Test Suite for the CAx Implementor Forum Round 15J

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Release 2.0

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1.0 <u>Introduction</u>

This document describes the suite of test cases to be used for the fifteenth 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: geometric and dimensional tolerances (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, 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.

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 for informational uses between CAD systems.

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 past tests and review meetings.

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, MS-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 15J of testing, CAx vendors will be testing this functionality within the AP203e2 migration efforts and therefore pre- and post-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 v1.4, dated December 2004.

1.3 Preliminary testing schedule

Date	Action
December 8, 2004 **(Wed)**	**Test Suite available /** **1st CAx Implementor Forum conference call**
ASAP	**Production Models released**
January 7, 2005 (Fri)	**Initial STEP files and native statistics due**
January 28 (Fri)	**STEP files and native statistics frozen**
February 15 (Tue)	**Target statistics due / 2nd conference call**
February 28 (Mon)	**Target statistics frozen**
March 8 (Tue)	**Pre-release of final statistics / 3rd conference call**
March 15 (Tue)	**Review meeting for test round**
March 16 – 17 **(Wed – Thu)**	**CAx Implementor Forum meeting,** **Asheville, NC**

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 <u>Synthetic test case specifications</u>

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 last 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 statistics 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.

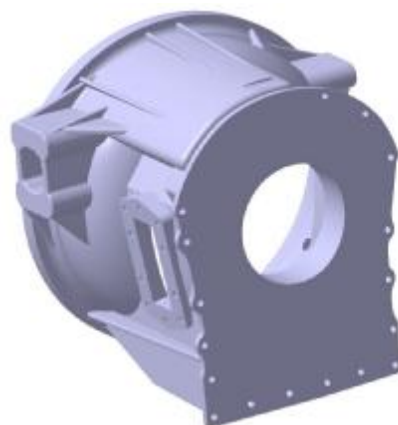### 2.1.3.1 Construction of the benchmark model

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 statistics in comma-delimited form (.CSV):

model	*b3*
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*
area	*Total surface area*
cx, cy, cz	*Centroid of all solids*
date	*Date submitted*
issues	*Short description of issues*

2.2 Model GD2: Geometric Dimensioning and Tolerancing

2.2.1 Motivation

Geometric and Dimensioning Tolerances are required for a number of business use case in the context of STEP data exchange. Among others, they are a prerequisite for long-term data archiving the way the aircraft industry plans to use it. In addition, the GD&T data can be used to drive downstream applications such as coordinate measuring and manufacturing

2.2.2 Approach

The functionality tested with this model is based on the harmonized approach for GD&T, described in detail in the updated GD&T Usage Guide (Version 2), which is available from the CAx-IF homepages under "Joint Testing Information".

2.2.3 Testing Instructions

1. Use inches for units.

2. Create a rectangular block at the origin with dimensions x =4, y=2, z=1.

3. Remove two 1 inch diameter through holes parallel to the Z axis centered in the block. The centerlines of the holes are at (1, 1, 0) and (3,1,0)

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. Assign a position tolerance to the pattern of holes diameter of .01 referencing Datum C and B in that order of precedence. See below.
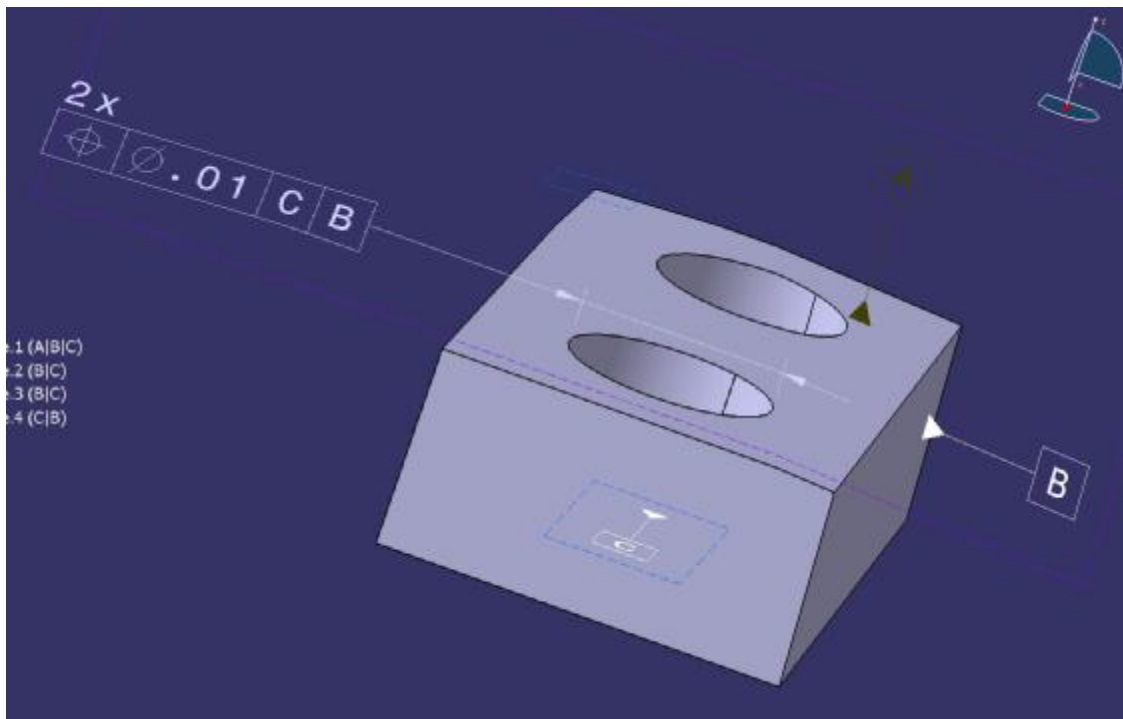

