AP242 and JT Standards Assessment: a focus on management of GD&T and PMI

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Foreword

Currently General Chairman of AIP-PRIMECA : Division of the French Society of Mechanical Engineering on Factories of the Future – integrated design and advanced manufacturing

From 2007 to 2012: Full Professor at the Université de Technologie de Compiègne and Dean of the Department of Mechanical Systems Engineering

From 1999 to 2007: Assistant Professor in charge of the MSc program on Information Technology for Mechanical Engineering (CAx, PDM, PLM, ERP)

1999 PhD on Computer Integrated Manufacturing at the University of Bordeaux

Recognized academic expert in the field of product lifecycle management, collaborative design, systems engineering, mechatronic design, digital factory, lean management, eco-design and sustainable manufacturing

Expert on the above mentioned fields for AFNOR, AIF, ANR, IFIP WG 5.1 and cooperation with numerous industrial partners
AP242 and JT Standards Assessment:

- New PLM Challenges in the Digital Transformation
- Standards Review: AP242 and JT
- Assessment Protocols and Use Cases Definition
- Main Results
- Synthesis and main outcomes
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New PLM Challenges in the Digital Transformation
Main concepts of Product Lifecycle Management

(Le Duigou, 2011)
Main concepts of Product Lifecycle Management

(Kibamba, 2011)
Main concepts of Product Lifecycle Management

ISO 14649 (STEP-NC)

Administrative parts

Complete machining

milling / drilling Part 11

Traditional turning

turning Part 12

EDM Part 13

Further technologies Part xx

Technology oriented process model

general process model

References:

- ISO 10303 (STEP)
- STEP AP 203: Geometry and topology
- STEP AP 224: Features
- STEP part 21: Syntax for data exchange
- STEP part 11: Modelling language EXPRESS

Further parts and APs

(Danjou, 2015)
Main concepts of Product Lifecycle Management

AP242 and JT Standards Assessment:

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• First choice has been done – to be in the ISO context
• Second choice - work in Model Based Definition (3D) context
• Assess the geometric definition
• And also the GD&T and PMI
Standards Review: AP242 and JT

ISO 10303 standard
STEP AP 242
for
Managed Model Based
3D Engineering
For the aerospace, automotive,
& other mechanical manufacturers
and their suppliers

http://www.ap242.org/
ISO 14306 - ISO JT for Visualization

(Pfouga & Stjepandić, 2015)
Integration in 3D models of GD&T and PMI according to contributions of ASME Y14.5 or UNM / GPS at ISO level
Standards Review: AP242 and JT

Integration in 3D models of GD&T and PMI according to contributions of ASME Y14.5 or UNM / GPS at ISO level

**Table 7. Classification of geometric characteristics according to ASME Y14.5-2009 standard**

<table>
<thead>
<tr>
<th>Application</th>
<th>Type of tolerance</th>
<th>Characteristic</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual features</td>
<td>Form</td>
<td>Straightness</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Flatness</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Circularity</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cylindricity</td>
<td>Φ</td>
</tr>
<tr>
<td>Individual or</td>
<td>Profile</td>
<td>Profile of a line</td>
<td>△</td>
</tr>
<tr>
<td>related features</td>
<td></td>
<td>Profile of a surface</td>
<td>△</td>
</tr>
<tr>
<td>Related features</td>
<td>Orientation</td>
<td>Angularity</td>
<td>/\</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Perpendicularity</td>
<td>/\</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parallelism</td>
<td>//</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td>Position</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concentricity</td>
<td>⊙</td>
</tr>
<tr>
<td>Run-out</td>
<td></td>
<td>Symmetry</td>
<td>⊥</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Circular run-out</td>
<td>⊥</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total run-out</td>
<td>/\</td>
</tr>
</tbody>
</table>

