Lib3MF

Open Source Toolkit for the 3D Manufacturing Format



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| **Version** | 1.0.1 |
| **Status** | Published |

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## About this Library

Lib3MF is a C++ implementation of the 3D Manufacturing Format file standard.

As 3MF shall become an universal 3D Printing standard, its quick adoption is very important. This library shall lower all barriers of adoption to any possible user, let it be software providers, hardware providers, service providers or middleware tools.

Its aim is to offer an open source way to integrate 3MF reading and writing capabilities, as well as conversion and validation tools for input and output data. The 3MF Library shall provide a clean and easy-to-use API to speed up the development and keep integration costs at a minimum.

While the current code is primarily made for a Microsoft Visual Studio Environment, a lot of energy has been put into keeping it as platform independent as far as possible. For example, it compiles well with the GCC compiler, but there is some work left to recode a few platform specific functionalities, which are now covered by the WinRT platform (like XML parsing and ZIP compression). As described below, we are looking for contributors with extensive experience in this field.

To understand this documentation in full extent, it is important to have taken a look at the 3MF specification 1.0, available for free download at <http://3mf.io/what-is-3mf/3mf-specification/>.

For the source code of the library code, please visit <https://github.com/3MFConsortium/lib3mf>.

Example code can be found at <https://github.com/3MFConsortium/lib3mf-examples>.

For any hints, feedback or contributions, please contact [lib3mf@netfabb.com](mailto:lib3mf@netfabb.com).

## General Architecture

The 3MF library API compiles into three different flavours, which are basically just bindings to the same class model:

1. A COM Interface to allow an object-oriented approach in many languages on the Windows platform (e.g. C# or Visual Basic)
2. A COM-like DLL Interface, which exposes the same API as the COM Interface, but comes without the need for global CLSID registration. This allows to link the library natively to many unmanaged object-oriented languages (e.g. C++ or Delphi)
3. A plain C Interface, which wraps the class structure of the API into pseudo-object-oriented. This works very well for C programs and other low level languages, as well as other operating systems.

In the first release, only (2) is fully implemented, while the others will require some work and a proof of concept implementation. More information can be found in the corresponding headers in

1. Include/Model/COM/NMR\_COMInterfaces.h
2. Include/Model/COM/NMR\_COMFactory.h
3. Include/Model/COM/NMR\_DLLInterfaces.h

## Examples

Currently, there are 4 examples which show how to use the library:

* *Cube*: a simple example how to create an empty 3MF document and add custom geometry to it.
* *Converter*: a simple program to convert 3MFs into (binary) STLs and back.
* *Components*: explains component handling in 3MF
* *ExtractInfo*: shows how to import a 3MF and navigate through the in memory representation of the model.

Please note, that you might need a proper understanding of the 3MF Specification in order to get the most out of the example code.

## COM Interfaces

For the 3MF Core spec, the following interfaces specify an in memory representation of the 3MF Document. For a detailed description, please refer to Include/Model/COM/NMR\_COMInterfaces.h.

|  |  |  |
| --- | --- | --- |
| **Interface** | **derived from** | **Description** |
| ILib3MFBase | IUnknown | ILib3MFBase is a base interface, which serves as parent for all interfaces related to the 3MF Library |
| ILib3MFModelWriter | ILib3MFBase | ILib3MFModelWriter encapsulates an writer class for writing the model into a specific file type. |
| ILib3MFModelReader | ILib3MFBase | ILib3MFModelReader encapsulates an reader class for reading a model from a specific file type. |
| ILib3MFModelResource | ILib3MFBase | ILib3MFModelResource is a base interface for all 3MF Resources. |
| ILib3MFModelResourceIterator | ILib3MFBase | ILib3MFModelResourceIterator is a helper class to iterate through arbitrary lists of 3MF resources |
| ILib3MFModelObjectResource | ILib3MFModelResource | ILib3MFModelObjectResource is a base interface for all 3MF Object Resources. |
| ILib3MFModelMeshObject | ILib3MFModelObjectResource | ILib3MFModelMeshObject encapsulates all methods for handling 3MF mesh objects. |
| ILib3MFModelComponentsObject | ILib3MFModelObjectResource | ILib3MFModelComponentsObject encapsulates all methods for handling 3MF component objects. |
| ILib3MFModelBaseMaterial | ILib3MFModelResource | ILib3MFModelBaseMaterial describes a basic material, as defined in the 3MF core specification. |
| ILib3MFModelComponent | ILib3MFBase | ILib3MFModelComponent encapsulates one component node of a 3MF component object. |
| ILib3MFModelBuildItem | ILib3MFBase | ILib3MFModelBuildItem encapsulates all methods for handling 3MF build items. |
| ILib3MFModelBuildItemIterator | ILib3MFBase | ILib3MFModelBuildItemIterator is a helper class to iterate through arbitrary lists of 3MF build items. |
| ILib3MFModelThumbnail | ILib3MFBase | ILib3MFModelThumbnail allows to access package and object thumbnails. |
| ILib3MFModel | ILib3MFBase | ILib3MFModel is the basic instance owning all In-Memory elements of a 3MF file. |
| ILib3MFModelFactory | ILib3MFBase | ILib3MFModelFactory is a factory interface for ILib3MFModel |

