05 –** Use a value other than 1 for M22 in a component transform
Requirement Reference	Link to Requirement in 3MF Specification

6.11.2 N_???_1604 Locally Defined Slice Stack and Sliceref

Test Scenario Description	Invalid Sliceref self-reference
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Have Sliceref point to the same part that contains the Sliceref statement referring to a locally defined slice stack
Requirement Reference	Link to Requirement in 3MF Specification

6.11.3 N_???_1605 Two Layered Slicestack Reference Abstraction

Test Scenario Description	Invalid 2 layers of abstraction in slicestack Sliceref references
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Define slicestack references with two layers of abstraction from the original slicestack
Requirement Reference	Link to Requirement in 3MF Specification could not find

6.11.4 N_???_1606 Ztop Smaller Than Zbottom

Test Scenario Description	Ztop Smaller Than Zbottom in sliced file
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Define slice with ztop smaller the zbottom value
Requirement Reference	Link to Requirement in 3MF Specification

6.11.5 N_???_1607 Ztop Lower Than Preceding Value

Test Scenario Description	Ztop lower than preceding value in sliced file
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** ztop slice value that is lower than the preceding value
Requirement Reference	Link to Requirement in 3MF Specification

6.11.6 N_???_1608 Non-Distinct v2 Attributes

Test Scenario Description	Non-distinct v2 references in polygon definition
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Sequential segments with the same v2 attribute index
Requirement Reference	Link to Requirement in 3MF Specification

6.11.7 N_???_1609 Polygon Slice Descriptions

Test Scenario Description	Invalid polygon definitions
Pass/Fail Criteria	01 to 03 – Printer should generate error
Test Case Iterations	**01 –** Polygon with a single point **02 –** Open Polygon
Requirement Reference	Link to Requirement in 3MF Specification

6.11.8 N_???_1610 Unique Slicestack ID

Test Scenario Description	Duplicate slicestack ID values
Pass/Fail Criteria	01– Printer should generate error
Test Case Iterations	**01 –** Duplicate slicestack IDs in same local file
Requirement Reference	Link to Requirement in 3MF Specification

6.11.9 N_???_1612 Overlapping Slicestacks

Test Scenario Description	Generate a sliced 3MF file with overlapping slicestacks
Pass/Fail Criteria	01 – Printer should generate error
Test Case Iterations	**01 –** Scenario where there two slicerefs in a slice stack, but the Z-axis alignment of the vertically adjacent slicestacks referenced are overlapping
Requirement Reference	Link to Requirement in 3MF Specification

6.12 Positive Beam Lattice Extension Test Cases

The following guideline will be used for implementation of Beam Lattice test cases:

- Tests will have beamlattice set as a required extension in the model element
- Tests will define a 3MF consortium copyright in metadata
- Expected result PNG files will be embedded in each test file
- Tests will include the UUID attribute where required in the production extension, although the production extension will not be listed as a required extension. Support for other production extension functionality will not be included in test cases, not will the functionality of any additional 3MF extensions
- Rendered objects in each test case should stay within the following boundaries:
    - printable-box="(35000.0,35000.0,35000.0) (200000.0,200000.0,200000.0)"
- In general, most test cases will include some token triangular mesh representation as that will be the typical use case for this 3MF extension.
- Tests involving pid, pindex, p1, or p2 attributes will map to the displaycolor attribute of basematerials with the knowledge that this will impact only display rendering and NOT printer output which will be monochrome.

6.12.1 P_2001 Beams and Triangular Mesh

Test Scenario Description	Render beam lattice both with and without triangular mesh representation
Pass/Fail Criteria	01 to 03 Printer should process correctly
Test Case Iterations	**01 –** Standalone beam lattice with no triangle element defined **02 –** Standalone beam lattice with empty triangle element defined **03 –** Beam lattice with triangular mesh representation
Requirement Reference	

6.12.2 P_2002 beamlattice Default Characteristics

Test Scenario Description	Exercise beamlattice attributes that control the default characteristics of the beams. Attributes tested include pid, pindex, radius, and cap (hemisphere, Butt, sphere).
Pass/Fail Criteria	01 to 06 - Printer should process correctly
Test Case Iterations	**01 –** Define several beam lattice structures each with a different default beam radius value **02 –** Demonstrate that if no beamlattice element pid and pindex values are specified, the object level pid and pindex attributes when pointed to the basematerials displaycolor impact the default color of the beams rendered on a display **03 –** Demonstrate that the beamlattice element's pid and pindex attributes override the object level pid and pindex values and that these beamlattice attributes impact only the rendering of beams on a display, not triangular mesh **04 –** Demonstrate that omitting the beamlattice element's cap attribute and specifying "sphere" for this attribute have an equivalent effect **05 –** Define several beam lattices structures each with a different default beam cap value including hemisphere, sphere, and butt (no beam cap1 or cap2 specified). Use r1 or r2 beam attributes to taper beams such that sphere caps can be differentiated from hemisphere caps **06 –** Define just beam element's cap1 or cap2 element to demonstrate that the cap enumeration not defined at the beam level uses the beamlattice cap specified.
Requirement Reference	

6.12.3 P_2003 beamlattice minlength

Test Scenario Description	Test the beamlattice element's minlength attribute using lattice structures with varying lengths, demonstrating the cutoff at which beam no longer render
Pass/Fail Criteria	01 to 02– Printer should process correctly
Test Case Iterations	**01 –** Define a beam lattice structure with graduated lengths of beams, demonstrate different minlength cutoffs. **02 –** Define a beam lattice structure where all beams are smaller than minlegth. Include a triangular mesh representation so something renders
Requirement Reference	

6.12.4 P_2004 clippingmode and clippingmesh

Test Scenario Description	Utilize the inside and outside clipping modes with a variant of triangular mesh geometries to clip beam lattice structures
Pass/Fail Criteria	01 to 06 – Printer should process correctly
Test Case Iterations	**01 –** Demonstrate that omitting clippingmode has the effect of doing nothing even if a clippingmesh is defined **02 –** Demonstrate that specifying "none" has the effect of doing nothing even if a clippingmesh is defined **03 –** Demonstrate inside clipping **04 –** Demonstrate outside clipping **05 –** Demonstrate that triangular mesh is not impacted by clippingmode of inside even if the clippingmesh intersects the triangular mesh object with mesh and lattice part of same object **06 –** Demonstrate that triangular mesh is not impacted by clippingmode of outside even if the clippingmesh intersects the triangular mesh object with mesh and lattice part of same object **07 –**Exercise several complex mesh geometries used as a clippingmesh using both inside and outside clipping **08 –** Demonstrate effect where there is no intersect between the beam lattice and the clippingmesh using both inside and outside clipping mode. For inside, no beams will get clipped, for outside all beams will get clipped. **09 –** Demonstrate effect where there is a 100% intersect between the beam lattice and the clippingmesh using both inside and outside clipping mode. For inside, all beams will get clipped, for outside no beams will get clipped. **10** - Demonstrate that specifying a clippingmode of "none" with no clippingmesh defined does not cause the rendered to generate an exception 11 - Demonstrate that triangular mesh is not impacted by clippingmode of inside even if the clippingmesh intersects the triangular mesh object with mesh and lattice as separate objects 12 - Demonstrate that triangular mesh is not impacted by clippingmode of outside even if the clippingmesh intersects the triangular mesh object with mesh and lattice as separate objects
Requirement Reference	

