



# STEP AP242 Benchmark

prostep ivip / AFNeT Short Report

Test report for the STEP AP242 Benchmark #4

PDM test cases

Version 1.0

## Abstract

The STEP AP242 Benchmark is an AFNeT and prostep ivip associations joint project with the support of several industry associations.

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

This document presents the test results of the PDM test cases.

The test criteria are exchange of PDM information, correctness and conformity of the STEP XML files, fulfilment of end-to-end assembly validation properties, and end-user validation. Furthermore, the test results are derived to provide conclusions on the general maturity of STEP AP242 Domain Model XML based implementations, related to the main PDM functionalities.

## Related websites

AP242 project: <http://www.ap242.org>

AP242 Benchmark: <http://benchmark.ap242.org/>

PDM-IF: <http://www.mbx-if.org/>

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# 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 Edition 3 was released as “International Standard” (IS) during 2022. Multiple COTS applications have been tested by the CAx Interoperability Forum and the PDM Interoperability Forum using the Domain Model already available since 2021.

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

Therefore, AFNeT and prostep ivip decided to conduct the STEP AP242 Benchmarks and to support the user community represented by several industry associations and manufacturers which drive the project, for getting an independent assessment of COTS STEP AP242 interfaces.

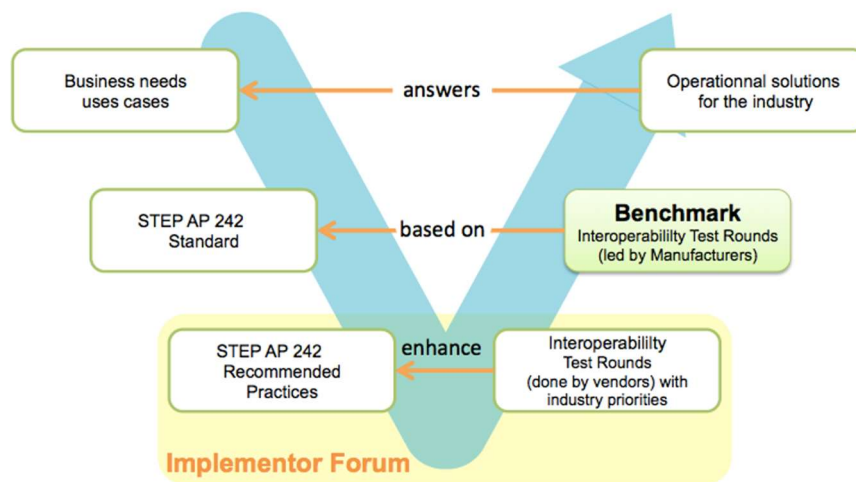


Figure 1 - V cycle for STEP AP242 solutions

The objective of this Benchmark is to provide a public status of STEP AP242 Edition 3’s PDM functionalities available for operational use, tested by the industry and to identify limitations of the tested PLM COTS AP242 applications.

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 PDM-IF,
- tests based on STEP AP242 COTS solutions available on the market or on their way to be shipped to the industry.

Additionally to the classical assembly structure, this document presents the test suite of the PDM test cases which cover the tests of the following AP242 PDM functionalities (so-called “extensions” of the benchmark):

- PDM Assembly with 3D Geometry represented with **Alternate and Substitute Parts**,
- PDM Assembly with 3D Geometry represented with **Product Configuration based on Effectivities**.

Since PLM and CAD vendors/integrators (called ‘participant’) 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 participant’s solutions. New editions of this Benchmark report will be published, addressing additional software & functionalities.



## 2 References and terms

### 2.1 Reference documents

Table 1 - Reference documents

Name	Status version	Link
<b>Recommended Practices for STEP AP242 Domain Model XML Product and Assembly Structure</b>	Release 3.1 (18th of Nov 2022)	<a href="http://www.mbx-if.org">www.mbx-if.org</a>
<b>Recommended Practices for STEP AP242 Domain Model XML Configuration Management</b>	Release 1.1 (6 <sup>th</sup> of April 2023)	<a href="http://www.mbx-if.org">www.mbx-if.org</a>
<b>STEP AP242 Edition 3 Domain Model XML Schema</b>	ISO 10303-4442 of AP242 Ed3	<a href="https://standards.iso.org/iso/ts/10303/-4442/ed-3/tech/xml-schema/domain_model/">https://standards.iso.org/iso/ts/10303/-4442/ed-3/tech/xml-schema/domain_model/</a>
<b>Reference sample files: choice among two STEP datasets for each test case:</b> <ul style="list-style-type: none"> <li>- one referencing STEP P21 geometries</li> <li>- one referencing JT geometries</li> </ul>	2023 January PDM-IF version	<a href="https://nextcloud.boost-lab.net/nextcloud/index.php/f/41888">https://nextcloud.boost-lab.net/nextcloud/index.php/f/41888</a>

### 2.2 Terms

AVP	Assembly Validation properties
Domain Model	AP242 Domain Model XML (ISO 10303-4442)
CAD	Computer-aided design
CAX-IF	CAX Interoperability Forum
COTS	Commercial off-the-shelf
PDM	Product Data Management
PDM-IF	PDM Interoperability Forum
IS	International Standard
ISO	International Organization for Standardization
LTA	Long-term archiving
PDF	Portable Document Format (ISO 32000)
3D PDF	3D viewer format defined by PDF/E (ISO 24517)
PLM	Product Lifecycle Management
Part 21	ISO 10303-21
STEP	Standard for the Exchange of Product model data
STEP AP242	Application protocol: Managed model-based 3D engineering

XML	Extensible Mark-up Language
XSD	XML Schema Definition

### 3 Test methodology

This document describes the suite of test cases to be used by the PDM work package of the STEP AP242 Benchmark #4. The Benchmark concentrates primarily on testing the interoperability and compliance of STEP processors based on AP242.

The reference datasets, the procedure and the test criteria are based on the PDM Interoperability Forum project.

#### 3.1 Functionalities tested in this benchmark

In this benchmark the two test cases, “*Alternate/Substitute Parts*” and “*Product Configuration based on effectivities*”, will be tested. The core capabilities are import and export of the reference datasets to and from PDM Systems using AP242 Domain Model XML Schema (XSD), with focus on:

- Completeness of the product structure, including identification information
- Completeness and correct positioning of the assembly, including assembly validation properties
- Transfer of PDM-specific attributes, with focus on Alternate/Substitute Parts and Product Configuration with Effectivities (so-called ‘extensions’ of the benchmark).

The tested capabilities are separated in independent test cases and therefore described in specific chapters: 4 and 0. As this benchmark contains two test cases, please see the testing procedure and criteria in the related chapter.

Independently from each other, each vendor decides if he participates:

- as a full PDM vendor (both imports and export) or as a pure data consumer (only imports, no export),
- with the basic (mandatory) scope or additionally with the optional extension scope defined for each test case. The basic scope is the pure assembly structure while the extension is the additional data specific to each testcase (see below).

#### 3.2 Testing instructions of the solutions

The selection of applications and the testing instruction are based on:

- 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 commitment of the support of the participants to the Benchmark Team.

The tests on the solution will be done via:

1. a remote server hosted by the participant and accessed via RDC or VNC protocols
2. or a virtual machine (VM) provided by the participant

#### **With:**

- all the necessary PLM and interface software, “**ready to use**” for the Benchmark Team including running licence, installations, and all necessary settings
- **a cookbook** detailing all steps needed to execute the tests **within the budgeted time**

The list of test solutions and their descriptions (type of application, version, target PDM system, etc.) will be included in the Benchmark report.

The files, documents and information will be stored on a dedicated secured website.

