CAD Working Group, SIGGRAPH 2014

CAD-to-X3D Conversion for Product Structure, Geometry Representation and Metadata

Hyokwang Lee and Don Brutzman
Web3D Korea Chapter / Web3D CAD Working Group
2015. 8. 11.

Introduction

- CAD-to-X3D Conversion
  - Conversion of CAD data into X3D representation for lightweight 3D visualization
  - ISO TC 184/SC4 STEP based approach

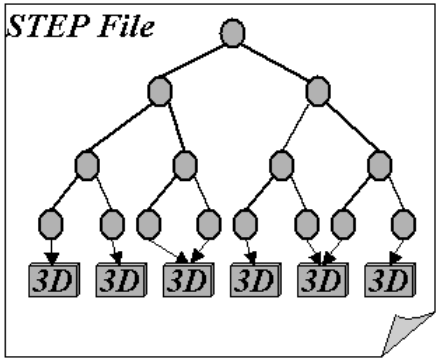
- Purpose
  - To provide a guide on the conversion of a CAD assembly data into X3D representation for lightweight visualization
  - To improve X3D specification for better representation of CAD data if necessary
  - To identify a basis for further cooperative work by ISO standards groups

- Scope of CAD-to-X3D includes
  - Product Structure (PS)
  - Geometry
  - Product Manufacturing Information (PMI)
  - 3D Printing model format for Additive Manufacturing (AM)

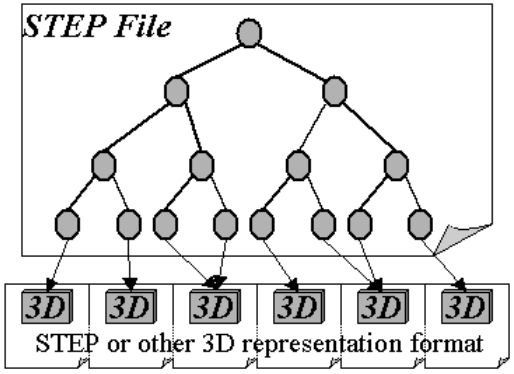
PS
PRODUCT STRUCTURE

Representation of PS in STEP*

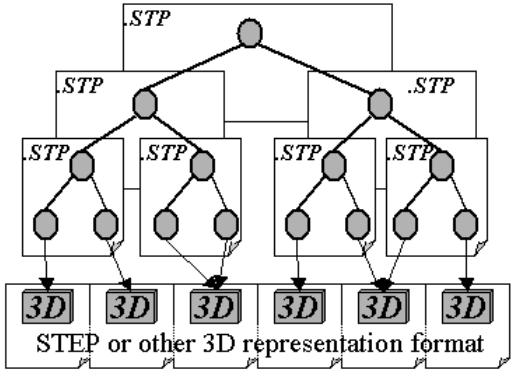
- Representation of PS in an assembly with external reference
  - Assembly and part geometries in the same file
  - An assembly file with external reference to geometry files => **external reference**
  - An assembly file with externally referenced sub-assemblies and geometry files => **nested external reference**



Assembly and part geometries in the same file



Assembly with external reference to 3D geometry file (in STEP or other format)



Nested assembly

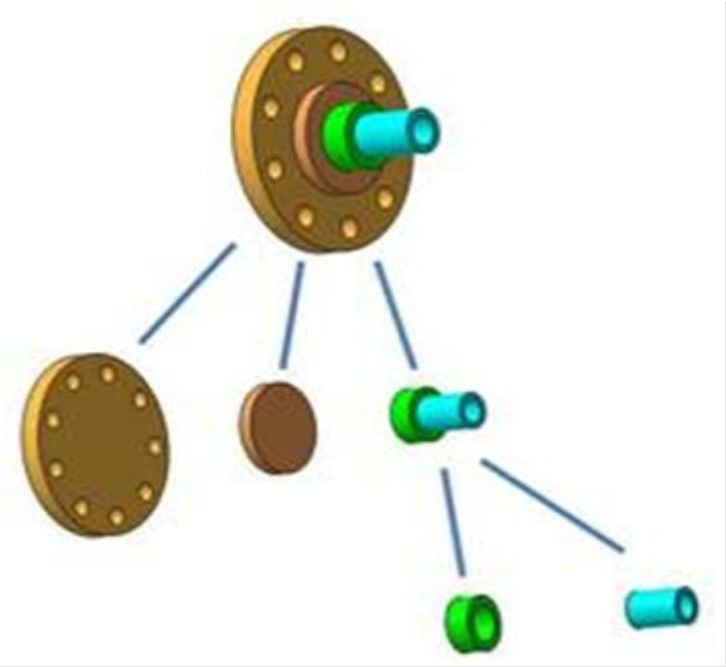
* STEP AP242 Project, http://www.ap242.org/geometry-assembly-pmi-interoperability