**Table 8. Geometric characteristics according to ISO 1101:2012 standard**

<table>
<thead>
<tr>
<th>Tolerances</th>
<th>Characteristics</th>
<th>Datum needed</th>
<th>Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form</td>
<td>Straightness</td>
<td>No</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>Flatness</td>
<td>No</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>Roundness</td>
<td>No</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Cylindricity</td>
<td>No</td>
<td>Φ</td>
</tr>
<tr>
<td>Orientation</td>
<td>Profile any line</td>
<td>No</td>
<td>△</td>
</tr>
<tr>
<td></td>
<td>Profile any surface</td>
<td>No</td>
<td>△</td>
</tr>
<tr>
<td></td>
<td>Parallelism</td>
<td>Yes</td>
<td>//</td>
</tr>
<tr>
<td></td>
<td>Perpendicularity</td>
<td>Yes</td>
<td>\</td>
</tr>
<tr>
<td></td>
<td>Angularity</td>
<td>Yes</td>
<td>/\</td>
</tr>
<tr>
<td>Location</td>
<td>Profile any line</td>
<td>Yes</td>
<td>△</td>
</tr>
<tr>
<td></td>
<td>Profile any surface</td>
<td>Yes</td>
<td>△</td>
</tr>
<tr>
<td></td>
<td>Position</td>
<td>Yes or no</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>Concentricity (for center points)</td>
<td>Yes</td>
<td>⊙</td>
</tr>
<tr>
<td></td>
<td>Coaxiality (for axes)</td>
<td>Yes</td>
<td>⊙</td>
</tr>
<tr>
<td>Run-out</td>
<td>Symmetry</td>
<td>Yes</td>
<td>△</td>
</tr>
<tr>
<td></td>
<td>Profile any line</td>
<td>Yes</td>
<td>△</td>
</tr>
<tr>
<td></td>
<td>Profile any surface</td>
<td>Yes</td>
<td>△</td>
</tr>
</tbody>
</table>
Outlines

AP242 and JT Standards Assessment:

• New PLM Challenges in the Digital Transformation
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• **Assessment Protocols and Use Cases Definition**
• Main Results
• Synthesis and main outcomes
Assessment Protocols and Use Cases Definition

Legacy Format

| CAD: Catia V5, Creo, NX | Translators: CoreTech., Datakit |

Part based on geometric features

Part based on NURBS

Assembly

Analysis principles:
- viewers
- browsers

Toolkits: JT2Go, OCC viewer, STEPfileAnalyzer, WinMerge

AP242

JT
Assessment Protocols and Use Cases Definition

Legacy Format

AP242 → JT
JT → AP242

Legacy Format

AP242 → JT
JT → AP242

Legacy Format
Overview of assessment protocols regarding use cases vs legacy CAD vs AP242 / JT

<table>
<thead>
<tr>
<th>Format</th>
<th>Subject</th>
<th>Description</th>
<th>SEM-SE1</th>
<th>ITP</th>
<th>VT</th>
<th>JT</th>
<th>SRT</th>
<th>CTR</th>
<th>CVR</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D CAD</td>
<td>Surface area: 0.1236918 m²</td>
<td>Volume: 0.0016747 m³</td>
<td>Centroid (mm):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Assessment Protocols and Use Cases Definition**
AP242 and JT Standards Assessment:

