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# 3MF Boolean Operations Extension

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## Specification & Reference Guide

**Version**    **0.7.0**

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**Status**     Draft

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## Preface

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### About this Specification

This 3MF Boolean Operations Extension is an extension to the core 3MF specification. This document cannot stand alone and only applies as an addendum to the core 3MF specification. Usage of this and any other 3MF extensions follow an a la carte model, defined in the core 3MF specification.

Part I, "3MF Documents," presents the details of the primarily XML-based 3MF Document format. This section describes the XML markup that defines the composition of 3D documents and the appearance of each model within the document.

Part II, "Appendices," contains additional technical details and schemas too extensive to include in the main body of the text as well as convenient reference information.

The information contained in this specification is subject to change. Every effort has been made to ensure its accuracy at the time of publication.

This extension **MUST** be used only with Core specification 1.x.

## Document Conventions

See [the 3MF Core Specification conventions](#).

In this extension specification, as an example, the prefix "o" maps to the xml-namespace "http://schemas.microsoft.com/3dmanufacturing/booleanoperations/2022/06". See [Appendix C. Standard Namespace](#).

## Language Notes

See [the 3MF Core Specification language notes](#).

## Software Conformance

See [the 3MF Core Specification software conformance](#).

# Part I: 3MF Documents

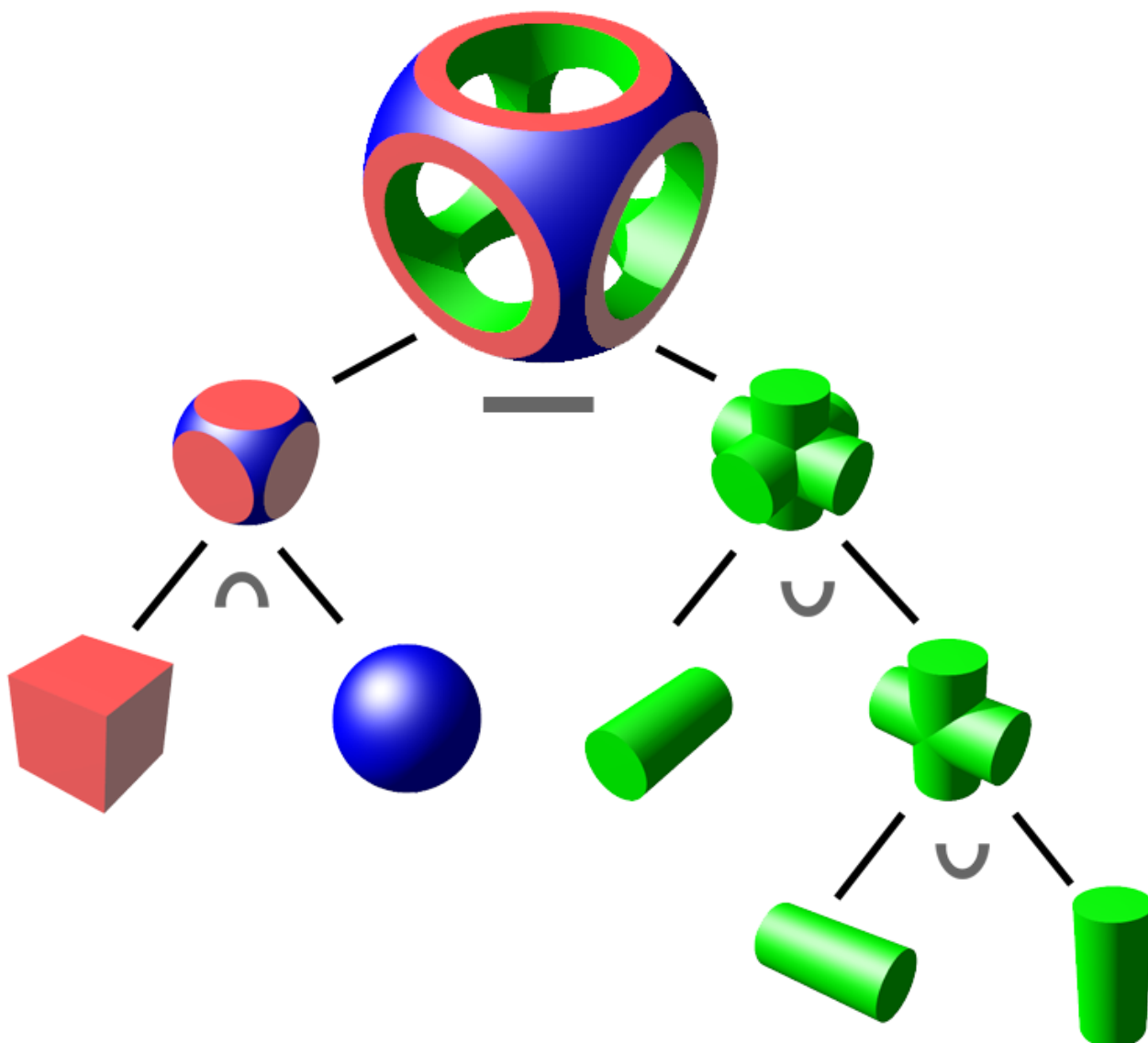
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## Chapter 1. Overview of Additions

