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NISTIR 7999

STEP File Analyzer User's Guide (Version 2)

Robert R. Lipman

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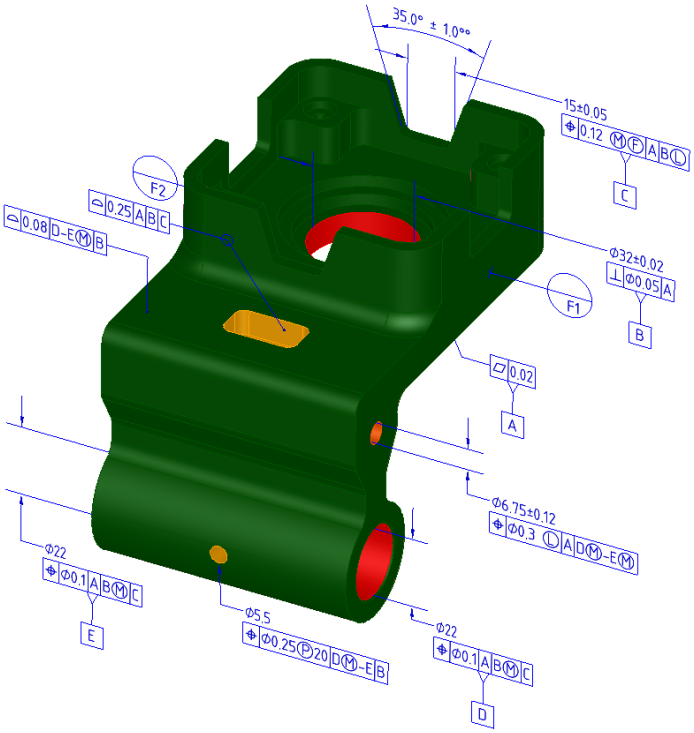

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NISTIR 7999

STEP File Analyzer User's Guide (Version 2)

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April 2014

U.S. Department of Commerce
Penny Pritzker, Secretary

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Patrick D. Gallagher, Under Secretary of Commerce for Standards and Technology and Director

PREFACE

This guide describes how to use the STEP File Analyzer, a software tool that analyzes and generates a spreadsheet from a STEP (STandard for the Exchange of Product model data) file. The spreadsheets simplify inspecting information in the STEP file at an entity and attribute level. STEP files can also be checked for conformance to recommended practices for semantic PMI, graphical PMI, and validation properties.

More information about the STEP File Analyzer and supplemental documentation can be found at http://www.nist.gov/el/msid/infotest/step-file-analyzer.cfm.

The STEP File Analyzer was developed as part of the Model-Based Engineering (MBE) project in the Engineering Laboratory's former Systems Integration for Manufacturing and Construction Applications Program (SIMCA) and was first released in 2012.

DISCLAIMERS

The STEP File Analyzer might not be up-to-date with the most recent recommended practices specified by the CAx Implementor's Forum. The software might also not check STEP files for conformance to every aspect of a recommended practice.

Any mention of commercial products in the STEP File Analyzer and this user's guide is for information purposes only; it does not imply recommendation or endorsement by NIST. For any of the web links in the software and this user's guide, NIST does not necessarily endorse the views expressed, or concur with the facts presented on those web sites.

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ACKNOWLEDGEMENTS

The author thanks Dr. Kent Reed, former leader of the NIST Computer Integrated Building Process Group, for his guidance in the development of the IFC File Analyzer (http://www.nist.gov/el/msid/infotest/ifc-file-analyzer.cfm) on which the STEP File Analyzer is based. The author also acknowledges the many software vendors and users who have provided invaluable feedback, suggestions, and bug reports about the software and supplied sample STEP files that were used to test and improve the capabilities of the software.

Cover image: Part with PMI annotations.

TABLE OF CONTENTS

1 INTRODUCTION 1

2 GETTING STARTED 2

2.1 INSTALLING THE STEP FILE ANALYZER 2
2.2 RUNNING THE STEP FILE ANALYZER 2
2.2.1 Installing the IFCsvr toolkit 3
2.3 GENERATING A SPREADSHEET FROM A STEP FILE 4
2.4 RECOVERING FROM A CRASH OF THE STEP FILE ANALYZER 4
2.5 UNINSTALLING THE STEP FILE ANALYZER 4

3 USER INTERFACE 5

3.1 MENU BAR 6
3.1.1 File Menu 6
3.1.2 Websites Menu 7
3.1.3 Help Menu 7
3.2 TABS BAR 8
3.3 STATUS TAB (FEEDBACK) 8

4 SAMPLE WORKSHEETS 9

4.1 SUMMARY WORKSHEET 9
4.2 ENTITY WORKSHEETS 10

5 OPTIONS TAB 11

5.1 SELECTIVELY PROCESS ENTITY TYPES 11
5.2 RECOMMENDED PRACTICE REPORTS 12
5.2.1 Semantic PMI Representation 12
5.2.1.1 Limitations of Reconstructing the Visual Presentation of Semantic PMI 19
5.2.2 Graphical PMI Presentation 19
5.2.3 Validation Properties 21
5.3 INVERSE RELATIONSHIPS AND USED IN 24
5.4 DISPLAY A STEP FILE IN OTHER APPLICATIONS 26
5.4.1 Indent STEP File 26

6 SPREADSHEET TAB 27

6.1 GENERATING TABLES 28
6.2 ROUNDING NUMBERS 28
6.3 MAXIMUM ROWS 29
6.4 OTHER OPTIONS 29

7 PROCESSING MULTIPLE STEP FILES 30

7.1 SUMMARY WORKSHEET 30
7.2 COVERAGE ANALYSIS WORKSHEETS 32

8 CRASH RECOVERY 34

9 COMMAND-LINE VERSION 36

10 REFERENCES 38

LIST OF FIGURES

Figure 1: IFCsvr installation dialogs 3
Figure 2: What to do if the STEP File Analyzer crashes 4
Figure 3: STEP File Analyzer user interface 5
Figure 4: File menu 6
Figure 5: Websites menu 7
Figure 6: Help menu 7
Figure 7: Tooltip help 8
Figure 8: Summary worksheet 9
Figure 9: Entity worksheet (datum_system) 10
Figure 10: Entity worksheet (draughting_model) 10
Figure 11: Entity worksheet (b_spline_surface_with_knots) 10
Figure 12: Options tab 11
Figure 13: Tooltip help for GD&T entities 12
Figure 14: Part with typical PMI annotations 13
Figure 15: Summary worksheet showing highlighted entities with semantic PMI 14
Figure 16: Semantic PMI example (dimensional_characteristic_representation) for dimensional tolerance 16
Figure 17: Semantic PMI example (datum_system) for datum reference frames 17
Figure 18: Semantic PMI example for a flatness tolerance with reference to a datum feature 17
Figure 19: Semantic PMI example for position tolerance with reference to datum feature and dimensional tolerance 17
Figure 20: Semantic PMI Summary worksheet 18
Figure 21: Flatness tolerance and datum feature 19
Figure 22: Graphical PMI example (annotation_occurrence) 20
Figure 23: VRML generated from graphical PMI 21
Figure 24: Validation properties example (property_definition) 22
Figure 25: Validation properties example with expanded columns 22
Figure 26: More validation property examples 23
Figure 27: Entity worksheet (shape_aspect_relationship) 24
Figure 28: Inverse Relationships and Used In example 25
Figure 29: Display STEP File in Other Applications 26
Figure 30: Indented STEP file 26
Figure 31: Spreadsheet tab 27
Figure 32: Entity worksheet (shape_aspect_relationship) with tables 28
Figure 33: Circle entity worksheet, with rounding (left) and without rounding (right) 28
Figure 34: Maximum rows example (cartesian_point) 29
Figure 35: File Summary worksheet when processing multiple STEP files 31
Figure 36: Graphical PMI Coverage Analysis worksheet 32
Figure 37: Semantic PMI Coverage Analysis worksheet 33
Figure 38: Dialogs that might be displayed when the STEP File Analyzer crashes 34
Figure 39: Determining which entity in the STEP File Analyzer caused a crash 35
Figure 40: Feedback when running the command-line version 37

1 Introduction

This guide describes how to use the STEP File Analyzer, a software tool that analyzes and generates a spreadsheet from a STEP (ISO 10303 – informally known as the STandard for Exchange of Product model data) [1,2,3] file. The spreadsheets simplify inspecting information from the STEP file at an entity and attribute level. In this report a "STEP file" refers to a file that is exported by CAD (Computer-Aided Design) software in a format described by ISO 10303-21 [4] and typically known as a Part 21 file.

Typical STEP file viewers show a 3D visualization of the part or model represented by the STEP file. The viewers usually have a high-level hierarchical display of the information in the STEP file where the user can drill down to individual attributes of parts. However, there is no way to view all of the actual STEP entities and their attributes at once. The STEP File Analyzer provides this capability by creating a spreadsheet from the STEP file (section 4).

The STEP File Analyzer also checks for conformance to recommended practices for semantic PMI (Product and Manufacturing Information), graphical PMI, and validation properties (section 5.2) [5]. Recommended practices are defined by the CAx Implementor Forum (CAx-IF). The objective of the CAx-IF is to advance CAx (mainly Computer-Aided Design, Engineering, and Manufacturing) software system translator development and to ensure that user requirements for interoperability are satisfied [6]. Semantic PMI includes all information necessary to represent GD&T without any graphical presentation elements, although an importing CAD system can attempt to recreate the visual presentation of the annotation. Product and manufacturing information may include geometric dimensions and tolerances (GD&T), 3D text annotations, surface finish, and material specifications. Graphical PMI presents GD&T annotations as a visual representation of geometric elements such as lines and arcs as part of the CAD model. The validation properties include geometric, PMI, assembly, annotation, attribute, and tessellated validation properties.

The STEP File Analyzer supports current and many older versions of the following STEP Application Protocols (AP). An AP is the implementable part of ISO 10303 on which translators are based on in a particular engineering domain.

- AP203 – Configuration Controlled 3D Design of Mechanical Parts and Assemblies [7]
- AP209 – Structural Analysis Design [8]
- AP210 – Electronic Assembly Interconnect and Packaging Design [9]
- AP214 – Automotive Design [10]
- AP242 – Managed Model Based 3D Engineering [11, 12, 13]

2 Getting Started

2.1 Installing the STEP File Analyzer

The link to the download request form for the STEP File Analyzer can be found on http://www.nist.gov/el/msid/infotest/step-file-analyzer.cfm. After submitting the download request, instructions about where to download the software is provided. The information is also emailed to the requestor. The software is downloaded as a zip file named `SFA.zip`.

The installation process does not require anything more than unzipping the file `SFA.zip`, which contains four files:

1. `STEP-File-Analyzer.exe` – STEP File Analyzer graphical user interface (GUI) version
2. `STEP-File-Analyzer-CL.exe` – STEP File Analyzer command-line version (section 9)
3. `SFA-Users-Guide.pdf` – This user's guide
4. `SFA-README-FIRST.pdf` – A readme file

There are no restrictions as to where the files are located in the computer's file system.

Microsoft Excel is required to generate a spreadsheet.

2.2 Running the STEP File Analyzer

The STEP File Analyzer can run on any Windows computer. The software (`STEP-File-Analyzer.exe`) is a 32-bit application. The size of the STEP file that can be translated by the software depends on the amount of computer memory and the options selected when running the software.

To run the STEP File Analyzer, simply double click on the icon for `STEP-File-Analyzer.exe`. Several setup functions are performed the first time the software is run:

1. The Disclaimers dialog is displayed.
2. This User's Guide is displayed.
3. The user is asked if a shortcut to the STEP File Analyzer can be created in the Start Menu and if an icon for the software can be placed on the Desktop. The STEP File Analyzer icon is a bluish circle with a frog. Creating the shortcut and icon facilitates running the software without having to remember where it is installed.
4. The Crash Recovery dialog is displayed (section 2.4).
5. The What's New information are displayed in the Status tab.
6. A file `STEP-File-Analyzer-options.dat` is created in the user's home directory that stores the current state of the STEP File Analyzer options. Do not edit this file.
7. The IFCsvr toolkit is installed.

2.2.1 Installing the IFCsvr toolkit

The IFCsvr toolkit [14] is used to read and process STEP files[1]. The installation of the IFCsvr toolkit is simple and straightforward. Two of the installation dialogs are shown in Figure 1. The default installation folder should be used as shown in the second dialog. It is important to let the installation process complete before processing any STEP files with the STEP File Analyzer.

Figure 1: IFCsvr installation dialogs

[1] Although the toolkit was originally written to work with IFC (Industry Foundation Classes) data exchange files [15], used in the building and construction industry, it has been adapted to work with STEP files.

2.3 Generating a spreadsheet from a STEP file

After the IFCsvr toolkit is installed, a spreadsheet can be generated from a STEP file that uses a supported AP. Go to the File menu, select 'Open STEP File(s)', select a STEP file on your computer, click Open in the dialog, and then click on the 'Generate Spreadsheet' button. Feedback will appear in the Status tab indicating the progress of processing the STEP file. The spreadsheet will be opened after it has been generated.

2.4 Recovering from a crash of the STEP File Analyzer

Sometimes the STEP File Analyzer will unexpectedly stop (crash) when processing a STEP file. This is usually due to either bugs in the STEP file or limitations of the IFCsvr toolkit. If this happens, simply restart the software and process the same STEP file again by using function key F1 or F4 if processing multiple STEP files. Figure 2 shows a dialog that is displayed the first few times the software is run.

The STEP File Analyzer keeps track of which entity type caused the crash for a particular STEP file and will not process that type again. More details about recovering from a crash are explained in section 8.