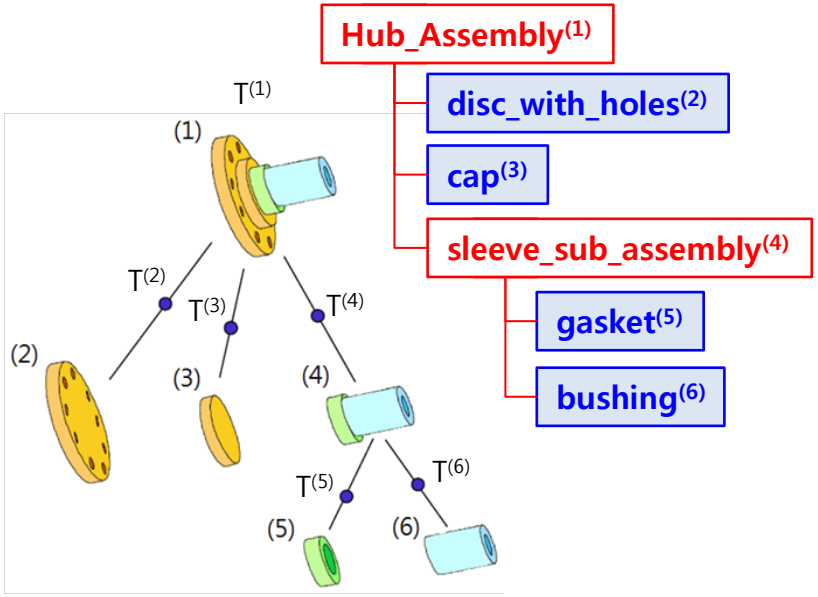
Representation of PS in X3D

- X3D nodes for PS
  - CADLayer / CADAssembly / CADPart / CADFace: parent-child relations
  - Transform / ClipPlane : transform and reveal geometric information
  - Inline : external referencing to a data file

- Methods for representing PS in X3D
  - A : assembly and part geometries in the same file
  - B : external reference
  - C : nested external reference

Hub assembly PS

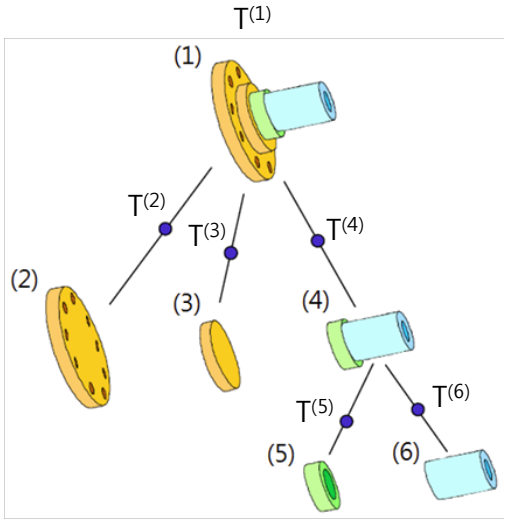




CATIA* Hub Assembly
(6 Files)

* CATIA : Dassault Systemes' CAD/CAM/CAE commercial solution, http://www.3ds.com/products-services/catia/