The testing process, including issue management and result recording, will be shared by e-mails.

## 4 Test Case 1: “Alternate and Substitute Parts”

### 4.1 General

In this test case the import and export of

- A1. Alternate Parts on Part Master Level,
- A2. Alternate Parts on Part Version Level,
- A3. Substitute Parts on Part Assembly Usage Level,
- A4. Substitute Parts on Part Assembly Occurrence Level,

to and from PDM Systems using “AP242 **Edition 3**” Domain Model XSD with focus on completeness, are tested.

Some PLM Systems do not support both Alternate Part approaches, nor both Substitute Part approaches. However, the Recommended Practices describe how to map an approach to the other during import.

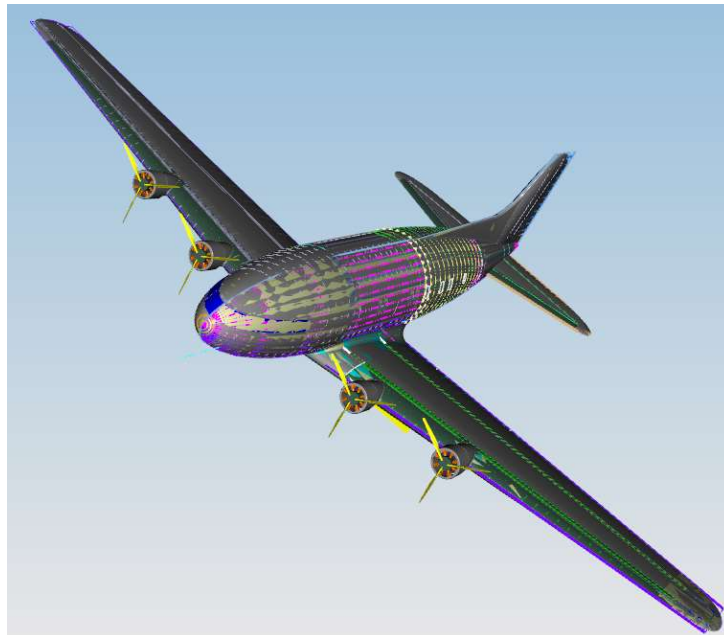
The COTS AP242 application shall import all four approaches as defined in the reference dataset and may:

- either map them to those approaches supported by the PDM system (for example from A1 to A2 or from A3 to A4 or conversely). In this case, during export, the mapped approaches will be re-exported. This kind of deviation from the sample file will not be considered as a failure during the evaluation;
- or the data model in the PDM system deviates from the AP242 data model: for example, the substitution is between an Occurrence and a PartVersion rather than between two Occurrences. In such cases, some bidirectional mappings might be not possible: this kind of deviation from the sample file will not be considered as a failure during the evaluation;
- or the PLM System includes customization that enables to support all the approaches and re-export them as defined in the sample file.

### 4.2 Test model overview

The reference dataset is provided as monolithic file.

The test model used in this test is a simplified “Boeing Stratoliner” model, made public by Boeing. It provides a representative complexity, near to real life data exchange.



*Figure 2 - Illustration of Stratoliner test model*

‘Symmetry of 3-9161’, ‘Symmetry of 3-9161\_1’ and ‘Symmetry of 3-9161\_2’ are defined as alternate parts of ‘3-9161 ---’ (on Part Master level) in both directions.

‘15-4775-2B’ Version A is defined as alternate part version to ‘15-4775-2A’ Version A in both directions.



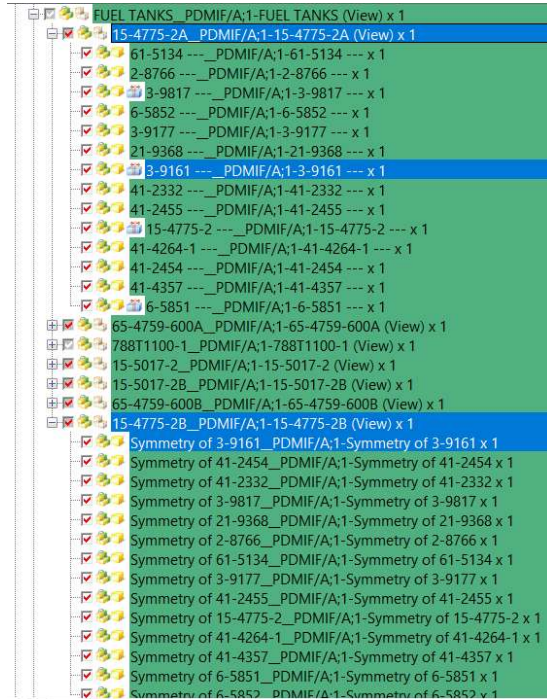


Figure 3 - Product Structure of the Stratoliner model

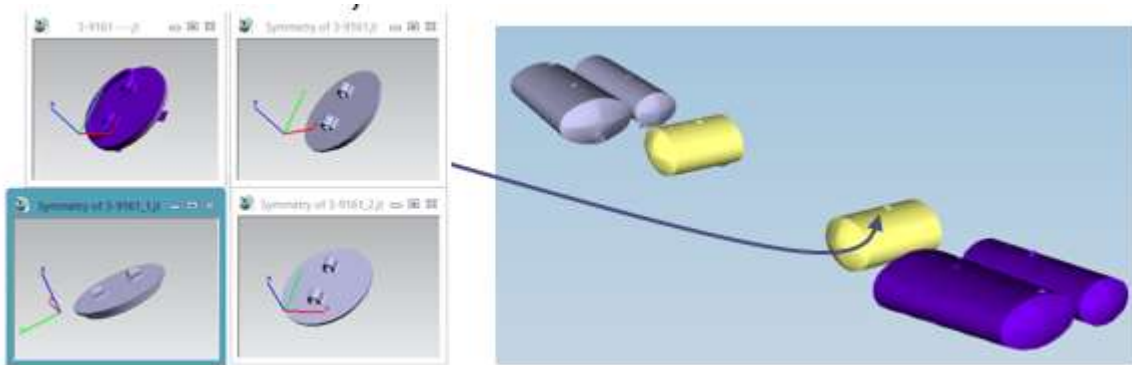


Figure 4 - Example of Alternate Dataset

1. Based on this data:

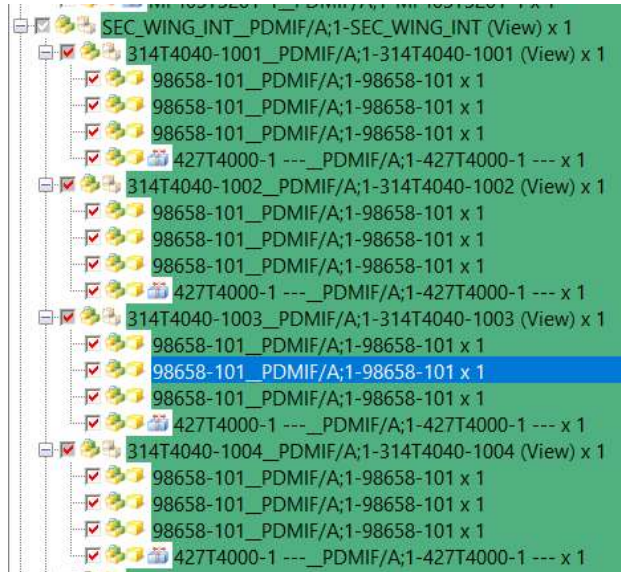


Figure 5 - Product Structure Alternate Dataset

If you want to create the Alternative and Substitute information in your system, you may do the following:

- a. Create 2 copies of the propeller blade '98658-101' called '98658-102' and '98658-103'. Also copy the geometry.