6.12.5 P_2005 representationmesh

Test Scenario Description	Include a representationmesh in a 3MF package with beam lattice structures
Pass/Fail Criteria	01 to 02 – Printer should process correctly
Test Case Iterations	**01 –** Triangular mesh representation of beamlattice as a representationmesh
Requirement Reference	

6.12.6 P_2006 Basic Beams

Test Scenario Description	Demonstrate various basic beam configurations
Pass/Fail Criteria	01 to 04– Printer should process correctly
Test Case Iterations	**01 –** Lattice structure with a single beam **02 –** Lattice structure with multiple intersecting beams **03 –** Lattice structure with beams intersecting triangular mesh geometry. Renderable mesh and lattice in separate objects **04 –** Test with multiple non-interconnected beams **05 –** Lattice structure with beams intersecting triangular mesh geometry. Renderable mesh and lattice in same object
Requirement Reference	

6.12.7 P_2007 Beam Lattice Vertex Mapping

Test Scenario Description	Demonstrate various mappings of the beam element's v1 and v2 attribute to vertex's
Pass/Fail Criteria	01 to 02 – Printer should process correctly
Test Case Iterations	**01 –** Beams defined with v1 and V2, no optional attributes, pointed at vertex indices both shared and not shared with triangular mesh **02 –** Illustrate 12 standard beam lattice drawn from Netfabb's ability to export lattice structures. Refer to Appendix B,
Requirement Reference	

6.12.8 P_2008 Beam r1 and r2 attributes

Test Scenario Description	Exercise a range of the beam elements r1 and r1 attributes beam radius values
Pass/Fail Criteria	01 to 05 – Printer should process correctly
Test Case Iterations	**01 –** Illustrate that r1 overrides beamlattice radius default **02 –** Range of r1 radius values (no r2) **03 –** Illustrate that r2 uses r1 value if r2 not defined. **04 –** Range of r2 radius values (r1 fixed value) **05 –** Illustrate a range of v1 and v2 radius values
Requirement Reference	

6.12.9 P_2009 beam Resource Mapping

Test Scenario Description	Range of values for the beam element's pid, p1, and p2 attributes with colors mapped to the displaycolor attribute of basematerials
Pass/Fail Criteria	01 to 03– Printer should process correctly
Test Case Iterations	**01 –** Demonstrate that pid overrides the beamlattice level pid **02 –** Range of index values for p1 **03 –** Range of index values for p1 and p2. Both values must be the same.
Requirement Reference	

6.12.10 P_2010 Beam Cap

Test Scenario Description	Range of values for the beam element's cap1 and cap2 attributes including values for sphere, butt, and hemisphere
Pass/Fail Criteria	01 to 05– Printer should process correctly
Test Case Iterations	**01 –** Demonstrate that cap1 explicitly defined cap values at the beamlattice level **02 –** Define several beam lattices structures each with different cap1 or cap2 values including hemisphere, sphere, and butt. **03 –** Demonstrate that cap2 overrides explicitly defined cap values at the beamlattice level **04 –**Matrix of combos of Cap1 and Cap2 attribute values. Use r1 or r2 beam attributes to taper beams such that sphere caps can be differentiated from hemisphere caps
Requirement Reference	

6.12.11 P_2011 beamsets

Test Scenario Description	Test of beamset references. Note that beamset does not impact the rendered appearance of the objects. There is currently no defined method of referencing beamsets in metadata.
Pass/Fail Criteria	01 to 03– Printer should process correctly
Test Case Iterations	**01 –** Define a single beamset with one beam ref **02 –** Define multiple beamsets with multiple beam ref **03 –** Include beamset name and identifier attributes
Requirement Reference	

6.12.12 P_2012 Units

Test Scenario Description	Create a simple 3MF file with beam lattice structures, then modify the 3D model files to support each of the supported enumerations for the unit attribute of the Model element.
Pass/Fail Criteria	01 to 07– Printer should process correctly
Test Case Iterations	**01 –** Micron **02 –** Millimeter **03 –** Centimeter **04 –** Inch **05 –** Foot **06 –** Meter **07 – Unspecified**
Requirement Reference	

6.12.13 P_2013 Object Type

Test Scenario Description	Render beam lattices structures with various object element type attribute values
Pass/Fail Criteria	01 to 03– Printer should process correctly
Test Case Iterations	**01 –** beamlattice defined in object of type “solidsupport” **02 –** beamlattice defined in object of type undefined (omit attribute) **03 –** beamlattice defined in object of type “model”
Requirement Reference	

6.12.14 P_2014 Beams and Triangles

Test Scenario Description	Combinations of beam of triangular mesh and beam lattice structures
Pass/Fail Criteria	01 to 02– Printer should process correctly
Test Case Iterations	**01 –** Mesh with minimum number of triangles and beam lattice **02 –** Coplanar triangle mesh and beam lattice. Impact on display color
Requirement Reference	

6.12.15 P_2015 Component, build, and transform

Test Scenario Description	Exercise beam lattice structures referenced via a component, in a build object, and transformed.
Pass/Fail Criteria	01 to 07– Printer should process correctly
Test Case Iterations	**01 –** Beam lattice stored in an object referenced by a component **02 –** Transform of a component that has a beam lattice definition (translate, scale, rotate, shear). Lattice Only **03 –** Built item transform of object with both beam lattice and triangular mesh (translate, scale, rotate, shear) **04 –** Build item compound transform from both component and build transform perspective. Lattice and Mesh Object. **05 –** Built item reference to matrix of objects: beam lattice only, triangle mesh only, both triangle mesh and beam mesh **06 –** Demonstrate that transforms are applied to clippingmesh **07 –** Implement a 3MF file where a transform is applied to a representationmesh
Requirement Reference	

6.12.16 P_2016 Fill Rules

Test Scenario Description	Demonstrate fill rules are applied with overlapping lattice structures and intersecting lattice and triangular mesh objects
Pass/Fail Criteria	01– Printer should process correctly
Test Case Iterations	**01 –** Test case with objects that illustrate the intersection of beam lattice structures and triangle mesh such that the fill rules are invoked.
Requirement Reference	

