



<AutomationML/>

**The Glue for Seamless
Automation Engineering**

**Best Practice Recommendations:
ExternalDataReference**

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Preface

AutomationML provides the basis for an efficient data exchange within the engineering process of production systems. The AutomationML standard series IEC 62714 “Engineering data exchange format for use in industrial automation systems engineering” already contains many use cases and guidelines of how system engineering information is modelled.

In order to specify these definitions with examples, to apply them to specific use cases, and to facilitate the first steps with AutomationML, specific issues for the modelling of data in AutomationML are illustrated in Best Practise Recommendations (BPR).

In addition, the BPR shall provide a consistent realisation for specific use cases and shall thus, complement the AutomationML standard documents.

1 Motivation for referencing external data

For a complete description of engineering results or components it might be useful to reference, out of AutomationML, additional descriptive documents. These documents do not necessarily contain automatically evaluable content but they can serve, e.g. as manuals, instructions, or specifications. For the user they only have the purpose to display or print the results.

Specific engineering results, e.g. control programs, can be referenced as well, so that an entirely documented engineering result or components can be delivered with an AutomationML-document.

Data within the documents shall be classified in a way, so that the documents can be identified and grouped regarding the format, the content type, or regarding the language.

Additionally, it shall be possible to store data, e.g. a description, in different languages.

By doing this, a software tool is able to open the attached documents in the correct language with an appropriate viewer.

2 Implementation

Each document is considered as an object that can refer to several files if necessary. Within these references the format of the file itself is named. The document can contain one or more languages and can represent one or more content types. In AutomationML these aspects are modelled as follows:

- Each document shall be modelled as an `InternalElement`.
- The content type shall be assigned to the `InternalElement` as a `RoleRequirement` or `SupportedRoleClass`. The assigned roles have to be directly or indirectly derived from the role class “AutomationMLBPRRoleClassLib/ExternalData” and shall specify the content of the document. Several content types can be assigned to a document using roles.
- If a document is language specific the `InternalElement` shall contain a CAEX attribute with name “aml-DocLang”, if a document contains more than one language it shall contain an unsorted attribute list with name “aml-DocLang” according to BPR_004E List Attributes. The value of the attribute contains the language according to RFC 5646. The attribute is optional but it is recommended to use it for all documents that are language specific.
- Each file assigned to the document is attached via an `ExternalInterface` (of the `InterfaceClass` “AutomationMLBPRInterfaceClassLib/ExternalDataReference”) as a child element of the `InternalElement`.
 - The `ExternalInterface` has an attribute “refURI” of the `AttributeDataType` “xs:anyURI”. The value contains the URI of the corresponding file. The attribute is mandatory.
 - The `ExternalInterface` has an attribute “MIMETYPE” of the `AttributeDataType` “xs:string”. The value contains the MIMETYPE of the corresponding file as main types and sub types according to the Multipurpose Internet Mail Extensions (MIME) standard described in RFC 2046. The attribute is mandatory.

