AFNeT STEP AP242 Benchmark

Test report for the STEP AP242 Benchmark #2

CAD test cases - Short Report v1.1

June 2017

Related websites

AP242 project:	http://www.ap242.org/
AP242 Benchmark:	http://benchmark.ap242.org/
PDM-IF:	http://www.pdm-if.org/
CAx-IF:	http://www.cax-if.org/

Preamble

The mission of the AFNeT association is to promote the use of digital technologies in the extended enterprise and in cross-company, cross-domain collaboration scenarios. To reach this goal, this association is strongly involved in the development and the support of deployment of PLM interoperability standards.

3D Model Based interoperability in global engineering and manufacturing of complex products relies on international open standards. The industries request the prequalication of PLM editor interoperability solutions; this function is ensured by the Implementor Forums.

Thus, AFNeT association has contributed to the launch and development of the STEP AP242 (ISO 10303-242) initiative since 2010. The availability of COTS STEP AP242 solutions for PDM, CAD and 3D visualization data interoperability is a key achievement of this challenge.

Today, we are pleased to provide you the results of the STEP AP242 Benchmark #2 report, focused on CAD test cases. The report for the PDM test case was provided as a separate document in April 2017, and was a joined action of ProSTEP iViP and AFNeT associations. New editions of this Benchmark report will be published, addressing additional software & functionalities.

This work has been realized with the support of Airbus, Dassault Aviation, Daher, MBDA, Liebherr, CETIM-CERTEC, CIMPA, Boost, ASD-SSG, GALIA, GIFAS, PFA, AFNeT Members and the AFNeT Benchmark Team.

Pierre Faure

Chairman of AFNeT

Content

Changes

Date	Version	Changes
21/06/2017	V1.1	Editorial corrections

1 Introduction

ISO 10303 STEP AP242 is available for the Automotive and Aerospace industries, as well as many other branches of the manufacturing industry, as a unique product standard for Managed model based 3D engineering data interoperability. STEP AP242 has been released as “International Standard” (IS) in August 2014. Multiple COTS applications have been tested by the CAx Implementor Forum and the PDM Implementor Forum.

STEP AP242 applications become increasingly important for CAD and PDM interoperability in the manufacturing industries. These STEP benchmark projects will allow our communities to reach a status of maturity for these applications, as the benchmarking activities are needed to apply quality control to AP242 based implementations.

Therefore, AFNeT association decided to conduct the STEP AP242 Benchmarks and to support the user community represented by several industry associations (ASD-SSG, GALIA, GIFAS, PFA) and manufacturers which drive the project, for getting an independent assessment of COTS STEP AP242 interfaces.

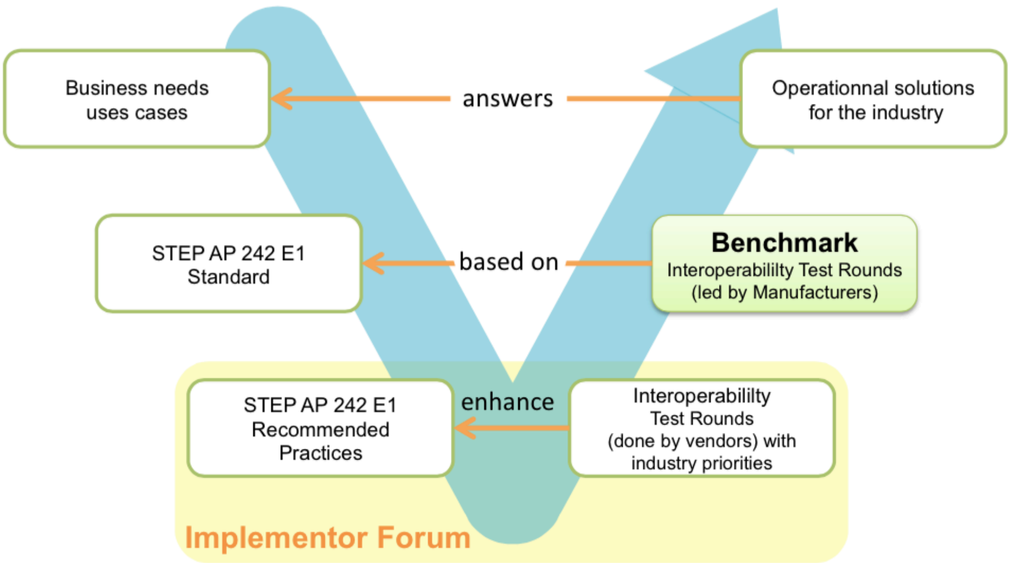

Figure 1: V cycle for STEP AP242 solutions

The objective of this Benchmark is to provide a public status of STEP AP242 functionalities available for operational use, tested by the industry and to identify limitations of the tested PLM COTS STEP AP242 applications.

This project is composed of two work packages:

- CAD work package managed by AFNeT,
- PDM work package managed commonly by AFNeT and ProSTEP iViP.

The organization of this Benchmark is based on the following principles:

- business priorities defined by the industry stakeholders supporting the STEP AP242 Benchmark,
- AP242 interoperability functionalities already tested by the CAx-IF and PDM-IF,
- tests based on STEP AP242 COTS solutions available on the market or on their way to be shipped to the industry.

This document presents the test results of the CAD work package which covers the tests of the following list of the main AP242 CAD functionalities:

- 3D geometry (exact and tessellated),
- 3D Product and Manufacturing Information (PMI) “graphic presentation” and “semantic representation”,

- P21 nested assembly structure and STEP BO Model XML assembly structure with external references to geometry,
- end-to-end conversions quality controls based on validation properties.

Since PLM Editors and CAD integrators constantly enhance the functionalities and robustness of their STEP AP242 interfaces, the results of this Benchmark provide a snapshot of the functionalities tested at a certain moment in time for a specific version of the Editors' solutions.

2 Terms and definitions

2.1 Terms

BO	Business Object (ISO10303-3001 AP242 Business Object Model)
CAD	Computer-Aided Design
CAx-IF	CAx Implementor Forum
COTS	Commercial Off The Shelf
DMU	Digital Mock-Up
EN	European Norms
IS	International Standard (status of maturity of ISO standards development)
ISO	International Organization for Standardization
GD&T	Geometric Dimensioning and Tolerancing
GVP	Geometric Validation Properties
LTA	Long-Term Archiving
LOTAR	LOng-Term Archiving and Retrieval
NIST	National Institute of Standards and Technology (US)
PDF	Portable Document Format
PMI	Product and Manufacturing Information
PLM	Product Life-cycle Management
P21	ISO 10303-21
STEP	STandard for the Exchange of Product model data
STEP AP203	Application Protocol: Configuration controlled 3D design of mechanical parts and assemblies (ISO10303-203:2011)
STEP AP214	Application Protocol: Core data for automotive mechanical design processes (ISO10303-214:2010)
STEP AP242	Application Protocol: Managed model-based 3D engineering (ISO10303-242:2014)
XML	Extensible Markup Language
UDA	User Defined Attributes

2.2 Definitions

2.2.1 Reminder of definition for PMI graphic presentation STEP AP242 edition 1

Graphic presentation is a type of presentation where the conveyed information is converted to geometric elements (lines, arcs, surfaces) by the source system in a way that preserves the exact appearance (colour, shape, positioning) of the presented information. The arrangement of these geometric elements can be interpreted by a competent human by looking at them, while the information content is no longer directly computer-accessible.