Figure 2: Shape of the GD2 model

8. 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.

This should create a part with a solid model, one dimensional tolerance, one position toler-ance, one perpendicularity tolerance and three datums as shown below.
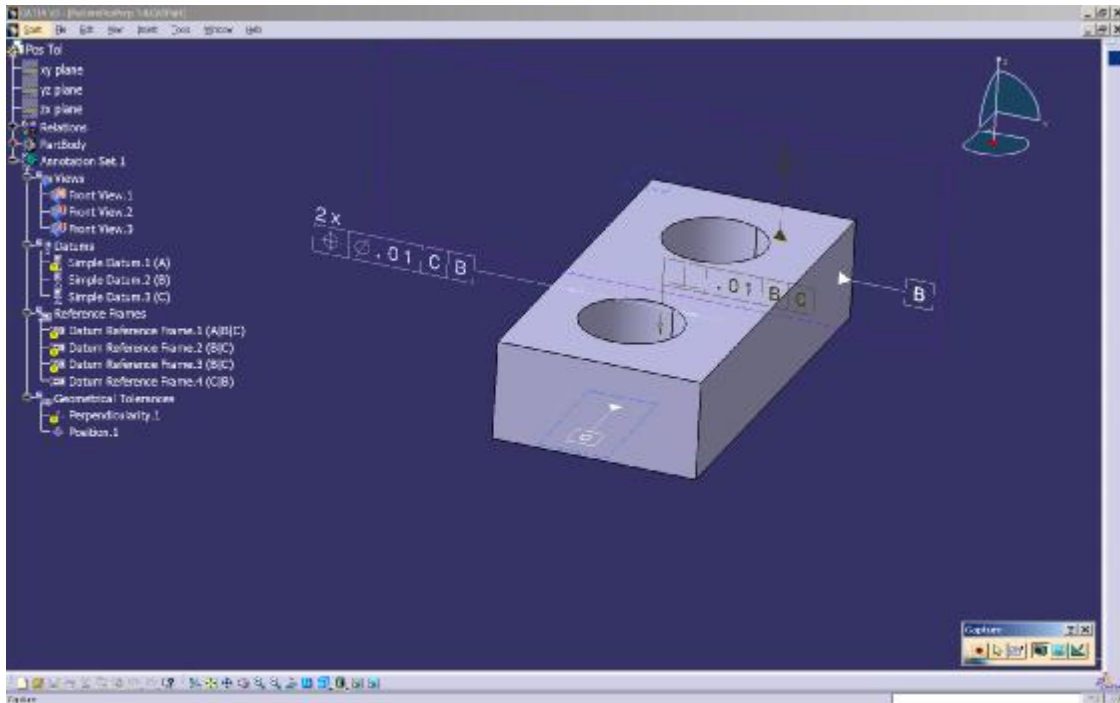
Figure 3: The GD2 model shown with the feature tree

2.2.3.1 Statistics

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

model	*gd2*
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*

2.3 Model DM1: Density and Material name

2.3.1 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.

2.3.2 Approach

It has been agreed that within the CAx-IF, the "simple approach" for exchanging Material and Density information will be used, i.e. the respective values will be mapped as general properties of the part. This is seen as a capability for basic information exchange between CAD systems. This approach is reflected in the current version of the Material and Density Recommended Practices.

For completeness, the Recommended Practices have been updated to also include the "detailed approach", where the material is represented as a product, and the density is attached to it either as general property or material property. This detailed approach is harmonized with the PDM schema, resp. AP209.

The new Recommended Practice document can be found on the CAx-IF web sites at http://www.cax-if.de/ and http://www.cax-if.org/ under "Joint Testing Information".