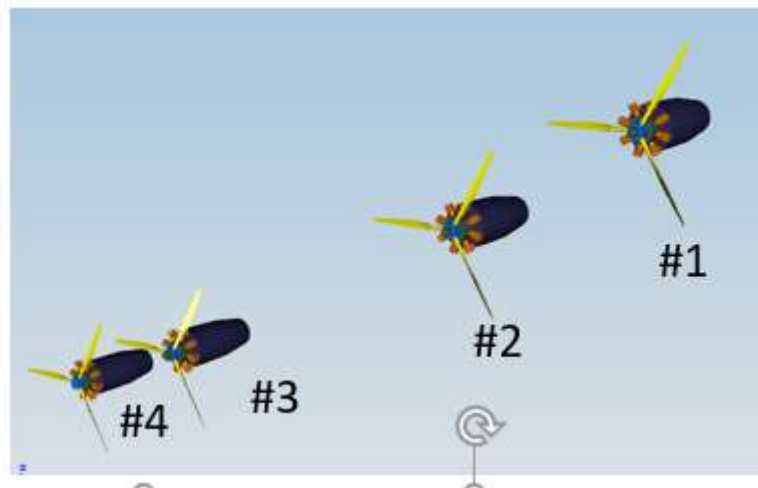


Figure 6 - Example Picture of Alternative propellers

- b. The Engines #1, #2 and #3 '314T4040-1001' builds the three propeller blades '98658-101' called '98658-102' and '98658-103'.
- c. For Engine #1, The occurrence 'PROP POS1.1' of '98658-102' is defined as a substitute of the occurrence 'PROP POS1.1' of '98658-101'. Ditto for the occurrence of 'PROP POS1.1' of '98658-103'. This in both directions.
- d. Ditto for the Engine #2 '314T4040-1002' on the occurrence 'PROP POS2.1'
- e. For Engine #3, the usage with find number 100 of '98658-101' is defined as a substitute of the usage with find number 100 of '98658-102'. Ditto for '98658-103'. This in both directions.

## 4.3 Test Procedure

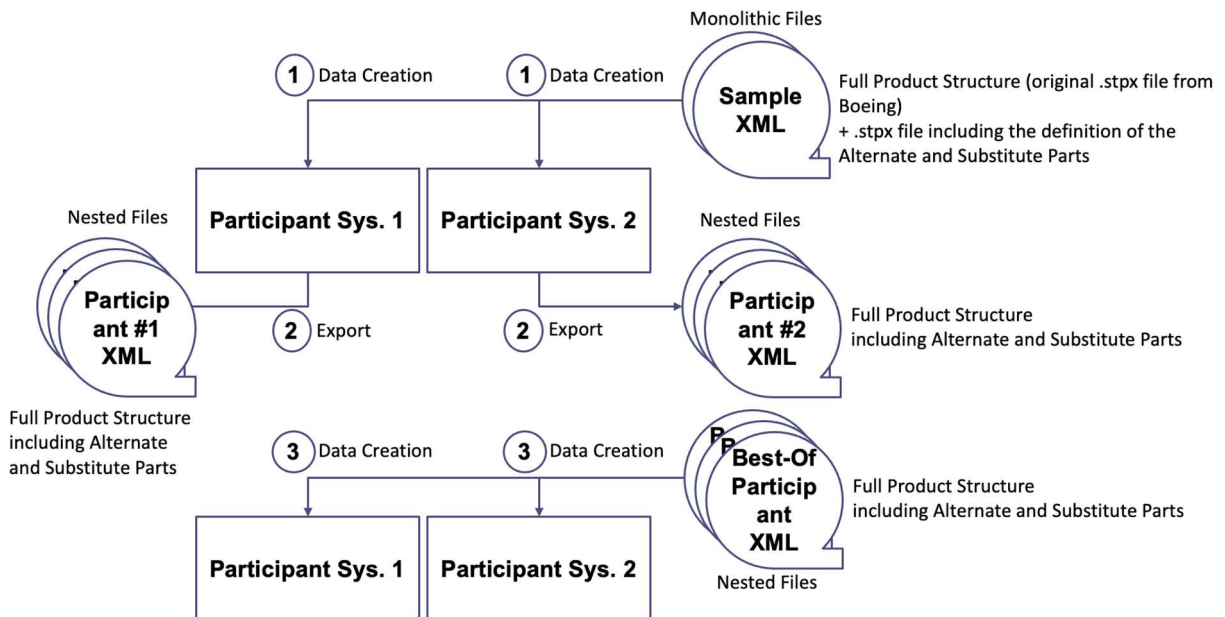


Figure 7 - Testing Procedure illustration

The steps shown on the graphic are:

1. Creation of the data in the source PDM systems, using the provided XML reference dataset (monolithic file).
2. Export of the data as nested files.

Use of a dedicated prefix so the data imported during step 3 doesn't collide with this data.

After these two steps have been performed for all participants, the best of all exported datasets will be chosen. If a second-best dataset provides enough quality, it shall be taken so that during step 3 the dataset and the target solution are not from the same participant.

3. Import of the (second) best dataset (nested files).

## 4.4 Test Criteria

The evaluation of the testing is done by using the testing criteria in the table below. The following criteria apply in both the exported STEP file and (except for the ExchangeContext) in the PDM/connector systems end-user graphical interface.

Additional criterium for the export and the second import: the support of nested files.

**Remark 1:** the original test models are provided in monolithic (not nested). Caution: the "Boeing Stratoliner" model, made public by Boeing relies on an older AP242 Edition (Edition 1) and may deviate to some of the current Recommended Practices. If Edition 1 is not supported by some of the participants, the CentreOfMass validation properties may be removed from the sample file (it will not be considered as a failure during the evaluation of the initial import). Doing so, the file gets compliant to Edition 3 and the URL can be changed to Edition 3.

**Remark 2:** the sample file that contains the Alternate and Substitute parts is a subset of the original dataset from Boeing. It can be used stand-alone without the original dataset from Boeing.

- Either read only the first file (for those participants that do not participate at the optional extension scope);
- Or import both files separately (for those participants that do participate at the optional extension scope).

**Remark 3:** as mentioned above, both sample files are based on original Boeing data and are using the CAX-Representation according to the Recommended Practices section 11.1 (no use of Document/DocumentVersion/DigitalDocumentDefinition). However, for the Benchmark, the PDM-Representation is expected during Export.

**Attributes mentioned with (\*) are part of the optional extension scope. The other ones are part of the mandatory basic scope.**

*Attributes mentioned in italic shall be exported (by the PDM solutions) and displayed during import, but do not need to be imported by the PDM solutions (mostly set automatically by the PDM system with the current user logged in and the actual date).*

Table 2 - Test criteria of Alternate/Substitute test case

Object	Expected Attribute	Expected Value
<b>ExchangeContext</b>	DefaultLanguage	"en_US"
	DefaultUnit	Reference to a Unit having Kind="SI system", Name="metre", Prefix="milli" and Quantity="length" as CharacterStrings
	IdentificationContext	Reference to the Organization, sender of the stpx file
<b>Part</b>	Id (role 'exchange identification information' in the context of the organization 'PDM-IF')	Value: see original test file
	Id (role 'identification information' in the context of the source/target organization)	Optional, as generated by the PDM system
	Id (role 'unique object identification information' in the context of the source/target organization)	Optional, as generated by the PDM system
	Name	Value: see original test file '/NULL' for nested (referenced) parts before the merge process of the nested files
	PartTypes	'piece part' for the single parts and for the nested (referenced) parts before the merge process of the nested files 'assembly' for the assembly nodes
<b>AlternatePartRelationship (*)</b>	Related (*)	Reference to the alternate Part
	(*)	'alternate'
<b>PartVersion</b>	Only one version shall be exported at a time (the newest one)	
	Id (role 'identification information' in the context of the Part.Id having the same role)	Optional, as generated by the PDM system. Shall concatenate the revision number and the sequence/generation/iteration number. For example: A.1 or 001,1 or '/ANY' for the nested (referenced) parts if the right version gets computed at runtime by the PDM application or during the merge process of the nested files
	ApprovalAssignment	Role: unset for the normal approval (Status = ClassString 'in progress' or 'approved')

