Charting the transition between Engineering Specifications, the 3D Model and Inspection through Quality Reporting
The power computer modeling: connecting tools and their functional users

1. Current limits in the “MBD authoring” phase
2. Integrated Product Life-Cycle Support – MBE
3. Lean Product Development – Bill of Characteristics - BoC
4. Future for MBSE – REQUIREment Management
Faurecia Automotive Seating

Footprint

USA
- Sterling Heights
- Riverside
- Cleveland
- Wentzville
- Cottondale
- Madison
- Simpsonville

Mexico
- San Luis Potosí
- Ramos
- Puebla

Morocco
- Konira
- Tunisia
- Ben Arous

China
- WuXi
- ChangChun
- AnYang
- WuHan
- Guangzhou
- ChengDu
- ShenYang
- YangZhou
- YangCheng

Iran
- Tehran

India
- Mumbai
- Pune
- Sanand

Brazil
- Quatro Bares
- Porto Real
- Sao Jose dos Finhais

Argentina
- San Jose

Uruguay
- Escobar

France
- Pantin
- Etrechet
- Creon
- Magny-Vermesles
- Montebello
- Nogent-le-Vernisson
- Palerins
- Sandouville
- Villiers le Morgon

Portugal
- Nieus
- Sao Joao de Madeira
- Fardela (AV)
- Vouzela

Germany
- Neuburg
- Neuenstadt
- Gladbach
- UK
- Banbury

Spain
- Madrid
- Pamplona
- Valladolid
- Vigo
- Vitoria-Gasteiz

Netherlands
- Sittard

Poland
- Gniez
- Jelcz
- Walbrzych

Czech Republic
- Pilsen
- Pilzen

Slovakia
- Locomo
- Trnava

Romania
- Târnava
- Valoia

Russia
- Saint Petersburg

Turkey
- Barca (JV)

South Korea
- Yeongheon

http://www.faurecia.com/en
Automotive Seating - North America

$1.7 bn  
NAO product sales

6,700  
people

12  
sites

1 R&D Center  
2 D&D Centers

Auburn Hills, MI  
headquarters

"The Problem with Digital Design"

Yes, digital design is a wonderful tool. But ....

- CAD, rapid prototyping and collaboration tools have increased effectiveness and efficiencies.
- Powerful analysis tools facilitate virtual testing, allowing engineers to vet concepts with the potential to reduce cost and improve design iteration. What’s wrong with that?
- Digital designs often appear complete before they actually are.
- This is one of the major reasons product failure and success rates have changed little over the past several decades.

The Problem with Digital Design

Tucker Marion, Sebastian Foxson and Marc H. Meyer
April 17, 2012

Yes, digital design is a wonderful tool. But unless it is supported with strong management processes, there can be unintended — and negative — consequences. The widespread adoption of digital design shows that it makes a powerful contribution to R&D effectiveness and efficiency. Design tools
A vicious cycle of ‘Guess & Check’

Product development costs increase

- Engineering changes made late in the process
  - Customer issues: Fit, Appearance & Warranty
- Lack of traceability for Quality metrics
  - Engineering changes made from unrepresentative results
- Predictive simulations not reflective of the actual process
  - FEA, DFEMA, Tolerance Stacks
- Test Failure traced to improper set-up
  - Not to design defects
A vicious cycle of ‘Guess & Check’

Product development costs increase

What then should the goal be? "Compatibility before Completion"
Model-Based Definition

Digital Product Definition standards

ASME Y14.41-2012
(Revision of ASME Y14.41-2003 (R2008))

Digital Product Definition Data Practices

Engineering Drawing and Related Documentation Practices

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

Digital Product Definition

Drawing-free Product Documentation

VDA Recommendation 4953 and a reader data sheet. Recommendation describes
the documentation within a drawing or all the information required
(PDF/A-3). This consists of metadata portion (STEP A)
as additional optional, uses
the appropriateness for use in different use cases on
PDF container makes it possible for management (PLM) will
stores. There is no longer an alternative parallel management
management, and also improve

Digital Engineering Visualization

VDA Verband der Automobilindustrie

VDA

OEDETTE

SWEDEN

JAMA

Japan Automobile Manufacturers Association, Inc.

