Update for PLM Seed Grant and Associated Work

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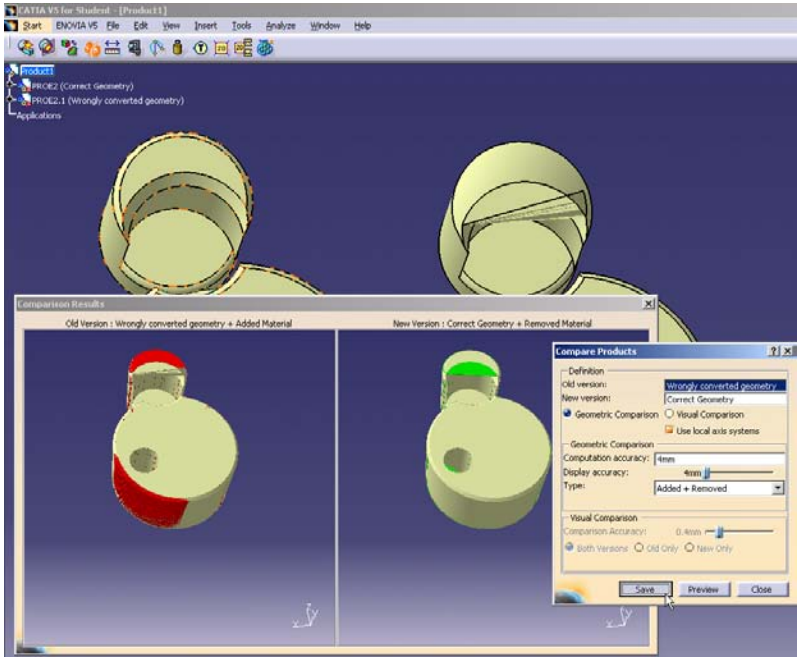
Original Project Objectives

- A case study to identify geometric traits within CAD data that cause errors when moving from one CAD system to another or from one version of a system to a later version of that same system.
- Articulating methods for creating geometry that would minimize the aforementioned errors.
- Investigating techniques for maintaining design intent within neutral file formats.
- Studying the methods by which current neutral file formats maintain design history and constraint schemes within the geometric database.

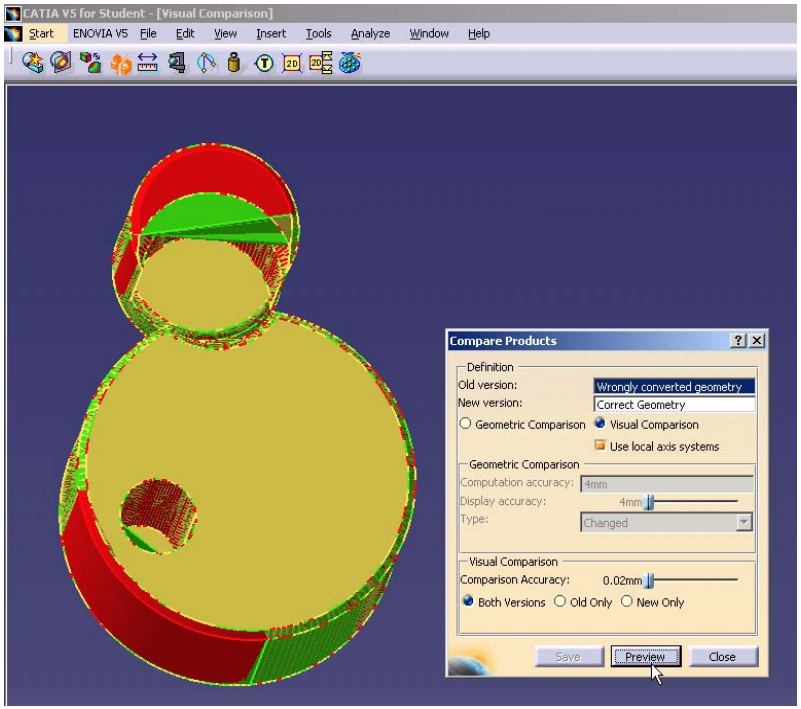
Data Exchange

- Visual analysis is a quick way to find differences between two models
- Visual analysis shows clearly where the geometry changes, but does not provide any hard data that can be analyzed
- Geometric analysis will be more efficient in providing a pattern