2.2.2 Reminder of definition for PMI semantic representation STEP AP242 edition 1

Source LOTAR EN9300 - P120

Semantic representation captures the meaning (intent) and relationships (context) of a character, word, phrase, sentence, paragraph, specification, or symbol without using any of the visual characters or constructs that are needed for a human to understand it – such as the letters, graphical symbols, lines and arrows used on engineering drawings.

The main purpose of semantic representation is to facilitate automated consumption of the data, e.g. for later re-use or for downstream applications. It applies to various types of data, such as PMI, Composite Material Definition, and others.

Example – The semantic representation of a Linear Dimension includes all of the information needed to understand the specification (the type of dimension, between which features it is defined…), without any of the graphic components such as dimension lines and extension lines, their direction, arrowheads and the dimension value.

2.2.3 Reminder of definition for the validation properties functionality

The validation properties are used within automatic processes to check the end-to-end consistency of data content during transformations from one format into another format.
At export, the GVP (Geometric Validation Properties) are written in the STEP file.
At import, the GVP are computed on the retrieved data and automatically compared to the value stored in the STEP file based on threshold and reported to the user.

3 Test methodology

3.1 Test procedure

The test procedure is:

- first, the creation of STEP files from all the selected applications;
- then, the selection per test case of one of the STEP file based on the syntax check and the loop tests (conversion from STEP to native with the same application used for the conversion from native to STEP);
- finally, the import of the selected STEP files into all in-scope applications.

These selections of STEP files have been done in order to decrease the test phase workload according to the availability of the resources. A systematic import of a STEP file in each application increases the workload, depending on the number of applications able to create the STEP files, and the quality issues of the STEP files.

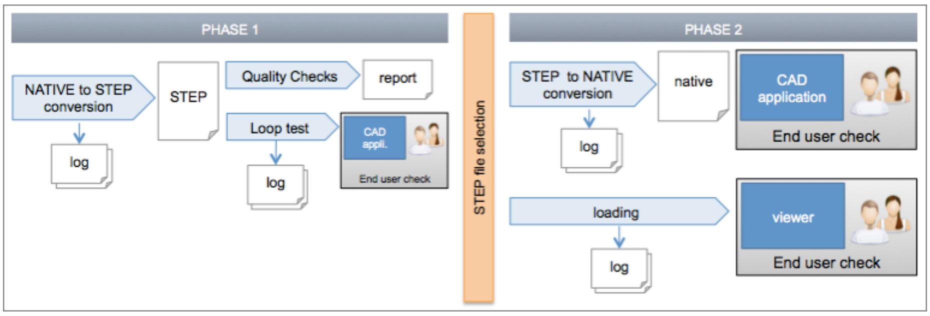

Figure 2: Illustration of the CAD test procedure

3.2 Rules for the STEP files selection

The general approach was to select a STEP file of good quality for each functionality tested in phase 2.

3.3 Test models

This section gives an overview of the test models. Each test model was available in six native CAD formats: CATIA V5, Creo, Inventor, NX, SOLIDWORKS and 3DEXPERIENCE.

3.3.1 Geometry test model

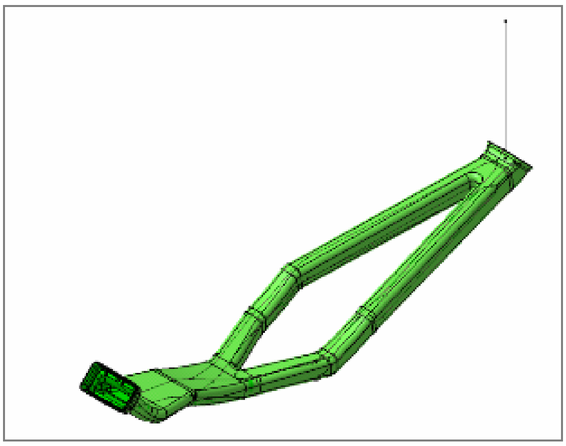

Figure 3: overview the model in CATIA

The test model contains:

- geometry;
  - solid,
  - “independent” surface (open shell) with transparent colour,
  - “independent” curves,
  - hidden/invisible geometries: not the same for each file format.
- User Defined Attributes.

3.3.2 Product Manufacturing Information (PMI) test model

The model comes from the NIST “MBE PMI Validation and Conformance Testing”.

http://www.nist.gov/el/msid/infotest/mbe-pmi-validation.cfm

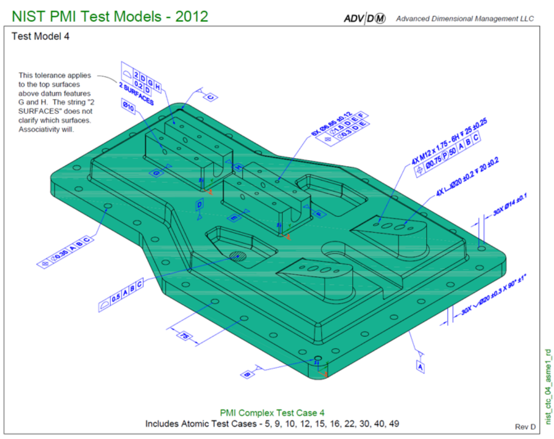

Figure 4: nist_ctc_04_asme1_rd

3.3.3 Assembly test model

The test models were available in the six native file formats. The test model is an assembly made of sub-assemblies and individual parts, represented by 3D solid models.