JAPIA

VDA

Verband der Automobilindustrie

SASIG 3D Annotated Model Standard

Version 1, Dated 06/2008

DEPARTMENT OF DEFENSE

STANDARD PRACTICE

TECHNICAL DATA PACKAGES

This standard is approved for use by all Departments and Agencies of the Department of Defense.

NOT MEASUREMENT SENSITIVE

MIL-STD-31000A
26 February 2013
SUPERSEDING
MIL-STD-31000
05 November 2009

faurecia SEATING
SASIG - a global consortium of automotive standards organizations

JAMA’s recent whitepaper identified “Quality Inspection” as:

- the ‘first-order’ MBE down-stream Use-Case
Integrated Product Life-Cycle Support

Model-Based Definition - MBD

- a system in which product 3D GD&T details are captured directly in the 3D model.
Model-Based Definition

Advantages to Digital Product Definition

- Comprised of annotated views of features with 3D GD&T PMI (FTA – Functional Tolerancing Annotation)
  - eliminating “ambiguity” in interpreting drawings by being responsive to interrogation
Model-Based Definition

Advantages to Digital Product Definition

- **Parent/Child dependencies/alignment**
  - Easily checked “Systematically” using 3D GD&T

All GD&T is contained in 3D Model
Model-Based Definition

Advantages to Digital Product Definition

- **Ease in Checking Inter-level zone dependencies**
  - Product Details Managed on Separate Drawings
  - Component details are not visible at the assembly level

Weld Zones in **Part Drawing**

Weld Callouts in **Assembly Drawing**
Limited Range in MBD Usage

Challenges for Digital Product Definition

- During most MBD ‘Authoring’ the primarily focus seems to be on Geometry solely for the Design, Analysis and Prototyping stages of Product Development.
Sharing information across modalities

Model-Based Enterprise - MBE

- Making the 3D CAD Model the single (authoritative) source for the set of all technical descriptions that denote in totality the:
  - physical geometry, configurations, annotations (3D GD&T = PMI)
  - functional relationships, attributes & procedural information

- required to ensure an item’s performance adequacy throughout the extended enterprise:
  - Acquisition (Purchasing) ▶ Analysis (Simulation) ▶ Inspection (Quality)
  - Manufacturing ▶ Testing ▶ Support Logistics
MBE - Integrated Product Life-Cycle

Accomplishments & Benefits

- Improves “Enterprise-wide” communication among: purchasing, design, development, engineering, suppliers, quality and validation, manufacturing and logistics
  - create a robust design - reducing engineering changes
  - optimizing designs for quality cost and delivery - shorten time to market

- Allows for greater flexibility in achieving design targets with comparative advantage
  - Effectiveness

- Achieves thoughtful allocation of economic tolerances for reduced manufacturing costs
  - Adaptability

- Focuses quality efforts on only the necessary, critical tolerances - saves inspection
  - Efficiency

- Achieves robust design with managed low risk of failure - lowers warrantee costs
  - Continuity
Integrated Product Life-Cycle Support

Depends on multiple output files as independent Objects or uses “outside’ of CAD

- **“Neutral” formats for geometry**
  - IGES – (the original)
  - Step
- **“Visualization” formats for PMI**
  - Siemens (nx) – JT
  - Dassault (CATIA) – 3DXML
- **TDP (Technical Data Package)**
  - a ‘Container’ for information not in 3D
  - Adobe – 3D pdf
- **All are considered ‘Derivatives’ Package**
  - made from (derived) the CAD
Integrated Product Life-Cycle Support

