Test Suite for the CAx Implementor Forum Round 14J

April – September 2004

Release 1.1

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1.0 Introduction

This document describes the suite of test cases to be used for the fourteenth round of testing of the CAx Implementor Forum (CAx-IF). The CAx-IF is a joint testing forum organized by PDES, Inc. and the ProSTEP-iViP association. The test rounds of the CAx-IF concentrate primarily on testing the interoperability and conformance of STEP processors based on AP 203 and AP 214.

The test rounds in general combine testing of synthetic and production models. Production models will in most cases be provided by the member companies of the organizations PDES, Inc. and ProSTEP-iViP. When production models are not available from the member companies, "production-like" models will be solicited from the various CAx-IF participants.

This test suite includes synthetic models for testing the following capabilities: instance styling, geometric dimensioning and tolerancing (GD&T), AP203 edition 2 migration, density and material names, AP210 and AP209 interoperability, and PDM-TDM/CAD integration.

Production models are provided for assemblies and piece parts. The basis for the production test cases is native CAD models. Each test case therefore originates from a single CAD system, and the set of test cases to be pre-processed (converted to STEP files) is unique for each CAD system. After pre-processing, the resulting STEP files are then to be imported/post-processed/read in by the rest of the participants.

1.1 Functionality tested in this round

Functionality tested in this round relates to: solid geometry exchange, assembly instance styling, geometric dimensioning and tolerancing, AP203 edition 2 migration, density and material properties, AP210 and AP209 interoperability, and PDM-TDM/CAD integration.

Solid geometry exchange aims for validation and improvement of the results of the 8th ProSTEP processor benchmark, using the same single piece part. The part should be exported in AP214-IS format in order to keep track of processor migration and interoperability with AP214-DIS.

For assembly instance styling, the objective is to be able to color instances of the same part, different colors in an assembly in order to emphasize certain parts in a given context.

Since a second edition of AP203 is now available, which shows significant differences in the data model compared to the first edition, extensive testing is needed to validate STEP data exchange with this new protocol.

The goal for GD&T is the ability to exchange tolerances for dimensions and geometry to drive downstream applications such as coordinate measuring and manufacturing.

The density and material names test case is designed to transfer these basic attributes using the 'general property' approach. In the future this approach will be extended or replaced with the full material properties approach as included e.g. in AP214.

For AP210 interoperability, the goal is to import an AP210 file in order to extract the included geometry, e.g. for collision testing when putting a circuit board into its casing.

Post-processing AP209 files also mainly aims for extracting the contained geometry. The test provides the opportunity to work on the issues identified during the Round9J tests and review meeting.

PDM-TDM/CAD integration uses external references, which are a mechanism for specifying external "documents" that are associated with objects defined within a STEP file. The external documents may be digital documents such as CAD native models, STEP files, WORD documents, or NC programs, OR non-digital documents such as technical drawings on paper, or hand-written documents. With respect to the CAx-IF, external references will be used to split a single STEP file into one file containing the part identification and assembly structure and several STEP files containing the component geometry.

In Round 14J of testing, CAx vendors will be testing this functionality within the AP203e2 migration efforts and therefore pre- and pros-process STEP files. In addition to the scenario where the complete assembly structure is included in one STEP file, an extension of the external references will be tested, where the assembly structure can be split into several STEP files itself.

In addition to synthetic models for the above capabilities, production models are included in this round of testing.

1.2 General test instructions for this round

The general procedures for communication of models and statistics are outlined in a separate document 'General Testing Instructions'. The general instructions can be retrieved from CAx Implementor Forum web sites. The latest version is v1.2, dated November 2001.

1.3 Preliminary testing schedule

Date	Action
April 30, 2004 (Fri)	**AP203e2 Schema available**
May 14 (Fri)	**Test Suite available / 1st CAx Implementor Forum conference call**
ASAP	**Production Models released**
June 21 (Mon)	**Initial STEP files and native stats due**
July 12 (Mon)	**STEP files and native stats frozen**
August 9 (Mon)	**Target stats due / 2nd conference call**
September 7 (Tue)	**Target stats frozen**
September 13 (Mon)	**Pre-release of final stats / 3rd conference call**
September 21 (Tue)	**Review meeting for test round**
September 22 – 23 (Wed – Thu)	**CAx Implementor Forum meeting, Darmstadt, Germany**

1.4 Copyrights on test cases

Not all of the production test cases which were provided by the PDES, Inc. and ProSTEP-iViP member companies are fully released for any purpose. The least common denominator is that the test cases can be freely distributed among the ProSTEP-iViP / PDES, Inc. Round Table participants and can be used for any purposes that are related to CAx-IF testing (i.e. testing, documentation of testing efforts), as long as a reference to the originating company is made.