2.3.3 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":
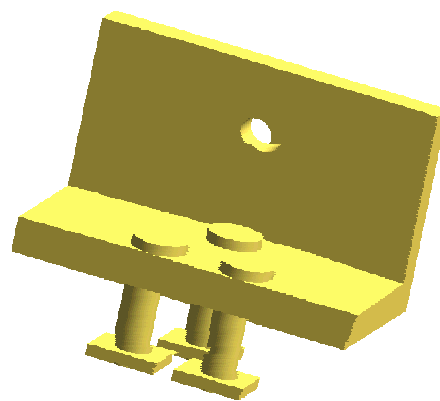

Figure 4: Shape of the DM1 model

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.

2.3.3.1 Statistics

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

model	*dm1*
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*
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*

2.4 Model AS1 / S1 : AP203 Edition 2 Migration

2.4.1 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.

2.4.2 Approach

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

Updated versions of the Recommended Practices for Geometric Validation Properties and those for External References are available from the CAx-IF web sites under 'Joint Testing Information'.

2.4.3 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 statistics 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): Nested External References
    - four PDM/structure files plus five single part geometry files
    - Including Document format properties if supported
    - According to version 2.1 of the External References Recommended Practices

2.4.3.1 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).
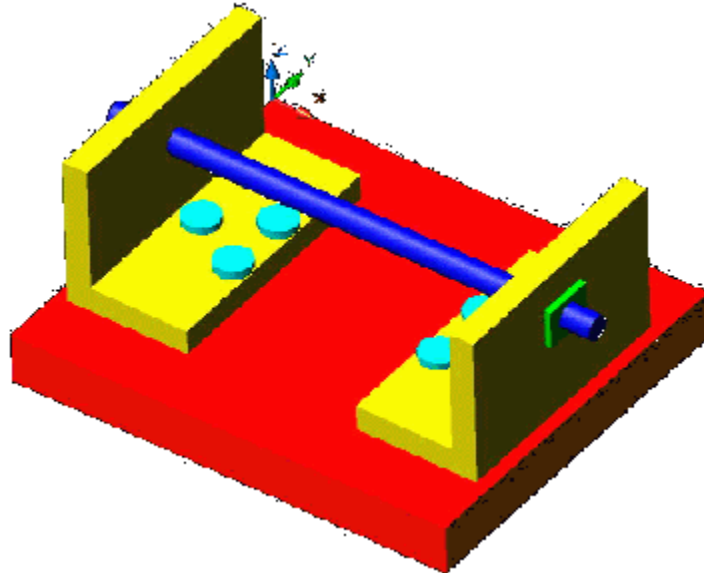

Figure 5: Shape of the AS1 model (toilet paper holder)
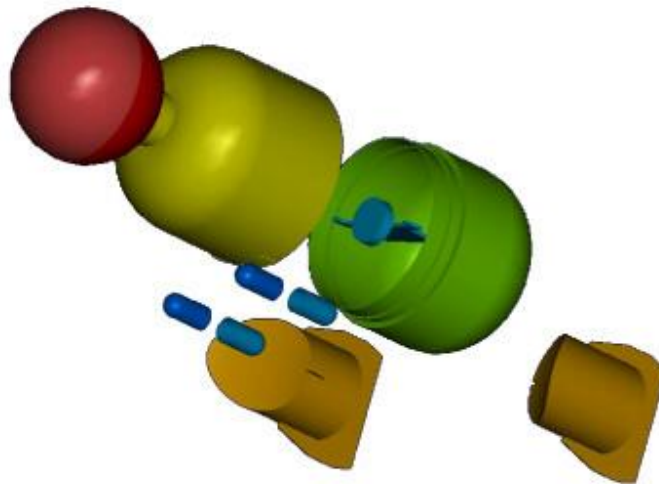

Figure 6: Exploded view of the S1 model (space ship)

2.4.3.2 File structure for Nested External References with AS1

In contrast to the External References tested in the CAx-IF before, where the complete structure of the assembly was contained in one file, which then referenced the geometry files, the structure itself is now split up into a number of files.

The business case for this is the exchange of very large structures. When only a single part or small subassembly has changed, there is no need to exchange the whole structure. With the nested external references, only the subassemblies affected by the change need to be transferred.