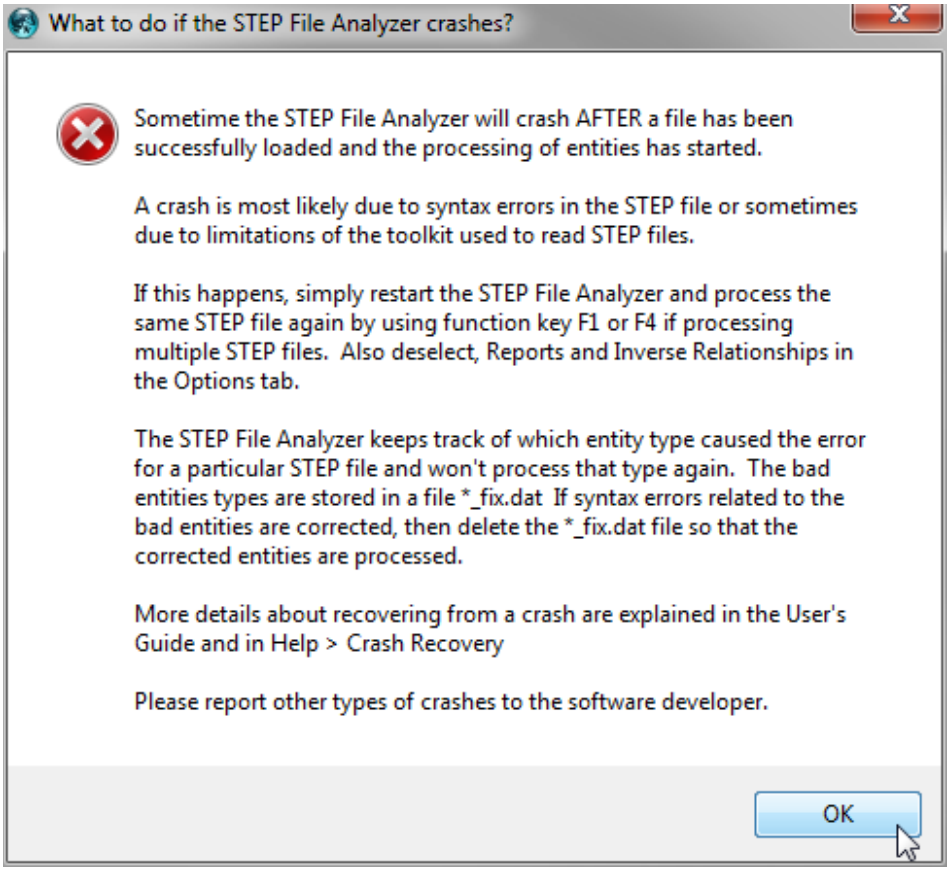


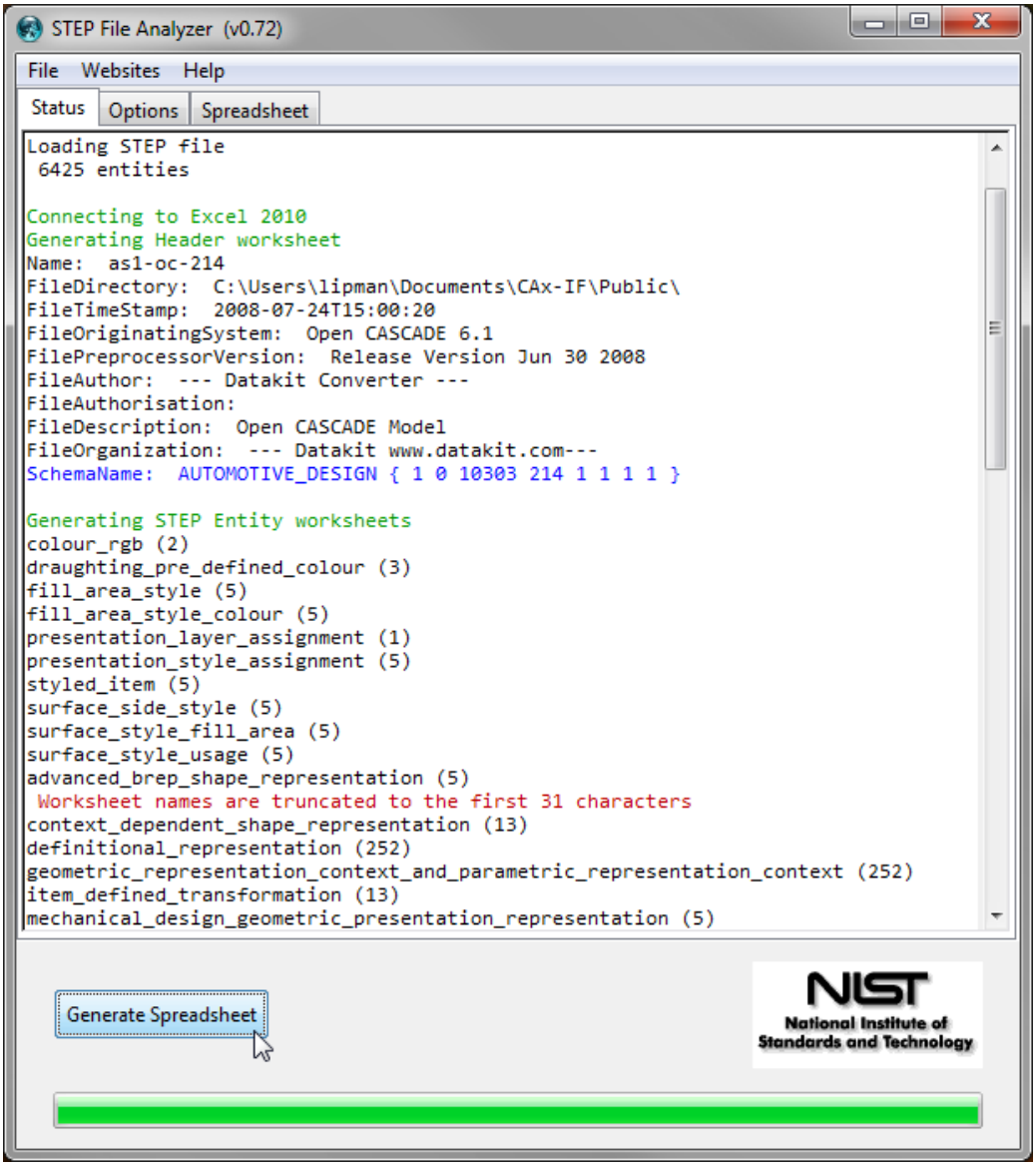
Figure 2: What to do if the STEP File Analyzer crashes

2.5 Uninstalling the STEP File Analyzer

The STEP File Analyzer can be uninstalled by manually deleting the two executable files, the `STEP-File-Analyzer-options.dat` file in the user's home directory, and the desktop icon for the software.

3 User Interface

Figure 3 shows the STEP File Analyzer user interface running on a Windows 7 computer. At the top of the user interface is the Menu bar with the File, Websites, and Help menus. Below that is the Tabs bar with tabs for Status, Options, and Spreadsheet. Below that is the Status window that displays text feedback when the STEP File Analyzer is running. Clicking on the Options and Spreadsheet tabs will switch to the user interface for those tabs. At the bottom of the user interface is the Generate Spreadsheet button, NIST logo, and Progress bar.



< Menu bar
< Tabs bar

< Status tab with text feedback

< Generate Spreadsheet button

< Progress bar

Figure 3: STEP File Analyzer user interface

3.1 Menu Bar

The menu bar contains three items: the File menu, the Websites menu, and the Help menu.

3.1.1 File Menu

From the File menu, shown in Figure 4, the user can select a single STEP Part 21 file to process with "Open STEP File(s)…". STEP files with extensions of .stp, .step, and .p21 are recognized. Compressed STEP files with an extension of .stpZ are also recognized. Only STEP files using the supported AP's can be processed (section 1).

Multiple STEP files can be processed at one time by selecting the "Open Multiple STEP Files in a Directory…" option where the user will be asked to select a directory to search for STEP files. The search for multiple files can be restricted to only the selected directory or to include all subdirectories.

Multiple STEP files can also be selected in the "Open STEP File(s)" dialog by holding down the control or shift key when selecting files. When spreadsheets from multiple STEP files are generated a File Summary spreadsheet is also generated, as is described in section 7.

Below the first solid line in the File menu is a list of up to 20 of the most recently translated STEP files that can be opened directly. Several function keys can be used to access features of the File menu and in the software.

- F1 generates a spreadsheet from the STEP file that is first in the list.
- F2 opens the last spreadsheet that was generated.
- F3 opens the last File Summary spreadsheet when multiple STEP files were processed.
- F4 generates multiple spreadsheets from the last directory selected.
- F5 and F6 decrease and increase, respectively, the size of the text in the Status tab.
- F7 toggles the text font in the Status tab.

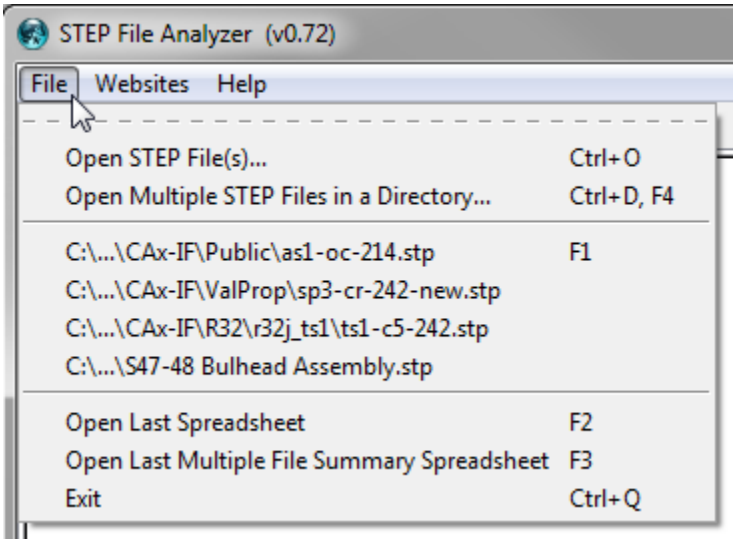


Figure 4: File menu

3.1.2 Websites Menu

The Websites menu, shown in Figure 5, provides links to useful resources related to the STEP File Analyzer, CAx-IF, NIST research, utility programs, organizations that are programmatically related to STEP, and to several websites with documentation for entities in STEP AP203, AP214, and AP242.

3.1.3 Help Menu

The Help Menu, shown in Figure 6, has five sections. In the first section,

- "User's Guide (pdf)" is a link to this document.
- "What's New" displays information in the Status tab about new features in the software. This information is automatically displayed every time a new version of the software is run.
- "Check for Update" opens up a web page that checks for the latest version of the STEP File Analyzer. Follow the instructions on that web page to download a new version of the software if one is available. This feature runs automatically if an update hasn't been checked for in the last 30 days.

The other topics in the Help menu display information in the Status tab and are similar to most information in this User's Guide.

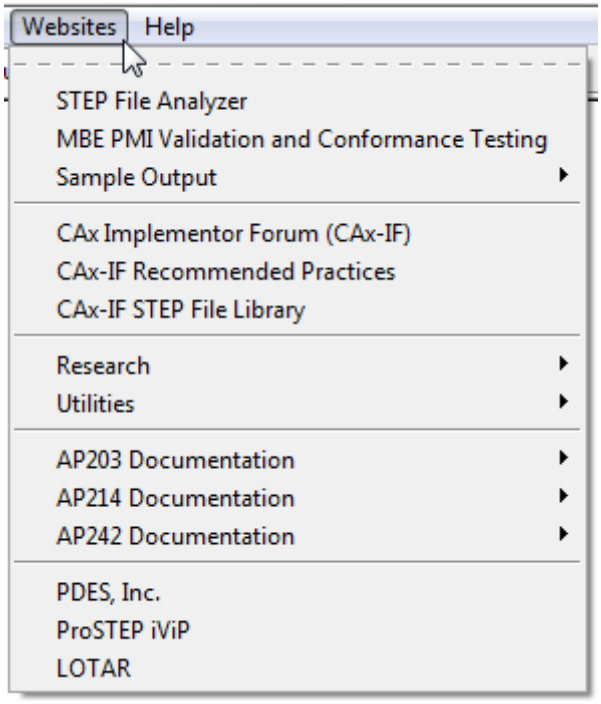


Figure 5: Websites menu

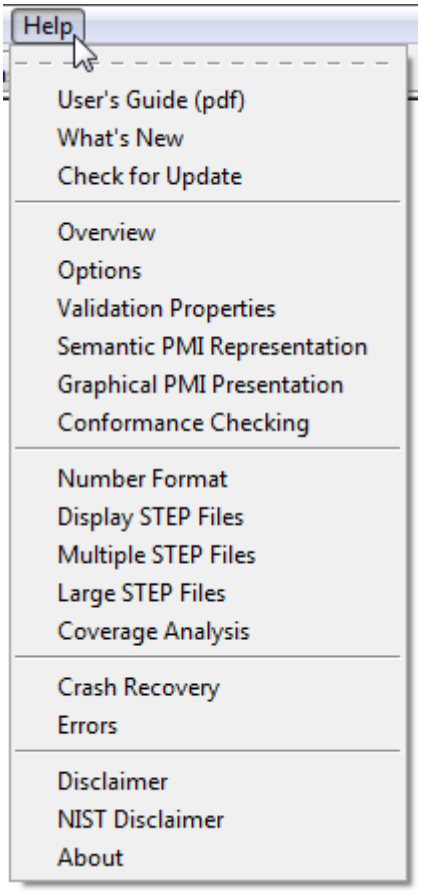


Figure 6: Help menu

Help is also available in the form of tooltips related to the display options in the tabs. Holding the mouse over any text in a tab for a second or two will display a tooltip. An example of the Validation Reports tooltip help in the Options tab is shown in Figure 7.

Features of the software that are not described in this User's Guide are explained in the Help menu topics or in tooltips.

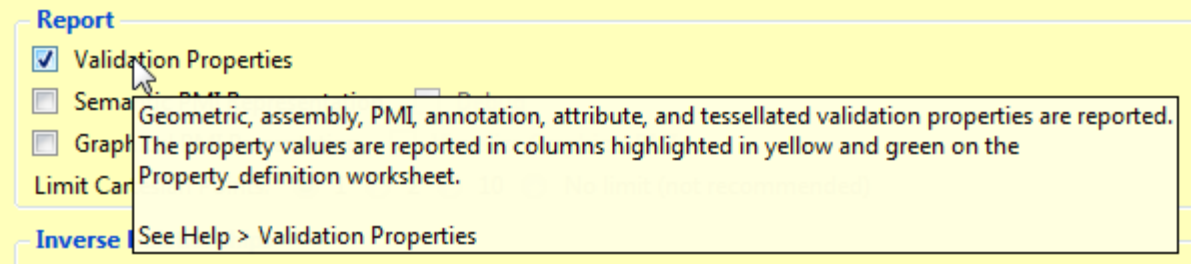


Figure 7: Tooltip help

3.2 Tabs Bar

The Tabs bar is located directly below the menu bar in Figure 3. Clicking on a tab will switch from the current tab to the selected tab. Except for the Status tab, the tabs contain the STEP File Analyzer display options that affect how a spreadsheet is generated from a STEP file. The options in the Options and Spreadsheet tabs are described in sections 5 and 6.

3.3 Status Tab (Feedback)

The Status tab displays important feedback during the generation of a spreadsheet from a STEP file. The feedback should not be ignored as it provides useful information related to the success in processing the STEP file. Some of the error, warning, or informational messages in the Status tab have a yellow background, red background, red, blue, or green text. Syntax error messages related to nonconformance to a recommended practice are highlighted with a red background. A brief example of the information in the Status tab is shown in Figure 3.

The following general sequence of status messages appears in the Status tab when a STEP file is processed:

- Messages about Connecting to IFCsvr, Loading STEP file, and Number of entities
  - The time to complete this step depends on the size of the STEP file
- Messages about Connecting to Excel and Generating Header worksheet
- Information from the STEP file header section
- STEP entities listed in the order they are processed
  - The number in parentheses is the number of entities of that type in the STEP file
  - The types of entities processed depends on the entities selected in the Process section of the Options tab (section 5.1)
- Possible messages about inverse relationships (section 0), checking recommended practices (section 5.2), and syntax errors
- Messages about Closing IFCsvr, Adding Summary worksheet, Formatting spreadsheet, Adding links to STEP documentation
- Messages about Saving and Loading the spreadsheet

4 Sample Worksheets

The spreadsheet generated by the STEP File Analyzer contains several worksheets. There are Summary and Header worksheets, along with a worksheet for each entity type that was processed from the STEP file. The type of entities processed depends on the entities selected in the Process section of the Options tab.