The test cases must not be used for any purposes other than the CAx-IF testing or outside of PDES, Inc. and ProSTEP-iViP.

2.0 Synthetic test case specifications

2.1 Model B3 : Benchmark model 'torque converter housing'

2.1.1 Motivation

As a result of the presentation of the results from the ProSTEP Processor Benchmarks, it has been agreed to re-test the latest test model used there in the CAx-IF with the latest processor versions. This is the first round of testing the model from the 8th Benchmark.

Note: Those vendors who like to re-test the 'classic' validation properties functionality as tested in the previous rounds may do this informally (i.e. no stats reported) with this model.

2.1.2 Approach

No new capability involved.

2.1.3 Testing Instructions

All vendors testing this model are encouraged to export the file in **AP214-IS** format. AP214-DIS should only be used if the IS version is not yet supported.

2.1.3.1 Construction of the benchmark model

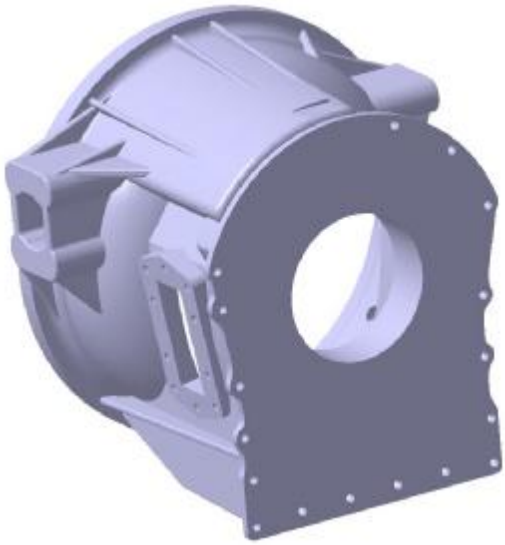


Figure 1: Shape of the B3 model (torque converter housing)

Those vendors who participated in the ProSTEP benchmark should re-use the torque converter housing model which has been constructed for that purpose. The modeling instructions may be found in the secure area of the CAx-IF web sites, http://www.cax-if.org/secure/ and http://www.cax-if.de/secure/, under 'Information on Round12J of Testing'.

2.1.3.2 Statistics

With each STEP file submitted for the b3 model, vendors must include a text file with the stats in comma-delimited form (.CSV):

model	*b3*
system_n	*Native system code*
system_t	*Target system code (for native stats use 'stp' for system_t)*
unit	*Units*
volume	*Total volume of all solids*
area	*Total surface area*
cx, cy, cz	*Centroid of all solids*
date	*Date submitted*
issues	*Short description of issues*

2.2 Model IS1: Assembly Instance Styling

2.2.1 Motivation

Assembly Instance Styling allows the assignment of different styles to different instances of the same part in order to emphasize this instance in a given context. For example one might want to color one instance of a bolt in a different color to point out it serves a special purpose, or one might define a certain part as being invisible because that part is of no interest in the given context but its geometry should be maintained in the model.

2.2.2 Approach

See the approach described in the 'Recommended Practices for Assembly Instance Styling', which is available from the CAx-IF web sites under 'Joint Testing Information' (http://www.cax-if.org/joint_testing_info.html and http://www.cax-if.de/joint_testing_info.html).

This document contains a STEP file example for the given test case.

Because of the complex structure in bigger assemblies, the first test of this functionality only uses the 'NAUO approach' described in the document mentioned above.

Note: Files provided in R14J should be according to the updated Release 1.1 of the Recommended Practices document.