Object	Expected Attribute	Expected Value
	<i>DateTimeAssignment</i>	Role 'creation', 'update' and/or 'lock'
	<i>OrganizationOrPersonInOrganizationAssignment</i>	Role 'owner', 'creator', 'editor' and/or 'locked by'
<b>PartVersionRelationship (*)</b>	Related (*)	Reference to the alternate PartVersion
	RelationType (*)	'alternative'
<b>PartView</b>	Only one view shall be exported at a time (the mechanical design view)	
	ClassifiedAs	'specified reference' for the nested (referenced) parts before the merge process of the nested files
	InitialContext	'mechanical design'. Refer to the "ViewContext template" in the recommended practices
<b>AssemblyDefinition</b>	If the PartView doesn't describe a single part (does not apply to the nested (referenced) parts before the merge process of the nested files)	
	AssemblyType	'design assembly'
<b>NextAssemblyViewUsage (*)</b>	Only to map FindNumber and/or AssemblyViewRelationshipSubstitutions	
	ClassifiedAs (*)	'alternative' if referenced by <a href="#">AssemblyViewRelationshipSubstitution.Related</a>
	Id (*)	Value: see original test file
	Related (*)	Reference to the PartView of the underlying part of sub-assembly
	RelationType (*)	'next assembly view'
	AssemblyViewRelationshipSubstitution (*)	
	Related (*)	Reference to the substitute NextAssemblyViewUsage
	Quantity (*)	BoM quantity of the related Part(View). <b>If NextAssemblyOccurrenceUsage are provided, their number shall be consistent with the value in Quantity.</b>
<b>NextAssemblyOccurrenceUsage</b>	In the PartView of an assembly node: one for each usage link within the assembly node	
	ClassifiedAs (*)	'alternative' if referenced by <a href="#">AssemblyOccurrenceRelationshipSubstitution.Related</a>
	RelationType	'next assembly occurrence'
	Related	Reference to the occurrence (i.e. the usage) of the underlying part of sub-assembly

Object	Expected Attribute	Expected Value
	Placement	CartesianTransformation with: RotationMatrix: xx xy xz yx yy yz zx zy zz (blank separated) TranslationVector: x y z (blank separated) <u>in Millimeters</u> No use of GeometricRepresentation-Relationship and its subtypes
	AssemblyOccurrenceRelationshipSubstitution (*)	
	Related (*)	Reference to the substitute NextAssemblyOccurrenceUsage
<b>SingleOccurrence</b>	In the PartView of the used part or sub-assembly: one for each direct usage of the part or sub-assembly within an assembly node	
	Id	Value: see original test file
<b>DocumentAssignment</b>	Optional for each PartView: one for the geometric model (no alternative geometries) and one for each non-geometric file	
	Role	CAD files or reference to a nested file before the merge process of the nested files: 'mandatory'
	AssignedDocument	Reference to a DocumentVersion (no direct reference to a DigitalFile, except in case of a reference to a nested file before the merge process of the nested files)
<b>Document</b>	One for each geometric model or non-geometric file	
	Id (role 'exchange identification information' in the context of the organization 'PDM-IF')	Value: see original test file
	Id (role 'identification information' in the context of the source/target organization)	Optional, as generated by the PDM system
	Id (role 'unique object identification information' in the context of the source/target organization)	Optional, as generated by the PDM system
	Name	Value: see original test file
	DocumentTypes	CAD files: 'primary geometry'
<b>DocumentVersion</b>	Only one version shall be exported at a time (the newest one)	
	Id (role 'exchange identification information' in the context of the Document.Id having the same role)	Value: see original test file



Object	Expected Attribute	Expected Value
	Id (role 'identification information' in the context of the Document.Id having the same role)	Optional, as generated by the PDM system. Shall concatenate the revision number and the sequence/generation/iteration number. For example: A.1 or 001,1
	Id (role 'unique object identification information' in the context of the source/target organization)	Optional, as generated by the PDM system
	ApprovalAssignment	Role: unset for the normal approval (Status = ClassString 'in progress' or 'approved')
	<i>DateTimeAssignment</i>	<i>Role 'creation', 'update' and/or 'lock'</i>
	<i>OrganizationOrPersonInOrganizationAssignment</i>	<i>Role 'owner', 'creator', 'editor' and/or 'locked by'</i>
<b>DocumentDefinition</b>	Only one view shall be exported at a time	
	Files	Reference to a DigitalFile (only one, no model splitting)
<b>DigitalFile</b>	One for each geometric model or non-geometric file or for each reference to a nested file before the merge process of the nested files	
	Id	Value: see original test file
	FileContent	(optional) Refer to the "ContentProperty template" of the recommended practices or 'assembly' for a reference to a nested file before the merge process of the nested files
	FileCreation	(optional) Refer to the "CreationProperty template" of the recommended practices
	FileFormat	Refer to the "FormatProperty template" of the recommended practices or 'UTF-8' and 'ISO 10303-242 Domain Model XML' for a reference to a nested file before the merge process of the nested files
	FileSize	(optional) Refer to the "SizeProperty template" of the recommended practices
	FileType	CAD files: 'geometry' or 'structured product data' for a reference to a nested file before the merge process of the nested files
<b>ExternalItem</b>	For each DigitalFile in "Locations": one for each geometric model or non-geometric file	
	Id	See DigitalFile.Id

Object	Expected Attribute	Expected Value
	Source	The following symbols shall be used: '/ or \' to depict the directory structure '; './ or '.\' To depict the current directory ..' to move up to the next higher directory
<b>PropertyValueAssignment</b>	Describing the assembly validation property 'number of children' (only on PartViews of kind AssemblyDefinition)	
	ClassifiedAs	'validation properties'
	AssignedPropertyValues	Refer to the "Assembly Validation Properties" of the recommended practices
<b>CentreOfMass</b>	Describing the assembly validation property 'notional solids centroid' (only on PartViews of kind AssemblyDefinition)	
	Role	'assembly validation property'
	CentrePoint	Refer to the "Assembly Validation Properties" of the recommended practices

## 5 Test Case 2: “Product Configuration based on effectivities”

### 5.1 General

“Product Configuration based on effectivities” test case is also named “Product Configuration UC2” within the PDM-IF project.

This test case is derived from the use case where an OEM has to send an explicit assembly with the filtering information that was used to filter the assembly based on a given configuration.

In this test case, the import and export of

- Explicit (resolved) product assembly structure
- Product Configuration object assigned to the assembly root node
- Effectivities assigned to the assembly relationships

to and from PDM Systems using “AP242 **Edition 3**” Domain Model XSD with focus on completeness are tested.

Some PLM Systems do not support Product Configuration and/or effectivities approaches.

However, the Recommended Practices describe how to map an approach to the other during import.

To achieve this, the PLM System does not need to be COTS but may include customization that enables an easy mapping of the approaches.

### 5.2 Test model overview

The reference dataset is provided as monolithic file.

The test model, which is used in this test case, is the “Mountain Bike” model. It provides a representative complexity, near to real life data exchange.