6.12.17 P_2017 Overlapping Beam surface

Test Scenario Description	Validate that whith overlapping bemns, the last beam rendered take precedence in terms of rendering color
Pass/Fail Criteria	01– Printer should process correctly
Test Case Iterations	**01 –** test with overlapping beams and different displaycolor values. Control of rendering by order in build item list
Requirement Reference	

6.13 Negative Beam Lattice Extension Test Cases

6.13.1 N_2501 Invalid ID

Test Scenario Description	Test invalid Beam Lattice extension ID mappings
Pass/Fail Criteria	01 to 04– Printer should generate error
Test Case Iterations	**01 –** invalid ID for beamlattice element's clippingmesh attribute **02 –** invalid ID for beamlattice element's representationmesh attribute **03 –** invalid ID for beamlattice element's pid attribute **04 –** invalid ID for beam element's pid attribute
Requirement Reference	

6.13.2 N_2502 Invalid Index Reference

Test Scenario Description	Test invalid Beam Lattice extension index mappings
Pass/Fail Criteria	01 to 06 – Printer should generate error
Test Case Iterations	**01 –** invalid index for beamlattice element's pindex attribute **02 –** invalid index for beam element's v1 attribute **03 –** invalid index for beam element's v2 attribute **04 –** invalid index for beam element's p1 attribute **05 –** invalid index for beam element's p2 attribute **06 –** invalid index for beamset element's ref attribute
Requirement Reference	

6.13.3 **N_2503 Miscellaneous Errors**

Test Scenario Description	Miscellaneous error conditions
Pass/Fail Criteria	01 to 08 – Printer should generate error
Test Case Iterations	**01 –** Define zero length beam with the beam elements v1 and v2 attributes pointed different vertices **02 –** Include beam lattice on an object with a type other than model or solidsupport **03–** Beam with v1 and v2 pointing to same vertex **04 –** Beam with r2 attribute defined without r1 **05** - Beamlattice with pid specified but no pid specified at object level **06** - Beam with pid specified but no pid specified at object level **07** – Invalid clippingmode enumeration **08** – Invalid cap mode enumeration at the beanlattice level
Requirement Reference	

6.13.4 **N_2504 clippingmesh Exceptions**

Test Scenario Description	Error conditions related to clippingmesh
Pass/Fail Criteria	01 to 05 – Printer should generate error
Test Case Iterations	**01 –** clippingmode other than none with no clippingmesh **02 –** clippingmesh as component object **03 –** clippingmesh as self-reference **04 –** clippingmesh with beam lattice **05 –** clippingmesh as a forward reference
Requirement Reference	

6.13.5 **N_2505 representationmesh Exceptions**

Test Scenario Description	Error conditions related to representationmesh
Pass/Fail Criteria	01 to 04 – Printer should generate error
Test Case Iterations	**01 –** representationmesh as component object **02 –** representationmesh as self-reference **03 –** representationmesh with beam lattice **04 –** representationmesh as a forward reference
Requirement Reference	

Note that some negative test cases may have device dependent behavior. In particular an invalid attribute enumeration might just cause the default enumeration to be used rather than fail. Need to review before release and possibly set up a separate category of tests>>

Appendix A - Test Object Library

3MF test case definitions may reference one or more test objects as defined in the following tables. Objects were generated from the following sources:

- ☐ Created by QualityLogic Staff using SolidWorks and exported to STL files
- ☐ SolidWorks SLDPRT files found on Thingiverse.com with Creative Commons license allowing commercial use, exported to STL files
- ☐ STL file found on Thingiverse.com with Creative Commons license allowing commercial use
- ☐ Created, then export from application such as NetFabb and Creo.

Objects where we have the SLDPRT file provide the greatest control over the mesh resolution, and a SolidWorks icon is shown in the tables below where we have access to this file type.

The object names define the nature and complexity of the object using the following format:

ABC_DDDD_EEEE

A = Object type

- ☐ S – Synthetic object, primarily simple geometric objects
- ☐ N – Natural objects, things found in nature
- ☐ M – Man-made objects, typically manufactured
- ☐ A – Assembly objects, sets of objects that comprise an assembly

B = Level of Detail where 1 is the least detailed and 3 is the most detailed

C = Level of curvature – Impacts triangle generation, 1 is least, 3 is most

DDDD = Object name

EEEE = Triangle count (High, Low, NA), differentiate same file captured at differing triangle densities

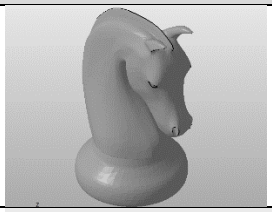
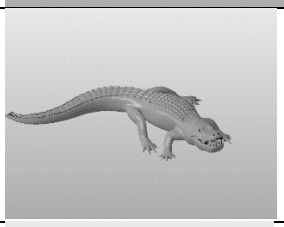
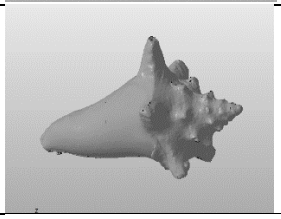
The categorization and ratings of objects are very subjective, with the only intent of these ratings being to assist in the selection of objects for test files.

Synthetic Objects

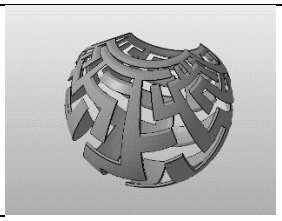
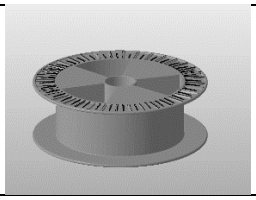
Object Name	Triangles	Image	Size (x, y, z) Attribution Link
S11_cube_NA	12		100, 100, 100 mm
S11_cube_fillet_high S11_cube_fillet_low	2,092 84		100, 100, 100 mm
S11_dodecahedron_NA	36		130, 137, 110 mm
S11_hex_pyramid_NA	10		76, 65.82, 90.42 mm
S11_octahedron_NA	8		57.74, 57.74, 100 mm
S11_pentagon_prism_NA	16		97.08, 92.33, 100 mm
S11_rectangle_pyramid_NA	8		100, 40, 34.64 mm

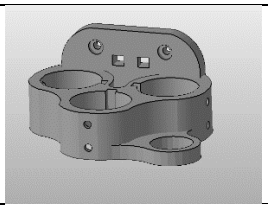
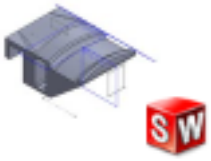
S12_cone_high S12_cone_low	1,440 62		55, 55, 95 mm
S12_cylinder_high S12_cylinder_low	2,880 120		50, 50, 100 mm
S12_ellipsoid_high S12_ellipsoid_low	545,760 2530		100, 100, 30 mm
S12_sphere_high S12_sphere_low	516,960 2,352		100, 100, 100 mm
S12_torus_high S12_torus_low	26,642 2,700		100, 100, 20 mm