4.1 Summary Worksheet

An example of a Summary worksheet is shown in Figure 8. Rows 1-5 contain basic information about the STEP file. Starting with row 8, each row in column A is the name of an entity processed from the STEP file. The entity names are linked to their corresponding worksheet. In this example, the entity name in parentheses in cell A12 is for a complex entity (characterized_representation)(draughting_model). Column B is the number of each entity type counted by the software. Column C is a link to documentation for that entity type in the AP.

At the bottom of the spreadsheet are tabs for the Summary, Header, and many entity worksheets. Entities in column A and in the worksheet tabs are grouped and colored according to the categories of entities in the Process section of the Options tab as described in section 5.1. Selecting a tab, using the links in column A, or using the Control-PageUp and Control-PageDown keys will switch to a different worksheet.

	A	B	C	D	E	F	G
1	**STEP File**	pp3_oc_242.stp					
2	**STEP Directory**	C:\Users\lipman\Documents\CAx-IF\R29\r29j_pp3					
3	**Application**	Datakit CrossCadWare V72 Feb 16 2012					
4	**Timestamp**	2012-16-03T18:37:42					
5	**Total Entities**	5461					
6							
7	**Entity**	**Count**	**AP242**				
8	camera_model_d3_multi_clipping	2	Doc				
9	integer_representation_item	4	Doc				
10	product_category_relationship	1	Doc				
11	characterized_item_within_representation	3	Doc				
12	(characterized_representation) _(draughting_model)	3	Doc				
13	leader_directed_callout	3	Doc				
14	colour_rgb	7	Doc				
15	curve_style	10	Doc				
16	(draughting_annotation_occurrence) _(geometric_representation_item) _(leader_curve)	6	Doc				
17	draughting_model_item_association	3	Doc				
18	draughting_pre_defined_colour	12	Doc				
19	draughting_pre_defined_curve_font	10	Doc				
20	fill_area_style	4	Doc				
21	fill_area_style_colour	4	Doc				
22	point_style	5	Doc				
23	pre_defined_marker	5	Doc				
24	presentation_style_assignment	19	Doc				
25	styled_item	13	Doc				
26	surface_side_style	4	Doc				
27	surface_style_fill_area	4	Doc				
28	surface_style_usage	4	Doc				
29	advanced_brep_shape_representation	1	Doc				
30	constructive_geometry_representation	3	Doc				

Summary | Header | camera_model_d3_multi_clipping | integer_representatio

Figure 8: Summary worksheet

4.2 Entity Worksheets

An example of an entity worksheet is shown in Figure 9. Row 1 contains the name of the entity and the number of entities. It is also a link back to the Summary worksheet. Row 2 contains a link to the entity documentation. Row 3 is the names of the entity attributes. The first column is the entity ID. The link to the Summary worksheet and entity documentation can be turned off in the Spreadsheets tab (section 6.4).

Starting with row 4, each row contains the attribute values for an entity. Column D is the of_shape attribute where, in this example, all of the values for the entities are product_definition_shape 37. This means that the of_shape attribute is a reference to the product_definition_shape entity with an ID of 37. In column F, the constituents attribute refers to either single or multiple datum_reference_compartment entities. The number in parentheses is the number of entity references and the numbers after the entity name are the entity IDs that are referenced.

	A	B	C	D	E	F
1	datum_system (7)					
2	Doc					
3	**ID**	**name**	**description**	**of_shape**	**product_definitional**	**constituents**
4	5814	DRF1		product_definition_shape 37	FALSE	(1) datum_reference_compartment 5815
5	6498	DRF2		product_definition_shape 37	FALSE	(2) datum_reference_compartment 6499 6500
6	8307	DRF3		product_definition_shape 37	FALSE	(3) datum_reference_compartment 8308 8309 8310
7	9073	DRF4		product_definition_shape 37	FALSE	(2) datum_reference_compartment 9074 9077
8	9398	DRF5		product_definition_shape 37	FALSE	(3) datum_reference_compartment 9399 9400 9401
9	9529	DRF6		product_definition_shape 37	FALSE	(2) datum_reference_compartment 9530 9533
10	9614	DRF7		product_definition_shape 37	FALSE	(2) datum_reference_compartment 9615 9616

Figure 9: Entity worksheet (datum_system)

In the example of an entity worksheet, shown in Figure 10, cells C4 and C6 refer to multiple entity types. Cell C5 refers to multiple styled_item entities, however, the entity IDs are not displayed because there is too much information for one worksheet cell.

	A	B	C
1	draughting_model (3)		
2	Doc		
3	**ID**	**name**	**items**
4	31471		(2) annotation_plane 29651 31466 (1) axis2_placement_3d 36
5	31941		(93) styled_item
6	32031	detail view	(1) axis2_placement_3d 36 (1) camera_model_d3_multi_clipping 32026

Figure 10: Entity worksheet (draughting_model)

Sometimes the STEP File Analyzer skips certain entity attributes due to limitations of the IFCsvr toolkit. A message about skipping an entity attribute will be displayed in the Status tab and question marks are displayed in the worksheet. For example, Figure 11 shows question marks (???) in column E where the control_points_list attributes were skipped.

	A	B	C	D	E
1	b_spline_surface_with_knots (730)				
2	Doc				
3	**ID**	**name**	**u_degree**	**v_degree**	**control_points_list**
4	51332		5	5	???
5	51464		3	1	???

Figure 11: Entity worksheet (b_spline_surface_with_knots)

5 Options Tab

Figure 12 shows the Options tab that enables the user to control which entities from the STEP file are written to the spreadsheet and to selectively add supplemental information to some worksheets.

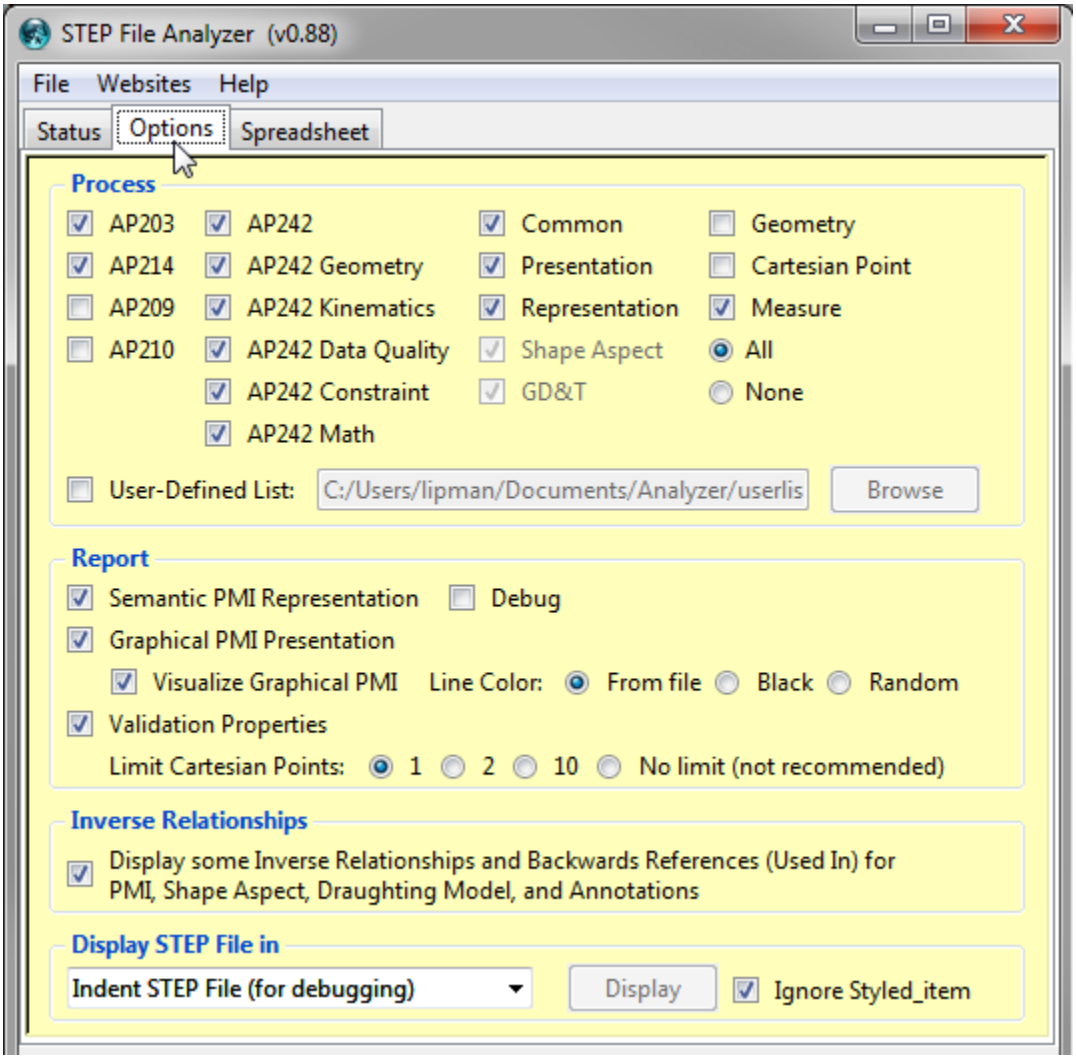


Figure 12: Options tab

5.1 Selectively Process Entity Types

The STEP File Analyzer can process any entity type from AP203, AP209, AP210, AP214, and AP242. The checkboxes in the Process section of the Options tab allow the user to selectively process different types of entities. Each checkbox corresponds to a category of entities. In the example in Figure 12, all entity types are processed except Geometry, Cartesian Point, AP209, and AP210 entities.

The 'All' button selects the selected entity categories shown in Figure 12. The 'None' button deselects all entity categories and also selects all three of the Report types for Validation Properties, Semantic PMI, and Graphical PMI. Selecting any of the three Report types automatically includes the necessary entities related to that report. For example, selecting the report for Semantic PMI automatically selects the entity categories for Shape Aspect and GD&T and disables deselecting them.

By processing only certain types of entities, the size of and time to generate a spreadsheet can be reduced. The categories of entities are also used to order and color the entity names on the Summary worksheet and tabs for the entity worksheets as shown in Figure 8. Each category of entities is assigned a different color and within each category the entities are listed in alphabetic order.

Holding the mouse over any checkbox for a second or two will display a tooltip that lists all of the entities in that category. An example of the tooltip for the GD&T (Geometric Dimensioning and Tolerancing) entities is shown in Figure 13. The tooltip indicates that there are 63 entities in the GD&T category. Some of the categories contain hundreds of entities and the tooltip might not fit on the screen.

A user-defined list can also be used to set which entities will be processed. The list is defined in a plain text file with the name of one entity type per line in lower case. When the User-Defined List option is selected, the Browse button will be activated to select the file that contains the list of entities.

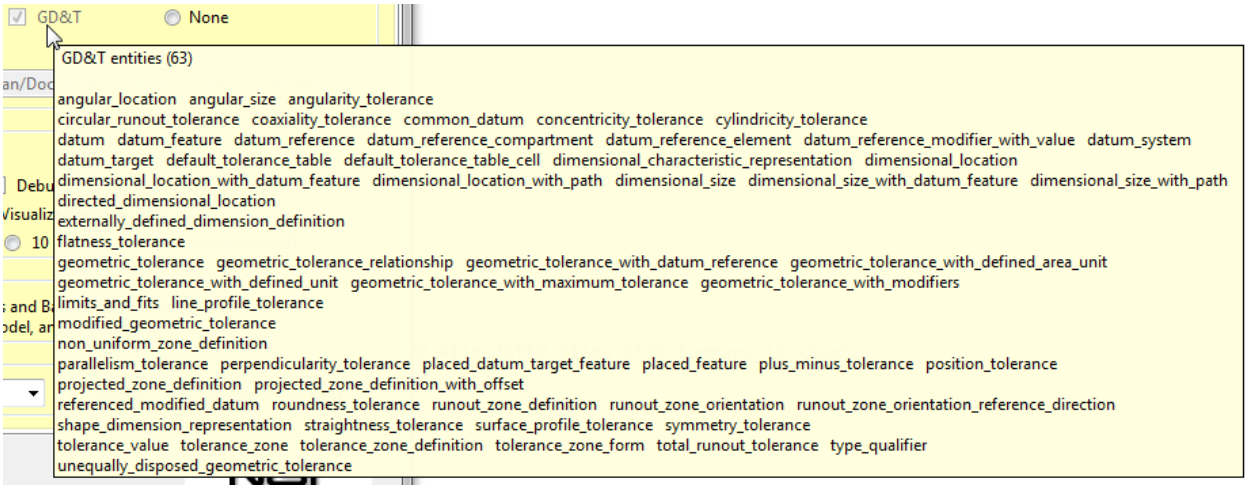


Figure 13: Tooltip help for GD&T entities

5.2 Recommended Practice Reports

Recommended practices are specifications that provide common implementation guidance associated with specific functionalities for data exchange. The CAx-IF has published recommended practices for communicating semantic PMI, graphical PMI, and validation properties in STEP files [16]. Recommended practices are not part of ISO 10303.

The STEP File Analyzer checks the STEP file for conformance to those recommended practices. Details about entity attribute values that indicate conformance are reported on various worksheets. Non-conformance is indicated by messages in the Status tab and spreadsheet cells are highlighted in red.

Section 5.2.1 discusses the report for semantic PMI representation. Section 5.2.2 discusses the report for graphical PMI presentation. Section 5.2.3 discusses the report for validation properties.

5.2.1 Semantic PMI Representation

Product and manufacturing information (PMI) are annotations and attributes that define product geometry and product specifications [17]. PMI includes 3D annotations to specify Geometric Dimensioning and Tolerancing (GD&T), as well as non-geometric data such as surface texture specifications, finish

requirements, process notes, material specifications, and welding symbols. GD&T is a symbolic language used to communicate tolerances on manufactured parts. The industry standards for presentation of GD&T in axonometric views in 3D space are ASME Y14.41-2003 [18] and ISO 16792:2006 [19]. Some common tolerances include dimensional tolerances on length and diameter, and geometric tolerances on flatness, position, surface profile, and circular runout.

Figure 14 shows a part with typical graphical PMI annotations including dimensions, geometric and dimensional tolerances, datum features, and datum targets. All of these types of PMI annotations are processed by the STEP File Analyzer.