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The 3MF Core Specification defines the <components> element in the <object> resource as definition of a logical association of different objects to form an assembly, with the intent to allow reuse of model definitions for an efficient encoding. The resultant shape of a <components> element is the aggregation (union) of each <component> object element.

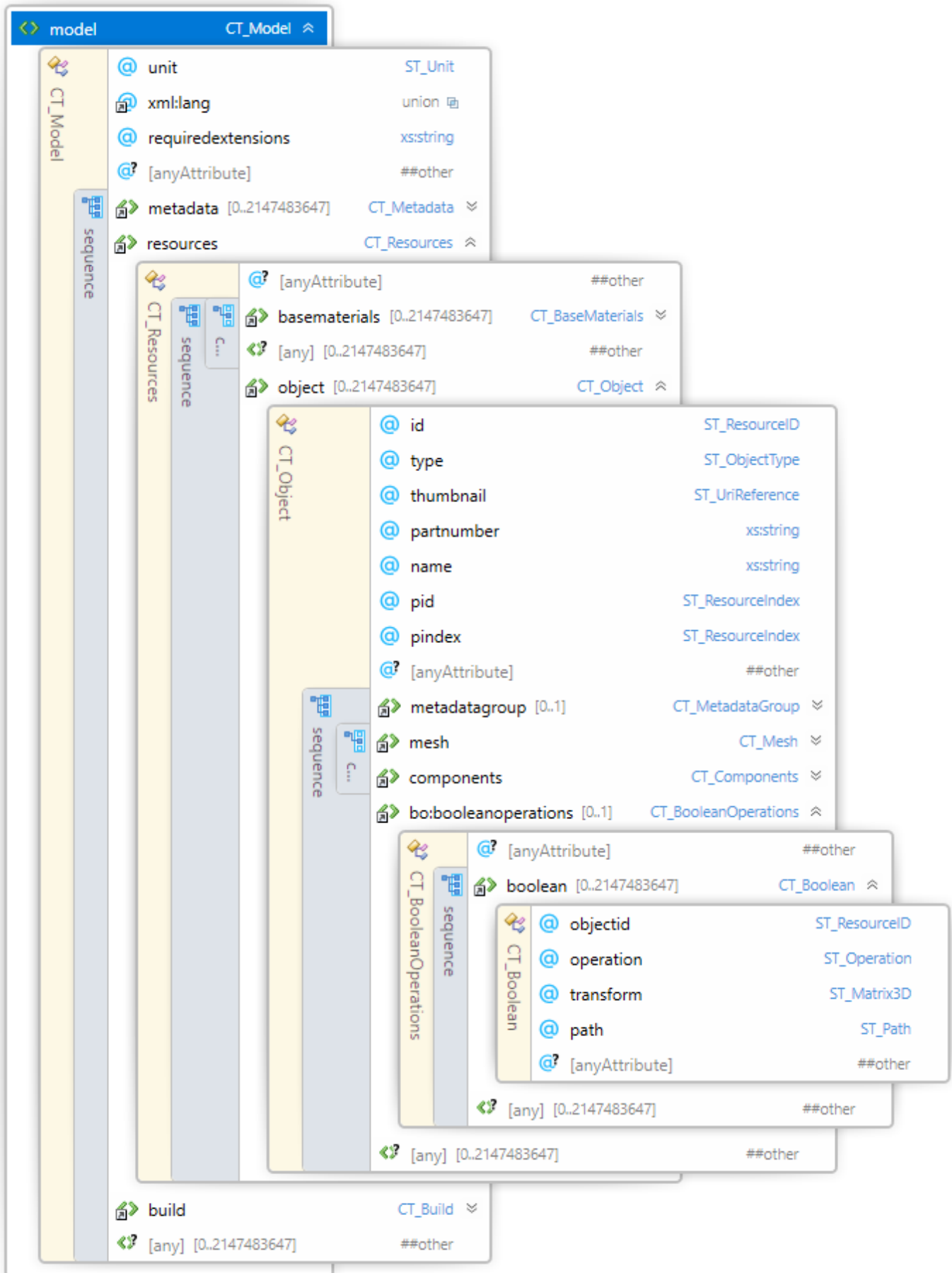
This extension is based in a simplified Constructive Solid Geometry ([CSG](#)) by limiting the scope of the subtracting boolean operations: difference and intersect.