2.2.3 Testing Instructions

2.2.3.1 Model Construction

For assembly instance styling we are using a very simple assembly which puts five instances of a solid yellow cube next to each other, as shown below in the wire frame view:

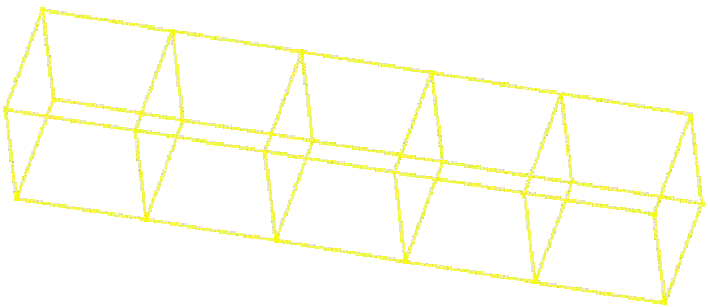


Figure 2: Wire frame view of the assembly before applying styles

Then, to two of the instances new styles are assigned. One instance is colored red, and another instance tagged as invisible. The assembly should then appear as shown below:

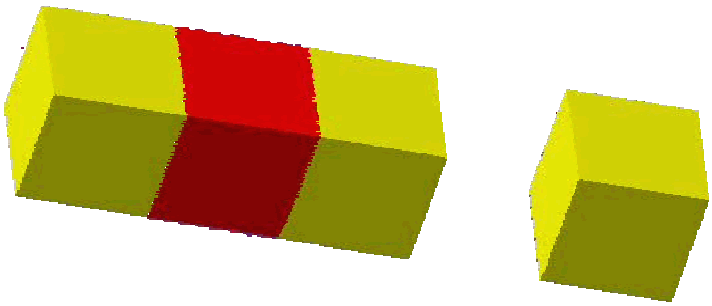


Figure 3: Shaded view of the assembly after styles have been applied to two instances

Note: Vendors participating in this test case do not need to support both coloring the instance and rendering it invisible. It is sufficient to support one of the included approached.

2.2.3.2 Statistics

With each STEP file submitted for the is1 model, vendors must include a text file with the stats in comma-delimited form (.CSV):

Note: As we have done with previous color test cases, screenshots will be collected. Please send in meaningful screenshots for your native model (file name 'is1-(native system code)-nat.jpg/.gif) and for each imported model (file name 'is1-(native system code)-(target system code).jpg/.gif).

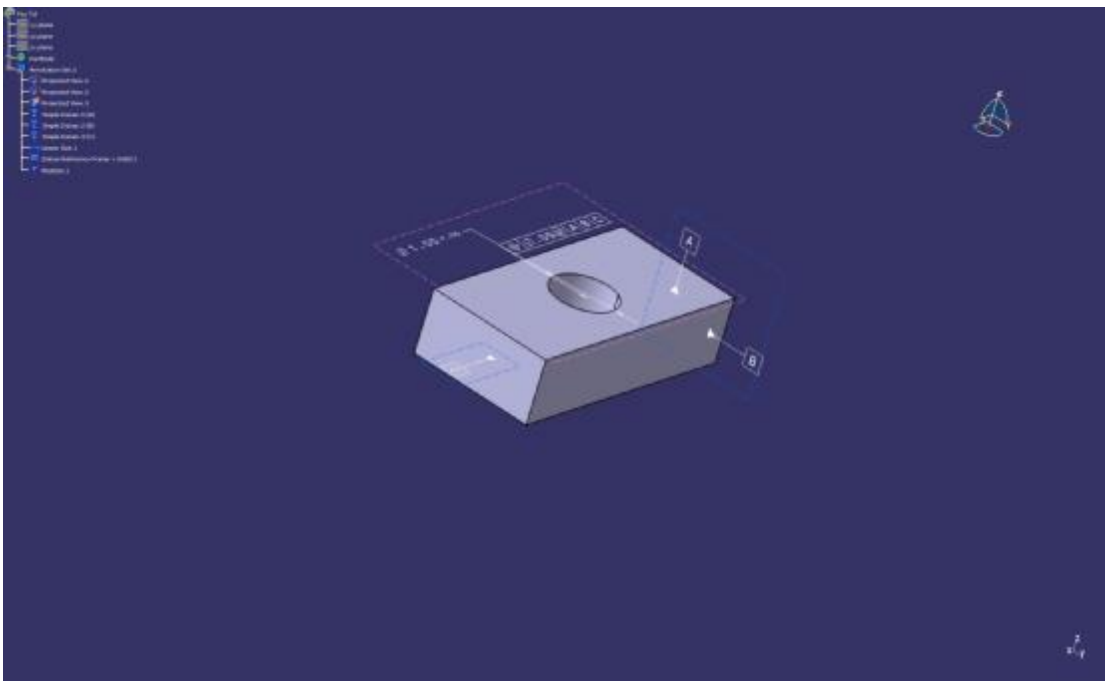
model	*is2*
system_n	*Native system code*
system_t	*Target system code (for native stats use 'stp' for system_t)*
unit	*Units*
volume	*Total volume of all solids*
area	*Total surface area*
cx, cy, cz	*Centroid of all solids*
base_color	*Original color assigned to the cube*
instance_-color	*Color assigned to the explicitly styled instance. If the color cannot be determined on import, please put in 'None'.* *If instance coloring is not tested, please put in 'N/A'.*
invisibility	*'Yes' – If one instance of the cube is tagged (found) as in-visible* *'No' – If invisible instance cannot be determined on import* *'N/A' – If invisibility is not supported on import or export.*
date	*Date submitted*