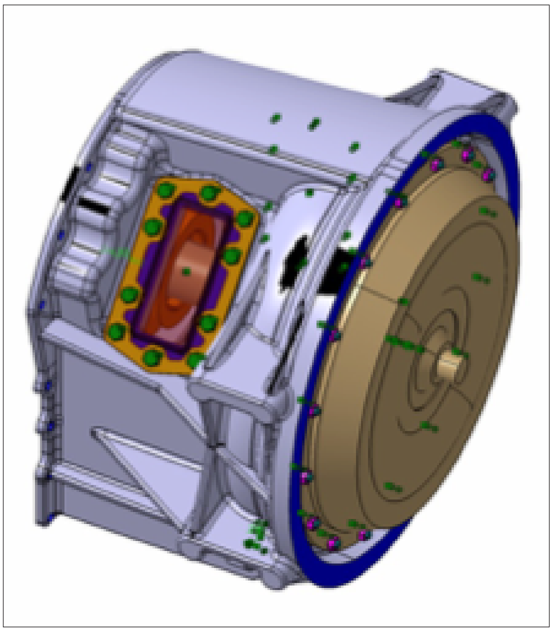

Figure 5: overview the geometry of the CAD assembly test case

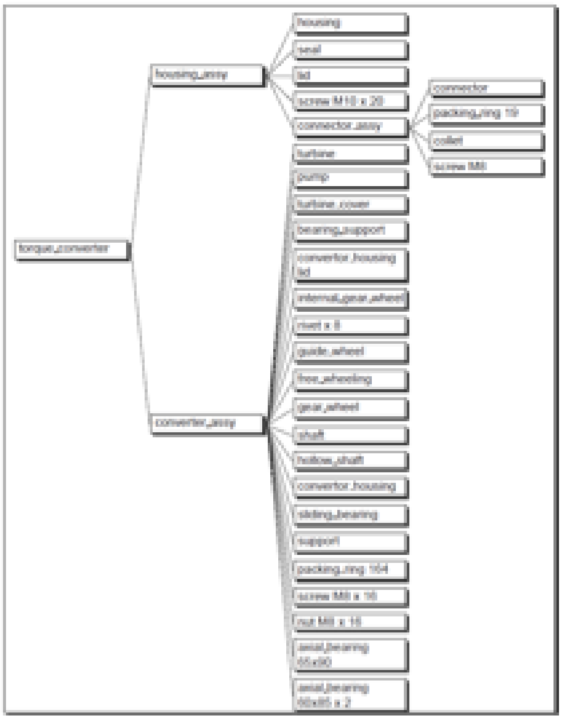

Figure 6: extract of the assembly structure of the CAD assembly test case

3.4 Test criteria

The general test criteria for each test are:

- end user validation: it consists of checking the completeness of critical content between the native and the target systems. For example, for the 3D exact geometry, it consists of visualising the geometry (solid, surface, curves) in the native and the target systems;
- validation properties: it consists of the comparison of the values stored in the STEP file and the values computed by the STEP interface/converter.

The issues reported to the PLM Editors included:

- the errors of conversions reported in the log files,
- the syntax check result,
- the STEP File Analyzer outputs,
- the errors of conversion detected by the visual control between the source CAD model and the converted CAD model.

3.5 Test cases

3.5.1 3D exact geometry (TC1)

The 3D exact geometry is used in various use cases such as the exchange of the CAD data, the LOng-Term Archiving and Retrieval of the CAD data.

The validation properties mechanism is essential to ensure the end-to-end quality control.

The approach of this TC1 is to export and import a STEP file containing the exact geometry (solid, surface, curve, point). The geometry test model has been used (see 3.3.1 Geometry test model).

3.5.2 3D tessellated geometry (TC2)

The 3D tessellated geometry is used for the Long-Term Archiving, the exchange of approximate geometry and the light visualization.

The approach of this TC2 is to export and import STEP files containing the tessellated geometry (solids, surfaces and curves). The geometry test model has been used (see 3.3.1 Geometry test model). The STEP interface or converters derived the tessellated geometry from the exact geometry.

3.5.3 PMI Graphic presentation (tessellated) on 3D exact geometry (TC3b)

Product and Manufacturing Information (PMI) is required for several business use cases in the context of STEP data exchange. Among others, it is a prerequisite for long-term data archiving.

The PMI test model has been used (see 3.3.2 Product Manufacturing Information (PMI) test model). The STEP interface or converter generates the STEP PMI tessellated presentation information corresponding to the PMI graphic presentation of the native CAD format.

3.5.4 PMI semantic representation link with graphic presentation and 3D exact geometry (TC3c)

Product and Manufacturing Information (PMI) is required for several business use cases in the context of STEP data exchange. Among others, it is a prerequisite for long-term data archiving. In addition, PMI can be used to drive downstream applications such as coordinate measuring and manufacturing.

Semantic PMI representation relates to the capability to store PMI data in the STEP file in a computer-interpretable way, so that it can be used for model redesign or downstream applications.

The PMI test model has been used (see 3.3.2 Product Manufacturing Information (PMI) test model). The PMI are exported to STEP using the PMI semantic entities, and also associated with the graphic presentations based on tessellated entities from the PMI.

3.5.5 PMI Graphic presentation on 3D tessellated geometry (TC4)

Product and Manufacturing Information (PMI) associated to 3D tessellated geometry is required for several business use cases in the context of STEP data exchange; for example, for manufacturing bids, it allows supporting a better intellectual property protection than the sending of the 3D exact geometry, but it supports also the PMI, mandatory to assess the Manufacturing cost.

The PMI test model has been used (see 3.3.2 Product Manufacturing Information (PMI) test model). The STEP interface or converter generates the STEP PMI tessellated presentation information corresponding to the PMI graphic presentation of the native CAD format. The PMI graphic tessellated presentation was associated to the tessellated geometry.

3.5.6 BO Model XML external references to STEP 3D tessellated geometry

The motivation of this test case is the exchange of an assembly structure referencing files containing tessellated geometry. The objective is to keep the native file structure of the CAD source system through the STEP conversion process to the target CAD system or 3D viewer. The AP242 edition 1 provides a Business Object (BO) Model, which is a comprehensive data model with an XML representation.

The STEP file must be created according to the CAx-IF Recommended Practices, and especially, to the CAx-IF Recommended Practices for STEP AP242 Business Object Model XML Assembly Structure.

3.5.7 CAD nested assembly files with references to 3D exact geometry (TC6d)

The motivation of this test case is the exchange and the Long-Term Archiving of CAD assembly structure referencing files containing exact geometry. For this test case, the objective is to keep the native file structure of the CAD source system through the STEP conversion process to the target CAD system or 3D viewer. The approach for the CAD nested assembly is to export and import the assembly structure in several files and the exact geometry in separate STEP files.

3.6 List of tested applications

This section describes the list of tested applications during this Benchmark. The selection of applications has been done according to:

- the needs of industry representatives supporting the benchmark,
- the availability of resources and funding,
- the availability of COTS tools according to the tests planning. The list of the software was selected in April 2016,
- the commitment of the support of PLM Editors to the benchmark.