MBE/MBD – 3D Model Data Use and Reuse

- ERP activity Types

Future State

<table>
<thead>
<tr>
<th>Domain/Order</th>
<th>Description</th>
<th>Context/Agent</th>
<th>ERP Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Management Program</td>
<td>uBoM</td>
<td>CVS, DPD, ECM, EDMS, IDEF, JRD, OS, VPPS</td>
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<td>02_A</td>
<td>Acquisition - procurement</td>
<td>BoC</td>
<td>COTS, DPM, MDM</td>
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<tr>
<td>03_E</td>
<td>Simulation - analysis; predictive - evaluative</td>
<td>BoC</td>
<td>CAE, CAV, FEA, PMECA, SDM</td>
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<td>eBoM</td>
<td>CPM, DPV, EDM, RDL, SBCE</td>
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<td>BoC</td>
<td>CAD, CSG, DPO, FACS, RMS, STEP, UEF</td>
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<td>06_P</td>
<td>Process/Manufacture</td>
<td>BoP, mBOM</td>
<td>CAAP, IMS, IMITI, MMS, MIPM, MRP</td>
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<td>07_I</td>
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<td>BoC</td>
<td>CMM, DMIS, ISIR, SIE, SPDM, VIM</td>
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<td>Testing - destructive</td>
<td>BoC</td>
<td>FRACAS</td>
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<td>09_Q</td>
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<td>BoD</td>
<td>APQP, PPAP, QAP</td>
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<td>10_L</td>
<td>Logistics support</td>
<td>BoD</td>
<td>DPM, PLCS, SPI, ROM, SOA</td>
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<td>10_La</td>
<td>Materials Management</td>
<td>pBoM</td>
<td>MIM</td>
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<tr>
<td>10_Lb</td>
<td>Execution</td>
<td>pBoM</td>
<td>FNA, PSI, UPC</td>
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<td>pBoM</td>
<td>PLM</td>
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<tr>
<td>10_Ld</td>
<td>Service_Field</td>
<td>sBoM</td>
<td>LORA, ROM, SOA</td>
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<td>11_R</td>
<td>Reclamation - recycling</td>
<td>BoC</td>
<td>Bill of Characteristics</td>
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<td></td>
<td>BoD</td>
<td>Bill of Documents</td>
<td></td>
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<tr>
<td></td>
<td>eBoM</td>
<td>Bill of Materials-Engineering</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mBOM</td>
<td>Bill of Materials-Manufacturing</td>
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<tr>
<td></td>
<td>pBoM</td>
<td>Bill of Materials-Production</td>
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<td></td>
<td>sBoM</td>
<td>Bill of Materials-Service</td>
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<td>uBoM</td>
<td>Bill of Materials-Unified</td>
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<td>BoP</td>
<td>Bill of Process</td>
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<td></td>
<td>BoS</td>
<td>Bill of Substance</td>
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</tbody>
</table>
Integrated Product Life-Cycle Support

MBE/MBD – 3D Model Data Use and Reuse

- Potential for moving from
  - “Presentational”

- To Semantic usage
  - “Representational”

*Drawing Centric*
- 2D Master Drawing – 3D model not verified or configuration controlled

*Model Centric*
- 2D Master Drawing with associative 3D model
  (Model is verified and configuration controlled)

*Model Based Definition*
- 3D Master CAD Model with 3D annotations – 2D drawings by exception

*Model Based Enterprise*
- 3D Master CAD Model with 3D annotations – Fully leveraged by the Enterprise

Drawings & Associated Lists

Models & Derivatives
Integrated Product Life-Cycle Support

MBE/MBD – 3D Model Data Use and Reuse

Potential for moving from

- “Presentational”

To Semantic usage

- “Representational”
Integrated Product Life-Cycle Support

‘Semantic’ 3D Model Data Use and Reuse

- Link enhanced Part Features definitions to:
  - Automate inputs into analysis tools
  - Behavioral characteristics of specific features
  - Establish feedback loops in the Design decision process
Capabilities of XML