issues	*Short description of issues*

2.3 Model GD1: Geometric Dimensioning and Tolerancing

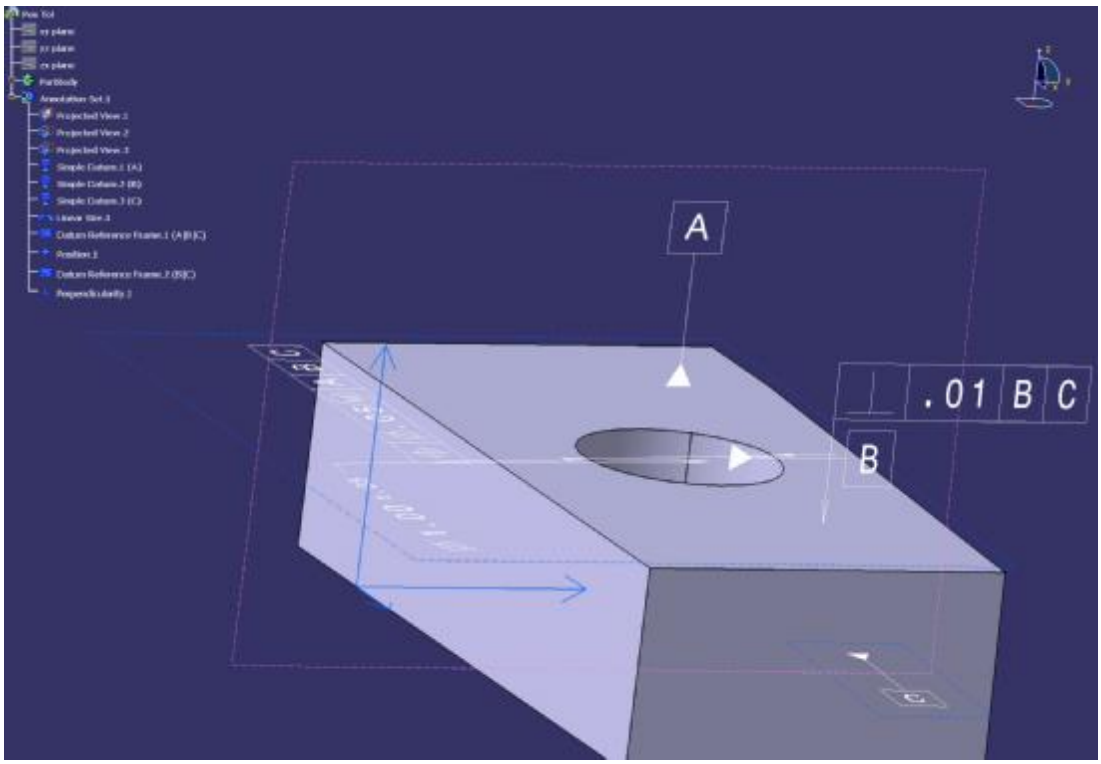
2.3.1 Testing Instructions

1. Use inches for units.
2. Create a rectangular block at the origin with dimensions x =3, y=3, z=1.
3. Remove a 1 inch diameter through hole parallel to the Z axis centered in the block. The centerline of the hole is at (1.5, 1, 0).
4. Assign Datum plane A to the top face, i.e. the XY plane where Z=1.
5. Assign Datum plane B to the side face, i.e., the XZ plane where Y=2.
6. Assign Datum C to the end face, i.e., the YZ plane where X=3.
7. Dimension the hole with a diameter dimension with a tolerance of +/- .05
8. Assign a position tolerance on the hole diameter of .05 with a Maximum Material Condition referencing Datum A, B and C in that order of precedence. See below.