Natural Objects

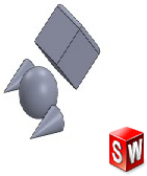
Object Name	Triangles	Image	Size (x, y, z) Attribution Link
N22_ChessHorse_high N22_ChessHorse_low	44,612 7,126		55.24, 67.07, 100 mm **chessHorse** by **jbarrettoda** is licensed under the**Creative Commons - Attribution** license.
N23_Deer_high N23_Deer_low	49,324 9,864		26.67, 75, 71.41 mm **Deer** by **YahooJAPAN** is licensed under the **Creative Commons - Attribution** license
N32_alligator_228_high N32_alligator_228_low	209,652 56,862		85, 121, 25 **Alligator** by **willie** is licensed under the **Creative Commons - Public Domain Dedication** license
N32_shell_high N32_shell_low	250,498 62,520		64.75, 75, 56.73 mm Unknown author
N33_Duck_NA	11,578		84.11, 68.58, 53 mm **Duck** by **Roboduck** is licensed under the **Creative Commons - Attribution** license

Man-Made, Manufactured Objects

Object Name	Triangles	Image	Size (x, y, z) Attribution Link
M11_box_NA	41,022		170, 11, 48 mm **Geeetech GT2560 housing** by **lukie80** is licensed under the **Creative Commons - Attribution** license
M11_Snorkle_high M11_Snorkle_low	1,524,106 8,838		150, 17, 104 mm **FJ Cruiser Snorkel Grill** by **LordNova2** is licensed under the **Creative Commons - Attribution - Share Alike** license
M11_stereographic_maze_lowres_NA	16,524		199, 199, 175 mm **Customizable stereographic projection lowres** by**threonin** is licensed under the **Creative Commons - Attribution - Share Alike** license
M11_Ventilated Build Platform_high M11_Ventilated Build Platform_low	210,302 12,638		100, 100, 6 mm **Ventilated Build Platform** by **deherzog** is licensed under the **Public Domain** license
M12_Extruder_Bowden_Adapterc_high M12_Extruder_Bowden_Adapterc_low	20,662 792		115, 19, 20 mm **bowden capable gregs extruder with adapters** by**nicksears** is licensed under the **Creative Commons - Attribution - Share Alike** license
M12_role_drum_NA	35,232		295, 296, 100 mm **Rouleau de PLA / ABS dispenser roll** by **Alf_Arobase**is licensed under the **GNU - GPL** license
M12_SW_Extruder-Hinged-Block_high M12_SW_Extruder-Hinged-Block_low	77,148 792		125, 66, 28 mm **bowden capable gregs extruder with adapters** by**nicksears** is licensed under the **Creative Commons - Attribution - Share Alike** license

M12_Tristruder_18mm_Probe_MouN_???_0high M12_Tristruder_18mm_Probe_MouN_???_0low	12,856 7,384		82, 62, 38 mm **Prusa i3 Tristruder with 18mm Probe Mount** by**insapio** is licensed under the **Creative Commons - Attribution** license
M21_flex_coupler_NA	14,558		50, 50, 100 mm **Flex Coupler with Embedded Hardware** by**chayesSAS** is licensed under the **Creative Commons - Attribution - Share Alike** license
M21_headphone_rest_high M21_headphone_rest_low	189,060 1,816		91, 42, 65 mm **HyperX Cloud Headset rest/stand** by **thatcloudguy** is licensed under the **Creative Commons - Attribution - Share Alike** license
M22_FPV_Pod_Camera_Plate_NA	17,912		81.87, 35.03, 100 mm **FPV Pod (Pan) - Hawkeye 1700 - GoPro/Xiaomi Yi + Board Cam Mount** by **BI0K3** is licensed under the**Creative Commons - Attribution - Share Alike**license
M22_FPV_Pod_Half_NA	47,476		80, 72, 155 mm **FPV Pod (Pan) - Hawkeye 1700 - GoPro/Xiaomi Yi + Board Cam Mount** by **BI0K3** is licensed under the**Creative Commons - Attribution - Share Alike**license

Assembly Objects

Object Name	Triangles	Image	Size (x, y, z) Attribution Link
chainassembly_low	13,020		173, 121, 223 mm
octohedron5_NA	40		122, 95, 129 mm
raindrop_low	25,350		270, 382, 319 mm
randomplacemeN_???_0NA	2608		209, 191, 270 mm

Appendix B – Color, Texture, Lattice Tables

The following textures and colors will be referenced in test case scenarios to simply the definition of test case intent as it applies to the 3MF Material and Properties Extension.

Standard Colors (from 3D Builder)

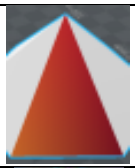
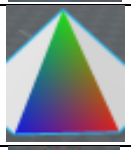
Name	RGB	Swatch
White	#FFFFFF #FFFFFFFF	
Black	#000000 #000000FF	
Gray	#808080 #808080FF	
Dark red	#880015 #880015FF	
Red	#EC1B23 #EC1B23FF	
Orange	#FF7F25 #FF7F25FF	
Yellow	#FEF100 #FEF100FF	
Lime	#B5E61D #B5E61DFF	
Green	#21BB4C #21BB4CFF	
Turquoise	#00A0E8 #00A0E8FF	
Indigo	#3E47CB #3E47CBFF	
Purple	#A349A4 #A349A4FF	

Saturated Colors

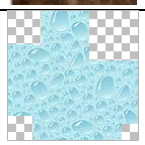
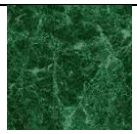
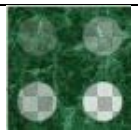
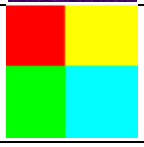
Name	RGB	Swatch
Rgb	#FF0000 #FF0000FF	
rGb	#00FF00 #00FF00FF	
rgB	#0000FF #0000FFFF	
RGb	#FFFF00 #FFFF00FF	
RgB	#FF00FF #FF00FFFF	
rGB	#00FFFF #00FFFFFF	
RGB	#FFFFFF #FFFFFFFF	
Rgb	#000000 #000000FF	