3.6.1 CAD systems and converters

Company	Application name	Tested conversion
Autodesk	Autodesk Inventor Professional 2017	STEP AP242 export and import
Dassault Systèmes	CATIA V5-6R2016 SP2 3DEXPERIENCE R2016x	STEP AP242 export and import
CT CoreTechnologie	3D_Evolution 4.0 SP2	CATIA V5←→STEP AP242 Creo←→STEP AP242 Inventor←→STEP AP242 NX←→STEP AP242 SOLIDWORKS←→STEP AP242
Datakit	CrossManager 16.2	CATIA V5←→STEP AP242 Creo→STEP AP242 Inventor→STEP AP242 NX←→STEP AP242 SOLIDWORKS→STEP AP242 STEP→3D PDF
Elysium	ASFALIS EX7.0	CATIA V5←→STEP AP242 Creo←→STEP AP242 Inventor←→STEP AP242 NX←→STEP AP242 SOLIDWORKS←→STEP AP242
Tech Soft 3D	Tetra4D Reviewer 2016.1.0	CATIA V5→STEP AP242 Creo→STEP AP242 Inventor→STEP AP242 NX→STEP AP242 SOLIDWORKS→STEP AP242 STEP AP242→3D PDF

Table 1: CAD systems and converters

3.6.2 3D Viewers

	Application name
CT CoreTechnologie	3D_Analyzer 4.0
Tech Soft 3D	Tetra4D Reviewer 2016 1.0

Table 2: 3D Viewers

3.7 STEP file selected as reference for phase 2

According to the STEP files selection rules described in section 3.2., the following table lists the origin of STEP files of each test case, used for the tests of phase 2:

TC n°	TC description	Origin of the STEP file
TC1	3D exact geometry	CATIA V5R25 from CrossManager 16.2
TC2	3D tessellated geometry	NX 10 from CrossManager 16.2
TC3b	PMI graphic tessellated presentation and exact geometry	CATIA V5R21 from CATIA V5-6R2016
TC3c	PMI semantic representation link with graphic presentation and 3D exact geometry	CATIA V5R21 from 3D_Evolution 4.0 SP2
TC4	PMI graphic tessellated presentation and tessellated geometry	CATIA V5R21 from 3D_Evolution 4.0 SP2
TC6c	BO model XML external reference to STEP geometry	3DEXPERIENCE R2016x
TC6d	CAD assembly AIM P21 nested assembly on exact geometry	NX 10 from 3D_Evolution 4.0 SP2

Table 3: STEP files selected as reference for phase 2

Known issues with the selected STEP files are the following:

Test case 1 “3D exact geometry”:

- 3D exact geometry doesn’t contain the validation properties for the User Defined Attributes nevertheless the files contains User Defined Attributes,
- some points are visible in the STEP file instead of being invisible.

Test case 3b “PMI graphic tessellated presentation and exact geometry”:

- it doesn’t contain the “affected area” validation properties,
- the crosshighlight between the PMI and its associative geometry was incorrect for two PMI.

Test case 4 PMI graphic tessellated presentation and tessellated geometry:

- the camera of the saved view contains an incorrect view window.

4 Test results for each tool

4.1 Summary of the test results

test result	symbol	% of success
Success	●	=100%
Partial success fail	◕	>=66%
	◑	>=33%
	◔	<33%
Total Fail	○	=0%
Not supported		0
Not tested		0

type	Source format	Target format	Solution name	TC1 3D exact geometry	TC2 3D Tessellated geometry	TC6c assembly BO model XML + tesselated geo.	TC6d CAD assembly (P21 & nested) +exact geometry
export	3DEXPERIENCE	STEP AP242	3DEXPERIENCE R2016x	◕	●	●	●
export	CATIA V5	STEP AP242	3DEvolution v4.0 SP2	◕	◕	●	●
export	CATIA V5	STEP AP242	CATIA V5-6R2016	◕	●	●	●
export	CATIA V5	STEP AP242	Tetra4D Reviewer 2016.1.0	◑			
export	CATIA V5	STEP AP242	CrossManager 16.2	●	●	◕	●
export	CATIA V5	STEP AP242	ASFALIS	◕		◕	
export	Creo	STEP AP242	3DEvolution v4.0 SP2	◕	●	◕	◕
export	Creo	STEP AP242	Tetra4D Reviewer 2016.1.0	◕			
export	Creo	STEP AP242	CrossManager 16.2	◕	◕	○	●
export	Creo	STEP AP242	ASFALIS	◕		◕	
export	Inventor	STEP AP242	Inventor Professional 2017	◕			
export	Inventor	STEP AP242	3DEvolution v4.0 SP2	◑	◑	◕	◕
export	Inventor	STEP AP242	Tetra4D Reviewer 2016.1.0	◑			
export	Inventor	STEP AP242	CrossManager 16.2	◑	◑	◑	◑
export	Inventor	STEP AP242	ASFALIS	◕		◕	
export	NX	STEP AP242	3DEvolution v4.0 SP2	◕	●	●	●
export	NX	STEP AP242	Tetra4D Reviewer 2016.1.0	◕			
export	NX	STEP AP242	CrossManager 16.2	◑	●	○	◕
export	NX	STEP AP242	ASFALIS	◕		◕	
export	SOLIDWORKS	STEP AP242	3DEvolution v4.0 SP2	◑	◑	●	◕
export	SOLIDWORKS	STEP AP242	Tetra4D Reviewer 2016.1.0	◑			
export	SOLIDWORKS	STEP AP242	CrossManager 16.2	◑	◑	◕	●
export	SOLIDWORKS	STEP AP242	ASFALIS	◑		◕	
import	STEP AP242	3DEXPERIENCE	3DEXPERIENCE R2016x	◕	●	●	◕
import	STEP AP242	3D PDF	Tetra4D Reviewer 2016.1.0	◕	●		●
import	STEP AP242	3D PDF	CrossManager 16.2	◕	◕		●
import	STEP AP242	CATIA V5	3DEvolution v4.0 SP2	◕	●	●	●
import	STEP AP242	CATIA V5	CATIA V5-6R2016	◕	●	●	◕
import	STEP AP242	CATIA V5	CrossManager 16.2	◕	◕		●
import	STEP AP242	CATIA V5	ASFALIS	◕		◕	
import	STEP AP242	Creo	3DEvolution v4.0 SP2	◕	●	●	●
import	STEP AP242	Creo	ASFALIS	◕		◕	
import	STEP AP242	Inventor	Inventor Professional 2017	◕	◕		◕
import	STEP AP242	Inventor	3DEvolution v4.0 SP2	◕	◕	◕	◕
import	STEP AP242	Inventor	ASFALIS	◕			
import	STEP AP242	NX	3DEvolution v4.0 SP2	◕	●	●	●
import	STEP AP242	NX	CrossManager 16.2	◑			
import	STEP AP242	NX	ASFALIS	◕		◕	
import	STEP AP242	SOLIDWORKS	3DEvolution v4.0 SP2	◕	●	●	●
import	STEP AP242	SOLIDWORKS	ASFALIS	◕		◕	
viewer	STEP AP242	Viewer	3DAnalyzer	◕	●	●	●
viewer	STEP AP242	Viewer	Tetra4D Reviewer 2016.1.0	◕	●		●