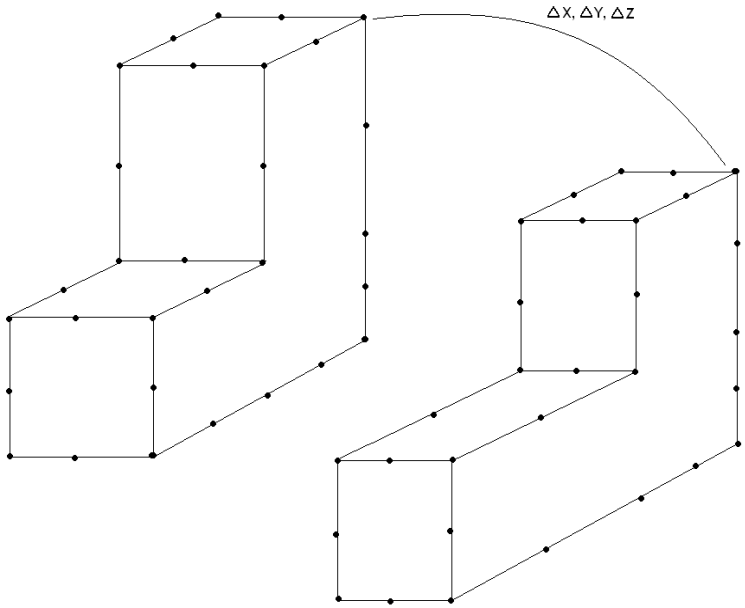
Data Exchange

- The point cloud technique will analyze the surface of two geometries and compare them
- Points are placed all over the surface of the first geometry at locations important to the shape
- When the file is exported and imported, these points move to reflect the unwanted change in geometry



Data Exchange

- Using a loop based algorithm, connections between these points will be made based on proximity
- The distance to the closest point on the modified geometry will be recorded to find where and how much exactly the geometry has changed
- The algorithm will also find the distance in the opposite direction to ensure points aren't skewed enough to fall into a different point's range, as this will provide inaccurate measurements



Data Exchange

- Upon examining many different models and many different combinations of exchange between software, hopefully a pattern can be found to help decode some of the errors
- With this information, many errors may be overcome simply by building the geometry slightly differently

CATIA → IGES → CATIA

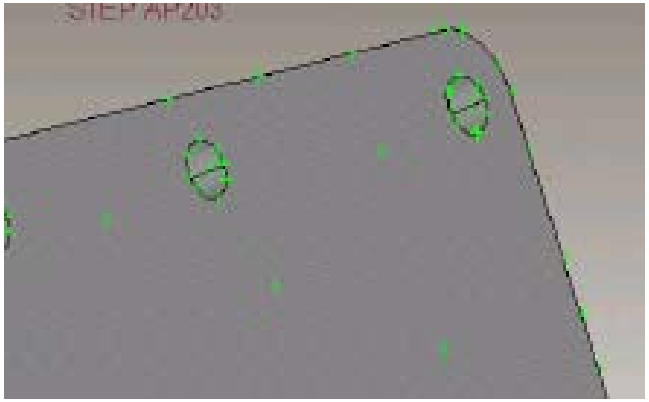
CATIA → STEP → Pro/E

Pro/E → STEP → NX3

Pro/E → IGES → CATIA

CATIA → STEP → NX3 → STEP → CATIA

Cloud of Points (COPS)



- inclusion of a set of points on each individual face to ensure that the translated face does not deviate from the original surface by more than an accepted amount
- Part of Geometric Validation Properties → STEP AP 203 E2
- Resolve false negative mass property validation
- Not supported by lightweight file formats

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Examination of lightweight visualization file formats

- JT
- 3DXML
- U3D

Task 1: Examine functionality of STEP AP 203 E 2 and the formats listed above using the current STEP standard to determine the scope.

