

ISO/IEC JTC 1/SC 24/WG 6
CAD-to-X3D Conversion

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Introduction

- CAD-to-X3D Conversion
 - Conversion of CAD data into X3D representation for lightweight 3D visualization
- Purpose
 - To provide a guide on the conversion of a CAD assembly data into X3D representation for lightweight visualization
 - To improve X3D specification for better treatment of CAD data
- Scope of CAD-to-X3D includes
 - Product structure (PS)
 - Geometry
 - Product Manufacturing Information (PMI)

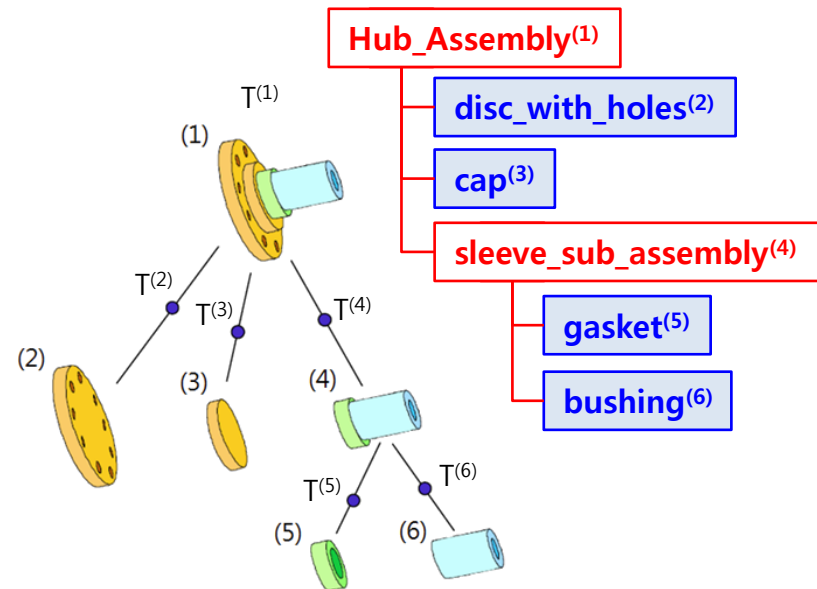
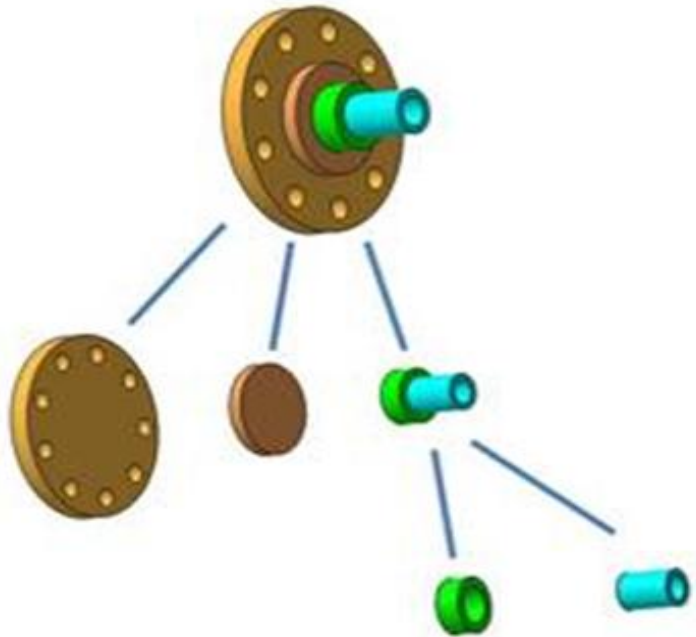
Scope of CAD-to-X3D

- CAD-to-X3D Conversion
 - PS
 - Representing a CAD Assembly data
 - Hierarchy / Transform / Reference
 - Geometry
 - Representing geometry data of a Part
 - CSG / B-REP / Features → Polygon / Surface
 - PMI
 - Geometry Dimension & Tolerance (GD&T)
 - Annotation (property, attribute)

X3D Representation of PS

- X3D Nodes for PS
 - CADAssembly / CADPart : parent-child relation
 - Transform : transform information
 - Inline : external referencing to a data file
- Methods for representing PS and geometry in X3D
 - A : One file with whole PS and all geometry data
 - B : One file with whole PS and external referencing to parts files
 - C : One assembly file with all sub-assemblies and parts referenced externally and hierarchically

Hub assembly PS



CATIA* Hub Assembly
(6 Files)

CatiaHubAssembly.X3D

```
<Transform DEF="T(1)">  
<CADAssembly name="Hub_Assembly">
```

```
<Transform DEF="T(2)">  
<CADAssembly name="disc_with_holes">  
<CADPart name="disc_with_holes" ...>  
<CADFace> ... </CADFace>  
</CADPart>  
</CADAssembly>  
</Transform>
```



```
<Transform DEF="T(3)">  
<CADAssembly name="cap">  
<CADPart name="cap" ...>  
<CADFace> ... </CADFace>  
</CADPart>  
</CADAssembly>  
</Transform>
```



```
<Transform DEF="T(4)">  
<CADAssembly name="sleeve_sub_assembly">  
<Transform DEF="T(5)">  
<CADAssembly name="gasket">  
<CADPart name="gasket" ...>  
<CADFace> ... </CADFace>  
</CADPart>  
</CADAssembly>  
</Transform>
```