Table 4: summary of the test results per tools for geometry and assembly test cases

type	Source format	Target format	Solution name	TC3b PMI graphic (tessellated) + exact geometry	TC3c PMI semantic linked with graphic	TC4 PMI graphic + tesselated geometry
export	3DEXPERIENCE	STEP AP242	3DEXPERIENCE R2016x	◕		◑
export	CATIA V5	STEP AP242	3DEvolution v4.0 SP2	●	●	●
export	CATIA V5	STEP AP242	CATIA V5-6R2016	◕		◑
export	CATIA V5	STEP AP242	CrossManager 16.2	◕	◕	◑
export	Creo	STEP AP242	3DEvolution v4.0 SP2	◕	◕	◕
export	Creo	STEP AP242	CrossManager 16.2	◑	◑	◑
export	Inventor	STEP AP242	Inventor Professional 2017		◑	
export	NX	STEP AP242	3DEvolution v4.0 SP2	◕	◑	●
export	NX	STEP AP242	CrossManager 16.2	◕	◑	●
export	SOLIDWORKS	STEP AP242	CrossManager 16.2	◑	◑	◑
import	STEP AP242	3DEXPERIENCE	3DEXPERIENCE R2016x	●		●
import	STEP AP242	3D PDF	Tetra4D Reviewer 2016.1.0	◕		◑
import	STEP AP242	3D PDF	CrossManager 16.2	●	●	●
import	STEP AP242	CATIA V5	3DEvolution v4.0 SP2	○		◑
import	STEP AP242	CATIA V5	CATIA V5-6R2016	●		●
import	STEP AP242	Inventor	Inventor Professional 2017	○		◑
import	STEP AP242	NX	3DEvolution v4.0 SP2	○	◔	◑
import	STEP AP242	SOLIDWORKS	3DEvolution v4.0 SP2	○	◔	○
viewer	STEP AP242	Viewer	3DAnalyzer	○	●	●
viewer	STEP AP242	Viewer	Tetra4D Reviewer 2016.1.0	●		●

Table 5: summary of the test results per tools for PMI test cases

The following table contains the ratios between the test criteria used to compute the "% of success" of each test case.

NOTE 1: In phase 1, only the CATIA's User Defined Attributes (UDA) were tested. In order to have equivalent ratios for all CAD systems, the UDA criterion is not considered in the summary.

NOTE 2: Due to the saved view issue of the TC4 selected STEP file, the associated criteria weight is set to null.

TC1 3D exact geometry		
End user validation	geometry	60%
	color	10%
	transparency	5%
	invisibility	5%
	UDA	0%
Geometric validation properties (GVP)	part	5%
	solid	5%
	shell	5%
	curve	5%
	UDA	0%
TC2 3D Tessellated geometry		
End user validation	geometry	60%
	color	20%
Validation properties	part	15%
	curve	5%
TC3b PMI graphic (tessellated) + exact geometry		
End user validation	Saved view	20%
	PMI graphic	30%
	PMI styling	5%
	PMI cross-highlight	20%
PMI VP	part level	15%
	PMI level	10%
TC3c PMI semantic linked with graphic		
End user validation	number of semantic PMI	20%
	validation of the semantic	50%
	link graphic / semantic	20%
PMI VP		10%
TC4 PMI graphic + tesselated geometry		
End user validation	Saved view	0%
	PMI graphic	50%
	PMI styling	15%
	PMI cross-highlight	35%
TC6c assembly BO model XML + tesselated geo.		
End user validation	Tessellated Geometry (compressed)	10%
	Assembly structure	70%
Assembly Validation properties		20%
TC6d CAD assembly (P21 & nested) +exact geometr		
End user validation	Exact Geometry	10%
	Assembly structure	70%
Assembly Validation properties		20%

Table 6: criteria ratios for each test cases

4.2 Autodesk – Inventor Professional 2017

The STEP interface of Inventor Professional supports the export of exact geometry (TC1) and semantic PMI (TC3c). At import, the exact geometry (TC1), the tessellated geometry (TC2), the graphic PMI (TC4) and the nested assembly file (TC6d) are supported.

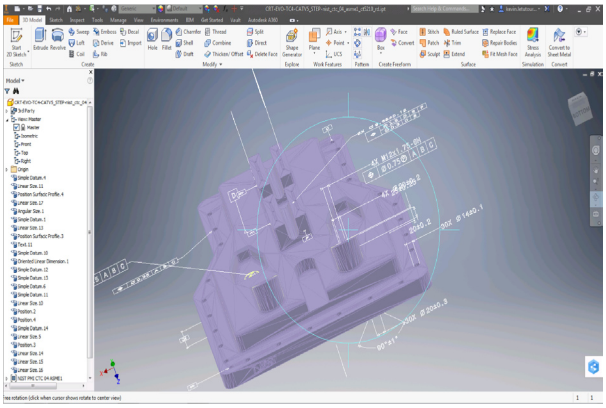

Figure 7: TC4 STEP file from 3D_Evolution (CATIA V5) imported in Inventor Professional

The results are particularly good for the supported functionalities. Nevertheless, some auxiliary functionalities are not supported. This is the reason of the partial result in the summary of each test case.

4.3 Dassault Systèmes – 3DEXPERIENCE R2016x & CATIA V5-6R2016 SP2

4.3.1 3DEXPERIENCE R2016x

The Dassault Systèmes STEP interface of 3DEXPERIENCE covers all the test cases of this Benchmark except for the TC3c semantic representation of the Product and Manufacturing Information (PMI).

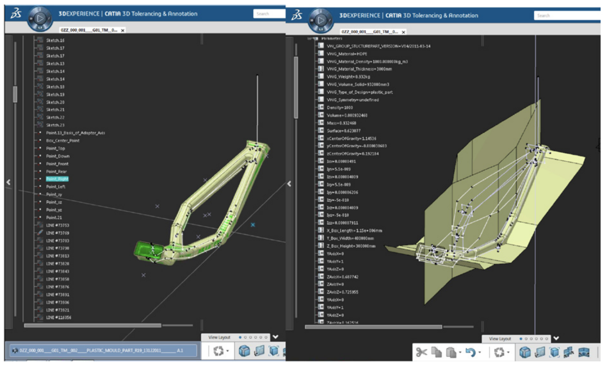

Figure 8: TC1 STEP from CrossManager (CATIA V5) imported in 3DExperience (on the right visible geometry / on the left invisible geometry)

The results at export and import are successful for the supported functionalities except for some PMI crosshighlight and the incomplete logs at the import of the selected assembly files.

4.3.2 CATIA V5-6R2016 SP2

The Dassault Systèmes STEP interface of CATIA V5 covers all the test cases of this Benchmark except the TC3c semantic representation of the Product and Manufacturing Information (PMI).