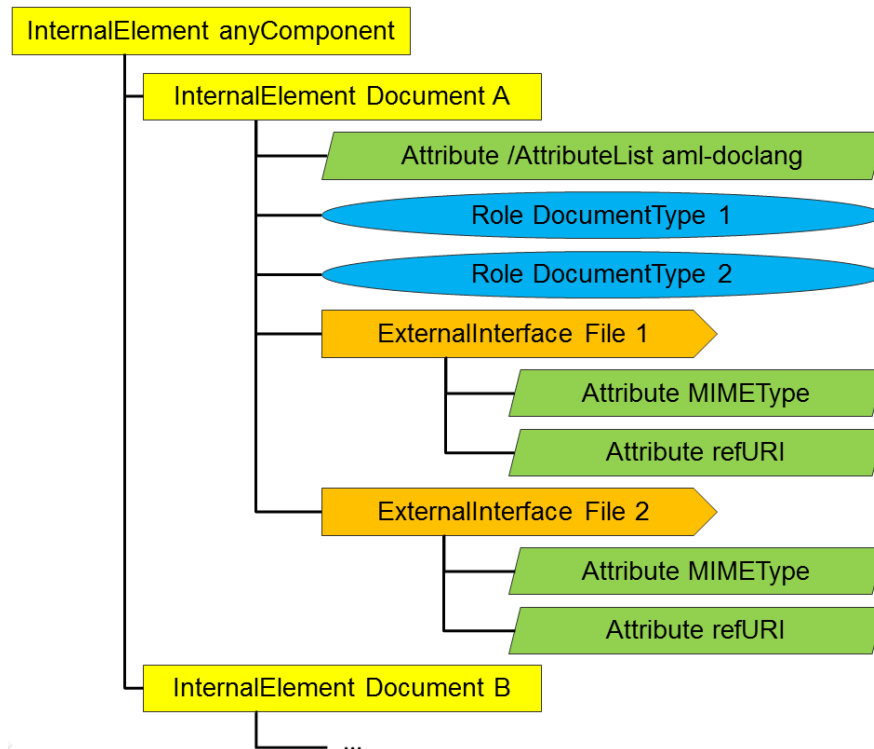


Figure 1 – Structure of an ExternalDataReference

3 Extensions of AutomationML libraries for ExternalDataReference

For the implementation of the ExternalDataReference the following extensions of AutomationML libraries are defined.

3.1 RoleClass

Table 1 – RoleClass ExternalData

Class name	ExternalData
Description	The role class “ExternalData” is an abstract role type for a document type and the base class for all document type roles. It describes different document types. AutomationML document objects shall directly or indirectly reference this role.
Parent class	AutomationMLBaseRoleClassLib/AutomationMLBaseRole
Path for element reference	AutomationMLBPRRoleClassLib/ExternalData
Attributes	None

3.2 InterfaceClass

Table 2 – InterfaceClass ExternalDataReference

Class name	ExternalDataReference
Description	The interface class “ExternalDataReference” shall be used in order to reference external documents out of the scope of AutomationML.
Parent class	AutomationMLInterfaceClassLib/AutomationMLBaseInterface/ExternalDataConnector
Path for element reference	AutomationMLBPRInterfaceClassLib/ExternalDataReference
Attributes	Name: MIMETYPE Name: refURI (by inheritance from parent class)

4 Example

The following examples show different possibilities to attach external data to an AutomationML object using the above defined RoleClasses, Attributes, and ExternalInterfaces.

4.1 Example 1: Each document class consists of a file

Within the first example a manual in German, a part list in German, and a part list in English are attached to a tool object each stored in a separate file. The both German documents are a PDF document, the English document is a Microsoft Word document. Figure 2 shows the structure of the documents.

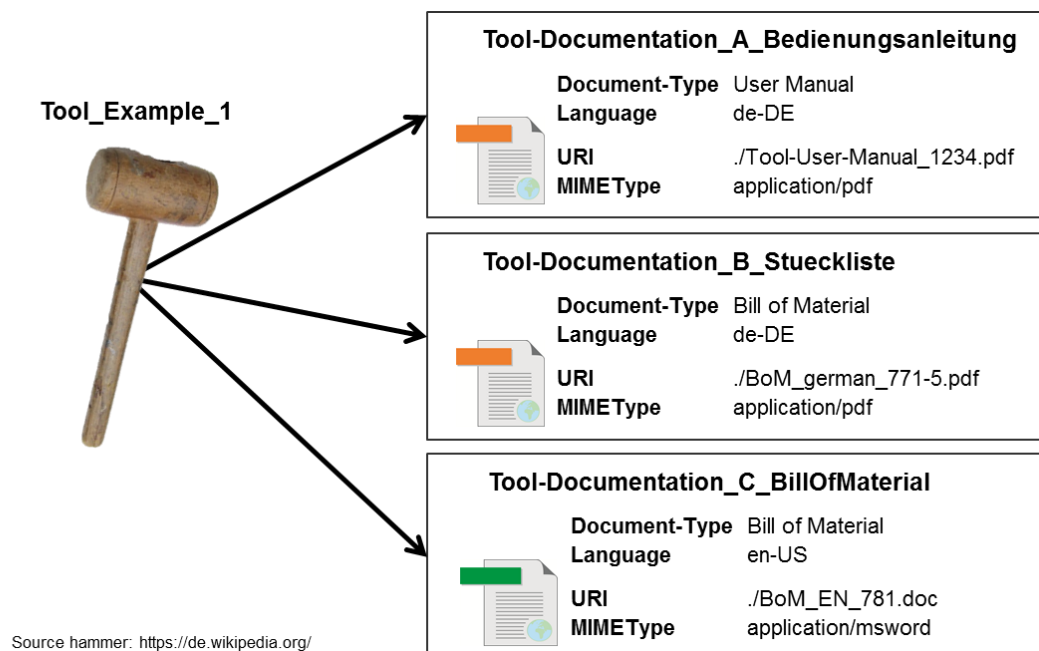


Figure 2 – Document structure of example 1

Figure 3 shows the example in the AutomationML Editor. Figure 4 shows the XML representation of the example.

For each document an InternalElement was created. To this InternalElement a RoleClass is assigned according to the document type. This RoleClass specifies the type and is derived from the RoleClass “ExternalData” (green frame in Figure 3).