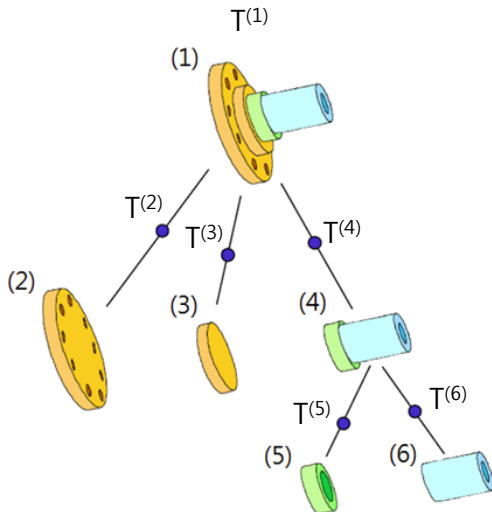


```
<Transform DEF="T(6)">  
<CADAssembly name="bushing">  
<CADPart name="bushing" ...>  
<CADFace> ... </CADFace>  
</CADPart>  
</CADAssembly>  
</Transform>
```



```
</CADAssembly>  
</Transform>  
</CADAssembly>  
</Transform>
```

- **A** : One file with whole PS and all geometry data

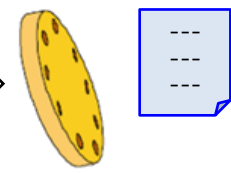


CatiaHubAssemblyInline.X3D

```
<Transform DEF="T(1)">  
<CADAssembly name="Hub_Assembly">  
  <Transform DEF="T(2)">  
    <CADAssembly name="disc_with_holes">  
      <Inline url="CatiaHubDiscWithHoles.x3d" />  
    </CADAssembly>  
  </Transform>  
</CADAssembly>
```

Reusable geometry files

CatiaHubDiscWithHoles.x3d



```
  <Transform DEF="T(3)">  
    <CADAssembly name="cap">  
      <Inline url="CatiaHubCap.x3d" />  
    </CADAssembly>  
  </Transform>
```

CatiaHubCap.x3d



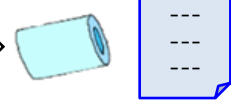
```
<Transform DEF="T(4)">  
<CADAssembly name="sleeve_sub_assembly">  
  <Transform DEF="T(5)">  
    <CADAssembly name="gasket">  
      <Inline url="CatiaHubGasket.x3d" />  
    </CADAssembly>  
  </Transform>  
</CADAssembly>
```

CatiaHubGasket.x3d

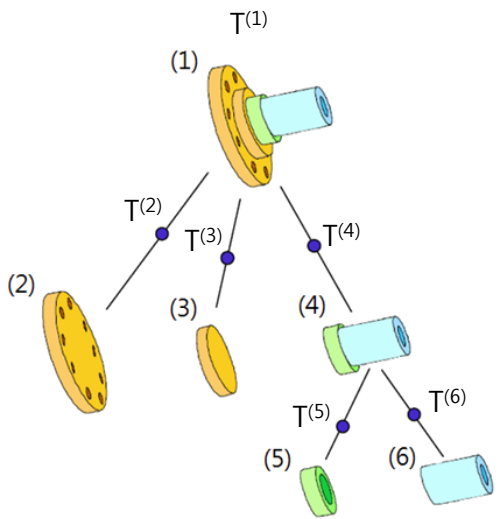


```
<Transform DEF="T(6)">  
<CADAssembly name="bushing">  
  <Inline url="CatiaHubBushing.x3d" />  
</CADAssembly>  
</Transform>
```