## Plain C Interfaces

In order to address a wider user base, the object-oriented interfaces above are also compiled into a DLL for emulating pseudo objects in a procedural language. We do not encourage to use this interface, but there are very valid use cases for it.

Please note, that this wrapper is a lot less type-safe than the other possibilities.

**Example**: The following code in COM

pModel->QueryWriter (L„3mf“, &pModelWriter);

will be translated into

lib3mf\_model\_querywriter (pModel, L„3mf“, &pModelWriter);

All these translations follow the same pattern. For more information, please compare the corresponding header files

1. Include/Model/COM/NMR\_COMInterfaces.h
2. Include/Model/COM/NMR\_DLLInterfaces.h

## Class Reference – Core Specification

The following list shall give a short class overview of the library. The interfaces are all defined centrally in one header file. Please read Include/Model/COM/NMR\_COMInterfaces.h for all details.

All Methods return a HRESULT defining the success of the operation. A successful operation always returns 0 (S\_OK), and a windows error code otherwise. If no success is returned, the output parameters might be in an undefined state.

1. **ILib3MFModelWriter**

ILib3MFModelWriter encapsulates a writer class for a writing the model into a specific file type. Current implementations include (binary) STL and 3MF.

Parent interface: *ILib3MFBase*

|  |  |  |
| --- | --- | --- |
| Method | Parameters | Description |
| WriteToFile | LPCWSTR **pwszFilename**: Filename to write into | Writes out the model as file. The file type is specified by the Model Writer class |
| WriteToStream | IStream\* **pStream***:* IStream to write into | Writes out the model into a COM IStream. Only available on Windows. |

1. **ILib3MFModelReader**

ILib3MFModelReader encapsulates a reader class for reading a model from a specific file type. Current implementations include (binary) STL and 3MF.

Parent interface: *ILib3MFBase*

|  |  |  |
| --- | --- | --- |
| Method | Parameters | Description |
| ReadFromFile | LPCWSTR **pwszFilename***:* Filename to read from | Reads a model from a file. The file type is specified by the Model Reader class. |
| ReadFromStream | IStream\* **pStream***:* IStream to read from | Reads a model from a COM IStream. Only available on Windows. |
| GetWarningCount | DWORD\* **pnWarningCount***:* filled with the count of the occurred warnings. | Returns warning and error count of the read process. |
| GetWarning | DWORD **nIndex***:* Index of the Warning. Valid values are 0 to WarningCount – 1.  DWORD\* **pErrorCode***:* filled with the error code of the warning  LPWSTR **pwszBuffer***:* filled with the error message, may be NULL  DWORD **cbBufferSize*:***size of pwszBuffer (including trailing 0).  DWORD\* **pcbNeededChars***:* filled with the count of the written bytes, or needed buffer size. | Returns warning and error information of the read process |

1. **ILib3MFModelResourceIterator**

ILib3MFModelResourceIterator is a helper class to iterate through arbitrary lists of 3MF resources.

Parent interface: *ILib3MFBase*

|  |  |  |
| --- | --- | --- |
| Method | Parameters | Description |
| MoveNext | BOOL\* **pbHasNext**: returns, if there is a resource to use | Iterates to the next resource in the list. |
| MovePrevious | BOOL\* **pbHasPrevious**: returns, if there is a resource to use | Iterates to the previous resource in the list. |
| GetCurrent | ILib3MFModelResource\*\* **ppResourceInstance**: returns the resource instance | Returns the resource the iterator points at. |
| Clone | ILib3MFModelResourceIterator\*\* **ppIterator**: returns the cloned Iterator instance | Creates a new resource iterator with the same resource list. |

1. **ILib3MFModelResource**

ILib3MFModelResource is a base interface for all 3MF Resources.

