Test Suite for the
CAx Implementor Forum
Round 24J

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1.0 <u>Introduction</u>

This document describes the suite of test cases to be used for the twenty-fourth 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 AP203 and AP214.

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 Association. 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: Presentation of Product Manufacturing Information (PMI), both as Polylines and semantically based on Representation, User Defined Attributes, and Supplemental Geometry.

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:

- **Product Manufacturing Information (PMI)** describes the capability to embed information about dimensions, tolerances and other parameters which are necessary input for the manufacturing of the part from the 3D model. Past tests in the CAx-IF were focused on the 'representation' approach, i.e. transport the PMI in a re-usable way, without displaying it in the 3D model. In Round24J, two different ways for 'presentation' of PMI in 3D will be tested:

  - "Polyline Presentation" refers to breaking down each annotation into polylines and arcs, and exchanging them as wireframe geometry. This preserves the exact shape of the annotation, but is human readable only.

  - "Representation and Semantic Presentation" relies on the "Representation" capability to render the information contents to be displayed. These are supplemented with basic styling and positioning information, to enable the importing CAD system to re-create the annotation elements using its internal PMI capability, and may be supplemented with additional textual information.

- **User Defined Attributes** are descriptions or values that can be added by the user in the CAD system and associated with a part or geometric elements in the model. Material or production costs are an example for this. This is the second test of this capability.

- **Supplemental Geometry** defines all geometric elements in a model that do not belong to the manufactured shape of the part, but serve as a reference basis for other information, such as the center line of a hole for example. This will be the second test of this functionality.

- **Production Models** are included in this round of testing in addition to the synthetic models for the above capabilities.

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 v1.7, dated July 2008.

1.3 Preliminary testing schedule

The following schedule has been agreed on for Round 24J:

Date	Action
May 13, 2009 **(Wed)**	**Test Suite available /** **1st CAx Implementor Forum conference call**
ASAP	**Production Models (native) released**
June 17 (Wed)	**Initial STEP files and native stats due**
July 29 **(Wed)**	**STEP files and native stats frozen /** **Initial release of files for testing**
August 12 (Wed)	**Initial Target stats due / 2nd conference call**
September 23 (Wed)	**Target stats frozen / 3rd conference call**
September 29 (Tue)	**Review meeting for test round**
September 30 – October 1 **(Wed – Thu)**	**CAx Implementor Forum meeting,** **Darmstadt, Germany**

The CAx-IF meeting will take place in conjunction with an "Infotplatform" (user group) meeting. The corresponding LOTAR workshop will take place one week before the CAx-IF meeting, due to planning constraints in the aerospace community. Joint conference calls will be available at both meetings.

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 PP1: PMI Polyline Presentation

2.1.1 Motivation

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

For documentation and long-term archiving purposes, the Polyline Presentation approach was suggested and developed by the LOTAR project group. It presents the PMI within the 3D model, broken down into lines and arcs, so that is looks exactly as generated by the native system.

2.1.2 Approach

The approach to be used is described in the latest working draft of the "Recommended Practices for PMI Representation & Presentation", which can be found in the member area of the CAx-IF web sites under "Information on Round24J of Testing".

Polyline annotations and the definition of saved views are in scope for this round of testing, as well as validation properties to verify the exchange of the Polyline transfer.

2.1.3 Testing Instructions

In Round 24J, the PMI test models from the LOTAR pilot activities shall be used, as in the previous rounds of testing.