CatiaHubBushing.x3d

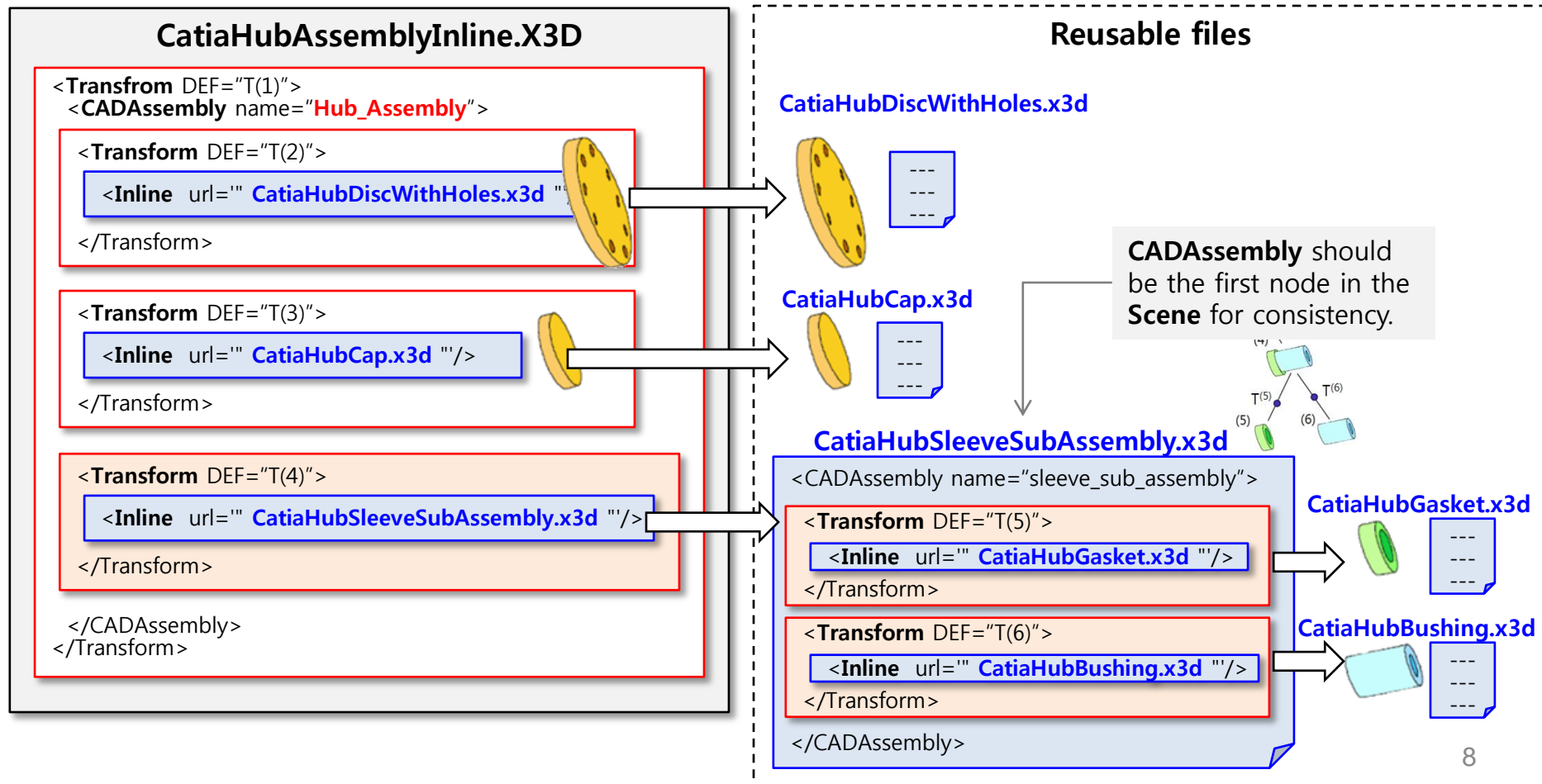


- **B** : One file with whole PS and all geometry data

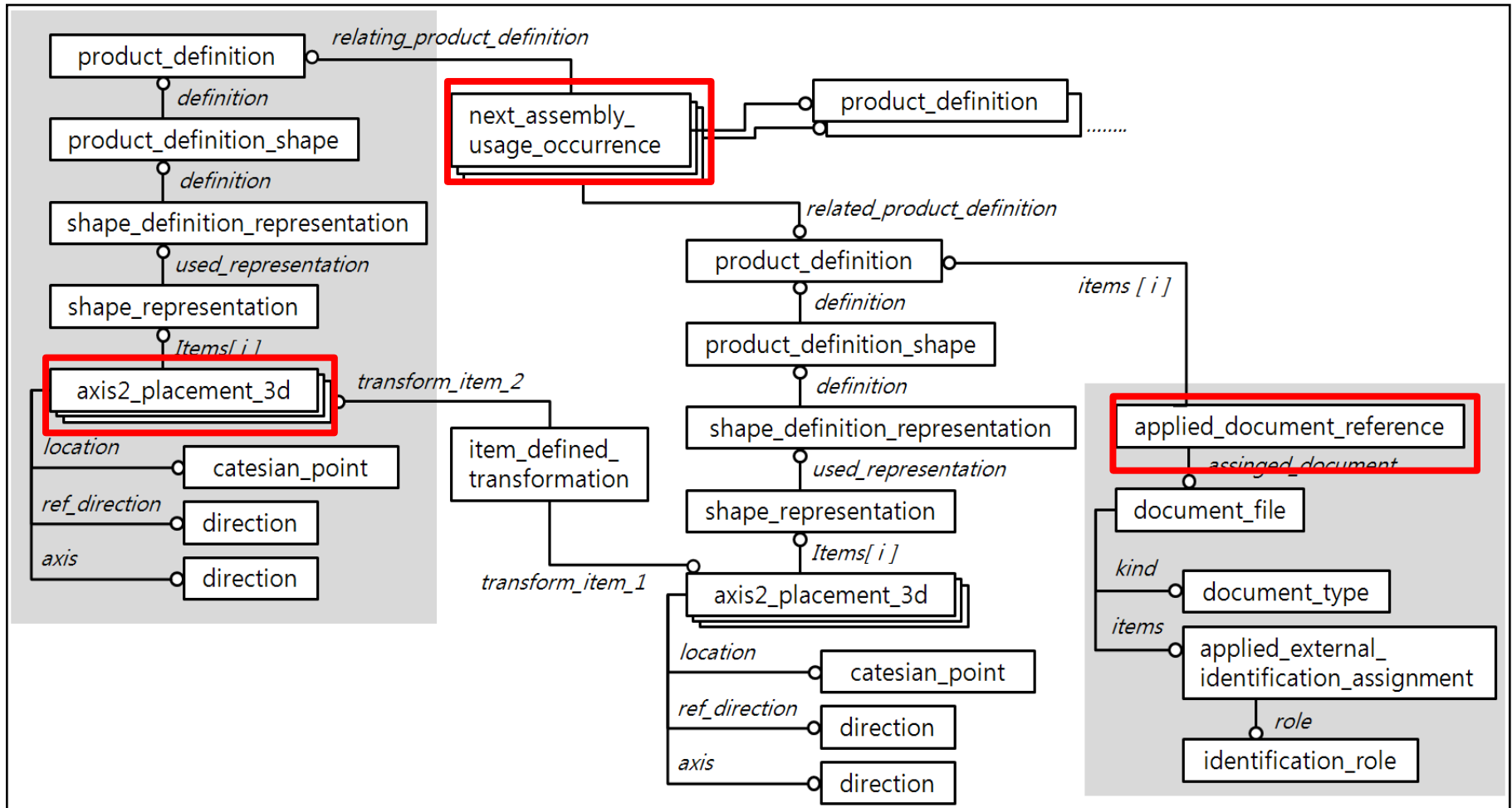


Methods for Representing PS in X3D

- **C** : One assembly file with all sub-assemblies and parts referenced externally and hierarchically