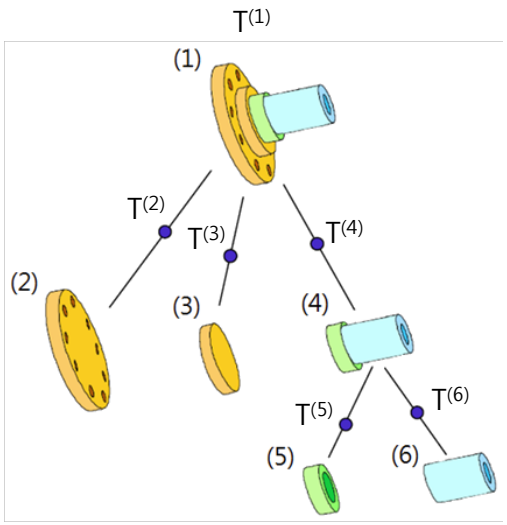
- **A** : assembly and part geometries in the same file



CatiaHubAssembly.X3D

```
<Transfrom 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>
```

- **B** : external reference



CatiaHubAssemblyInline.X3D

```
<Transfrom DEF="T(1)">
  <CADAssembly name="Hub_Assembly">
    <Transform DEF="T(2)">
      <CADAssembly name="disc_with_holes">
        <Inline url='" CatiaHubDiscWithHoles.x3d "'/>
      </CADAssembly>
    </Transform>
    <Transform DEF="T(3)">
      <CADAssembly name="cap">
        <Inline url='" CatiaHubCap.x3d "'/>
      </CADAssembly>
    </Transform>
    <Transform DEF="T(4)">
      <CADAssembly name="sleeve_sub_assembly">
        <Transform DEF="T(5)">
          <CADAssembly name="gasket">
            <Inline url='" CatiaHubGasket.x3d "'/>
          </CADAssembly>
        </Transform>
        <Transform DEF="T(6)">
          <CADAssembly name="bushing">
            <Inline url='" CatiaHubBushing.x3d "'/>
          </CADAssembly>
        </Transform>
      </CADAssembly>
    </Transform>
  </CADAssembly>
</Transform>
```