This document describes a new element `<booleanoperations>` in the `<object>` elements that specify options subtracting operations. This element is OPTIONAL for producers but MUST be supported by consumers that specify support for the 3MF Boolean Operations Extension.

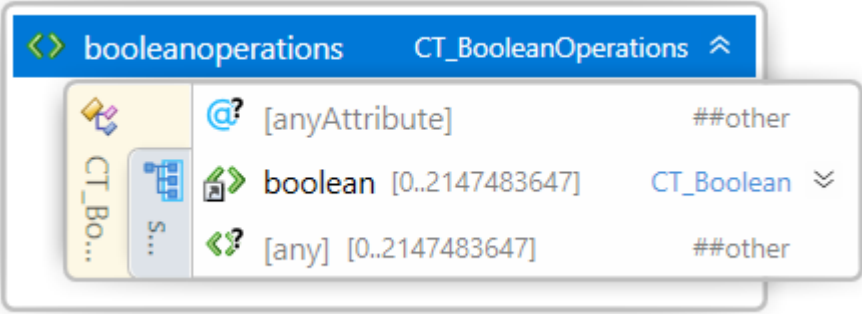
To avoid data loss while parsing, a 3MF package which uses referenced objects MUST enlist the 3MF Boolean Operations Extension as “required extension”, as defined in the core specification. However, if the 3MF Boolean Operations Extension is not enlisted a required, any consumer non-supporting the 3MF Boolean Operations Extension may be able to process the rest of the document.

**Figure 1-1: Overview of 3MF Boolean Operations Extension XML structure**



## Chapter 2. Boolean Operations

Element <booleanoperations>

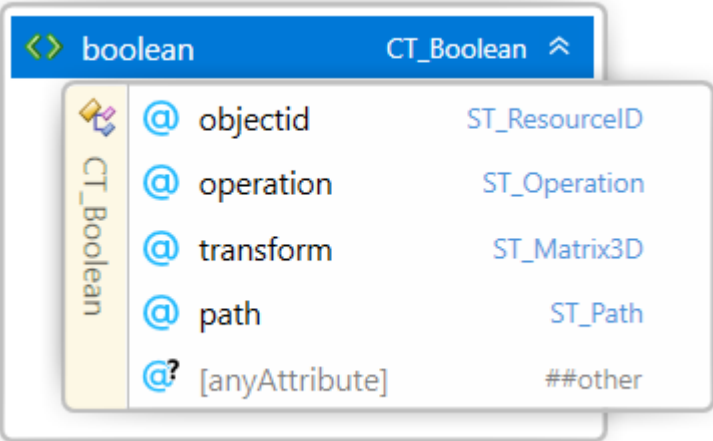


The optional `<booleanoperations>` element contains one or more `<boolean>` elements to perform subtractive boolean operations to the mesh or components elements in the enclosing object.

The boolean operations are iteratively applied in the order defined by the `<boolean>` sequence.