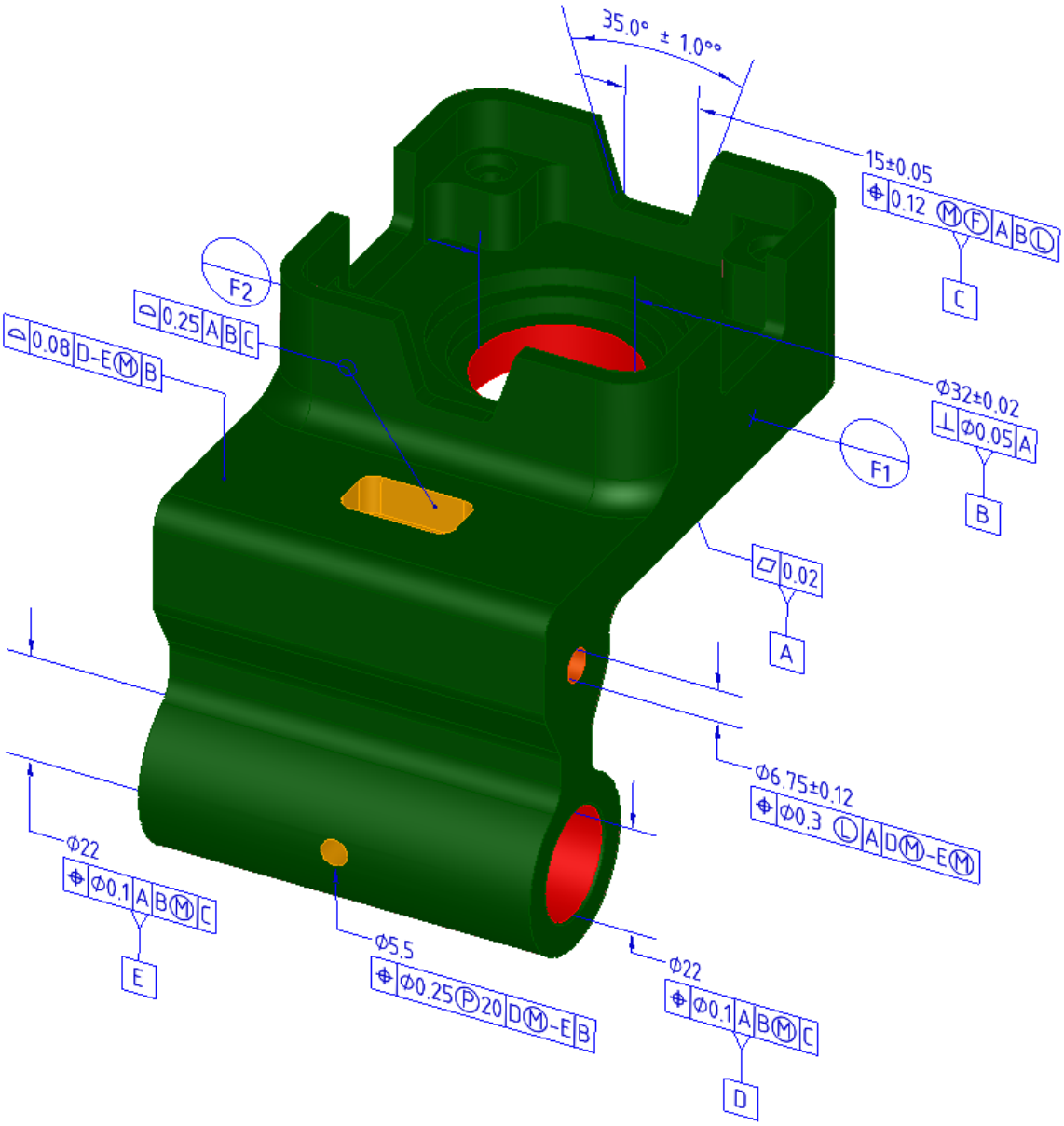
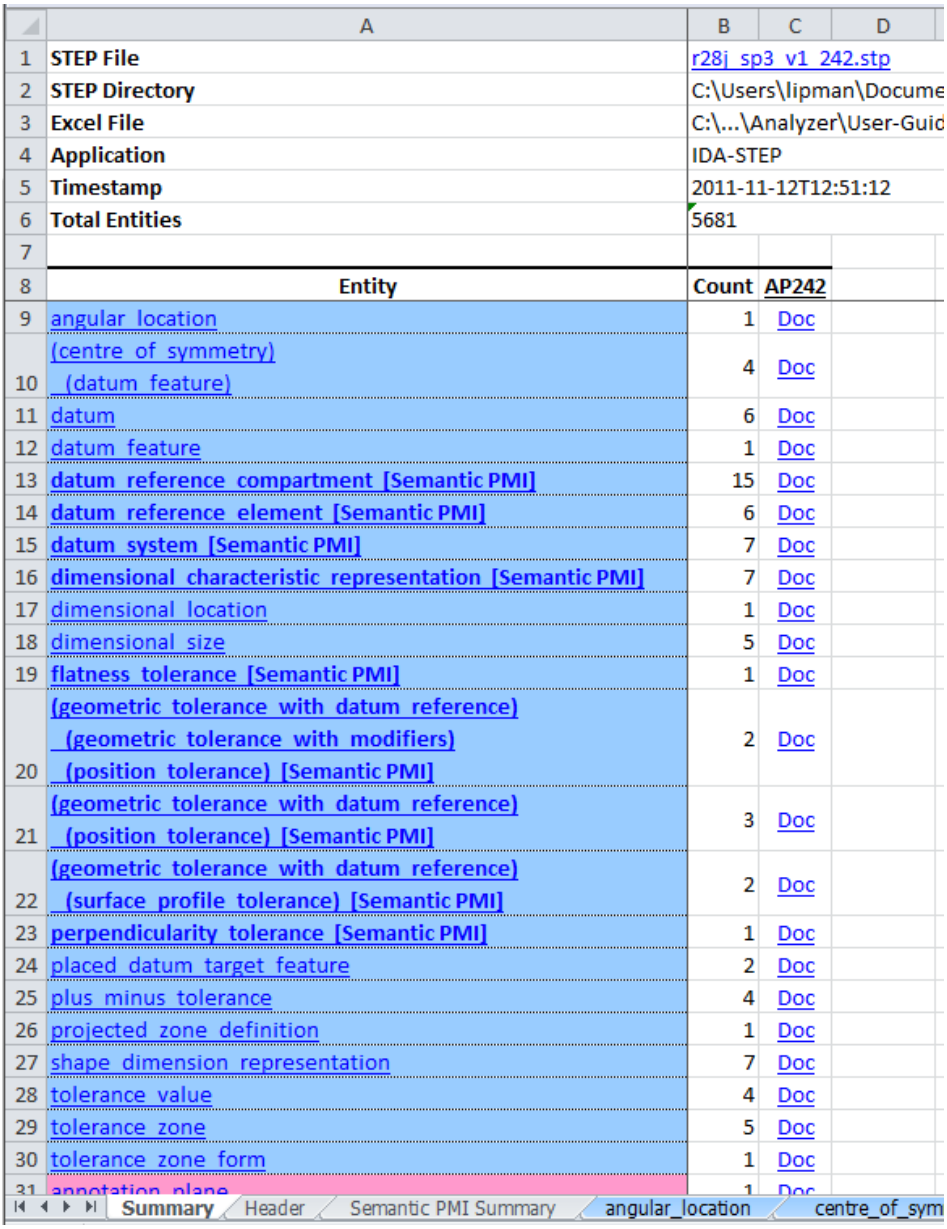


Figure 14: Part with typical PMI annotations

Semantic PMI includes all information necessary to represent GD&T without any graphical presentation elements. Semantic PMI is associated with CAD model geometry and is computer-interpretable to facilitate automated consumption by downstream applications for manufacturing, measurement, inspection, and others. Semantic PMI does not contain any information regarding its visual appearance although an importing CAD system can attempt to recreate the visual presentation of the annotation.

Figure 15 shows the summary worksheet, similar to Figure 8, with entities highlighted that have information related to semantic PMI. All of the worksheets for the highlighted entities will have extra columns with semantic PMI information. Rows 13-15 are entities related to the datum reference frame. Row 16 is the dimensional_characteristic_representation entity which is associated with all dimensional tolerances. Rows 19-23 are entities related to geometric tolerances.



	A	B	C	D
1	**STEP File**	r28j_sp3_v1_242.stp		
2	**STEP Directory**	C:\Users\lipman\Docume		
3	**Excel File**	C:\...\Analyzer\User-Guid		
4	**Application**	IDA-STEP		
5	**Timestamp**	2011-11-12T12:51:12		
6	**Total Entities**	5681		
7				
8	**Entity**	**Count**	**AP242**	
9	angular_location	1	Doc	
10	(centre_of_symmetry) (datum_feature)	4	Doc	
11	datum	6	Doc	
12	datum_feature	1	Doc	
13	**datum_reference_compartment [Semantic PMI]**	15	Doc	
14	**datum_reference_element [Semantic PMI]**	6	Doc	
15	**datum_system [Semantic PMI]**	7	Doc	
16	**dimensional_characteristic_representation [Semantic PMI]**	7	Doc	
17	dimensional_location	1	Doc	
18	dimensional_size	5	Doc	
19	**flatness_tolerance [Semantic PMI]**	1	Doc	
20	**(geometric_tolerance_with_datum_reference) (geometric_tolerance_with_modifiers) (position_tolerance) [Semantic PMI]**	2	Doc	
21	**(geometric_tolerance_with_datum_reference) (position_tolerance) [Semantic PMI]**	3	Doc	
22	**(geometric_tolerance_with_datum_reference) (surface_profile_tolerance) [Semantic PMI]**	2	Doc	
23	**perpendicularity_tolerance [Semantic PMI]**	1	Doc	
24	placed_datum_target_feature	2	Doc	
25	plus_minus_tolerance	4	Doc	
26	projected_zone_definition	1	Doc	
27	shape_dimension_representation	7	Doc	
28	tolerance_value	4	Doc	
29	tolerance_zone	5	Doc	
30	tolerance_zone_form	1	Doc	
31	annotation_plane	1	Doc	

Summary | Header | Semantic PMI Summary | angular_location | centre_of_sym

Figure 15: Summary worksheet showing highlighted entities with semantic PMI

Figure 16 shows the dimensional_characteristic_representation worksheet with the semantic PMI, shown in columns D through J, for dimensional tolerances. In row 3, the parenthetic notation indicates the section number in the CAx-IF recommended practice for semantic PMI related to that piece of information. For example, sections 5.1.1 (column D) and 5.2.1 (column E) in the recommended practice specify allowable attribute values shown in those columns.

- Column D shows the name attribute of the entity type shown in column B.
- Column E shows the name attribute of the entity type shown in column C.
- Column F shows the length or angle value associated with the shape_dimension_representation entity in column C.
- Column G shows the name value associated with the length or angle value in column F.
- Column H shows the plus-minus bounds associated with the dimensional tolerance.
- Column I shows the reference of the dimensional tolerance to associated geometric entities. In this case, the association is through shape_aspect entities which refer to advanced_face entities.
- Column J shows the reconstructed visual presentation of the semantic PMI for the dimensional tolerance.
    - Cell J4 shows an angular tolerance with plus-minus bounds.
    - Cell J5 shows a length tolerance with plus-minus bounds
    - Cells J6 through J10 show dimensional tolerances for the diameter of holes, some with plus-minus bounds.

The dimensional tolerances in column J correspond to the PMI annotations in Figure 14.

	A	B	C	D	E	F	G	H	I	J
1	dimensional_characteristic_representation (7)									
2	Doc			Semantic PMI Representation						
3	ID	dimension	representation	dimension name (Sec. 5.1.1)	representation name (Sec. 5.2.1)	length/angle	length/angle name	plus minus bounds (Sec. 5.2.3)	associated geometry (Sec. 5.1.1, 5.1.5)	Dimensional Tolerance
4	11080	angular_location 5173	shape_dimension_representation 11081		independency	35		-1.0 1.0	(2) advanced_face 3092 4037 < (2) shape_aspect 5171 5172	35.0° ± 1.0
5	11156	dimensional_location_with_datum_feature 6431	shape_dimension_representation 11157	linear distance	independency	15		-0.05 0.05	(2) advanced_face 4191 4392 < (2) shape_aspect 6429 6430	15.0 ± 0.05
6	11169	dimensional_size_with_datum_feature 5472	shape_dimension_representation 11170	diameter	independency	32		-0.02 0.02	(1) advanced_face 1157 < dimensional_size_with_datum_feature 5472	Ø32.0 ± 0.02
7	11172	dimensional_size_with_datum_feature 7622	shape_dimension_representation 11173	diameter	independency	22			(1) advanced_face 704 < dimensional_size_with_datum_feature 7622	Ø22.0
8	11175	dimensional_size 8595	shape_dimension_representation 11176	diameter	independency	6.75		-0.12 0.12	(1) advanced_face 546 < shape_aspect 8594	Ø6.75 ± 0.12
9	11178	dimensional_size_with_datum_feature 9049	shape_dimension_representation 11179	diameter	independency	22			(1) advanced_face 842 < dimensional_size_with_datum_feature 9049	Ø22.0
10	11181	dimensional_size 10083	shape_dimension_representation 11182	diameter	independency	5.5			(1) advanced_face 985 < shape_aspect 10082	Ø5.5

Figure 16: Semantic PMI example (dimensional_characteristic_representation) for dimensional tolerance

Figure 17 shows the datum_system worksheet with the semantic PMI for datum reference frames in column G. The visual presentation of the datum reference frame is reconstructed by following the entities referred to in column F. Those entities refer to the individual components of the datum reference frame including least and maximum material condition (L and M in circles) modifiers.

	A	B	C	D	E	F	G
1	datum_system (7)						
2	Doc						Semantic PMI Representation
3	ID	name	description	of_shape	product_definitional	constituents	Datum Reference Frame
4	5814	DRF1		product_definition_shape 37	FALSE	(1) datum_reference_compartment 5815	A
5	6498	DRF2		product_definition_shape 37	FALSE	(2) datum_reference_compartment 6499 6500	A | B Ⓛ
6	8307	DRF3		product_definition_shape 37	FALSE	(3) datum_reference_compartment 8308 8309 8310	A | B Ⓜ | C
7	9073	DRF4		product_definition_shape 37	FALSE	(2) datum_reference_compartment 9074 9077	D Ⓜ-E | B
8	9398	DRF5		product_definition_shape 37	FALSE	(3) datum_reference_compartment 9399 9400 9401	A | B | C
9	9529	DRF6		product_definition_shape 37	FALSE	(2) datum_reference_compartment 9530 9533	D-E Ⓜ | B
10	9614	DRF7		product_definition_shape 37	FALSE	(2) datum_reference_compartment 9615 9616	A | D Ⓜ-E Ⓜ

Figure 17: Semantic PMI example (datum_system) for datum reference frames

Figure 18 shows the flatness_tolerance worksheet with the reconstructed visual presentation for a flatness tolerance in column F. The reconstructed visual presentation of the semantic PMI is limited by the character set available in the spreadsheet. The flatness tolerance symbol (parallelogram) appears a bit small and misshapen. All of the lines for the compartments of the feature control frame are not shown. The combination of the inverted triangle, vertical line, and 'A' in brackets represents the reference to datum feature 'A'.