Task 2: Examine the formats listed above relative to the functionality of the formats: openness, accessibility, extensibility, interoperability, and security.

Task 3: Development of use-case scenarios that demonstrate the effective use of standard data formats, visualization formats, and native formats.

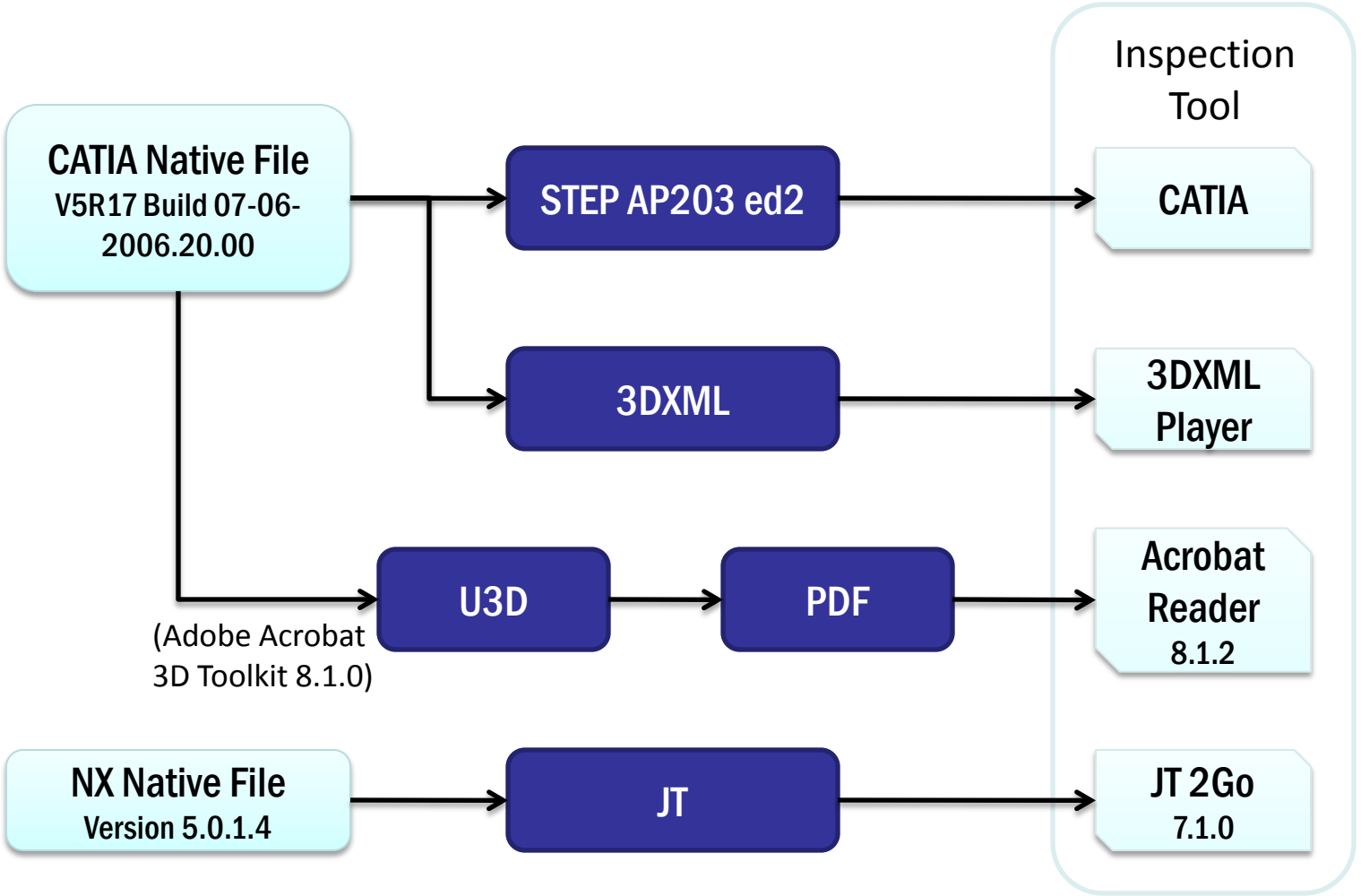
Format Comparison I

Categories	Specific features	STEP	JT	3DXML	U3D
Geometry	B-rep solids	O	O	O	O
	Curve bounded surfaces	O	O	O	O
	Wireframe	O	O	O	O
Model Viewing	3D to 2D view	O			
	Basic drafting	O			
	Associative dimensions	O			
Form features	C-sunk, c-bore	O			
	Round hole specs	O			
	Threads	O			
3D associative text		O	O		