*Upper case RGB = FF, Lower Case rgb = 00

Gradient Combinations

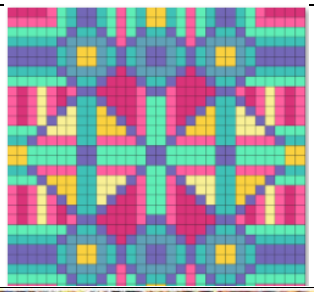
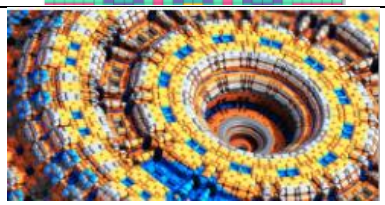
Name	P1	P2	P3	
Gradient_01	White	Black	Gray	
Gradient_02	Dark red	Red	Orange	
Gradient_03	Yellow	Lime	Green	
Gradient_04	Turquoise	Indigo	Purple	
Gradient_05	Rgb	rGb	rgB	
Gradient_06	RGb	RgB	rGB	
Gradient_07	RGB	Rgb	rgb	
Gradient_08	RGB	rGb	rgb	
Gradient_09	RGB	rgB	rgb	

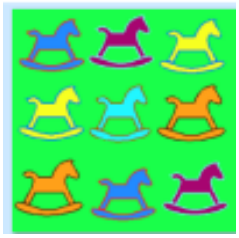
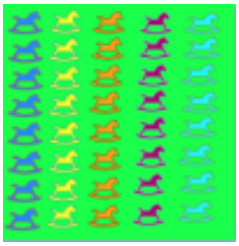
Small Texture Swatches (from 3D Builder)

Name/File	Size	Swatch	Swatch W/Alpha
brmarble.jpg brmarble.png brmarble_A.png	128 X 128		
droplets.jpg droplets.png droplets_A.png droplets_mono.png droplets_mono_A.png	128 X 128		
grmarble.jpg grmarble.png grmarble_A.png	128 X 128		
oak.jpg oak.png oak_A.png oakNumbers.png	128 X 128	 	
pitissue.jpg pitissue.png pitissue_A.png	128 X 128		
purmesh.jpg purmesh.png purmesh_A.png	128 X 128		
quads.jpg quads.png quads_A.png	720 X 720		

PNG without alpha are 24 bit, with alpha are 32 bit

Large Texture Images (Pixabay – No Attribution Required)

Name/File	Size/ Original File Name	Photo
photo_1.jpg photo_1.png photo_1.png_48 photo_1.png_16 16/48 = bit depth	1280 X 833 background-1655938_1280.jpg	
photo_2.jpg photo_2.png	1280 X 829 background-2090828_1280.jpg	
photo_3.jpg photo_3.png	1280 X 1280 checkerboard-1943243_1280.png	
photo_4.jpg photo_4.png	1280 X 720 complex-664440_1280.jpg	
photo_5.jpg photo_5.jpg	1280 X 853 snail-shells-65358_1280.jpg	
photo_6.jpg photo_6.png	960 X 1280 substances-43315_1280.jpg	

Name/File	**Size/ Original File Name**	**Photo**
Woman_200.jpg Woman_3000.jpg	200 X 200 3000 X 3000 woman-101542.jpg	
Horse_350.png Horse_4000.png	350 X 350 4000 X 4000 Created in Paint Program	 

Public Domain PngSuite – Basic Formats

basn0g01 - black & white

basn0g02 - 2 bit (4 level) grayscale

basn0g04 - 4 bit (16 level) grayscale

basn0g08 - 8 bit (256 level) grayscale

basn0g16 - 16 bit (64k level) grayscale

basn2c08 - 3x8 bits rgb color

basn2c16 - 3x16 bits rgb color

basn3p01 - 1 bit (2 color) paletted

basn3p02 - 2 bit (4 color) paletted

basn3p04 - 4 bit (16 color) paletted

basn3p08 - 8 bit (256 color) paletted

basn4a08 - 8 bit grayscale + 8 bit alpha-channel

basn4a16 - 16 bit grayscale + 16 bit alpha-channel

basn6a08 - 3x8 bits rgb color + 8 bit alpha-channel

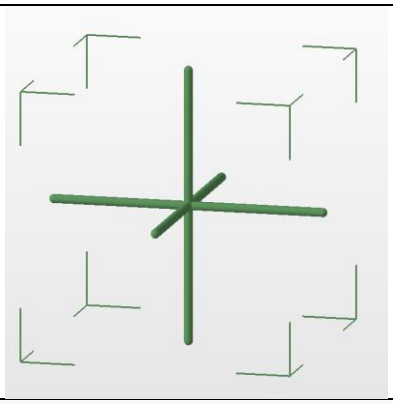
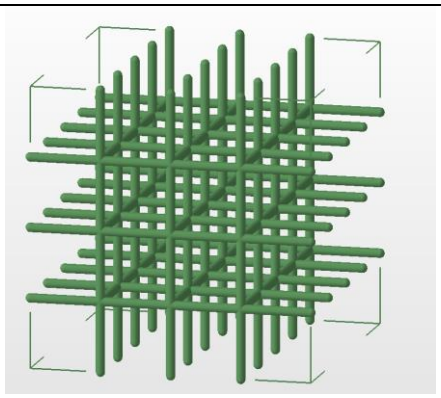
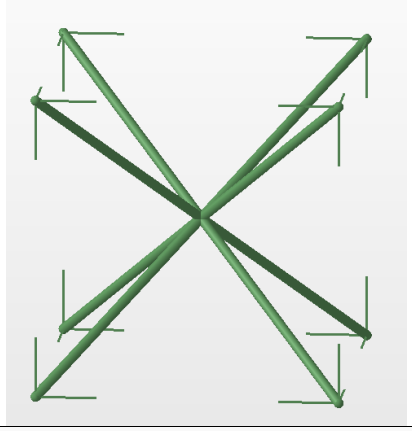
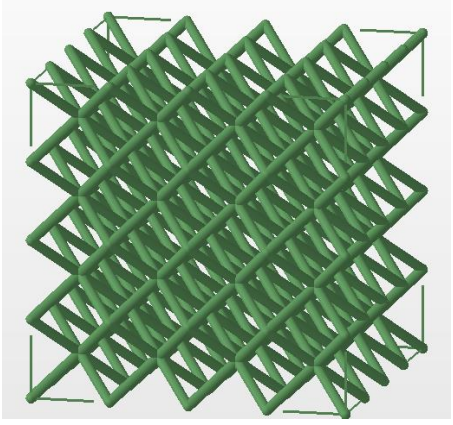
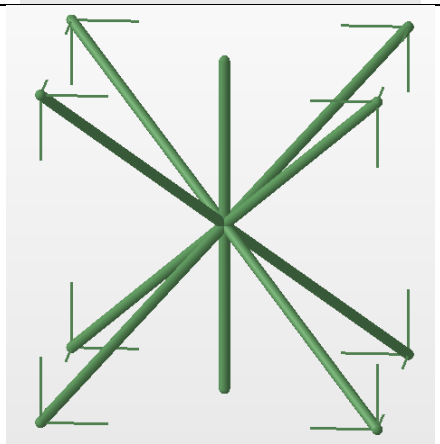
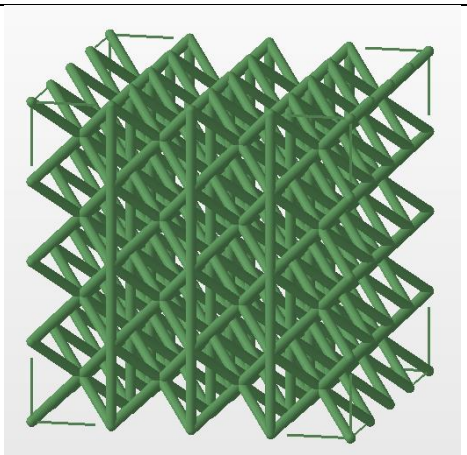
basn6a16 - 3x16 bits rgb color + 16 bit alpha-channel