	A	B	C	D	E	F
1	flatness_tolerance (1)					
2	Doc					Semantic PMI Representation
3	ID	name	description	magnitude	toleranced_shape_aspect	GD&T Annotation
4	5584	GT1		0.02 (length_measure_with_unit 5585)	datum_feature 5583	⏥ | 0.02 ▽ | [A]

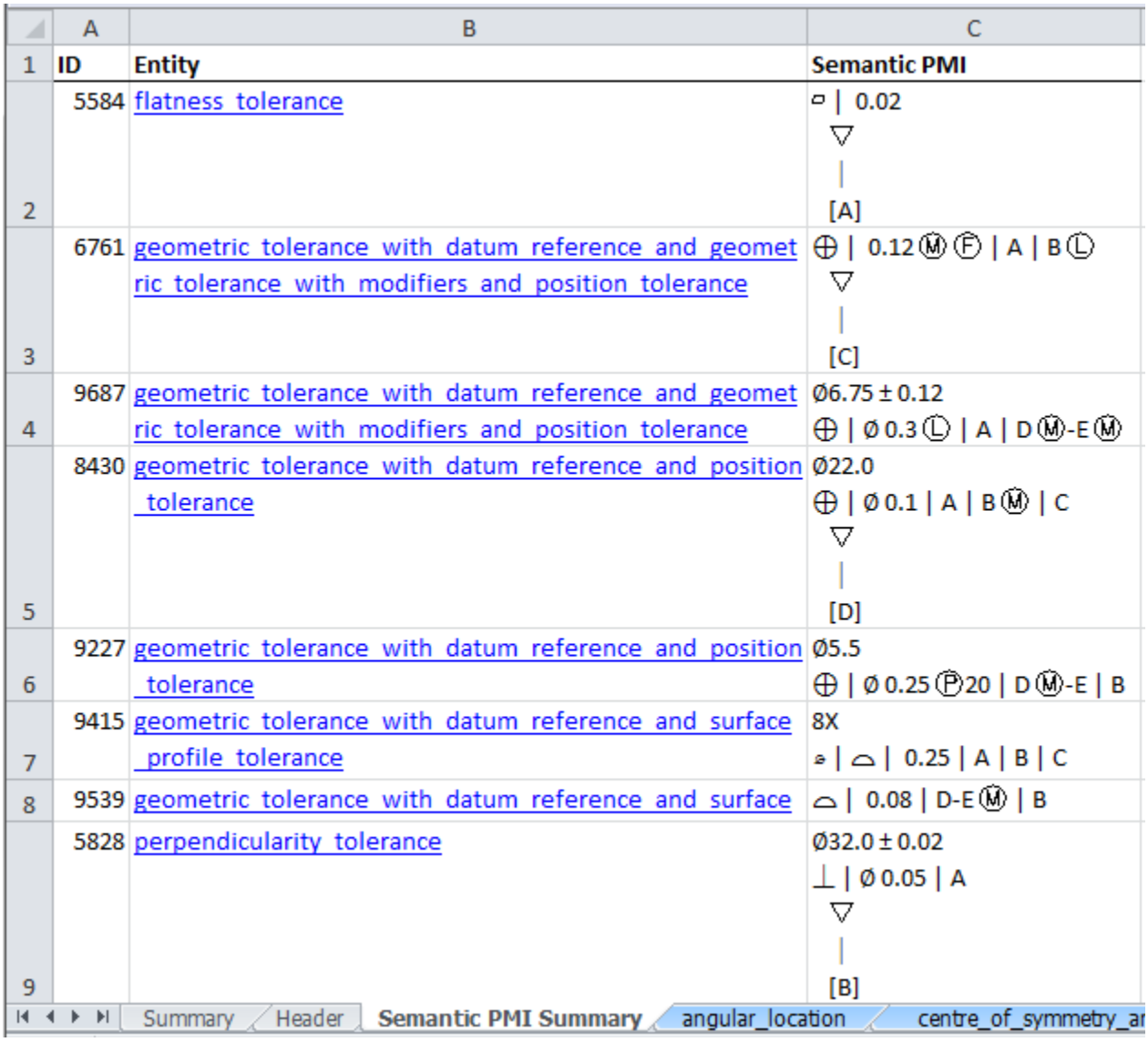
Figure 18: Semantic PMI example for a flatness tolerance with reference to a datum feature

Figure 19 shows the position_tolerance worksheet with the reconstructed visual presentations of two position tolerances. In the first line of cell H4, the position tolerance zone definition contains maximum material condition (M in the circle) and free-state (F in the circle) modifiers along with a datum reference frame with a least material condition (L in the circle) modifier. In cell H5, the associated dimensional tolerance in the first line is shown with the feature control frame in the second line. Cell I5 provides some diagnostic information to show the association between the geometric and dimensional tolerances.

	A	B	C	D	E	F	G	H	I
1	geometric_tolerance_with_datum_reference_and_geometric_tolerance_with_modifiers_and_position_tolerance (2)								
2	Doc							Semantic PMI Representation	
3	ID	name	description	magnitude	toleranced_shape_aspect	datum_system	modifiers	GD&T Annotation	Path to DimTol from toleranced_shape_aspect
4	6761	GT3		0.12 (length_measure_with_unit 7626)	centre_of_symmetry_and_datum_feature 6648	(1) datum_system 6498	maximum_material_requirement free_state	⌖ | 0.12 Ⓜ Ⓕ | A | B Ⓛ ▽ | [C]	
5	9687	GT9		0.3 (length_measure_with_unit 9688)	centre_of_symmetry 9686	(1) datum_system 9614	least_material_requirement	Ø6.75 ± 0.12 ⌖ | Ø 0.3 Ⓛ | A | D Ⓜ-E Ⓜ	<< shape_aspect_deriving_relationship 12237 > shape_aspect 9623 << dimensional_size 9624

Figure 19: Semantic PMI example for position tolerance with reference to datum feature and dimensional tolerance

As a convenience, all of the GD&T annotations in column H from worksheets similar to Figure 19 are collected on the Semantic PMI Summary worksheet. Figure 20 shows an example of the Semantic PMI Summary worksheet. The GD&T annotations in column H in Figure 19 are in rows 3 and 4 of Figure 20. The semantic PMI in column C corresponds to the PMI annotations in Figure 14.



	A	B	C
1	**ID**	**Entity**	**Semantic PMI**
2	5584	flatness_tolerance	▱ | 0.02 ▽ | [A]
3	6761	geometric_tolerance_with_datum_reference_and_geometric_tolerance_with_modifiers_and_position_tolerance	⌖ | 0.12 Ⓜ Ⓕ | A | B Ⓛ ▽ | [C]
4	9687	geometric_tolerance_with_datum_reference_and_geometric_tolerance_with_modifiers_and_position_tolerance	Ø6.75 ± 0.12 ⌖ | Ø 0.3 Ⓛ | A | D Ⓜ-E Ⓜ
5	8430	geometric_tolerance_with_datum_reference_and_position_tolerance	Ø22.0 ⌖ | Ø 0.1 | A | B Ⓜ | C ▽ | [D]
6	9227	geometric_tolerance_with_datum_reference_and_position_tolerance	Ø5.5 ⌖ | Ø 0.25 Ⓟ 20 | D Ⓜ-E | B
7	9415	geometric_tolerance_with_datum_reference_and_surface_profile_tolerance	8X ⌾ | ⌓ | 0.25 | A | B | C
8	9539	geometric_tolerance_with_datum_reference_and_surface	⌓ | 0.08 | D-E Ⓜ | B
9	5828	perpendicularity_tolerance	Ø32.0 ± 0.02 ⊥ | Ø 0.05 | A ▽ | [B]

Summary | Header | **Semantic PMI Summary** | angular_location | centre_of_symmetry_ar

Figure 20: Semantic PMI Summary worksheet

5.2.1.1 Limitations of Reconstructing the Visual Presentation of Semantic PMI

The reporting of semantic PMI representation in the spreadsheet is still under development at NIST and depends on updates to CAx-IF recommended practices. The results presented here might change with future versions of the software. The reconstruction of the visual presentation of semantic PMI might not correspond exactly to the modeled graphical PMI.

The semantic association of the datum feature with a geometric tolerance is based on each referring to the same geometric face in the STEP file. The graphical PMI for this annotation might show it as two separate annotations, the geometric tolerance and datum feature, each with leader lines to the same geometric face as shown in Figure 21. Leader lines are a graphical PMI element and there is no semantic representation of them in the STEP file. Therefore the semantic PMI shown in cells C2, C3, C5, and C9 in Figure 20 might actually appear graphically without the datum features attached to the feature control frame.

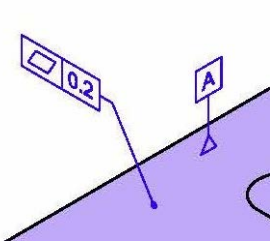


Figure 21: Flatness tolerance and datum feature

Cell C7 in Figure 20 contains the feature count modifier '8X'. This is not necessary for the reconstruction of the visual presentation because the all-around symbol (tiny circle with a bent line through it) is used in the feature control frame. The software errs on the side of showing a feature count modifier even though one might not appear in the graphical PMI. The feature count modifier is determined by counting how many geometric faces a tolerance is associated with.

Sometimes the software does not find an expected association between a dimensional tolerance and a geometric tolerance. The association is found by each tolerance referencing the same geometric face. In that case, the dimensional tolerance will not be displayed above the geometric tolerance.

5.2.2 Graphical PMI Presentation

Graphical PMI presents GD&T annotations as a visual representation of geometric elements such as lines and arcs as part of the CAD model, i.e., how the annotation is drawn on the model. Graphical PMI is not intended to be computer-interpretable and does not carry any semantic representation information although it can be linked to its corresponding semantic representation.

Figure 22 shows an example of how graphical PMI is reported in the spreadsheet. The report for graphical PMI only contains information about the graphical elements (points, lines, colors) needed to display graphical PMI annotations.

The information is always reported on the annotation_occurrence (as in this example) or annotation_curve_occurrence worksheets. Columns B, C, and D show the entity attributes. Columns E through I show the values associated with the graphical PMI.

- Column E shows the name attribute of the geometric_curve_set in column D.
- Column F shows the element attributes of the geometric_curve_set. In this case, the elements refer to polyline entities.
- Column G shows the cartesian_point entities that make up the polyline entities.
- Column H shows the curve_style associated with the presentation_style_assignment in column B.
- Column I shows the color associated with the curve_style in column H.
- Other columns not shown may contain saved views the annotation is associated with, PMI validation properties, and geometry entities that are associated with the annotation.

	A	B	C	D	E	F	G	H	I
1	annotation_occurrence (17)								
2	Doc								Graphical PMI Presentation
3	ID	name	styles	item	name	elements	points	presentation style	colour
4	7750	AE_DRIVEN_DIM0	(1) presentation_style_assignment 7749	geometric_curve_set 7747	diameter dimension	(47) polyline 7608 7611 7614 7617 7620 7623 7626 7629 7632 7635 7638 7641 7644 7647 7650 7653 7656 7659 7662 7665 7668 7671 7674 7677 7680 7683 7686 7689 7692 7695 7698 7701 7704 7707 7710 7713 7716 7719 7722 7725 7728 7731 7734 7737 7740 7743 7746	(1 of 2) cartesian_point 7606 (1 of 2) cartesian_point 7609 (1 of 2) cartesian_point 7612 (1 of 2) cartesian_point 7615 (1 of 2) cartesian_point 7618 (1 of 2) cartesian_point 7621	curve_style 7748	colour_rgb 1 (0.0 0.0 0.9411764705882)
5	9355	AE_DRIVEN_DIM1	(1) presentation_style_assignment 9354	geometric_curve_set 9352	linear dimension	(136) polyline	(1 of 2) cartesian_point 8944 (1 of 2) cartesian_point 8947 (1 of 2) cartesian_point 8950	curve_style 9353	colour_rgb 1 (0.0 0.0 0.9411764705882)
6	10706	AE_DRIVEN_DIM2	(1) presentation_style_assignment 10705	geometric_curve_set 10703	linear dimension	(100) polyline	(1 of 2) cartesian_point 10403 (1 of 2) cartesian_point 10406 (1 of 2) cartesian_point 10409	curve_style 10704	colour_rgb 1 (0.0 0.0 0.9411764705882)
7	11751	AE_DRIVEN_DIM3	(1) presentation_style_assignment 11750	geometric_curve_set 11748	linear dimension	(100) polyline	(1 of 2) cartesian_point 11448 (1 of 2) cartesian_point 11451 (1 of 2) cartesian_point 11454	curve_style 11749	colour_rgb 1 (0.0 0.0 0.9411764705882)
8	12898	AE_DRIVEN_DIM4	(1) presentation_style_assignment 12897	geometric_curve_set 12895	linear dimension	(134) polyline	(1 of 2) cartesian_point 12493 (1 of 2) cartesian_point 12496 (1 of 2) cartesian_point 12499	curve_style 12896	colour_rgb 1 (0.0 0.0 0.9411764705882)
9	14077	AE_DRIVEN_DIM4_1	(1) presentation_style_assignment 14076	geometric_curve_set 14074	linear dimension	(2) polyline 14070 14073	(1 of 2) cartesian_point 14068 (1 of 2) cartesian_point 14071	curve_style 14075	colour_rgb 11 (0.7607843137255 0.7607843137255 0.8)

Figure 22: Graphical PMI example (annotation_occurrence)

A VRML (Virtual Reality Modeling Language) file of the graphical PMI can also be generated. VRML is a standard file format for 3D models that can be displayed with VRML software or web browser plugins [20]. The VRML file only contains the line segments that make up the graphical PMI and not the part geometry to which it is applied. Figure 23 is a screenshot from a viewer of the VRML file generated from the graphical PMI. The PMI corresponds to some of annotations shown in Figure 14.