9. Assign a perpendicularity tolerance of .01 on the top face (the same face as Datum A) referencing Datum B and Datum C in that order of precedence.
10. If you are exporting the presentation for the GD&T symbols, use your systems default procedure to capture and present the data. All exporting and importing systems should submit a screen capture as well.

This should create a part with a solid model, one dimensional tolerance, one position tolerance, one perpendicularity tolerance and three datums as shown below.



2.3.1.1 Statistics

With each STEP file processed for the GD&T model, vendors must include a text file with the stats in comma-delimited form (.CSV):

model	*gd1*
unit	*Units*
volume	*Total volume of all solids*
area	*Total surface area of all solids*
cx, cy, cz	*Centroid of all solids*
dim_found	*The number of dimensions processed.*
datum_found	*The number of datums processed.*
tol_processed	*The number of tolerances processed.*
date	*Date submitted*
issues	*Short description of issues*

2.4 Model DM1: Density and Material name

2.4.1 Motivation

Up to now, it has not been possible to transfer different materials via STEP. On export, a consistent density for all parts is assumed.

The scope of this test is to provide a first approach to transfer density values (as real values) and material names (as strings). Using the density information, the center of geometry of a model can be distinguished from the center of gravity. The material name can be used to receive further information about that material from a database.

On a long-term perspective, the goal is to implement the “full” material properties as they are defined in AP214 and AP209.

2.4.2 Approach

The exchange of density and material name information is tested using the ‘general property’ approach (“valprops-like”), described in the “Recommended Practices for Density and Material Name”, which will be available from the CAx-IF web sites.

2.4.3 Testing Instructions

The test model is based on a sub-assembly of the well-known AS1 model, i.e. one of the “L-bracket assemblies”:

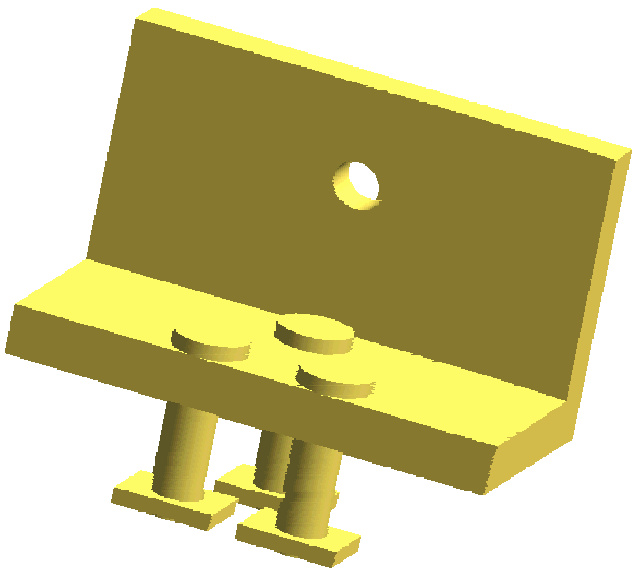


Figure 4: Shape of the DM1 model

This sub-assembly is composed of three individual parts, each of which should be assigned a different density and material name. Suggested values are:

Part	Density	Material name
L-bracket	.160 lb/cu in	AMS 4928; Titanium 6-4
Bolt	.285 lb/cu in	AMS 5613; Greek Ascoloy
Nut	.297 lb/cu in	AMS 5662; Inconel 718

Due to the different densities, the center of gravity will differ from the center of geometry. These coordinates, besides the transferred values for density and material, will be the focus of this test.