Colors	Simple colors	O	O	O	O
	Lighting material		O	O	O

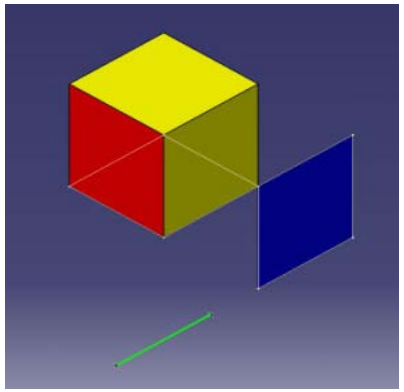
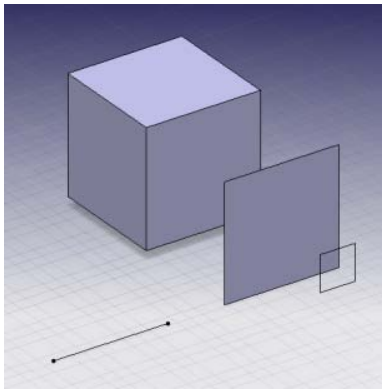
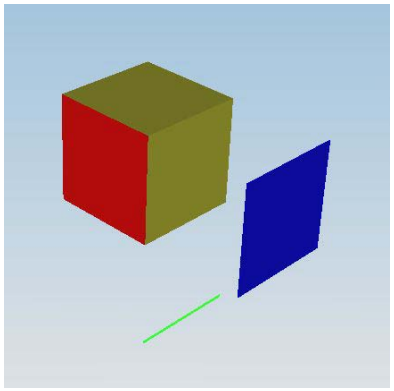
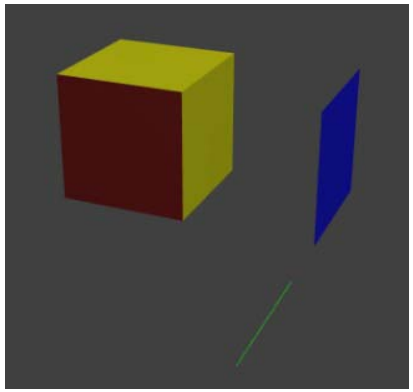
Format Comparison II

Categories	Specific features	STEP	JT	3DXML	U3D
GD & T Support	Representation	O			
	Presentation	O	O		
Mechanical Properties	Materials – lighting		O	O	O
	Density	O	O		
Construction History		O			
Geometric Validation Properties (GVP)	Basic validation properties	O	O		
	Cloud of Points (COPS)	O			
Assembly	Instance Styling	O	O	O	O
	External References	O	O	O	O
Level-of-Detail			O	O	O
Data compression			O	O	O
Key-frame Animation					O