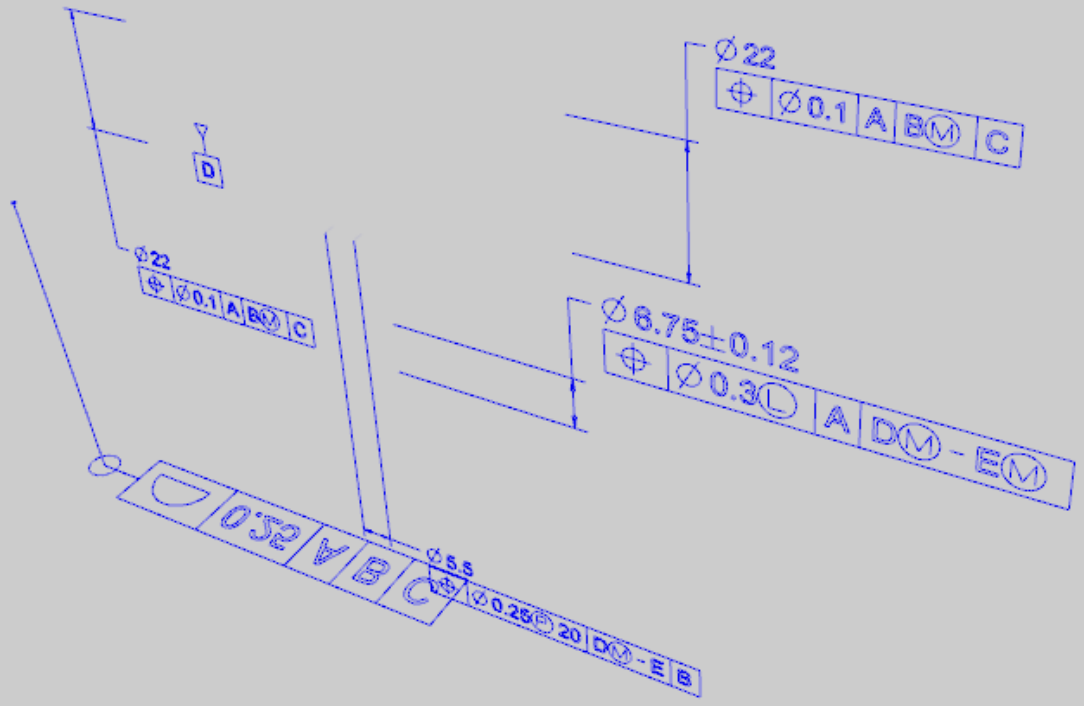


Figure 23: VRML generated from graphical PMI

5.2.3 Validation Properties

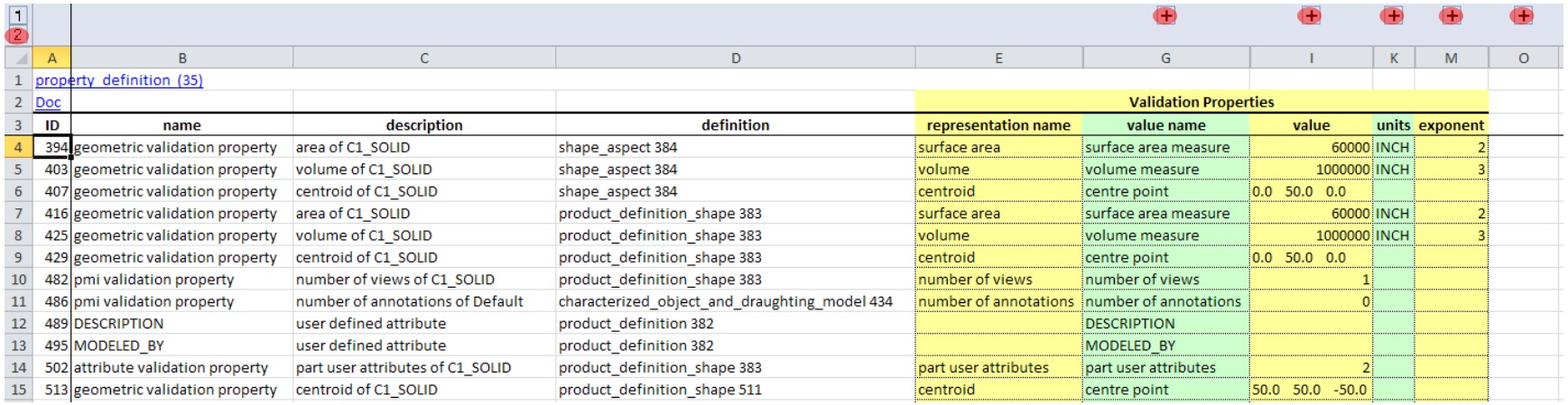
Validation properties are an important tool to verify the information in a STEP file [21]. For example, geometric validation properties are characteristics of solid and surface models, such as area, volume, and centroid. Geometric validation properties could be written to a STEP file when it is exported from a CAD system. When the STEP file is imported to a receiving CAD system, that system can compute the same validation properties and compare them to the values from the originating system in the STEP file. If the computed validation properties are within an agreed tolerance to the original validation properties, then the exchange of geometric information has been validated.

Figure 24 shows an example of a validation properties report. The report is always on the property_definition worksheet. The validation properties are shown in the yellow and green columns E, G, I, K, and M. Row 3 contains the names of the type of value in those columns. The values in cells I6, I9, and I15 are cartesian coordinates. Empty cells E12 and E13 indicate that values for those attributes were not specified in the STEP file. If no values for units and exponent appear in rows K and M, then none are required based on the type of value in row I.

To see the hidden columns F, H, J, L, and N, click on the plus (+) signs above the columns or the "2" in the upper left corner as highlighted in red in Figure 24. Those columns contain the entity attribute name and ID for the corresponding validation property value in the column to the left. Displaying the hidden columns shows where the validation property values come from in the STEP file.

The hidden columns F, H, J, and L are shown in Figure 25. Columns M and N are not shown. For example, the value in cell G4 "surface area measure" comes from the measure_representation_item name attribute of entity ID 393. The expanded columns can be hidden again by clicking on the minus (-) signs above the columns or the "1" in the upper left corner.

Figure 26 shows more examples of geometric, PMI, and tessellated validation properties

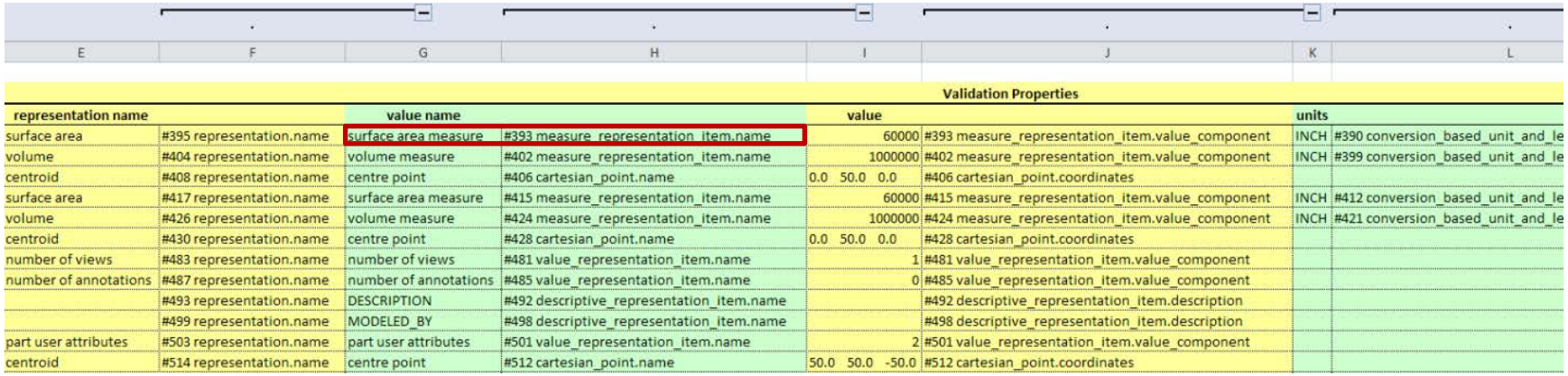


property_definition (35)

Doc

				Validation Properties				
ID	name	description	definition	representation name	value name	value	units	exponent
394	geometric validation property	area of C1_SOLID	shape_aspect 384	surface area	surface area measure	60000	INCH	2
403	geometric validation property	volume of C1_SOLID	shape_aspect 384	volume	volume measure	1000000	INCH	3
407	geometric validation property	centroid of C1_SOLID	shape_aspect 384	centroid	centre point	0.0 50.0 0.0		
416	geometric validation property	area of C1_SOLID	product_definition_shape 383	surface area	surface area measure	60000	INCH	2
425	geometric validation property	volume of C1_SOLID	product_definition_shape 383	volume	volume measure	1000000	INCH	3
429	geometric validation property	centroid of C1_SOLID	product_definition_shape 383	centroid	centre point	0.0 50.0 0.0		
482	pmi validation property	number of views of C1_SOLID	product_definition_shape 383	number of views	number of views	1		
486	pmi validation property	number of annotations of Default	characterized_object_and_draughting_model 434	number of annotations	number of annotations	0		
489	DESCRIPTION	user defined attribute	product_definition 382		DESCRIPTION			
495	MODELED_BY	user defined attribute	product_definition 382		MODELED_BY			
502	attribute validation property	part user attributes of C1_SOLID	product_definition_shape 383	part user attributes	part user attributes	2		
513	geometric validation property	centroid of C1_SOLID	product_definition_shape 511	centroid	centre point	50.0 50.0 -50.0		

Figure 24: Validation properties example (property_definition)



				Validation Properties				
representation name		value name		value			units	
surface area	#395 representation.name	surface area measure	#393 measure_representation_item.name	60000	#393 measure_representation_item.value_component		INCH	#390 conversion_based_unit_and_le
volume	#404 representation.name	volume measure	#402 measure_representation_item.name	1000000	#402 measure_representation_item.value_component		INCH	#399 conversion_based_unit_and_le
centroid	#408 representation.name	centre point	#406 cartesian_point.name	0.0 50.0 0.0	#406 cartesian_point.coordinates			
surface area	#417 representation.name	surface area measure	#415 measure_representation_item.name	60000	#415 measure_representation_item.value_component		INCH	#412 conversion_based_unit_and_le
volume	#426 representation.name	volume measure	#424 measure_representation_item.name	1000000	#424 measure_representation_item.value_component		INCH	#421 conversion_based_unit_and_le
centroid	#430 representation.name	centre point	#428 cartesian_point.name	0.0 50.0 0.0	#428 cartesian_point.coordinates			
number of views	#483 representation.name	number of views	#481 value_representation_item.name	1	#481 value_representation_item.value_component			
number of annotations	#487 representation.name	number of annotations	#485 value_representation_item.name	0	#485 value_representation_item.value_component			
	#493 representation.name	DESCRIPTION	#492 descriptive_representation_item.name		#492 descriptive_representation_item.description			
	#499 representation.name	MODELED_BY	#498 descriptive_representation_item.name		#498 descriptive_representation_item.description			
part user attributes	#503 representation.name	part user attributes	#501 value_representation_item.name	2	#501 value_representation_item.value_component			
centroid	#514 representation.name	centre point	#512 cartesian_point.name	50.0 50.0 -50.0	#512 cartesian_point.coordinates			

Figure 25: Validation properties example with expanded columns

property_definition (100 of 4355)

Doc

ID	name	description	definition	Validation Properties				
				representation name	value name	value	units	exponent
137705	geometric validation property	Main:t2:::0	product_definition_shape 43	volume	volume measure	105.1380679	INCH	3
137721	geometric validation property	Main:t2:::0	product_definition_shape 43	centroid	centre point	-0.454667976545899 0.53787536491866 0.023995198699849		
137725	geometric validation property	Main:t2:::0	product_definition_shape 43	surface area	surface area measure	1728.486057	INCH	2
137745	geometric validation property	volume of solid	shape_aspect 137741	volume	volume	105.1409553	INCH	3
137759	geometric validation property		shape_aspect 137755	smooth sampling points (5 of 5)	(1) sampling point	10.113988020620653 1.006420893615678 4.293254962336012		
					(2) sampling point	10.11396612461185 1.009631340423488 4.293306546100149		
					(3) sampling point	10.113944228603046 1.012841787231298 4.293358129864288		
					(4) sampling point	10.111001407560927 1.008026117019583 4.292017659340621		
					(5) sampling point	10.108036690510007 1.006420893615678 4.290728772581091		

property_definition (48)

Doc

ID	name	description	definition	Validation Properties			
				representation name	value name	value	units
11982	pmi validation property	centroid of AE_SYMBOL0	characterized_item_within_representation 11980	centroid	polyline curve centroid	69.51632922137 -2.698673248291 17.55111653224	
11987	pmi validation property	polyline curve length of AE_SYMBOL0	characterized_item_within_representation 11980	polyline curve length	polyline curve length	79.20645849	millimetre
12233	pmi validation property	centroid of AE_SYMBOL0	characterized_item_within_representation 12231	centroid	polyline curve centroid	59.26289617798 -2.698673248291 14.60382417057	
12238	pmi validation property	polyline curve length of AE_SYMBOL0	characterized_item_within_representation 12231	polyline curve length	polyline curve length	42.47388876	millimetre
15428	pmi validation property	centroid of AE_SYMBOL1	characterized_item_within_representation 15426	centroid	polyline curve centroid	-65.00318182046 -8.80285358429 24.20145145342	
15433	pmi validation property	polyline curve length of AE_SYMBOL1	characterized_item_within_representation 15426	polyline curve length	polyline curve length	75.99734158	millimetre
15780	pmi validation property	centroid of AE_SYMBOL1	characterized_item_within_representation 15778	centroid	polyline curve centroid	-59.21002034139 -8.80285358429 20.18248899104	
15785	pmi validation property	polyline curve length of AE_SYMBOL1	characterized_item_within_representation 15778	polyline curve length	polyline curve length	44.68662937	millimetre
15793	pmi validation property	number of annotations of R29J_SP3_CREO	product_definition_shape 7537	number of annotations	number of annotations	24	

property_definition (70)

Doc

ID	name	description	definition	Validation Properties				
				representation name	value name	value	units	exponent
176	tessellated validation property	centroid	shape_aspect 170	centroid	centre point	-186.917057986 80.2823927006 0.00143892067884		
182	tessellated validation property	surface area	shape_aspect 170	surface area	surface area measure	22999.10105	millimetre	2
186	tessellated validation property	number of facets	shape_aspect 170	number of facets	number of facets	174		
190	tessellated validation property	number of facets	product_definition_shape 38	number of facets	number of facets	174		
194	tessellated validation property	surface area	product_definition_shape 38	surface area	surface area measure	22999.10105	millimetre	2
198	tessellated validation property	centroid	product_definition_shape 38	centroid	centre point	-186.917057986 80.2823927006 0.00143892067884		

Figure 26: More validation property examples

5.3 Inverse Relationships and Used In

In a STEP schema, an entity attribute whose value consists of entity references, in which the referenced entity has attributes referring to the referencing attribute's entity is called an inverse attribute. This establishes an inverse relationship [22]. Inverse relationships are explicitly defined in a STEP schema and reporting of some of those relationships has been implemented in the STEP File Analyzer.

For example, Figure 27 is an entity worksheet for shape_aspect_relationship that shows the relationship established between the attribute values for relating_shape_aspect and related_shape_aspect in columns D and E.

	A	B	C	D	E
1	shape	aspect	relationship	(7)	
2	Doc				
3	**ID**	**name**	**description**	**relating_shape_aspect**	**related_shape_aspect**
13	12256			datum_feature 5583	datum 5618
14	12257			centre_of_symmetry_and_datum_feature 5827	datum 5932
15	12258			centre_of_symmetry_and_datum_feature 6648	datum 6650
16	12259			centre_of_symmetry_and_datum_feature 8319	datum 8320
17	12260			centre_of_symmetry_and_datum_feature 8829	datum 8935
18	12261			placed_datum_target_feature 9908	datum 9907
19	12262			placed_datum_target_feature 9953	datum 9907

Figure 27: Entity worksheet (shape_aspect_relationship)

Figure 28 shows the inverse relationship, in column G, between datum and other entities as established by shape_aspect_relationship. Column H, with the Used In header, shows where `datum` is referred to from other entity attributes although not by an inverse relationship established by a STEP schema. The tooltip in the Options tab for the Inverse Relationships selection will show the list of Inverse and Used In relationships that are processed.