2.4.3.1 Statistics

With each STEP file submitted for the dm1 model, vendors must include a text file with the stats in comma-delimited form (.CSV):

model	*dm1*
system_n	*Native system code*
system_t	*Target system code (for native stats use 'stp' for system_t)*
unit	*Units*
volume	*Total volume of all solids*
area	*Total surface area*
geoX, geoY, geoZ	*Geometric centroid of all solids*
gravX, gravY, gravZ	*Center of gravity for all solids*
densityLB, densityNut, densityBolt	*Density values for the three parts*
materialLB, materialNut, materialBolt	*Material names for the three parts*
date	*Date submitted*
issues	*Short description of issues*

2.5 Model AS1 / S1 : AP203 Edition 2 Migration

2.5.1 Motivation

With the release of AP203 Edition 2, a new version of a widely used application protocol is available, which in many areas shows significant differences compared to the first edition. These are caused by the use of new versions of STEP resource parts (as was the case during AP214 CD to DIS migration) as well as an extension of the scope.

This calls for a series of tests. On the one hand, functionalities already implemented need to be carried over to and verified with the new edition. This includes geometry and assembly structure, colors, layers, geometric validation properties and other established capabilities. On the other hand, functionalities which were not included in AP203 Edition 1 (and its modular extensions), such as external references, need to be tested. The test cases defined in this section will serve as a first effort in this area.

Other new capabilities in AP203e2, such as GD&T, Construction History and others, will be examined in separate test cases.

2.5.2 Approach

All STEP files submitted for this test case should be compliant to the AP203e2 longform schema, which is available from the CAx-IF web sites under 'Joint Testing Information'.

2.5.3 Testing Instructions

Two models will be tested with AP203e2. Both models will cover geometry and assembly structure. In addition, vendors are encouraged to include solid and (overriding) face colors in both models, although these will be tested only informally (i.e. no stats collected, only visual confirmation).

There will also be functionalities specific to each of the test cases:

- S1 (Space ship): Geometric Validation Properties ("extended" if supported)
- AS1 (Toilet paper holder): External references
    - one PDM/structure file plus five single part geometry files
    - Including Document format properties if supported
    - According to the 2nd edition of the External References Rec. Pracs.
- An extension of AS1 or an additional test model to test 'nested' external references will be included at a later point in time.

2.5.3.1 Construction of the AS1 and S1 model

Both the S1 and the AS1 model are well-known test cases within the CAx-IF. Therefore, the modeling instructions will not be listed in detail here, since most of the participants already have these models available in their systems.

Detailed modeling instructions are included in older test suite documents. Should additional information be required, please contact the facilitators (cax-test-admin-l@cax-if.org).

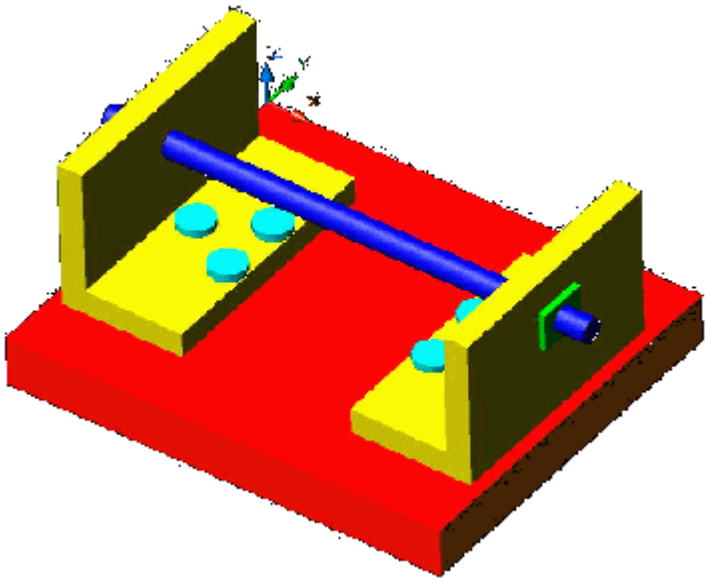


Figure 5: Shape of the AS1 model (toilet paper holder)