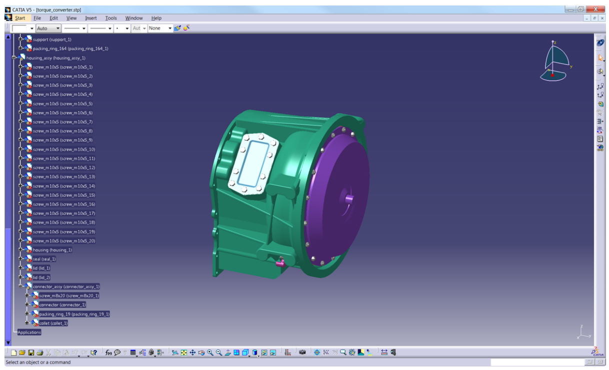

Figure 9: TC6d STEP files from 3D_Evolution (NX) imported in CATIA V5

The results at export and import are successful for the supported functionalities except for some PMI crosshighlights and the incomplete log at import of the selected assembly files.

4.4 CT CoreTechnologie - 3D_Evolution 4.0 SP2 & 3D_Analyzer

4.4.1 3D_Evolution 4.0 SP2

During this Benchmark, the 3D_Evolution application was used as a converter from:

- CATIA V5, Creo, Inventor, NX and SOLIDWORKS formats to STEP AP242,
- from STEP AP242 to CATIA V5, Creo, Inventor, NX and SOLIDWORKS formats. For these conversions a plugin has been installed in the CAD systems.

The supported test cases depend on the format:

- all the tests cases are supported at export from CATIA, Creo and NX formats,
- for Inventor and SOLIDWORKS, the supported test cases at export are TC1 (3D exact geometry), TC2 (3D Tessellated geometry), TC6c (BO Model XML assembly structure) and TC6d (P21 CAD nested assembly) with exact geometry),
- all test cases are supported at import to NX, SOLIDWORKS. All test cases are also supported at import to CATIA except for TC3c, but this is due to the target format.
- at import to Creo and Inventor, the supported test cases are TC1 (3D exact geometry), TC2 (3D Tessellated geometry), TC6c (BO Model XML assembly structure) and TC6d (P21 CAD nested assembly) with exact geometry).

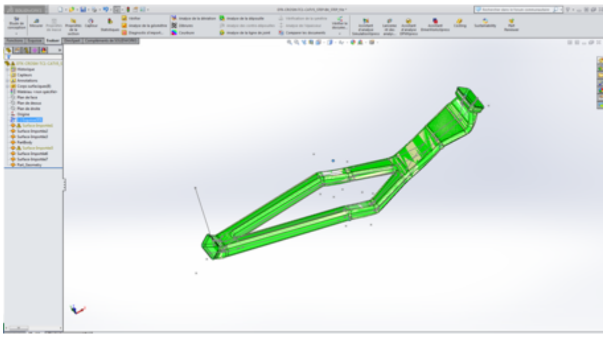

Figure 10: TC1 STEP from CrossManager (CATIA V5) imported in SOLIDWORKS by 3D_Evolution

Considering CATIA to STEP conversions, NX to STEP conversions, Creo to STEP conversions, and the good coverage of the functionalities for all test cases, the test results are successful for the most important functionalities.

For all formats, the conversions of assembly structures (P21 and BO Model) were successful.

The validation properties HTML reports offer a detailed overview of the information.

4.4.2 3D_Analyzer

3D_Analyzer was benchmarked as a STEP file viewer. All the test cases and functionalities of this Benchmark are supported by 3D_Evolution.

The test results are a total success for TC2 (3D tessellated geometry), TC3c (PMI semantic), TC4 (PMI graphic and tessellated geometry), TC6c (BO model XML external reference to STEP geometry) and TC6d (CAD assembly AIM P21 nested assembly on exact geometry).

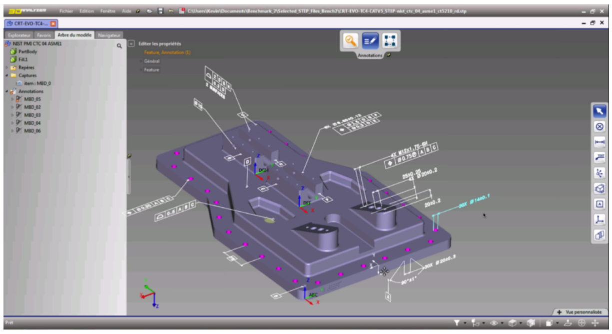

Figure 11: TC4 STEP file from 3D_Evolution (CATIA V5) imported in 3D_Analyzer

4.5 Datakit – CrossManager 16.2

CrossManager is a STEP converter that supports the conversion from CATIA, Creo, Inventor, NX and SOLIDWORKS format to STEP AP242. CrossManager allows the creation of 3DPDF, CATIA and NX files from STEP AP242 file.

The supported test cases depend on the format:

- all test cases are supported at export from CATIA, Creo, NX and SOLIDWORKS formats,
- from the imported Inventor file, the supported test cases are TC1 (3D exact geometry), TC2 (3D Tessellated geometry), TC6c (BO Model XML assembly structure) and TC6d (P21 CAD nested assembly) with exact geometry),
- to CATIA, the supported test cases are TC1 (3D exact geometry), TC2 (3D Tessellated geometry) and TC6d (CAD assembly (P21 & nested) with exact geometry),
- on the exported file to NX, the supported test cases are TC1 (3D exact geometry), TC2 (3D Tessellated geometry).

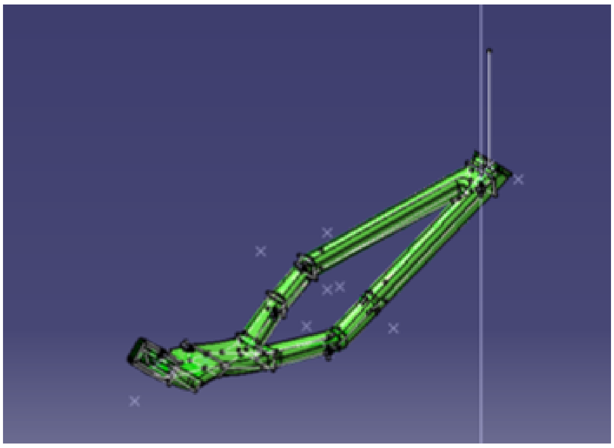

Figure 12: TC1 STEP from CrossManager (CATIA V5) imported in CATIA

For CATIA to STEP conversion, in addition to the good coverage of the functionalities for all test cases, the test results are successful. For STEP to CATIA conversion, the test results are successful but the supported test cases are limited to geometry and assembly.

For STEP to 3D PDF conversion, the test results are successful too but the TC6c (BO Model XML) test case is not supported.

For the others CAD format to STEP conversions, the main issues were on the conversion of some curves, on saved views, few graphic presentations, and on the BO Model XML assembly.

4.6 Elysium – ASFALIS EX7.0

ASFALIS is a solution for CAD data translation and distribution that supports conversions between STEP and CATIA, Creo, Inventor, NX, SOLIDWORKS formats. ASFALIS allows the conversion of the TC1 “exact geometry” and the TC6c “BO Model XML” assembly structure.