	A	B	C	D	E	F	G	H
1	datum (6)							
2	Doc							
3	**ID**	**name**	**description**	**of_shape**	**product_definitional**	**identification**	**INV-relating_shape_aspect**	**Used In**
4	5351			product_definition_shape 37	FALSE	A	(1) datum_feature 5350	(5) datum_reference_compartment.base 5848 8010 9929 10494 10875
5	5473			product_definition_shape 37	FALSE	B	(1) dimensional_size_with_datum_feature 5472	(5) datum_reference_compartment.base 8011 10196 10371 10495 10876
6	6432			product_definition_shape 37	FALSE	C	(1) dimensional_location_with_datum_feature 6431	(2) datum_reference_compartment.base 8012 10496
7	7868			product_definition_shape 37	FALSE	D	(1) dimensional_size_with_datum_feature 7622	(3) datum_reference_element.base 9931 10194 10369
8	9211			product_definition_shape 37	FALSE	E	(1) dimensional_size_with_datum_feature 9049	(3) datum_reference_element.base 9932 10195 10370
9	11191			product_definition_shape 37	FALSE	F	(2) placed_datum_target_feature 10709 10754	

Figure 28: Inverse Relationships and Used In example

5.4 Display a STEP File in Other Applications

The “Display STEP File in” option is a convenient way to display a STEP file in other applications. Figure 29 shows the pull-down menu, listing some of the applications that can display a STEP file on the author’s computer. The Notepad or WordPad text editors will always appear in the menu, along with the option to “Indent STEP File (for debugging)” which is described in section 5.4.1. In this example, several STEP file viewers and conformance checkers also appear in the pull-down menu. Applications will appear in the pull-down menu if they are installed in their default location. To display a STEP file in one of the applications, select the application from the pull-down menu and click the Display button.

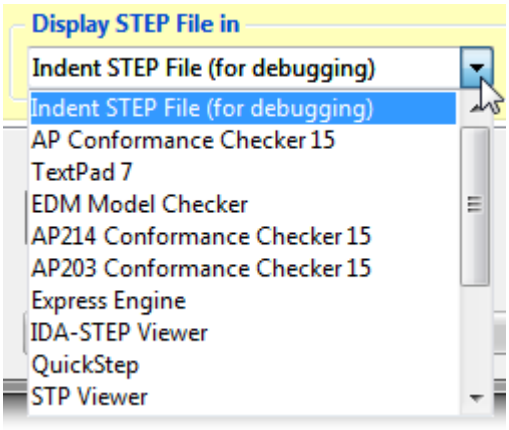


Figure 29: Display STEP File in Other Applications

5.4.1 Indent STEP File

The option to “Indent STEP File” will display the STEP file in a text editor, however, the STEP entities will be rearranged and indented to show the hierarchy of information in the STEP file. This is a useful feature to help debug a STEP file, but is not recommended for large STEP files. Figure 30 shows a sample of the “indented” output. In this sample, it is easy to see how flatness_tolerance (#5584) refers to length_measure_with_unit (#5585) and datum_feature (#5583). An “indented” portion of the STEP file starts with entities that will generate useful output and stops with other entities to prevent the “indented” file from getting too large. Basic geometric entities such as cartesian_point and direction are usually not included in the “indented” file.

```
#5584=FLATNESS_TOLERANCE('GT1',$,#5585,#5583);
  #5585=LENGTH_MEASURE_WITH_UNIT(LENGTH_MEASURE(0.02),#24);
    #24=(LENGTH_UNIT()NAMED_UNIT(*)SI_UNIT(.MILLI.,.METRE.));
  #5583=DATUM_FEATURE('F116',$,#37,.T.);
    #37=PRODUCT_DEFINITION_SHAPE('None','None',#36);
      #36=PRODUCT_DEFINITION('None','None',#34,#35);
        #34=PRODUCT_DEFINITION_FORMATION('','None',#32);
          #32=PRODUCT('GDT_Test_Part_2011_1-id','','None',(#12273));
            #12273=PRODUCT_CONTEXT('part',#29,'');
              #29=APPLICATION_CONTEXT('automotive design');
        #35=PRODUCT_DEFINITION_CONTEXT('part definition',#29,'design');
```

Figure 30: Indented STEP file

6 Spreadsheet Tab

The Spreadsheet tab, shown in Figure 31, contains several more options that affect how information is written to the spreadsheet.

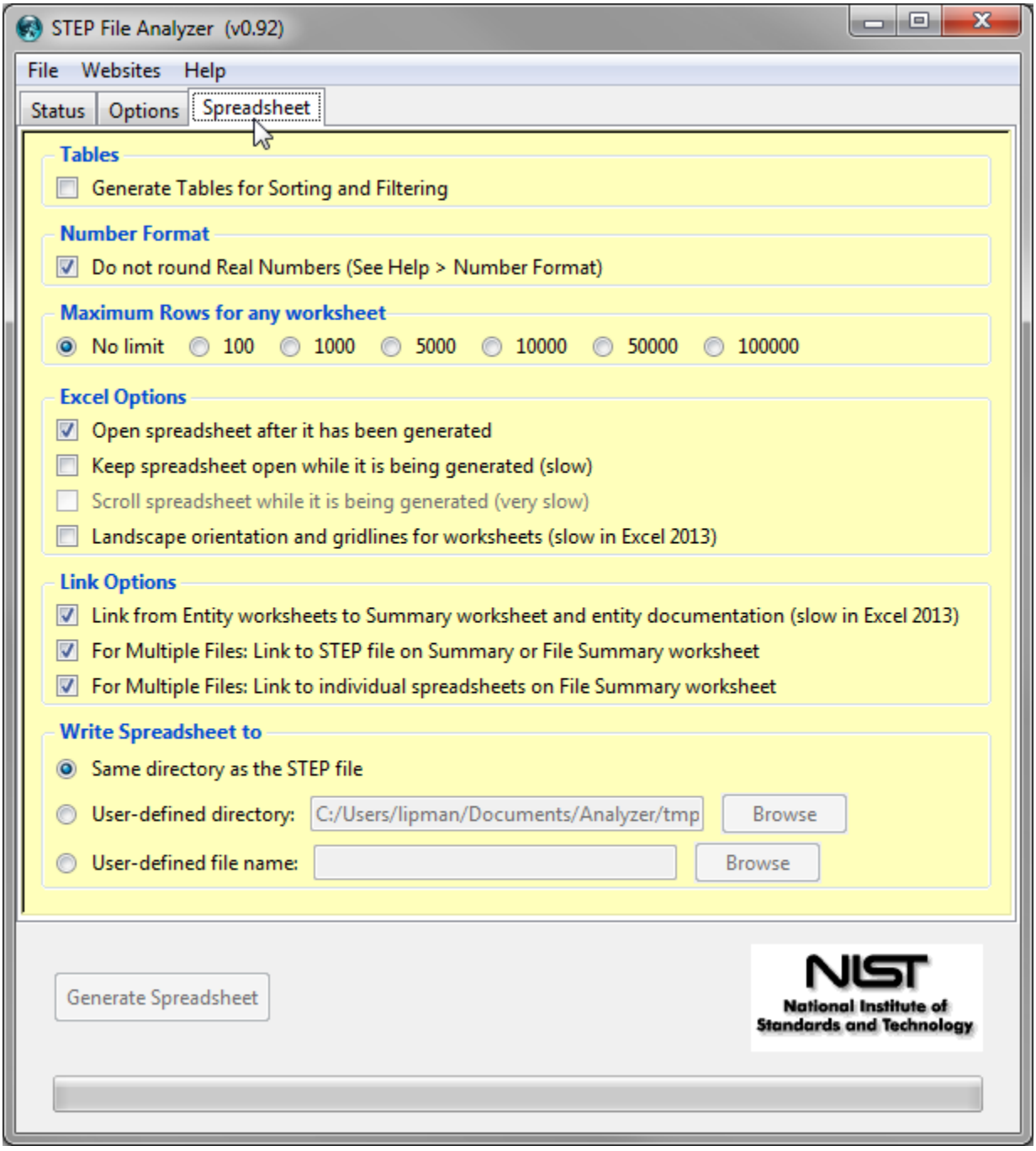


Figure 31: Spreadsheet tab

6.1 Generating Tables

Similar to Figure 27, Figure 32 shows the shape_aspect_relationship worksheet with the option for generating tables turned on. With this option, pull-down menus (selector on the right of each cell in row 3) are displayed with the column headers in row 3 that access functions to sort and filter the rows.

	A	B	C	D	E
1	shape	aspect relationship (7)			
2	Doc				
3	ID	nam	descriptio	relating_shape_aspect	related_shape_aspec
4	12256			datum_feature 5583	datum 5618
5	12257			centre_of_symmetry_and_datum_feature 5827	datum 5932
6	12258			centre_of_symmetry_and_datum_feature 6648	datum 6650
7	12259			centre_of_symmetry_and_datum_feature 8319	datum 8320
8	12260			centre_of_symmetry_and_datum_feature 8829	datum 8935
9	12261			placed_datum_target_feature 9908	datum 9907
10	12262			placed_datum_target_feature 9953	datum 9907

Figure 32: Entity worksheet (shape_aspect_relationship) with tables

6.2 Rounding Numbers

By default, when the STEP File Analyzer adds a single real number to a worksheet cell, Excel might round the number. Figure 33, on the left, shows values of radius in column D that are rounded. Using the Number Format option in the Spreadsheet tab to not round real numbers, results in the radius values displayed with full precision in the worksheet on the right. The non-rounded real numbers are the actual values that appear in a STEP file. The non-rounded real numbers are indicated by the small green triangle in the upper left corner of a cell. The non-rounded real numbers are also left justified as opposed to the rounded real numbers that are right-justified. Real numbers that appear in pairs or triplets, such as cartesian points, are never rounded.

	A	B	C	D
1	circle (146)			
2	Doc			
3	ID	name	position	radius
4	86		axis2_placement_3d 85	3
5	103		axis2_placement_3d 102	3
6	128		axis2_placement_3d 127	3
7	145		axis2_placement_3d 144	3
8	170		axis2_placement_3d 169	3
9	187		axis2_placement_3d 186	3
10	212		axis2_placement_3d 211	3
11	229		axis2_placement_3d 228	3
12	358		axis2_placement_3d 357	3.375
13	388		axis2_placement_3d 387	3.375

	A	B	C	D
1	circle (146)			
2	Doc			
3	ID	name	position	radius
4	86		axis2_placement_3d 85	2.999999999999695
5	103		axis2_placement_3d 102	2.999999999999695
6	128		axis2_placement_3d 127	2.999999999999792
7	145		axis2_placement_3d 144	2.999999999999792
8	170		axis2_placement_3d 169	2.999999999999695
9	187		axis2_placement_3d 186	2.999999999999695
10	212		axis2_placement_3d 211	2.999999999999803
11	229		axis2_placement_3d 228	2.999999999999803
12	358		axis2_placement_3d 357	3.375
13	388		axis2_placement_3d 387	3.375

Figure 33: Circle entity worksheet, with rounding (left) and without rounding (right)

6.3 Maximum Rows

The maximum rows option in the Spreadsheet tab limits the maximum numbers of rows in any spreadsheet to the selected value. This is a way to reduce the size of the spreadsheet and speed processing of the STEP file. Figure 34 is an example where only the first 100 of 43681 rows for the cartesian_point entities are written to the worksheet.

	A	B	C
1	cartesian_point (100 of 43681)		
2	Doc		
3	**ID**	**name**	**coordinates**
4	18	#18	-0.9881 1.634176638 18.017717023
5	20	#20	-0.9881 1.547763978 17.548888756
6	22	#22	-0.892674976425 1.568442637 17.469469568
7	24	#24	-0.247174976425 1.828113272 17.582158424
8	26	#26	-0.1846 1.864882875 17.656001817
9	28	#28	-0.1846 1.961858223 18.18213751
10	30	#30	0.3089 2.140780414 18.161940186

Figure 34: Maximum rows example (cartesian_point)

6.4 Other Options

The other options on the Spreadsheet tab control:

- opening the spreadsheet after or while it is being generated
- setting landscape orientation and gridlines for the worksheets
- generating links from entity worksheets to the Summary worksheet and entity documentation
- generating links on the File Summary worksheet when multiple STEP files are processed
- specifying where to write the spreadsheet

7 Processing Multiple STEP Files

The capability to process multiple STEP files at once is an easy way to process many STEP files with only a few mouse clicks and to compare entity usage across multiple STEP files.

There are two ways to select multiple STEP files. The first is to use the "Open Multiple STEP Files in a Directory" option from the File menu as shown in Figure 4. The user can select a directory in which all STEP files in that directory will be processed. Subdirectories of the selected directory can also be searched. The other way is to select multiple individual STEP files when using the "Open STEP File(s)" option from the File menu. Multiple STEP files can be selected in the Open File(s) dialog by holding down the control or shift key when selecting files.

7.1 Summary Worksheet

When processing multiple STEP files a second spreadsheet is generated, in addition to the individual spreadsheets for each STEP file. The second spreadsheet is a summary of the entities found in the multiple files as shown in Figure 35. In this example five STEP files were processed. Starting with row 10, column A lists all of the entity types in all five files with links to entity documentation. The entities in column A are grouped and colored according to the categories of entities in the Process section of the Options tab as described in section 5.1. Columns B through F contain the entity counts for each of the five STEP files. Column G is the total entity count for all of the files and column H is the total number of files that an entity appears in.

Row 1 is the top-level directory where all of the STEP files are located. Row 3 contains links to the individual spreadsheets. Row 4 contains the name of the STEP file and a link to it. The file name can also contain the file's subdirectory. Clicking on the STEP file link will display it in whatever program is registered to display STEP files on the user's computer. The links in rows 3 and 4 can be turned off in the Spreadsheet tab with the selections for Link Options. Rows 5 through 9 contain, respectively, the file timestamp, software that generated the STEP file, the STEP AP from the file, the size of the STEP file, and the number of entities in the STEP file.