Reusable geometry files

CatiaHubDiscWithHoles.x3d

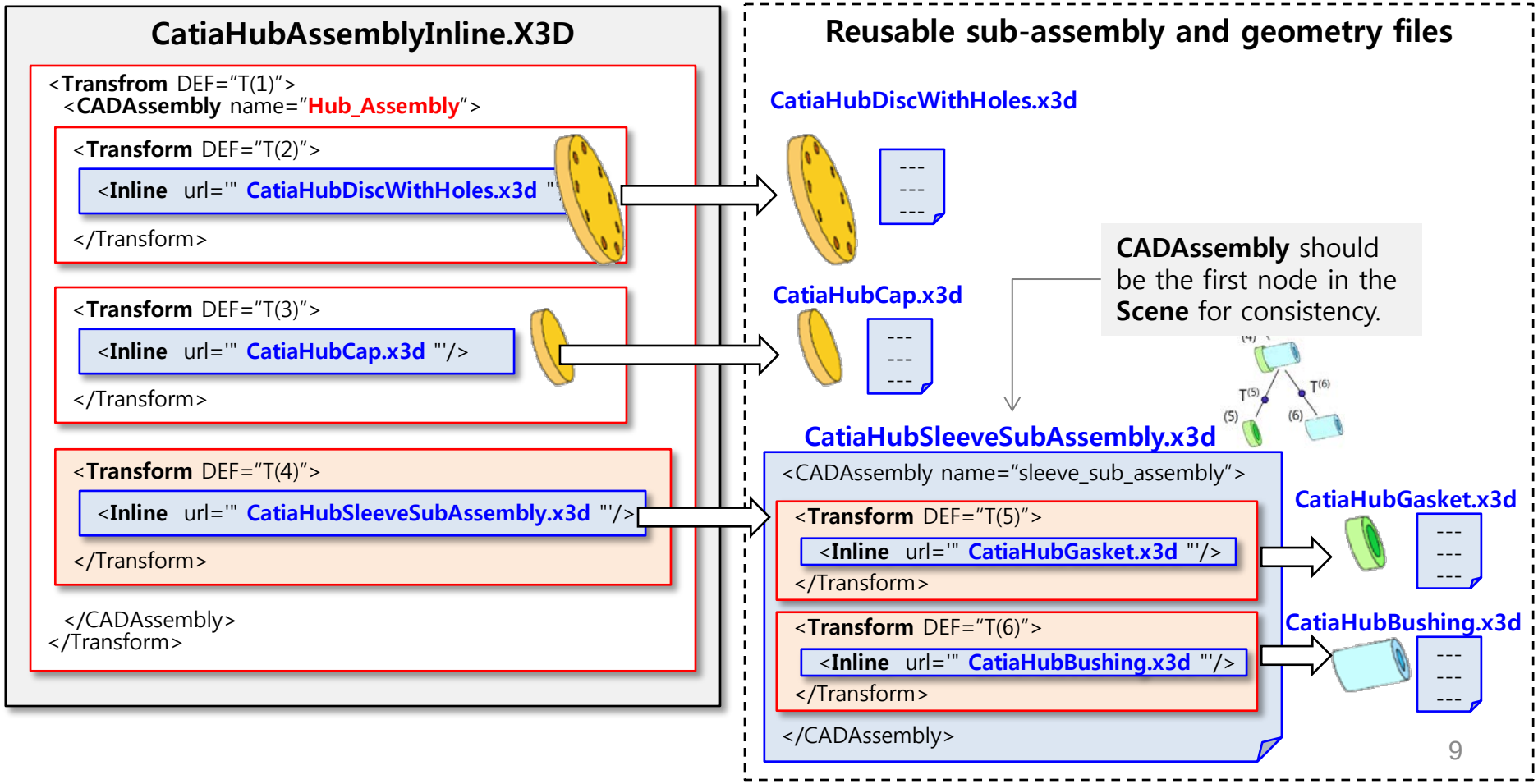
CatiaHubCap.x3d

CatiaHubGasket.x3d

CatiaHubBushing.x3d

Methods for Representing PS in X3D

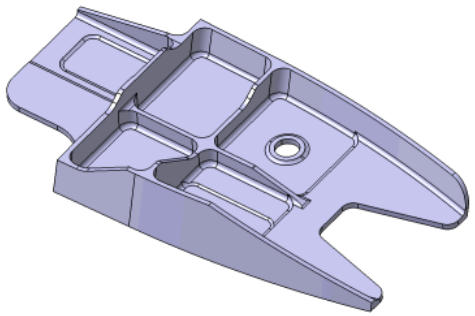
- **C** : nested external reference



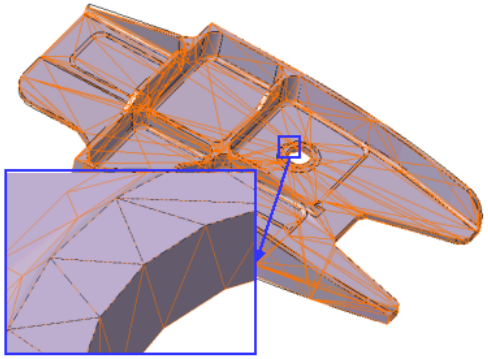
GEOMETRY

Representation of Geometry in STEP*

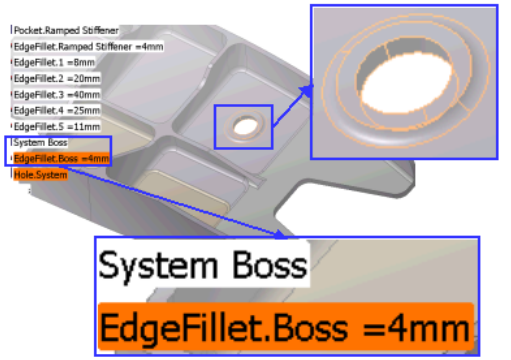
3D exact explicit geometry



3D tessellated explicit geometry



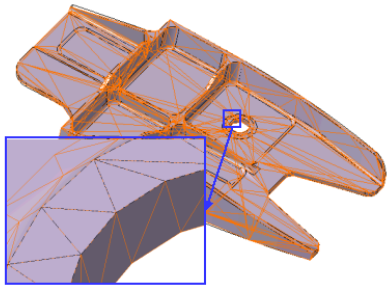
3D parametric & constr. History



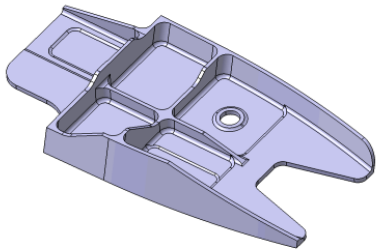
- Exact shape representation (STEP AP 214 and 203)
- Tessellated shape representation
- Parametric Representation