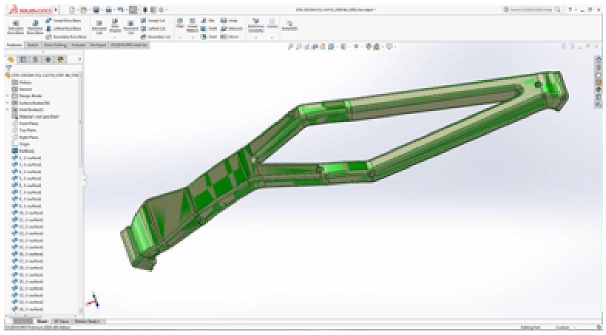

Figure 13: TC1 STEP from CrossManager (CATIA V5) converted to SOLIDWORKS format by ASFALIS

For CATIA, Creo, NX and SOLIDWORKS formats, the conversion results are particularly good for the supported functionalities. Nevertheless, some auxiliary functionalities are not supported. This is the reason of the partial result in the summary of each test case.

4.7 Tech Soft 3D – Tetra4D Reviewer 2016.1.0

The Tetra4D Reviewer was benchmarked as a converter from CAD format to STEP, as a converter from STEP AP242 to 3D PDF, and as a STEP viewer.

The Tetra4D Reviewer allows the conversion from CATIA V5, Creo, Inventor, NX and STEP AP242 for the test case 3D exact geometry (TC1).

The Tetra4D Reviewer supports the visualization of the STEP AP242 files for the TC1 (3D exact geometry), TC2 (3D Tessellated geometry), TC3b (PMI graphic with exact geometry), TC4 (PMI graphic with tessellated geometry), TC6d (CAD assembly (P21 & nested) with exact geometry).

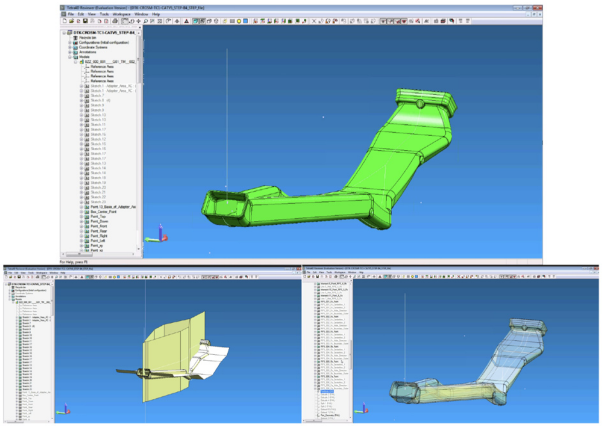

Figure 14: TC1 STEP from CrossManager (CATIA V5) imported in Tetra4D Reviewer (the top picture: visible geometry/ the bottom left invisible geometry / the bottom right shows the surface transparency)

The conversion of the TC1 from NX and Creo is successful. Nevertheless, some auxiliary functionalities are not supported. This is the reason of the partial result in the summary of each test case.

The results of the visualization test are successful for all supported test cases.

5 Test results for each test case

5.1 3D exact geometry (TC1)

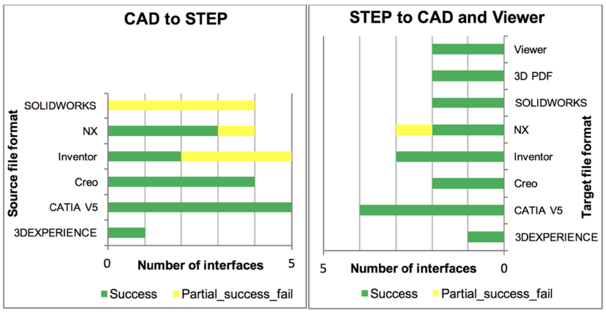

Figure 15: summary for the criteria exact geometry (solid, "independent" surface and curves) (end user validation excluding the colour/transparency, the invisibility, the UDA)

Many COTS solutions are available for the exchange in STEP of 3D geometry with styling information, which is necessary for the exchange of 3D digital mock-up, as an example. Auxiliary functionalities such as transparency, invisibility or UDA, are less implemented. Geometry Validation Property functionality is less supported as well, but this an important and major one, mandatory for some use cases. In addition, some validation issues were found due to the lack of recommendations for the validation of invisible geometry. Globally, for this test case, the tested tools presented good results.

5.2 3D tessellated geometry (TC2)

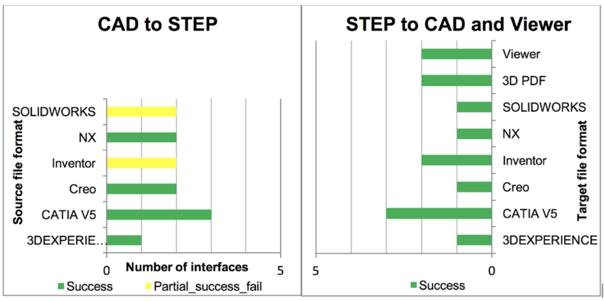

Figure 16: summary for the criteria "tessellated geometry" (end user validation excluding the presentation of the geometry)

Exchange of tessellated geometry in STEP is robustly supported for most of the COTS tools. Some unsuccessful results are observed for the tessellated curves and the tessellated Geometry Validation Properties at curve entity level. Tessellated geometry export and import functionalities are used for instance for lightweight 3D model data exchange.

5.3 PMI Graphic presentation (tessellated) on 3D exact geometry (TC3b)

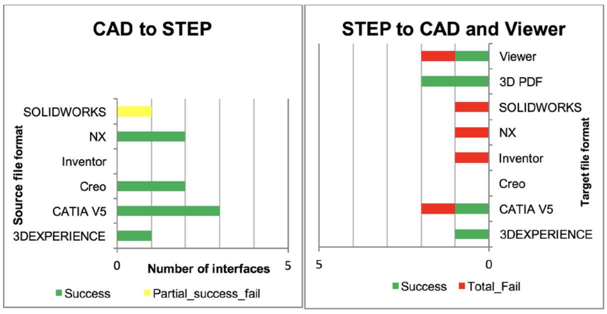

Figure 17: test result on PMI graphic presentation (on the left export / on the right import and viewer)

The test results show an issue of robustness when writing the saved views and crosshighlights. Moreover, an issue of robustness is also observed when reading the selected dataset created by a different interface. After the analysis of this serious issue, the functionalities needed for the exchange of graphic tessellated annotations associated to exact geometry present positive results.