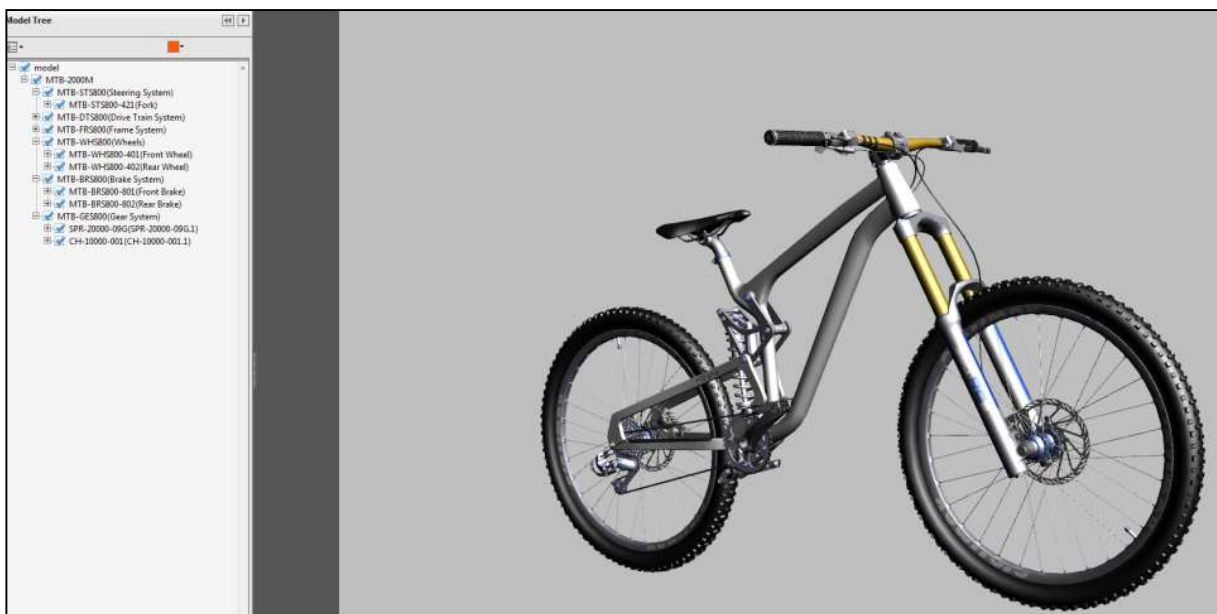


Figure 8 - Illustration of the Mountain Bike test model

The test model is the result of a filtering of the assembly based on a configuration, as illustrated in Figure 9.

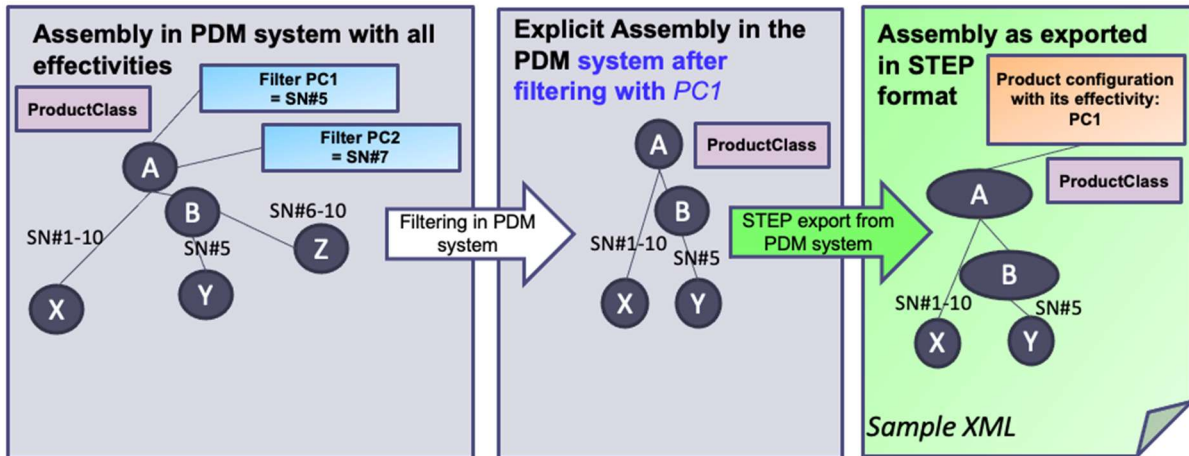


Figure 9 - Illustration of filtering in PDM system and export in STEP

The aim of this test case is **not to process such a filter**, but to exchange the filtering result (the green test model in the above figure) between the benchmark participants.

The test model uses a ProductConfiguration object assigned to the assembly root node:

- A SerialEffectivity SN#5 (Serial Number "5") is assigned to ProductConfiguration in order to convey the filtering information;
- Effectivities are assigned to some assembly relationships. Two types of effectivities are used in the test model:
  - SerialEffectivity SN#5-5 (Serial Number "5") used 3 times in the assembly,
  - SerialEffectivity SN#1-10 (Serial Numbers "1" to "10") used 4 times in the assembly.

Both data is only 'for information' and do not need to be processed as filter nor as effectivities. Nevertheless, they shall be re-exported like in the sample file (and not as string properties, for example).

### 5.3 Test Procedure

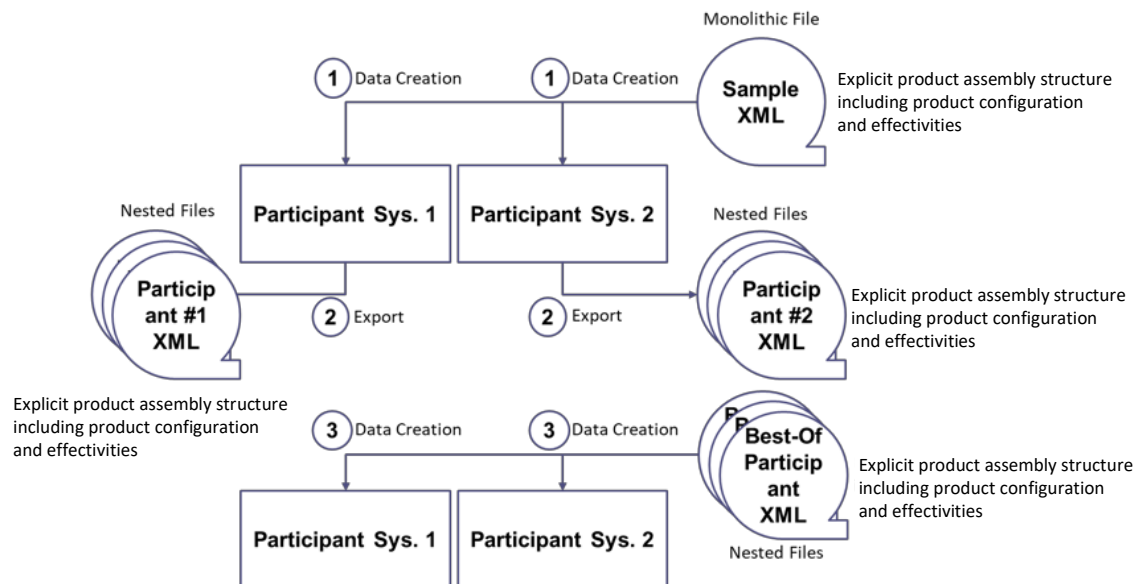


Figure 10 - Testing Procedure illustration

The steps shown on the graphic are:

1. Creation of the data in the source PDM system, using the provided XML reference dataset (monolithic file).

2. Export of the data as nested files.  
Use of a dedicated prefix so the data imported during step 3 doesn't collide with this data.