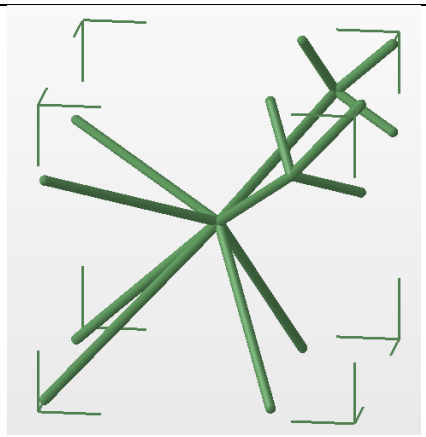
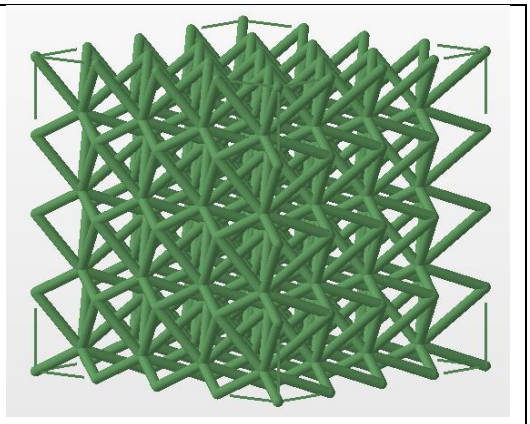
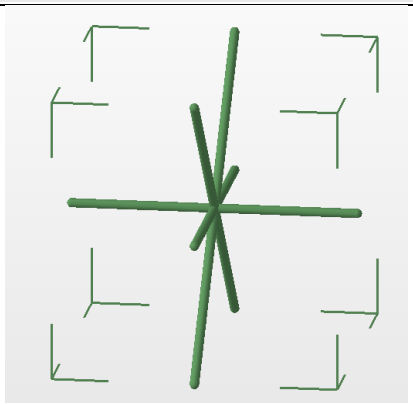
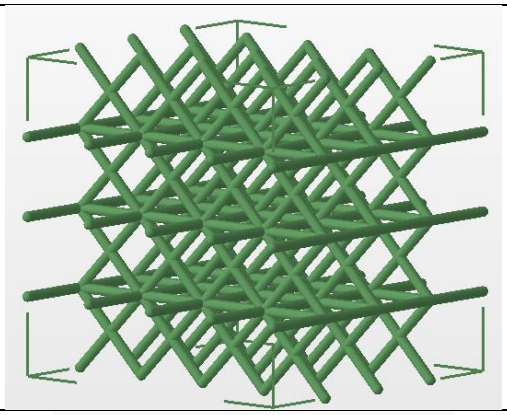
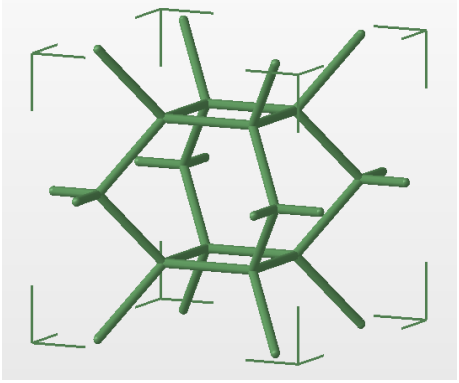
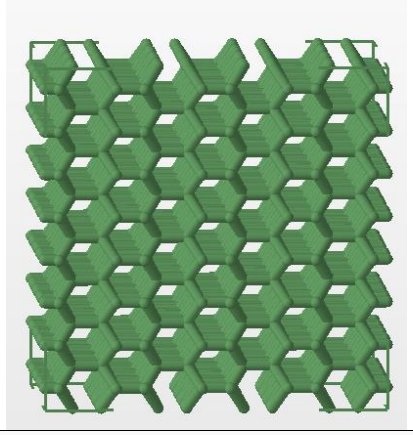
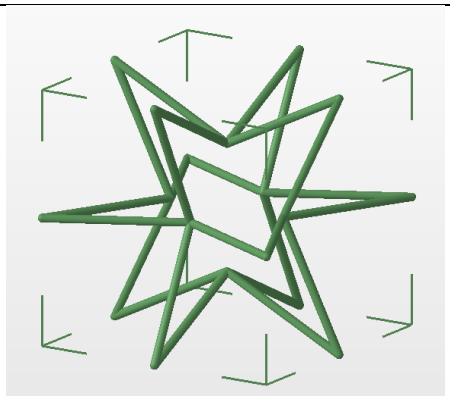
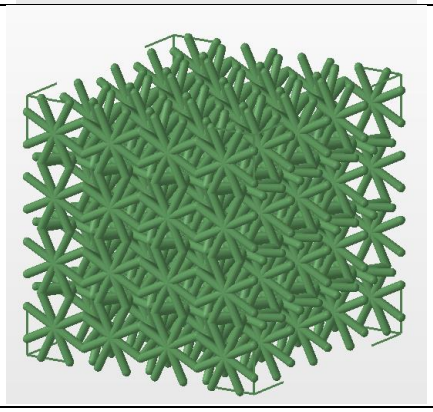
Multi-Property Sets

Name	Layer 1	Layer 2	Layer 3
MultiProp_1	Solid Color Lime	Texture brmarble_A.png	
MultiProp_2	Gradient3	Texture grmarble_A.png	
MultiProp_3	Texture oak.jpg	Solid Color Yellow Alpha #7f	
MultiProp_4	Texture photo_3.jpg	Gradient_05 Alpha #00 on P1	
MultiProp_5	Texture photo_6.png	Texture droplets_A.png	
MultiProp_6	GradieN_???_07	Texture droplets_A.png	Texture pitissue_A.png
MultiProp_7	Texture photo_4.jpg	Solid Color Orange Alpha #7F	Texture oak_A.png
MultiProp_8	Texture purmesh.png	Texture brmarble_A.png	Gradient Alpha of #3f on P1, P2, P3

Beam Lattice Structures

The following beam lattice geometries are representative of lattices that will be used in test cases. Lattice structures may be mapped to a specific geometric shape as show in Appendix A. Application programs such as NetFabb will be used to generation 3MF XML Beam lattice objects for inclusion in test cases. The lattices show below are representative of the lattices that will be used in test cases.