Parent interface: *ILib3MFBase*

|  |  |  |
| --- | --- | --- |
| Method | Parameters | Description |
| GetResourceID | DWORD\* **pnResourceID**: Filled with the ID of the Resource Instance | Retrieves the ID of a Model Resource Instance |

1. **ILib3MFModelObjectResource**

ILib3MFModelObjectResource is a base interface for all 3MF Object Resources, i.e. Mesh Objects and Component Objects.

Parent interface: *ILib3MFModelResource*

|  |  |  |
| --- | --- | --- |
| Method | Parameters | Description |
| GetType | DWORD\* **pObjectType**: returns object type constant. See ModelTypes.h for more information. | Retrieves an object's type. |
| SetType | DWORD **ObjectType*:*** object type constant. See ModelTypes.h for more information | Sets an object's type. |
| GetName | LPWSTR **pwszBuffer*:*** buffer to fill  ULONG **cbBufferSize*:*** size of buffer to fill. needs to be at least string length + 1  ULONG\* **pcbNeededChars*:*** returns needed characters in buffer | Retrieves an object's name string. |
| SetName | LPCWSTR **pwszName*:*** new name of the object. (e.g. "Car") | Sets an object's name string. |
| GetPartNumber | LPWSTR **pwszBuffer*:*** buffer to fill  ULONG **cbBufferSize*:*** size of buffer to fill. needs to be at least string length + 1  ULONG**pcbNeededChars*:*** returns needed characters in buffer | Retrieves an object's part number string. |
| SetPartNumber | LPCWSTR **pwszPartNumber*:*** new part number string for referencing parts from an outside context. | Sets an object's part number string. |

1. **ILib3MFModelMeshObject**

ILib3MFModelMeshObject encapsulates all methods for handling 3MF mesh objects.

Parent interface: *ILib3MFModelObjectResource*

|  |  |  |
| --- | --- | --- |
| Method | Parameters | Description |
| GetVertexCount | DWORD\***pnVertexCount**: filled with the vertex count | Returns the vertex count of a mesh object. |
| GetTriangleCount | DWORD\* **pnTriangleCount**: filled with the triangle count | Returns the triangle count of a mesh object. |
| GetVertex | DWORD **nIndex**: Index of the vertex (0 to vertexcount - 1)  MODELMESHVERTEX\* **pVertex**: filled with the vertex coordinates | Returns coordinates of a single vertex of a mesh object. |
| SetVertex | DWORD **nIndex**: Index of the vertex (0 to vertexcount - 1)  MODELMESHVERTEX\* **pVertex**: contains the vertex coordinates | Sets the coordinates of a single vertex of a mesh object. |
| AddVertex | MODELMESHVERTEX\* **pVertex**: contains the vertex coordinates  DWORD\* **pnIndex**: filled with the new Index of the vertex | Adds a single vertex to a mesh object. |
| GetTriangle | DWORD **nIndex**: Index of the triangle (0 to trianglecount - 1)  MODELMESHTRIANGLE\* **pTriangle**: filled with the triangle indices | Returns indices of a single triangle of a mesh object. |
| SetTriangle | DWORD **nIndex*:*** Index of the triangle (0 to trianglecount - 1)  MODELMESHTRIANGLE\* **pTriangle**: contains the triangle indices | Sets the indices of a single triangle of a mesh object |
| AddTriangle | MODELMESHTRIANGLE\* **pTriangle**: contains the triangle indices  DWORD\* **pnIndex**: filled with the new Index of the vertex | Adds a single triangle to a mesh object. |
| GetVertices | MODELMESHVERTEX\* **pVertices**: buffer filled with the vertex coordinates  DWORD **nBufferSize**: size of the buffer in elements, must be at least vertexcount  DWORD\* **pnVertexCount**: returns how many vertices have been written | Retrieves all vertex coordinates of a mesh object. |
| GetTriangleIndices | MODELMESHTRIANGLE\* **pIndices**: buffer filled with the triangle indices  DWORD **nBufferSize**: size of the buffer in elements, must be at least trianglecount  DWORD\* **pnTriangleCount**: returns how many triangles have been written | Retrieves all triangle indices of a mesh object. |
| SetGeometry | MODELMESHVERTEX\* **pVertices**: Array of vertex coordinates  DWORD **nVertexCount**: Size of the vertex array  MODELMESHTRIANGLE\* **pTriangles**: Array of triangle indices  DWORD **nTriangleCount**: Size of the triangle array | Sets the whole geometry of a mesh object. |

1. **ILib3MFModelComponentsObject**

ILib3MFModelComponentsObject encapsulates all methods for handling 3MF component objects.