After these two steps have been performed for all participants, the best of all exported datasets will be chosen. If a second-best dataset provides enough quality, it shall be taken so that during step 3 the dataset and the target solution are not from the same participant.

3. Import of the (second) best dataset (nested files).

## 5.4 Test Criteria

The evaluation of the testing is done by using the testing criteria in the table below. The following criteria apply in both the exported STEP file and (except for the ExchangeContext) in the PDM/connector systems end-user graphical interface.

Additional criterium for the export and the second import: the support of nested files.

**Remark:** the original test models are provided in monolithic (not nested).

The nested files will contain some circular links:

- within the nested file of the ProductClass, the ProductConfiguration will reference the nested file that describes the top node of the product structure;
- within the nested file of any assembly part, the ProductConfiguration used for ExchangeContext.IdentificationContext and its ProductClass will reference the nested file that describes the ProductClass (such circular link is all right and shall be supported).

**Attributes mentioned with (\*) are part of the optional extension scope. The other ones are part of the mandatory basic scope.**

*Attributes mentioned in italic shall be exported (by the PDM solutions) and displayed during import, but do not need to be imported by the PDM solutions (mostly set automatically by the PDM system with the current user logged in and the actual date).*

Table 3 - Test criteria of Product Configuration based on effectivities test case

Object	Expected Attribute	Expected Value
<b>ExchangeContext</b>	DefaultLanguage	"en-US"
	DefaultUnit	Reference to a Unit having Kind="SI system", Name="metre", Prefix="milli" and Quantity="length" as CharacterStrings
	IdentificationContext	Reference to the uid of the ProductConfiguration.Identifier (*) rather than the reference to the Organization, sender of the stpx file
<b>Part</b>	Id (role 'exchange identification information' in the context of the organization 'PDM-IF')	Value: see original test file
	Id (role 'identification information' in the context of the source/target organization)	Optional, as generated by the PDM system
	Id (role 'unique object identification information' in the context of the source/target organization)	Optional, as generated by the PDM system

Object	Expected Attribute	Expected Value
	Name	Value: see original test file '/NULL' for nested (referenced) parts before the merge process of the nested files
	PartTypes	'piece part' for the single parts and for the nested (referenced) parts before the merge process of the nested files 'assembly' for the assembly nodes
<b>PartVersion</b>	Only one version shall be exported at a time (the newest one)	
	Id (role 'identification information' in the context of the Part.Id having the same role)	Optional, as generated by the PDM system. Shall concatenate the revision number and the sequence/generation/iteration number.
	ApprovalAssignment	Role: unset for the normal approval (Status = ClassString 'in progress' or 'approved')
	<i>DateTimeAssignment</i>	<i>Role 'creation', 'update' and/or 'lock'</i>
	<i>OrganizationOrPersonInOrganizationAssignment</i>	<i>Role 'owner', 'creator', 'editor' and/or 'locked by'</i>
<b>PartView</b>	Only one view shall be exported at a time (the mechanical design view)	
	ClassifiedAs	'specified reference' for the nested (referenced) parts before the merge process of the nested files
	InitialContext	'mechanical design'. Refer to the "ViewContext template" in the recommended practices
<b>AssemblyDefinition</b>	If the PartView doesn't describe a single part (does not apply to the nested (referenced) parts before the merge process of the nested files)	
	AssemblyType	'design assembly'
<b>NextAssemblyOccurrenceUsage (NAOU)</b>	In the PartView of an assembly node: one for each usage link within the assembly node	
	RelationType	'next assembly occurrence'
	Related	Reference to the occurrence (i.e. the usage) of the underlying part of sub-assembly
	Placement	CartesianTransformation with: RotationMatrix: xx xy xz yx yy yz zx zy zz (blank separated) TranslationVector: x y z (blank separated) <u>in Millimeters</u> No use of GeometricRepresentation-Relationship and its subtypes
<b>EffectivityAssignment (*)</b>	Embedded in 7 of the NAOU Objects (so called "occurrence effectivity")	
	AssignedEffectivity	References the SerialEffectivity #1 (in 4 NAOU) or #2 (in 3 NAOU)
	Effectivityindication	"true"
	Role	"actual"



Object	Expected Attribute	Expected Value
<b>SingleOccurrence</b>	In the PartView of the used part or sub-assembly: one for each direct usage of the part or sub-assembly within an assembly node	
	Id	Value: see original test file
<b>DocumentAssignment</b>	Optional for each PartView: one for the geometric model (no alternative geometries) and one for each non-geometric file	
	Role	CAD files or reference to a nested file before the merge process of the nested files: 'mandatory'
	AssignedDocument	Reference to a DocumentVersion (no direct reference to a DigitalFile), except in case of a reference to a nested file before the merge process of the nested files)
<b>Document</b>	One for each geometric model or non-geometric file	
	Id (role 'exchange identification information' in the context of the organization 'PDM-IF')	Value: see original test file
	Id (role 'identification information' in the context of the source/target organization)	Optional, as generated by the PDM system
	Id (role 'unique object identification information' in the context of the source/target organization)	Optional, as generated by the PDM system
	Name	Value: see original test file
	DocumentTypes	CAD files: 'primary geometry'
<b>DocumentVersion</b>	Only one version shall be exported at a time (the newest one)	
	Id (role 'exchange identification information' in the context of the Document.Id having the same role)	Value: see original test file
	Id (role 'identification information' in the context of the Document.Id having the same role)	Optional, as generated by the PDM system. Shall concatenate the revision number and the sequence/generation/iteration number. For example: A.1 or 001,1
	Id (role 'unique object identification information' in the context of the source/target organization)	Optional, as generated by the PDM system
	ApprovalAssignment	Role: unset for the normal approval (Status = ClassString 'in progress' or 'approved')
	<i>DateTimeAssignment</i>	<i>Role 'creation', 'update' and/or 'lock'</i>

Object	Expected Attribute	Expected Value
	<i>OrganizationOrPersonInOrganizationAssignment</i>	Role 'owner', 'creator', 'editor' and/or 'locked by'
<b>DocumentDefinition</b>	Only one view shall be exported at a time	
	Files	Reference to a DigitalFile (only one, no model splitting)
<b>DigitalFile</b>	One for each geometric model or non-geometric file or for each reference to a nested file before the merge process of the nested files	
	Id	Value: see original test file
	FileContent	(optional) Refer to the "ContentProperty template" of the recommended practices or 'assembly' for a reference to a nested file before the merge process of the nested files
	FileCreation	(optional) Refer to the "CreationProperty template" of the recommended practices
	FileFormat	Refer to the "FormatProperty template" of the recommended practices or 'UTF-8' and 'ISO 10303-242 Domain Model XML' for a reference to a nested file before the merge process of the nested files
	FileSize	(optional) Refer to the "SizeProperty template" of the recommended practices
	FileType	CAD files: 'geometry' or 'structured product data' for a reference to a nested file before the merge process of the nested files
<b>ExternalItem</b>	For each DigitalFile in "Locations": one for each geometric model or non-geometric file	
	Id	See DigitalFile.Id
	Source	The following symbols shall be used: '/' or '\ ' to depict the directory structure '.' , './' or '.\ ' To depict the current directory '..' to move up to the next higher directory
<b>PropertyValueAssignment</b>	Describing the assembly validation property 'number of children' (only on PartViews of kind AssemblyDefinition)	
	ClassifiedAs	'validation properties'
	AssignedPropertyValues	Refer to the "Assembly Validation Properties" of the recommended practices
<b>CentreOfMass</b>	Describing the assembly validation property 'notional solids centroid' (only on PartViews of kind AssemblyDefinition)	
	Role	'assembly validation property'
	CentrePoint	Refer to the "Assembly Validation Properties" of the recommended practices
<b>ProductClass (*)</b>	(Subtype of ProductConcept)	