* STEP AP242 Project, http://www.ap242.org/geometry-assembly-pmi-interoperability

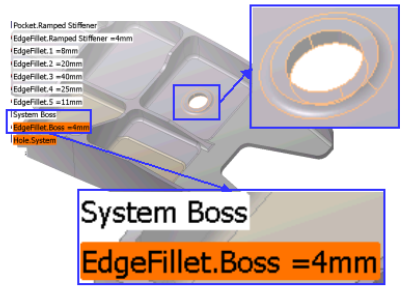
3D tessellated explicit geometry



3D exact explicit geometry



3D parametric & constr. History



Geometry conversion

- Polygon-based representation
  - [Indexed]Triangle[Fan|Strip]Set
  - IndexedFaceSet
  - [Indexed]QuadSet
- Surface-based representation
  - Primitives
  - Extrusion
  - NURBS component

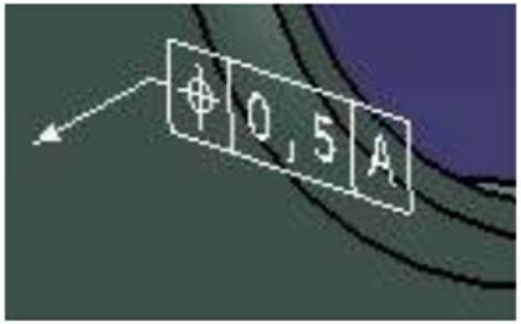
Mapping of STEP vocabularies to existing parametric X3D nodes

PMI

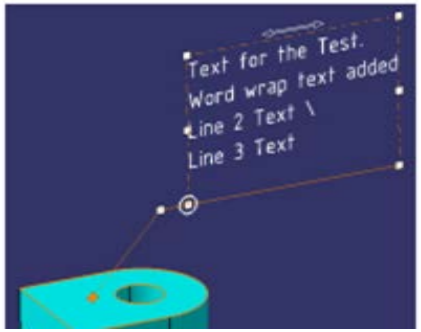
PRODUCT MANUFACTURING INFORMATION

PMI representation in STEP* and LOTAR**

- Product Manufacturing Information
  - Geometry Dimension & Tolerance(GD&T) / annotations / symbols



3D GD&T

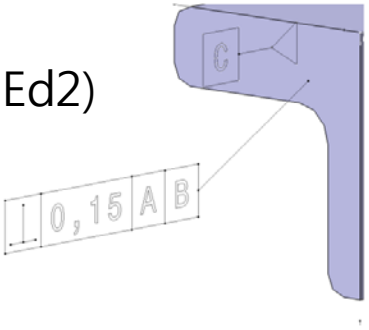


3D annotations

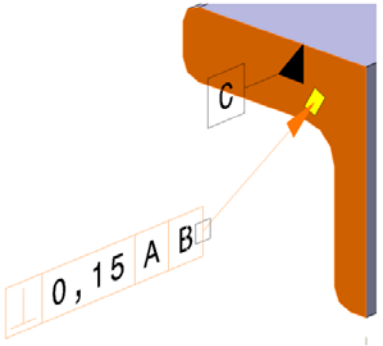
3D symbols

- Graphic representation
  - STEP geometric entities
    - polylines (AP 214 / AP 203 Ed2)
    - tessellated (AP 242)
- Semantic representation
  - PMI semantic entities