Conversion Procedures

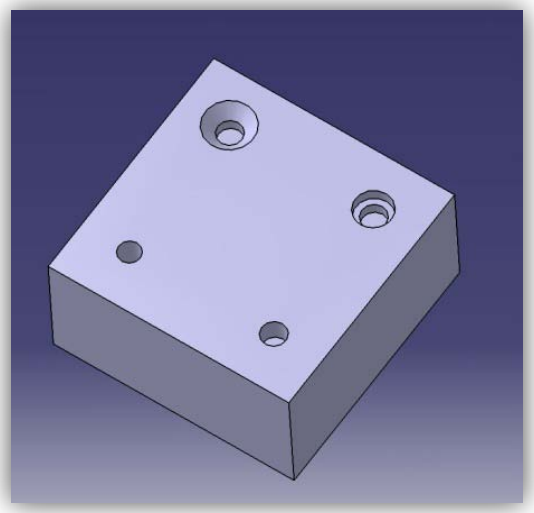


Test 1: Colors & Geometries

STEP	3DXML	JT	U3D
			

- Geometry: solid, surface, wireframe translation success.
- Simple color – Not translated for 3DXML
  - Only support color with material assignment
  - CATIA V5R18 fixed problem

Test 2: Form feature & Construction History



Features defined in native system:

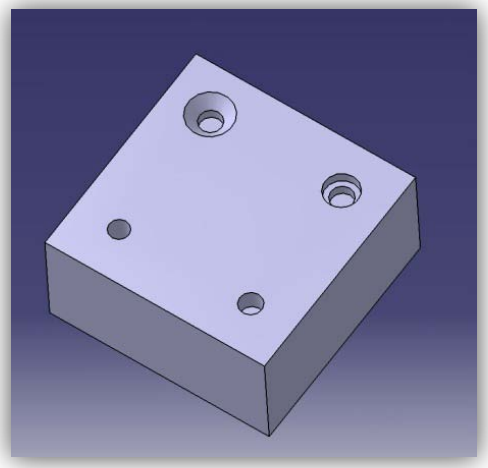
- Simple hole
- Threaded hole
- Counter bore hole
- Counter sunk hole

Files inspected with text editor

STEP	3DXML	JT	U3D
Not translated	Unsupported	Unsupported	Unsupported

Not able to read with plain text editor as files are bit-encoded

Test 3a: Mechanical Properties



- Steel material assigned to part
- Files inspected with text editor

STEP	3DXML	JT	U3D
Not translated	Unsupported (partial)	Unable to check	Not translated

Only material's lighting properties found

Test 3b: Geometric Validation

Properties	CATIA native	3DXML	Difference (%)
Volume (m^3)	4.957×10^{-4}	4.958×10^{-4}	0.020173492
Surface (m^2)	0.041	0.041	0.000
Cx (mm)	50.054	50.054	0.000
Cy (mm)	50.012	50.010	0.00399904023
Cz (mm)	24.825	24.831	0.0241691843
Mass (kg)	3.896	.496	87.2689938
Density (kg m^3)	7860	n/a	n/a

- No inspection tool for GVP in 3DXML player, JT2Go, Adobe Reader
- 3DXML inspected with CATIA V5R17
- JT produced error when inspected with NX:

  "Unable to select part body for analysis"