Each InternalElement has an attribute “aml-DocLang” which value contains the language of the document. Furthermore, each InternalElement has an ExternalInterface that is derived from the InterfaceClass “ExternalDataReference”. The attribute “MIMEType” provides information about the document format of the file that is referenced by the URI that is stored within the attribute “refURI”.

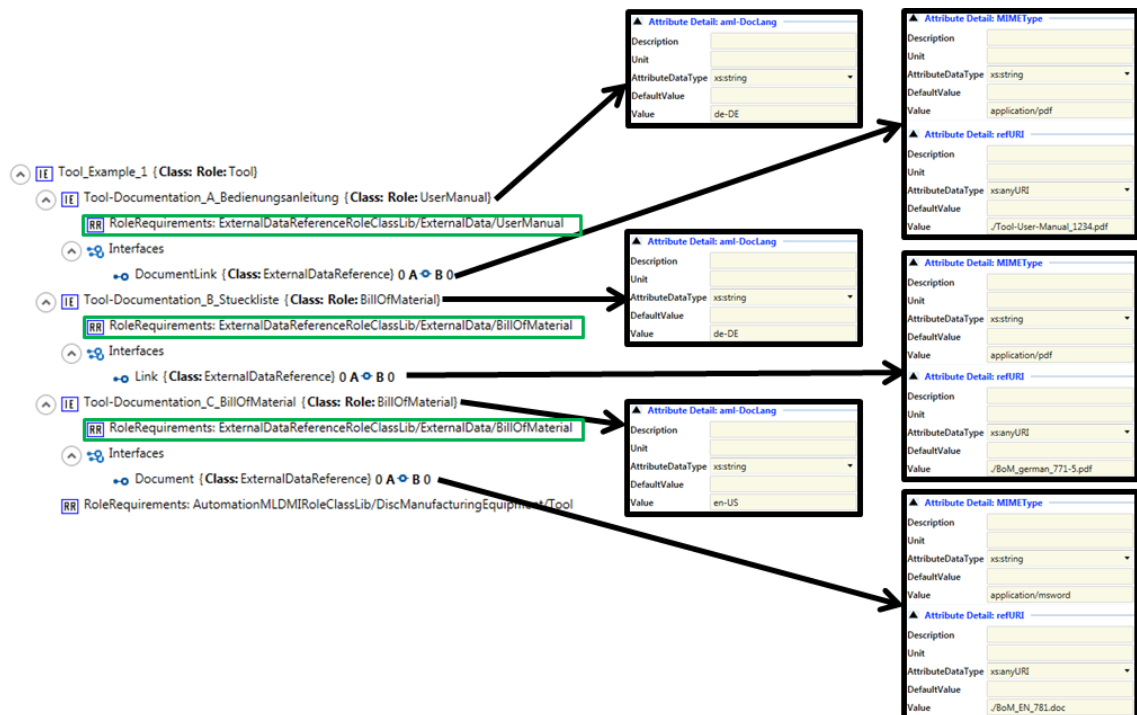


Figure 3 – View of example 1 within the AML Editor

```

<InternalElement Name="Tool_Example_1" ID="be3646cf-2f2a-43d3-a1fc-3012c6828ab5">
  <InternalElement Name="Tool-Docmentation_A_Bedienungsanleitung" ID="554baab0-30ba-4e53-8932-14ec25cce921">
    <Attribute Name="aml-DocLang" AttributeDataType="xs:string">
      <Value>de-DE</Value>
    </Attribute>
    <ExternalInterface Name="DocumentLink" RefBaseClassPath="AutomationMLBPRInterfaceClassLib/ExternalDataReference" ID="0a5ec13b-949e-4ac1-894b-0875d96fa204">
      <Attribute Name="MimeType" AttributeDataType="xs:string">
        <Value>application/pdf</Value>
      </Attribute>
      <Attribute Name="refURI" AttributeDataType="xs:anyURI">
        <Value>./Tool-User-Manual_1234.pdf</Value>
      </Attribute>
    </ExternalInterface>
    <RoleRequirements RefBaseRoleClassPath="AutomationMLBPRRoleClassLib/ExternalData/UserManual" />
  </InternalElement>
  <InternalElement Name="Tool-Docmentation_B_Stueckliste" ID="3ccc2762-d560-4c35-8f89-ff2316516a6f">
    <Attribute Name="aml-DocLang" AttributeDataType="xs:string">
      <Value>de-DE</Value>
    </Attribute>
    <ExternalInterface Name="Link" RefBaseClassPath="AutomationMLBPRInterfaceClassLib/ExternalDataReference" ID="d7941629-03ac-4b95-8c24-e0f76853aa0a">
      <Attribute Name="MimeType" AttributeDataType="xs:string">
        <Value>application/pdf</Value>
      </Attribute>
      <Attribute Name="refURI" AttributeDataType="xs:anyURI">
        <Value>./BoM_german_771-5.pdf</Value>
      </Attribute>
    </ExternalInterface>
    <RoleRequirements RefBaseRoleClassPath="AutomationMLBPRRoleClassLib/ExternalData/BillOfMaterial" />
  </InternalElement>