Note that **all** CAx-IF participants, even / especially those who have not implemented Polyline Presentation, are asked to import the resulting STEP files. Since the annotations basically are broken down into wireframe geometry (which has been tested in R20J-R21J), the question is to what extend the information can be found by arbitrary CAD systems.
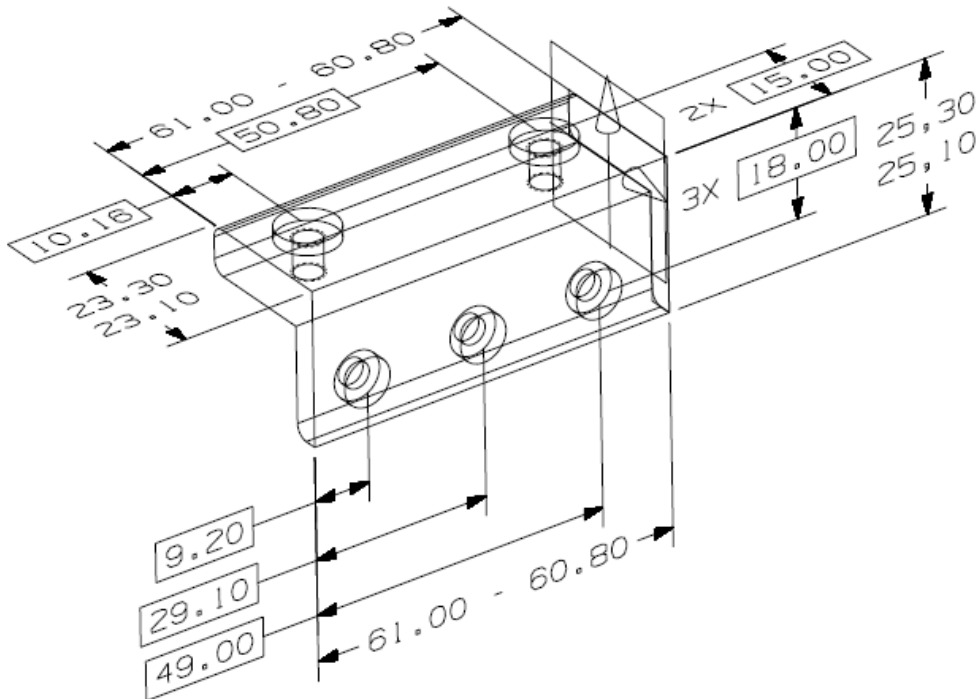
Figure 1: Example for a user-provided part with tolerances.

Compared to the Polyline presentation as tested in Round22J, the following additional functionality may be included in the test files provided for this round of testing, as far as it has been implemented by the CAx-IF participants and is described in the Recommended Practices:

- Definition of "saved views" – if supported, include at least one saved view in the model, which contains a subset of annotations in the file, and provides a pre-defined position of the model in the design space. It is recommended to provide a screenshot illustrating the model position and annotation subset, in addition to the screenshot showing the overall model layout.

- Cross-highlighting of annotations and annotated shape – if supported, include in the STEP file the information necessary to maintain the association between annotations and the annotated shape elements in a way, that after import, when highlighting an annotation, the shape elements annotated by it are highlighted, too, and vice versa.

- PMI Validation Properties for Polylines – if supported, include the validation properties "Polyline Curve Length" (section 10.3.1 in the PMI Rec.Pracs.) and "Polyline Centroid" (section 10.3.2) in the files, and evaluate these after import. The "Equivalent Unicode String" validation property will not be formally tested this round, as the definition for how to derive this string in an unambiguous and system-independent way are still ongoing.

In addition to these functionalities, several alternatives for the definition of the Polylines themselves will be investigated in Round24J. These are:

- 3D Polylines – as tested before

- 2D Polylines – using pcurves based on two-dimensional polylines within a plane to draw the annotation. See the "Polyline Alternatives" document, section 8.1.2, available in the member area of the CAx-IF web sites.

- Filled Polylines – intended to display the rendered characters as filled characters (faces) instead of only their outlines. See the "Polyline Alternatives" document, section 8.1.3, available in the member area of the CAx-IF web sites.

It shall be stated in the 'scope' filed of the statistics which of these approaches was used for testing.

2.1.3.1 Test Models

Test Models for CATIA V5 and UG NX are available in the CAx-IF File Repository under "Round 22J > GDandT Test Models". Additional test models containing GD&T information for other CAD systems are welcome.

2.1.3.2 Statistics

For each STEP file submitted for the PP1 model, vendors must submit the corresponding native statistics to the online statistics and results database, CAESAR. To do so, log in to CAESAR, go to "Test Rounds > R24J Test Cases > PP1 Data Sheet", and either fill in the web form, or upload a comma-delimited file (.csv) with the data as listed below.