5.4 PMI semantic representation link with graphic presentation and 3D exact geometry (TC3c)

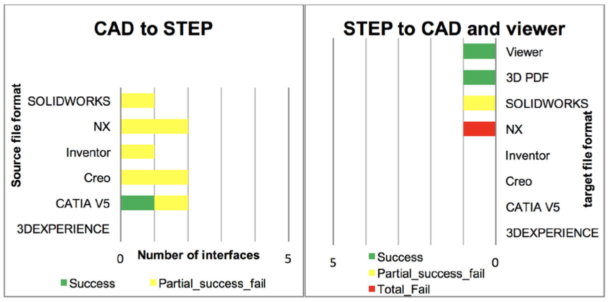

Figure 18: test result on the semantic PMI test case

The implementations are limited. It can be noted that conversion of the semantic PMI is a recent functionality and the related Recommended Practices have been released recently. Currently there are at least one export solutions for each source format, whereas there is a lack of import solutions. Only one major CAD Editor has provided an implementation. More advanced solutions are developed by specialized converter software editor. Knowing that the semantic PMI mechanism is complex, constantly evolving, and that the target objective is to combine the graphic annotations with the semantic annotations, the results are promising.

As a remark, the initial intent was to use a test case using ISO GPS (ISO 1101, etc.), but because of a lack of test cases designed with this standard in each format, this Benchmark used the test case based on the ASME standard.

5.5 PMI graphic presentation on 3D tessellated geometry (TC4)

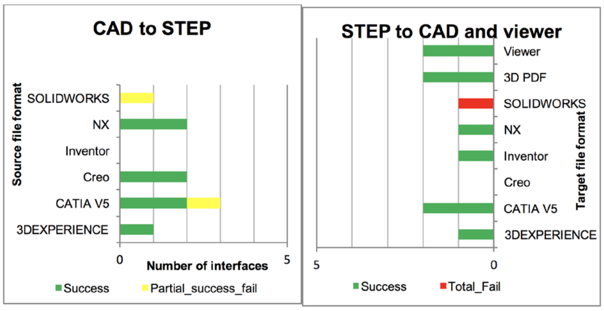

Figure 19: test result on PMI graphic presentation

The test results show again an issue of robustness when writing the saved views and crosshighlights. But, the graphic tessellated annotations and the tessellated geometry conversion results are positive results.

5.6 BO model XML external references to STEP 3D tessellated geometry (compressed) (TC6c)

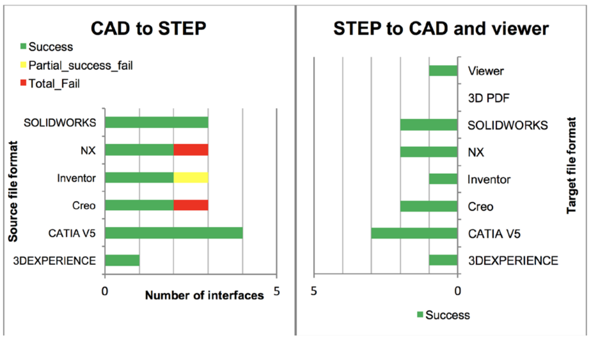

Figure 20: result on assembly structure

The test results for the BO Model XML are positive despite of the recent publication of the STEP AP242 edition 1. The latter is the first standard to propose the BO Model XML implementation.

A COTS tool for the conformance to the Recommended Practices is needed for the future benchmark. A candidate tool may be the tool in development by the PDM-IF community.

5.7 CAD assembly (nested) files with reference to 3D exact geometry (TC6d)

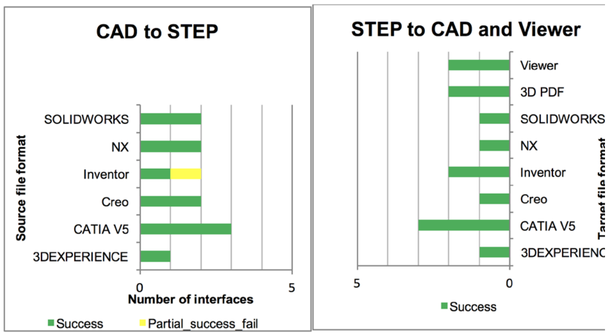

Figure 21: Result on assembly structure

The exchange of nested assembly is particularly robust and well supported for most of the tested COTS tools. Similar results were provided in STEP AP242 Benchmark #1 test report.

6 Summary

STEP AP242 (ISO 10303-242 “Managed model based 3D engineering”) has been published as “International Standard” in August 2014.

The objectives of the industry are reached only when COTS STEP AP242 applications are available and used by a broad community, with the appropriate level of functionalities and quality.

This Benchmark #2 provides a snapshot of STEP AP242 interoperability functionalities of priority 1 requested by the industries. It is focused on a specific scope of STEP AP242 edition 1 functionalities already assessed by the CAx-IF.

The following criteria were evaluated:

- syntax quality control of STEP files,
- validation of the conversion of the detailed content of the source information,
- end-to-end quality control of conversion based on STEP validation properties.

For 3D geometry (exact and tessellated) and for P21 nested assembly structure, the results show that a high level of quality of STEP AP242 processors is already achieved for the main functionalities, based on the extended operational uses of STEP AP203 and AP214 converters. Transparency, invisibility and User Defined Attributes functionalities are less implemented. Geometry Validation Property functionalities are less supported as well, but this an important and major capability, mandatory for some use cases.

For 3D geometry (exact and tessellated) associated with 3D PMI graphic presentation, the results are promising and we are still expecting better results with the availability of new COTS applications in the next STEP AP242 benchmarks.

For 3D exact geometry associated with 3D PMI semantic, the implementations are limited but the results are promising. Only one major CAD Editor has provided an implementation. More advanced solutions are developed by specialized converter software editor. All major CAD editors have announced the support of this functionality in the latest version of their CAD system.

The test of this functionality will be a key priority for the next STEP AP242 Benchmark.

For STEP AP242 BO Model XML assembly referencing 3D geometry, test results present a good and positive level of implementation despite of the recent publication of the related Recommended Practices.

Some findings of the AFNeT Benchmark will be communicated to the CAx-IF as an input for the update of the STEP AP242 Recommended Practices. In addition, other outcomes will be provided for the development of STEP AP242 edition 2, and for requirements of edition 3.

The use of international open standards for 3D Model Based interoperability is a key enabler to support global engineering and manufacturing of complex products within the extended enterprise. It also contributes to ensure a better independence regarding PLM Editor’s proprietary formats, and long-term preservation of 3D Model Based design. The availability of COTS STEP AP242 solutions for PDM, CAD and 3D visualization data interoperability contributes to answer to this challenge.

The present Benchmark provides the status of COTS STEP AP242 CAD converters and viewers in early 2016. The versions of these applications released in 2017 provide important enhancements. Their testing will be completed by next benchmark editions.

7 Publication of the long reports

Detailed documentation of the STEP AP242 Benchmarks of the CAD test cases is only available for the members of the AFNeT, and can be downloaded from the following website: http://www.afnet.fr/dotank/sps/ap242benchmark/

Short Reports are publicly available on http://benchmark.ap242.org/

AFNeT - ProSTEP iViP STEP AP242 Benchmark of PDM test case is also available on these websites.

8 Acknowledgements

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