  <InternalElement Name="Tool-Docmentation_C_BillOfMaterial" ID="ff682cfc-93a5-4145-9f7c-595d24d05088">
    <Attribute Name="aml-DocLang" AttributeDataType="xs:string">
      <Value>en-US</Value>
    </Attribute>
    <ExternalInterface Name="Document" RefBaseClassPath="AutomationMLBPRInterfaceClassLib/ExternalDataReference" ID="9ccfffc16-9ef7-4a4b-b518-0933997e3efa">
      <Attribute Name="MimeType" AttributeDataType="xs:string">
        <Value>application/msword</Value>
      </Attribute>
      <Attribute Name="refURI" AttributeDataType="xs:anyURI">
        <Value>./BoM_EN_781.doc</Value>
      </Attribute>
    </ExternalInterface>
    <RoleRequirements RefBaseRoleClassPath="AutomationMLBPRRoleClassLib/ExternalData/BillOfMaterial" />
  </InternalElement>
  <RoleRequirements RefBaseRoleClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Tool" />
</InternalElement>

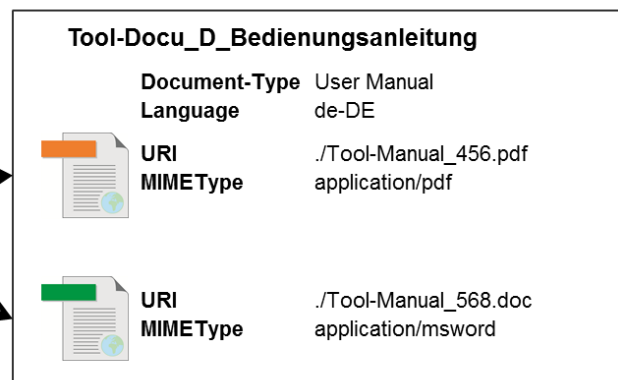
```

Figure 4 – XML representation of example 1

4.2 Example 2: A document consists of several files

In the second example a manual in German is attached to a tool object that consists of two files. One of the two files is a PDF format, the other a Microsoft Word format. Figure 5 shows the structure of the files.

Tool_Example_2



Source screwdriver: <https://de.wikipedia.org/>

Figure 5 – Document structure of example 2

Figure 6 shows the example in the AutomationML Editor. Figure 7 shows the XML representation of the example.

For the documentation an InternalElement was created. To this InternalElement a RoleClass is assigned according to the document type. This RoleClass specifies the type and is derived from the RoleClass "ExternalData" (green frame in Figure 6)

This InternalElement has an attributes „aml-DocLang“ which value contains the language of the document. Furthermore, the InternalElement has two ExternalInterface these are derived from the InterfaceClass "ExternalDataReference". The Attribute "MIMETYPE" provides information about the document format of the file that is referenced by the URI that is stored within the attribute "refURI".