STEP AP203ed2 instance diagram for PS

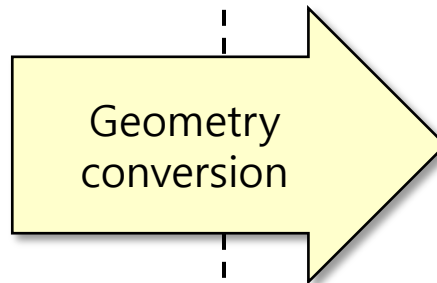


Conversion of CAD Part Geometry into X3D

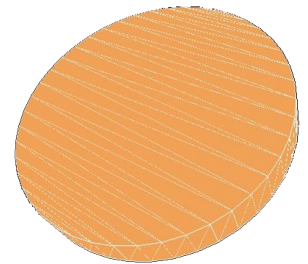
- CSG (implicit)
 - Solid primitives / boolean operations

- B-REP (implicit)
 - Geometry / Topology

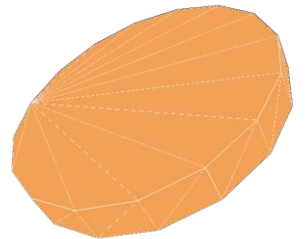
- Feature-based modeling
 - Features



- Polygon-based
 - Polygon-based nodes



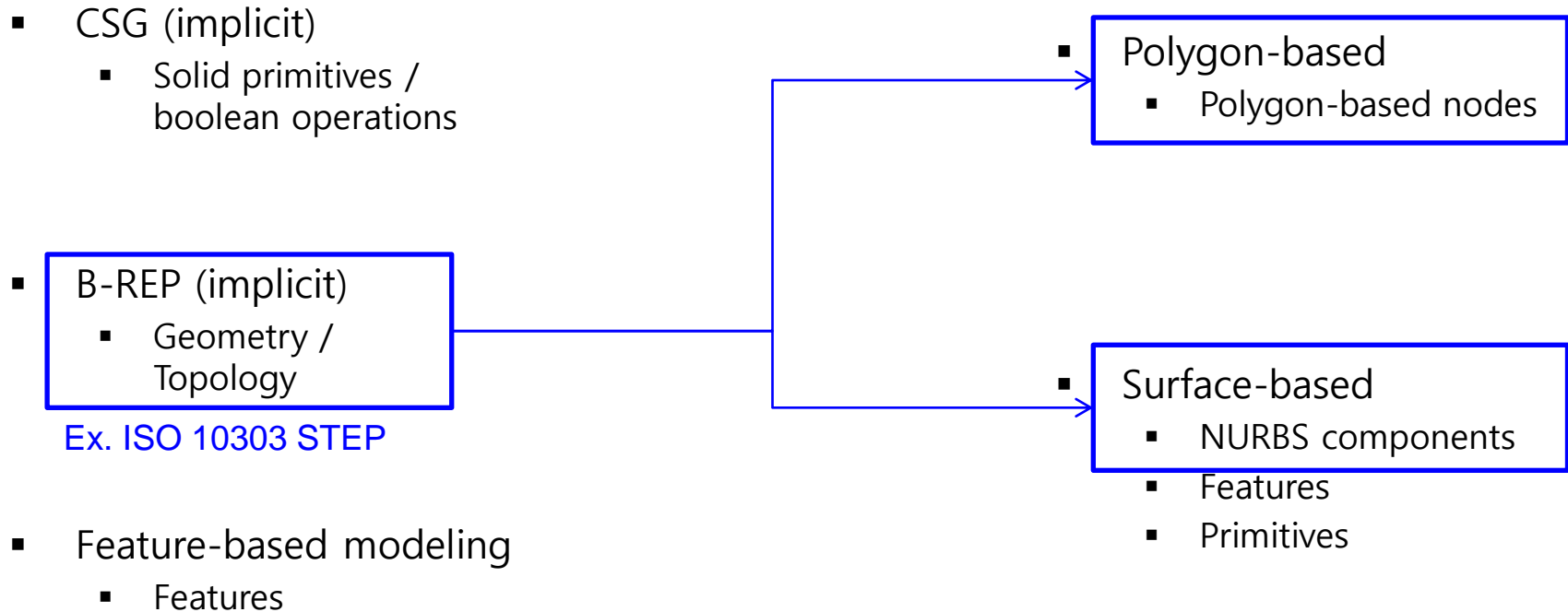
- Surface-based
 - NURBS components
 - Features
 - Primitives