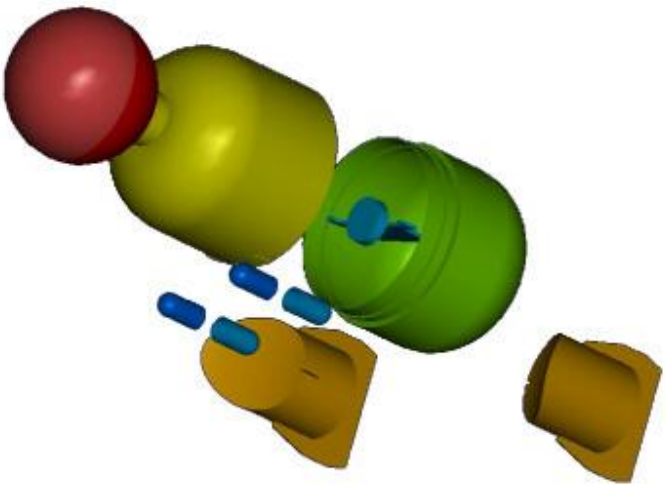


Figure 6: Exploded view of the S1 model (space ship)

2.5.3.2 Statistics

With each STEP file submitted for the migration models, vendors must include a text file with the stats in comma-delimited form (.CSV):

2.5.3.2.1 S1 model

model	*s1*
system_n	*native system code*
system_t	*target system code (for native statistics use 'stp' for system_t)*
unit	*units*
volume	*total volume of all solids*
validation_ volume	*total volume of all solids as received via the validation property capability.*
valid_vol	*pass/fail, is the instantiation of the validation property 'volume' in the STEP file as per the recommended practices for validation properties?*
area	*total surface area of all solids*
validation_area	*total surface area of all solids (entire assembly) as received via the validation property capability.*
valid_area	*pass/fail, is the instantiation of the validation property 'area' in the STEP file as per the recommended practices for validation properties?*
cx cy cz	*Centroid of all solids*
validation_cx validation_cy validation_cz	*Centroid of all solids (entire assembly) as received via the validation property capability.*
valid_cent	*pass/fail, is the instantiation of the validation property 'centroid' in the STEP file as per the recommended practices for validation properties?*
extended_gvp	*all/partial/none, whether the extended geometric validation properties were included resp. found for the subassemblies.*
date	*date submitted*
issues	*short description of issues*

2.5.3.2.2 AS1 model

model	*as1*
system_n	*native system code*
system_t	*target system code (for native statistics use 'stp' for system_t)*
unit	*Units*
fref_found	*All – all file references for the external geometry can be found and the file node associations to model parts can be established*

	Partial – some of the file references for the external geometry can be found and some of the file node association to model parts can be established *None – no references found or associations can not be established*
fref_processed	*All – all referenced files can be processed to construct the overal model* *Partial - all referenced files can be processed to construct the overal model* *None – referenced files can not be processed*
volume	*total volume of all solids*
area	*total surface area of all solids*
cx cy cz	*Centroid of all solids*

2.6 Joint Test case with AP209 (EA) Group

2.6.1 Motivation

Since the number of APs used in every day data exchange is constantly increasing, the subject of AP interoperability is of growing interest. The focus of this test is on extracting the geometry (design shape) from a 209 file and converting it to an AP203 or AP214 detail/part or assembly.

Note: Since no test models were submitted, this test will be skipped in Round14J. The joint testing will be resumed in future test rounds.

2.7 Handling of large STEP files

2.7.1 Motivation

While usually test models within the CAx-IF are rather small (some 100kB), STEP files in productive environments can easily reach sizes close to 100MB. Files this big often cause problems when trying to import them, especially very long processing times.

One way to avoid this is to split assemblies into several smaller files using the External References mechanism. However, this is every so often not possible, e.g. because one of the systems involved doesn't support external references, or because the STEP file originated from a large single part, e.g. a cylinder head.

2.7.2 Approach

No new capabilities involved.

2.7.3 Testing instructions

A large STEP file (about 70MB in size) will be submitted. The testing procedure is the same as with the Production Models. All participants are asked to import this model into theirs systems and give feedback on the performance, i.e. processing time.