Information basically organized into three dimensions

- **Semiotic** – the study of signs, describing the productive and perceptive levels, processes, and analyses of symbolic forms
  - Poietic (creation) vs Esthesic (reception - sensory)
- **Semantic** – the relation between signs and the things to which they refer; their signifiers (their denotata) or meaning
- **Ontological** - formally representing knowledge as a schema for concepts within a domain
Capabilities of XML

- naturally lead to the establishment of a "controlled vocabulary" or Ontic Range

for use in defining a ‘criterion of identity’ for the construction of computer-readable (MBD) models of design specification

- An Ontology’s components are commonly structured as (things like):
  - **Individuals**: instances or objects
  - **Classes**: sets, collections, concepts, types of objects, or kinds of things
  - **Relationships**: ways in which Classes and Individuals can be related to one another
  - **Attributes**: aspects, properties, features, characteristics, or parameters that objects (and classes) can have
The QIF BoC and PPAP's PSW Elements

Model Based Dimensional Schema for PMI (FTA)

- Quality Info Framework Part # Planning

Bill Of Characteristics

AIAG PPAP-v4 Section 2, Paragraph 2
## PPAP Requirements for PSW Elements

### AIAG PPAP-v4 Section 2, Paragraph 2.17

<table>
<thead>
<tr>
<th>Order</th>
<th>PSW Element (PPAP, APIQ)</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
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<tbody>
<tr>
<td>1</td>
<td>Design Records &amp; Baked Part print(s)</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>*</td>
<td>R</td>
</tr>
<tr>
<td>2</td>
<td>Authorized Engineering Change (documents)</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>*</td>
<td>R</td>
</tr>
<tr>
<td>3</td>
<td>Customer Engineering Approval</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
<td>R</td>
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<td>4</td>
<td>Design Failure Mode and Effect Analysis (DFMEA)</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
<td>R</td>
</tr>
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<td>5</td>
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<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
<td>R</td>
</tr>
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<td>6</td>
<td>Process Failure Mode and Effect Analysis (PFMEA)</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
<td>R</td>
</tr>
<tr>
<td>7</td>
<td>Control Plan</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>*</td>
<td>R</td>
</tr>
<tr>
<td>8</td>
<td>Measurement System Analysis Studies (MSA)</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
<td>R</td>
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<td>9</td>
<td>Dimensional Results</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
<td>R</td>
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<td>10</td>
<td>Records of Material Test / Performance Test Results</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>*</td>
<td>R</td>
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<tr>
<td>11</td>
<td>Initial Process (OQ - Capability) Studies</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>*</td>
<td>R</td>
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<tr>
<td>12</td>
<td>Qualified Laboratory Documentation</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>*</td>
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<td>13</td>
<td>Appearance Approval Report AAR</td>
<td>S</td>
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<td>S</td>
<td>S</td>
<td>R</td>
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<tr>
<td>14</td>
<td>Sample Production Parts</td>
<td>R</td>
<td>S</td>
<td>S</td>
<td>*</td>
<td>R</td>
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<tr>
<td>15</td>
<td>Master Sample</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>*</td>
<td>R</td>
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<tr>
<td>16</td>
<td>Checking Jigs</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>*</td>
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<tr>
<td>17</td>
<td>Sample Production Parts</td>
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<td>R</td>
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<td>R</td>
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<tr>
<td>18</td>
<td>Master Sample</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>*</td>
<td>R</td>
</tr>
</tbody>
</table>

**APQP PPAP Submission Levels:**
- **R** - Required: Must be submitted by the supplier.
- **S** - Suggested: Recommended for submission.
- ***** - Optional: May be submitted by the supplier.

### Classes of Retention/Submission Requirements:
- **R** - The organization shall Submit the customer and Retain a copy of records or documentation Items at appropriate locations.
- **S** - The organization shall Retain at appropriate locations and make available to the customer upon request.
- ***** - The organization shall Retain at appropriate locations and Submit to the customer upon request.