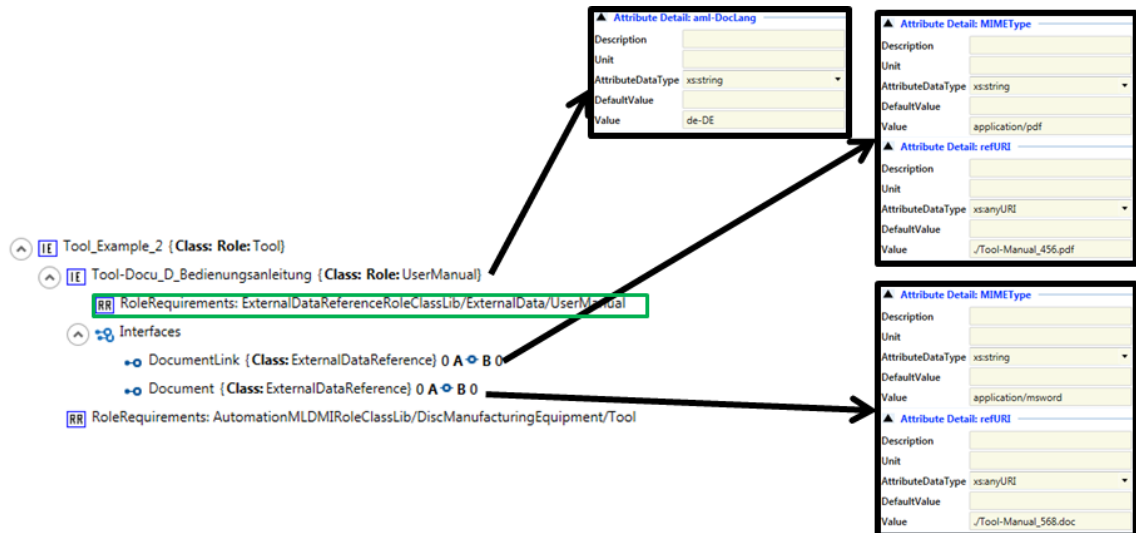


Figure 6 – View of example 2 within the AML Editor

```
<InternalElement Name="Tool_Example_2" ID="15248e57-3220-4a2b-9865-f20467c5b4da">
  <InternalElement Name="Tool-Docu_D_Bedienungsanleitung" ID="628b1ce7-15b9-4210-ba73-eb53146f046b">
    <Attribute Name="aml-DocLang" AttributeDataType="xs:string">
      <Value>de-DE</Value>
    </Attribute>
    <ExternalInterface Name="DocumentLink" RefBaseClassPath="AutomationMLBPRInterfaceClassLib/ExternalDataReference" ID="bdb1ffd5-7149-4f68-91d8-69419bcb4f7">
      <Attribute Name="MIMETYPE" AttributeDataType="xs:string">
        <Value>application/pdf</Value>
      </Attribute>
      <Attribute Name="refURI" AttributeDataType="xs:anyURI">
        <Value>./Tool-Manual_456.pdf</Value>
      </Attribute>
    </ExternalInterface>
    <ExternalInterface Name="Document" RefBaseClassPath="AutomationMLBPRInterfaceClassLib/ExternalDataReference" ID="a8053735-9d89-447d-b9a3-8f70aabe79">
      <Attribute Name="MIMETYPE" AttributeDataType="xs:string">
        <Value>application/msword</Value>
      </Attribute>
      <Attribute Name="refURI" AttributeDataType="xs:anyURI">
        <Value>./Tool-Manual_568.doc</Value>
      </Attribute>
    </ExternalInterface>
    <RoleRequirements RefBaseClassPath="AutomationMLBPRRoleClassLib/ExternalData/UserManual" />
  </InternalElement>
  <RoleRequirements RefBaseClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Tool" />
</InternalElement>
```

Figure 7 – XML representation of example 2

4.3 Example 3: A document contains several classes of documents

In the third example a bilingual manual in German and English is attached to a tool object. The document is a PDF format. Figure 8 shows the structure of the document

Tool_Example_3

**Lang-mixed_Tool-Docu_E_Manual****Document-Type** User Manual**Language** en-US
de-DE**URI** ./Manual_AB3882.pdf**MIMeType** application/pdfSource shovel: <https://de.wikipedia.org/>

Figure 8 – Document structure of example 3

Figure 9 shows the example in the AutomationML Editor. Figure 10 shows the XML representation of the example.

For the documentation an InternalElement was created. To this InternalElement a RoleClass is assigned according to the document type. This RoleClass specifies the type and is derived from the RoleClass “ExternalData” (green frame in Figure 9).

This InternalElement has a list of attributes „aml-DocLang” which list items contains the languages of the document. Furthermore, the InternalElement has an ExternalInterface that is derived from the InterfaceClass “ExternalDataReference”. The attribute “MIMeType” provides information about the document format of the file that is referenced by the URI that is stored within the attribute “refURI”.