Note that in order to count the GD&T elements for the statistics, as per agreement during the Round 22J Review Meeting, the names of the `geometric_curve_set`s shall be considered.

See Table 6 (section 8.2) in the PMI Recommended Practices for details.

column name	description
model	The name of the test model
system_n	The system code of the CAD system creating the STEP file
system_t	The system code of the CAD system importing the STEP file. For native stats, enter 'stp'
unit	The unit the model is designed in
volume	Total volume of all solids
area	Total surface area of all solids
scope	A short designation of the scope tested in the model. In the case of PP1 it is one of - "3D Polylines" - "2D Polylines"

	- "Filled Polylines"
cx	Centroid of all solids
cy	
cz	
dimension	The number of dimensions processed
datums	The number of datums processed
datum_targets	The number of datum targets processed
tolerances	The number of tolerances processed
labels	The number of labels processed
saved_view	The name of the Saved View which is the basis for the view-related statistics
view_annot	The number of annotations included in the specified saved view.
view_pos	pass/fail, whether the position stored for the Saved View could be restored successfully. It is recommended to provide a screenshot illustrating the position of the model for the specified view.
highlight	all/partial/none – whether the cross-highlighting for annotations and annotated shape elements works correctly
poly_length	all/partial/none – whether the lengths of the Polyline annotation was validated successfully for all, some or none of the given annotations.
poly_cent	all/partial/none – whether the positioning of the Polyline annotation was validated successfully for all, some or none of the given annotations.
valid_poly_vp	pass/fail, is the instantiation of the Polyline-related validation properties in the STEP file as per the PMI recommended practices?
date	The date when the statistics were last updated (will be filled in automatically)
issues	A short statement on issues with the file

2.2 Model SP1: PM1 Representation & Semantic Presentation

2.2.1 Motivation

Product Manufacturing Information is required for a number of business use cases in the context of STEP data exchange. Among others, they are a prerequisite for long-term data archiv-

ing. In addition, the PMI can be used to drive downstream applications such as coordinate measuring and manufacturing.

In contrast to the Polyline approach, Semantic Presentation relies on the PMI Representation capability to define the contents to be displayed, and supplements these with positioning and styling information to create the appropriate notes in 3D space. (Associative) 3D Annotations including Unicode characters have been tested in previous rounds in preparation for this test case.

2.2.2 Approach

The approach to be used is described in the latest working draft of the "Recommended Practices for PMI Representation & Presentation", which can be found in the member area of the CAx-IF web sites under "Information on Round24J of Testing".

2.2.3 Testing Instructions

In Round 24J, the PMI test models from the LOTAR pilot activities shall be used, as in the previous rounds of testing.

Figure 2: Example for a user-provided part with tolerances.

In addition to the Semantic Presentation as tested in Round22J, the following additional functionality may be included in the test files provided for this round of testing, as far as it has been implemented by the CAx-IF participants and is described in the Recommended Practices:

- Definition of "saved views" – if supported, include at least one saved view in the model, which contains a subset of annotations in the file, and provides a pre-defined position of the model in the design space. It is recommended to provide a screenshot illustrat-

ing the model position and annotation subset, in addition to the screenshot showing the overall model layout.

- Cross-highlighting of annotations and annotated shape – if supported, include in the STEP file the information necessary to maintain the association between annotations and the annotated shape elements in a way, that after import, when highlighting an annotation, the shape elements annotated by it are highlighted, too, and vice versa.

Note that models with representation only, semantic presentation only, or both, are allowed in this test. This shall be stated in the "scope" column in the statistics.

2.2.3.1 Test Models

Test Models for CATIA V5 and UG NX are available in the CAx-IF File Repository under "Round 22J > GDandT Test Models". Test Models containing GD&T information for other CAD systems are welcome.

2.2.3.2 Statistics

For each STEP file submitted for the SP1 model, vendors must submit the corresponding native statistics to the online statistics and results database, CAESAR. To do so, log in to CAESAR, go to "Test Rounds > R24J Test Cases > SP1 Data Sheet", and either fill in the web form, or upload a comma-delimited file (.csv) with the data as listed below.