### 17 Customer Requirements

**FINDINGS & INSIGHTS**

Survey results reveal that OEMs and suppliers both rank Problem Solving and Customer-Specific Requirements (CSRs) as the most critical issues impacting quality. Quality Management System (QMS), Product Development, and Loss of Experience round out the top five issues as ranked by all respondents.
Model Based Enterprise Quality use-case

Requirements Define the desired outcomes

- **Subsuming (‘Rolling down’) Requirements from the System (External/Environment) through Process (Assembly) to the individual Item (Part Characteristics):**
  - **Clarifies** expected variation - stakeholders (customers) can become aware of potential alternatives.
  - **Reduces conflicts** - such as tradeoffs between costs performance and divergent stakeholder interests.
  - **Establishes Traceability** for complete data driven framework/hierarchy used in coordinating System/Assembly/Part performance.
  - **Connects** - stakeholder (external ‘up-stream’ customer /internal ‘down-stream use-case derivatives) expectations to the Design process.
Role of Requirements in Product Development

Getting the Right Product

Types of Errors in Requirements *
Incorrect assumptions 49%
Omitted 29%
Inconsistent 13%
Ambiguous 5%

* from Ivy F. Hooks’ – “Customer-Centered Products: Creating Successful Products Through Smart Requirements Management”
PPAP Requirements for PSW Elements

APQP - Quality Function Deployment

- Characteristics are “Instantiations” of Requirements

http://www.aiag.org/store
## PPAP Requirements for PSW Elements

### AIAG PPAP-v4 Section 2, Paragraph 2.1

<table>
<thead>
<tr>
<th>Order</th>
<th>PSW Element (PPAP APQP)</th>
<th>APQP APQP Submission Levels:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design Record</td>
<td>R - Part Selection Warrant (PSW) only submitted to:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S - PSW with product sample</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R - PSW with product samples</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S - PSW and other requirement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R - PSW with product samples available for re</td>
</tr>
<tr>
<td>2</td>
<td>Customer Engineering Approval</td>
<td>S - The organization shall retain a copy of records or the appropriate locations</td>
</tr>
<tr>
<td>3</td>
<td>Design Failure Mode and Effect Analysis (DFMEA)</td>
<td>R - The organization shall retain a copy of records or the appropriate locations</td>
</tr>
<tr>
<td>4</td>
<td>Process Flow Diagram</td>
<td>R - The organization shall retain a copy of records or the appropriate locations</td>
</tr>
<tr>
<td>5</td>
<td>Process Failure Mode and Effect Analysis (PFMEA)</td>
<td>R - The organization shall retain a copy of records or the appropriate locations</td>
</tr>
<tr>
<td>6</td>
<td>Control Plan</td>
<td>R - The organization shall retain a copy of records or the appropriate locations</td>
</tr>
<tr>
<td>7</td>
<td>Measurement System Analysis Studies (MSA)</td>
<td>R - The organization shall retain a copy of records or the appropriate locations</td>
</tr>
<tr>
<td>8</td>
<td>Dimensional Results</td>
<td>R - The organization shall retain a copy of records or the appropriate locations</td>
</tr>
<tr>
<td>9</td>
<td>Records of Material Test / Performance Test Results</td>
<td>R - The organization shall retain a copy of records or the appropriate locations</td>
</tr>
<tr>
<td>10</td>
<td>Initial Process (Cpk - Capability) Studies</td>
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<td>12</td>
<td>Appearance Approval Report (AIR)</td>
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<td>13</td>
<td>Sample Production Parts</td>
<td>R - The organization shall retain a copy of records or the appropriate locations</td>
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<td>14</td>
<td>Master Sample</td>
<td>R - The organization shall retain a copy of records or the appropriate locations</td>
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<td>Checking Aids</td>
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<td>17</td>
<td>Part Submission Warrant (PSW)</td>
<td>R - The organization shall retain a copy of records or the appropriate locations</td>
</tr>
</tbody>
</table>