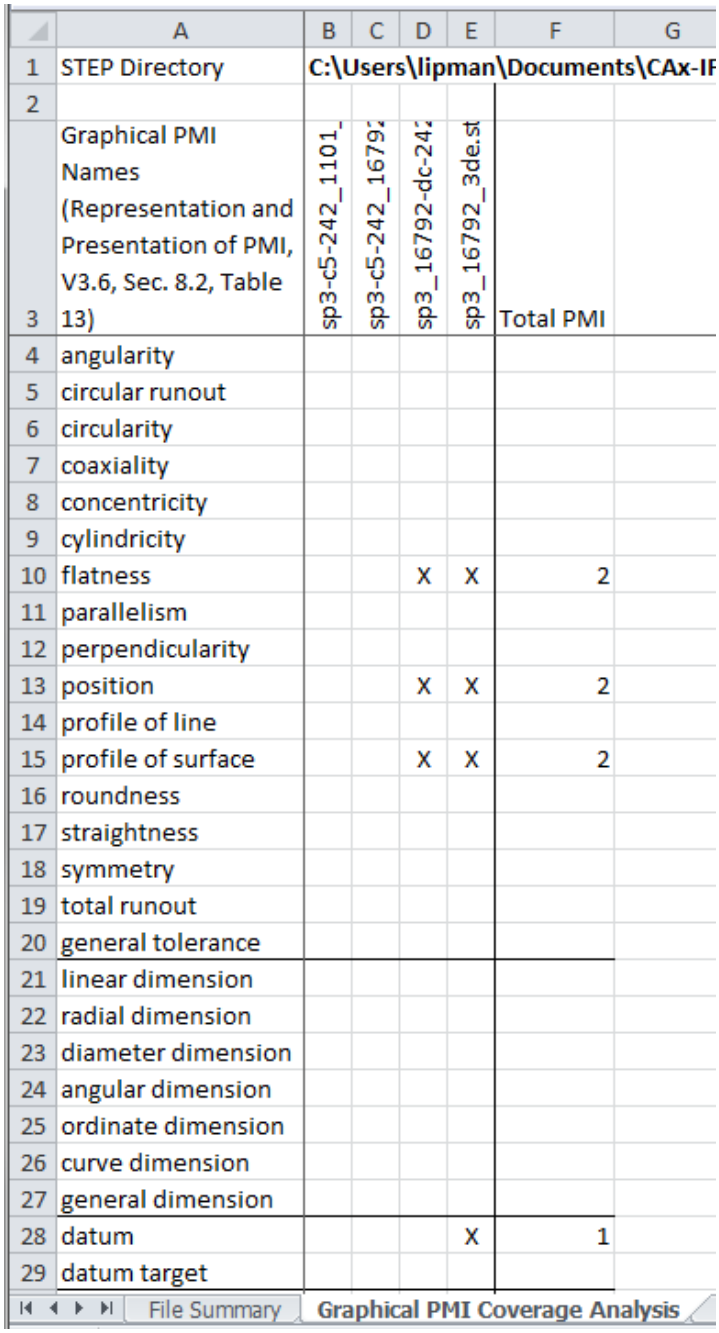
	A	B	C	D	E	F	G
1	STEP Directory	C:\Users\lipman\Documents\CAx-IF\Semantic\Curre					
2							
3		Link (1)	Link (2)	Link (3)	Link (4)		
4		sp3-c5-242_1101_v1.stp	sp3-c5-242_16792.stp	sp3_16792-dc-242-V2.stp	sp3_16792_de.stp		
5			13-09-10	13-09-13	13-09-17		
6		CATIA V5	CATIA V5	Datakit CrossCad	CT		
7		AP242	AP242	AP242	AP242		
8		743 Kb	186 Kb	82 Kb	168 Kb		
9	Entity	9972	2187	1633	2582	Total Entities	Total Files
10	complex_triangulated_surface_set	76	22			98	2
11	coordinates_list	302	135			437	2
12	(over_riding_styled_item) (tessellated_annotation_occurrence)	1				1	1
13	(repositioned_tessellated_item) (tessellated_geometric_set)	25	11			36	2
14	tessellated_annotation_occurrence	24	11			35	2
15	tessellated_curve_set	226	113			339	2
16	angular_location	1				1	1
17	(composite_shape_aspect) (datum_feature)			1		1	1
18	datum	6	2	2	2	12	4
19	datum_feature	6	2	1	2	11	4
20	datum_reference_compartment	19	4	5	5	33	4
21	datum_reference_element	8				8	1
22	datum_system	9	3	4	2	18	4
23	dimensional_characteristic_representation	7	3	3		13	3
24	dimensional_location	1	1			2	2
25	dimensional_size	5	2	3		10	3
26	flatness_tolerance	1	1	1	1	4	4

File Summary | Graphical PMI Coverage Analysis | Semantic PMI Coverage Analysis

Figure 35: File Summary worksheet when processing multiple STEP files

7.2 Coverage Analysis Worksheets

Coverage analysis worksheets for graphical and semantic PMI are generated when multiple STEP files are processed. Figure 36 shows the worksheet that is generated for coverage analysis of graphical PMI. Column A in rows 4 through 29 are the names of the types of graphical PMI that are related to tolerances, dimensions, and datums. The names are from a table in the CAx-IF recommended practice for the presentation of PMI [23]. Columns B through E refer to four STEP files. When there is an 'X' in those columns, then that file contains graphical PMI with that name. Column F counts the total number of STEP files that contain that type of graphical PMI.



	A	B	C	D	E	F	G
1	STEP Directory	C:\Users\lipman\Documents\CAx-IF					
2							
3	Graphical PMI Names (Representation and Presentation of PMI, V3.6, Sec. 8.2, Table 13)	sp3-c5-242_1101_	sp3-c5-242_1679	sp3_16792-dc-242	sp3_16792_3de.st	Total PMI	
4	angularity						
5	circular runout						
6	circularity						
7	coaxiality						
8	concentricity						
9	cylindricity						
10	flatness			X	X	2	
11	parallelism						
12	perpendicularity						
13	position			X	X	2	
14	profile of line						
15	profile of surface			X	X	2	
16	roundness						
17	straightness						
18	symmetry						
19	total runout						
20	general tolerance						
21	linear dimension						
22	radial dimension						
23	diameter dimension						
24	angular dimension						
25	ordinate dimension						
26	curve dimension						
27	general dimension						
28	datum				X	1	
29	datum target						

File Summary | Graphical PMI Coverage Analysis

Figure 36: Graphical PMI Coverage Analysis worksheet

Figure 37 shows the worksheet that is generated for coverage analysis of semantic PMI. Column A in rows 4 through 36 contain different types of GD&T related to geometric and dimensional tolerances. Rows 37 through 117 are not shown and contain more types of GD&T and associated modifiers. The numbers in parentheses refer to the sections in the CAx-IF recommended practice for the representation of PMI [23] where there is implementation guidance for that type of GD&T. Columns B through E refer to four STEP files and contain the number of occurrences of that type of GD&T in the file. Column F counts the total number of occurrences for all STEP files that contain that type of GD&T. Counting the number of occurrences of a type of GD&T is useful when comparing STEP files generated by different CAD systems of the same model with the same GD&T.

	A	B	C	D	E	F
1	STEP Directory	C:\Users\lipman\Document				
2						
3	Semantic PMI	sp3-c5-242_	sp3-c5-242_	sp3_16792-	sp3_16792_	Total PMI
4	angularity_tolerance ∠					
5	circular_runout_tolerance ↗					
6	coaxiality_tolerance ◎					
7	concentricity_tolerance ◎					
8	cylindricity_tolerance ⌭					
9	flatness_tolerance ▱	1	1	1	1	4
10	line_profile_tolerance ⌒					
11	parallelism_tolerance //					
12	perpendicularity_tolerance ⊥	1				1
13	position_tolerance ⌖	5	1	2	2	10
14	roundness_tolerance ○					
15	straightness_tolerance -					
16	surface_profile_tolerance ⌓	2	2	2	2	8
17	symmetry_tolerance ⌯					
18	total_runout_tolerance ⌰					
19	dimensional location (5.1.1)	1	1			2
20	angular location (5.1.2)	1				1
21	dimensional size (5.1.5)	5	2	3		10
22	curve length					
23	diameter Ø	5	2	2		9
24	radius R			1		1
25	basic dimension (5.3)					
26	reference dimension (5.3)					
27	dimension modifier (5.3)					
28	plusminus - equal (5.2.3)	4	2	1		7
29	plusminus - unequal (5.2.3)		1			1
30	value range (5.2.4)			2		2
31	type qualifier (5.2.2)					
32	tolerance class (5.2.5)					
33	datum (6.5)	6	2	2	2	12
34	placed datum target (6.6)					
35	multiple datum features (6.9.8)	4				4
36	tolerance zone (6.9.2)	9	4	2	4	19

Figure 37: Semantic PMI Coverage Analysis worksheet

8 Crash Recovery

As explained in section 2.4, sometimes the STEP File Analyzer will crash when processing a STEP file. This is most likey due to either syntax errors in the STEP file or due to limitations of the IFCsvr toolkit (section 2.2.1). If a crash occurs, one or more of the dialogs in Figure 38 might be displayed in Windows 7. If this happens, simply close the dialog(s), restart the software, and process the same STEP file again by using function key F1 or F4 if processing multiple files. The software keeps track of which entity type caused the crash for a particular STEP file and won't process that type again. A message will be displayed in the Status tab if a particular type of entity won't be processed.

The entity types that won't be processed again are stored in a file *_fix.dat where '*' is the name of the STEP file. No matter what the reason is for the crash, that file will always be generated. Even if the user stops the STEP File Analyzer in the middle of processing a STEP file, the file *_fix.dat will be generated. Therefore, the next time the software is run, the entity type that was being processed when the user stopped the software will not be processed. In this case, or if the syntax errors related to the bad entity are corrected, the *_fix.dat file can be deleted or edited.

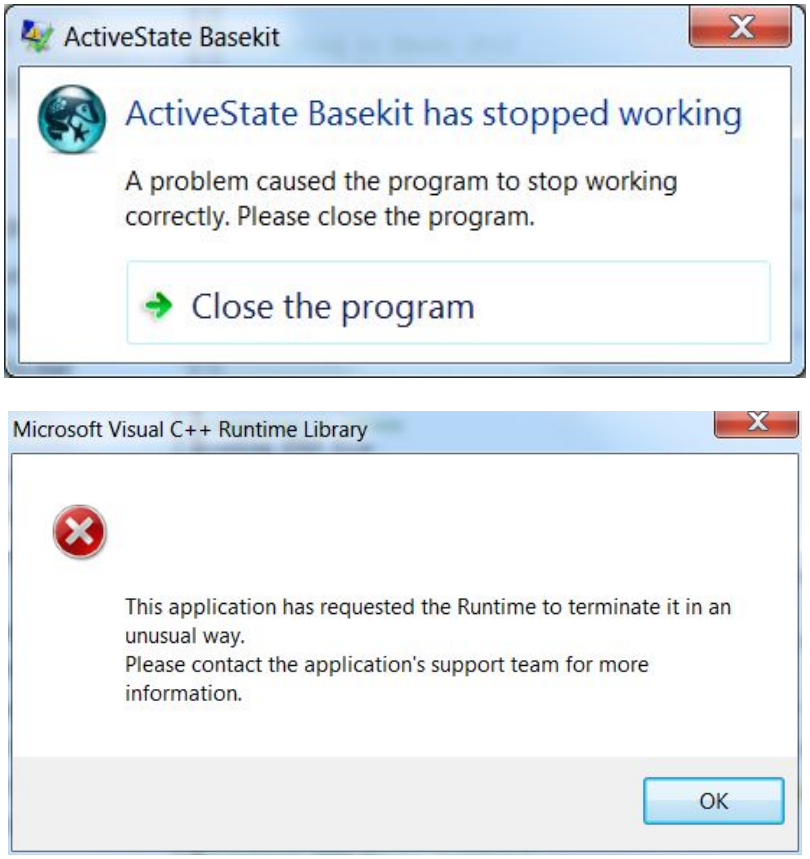


Figure 38: Dialogs that might be displayed when the STEP File Analyzer crashes

If the STEP File Analyzer crashes, the user can also see which entity type caused the crash. Figure 39 shows that the software crashed when processing an annotation_plane entity. Another way to prevent that entity type from being processed is to deselect, in the Process section of the Options tab, the category of entity that contains the entity that caused the crash. That will prevent that entity from being processed along with all other entities of that category.

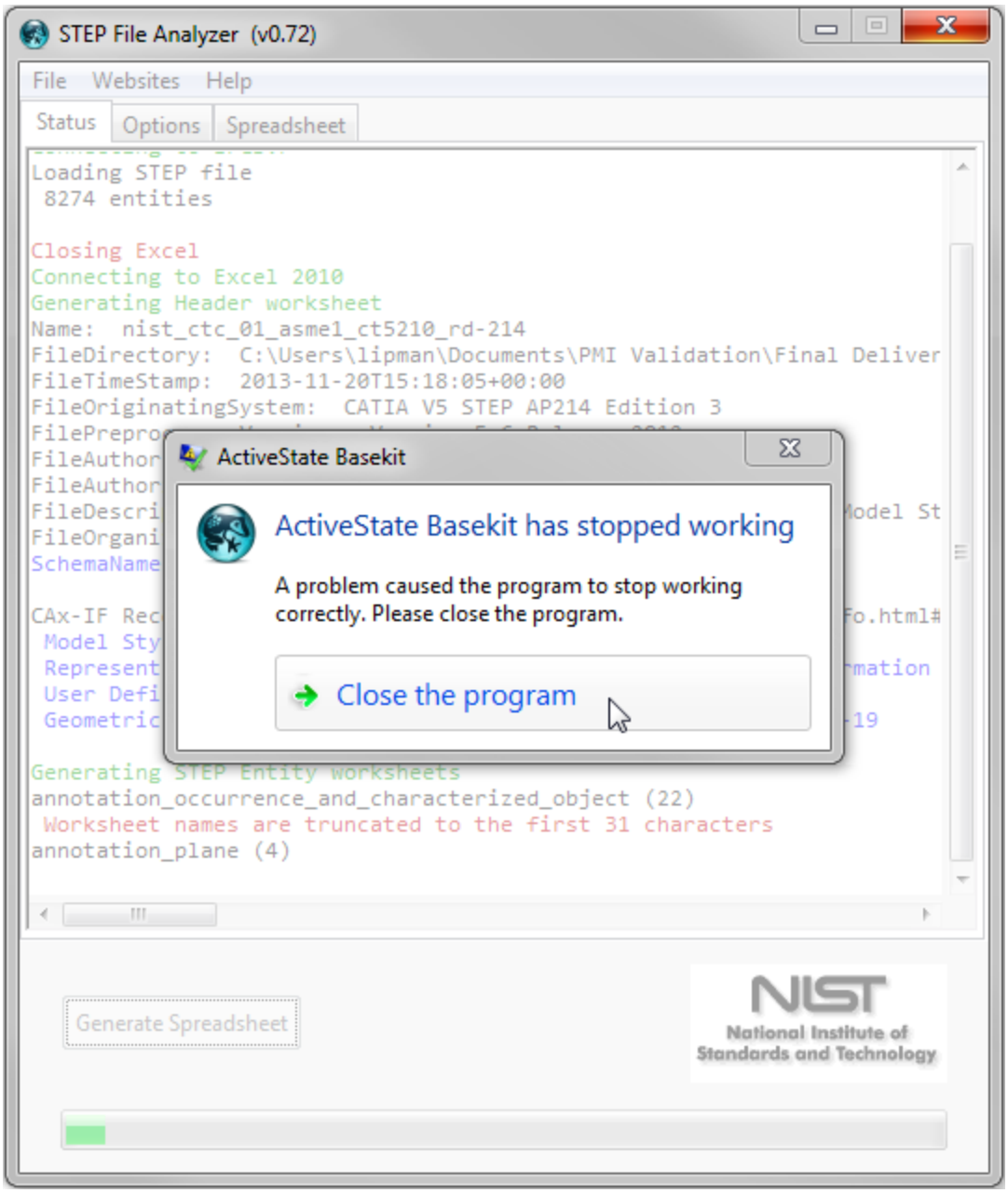


Figure 39: Determining which entity in the STEP File Analyzer caused a crash

9 Command-line Version

A command-line (console) version of the STEP File Analyzer is available.
`STEP-File-Analyzer-CL.exe` can be run from a Windows command prompt by going to the Windows start menu, selecting Run, and entering "cmd". This will open up the command prompt window. To run the command-line version, change to the directory where the program is located. Then enter the name of the program and the name of the STEP file to translate as shown in Figure 40.

To facilitate running the command-line version, the PATH environment variable can be set to include the directory where the command-line executables are located. A batch file can also be created to run the command-line executable. If the STEP file is not located in the same directory as the command-line executable, then the STEP file name should also include the directory pathname for the file.

Entering the name of the program without a STEP file name will display the command-line options. The program will use whatever options were last used when the GUI version was run.

When the command-line version is run, feedback is provided that is similar to what is displayed in the Status tab (section 3.3) as shown in Figure 40.

Figure 40: Feedback when running the command-line version

10 References

All websites were successfully accessed in April 2014.

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