Note that in order to count the GD&T elements for the statistics, as per agreement during the Round 22J Review Meeting, the actual STEP entity types (`datum`, `datum_target`,...) shall be considered.

column name	description
model	The name of the test model, see test models table
system_n	The system code of the CAD system creating the STEP file
system_t	The system code of the CAD system importing the STEP file. For native stats, enter 'stp'
unit	The unit the model is designed in
volume	Total volume of all solids
area	Total surface area of all solids
scope	A short designation of the scope tested in the model. In the case of SP1 it is one of - "Representation only" - "Semantic Presentation only" - "Representation and Semantic Presentation"
cx	Centroid of all solids
cy	

cz	
dimension	The number of dimensions processed
datums	The number of datums processed
datum_targets	The number of datum targets processed
tolerances	The number of tolerances processed
labels	The number of labels processed
saved_view	The name of the Saved View which is the basis for the view-related statistics
view_annot	The number of annotations included in the specified saved view.
view_pos	pass/fail, whether the position stored for the Saved View could be restored successfully. It is recommended to provide a screenshot illustrating the position of the model for the specified view.
highlight	all/partial/none - whether the cross-highlighting for annotations and annotated shape elements works correctly
date	The date when the statistics were last updated (will be filled in automatically)
issues	A short statement on issues with the file

2.3 Model UD1: User Defined Attributes

2.3.1 Motivation

Most CAD systems allow the user to add user-defined attributes in the form of key-value pairs to a part or shape. These carry information which can not be derived from the geometry, such as material costs, but is of relevance to downstream processes or for archiving purposes. In Round 23J, this capability will be tested for the first time.

2.3.2 Approach

The approach to be used to transfer the user-defined attributes is described in the Draft Recommended Practices for User Defined Attributes, which are available in the member area of the CAx-IF homepages under "Information on Round 23J of Testing".

User Defined Attributes can be attached to either a single part, an instance of an assembly component or a geometric element of its shape. Each attribute can be descriptive (i.e. the value is a text string) or numeric (with and without unit).

2.3.3 Testing Instructions

The User Defined Attributes shall be tested using the well-known as AS1 model.

2.3.3.1 Construction of the model

The following attributes are suggested values for use in the UD1 test. **Note** that the locations where the attributes should be attached (solid/surface, instance, part/product) are proposals, not mandatory. All attribute types should be contained in the model and attached in the file structure where meaningful for the originating system.

- To one of the faces of the 'plate' part, add a descriptive attribute (see section 5.1 in the Recommended Practices):
    - Name: 'Surface Finish'
    - Description: 'Anodize per specification MIL-A-8625, Type I'
- To the two instances of the L-bracket assembly, add a value attribute each (see section 5.2 in the Recommended Practices):
    - Name: 'asm_step'
    - Values: 1. and 2. respectively
- To the 'plate' part, add a measure attribute (see section 5.3 in the Recommended Practices):
    - Name: 'weight'
    - Unit: kilograms (kg) or pounds (lbs)
    - Value: <calculated weight of component preferred but generic value can be provided if necessary>

It is allowed to add additional information to each of the attributes (see section 5.4 in the Recommended Practices).

2.3.3.2 Statistics

For each STEP file submitted for the UD1 model, vendors must submit the corresponding native statistics to the online statistics and results database, CAESAR. To do so, log in to CAESAR, go to "Test Rounds > R23J Test Cases > UD1 Data Sheet", and either fill in the web form, or upload a comma-delimited file (.csv) with the following data:

column name	description
model	The name of the test model, here: 'UD1'
system_n	The system code of the CAD system creating the STEP file
system_t	The system code of the CAD system importing the STEP file. For native stats, enter 'stp'
face_attr	pass/fail, has the User Defined Attributed at the solid/surface level been processed correctly?
instance_attr	pass/fail, has the User Defined Attribute at the assembly component instance level been processed correctly?

part_attr	pass/fail, hast the User Defined Attribute at the part/product level been processed correctly?
valid_attr	pass/fail, is the instantiation of the user defined attributes as per the recommended practices?
date	The date when the statistics were last updated (will be filled in automatically)
issues	A short statement on issues with the file

2.4 Model SG1: Supplemental Geometry

2.4.1 Motivation

When designing a part in a CAD system, geometrical elements are often created that do not belong to the actual, i.e. manufactured, shape of the part, but are used to either create other geometric shapes, or to relate additional information about the part.