Graphic presentation



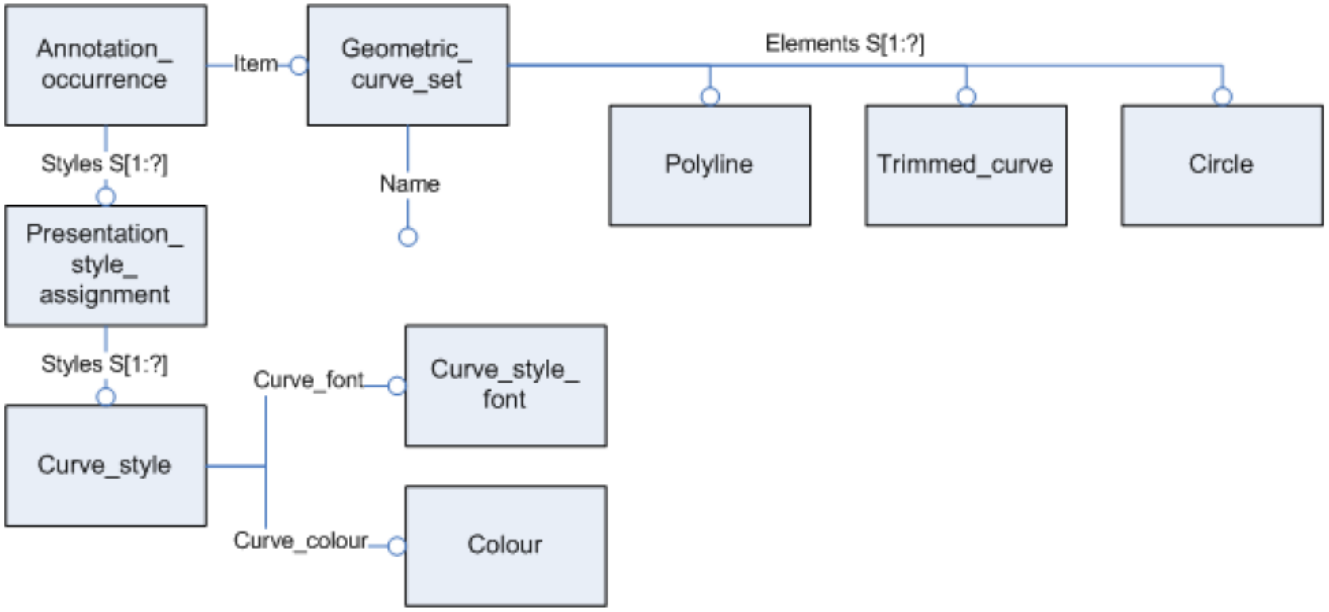
Semantic representation



* STEP AP242 Project, http://www.ap242.org/geometry-assembly-pmi-interoperability
** LOng Term Archiving and Retrieval, http://www.lotar-international.org/

PMI Representation in STEP*

- Presentation of 3D PMI as polylines (AP 214 / AP 203 Ed2)*
  - A geometric_curve_set of polylines, circles and trimmed_curves
  - Tessellated presentation and semantic presentation currently under test by CAx-IF**
- Styling of the annotation
  - Graphic characteristics (colour, line type and width)
  - Optional attributes (types of annotation, layer)



* Recommended Practices for Geometric Dimensions & Tolerances (GD&T) "Polyline Presentation", Release 1.0, CAx-IF & LOTAR, June 16, 2008.