2.1. Boolean

Element `<boolean>`



Name	Type	Use	Default	Annotation
objectid	<b>ST_ResourceID</b>	required		It references an object id performing the boolean operation.
operation	<b>ST_Operation</b>	required		Subtracting boolean operation
transform	<b>ST_Matrix3D</b>			A matrix transform (see <a href="#">3.3. 3D Matrices</a> ) applied to the item to be outputted.
path	<b>ST_Path</b>			A file path to the model file being referenced. The path is an absolute path from the root of the 3MF container.

@anyAttribute

The `<boolean>` element selects a pre-defined object resource to be booleaned to the mesh or component tree in the enclosing object.

**objectid** - Selects the object with the mesh or component to subtract. The object MUST be a mesh object of type "model" (i.e. not a components object), and MUST NOT contain a Boolean Operation.

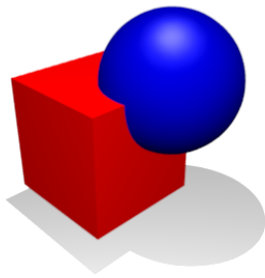
**operation** - The subtracting boolean operation to perform. The options for the subtracting operations are the following:

1. *difference*. The new object shape is defined by the shape in the enclosing object shape that is not in the subtracting object shape. The new object surface property, where overlaps, is defined by the object surface property of the subtracting object(s).
2. *intersection*. The new object shape is defined as the common (clipping) shape in all objects. The new object surface property is defined as the object surface property of the object clipping that surface.

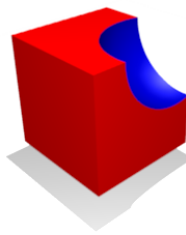
**Note:** The "operation" attribute does not define a *union* operation, since it is implicit performed by the components tree, as defined by [the 3MF Core Specification Components](#).

**transform** - The transform to apply to the selected object before the boolean operation.

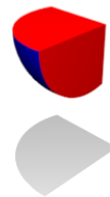
**path** - When used in conjunction with [the 3MF Production extension](#), the "path" attribute references objects in non-root model files. Path is an absolute path to the target model file inside the 3MF container that contains the target object. The use of the path attribute in a <boolean> element is ONLY valid in the root model file.



**union:** components of objects



**difference:** subtraction of object from another one



**intersection:** portion common to objects

The boolean operations follow the fill rule conversion defined by [the 3MF Core Specification fill rule](#).

## Part II. Appendices

### Appendix A. Glossary

See [the 3MF Core Specification glossary](#).

### Appendix B. 3MF XSD Schema

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema
  xmlns="http://schemas.microsoft.com/3dmanufacturing/booleanoperations/2022/06"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"

  targetNamespace="http://schemas.microsoft.com/3dmanufacturing/booleanoperations/2022/06"
  elementFormDefault="unqualified" attributeFormDefault="unqualified"
```

```

blockDefault="#all">
  <xs:import namespace="http://www.w3.org/XML/1998/namespace"
    schemaLocation="http://www.w3.org/2001/xml.xsd"/>
  <xs:annotation>
    <xs:documentation><![CDATA[   Schema notes:

```

Items within this schema follow a simple naming convention of appending a prefix indicating the type of element for references:

Unprefixed: Element names

CT\_: Complex types

ST\_: Simple types

```

  ]]></xs:documentation>
</xs:annotation>
<!-- Complex Types -->
<xs:complexType name="CT_Object">
  <xs:sequence>
    <xs:element ref="booleanoperations" minOccurs="0" maxOccurs="1"/>
    <xs:any namespace="##other" processContents="lax" minOccurs="0"
maxOccurs="2147483647"/>
  </xs:sequence>
</xs:complexType>

<xs:complexType name="CT_BooleanOperations">
  <xs:sequence>
    <xs:element ref="boolean" minOccurs="0" maxOccurs="2147483647"/>
    <xs:any namespace="##other" processContents="lax" minOccurs="0"
maxOccurs="2147483647"/>
  </xs:sequence>
  <xs:anyAttribute namespace="##other" processContents="lax"/>
</xs:complexType>