The main business applications for this capability are the transfer of reference elements for PMI information, such as cutting planes and center lines, and named axis placements as tool targets for machining applications.

In Round 24J, this capability will be tested for the first time.

2.4.2 Approach

The approach to be used is described in the Draft Recommended Practices for Supplemental Geometry (v0.4), which is available in the member area of the CAx-IF homepages under "Information on Round 24J of Testing". Note these include a significant change of the file structure compared to what has been tested in Round23J.

2.4.3 Testing Instructions

The transfer of supplemental geometry will be tested using a simple test model (see below). The following elements shall be included:

- The center line for the cylindrical hole through the part

- A reference plane at the upper end of the truncated cone, its face normal parallel to the center line of the hole

- Four named axis placements along the outer top edge of the part

Note that when comparing the results, the supplemental geometry elements may look differently in different CAD systems (e.g. bound vs. unbound plane). The essential criteria is, are they correctly identified as supplemental geometry elements in the target system.

In addition to the scope tested in Round 23J, for those systems supporting it, PMI elements shall be added referencing supplemental geometry elements. For an example illustration, see the Supplemental Geometry Rec.Pracs. It is recommended to add a datum to the reference plane and a dimension to the center axis, plus a tolerance referencing the datum to define meaningful PMI content.

Both Polyline or Semantic Presentation can be used to display these. It is recommended to note the approach used in the "issues" column of the statistics. If no PMI elements are included, the respective columns in the statistics shall be filled with "na".
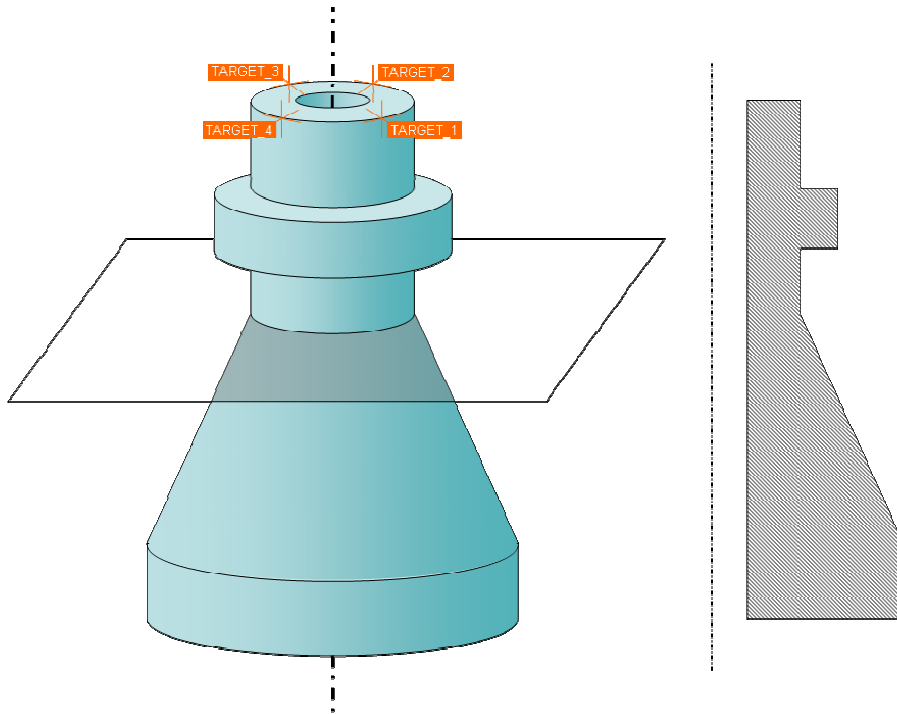
2.4.3.1 Construction of the SG1 model

Figure 2: Sketch of the SG1 model.

Dimensions for the part are arbitrary; suggested values are height 15cm, base diameter 10cm and tip diameter 5cm.