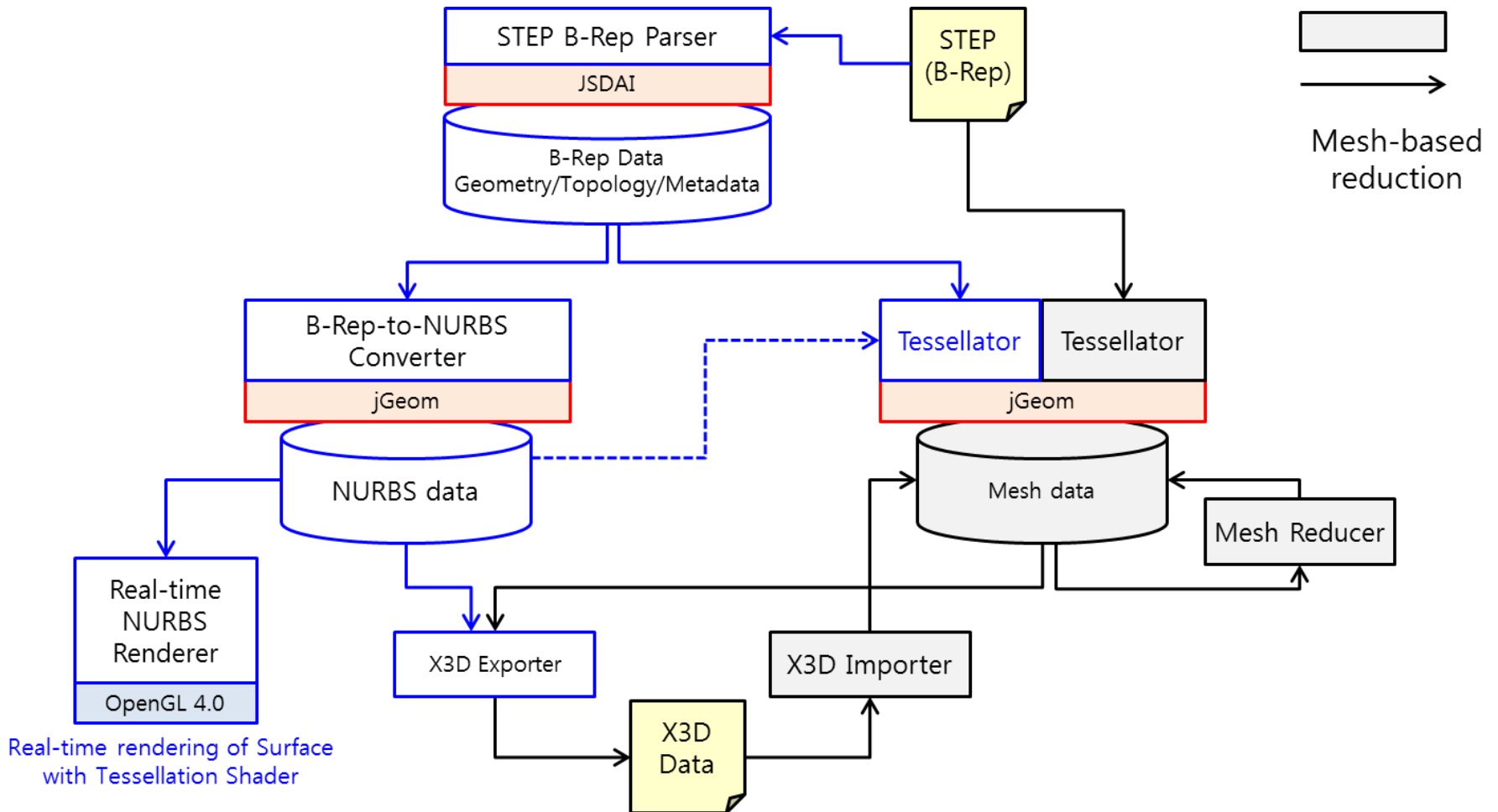
Extraction of CAD data

Writing as X3D

Conversion of CAD Part Geometry into X3D



System diagram for STEP-to-X3D conversion of geometry data



Standard for PMI



Preparation of « STEP AP 242 edition 2 » project



- Business requirements for enhancement of AP 242 ed2 to cover new business requirements, such as:
 - extension of CAD 3D Mechanical
 - 3D PMI (update of ISO standards for 3D Geometric Dimensioning & Tolerancing)
 - 3D parametric, 3D tessellated geometry [← External Element Reference](#)
 - Composite design and manufacturing
 - Electrical Harness
 - Kinematics
- Organization of an international workshop to prepare a **white paper for STEP AP 242 ed. 2 project** on the 18th – 19th of Sept. 2013 in USA, Charleston, PDES Inc,

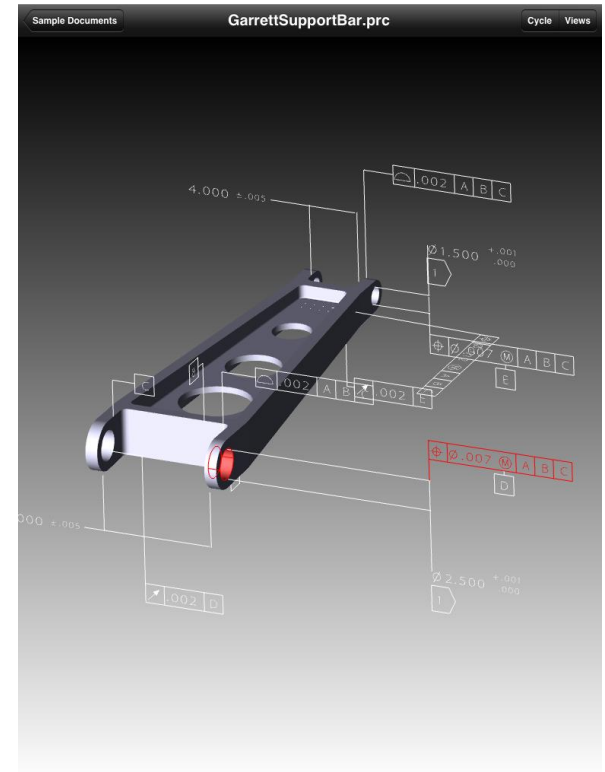
	2009	2010	2011	2012	2013	2014	2015	2016	
AP 242 ed. 1	WP ▼ 11	NWI ▼ 09	CD ▼ 05		DIS ▼ 05	IS ▼ 01			
AP 242 ed. 2	Anticipated planning (To be confirmed with the AP 242 ed2 white paper)				WP ▼ 11	NWI ▼ 03	CD ▼ 05	DIS ▼ 05	IS ▼ 12

Extraction of PMI from CAD Data

- Interfaces provided by CAD systems
- STEP AP242 [ed2](#)
 - Not public yet
 - Legacy CAD systems don't support exporting to AP242 [ed2](#) yet.
 - AP203 / AP214 supported