<xs:complexType name="CT_Boolean">
  <xs:attribute name="objectid" type="ST_ResourceID" use="required"/>
  <xs:attribute name="operation" type="ST_Operation" use="required"/>
  <xs:attribute name="transform" type="ST_Matrix3D"/>
  <xs:attribute name="path" type="ST_Path"/>
  <xs:anyAttribute namespace="##other" processContents="lax"/>
</xs:complexType>

<!-- Simple Types -->
<xs:simpleType name="ST_Operation">
  <xs:restriction base="xs:string">
    <xs:enumeration value="difference"/>
    <xs:enumeration value="intersection"/>
  </xs:restriction>
</xs:simpleType>

<!-- Elements -->
<xs:element name="object" type="CT_Object"/>
<xs:element name="booleanoperations" type="CT_BooleanOperations"/>
<xs:element name="boolean" type="CT_Boolean"/>
</xs:schema>

```

## Appendix C. Standard Namespace

BooleanOperation <http://schemas.microsoft.com/3dmanufacturing/booleanoperations/2022/06>

## Appendix D: Example file

### 3D model

```
<?xml version="1.0" encoding="utf-8" standalone="no"?>
<model xmlns="http://schemas.microsoft.com/3dmanufacturing/core/2015/02"
  xmlns:o="http://schemas.microsoft.com/3dmanufacturing/booleanoperations/2022/06"
  6"
  requiredextensions="o" unit="millimeter" xml:lang="en-US">
  <resources>
    <basematerials id="2">
      <base name="Red" displaycolor="#FF0000" />
      <base name="Green" displaycolor="#00FF00" />
      <base name="Blue" displaycolor="#0000FF" />
    </basematerials>
    <object id="3" type="model" name="Cube" pid="2" pindex="0">
      <mesh>
        <vertices>...</vertices>
        <triangles>...</triangles>
      </mesh>
    </object>
    <object id="4" type="model" name="Sphere" pid="2" pindex="2">
      <mesh>
        <vertices>...</vertices>
        <triangles>...</triangles>
      </mesh>
    </object>
    <object id="5" type="model" name="Cylinder" pid="2" pindex="1">
      <mesh>
        <vertices>...</vertices>
        <triangles>...</triangles>
      </mesh>
    </object>
    <object id="6" type="model" name="Intersected">
      <components>
        <component objectid="3" transform="0.0741111 0 0 0 0.0741111 0 0 0
0.0741111 2.91124 -0.400453 1.60607" />
      </components>
      <booleanoperations>
        <boolean objectid="4" bo:operation="intersection"
transform="0.0741111 0 0 0 0.0741111 0 0 0 0.0741111 2.91124 -0.400453 1.60607"/>
      </booleanoperations>
    </object>
```



```

    <object id="10" type="model" name="Full part">
      <components>
        <component objectid="6"/>
      </components>
      <booleanoperations>
        <boolean objectid="5" bo:operation="difference"
transform="0.0271726 0 0 0 0 0.0271726 0 -0.0680034 0 4.15442 3.58836 5.23705" />
        <boolean objectid="5" bo:operation="difference"
transform="0.0272014 0 0 0 0.0272012 0 0 0 0.0680035 4.05357 6.33412 3.71548" />
        <boolean objectid="5" bo:operation="difference" transform="0 0
-0.0272013 0 0.0272013 0 0.0680032 0 0 5.05103 6.32914 3.35287" />
      </booleanoperations>
    </object>
  </resources>
</build>
  <item objectid="10" transform="25.4 0 0 0 25.4 0 0 0 25.4 0 0 0" />
</build>
</model>

```

## References

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### CSG

From Wikipedia, the free encyclopedia. "Constructive solid geometry".

[https://en.wikipedia.org/wiki/Constructive\\_solid\\_geometry](https://en.wikipedia.org/wiki/Constructive_solid_geometry)

Cornelia Haslinger, Universität Salzburg. "Constructive Solid Geometry in Education". [https://www.uni-salzburg.at/fileadmin/multimedia/Mathematik/images/EMMA/Workshop\\_Turkey/education\\_days/CSG\\_Haslinger\\_low\\_quality.pdf](https://www.uni-salzburg.at/fileadmin/multimedia/Mathematik/images/EMMA/Workshop_Turkey/education_days/CSG_Haslinger_low_quality.pdf).

See the [3MF Core Specification references](#) for additional references.