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Main Results

1) Translated geometric definition are globally **OK** with Validation Properties check
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<table>
<thead>
<tr>
<th>Pièce Prismatique</th>
<th>Step Catia/JT Cátia</th>
<th>Step Créo/JT Créo</th>
<th>Step NX/JT NX</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>En comparant le Step et le JT on remarque que le JT contient le descriptif des VP à contrario du Step(volume,surface,centroid) Comparer les deux fichiers n’est pas facile étant donné que chacun d’eux n’ont pas la même structure et n’écrivent pas les entités de la même façon. Ici on constate 4286 entités pour le step et 3937 ou 4330 pour le JT sans/avec cumul des bloc d’écriture. Le format JT contient quant à lui plusieurs.</td>
<td>Pour cette pièce, le format JT comporte une partie “metadata” décivant l’ensemble des paramètres relatifs aux perçages tordus de la pièce. Comme les comparaisons précédentes le JT comporte plusieurs bloc d’écriture, tandis que le step comporte un seul bloc détaillé. Ici on constate 4544 entités pour le step et 3899 ou 4290 pour le JT sans/avec cumul des bloc d’écriture.</td>
<td>Ici on constate 4279 entités pour le step et 3619 pour le JT (cumul de tout les bloc d’écriture). Ici on constate 4279 entités pour le step et 2899 ou 3619 pour le JT sans/avec cumul des bloc d’écriture.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aube</th>
<th>Step Catia/JT Cátia</th>
<th>Step Créo/JT Créo</th>
<th>Step NX/JT NX</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ici on constate 5031 entités pour le step et 1572 ou 1840 pour le JT sans/avec cumul des bloc d’écriture. On remarque donc ici que la géométrie “surfacique” est beaucoup moins transcrire sur le JT que sur le Step. Ici les VP du JT sont à 0.</td>
<td>Ici on constate 9038 entités pour le step et 1534 ou 2061 pour le JT sans/avec cumul des bloc d’écriture. On remarque donc ici que la géométrie “surfacique” est beaucoup moins transcrire sur le JT que sur le Step.</td>
<td>Ici on constate 10338 entités pour le step et 1196 ou 1790 pour le JT sans/avec cumul des bloc d’écriture. On remarque donc ici que la géométrie “surfacique” est beaucoup moins transcrire sur le JT que sur le Step.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assemblage Aube</th>
<th>Step Catia/JT Cátia</th>
<th>Step Créo/JT Créo</th>
<th>Step NX/JT NX</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ici on constate 3231 entités pour le step et 1572 ou 1857 pour le JT sans/avec cumul des bloc d’écriture. On remarque donc ici que la géométrie “surfacique” est beaucoup moins transcrire sur le JT que sur le Step. Ici les VP du JT sont à 0. On constate de plus une erreur concernant la répétition circulaire des aubes, celle-ci n’est pas prise en compte.</td>
<td>Ici on constate 9161 entités pour le step et 1534 ou 2061 pour le JT sans/avec cumul des bloc d’écriture. On remarque donc ici que la géométrie “surfacique” est beaucoup moins transcrire sur le JT que sur le Step. Ici une grande partie du fichier JT est consacré au bloc “metadata”</td>
<td>Ici on constate 10549 entités pour le step et 1196 ou 1790 pour le JT sans/avec cumul des bloc d’écriture. On remarque donc ici que la géométrie “surfacique” est beaucoup moins transcrire sur le JT que sur le Step.</td>
</tr>
</tbody>
</table>
1) Translated geometric definitions are globally **OK** with Validation Properties check
2) Translated PMI specifications are MODERATELY SATISFACTORY

- Références: 3 surfaces (A,B,C)
- Cotation Géométriques:
  - Planité: 0.2
  - Perpendiculatité: 1.5A
  - Localisation surfacique: 0.5A
  - Localisation: 0.75ABC
  - Localisation: 0.75ABC
  - Localisation surfacique: 1.25ABC
- Cotation Dimensionnelles:
  - Ø35 ± 0.2; Ø35 ± 0.2; Ø20 ± 0.05-0.1; Ø20 ± 0.1-0.05; Ø25 ± 0.15
- Note: A=B

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Translated PMI specifications are MODERATELY SATISFACTORY.
Main Results

2) Translated PMI specifications are MODERATELY SATISFACTORY
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Conclusions

• **GOOD** results on geometric definition on AP242 and JT
  ...some troubles on assembly but it sounds it is a question of mistake in using translators than wrong definition in the standards

• **More DIFFICULTIES** in translating PMI on JT then AP242 ...
  ...clarifying semantic representations and graphical presentations
Future Work

• More use cases, more criteria, more translators or direct translator in CAD systems!

• Method without toolkit for browsing and processing of JT binary files

• Question still open on exact geometric definition vs tessellated definition vs large model rendering, and on associativity between PMI with geometry (exact or tessellated)

The role of MBD and 3D Models as unquestionable backbone Digital Transformation of company?


Thanks for your attention

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