Lattice Name	1 Cell	Multiple Cells
Grid		
X		
Star		

W		
E		
hexagon		
Cross Pattee		

Appendix C - Test Case to Test Suite Mapping

The tables below provide a mapping as to which test cases are supported in each of the 7 test suites. The test case name will start with an indication as to whether it is a positive of negative test case (P or N) followed by the three-digit extension indicator shown in the column header (i.e. SPX), then the test case ID (0101_01). This will result in a test case number such as P_SPX_0101_01.

Positive Test Cases

Test Case	Suites and Extensions Supported						
	Suite 1 SPX	Suite 2 XPM	Suite 3 XXX	Suite 4 SXX	Suite 5 XPX	Suite 6 XXM	Suite 7 BXX
OPC							
0101_01	•	•	•	•	•	•	
0101_02	•	•	•	•	•	•	
0101_03	•	•	•	•	•	•	
0102_01	•	•	•	•	•	•	
0102_02	•	•	•	•	•	•	
0102_03	•	•	•	•	•	•	
0103_01	•	•	•	•	•	•	
0104_01	•	•	•	•	•	•	
0104_02	•	•	•	•	•	•	
0104_03	•	•	•	•	•	•	
0106_01	•	•	•	•	•	•	
0106_02	•	•	•	•	•	•	
0107_01	•	•		•	•		
0107_02	•	•		•	•		
Core							
0302_01	•	•	•	•	•	•	
0302_02	•	•	•	•	•	•	
0302_03	•	•	•	•	•	•	
0304_02	•	•	•	•	•	•	
0304_03	•	•	•	•	•	•	
0304_04	•	•	•	•	•	•	
0306_01	•	•	•	•	•	•	
0306_02	•	•	•	•	•	•	
0306_03	•	•	•	•	•	•	
0306_04	•	•	•	•	•	•	
0306_05	•	•	•	•	•	•	
0306_06	•	•	•	•	•	•	
0306_07	•	•	•	•	•	•	
0307_01	•	•	•	•	•	•	
0308_01	•	•	•	•	•	•	
0309_01	•	•	•	•	•	•	
0310_01	•	•	•	•	•	•	
0311_01	•	•	•	•	•	•	
0312_01	•	•	•	•	•	•	
0313_01	•	•	•	•	•	•	
0314_01	•	•	•	•	•	•	
0314_02	•	•	•	•	•	•	

0314_03		•	•		•	•	
0314_04		•	•		•	•	
0314_05		•	•		•	•	
0315_01	•	•	•	•	•	•	
0316_01	•	•	•	•	•	•	
0317_01	•	•	•	•	•	•	
0318_01	•	•	•	•	•	•	
0319_01	•	•	•	•	•	•	
0321_01	•	•	•	•	•	•	
0322_01	•	•	•	•	•	•	
0323_01	•	•	•	•	•	•	
0323_02	•	•	•	•	•	•	
0324_01	•	•			•		
0325_01	•	•	•	•	•	•	
0326_01	•	•	•	•	•	•	
0326_02	•	•	•	•	•	•	
0326_03		•	•		•	•	
0327_01	•	•	•	•	•	•	
0328_01	•	•	•	•	•	•	
0328_02	•	•	•	•	•	•	
0329_01	•	•	•	•	•	•	
0330_01	•	•	•	•	•	•	
0331_01	•	•	•	•	•	•	
0333_01	•	•	•	•	•	•	
0333_02	•	•	•	•	•	•	
0333_03		•	•		•	•	
0334_01	•	•	•	•	•	•	
0334_02	•	•	•	•	•	•	
0335_01	•	•		•	•		
0335_02	•	•	•	•	•	•	
0335_03	•	•	•	•	•	•	
0335_04	•	•	•	•	•	•	
0336_01	•	•	•	•	•	•	
0336_02	•	•	•	•	•	•	
0337_01	•	•	•	•	•	•	
0337_02	•	•	•	•	•	•	
0337_03	•	•	•	•	•	•	
0337_04	•	•	•	•	•	•	
0337_05	•	•	•	•	•	•	
0337_06	•	•			•		
0338_01	•	•	•	•	•	•	
0339_01	•	•	•	•	•	•	
0340_01	•			•			
0340_02	•			•			
0340_03	•			•			
0340_04	•			•			
Material							
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0501_04		•				•	

0501_07		•				•	
0501_08		•				•	
0501_09		•				•	
0502_01		•				•	
0502_02		•				•	
0502_03		•				•	
0502_04		•				•	
0502_05		•				•	
0503_01		•				•	
0503_02		•				•	
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0503_06		•				•	
0503_07		•				•	
0503_08		•				•	
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0504_02		•				•	
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0506_01		•				•	
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0530_09		•				•	
Production							
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0701_12	•						
0701_13	•						
0701_14	•						
0702_01		•			•		
0702_02		•			•		
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0702_05		•			•		
0702_06		•			•		
0703_01	•	•			•		
0703_02	•	•			•		

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0703_04	•	•			•		
0703_05	•	•			•		
0703_06	•	•			•		
0703_07	•	•			•		
0703_08	•	•			•		
0703_09	•	•			•		
0703_10	•	•			•		
0703_11	•	•			•		
0703_12	•	•			•		
0704_01	•						
0704_02	•						
0704_03	•						
0704_04	•						
0705_01	•	•			•		
0706_01	•	•			•		
Misc							
0901_01	•	•	•	•	•	•	
0901_02	•	•	•	•	•	•	
0901_03	•	•	•	•	•	•	
0901_04	•	•	•	•	•	•	
0901_05	•	•	•	•	•	•	
0901_06	•	•	•	•	•	•	
0901_07	•	•	•	•	•	•	
0901_08	•	•	•	•	•	•	
0901_09	•	•	•	•	•	•	
0901_10	•	•	•	•	•	•	
0901_11	•	•	•	•	•	•	
0901_12	•	•	•	•	•	•	
0902_01	•	•	•	•	•	•	
0902_02	•	•	•	•	•	•	
0902_03	•	•	•	•	•	•	
0902_04	•	•	•	•	•	•	
0902_05	•	•	•	•	•	•	
0902_06	•	•	•	•	•	•	
0903_01	•	•	•	•	•	•	
0903_02	•	•	•	•	•	•	
0903_03	•	•	•	•	•	•	
0903_04	•	•	•	•	•	•	
0903_06	•	•	•	•	•	•	
0904_01	•	•	•	•	•	•	
0904_02	•	•	•	•	•	•	
0904_03	•	•	•	•	•	•	
0904_04	•	•	•	•	•	•	
0905_01	•	•	•	•	•	•	
0905_02	•	•	•	•	•	•	
0905_03	•	•	•	•	•	•	
0905_04	•	•	•	•	•	•	
0905_05	•	•	•	•	•	•	
0905_06	•	•	•	•	•	•	
0905_07	•	•	•	•	•	•	