Object	Expected Attribute	Expected Value
	Id (*) (role 'exchange identification information' in the context of the organization 'PDM-IF')	Value: see original test file
	Id (*) (role 'identification information' in the context of the source/target organization)	Optional, as generated by the PDM system
	Id (*) (role 'unique object identification information' in the context of the source/target organization)	Optional, as generated by the PDM system
	LevelType (*)	"product family" as CharacterString
<b>ProductConfiguration (*)</b>	Embedded in the ProductClass	
	Id (*)	Value: see original test file (with same role of ProductClass.Id and context=uid of ProductClass.Id)
	Name (*)	"Product Configuration for filter context" as CharacterString
<b>EffectivityAssignment (*)</b>	Embedded in the ProductConfiguration Object (so called "filtering information")	
	AssignedEffectivity (*)	References the SerialEffectivity #2
	EffectivityIndication (*)	"true"
	Role (*)	"actual"
<b>ProductDesignAssociation (*)</b>	Embedded into ProductConfiguration	
	AssociatedDesign (*)	References the PartVersion of the assembly root node
<b>SerialEffectivity #1 (*)</b>	(Subtype of Effectivity)	
	EffectivityContext (*)	Reference to the ProductClass
	StartId (*)	IdentifierString = "1"
	EndId (*)	IdentifierString = "10"
<b>SerialEffectivity #2 (*)</b>	(Subtype of Effectivity)	
	EffectivityContext (*)	Reference to the ProductClass
	StartId (*)	IdentifierString = "5"
	EndIf (*)	IdentifierString = "5"

## 6 Result matrices

This section specifies the evaluation criteria and associated result symbols. The test result tables in 0 are based on these matrices.

### 6.1 Import matrix

This matrix is used:

- for each solution and for each test case,
- for the initial import and for the re-import steps,
- once for the basic mandatory scope and once for the optional extension defined for the test case.

Table 4 - Description import matrix

Test Result		Definition for initial or re-import	Symbol	Number of warnings (W) / errors(E) x,a,b,c,d,z, t= numbers	Number of violated attribute value level criteria (from M in total)		Overall percentage (formula depending on each test case, considers only the critical data)
					Uncritical	Critical	
Success		No warnings/error messages All imported testcase relevant data is as expected	✓	W:0 E:0	0	0	100%
Partial success	non critical	Warnings/Error messages Partially missing/wrong data in the target system that does not affect the testcase relevant data	◆	W:x E:0	x	0	100%
	critical	Warnings/Errors messages Partially missing/wrong data in the target system that affect the testcase relevant data	◆	W:a E:b	y	s	>= 60%
Fail		Warnings/Error messages:					
		Complete missing/wrong data in the target system that affect the testcase relevant data	✗	W:c E:d	z	t	< 60%
		It was not possible within the budgeted time to run the testcase due to technical problems with the vendor solution	✗	n/a	n/a	n/a	n/a
Not tested		Testcase extension is not in scope for the vendor solution	○				
Not applicable		No results to provide regarding the solution type	n/a				

Warning and Error messages just help the testing team to identify the issues.

No warning/error messages means that the solution is perfectly prepared for the test data, already tested during the PDM-IF test rounds and provided before the benchmark. Therefore, warnings/errors shall NOT be deactivated in the participant's solution!

The “attribute value level criteria” are defined in the “Test Criteria” section of each test case. They are critical if they are necessary to support the test case.

The short report contains only the first 3 columns and cover all solutions (one column ‘Symbol’ per solution for the basic mandatory scope and one column ‘Symbol’ for the optional extension defined for the test case) in one big table for each test case.

The long report contains all columns plus the list of issues in multiple tables.

## 6.2 Export matrix

This matrix is used:

- for each solution and for each test case,
- for the export step,
- once for the basic mandatory scope and once for the optional extension defined for the test case.

Table 5 - Description Export Matrix

Test Result	Definition for <b>export</b>		Symbol	XSD violation : Critical	Number of violated Schematron Rules (from N in total)		Number of violated attribute value level criteria (from M in total)		Overall percentage (formula depending on each test case, considers only the critical rules/data)
					Uncritical	Critical	Uncritical	Critical	
Success	No violation of the XSD No deviation to the Rec. Pracs. All testcase relevant data is as expected		✓	0	0	0	0	0	100%
Partial success	non critical	No violation of the XSD Deviation to the Rec. Pracs. or missing/wrong/additional data that most probably <u>don't lead</u> to a bad interpretation or non-consumption of some of the testcase relevant data by the target system	◆	0	a	0	g	0	100%
	critical	Violation of the XSD Deviation to the Rec. Pracs. or missing/wrong/additional data that most probably <u>lead</u> to a bad interpretation or non-consumption of some of the testcase relevant data by the target system	◆	y	b	e	h	k	>= 60%

	Violation of the XSD Deviation to the Rec. Practs. or missing/wrong/additional data that most probably <u>lead</u> to a bad interpretation or non-consumption of the <u>whole testcase relevant data</u> by the target system	×	z	c	f	i	l	< 60%
	It was not possible within the budgeted time to run the testcase due to technical problems with the vendor solution	×	n/a	n/a	n/a	n/a	n/a	n/a
Not tested	Testcase extension is not in scope for the vendor solution	○						
Not applicable	No results to provide regarding the solution type (for example data consumer)	n/a						

No XSD nor schematron rules' violations means that the solution is perfectly prepared for the test data, already tested during the PDM-IF test rounds and provided before the benchmark.

XSD violations are always considered as critical.

The "attribute value level criteria" are defined in the "Test Criteria" section of each test case. They are critical if they are necessary to support the test case.

The short report contains only the first 3 columns and cover all solutions (one column 'Symbol' per solution for the basic mandatory scope and one column 'Symbol' for the optional extension defined for the test case) in one big table for each test case.

The long report contains all columns plus the list of issues.



## 7 Benchmark participants and results

This chapter provides the list of participants, the overview of all test results of Test Case 1 and Test Case 2, and the detailed results for each solution.

### 7.1 Participants

#### 7.1.1 Dassault Systèmes

Table 6 - Dassault Systèmes 3DEXPERIENCE R2023xFD05

<b>Solution / Tested Version:</b>	3DEXPERIENCE R2023xFD05
<b>Solution Type:</b>	PDM System
<b>Description:</b>	The 3DEXPERIENCE platform puts the human experience at the centre of design and engineering. Virtual Twin Experiences transform the way organizations conceive, develop, and realize new products to deliver a competitive edge through innovative customer experiences. With multi-discipline collaboration on a single platform, teams develop products for sustainability using performance data, generative design and related technologies to understand lifecycle impact and make better, more informed decisions. In this benchmark, we leverage various applications of the 3DEXPERIENCE related to design and product structure.