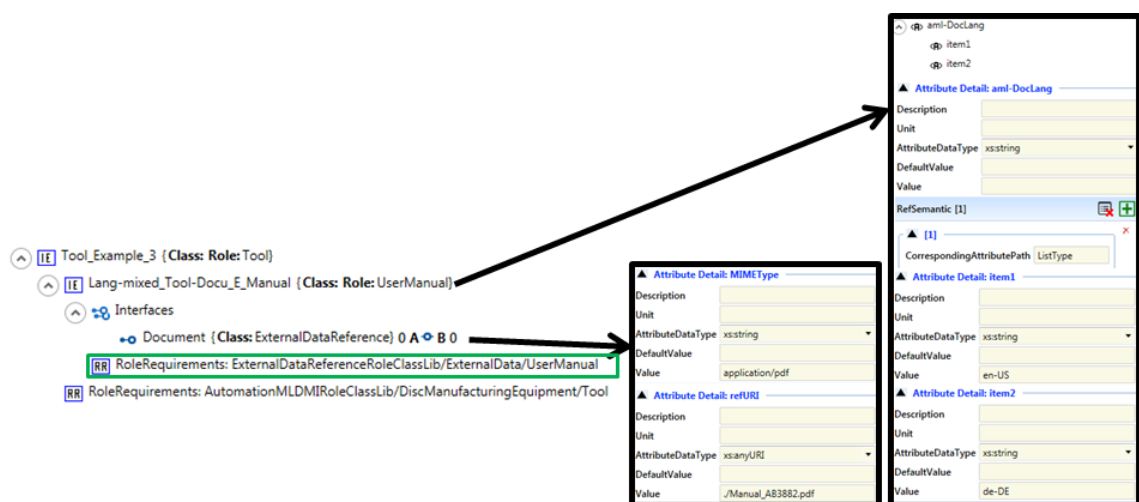


Figure 9 – View of example 3 within the AML Editor

```

<InternalElement Name="Tool_Example_3" ID="827cbadb-cbc0-4796-93d3-ea43a6f843d6">
  <InternalElement Name="Lang-mixed_Tool-Docu_E_Manual" ID="a7c2ae0e-93a1-4bf0-bf10-16c06e2eb179">
    <Attribute Name="aml-DocLang" AttributeDataType="xs:string">
      <RefSemantic CorrespondingAttributePath="ListType" />
    <Attribute Name="item1" AttributeDataType="xs:string">
      <Value>en-US</Value>
    </Attribute>
    <Attribute Name="item2" AttributeDataType="xs:string">
      <Value>de-DE</Value>
    </Attribute>
  </InternalElement>
  <ExternalInterface Name="Document" RefBaseClassPath="AutomationMLBPRInterfaceClassLib/ExternalDataReference" ID="bc30b4a2-32c9-434b-9ffa-52b18068824f">
    <Attribute Name="MimeType" AttributeDataType="xs:string">
      <Value>application/pdf</Value>
    </Attribute>
    <Attribute Name="refURI" AttributeDataType="xs:anyURI">
      <Value>./Manual_AB3882.pdf</Value>
    </Attribute>
  </ExternalInterface>
  <RoleRequirements RefBaseRoleClassPath="AutomationMLBPRRoleClassLib/ExternalData/UserManual" />
</InternalElement>
<RoleRequirements RefBaseRoleClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Tool" />
</InternalElement>

```

Figure 10 – XML representation of example 3

4.4 Example 4: A document consists of several classes of documents

In the forth example a manual and a part list in English is attached to a tool object. Both documents are summarized in one file of the Microsoft Word format. Figure 11 shows the structure of documents.

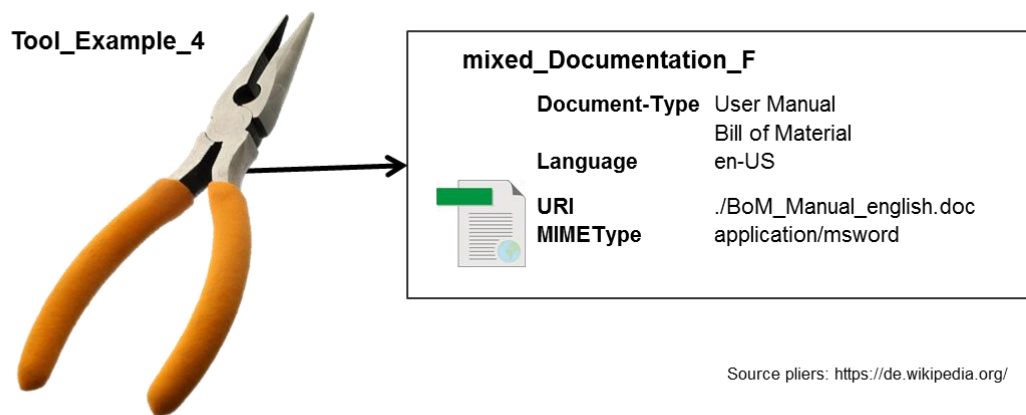


Figure 11 – Document structure of example 4

Figure 12 shows the example in the AutomationML Editor. Figure 13 shows the XML representation of the example.

For the documentation an InternalElement was created. To this InternalElement two RoleClasses are assigned (as RoleRequirement and as SupportedRoleClass) according to the document type within the file. These RoleClasses specify the types and are derived from the RoleClass “ExternalData” (green frame in Figure 12).