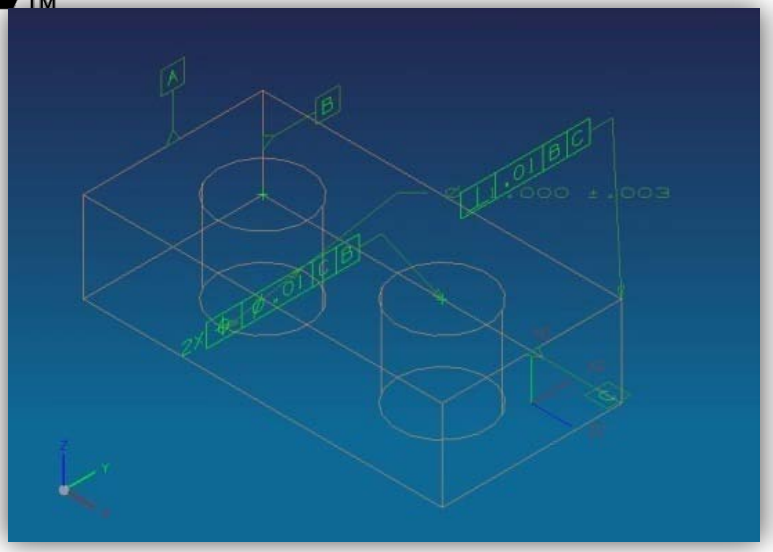
Test 4: Drafting capabilities

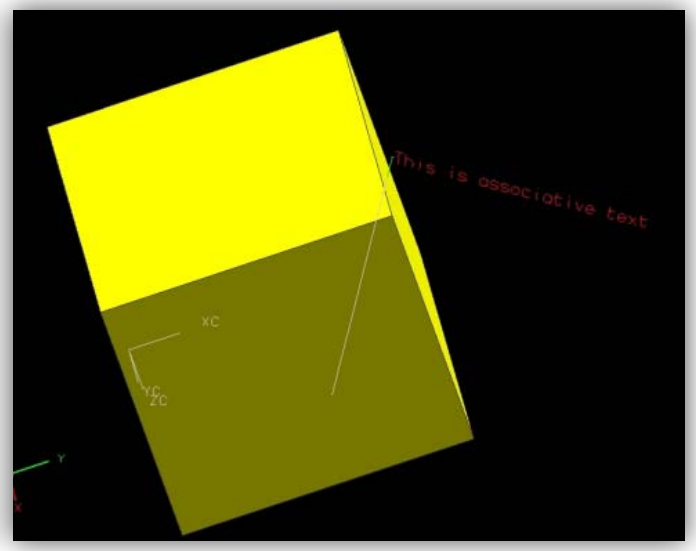
- 3-view and isometric view captured from 3D model into 2D drawing file
- Attempted to export drawing file

STEP	3DXML	JT	U3D
Not translated	Unsupported	Unsupported	Good

.DWG file exported from native system. Displayed correctly in PDF, but no association with 3D model.

Test 5: GDT & 3D Text





STEP	3DXML	JT	U3D
Not translated	Unsupported	Unsupported	Unsupported

Not displayed in viewer, but codes in file showed certain info related to 3D annotation

Discussion

- **Testing relies on translators & viewers**
  - 3rd party translator possibly yield different results
  - More advanced viewer possibly take full advantage of file format's capabilities (e.g. Teamcenter for JT)
- **Many STEP AP203 ed2 features not available with the lightweight formats (consistent with documentation)**
  - Form features
  - Construction history
  - Drafting capabilities

Discussion

- Some features possibly not available by default -> need to be extended manually
  - PMI info / GD & T
- Additional features of lightweight formats NOT part of STEP's specification suggest emphasis on visualization purposes
  - Utilizes some level of file compression
  - Advanced material lighting properties
  - Level of Detail mechanism
  - Key frame/ bone-based animation (U3D only)

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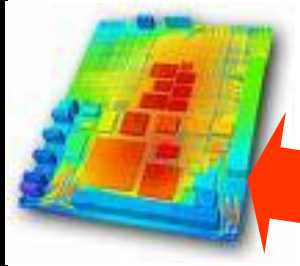
Why is this important?

- No standard method of assessing visualization formats.
- Industry looking for a way to display/store/retain data in lightweight formats
- Some “lightweight” formats are not lightweight
- Visualization formats used in different ways
  - Engineering
  - Marketing
  - Data Retention

Where are visualization formats used?

Service & Support



Analysis

Mech Design (MCAD)

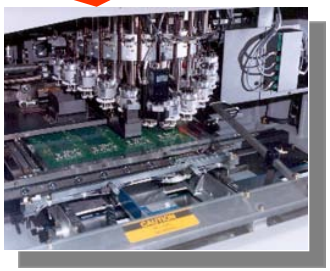
CAD Data

Customer

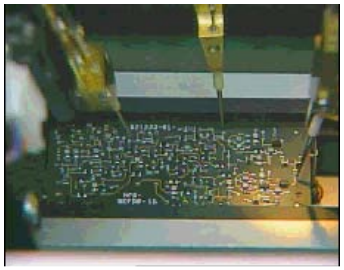
Enterprise PDM/PLM

Producibility & Simulation

Fabrication



Assembly



Inspection & Test

Courtesy of Phil Rosche & Kevin Fischer

Methodology

- **Research**
  - Background on three visualization formats (JT, 3DXML, U3D) & ISO 10303 (STEP AP203 e2)
  - CAx Implementation of visualization formats
  - Existing standards & standards creation
  - STEP/standards development
- **Participant characteristics**
  - Various industry segments
  - Various uses of visualization formats
  - Various levels of experience with formats