2.4.3.2 Statistics

For each STEP file submitted for the SG1 model, vendors must submit the corresponding native statistics to the online statistics and results database, CAESAR. To do so, log in to CAESAR, go to "Test Rounds > R24J Test Cases > SG1 Data Sheet", and either fill in the web form, or upload a comma-delimited file (.csv) with the following data:

column name	description
model	The name of the test model, here: 'SG1'
system_n	The system code of the CAD system creating the STEP file
system_t	The system code of the CAD system importing the STEP file. For native stats, enter 'stp'.
unit	The unit the model is designed in

volume	Total volume of all solids
area	Total surface area of all solids
cx	Centroid of all solids
cy	
cz	
center_line	pass/fail, if the center line was found in the STEP file and correctly displayed in the CAD system.
ref_plane	pass/fail, if the reference plane was found in the STEP file and correctly displayed in the CAD system.
tool_tgt	pass/fail, if the named axis placements (tool targets) were found in the STEP file and correctly displayed in the CAD system or identified in the product structure.
valid_sup_-geo	pass/fail, whether the implementation of the supplemental geometry elements in the STEP file is as defined in the recommended practices.
dimension	The number of dimensions processed
datums	The number of datums processed
tolerances	The number of tolerances processed
labels	The number of labels processed
date	The date when the statistics were last updated (will be filled in automatically)
issues	A short statement on issues with the file

3.0 <u>Production models: PM20</u>

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 iViP member companies and vendors have supplied these models.

3.2 Approach

Testing of Production Models focuses mainly on data quality, not on specific functionalities. Assemblies should therefore be exported as a single STEP file. The file format should be either AP214-IS or AP203e2. In order to support quality validation of the Production Model exchange, all vendors shall include the maximum level of Validation Properties they support. In addition, since Round18J, the native and target statistics will include ValProps.

All source system native models and STEP files may be analyzed for data quality by the "CADIQ" developers. STEP syntax and structure will be checked by the CAx-IF facilitators. In order to enable an end-to-end analysis of the data exchange, all vendors importing Production Model STEP files are asked to submit the resulting target model from their system along with or instead of the target statistics.

3.3 Testing Instructions

The native models as provided by the user companies should be exported to STEP by all participants who maintain a STEP processor for the respective CAD system. The native models will be made available on the CAx-IF File Repository in the member area under "Round 23J > Production Models".

3.3.1 List of available models

Model name	Stats code	Native System	Remarks
Cursor Control Panel Assembly	pm22_cur	UG NX	
Display Control Panel Assembly	pm22_dis	UG NX	
Pilot Seat	pm22_seat	Pro/E	
Support Frame	pm22_frame	Pro/E	

3.3.2 Results

For each STEP file submitted for the PM22 model, vendors must submit the corresponding native statistics to the online statistics and results database, CAESAR. To do so, log in to CAESAR, go to "Test Rounds > R24J Test Cases > PM22 Data Sheet", and either fill in the web form, or upload a comma-delimited file (.csv) with the following data:

column name	description
model	The name of the test model, e.g. 'PM22' (see stats code above)
system_n	The system code of the CAD system creating the STEP file
system_t	The system code of the CAD system importing the STEP file. For native stats, enter 'stp'
unit	The unit the model is designed in
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' the STEP file as per the recommended practices for validation properties?
cx	Centroid of all solids
cy	
cz	
validation_cx	Centroid of all solids (entire assembly) as received via the validation property capability
validation_cy	
validation_cz	
valid_cent	pass/fail, is the instantiation of the validation property 'centroid' in the STEP file as per the recommended practices for validation properties?
model_size	model_size is the length of the space diagonal of the 3dimensional bounding box enclosing all entities in the model. The result is the Centroid deviation divided by the model_size
shoveit_ok	pass/fail, indicates whether the model passed comparison of the Extended GVP (i.e. no parts/subassemblies misplaced), or failed.
valid_shoveit	pass/fail, indicates whether the target system considers the implementation of the instance information valid as per the recommended practices
date	The date when the statistics were last updated (will be filled in automatically)
issues	A short statement on issues with the file