This InternalElement has an attributes “aml-DocLang” which value contains the language of the document. Furthermore, the InternalElement has an ExternalInterface that is derived from the InterfaceClass “ExternalDataReference”. The attribute “MimeType” provides information about the document format of the file that is referenced by the URI that is stored within the attribute “refURI”.

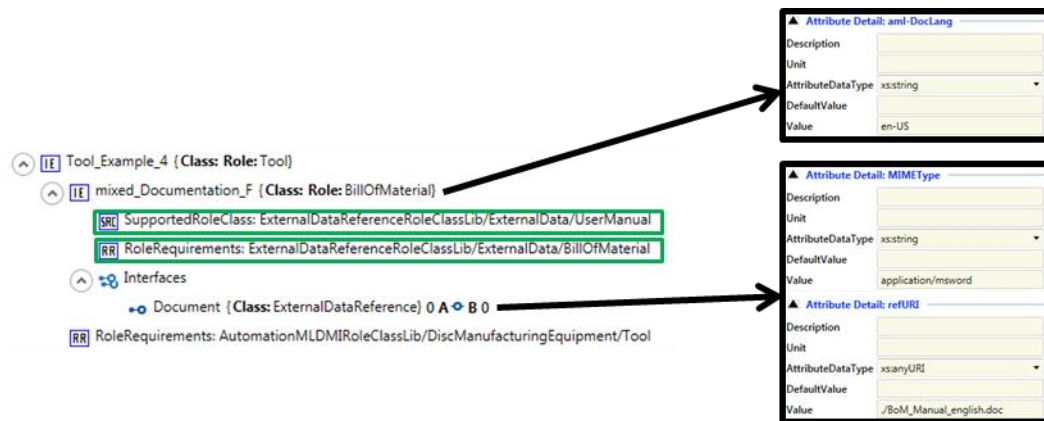


Figure 12 – View of example 4 in the AML Editor

```
<InternalElement Name="Tool_Example_4" ID="44f7fc77-bbdb-4158-a50d-53ef6ef6f2e6">
  <InternalElement Name="mixed_Documentation_F" ID="4dd5f1f7-fc7f-4658-a853-df2d0e2186cd">
    <Attribute Name="aml-DocLang" AttributeDataType="xs:string">
      <Value>en-US</Value>
    </Attribute>
    <ExternalInterface Name="Document" RefBaseClassPath="AutomationMLBPRInterfaceClassLib/ExternalDataReference" ID="82c199be-76a6-49a1-a5d5-d8246518d67b">
      <Attribute Name="MIMEType" AttributeDataType="xs:string">
        <Value>application/msword</Value>
      </Attribute>
      <Attribute Name="refURI" AttributeDataType="xs:anyURI">
        <Value>/BoM_Manual_english.doc</Value>
      </Attribute>
    </ExternalInterface>
    <SupportedRoleClass RefRoleClassPath="AutomationMLBPRRoleClassLib/ExternalData/UserManual" />
    <RoleRequirements RefBaseRoleClassPath="AutomationMLBPRRoleClassLib/ExternalData/BillOfMaterial" />
  </InternalElement>
  <RoleRequirements RefBaseRoleClassPath="AutomationMLDMIRoleClassLib/DiscManufacturingEquipment/Tool" />
</InternalElement>
```

Figure 13 – XML representation of example 4

5 References

IETF RFC 2046, Multipurpose Internet Mail Extensions (MIME) Part Two: Media Types
(Available at <<https://www.rfc-editor.org/rfc/rfc2046.txt>>)

IETF RFC 5646, Tags for Identifying Languages
(Available at <<https://www.rfc-editor.org/rfc/rfc5646.txt>>)

BPR_004E List Attributes, Best Practice Recommendations: Modelling of List Attributes in AutomationML
(Available at <https://www.automationml.org/o.red/uploads/dateien/1456736758-BPR_004E_List_Attributes_Jan2016.pdf>)