### DESIGN RECORD / BUBBLE PRINT: SAMPLE

![Design Record Image]
PPAP Requirements for PSW Elements

AIAG PPAP-v4 Section 2, Paragraph 2.1

1. Design Record

DESIGN RECORD / BUBBLE PRINT: SAMPLE

Today: 2D Drawing
Future: 3D Annotated Model
PSW Element - Design Record

AIAG PPAP-v4 Section 2, Paragraph 2.1

- **ASME Y14.41 (ISO 1672)**
  Digital Elements, Attributes & Annotations in Associated Groups
  - PPAP (Y14.45) ‘Characteristics’ correspond to PMI:
**PSW Element - Dimensional Results**

**AIAG PPAP-v4 Section 2, Paragraph 2.9**

- reporting of assessment of product characteristics (showing "ok" or "not ok") comparison of their measured results to their published specifications.

---

**9 Dimensional Results**

<table>
<thead>
<tr>
<th>Order</th>
<th>PSW Element (PPAP, APQP)</th>
<th>APQP PPAP Submission Levels:</th>
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<tbody>
<tr>
<td>1</td>
<td>Design Records &amp; Rubber Print(s)</td>
<td>1. Part Submission: Warrant (PSW)</td>
</tr>
<tr>
<td>2</td>
<td>Authorized Engineering Change (documents)</td>
<td>2. PSW with product samples and limit</td>
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<tr>
<td>3</td>
<td>Customer Engineering Approval</td>
<td>3. PSW with product samples and core</td>
</tr>
<tr>
<td>4</td>
<td>Design Failure Mode and Effect Analysis (DFMEA)</td>
<td>4. PSW with other requirements as defined</td>
</tr>
<tr>
<td>5</td>
<td>Process Flow Diagram</td>
<td>5. PSW with product samples and core available for review at th</td>
</tr>
<tr>
<td>6</td>
<td>Process Failure Mode and Effect Analysis (PFMEA)</td>
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<tr>
<td>7</td>
<td>Control Plan</td>
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<td>Measurement System Analysis Studies (MSA)</td>
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</tbody>
</table>

**AIAG PPAP-v4 Section 2, Paragraph 2.9**

1. **ITEM**: Numbering needs to match Design Records / "Bubble Print"  
2. **DIMENSIONAL / SPECIFICATION**: Mark the low & high values in the MIN / MAX respectively  
3. **GAGE TYPE**: Mark the gage used to measure item  
4. **QTY TESTED**: Mark how many parts measured (at a minimum 1 piece per cavity if applicable)  
5. **DATA**: Mark actual results  
6. **OK / NOT OK**: Check each measurement as good or bad by marking OK / NOT OK appropriately  
7. **SIGNATURE SECTION**: Fill in Name, Signature, Title and Date for supplier sign off
PSW Element - Dimensional Results

AIAG PPAP-v4 Section 2, Paragraph 2.9

- reporting of assessment of product characteristics (showing "ok" or "not ok")
  comparison of their measured results to their published specifications.

- Multiples dimensions shall be measured in each places as defined in the drawing
- Each measured place shall be recorded on the dimension report.
- Based on the above examples, you shall list measured places with :17.1, 17.2 and 18.1, 18.2.
1.1.8 Characteristic Identifier
An index number or letter, or a combination of a letter and a number that is associated with each tolerance or specification on a drawing. These identifiers are used to link data in a measurement report with a given tolerance specification. Characteristic identifiers are also used to set the order in which data is presented in a report, this does not mandate the order in which data is gathered.
AM – Additive Manufacturing - 3D Printing