Methodology

- **Industry Sample**
  - 15 interviewees
- **Industry Segments**
  - Aerospace
  - Defense
  - Manufacturing
  - Government
  - Consulting
- **Participant selected based on expertise, industry segment, and use of formats regularly**

Methodology

- **Creating Questionnaire**
  - Developed from preliminary metrics.
  - Questions on openness, extensibility, accessibility, interoperability, & security
  - Questions rated with Likert scale & some open-ended questions
  - Question examples:
    - In your experience and in your opinion how important is it for a lightweight visualization format to be non-proprietary?
    - Is interoperability an issue that is important to the effectiveness of a lightweight visualization format?

Results

- **Data collection from questionnaire/interviews**
  - Average of 5 main categories to show which topic was most important to industry interviewees (n=15)

	O	E	A	I	S
AVERAGES	4.25641	4.1	4.068966	4.428571	4.2

  - Average distributed through industry segments

INDUSTRY	O	E	A	I	S
Aerospace	4.105263	3.833333	4.058824	4.375	4.333333
Government	4.75	4	4.333333	4.5	3
Consulting	4	5	4	4.666667	5
Manufacturing	4.75	3	4	4	1
Defense	4.083333	4	4.111111	4.555556	5

Results

- Interoperability was the most important functionality of a visualization format.
- Accessibility was the least important functionality of a visualization format.

	Openness	Extensibility	Accessibility	Interoperability	Security
MAX	4.75	5.00	4.33	4.67	5.00
	Manufacturing / Government	Consulting	Government	Consulting	Consulting/ Defense
MIN	4.00	3.00	4.00	4.00	1.00
	Consulting	Manufacturing	Consulting	Manufacturing	Manufacturing

Metrics

Visualization Format Metrics	No	Partial	Yes
OPENNESS			
Is it a proprietary format?			
Does the format have an explicity described implementation method?			
Does the format have documentation & services pertaining itself?			
Is the format publically available?			
Totals			
EXTENSIBILITY			
Does the format have the ability to contain various types of geometry?			
Does this format support validation?			
Does this format support animation?			
Does this format support assemblies?			
Does the format support annnotations?			
Does the format support geometric dimensioning and tolerancing (GD&T)?			
Does the format support various forms of graphical properties?			
Does the format retain metadata?			
Totals			
ACCESSIBILITY			
Does the format need to be viewed in a specific viewer?			
Can the format be edited with a simple text editor?			
Can the training for this format be achieved in a limited time relative to the capacity of the format?			
Totals			
INTEROPERABILITY			
Does this format have a broad functionality?			
Can this format be applied to its intended application without the use of add-ons?			
Totals			
SECURITY			
Can this format be secured with passwords?			
Can this format be secured by using estimated geometry?			
Can this format be IP restricted?			
Can this format handle limited use technologies?			
Totals			

Conclusions (preliminary)

- Members of PDES Inc. are looking for a way to find a lightweight compliment to the STEP format
  - Functionality
  - Replacement?
  - Complimentary?
- Metrics should help quantify what is needed
- Metrics will assess any lightweight format, not just the three looked at in this study

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Possible use cases

- Collaborative design evaluation – load part, interrogate, annotate, communicate
- Request for quote/bid – includes scenario from Item 1, and issues related to permissions and security
- Design to manufacturing – the overall concern is what point does complexity of the shared data cause the viewing technology to fail or become cumbersome?
- Engineering change order (as time and resources allow) – evaluation points to be determined
- Design to analysis (as time and resources allow) – evaluation points to be determined
- Others as available

Questions / Comments