6 XML representation of extensions of AutomationML libraries

```
<?xml version="1.0" encoding="utf-8"?>
<CAEXFile FileName="ExternalDataReference_BPR-Libraries.aml" SchemaVersion="2.15"
  xsi:noNamespaceSchemaLocation="CAEX_ClassModel_V2.15.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <AdditionalInformation>
    <WriterHeader>
      <WriterName>AutomationML e.V.</WriterName>
      <WriterID>AutomationML e.V.</WriterID>
      <WriterVendor>AutomationML e.V.</WriterVendor>
      <WriterVendorURL>www.AutomationML.org</WriterVendorURL>
      <WriterVersion>1.0</WriterVersion>
      <WriterRelease>1.0.0</WriterRelease>
      <LastWritingDateTime>2016-07-01</LastWritingDateTime>
      <WriterProjectTitle>Automation Markup Language BPR Libraries</WriterProjectTitle>
      <WriterProjectID>Automation Markup Language BPR Libraries</WriterProjectID>
    </WriterHeader>
  </AdditionalInformation>
  <AdditionalInformation AutomationMLVersion="2.0" />
</CAEXFile>
```

```

<InterfaceClassLib Name="AutomationMLInterfaceClassLib">
  <Description>Standard Automation Markup Language Interface Class Library</Description>
  <Version>2.2.0</Version>
  <InterfaceClass Name="AutomationMLBaseInterface">
    <InterfaceClass Name="Order" RefBaseClassPath="AutomationMLBaseInterface">
      <Attribute Name="Direction" AttributeDataType="xs:string" />
    </InterfaceClass>
    <InterfaceClass Name="PortConnector" RefBaseClassPath="AutomationMLBaseInterface" />
    <InterfaceClass Name="InterlockingConnector" RefBaseClassPath="AutomationMLBaseInterface" />
    <InterfaceClass Name="PPRConnector" RefBaseClassPath="AutomationMLBaseInterface" />
    <InterfaceClass Name="ExternalDataConnector" RefBaseClassPath="AutomationMLBaseInterface">
      <Attribute Name="refURI" AttributeDataType="xs:anyURI" />
      <InterfaceClass Name="COLLADAInterface" RefBaseClassPath="ExternalDataConnector" />
      <InterfaceClass Name="PLCopenXMLInterface" RefBaseClassPath="ExternalDataConnector" />
    </InterfaceClass>
    <InterfaceClass Name="Communication" RefBaseClassPath="AutomationMLBaseInterface">
      <InterfaceClass Name="SignalInterface" RefBaseClassPath="Communication" />
    </InterfaceClass>
  </InterfaceClass>
</InterfaceClassLib>
<InterfaceClassLib Name="AutomationMLBPRInterfaceClassLib">
  <Version>1.0.0</Version>
  <InterfaceClass Name="ExternalDataReference"
RefBaseClassPath="AutomationMLInterfaceClassLib/AutomationMLBaseInterface/ExternalDataConnector" ID="{320f7f3a-6df8-
4ccd-af35-a4367b37eb7a}">
    <Attribute Name="MIMEType" AttributeDataType="xs:string" />
  </InterfaceClass>
</InterfaceClassLib>
<RoleClassLib Name="AutomationMLBaseRoleClassLib">
  <Description>Automation Markup Language base role class library</Description>
  <Version>2.2.0</Version>
  <RoleClass Name="AutomationMLBaseRole">
    <RoleClass Name="Group" RefBaseClassPath="AutomationMLBaseRole">
      <Attribute Name="AssociatedFacet" AttributeDataType="xs:string" />
    </RoleClass>
    <RoleClass Name="Facet" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Port" RefBaseClassPath="AutomationMLBaseRole">
      <Attribute Name="Direction" AttributeDataType="xs:string" />
      <Attribute Name="Cardinality">
        <Attribute Name="MinOccur" AttributeDataType="xs:unsignedInt" />
        <Attribute Name="MaxOccur" AttributeDataType="xs:unsignedInt" />
      </Attribute>
      <Attribute Name="Category" AttributeDataType="xs:string" />
      <ExternalInterface Name="ConnectionPoint" ID="9942bd9c-c19d-44e4-a197-11b9edf264e7"
RefBaseClassPath="AutomationMLInterfaceClassLib/AutomationMLBaseInterface/PortConnector" />
    </RoleClass>
    <RoleClass Name="Resource" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Product" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Process" RefBaseClassPath="AutomationMLBaseRole" />
    <RoleClass Name="Structure" RefBaseClassPath="AutomationMLBaseRole">
      <RoleClass Name="ProductStructure" RefBaseClassPath="Structure" />
      <RoleClass Name="ProcessStructure" RefBaseClassPath="Structure" />
      <RoleClass Name="ResourceStructure" RefBaseClassPath="Structure" />
    </RoleClass>
    <RoleClass Name="PropertySet" RefBaseClassPath="AutomationMLBaseRole" />
  </RoleClass>
</RoleClassLib>
<RoleClassLib Name="AutomationMLBPRRoleClassLib">
  <Version>1.0.0</Version>
  <RoleClass Name="ExternalData" RefBaseClassPath="AutomationMLBaseRoleClassLib/AutomationMLBaseRole" />
</RoleClassLib>
</CAEXFile>

```

Figure 14 – XML representation of the AutomationML libraries