0905_08	•	•	•	•	•	•	
0905_09	•	•	•	•	•	•	
0905_10	•	•	•	•	•	•	
0905_12	•	•	•	•	•	•	
0905_13	•	•	•	•	•	•	
0906_01	•	•	•	•	•	•	
0906_02	•	•	•	•	•	•	
0906_03	•	•	•	•	•	•	
0906_04	•	•	•	•	•	•	
0906_05	•	•	•	•	•	•	
0906_06	•	•	•	•	•	•	
0907_01	•	•	•	•	•	•	
0907_02	•	•	•	•	•	•	
0907_03	•	•	•	•	•	•	
0907_04	•	•	•	•	•	•	
0909_01	•	•	•	•	•	•	
0909_02	•			•			
0909_03	•	•	•	•	•	•	
0909_04		•	•		•	•	
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0909_06	•			•			
0909_07		•			•		
0909_08		•			•		
0910_01	•	•	•	•	•	•	
0910_02	•	•	•	•	•	•	
0910_03	•	•	•	•	•	•	
0910_04	•	•	•	•	•	•	
0910_05	•	•	•	•	•	•	
0910_06	•	•			•		
0911_01	•	•	•	•	•	•	
0912_01	•	•	•	•	•	•	
0913_01	•	•	•	•	•	•	
0914_01	•	•		•	•	•	
0915_01	•	•			•		
Slice							
1501_01	•			•			
1501_02	•			•			
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1517_02	•			•			
1518_01	•			•			
Beam							
2001_01	•						•
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2013_02	•						•
2013_03	•						•
2014_01	•						•
2014_02	•						•
2015_01	•						•
2015_02	•						•
2015_03	•						•
2015_04	•						•
2015_05	•						•
2015_06	•						•
2015_07	•						•
2016_01	•						•
2017_01	•						•

Negative Test Cases

Test Case	Suites and Extensions Supported						
	Suite 1 SPX	**Suite 2 XPM**	**Suite 3 XXX**	**Suite 4 SXX**	**Suite 5 XPX**	**Suite 6 XXM**	**Suite 7 BXX**
OPC							
0202_01	•	•	•	•	•	•	
0203_01	•	•	•	•	•	•	
0204_01	•	•	•	•	•	•	
0205_01	•	•	•	•	•	•	
0205_02	•	•	•	•	•	•	
0206_01	•	•	•	•	•	•	
0207_01	•	•	•	•	•	•	
Core							
0402_01	•	•	•	•	•	•	
0402_02	•	•	•	•	•	•	
0402_03	•	•	•	•	•	•	
0402_04	•	•	•	•	•	•	
0403_01	•	•	•	•	•	•	
0404_01	•	•	•	•	•	•	
0404_02	•	•	•	•	•	•	
0404_03	•	•	•	•	•	•	
0404_04	•	•	•	•	•	•	
0405_01	•	•	•	•	•	•	
0405_02	•	•	•	•	•	•	
0405_03	•	•			•		
0405_05	•	•	•	•	•	•	
0406_01	•	•	•	•	•	•	
0406_02	•	•			•		
0407_01	•	•			•		
0407_02	•	•	•	•	•	•	
0409_01	•	•	•	•	•	•	
0410_01	•	•	•	•	•	•	
0410_02	•			•			
0410_03	•	•	•	•	•	•	
0410_04	•			•			
0411_01	•	•	•	•	•	•	
0412_01	•	•	•	•	•	•	
0412_02	•			•			
0412_03	•			•			
0412_04	•			•			
0413_01	•	•			•		
0413_02	•	•	•	•	•	•	
0415_01	•	•			•		
0415_02	•	•			•		
0415_03	•	•			•		
0415_04		•			•		
0416_01		•	•		•	•	
0416_02		•	•		•	•	
0417_01	•			•			
0418_01		•	•		•	•	

0419_01	•	•	•	•	•	•	
0420_01	•	•	•	•	•	•	
0421_01	•	•	•	•	•	•	
0422_01	•	•	•	•	•	•	
0424_01	•	•	•	•	•	•	
0426_01		•	•		•	•	
0427_01	•	•	•	•	•	•	
0428_01	•	•	•	•	•	•	
Material							
0601_01		•				•	
0601_02		•					
0602_01		•				•	
0602_02		•				•	
0602_03		•				•	
0602_04		•				•	
0604_01		•				•	
0604_02		•				•	
0604_03		•				•	
0604_04		•				•	
0605_01		•				•	
0605_02		•				•	
0606_01		•				•	
0606_02		•				•	
0606_03		•				•	
0607_01		•				•	
0608_01		•				•	
0609_01		•				•	
0609_02		•				•	
0609_03		•				•	
0609_04		•				•	
0609_05		•				•	
0609_06		•				•	
0609_07		•				•	
0609_08		•				•	
0609_09		•				•	
0609_10		•				•	
0609_11		•				•	
0610_01		•				•	
0610_02		•				•	
0610_03		•				•	
Production							
0801_01	•	•			•		
0801_02	•	•			•		
0801_03	•	•			•		
0801_04	•	•			•		
0801_05	•	•			•		
0801_06	•	•			•		
0801_07	•						
0801_08	•						
0801_09	•						
0802_01	•	•			•		

0802_02	•	•			•		
0802_03	•	•			•		
0802_04	•	•			•		
0802_05	•	•			•		
0803_01	•	•			•		
Slice							
1601_01	•			•			
1601_02	•			•			
1601_03	•			•			
1601_04	•			•			
1601_05	•			•			
1604_01	•			•			
1605_01	•			•			
1606_01	•			•			
1607_01	•			•			
1608_01	•			•			
1609_01	•			•			
1609_02	•			•			
1610_01	•			•			
1612_01	•			•			
Beam							
2501_01	•						•
2501_02	•						•
2501_03	•						•
2501_04	•						•
2502_01	•						•
2502_02	•						•
2502_03	•						•
2502_04	•						•
2502_05	•						•
2502_06	•						•
2503_01	•						•
2503_02	•						•
2503_03	•						•
2503_04	•						•
2503_05	•						•
2503_06	•						•
2503_07	•						•
2503_08	•						•
2504_01	•						•
2504_02	•						•
2504_03	•						•
2504_04	•						•
2504_05	•						•
2505_01	•						•
2505_02	•						•
2505_03	•						•
2505_04	•						•