Parent interface: *ILib3MFModelObjectResource*

|  |  |  |
| --- | --- | --- |
| Method | Parameters | Description |
| AddComponent | ILib3MFModelObjectResource\* **pObject**: object to add as component. May not lead to circular references!  MODELTRANSFORM\* **pmTransform**: optional transform matrix for the component  ILib3MFModelComponent\*\* **ppComponent**: returns new component instance | Adds a new component to a component object. |
| GetComponent | DWORD **nIndex**: index of the component to retrieve (0 to componentcount - 1)  ILib3MFModelComponent\*\* **ppComponent**: retrieves component instance | Retrieves a component from a component object. |
| GetComponentCount | DWORD\* **pComponentCount**: returns the component count | Retrieves the component count of a component object. |

1. **ILib3MFModelComponent**

ILib3MFModelComponent encapsulates one component node of a 3MF component object. It links to other object resources of the same model.

Parent interface: *ILib3MFBase*

|  |  |  |
| --- | --- | --- |
| Method | Parameters | Description |
| GetObjectResourceID | DWORD\* **pnResourceID**: returns the associated resource ID | Returns the associated resource ID of the component. |
| GetObjectResource | ILib3MFModelObjectResource\*\***ppResource**: returns the associated resource instance | Returns the associated resource Instance of the component. |
| GetTransform | MODELTRANSFORM\* **pmTransformation**: filled with the component transformation matrix. | Returns the transformation matrix of the component. |
| SetTransform | MODELTRANSFORM\* **pmTransformation**: new transformation matrix | Sets the transformation matrix of the component. |
| HasTransform | BOOL\* **pbHasTransform**: if true is returned, the transformation is not equal to the identity | Returns, if the component has a different transformation than the identity matrix. |

1. **ILib3MFModelBuildItemIterator**

ILib3MFModelBuildItemIterator is a helper class to iterate through arbitrary lists of 3MF build items.

Parent interface: *ILib3MFBase*

|  |  |  |
| --- | --- | --- |
| Method | Parameters | Description |
| MoveNext | BOOL\* **pbHasNext**: returns, if there is a build item to use | Iterates to the next build item in the list. |
| MovePrevious | BOOL\* **pbHasPrevious**: returns, if there is a build item to use | Iterates to the previous build item in the list. |
| GetCurrent | ILib3MFModelBuildItem\*\* **ppBuildItemInstance**: returns the build item instance | Returns the build item the iterator points at. |
| Clone | ILib3MFModelBuildItemIterator\*\* **ppIterator**: returns the cloned Iterator instance | Creates a new build item iterator with the same build item list. |

1. **ILib3MFModelBuildItem**

ILib3MFModelBuildItem encapsulates all methods for handling 3MF build items.

Parent interface: *ILib3MFBase*

|  |  |  |
| --- | --- | --- |
| Method | Parameters | Description |
| GetObjectResourceID | DWORD\* **pnID**: returns the associated resource ID | Retrieves the object resource associated to a build item. |
| GetObjectResource | ILib3MFModelObjectResource\*\***ppResource**: returns the associated resource instance | Returns the associated resource Instance of the build item. |
| GetObjectTransform | MODELTRANSFORM\* **pmTransformation**: filled with the component transformation matrix. | Returns the transformation matrix of the build item. |
| SetObjectTransform | MODELTRANSFORM\* **pmTransformation**: new transformation matrix | Sets the transformation matrix of the build item. |
| HasObjectTransform | BOOL\* **pbHasTransform**: if true is returned, the transformation is not equal to the identity | Returns, if the build item has a different transformation than the identity matrix. |
| GetPartNumber | LPWSTR **pwszBuffer**: buffer to fill  ULONG **cbBufferSize**: size of buffer to fill. needs to be at least string length + 1.  ULONG\* **pcbNeededChars**: returns needed characters in buffer | Retrieves a build item's part number string. |
| SetPartNumber | LPCWSTR **pwszPartNumber**: new part number string for referencing parts from the outside world. | Sets a build item's part number string |

1. **ILib3MFModel**

ILib3MFModel is the basic instance owning all In-Memory elements of a 3MF file.