The important basic assumption is that each structure file represents one node in the assembly structure. Hence, AS1 will be broken down to the following files:
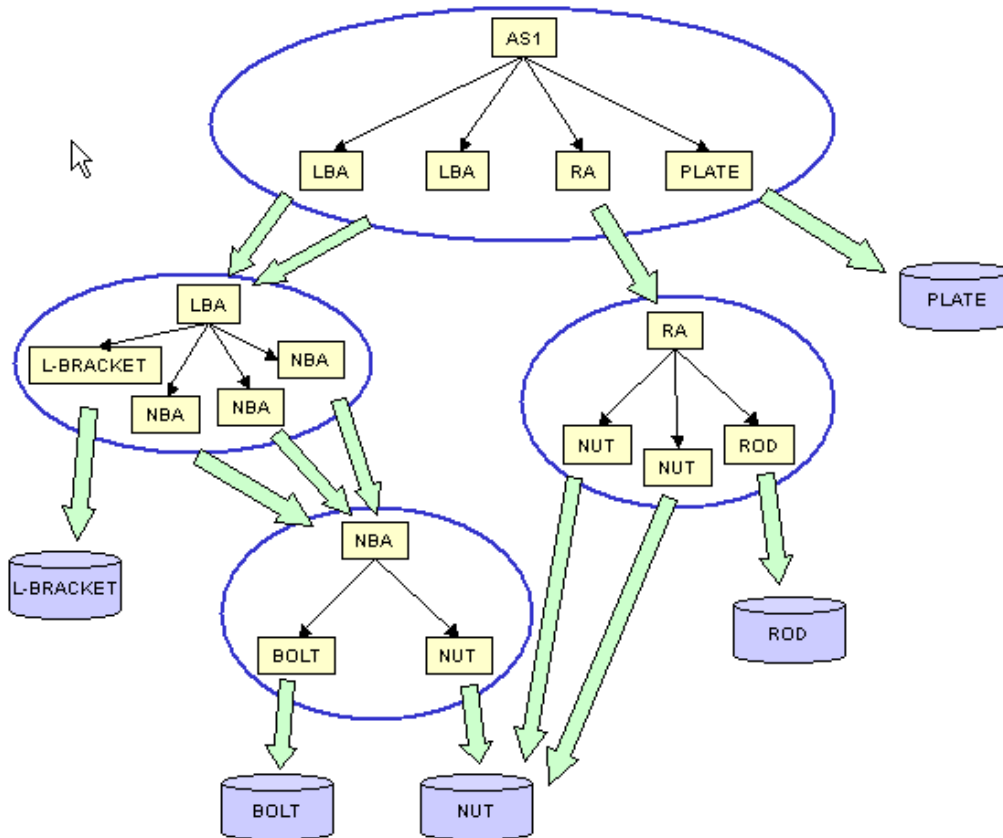
Figure 7: Structure of AS1 with nested external references.

Each of the blue ellipses represents a structure file. The table below lists the files with the recommended file name, assuming AP203 file format and exporting system XY. Structure files are marked yellow, geometry blue.

Element	Contains	Filename
AS1	Assembly root node	AS1-XY-203.stp
LBA	L-Bracket Assembly	AS1-XY-LBA.stp
RA	Rod-Assembly	AS1-XY-RA.stp
Plate	Geometry for Plate	AS1-XY-Plate.stp
L-Bracket	Geometry for L-Bracket	AS1-XY-L-Bracktet.stp

NBA	Nut-Bolt-Assembly	AS1-XY-NBA.stp
Rod	Geometry for Rod	AS1-XY-Rod.stp
Bolt	Geometry for Bolt	AS1-XY-Bolt.stp
Nut	Geometry for Nut	AS1-XY-Nut.stp

2.4.3.3 Statistics

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

2.4.3.3.1 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 valida-tion 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 vali-dation property capability.*
valid_cent	*pass/fail, is the instantiation of the validation property 'centroid' in the STEP file as per the recommended practices for valida-tion 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*

2.4.3.3.2 AS1 model

For the external references test case, only one set of statistics needs to be submitted for the root node file.

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

2.5 Joint Test case with AP209 (EA) Group

2.5.1 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.

2.6 Import of old STEP and Native Files

2.6.1 Motivation

In the light of the Long-Term Archiving (LOTAR / LTDR) efforts, it is very interesting to get an impression how old CAD models behave when they are being imported into the current versions of the respective systems. The CAx-IF with its extensive file archives, which, including preceding activities, reach back as far as ten years, offers the chance to import both the native model and the STEP file originally created from it.

2.6.2 Testing Instructions

All participating vendors are asked to import the old STEP files provided in the file vault in the member area of the CAx-IF homepage, and report their findings. The basic set of target statistics (see Production Models, section 3.3.2, below) is welcome.

All vendors maintaining STEP processors for the originating system of the old native model are asked to try and import the old part into their system and report their findings.

3.0 Production models: PM13

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
Vane Cluster	Unigraphics	214-IS	pm13-ug-214.stp	

Casing	Pro/E			

3.3.2 Statistics

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

model	*pm13*
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*