Representing PMI using X3D

- Part 1: Architecture and base components
 - 7 Core components
 - Metadata
 - 12 Shape component
 - Appearance / LineProperties / Material / Shape / ...
 - 14 Geometry2D component
 - Arc2D / Circle2D / Polyline2D / Rectangle2D / ...
 - 15 Text component
 - Font / Text
 - X. Annotation component (Extension Proposal)
 - Information / target / visual connection
 - Metadata / Text



3D GD&T and PMI in PDF3D*



Who we are



What we do



How you can join



STEP File Library



FAQs



Links



Participating Vendors



Implementation Coverage



CAX IF Calendar



Joint Testing Information



Test Rounds



Recommended Practices



EXPRESS Schemas



Models to be Tested
in Current Round



CAX IF Member Area

The CAX Implementor Forum is significantly improving STEP translator quality and decreasing translator time-to-market.

The CAX Implementor Forum is a joint testing effort between [PDES, Inc.](#) and [ProSTEP iVIP](#). The objective of the forum is to accelerate CAX translator development and ensure that users' requirements are satisfied. The CAX Implementor Forum is an approach to establish a common test activity in the CAD area by merging PDES, Inc.'s STEPnet and ProSTEP iVIP's CAD Round Table.

The goals of the CAX Implementor Forum are to:

- ▶ Implement functionality for today's needs
- ▶ Identify functionality for tomorrow's needs
- ▶ Avoid roadblocks by establishing agreed upon approaches
- ▶ Increase user confidence by providing system and AP interoperability testing
- ▶ Ensure new functionality does not adversely impact existing implementations

The CAX Implementor Forum is significantly improving STEP translator quality and decreasing translator time-to-market.

For more information on CAX Implementor Forum, send email to:
cax-test-admin-l@scra.org

(i) [Imprint](#)

CAX-IF Recommendation

- [Recommended Practices for External References](#) with References to the PDM Schema Usage Guide (Release 2.1 January 19, 2005)
 - "[External References](#)" approach for CAX and PDM data exchange

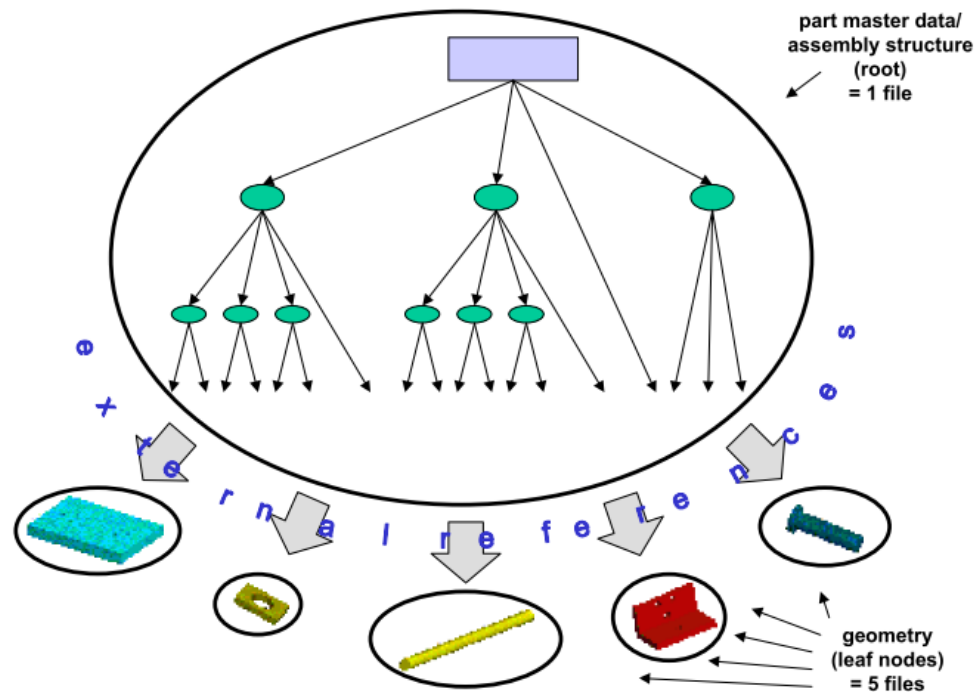


Figure 1: Relationship of generated files

CAX-IF Recommendation

- [Recommended Practices for External References](#) with References to the PDM Schema Usage Guide (Release 2.1 January 19, 2005)
 - "[External References](#)" approach for CAX and PDM data exchange
 - An overview on how to apply [the external reference mechanism described in the PDM Schema Usage Guide](#) (http://www.pdm-if.org/pdm_schema/)
 - To provide CAX vendors a guideline for their implementations
 - a list of relevant sections in the PDM Schema Usage Guide

CAX-IF

Recommended Practices for External References

- External References Test Scenario
 - The '[master](#)' file shall use the actual PDM Schema or the IS version of AP214 as its file schema.
 - The [leaf nodes](#) of the assembly tree then reference the appropriate [geometry externally](#).
 - The geometry part files shall be conformant to either AP203 or AP214 and contain only geometry definitions.