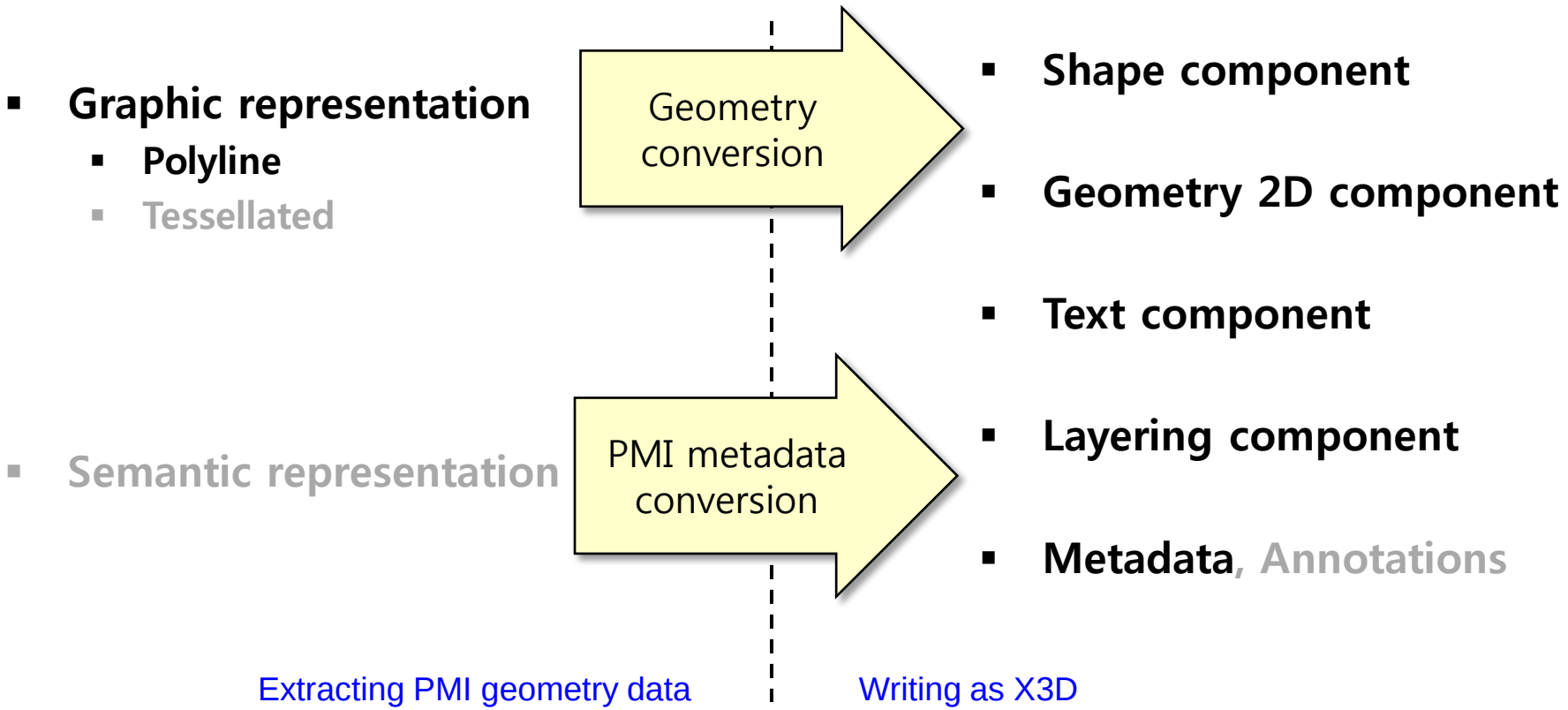
** Test Suite for the CAx Implementor Forum Round 34J April-September 2014, Release 1.0, CAx-IF, June 30, 2014.

Representing PMI in X3D

- A rich set of X3D metadata capabilities exist which might capture all relevant PMI when exporting X3D models

- Part 1: Architecture and base components
  - 7 Core component
    - MetadataSet, typed Metadata nodes
  - 12 Shape component
    - Appearance / FillProperties / LineProperties / Material / TwoSided Material / …
  - 14 Geometry2D component
    - Arc2D / Circle2D / Polyline2D / Rectangle2D / …
  - 15 Text component
    - FontStyle / Text
  - 35 Layering component
    - Layer / LayerSet / …
  - X. Annotation component (extension proposal for X3D version 3.4)

Conversion of STEP 3D PMI into X3D



Summary & Plan

- Propose new work Technical Report for ISO/IEC JTC1 SC24
  - **CAD-to-X3D Conversion for**
    - **Product Structure**
    - **Geometry Representation**
    - **Metadata**
  - Scope of work includes
    - Product structure and Geometry
    - PMI and Metadata
    - 3D printing and Additive Manufacturing (AM)
- Plan
  - X3D suitability for STEP PS/PMI and 3D printing
    - PMI metadata capture readiness, initial assessment of next steps
    - 3D Printing model format for Additive Manufacturing (AM) readiness, initial assessment of next steps

Thank you!

Hyokwang Lee
adpc92@gmail.com

Don Brutzman
brutzman@nps.edu

web 3D Korea web 3D CONSORTIUM