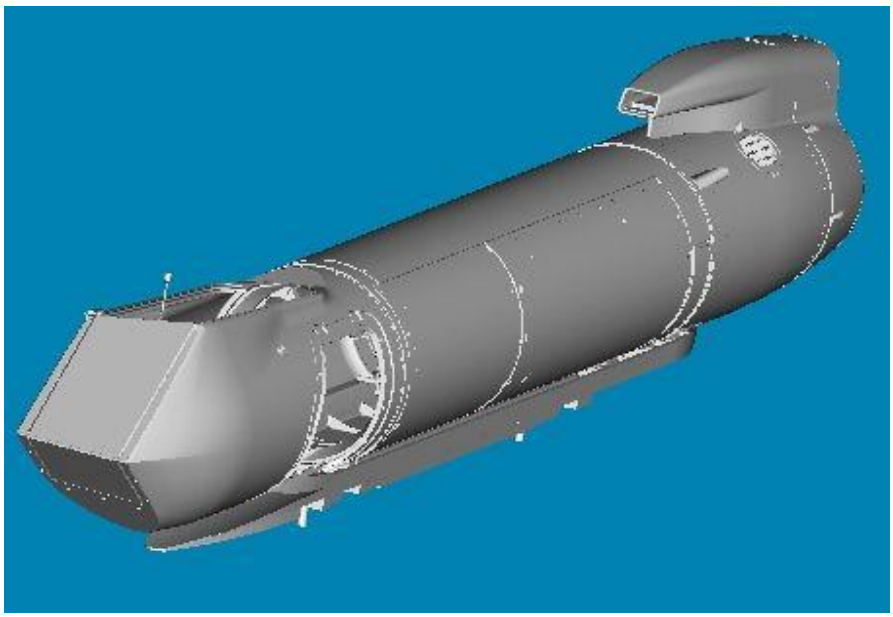


Figure 7: Shape of the "Pod Assembly" used in this test.

2.7.3.1 Statistics

When importing the large STEP file, vendors must submit a text file with the stats in comma-delimited form (.CSV):

model	*Large1*
unit	*Units*
volume	*Total volume of all solids*
area	*Total surface area of all solids*
cx, cy, cz	*Centroid of all solids*
cputime	*CPU time used by the import process*
memusage	*Memory usage during import*
date	*Date submitted*

issues	*Short description of issues*

Note: The “cputime” and “memusage” fields themselves do not provide an objective measure of the import performance, since they are among other things dependent on the hardware the software runs on. But they may be used for discussion, and for comparison with results achieved during a similar test with the same model at PROSTEP.

3.0 Production models: PM12

3.1 Motivation

In an attempt to test the STEP processors on real world models, the CAx Implementor Forum will be testing production parts in this round and future rounds of CAx-IF testing. These production models are characteristic for components and assemblies that are encountered in the aerospace and automotive industries. PDES, Inc. and ProSTEP member companies and vendors have supplied these models.

3.2 Approach

STEP files provided by member companies and vendors have been analysed for quality of (solid and/or surface) geometry as well as syntax and structure. The model quality issues (if any) have been documented in a README file which accompanies the STEP files. In this round of testing production models, simple comparison of mass property data (volume, surface area, Centroid) will be used as a basis for validating success/failure of the exchange.

3.3 Testing Instructions

3.3.1 List of available models

Model name	Exporting System	AP	Filename	Remarks
Helmet Jaw	Alias	AP214 IS	pm12-al-214.stp pm12-al2-214.stp	“al2” is a stitched version of the model
Engine Assembly	Dassault CATIA V4 ½	AP203e2 AP214 IS	pm12-ct4-214.stp HOLLAND….step	External References to 121 geometry files. The geometry is V4, the structure has been recreated with V5.
	Dassault CATIA V5	AP214 IS	pm12-ct5-214.stp	See Readme
	T-Systems CATIA V5	AP214 IS	pm12-sy-214.stp	See Readme
Shaver	Inventor	AP214 IS	pm12-in-214.stp	-/-

Turbine Blade	Theorem-UG	AP214 IS	pm12-tu-214.stp	-/-
	Unigraphics	AP214 IS	pm12-ug-214.stp	-/-

3.3.2 Statistics

With each STEP file processed for the production models, vendors must include a text file with the stats in comma-delimited form (.CSV):

model	*pm12*
unit	*Units*
volume	*Total volume of all solids*
area	*Total surface area of all solids*
cx, cy, cz	*Centroid of all solids*
date	*Date submitted*
issues	*Short description of issues*