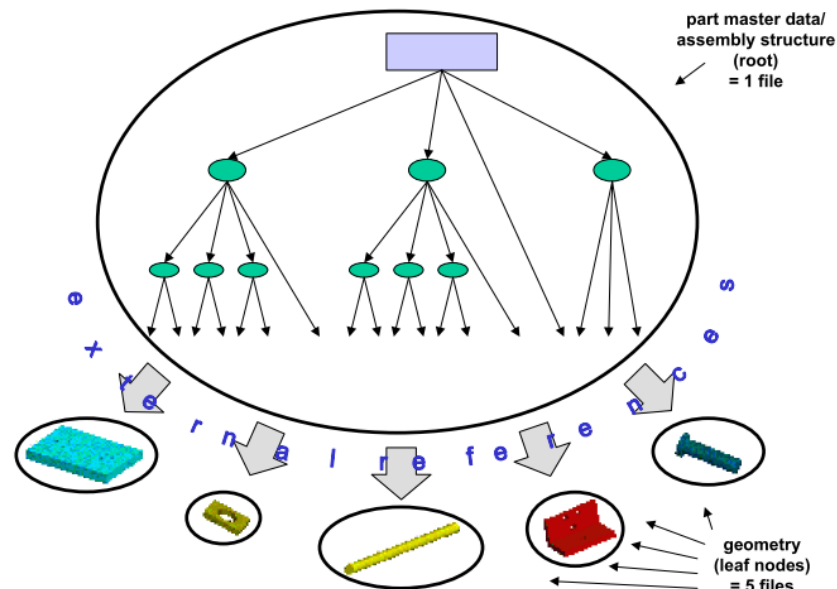


Figure 1: Relationship of generated files

CAX-IF

Recommended Practices for External References

- Possible Scenarios
 - CAX to CAX exchange
 - the set of STEP files is both written and read by – possibly different – CAX systems.
 - CAX to PDM exchange
 - the set of STEP files is written by a CAX system, while a PDM system is on the receiving end.

CAX-IF

Recommended Practices for External References

- External References Test Scenario
 - The '[master](#)' file shall use the actual PDM Schema or the IS version of AP214 as its file schema.
 - The [leaf nodes](#) of the assembly tree then reference the appropriate [geometry externally](#).
 - The geometry part files shall be conformant to either AP203 or AP214 and contain only geometry definitions.

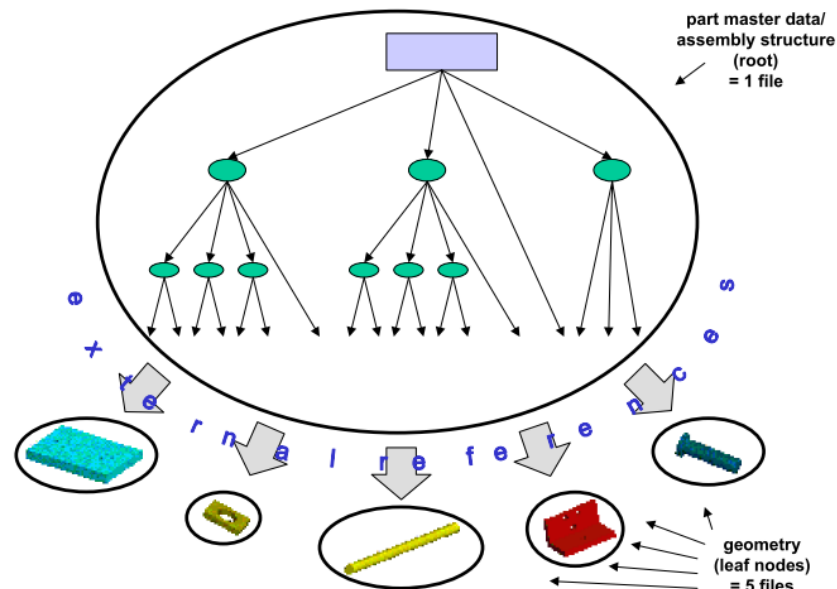


Figure 1: Relationship of generated files

CAX-IF

Recommended Practices for External References

- Nested External References
 - The “master” file itself is split into several parts, where each file represented one node in the assembly structure

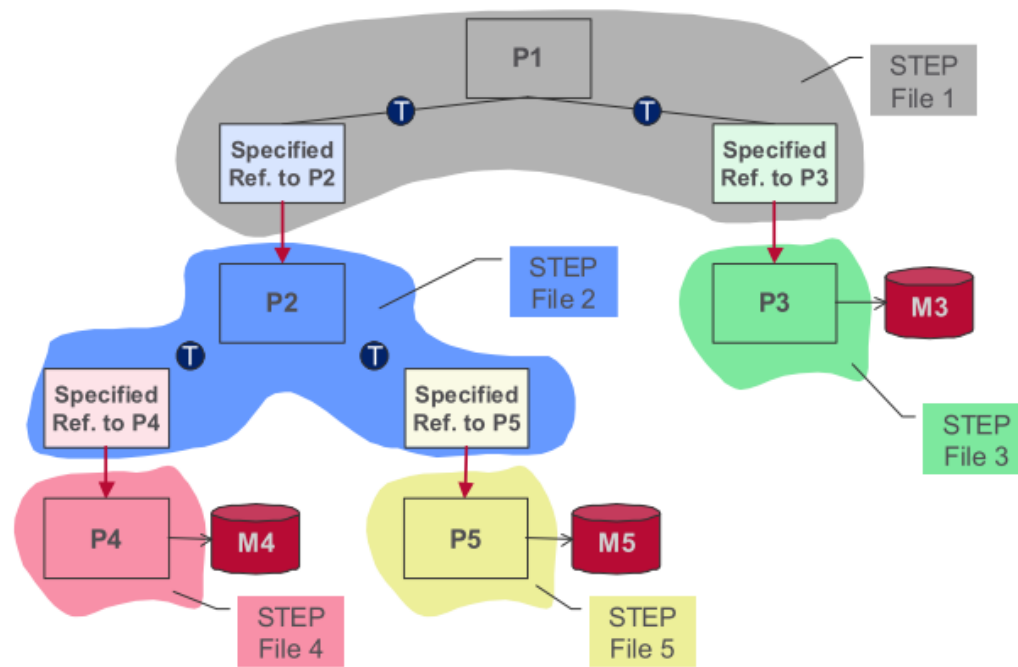


Figure 2: Reference mechanism with nested external references. Leaf nodes (P3, P4, P5) are geometry files.