Parent interface: *ILib3MFBase*

|  |  |  |
| --- | --- | --- |
| Method | Parameters | Description |
| SetUnit | DWORD **Unit**: enum value for the model unit (see NMR\_ModelTypes.h for details) | sets the units of a model |
| GetUnit | DWORD\* **pUnit**: enum value for the model unit (see NMR\_ModelTypes.h for details) | retrieves the units of a model |
| SetLanguage | LPCWSTR **pwszLanguage**: Language string identifier | sets the language of a model |
| GetLanguage | LPWSTR **pwszBuffer**: buffer to fill  ULONG **cbBufferSize**: size of buffer to fill. needs to be at least string length + 1.  ULONG\* **pcbNeededChars**: returns needed characters in buffer | retrieves the language of a model |
| QueryWriter | LPCWSTR **pwszWriterClass**: string identifier for the file (currently "stl" and "3mf")  ILib3MFModelWriter\*\* **ppWriter**: returns the writer instance | creates a model writer instance for a specific file type |
| QueryReader | LPCWSTR **pwszReaderClass**: string identifier for the file (currently "stl" and "3mf")  ILib3MFModelReader \*\* **ppReader**: returns the reader instance | creates a model reader instance for a specific file type |
| GetResourceByID | DWORD **nResourceID**: Resource ID  ILib3MFModelResource\*\* **ppResource**: returns the resource instance | finds a model resource by its id |
| GetBuildItems | ILib3MFModelBuildItemIterator\*\* **ppIterator**: returns the iterator instance | creates a build item iterator instance with all build items |
| GetResources | ILib3MFModelResourceIterator\*\* **ppIterator**: returns the iterator instance | creates a resource iterator instance with all resources |
| GetObjects | ILib3MFModelResourceIterator\*\* **ppIterator**: returns the iterator instance | creates a resource iterator instance with all object resources |
| GetMeshObjects | ILib3MFModelResourceIterator\*\* **ppIterator**: returns the iterator instance | creates a resource iterator instance with all mesh object resources |
| GetComponentsObjects | ILib3MFModelResourceIterator\*\* **ppIterator**: returns the iterator instance | creates a resource iterator instance with all component object resources |
| MergeToModel | ILib3MFModel\*\* **ppMergedModel**: returns the merged model instance | merges all components and objects which are referenced by a build item. The memory is duplicated and a new model is created. |
| AddMeshObject | ILib3MFModelMeshObject\*\* **ppMeshObject**: returns the mesh object instance | adds an empty mesh object to the model |
| AddComponentsObject | ILib3MFModelComponentsObject\*\* **ppComponentsObject**: ppComponentsObject returns the component object instance | adds an empty component object to the model |
| AddBuildItem | ILib3MFModelObjectResource\*\* **pObject**: Object instance associated with the build item  MODELTRANSFORM\* **pTransform**: Transformation matrix to be used  ILib3MFModelBuildItem\*\* **ppBuildItem**: returns the build item instance | adds a build item to the model |

1. **ILib3MFModelFactory**

ILib3MFModelFactory is the global factory class for model instances.

Parent interface: *ILib3MFBase*

|  |  |  |
| --- | --- | --- |
| Method | Parameters | Description |
| CreateModel | ILib3MFModel\*\* **ppModel**: returns created model instance | creates an empty model instance |
| GetSpecVersion | DWORD\* **pMajorVersion**: returns the major version of the specification  DWORD\* **pMinorVersion**: returns the major version of the specification | retrieves the current version of the 3MF implementation and specification |
| GetInterfaceVersion | DWORD\* **pInterfaceVersion**: returns the interface version of the DLL | retrieves the current interface version of the library (build version). this version will increment with each official release of the library, and may be used to ensure API compatibility. |

## License

The 3MF Library is released under the simplified BSD License (<http://opensource.org/licenses/BSD-2-Clause>). In short, this means it is allowed to use this code in closed source applications, open source applications and web services at no charge.

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## Contributors

The current code base is maintained by the 3MF consortium, and is assembled with contributions from the following consortium members:

* Microsoft Corporation, Redmond, WA
* netfabb GmbH, Lupburg, Germany

The development has just begun. We invite everyone interested to contribute test results, bug reports, suggestions or code contributions under the simplified BSD License. We are actively looking for testers on all different platforms and in all different programming languages.

If you are making language bindings for your favourite language, we plead with you to release it public into the Lib3MF repository, as this will enable others to spread the format in an easy way.

The current version of this document and the library code can be obtained from github at <https://github.com/3MFConsortium/lib3mf>.

For more information, contact the 3MF Working Group at <http://3mf.io> or send a mail to [lib3mf@netfabb.com](mailto:lib3mf@netfabb.com).