#### 7.1.2 Datakit

Table 7 - Datakit CrossManager V2023.4

<b>Solution / Tested Version:</b>	CrossManager V2023.4
<b>Solution Type:</b>	Converter (for 3DPDF in this benchmark)
<b>Description:</b>	<p>DATAKIT provides CrossManager , a standalone software allowing an end user to convert files from PLM formats. It acts by selecting one or several CAD files to translate them automatically in the target format.</p> <p>CrossManager is based on CrossCad/Ware libraries V2023.4, which provide an Application Program Interface which enables interoperability among CAD systems, allowing a caller application to access the data stored in native or standard data files, as well as to write them.</p> <p>CrossManager and CrossCad/Ware are quarterly updated, for best reactivity on evolution of formats and on customer demand. In the frame of STEP Benchmark, the conversion was done from STEP to 3DPDF, hence producing a PDF file which can then be read off-line, for instance with Acrobat Reader viewing application.</p>

### 7.1.3 Elysium

Table 8 - Elysium 3DxSUITE EX10.0

<b>Solution / Tested Version:</b>	3DxSUITE EX10.0
<b>Solution Type:</b>	Converter / Viewer
<b>Description:</b>	The solution 3DxSUITE is an all-in-one platform to support the MBE lifecycle. Every processing option is flexibly configurable to individual needs. All major CAD systems are supported by this solution and the conversion to many standard formats can be done, including STEP AP242.

### 7.1.4 PROSTEP AG

Table 9 - PROSTEP AG OpenPDM 9.5.2

<b>Solution / Tested Version:</b>	OpenPDM 9.5.2 for TeamCenter 13
<b>Solution Type:</b>	PDM Connector
<b>Description:</b>	OpenPDM is a suite for PLM integration, offering connectivity to many systems and file formats in the PLM world. The AP242 Connector is one piece in this suite, offering reading and writing of AP242 XML files. It offers out-of-the-box support for all use cases described in the Recommended Practises for part, assembly, or configured product structure transfer. Reading and writing of additional information are also possible. PROSTEP participated in the benchmark with a basic showcase for part and assembly transfer.

### 7.1.5 Threedy

Table 10 - Threedy instant3Dhub 3.7.2

<b>Solution / Tested Version:</b>	instant3Dhub 3.7.2
<b>Solution Type:</b>	Web Viewer
<b>Description:</b>	instant3Dhub, developed by Threedy GmbH, is an innovative visual computing platform designed to revolutionize the way industry handles 3D CAD data. More than just a viewer for CAD models, it serves as a versatile API, empowering developers to build complex digital web products. This platform stands out for its ability to not only display intricate large 3D models but also to facilitate the creation of sophisticated web-based applications. Integrating seamlessly with existing systems, instant3Dhub offers a scalable and efficient solution increasing CAD data utility in various industries, unlocking new possibilities in the realm of digital product development and visualization.

## 7.1.6 T-Systems

Table 11 - T-Systems COMPDM 2023.2

<b>Solution / Tested Version:</b>	COMPDM 2023.2 for Aras Innovator 25
<b>Solution Type:</b>	PDM Connector
<b>Description:</b>	<p>The application COMPDM is designed to connect three worlds: product lifecycle management systems (PLM), computer aided design systems (CAD), and the international standard ISO 10303 (STEP) for product data representation, exchange, and long-term archiving.</p> <p>COMPDM clients allow for an easy definition and maintenance of data exchange processes between any of these worlds. A very simple and straightforward user interface allows the end user to start and monitor preconfigured exchange processes.</p> <p>The COMPDM server manages and executes data exchange processes in a highly efficient manner, including import to and extraction from PLM systems and conversions of CAD files according to your requirements.</p>

## 7.2 Overview of test results

This clause presents the, based all test criteria and all tested applications. This clause presents the Table 12 and the Table 13, for all test criteria and all tested applications, which are based on the evaluation criteria described in 6 Result matrices. tables are included in both public and private test result reports.

Table 12 - Test Results overview Test Case 1 of solutions

Vendor, Solution	Dassault Systèmes, 3DEXPERIENCE R2023xFD05	Datakit, CrossManager V2023.4	Elysium, 3DxSUITE EX10.0	PROSTEP AG, OpenPDM 9.5.2 for TeamCenter 13	Threedy, instant3Dhub 3.7.2	T-Systems, COMPDM 2023.2 for Aras Innovator 25
<b>Import Criteria</b>						
Nested Files	✗	✓	✓	✓	✗	✓
Alternate	✓	○	○	○	○	✓
Substitute	◆	○	○	○	○	✓
Assembly Structure, Part, Document, DigitalFile	✓	✓	✓	✓	✗	✓
<b>Export Criteria</b>						
Syntax, Structure, Compliance	✓	n/a	n/a	✓	n/a	✓
Nested Files	✓			✓		✓
Alternate	✓			○		✓
Substitute	◆			○		✓
Assembly Structure, Part, Document, DigitalFile	◆			◆		✓

Table 13 - Test Results overview Test Case 2 of all vendors

Vendor, Solution	Dassault Systèmes, 3DEXPERIENCE R2023xFD05	Datakit, CrossManager V2023.4	Elysium, 3DxSUITE EX10.0	PROSTEP AG, OpenPDM 9.5.2 for TeamCenter 13	Threedy, instant3Dhub 3.7.2	T-Systems, COMPDM 2023.2 for Aras Innovator 25
<b>Import Criteria</b>						
Nested Files	◆	✓	✓	✓	✓	✓
Product Configuration	○	○	○	○	○	✓
Assembly Structure, Part, Document, DigitalFile	✓	✓	✓	✓	✓	✓
<b>Export Criteria</b>						
Syntax, Structure, Compliance	✓			✓		✓
Nested Files	◆			✓		✓
Product Configuration	✓	n/a	n/a	○	n/a	✓
Assembly Structure, Part, Document, DigitalFile	◆			◆		✓

## 8 Conclusion

The use of international open standards for 3D model interoperability is seen as key to supporting the global development and manufacturing of complex products within the extended enterprise. However, industry requirements for 3D model-based design can only be fulfilled if commercial STEP AP242 applications are available that are used by a broad community and provide an appropriate level of functionality and reliability.

The present AP242 benchmark shows the status of commercial STEP AP242 converters and viewers in 2023. The quality level of implementations for the exchange of PDM product structures based on AP242 3<sup>rd</sup> Edition Domain Model XML has greatly improved since the last benchmark. The PDM Interoperability Forum (PDM-IF), which is jointly supported by AFNeT and prostep ivip, has contributed significantly to this success with its Recommended Practices. These implementation guidelines provide uniform mappings of industry requirements to the STEP data model, thus ensuring interoperability applications of all kinds and from all vendors.

In this benchmark, the export and import for PDM systems, reading and writing for converters, and 3D visualization were tested. The following criteria were evaluated:

- Conformity of the data records with the AP242 standard,
- Conformity of the data sets with the Recommended Practices of the PDM-IF,
- PDM assembly with 3D geometry,
- Nested files,
- Assembly validation properties,
- Alternative and substitute parts,
- Product configuration based on effectivities.

Most of the PDM capabilities in question are reliably supported. The conformity of the generated STEP files with standard and recommended practices is almost perfect.

There is still room for improvement in the support for assembly validation, which is not yet available in all applications, as well as in the handling of nested assemblies and very large models.

In conclusion, the current versions of the applications involved in the benchmark offer important enhancements that provide a solid foundation for the successful use of STEP AP242 in the industry.

Future iterations of the AP242 benchmark will cover additional software tools and extended functionalities, especially with regard to the upcoming 4<sup>th</sup> Edition of AP242. This will include improvements to the existing scope and new capabilities based on industry requirements as considered in the PDM-IF.

## 9 Publications

The detailed documentation of the PDM and CAD test cases in STEP AP242 Benchmarks is only available for the participating Vendors & Industrials of the AFNeT and prostep ivip associations, and is accessible from the following websites:

- **WILL BE AVAILABLE WHEN READY FOR PUBLICATION**
- [www.prostep.org AP242 Benchmarks URL](http://www.prostep.org/AP242/Benchmarks)

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

## 10 Acknowledgements

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