CAX-IF

Recommended Practices for External References

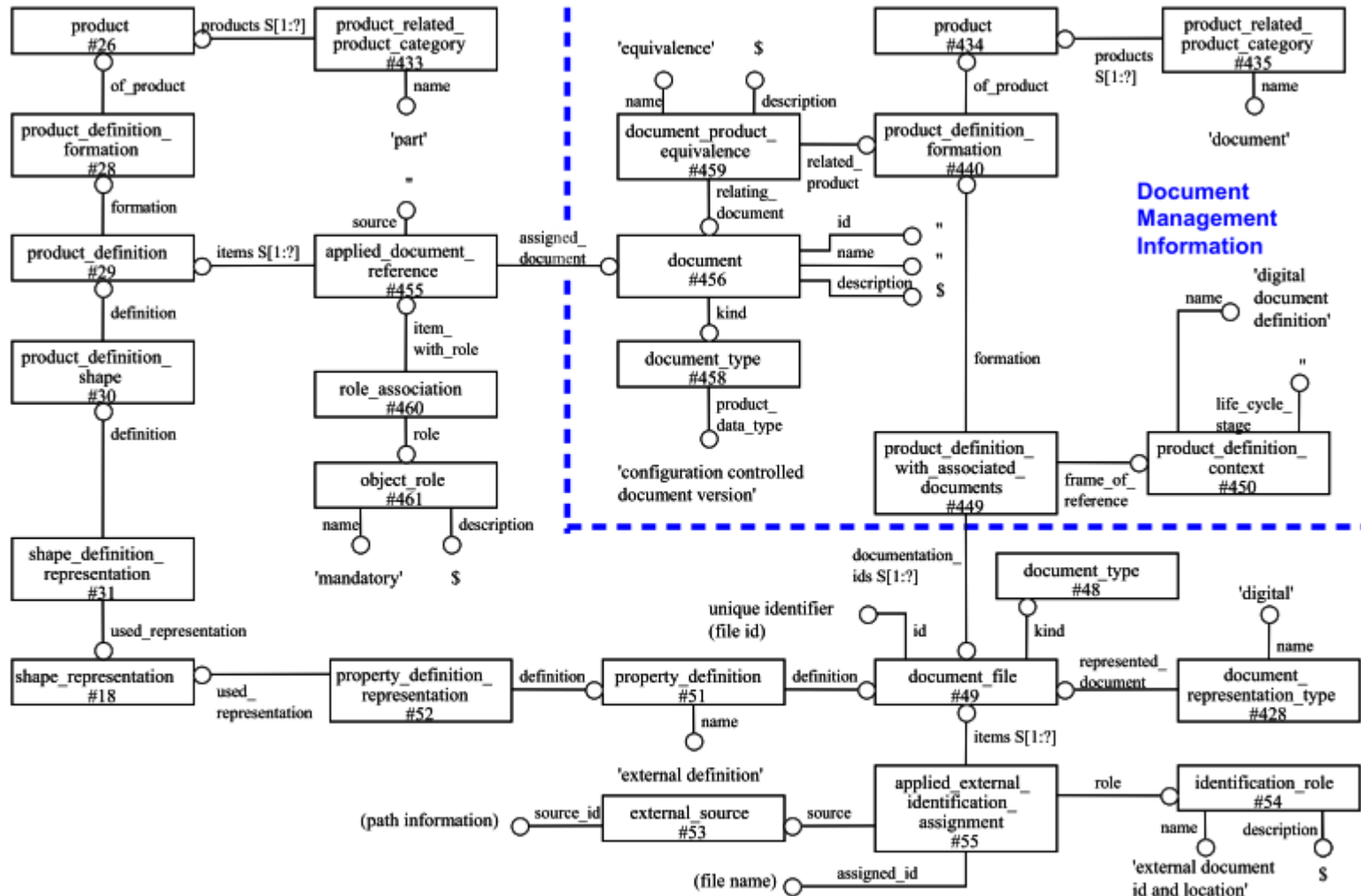


Figure 3: Instance diagram for external references

CAX-IF Topics in ISO TC 184/SC 4 meeting

- PMI / 3D Tessellated Geometry / External Element Reference
- CAD-CAM Interoperability
- CAX-IF Round 32J
- ...

Recommendations

- Similar approach in STEP to CAD-to-X3D Conversion
 - an external references recommended practice from the CAX-IF to represent assemblies and part geometry models in different files.
 - Not all CAD systems can handle external references, but CATIA can.
- It would be useful to document in the recommended practice and implement in an open source reference implementation.
 - A formal mapping between X3D and STEP
ISO TC 184/SC4 requirements for visualization report for X3D
http://www.web3d.org/wiki/index.php/TC184_Visualization_Requirements_for_X3D_CAD#Requirement_1:_STEP_Consistency
- Open source www.stepcode.org for the STEP/IFC to X3D direct translation for future work.

Summary

- CAD-to-X3D Conversion
 - Conversion of CAD data into X3D representation
 - PS
 - Hierarchy / Transform / Reference
 - Geometry
 - CSG / B-REP / Features → Polygon / Surface
 - PMI
 - GD&T / Annotation
- CAX-IF
 - Recommended Practices for External References

Next Steps

- CAD-to-X3D Conversion Test
 - PS with CAX-IF Recommended Practices
 - Polygon and Surface based Geometry
 - PMI representation for GD&T / Annotation

Thank you!

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