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
<th>Standard</th>
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</thead>
<tbody>
<tr>
<td>attribute</td>
<td>characteristic of data, representing one or more aspects, descriptors, or elements of the data. Discussion - In object-oriented systems, attributes are characteristics of objects. In XML, attributes are characteristics of elements.</td>
<td>ISO/ASTM 52915:2013</td>
</tr>
<tr>
<td>Characteristic Identifier</td>
<td>an index number and/or letter that is systematically associated with, each tolerance or specification on a design</td>
<td>ASME Y14.45; 1.1.8</td>
</tr>
<tr>
<td>display management</td>
<td>the ability to enable or disable the display of all annotation, or by criteria; such as 'type' or selection, except for Security Markings (sec 5.4)</td>
<td>ASME Y14.41-2012; 7.1.1</td>
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<tr>
<td>QIF</td>
<td>Quality Information Framework (QIF) is an integrated set of XML schema based standards enabling the seamless flow of information within computer-aided quality measurement systems. All information models for transporting quality data are derived from common model libraries so that common information modeling components can be reused throughout the entire quality measurement process. As</td>
<td>ANSI QIF 2.0</td>
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<tr>
<td>Measurand</td>
<td>or the “Measured Mating envelope” Similar to ‘Actual Mating Envelope’ a theoretical term, as defined in ASME Y14.5-2009, but subject to measurement uncertainty</td>
<td>ASME Y14.45; 1.3.7</td>
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<tr>
<td>Reporting Coordinate System</td>
<td>A coordinate system rotationally or translationally shifted from the datum reference frame axes that are defined from the set of datum features. &quot;Shifted&quot; Datum Reference Frame Coordinate Axes are used to enable clear reporting of position tolerance measurement data location components for features that are not orthogonal to the naturally established datum reference frame.</td>
<td>ASME Y14.45; 1.3.15</td>
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</table>
## PPAP Requirements for PSW Elements

### AIAG PPAP-v4 Section 2, Paragraph 2.10

- **Print Notes capture Material Specification**

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<tr>
<th>Order</th>
<th>PSW Element (PPAP, APQP)</th>
<th>Requirement 1</th>
<th>Requirement 2</th>
<th>Requirement 3</th>
<th>Requirement 4</th>
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<td>Design Records &amp; Bubbled Part Print(s)</td>
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<tr>
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<td>R</td>
<td>S</td>
<td>*</td>
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<tr>
<td>3</td>
<td>Customer Engineering Approval</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
</tr>
<tr>
<td>4</td>
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<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
</tr>
<tr>
<td>5</td>
<td>Process Flow Diagram</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
</tr>
<tr>
<td>6</td>
<td>Process Failure Mode and Effect Analysis (PFMEA)</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
</tr>
<tr>
<td>7</td>
<td>Control Plan</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
</tr>
<tr>
<td>8</td>
<td>Test Measurement System Analysis Studies (TMSA)</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
</tr>
<tr>
<td>9</td>
<td>Dimensional Results</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
</tr>
<tr>
<td>10</td>
<td>Material Test Results &amp; Records</td>
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<td>S</td>
<td>S</td>
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<tr>
<td>11</td>
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<td>S</td>
<td>*</td>
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<tr>
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<td>R</td>
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<tr>
<td>14</td>
<td>Master Sample</td>
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<td>S</td>
<td>*</td>
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<tr>
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<td>Checking Aids</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
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<tr>
<td>16</td>
<td>Customer-Specific Requirements (CSR)</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>*</td>
</tr>
<tr>
<td>17</td>
<td>Part Submission Warrant (PSW)</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
</tbody>
</table>

1. **Design Record Requirement**
2. **ASTM Chemical Requirement**
3. **ASTM Mechanical Requirement**
4. PPAP document to outline requirement and actuals per the print and industry standard (ASTM)
**PPAP Requirements for PSW Elements**

**AIAG PPAP-v4 Section 2, Paragraph 2.10**

- Print Notes capture Material Specification

<table>
<thead>
<tr>
<th>Order</th>
<th>PSW Element (PPAP, APQP)</th>
<th>APS</th>
<th>SPS</th>
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<th>DMT</th>
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<td>R</td>
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<td>R</td>
<td>R</td>
<td>R</td>
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<td>Process Failure Mode and Effect Analysis (PFMEA)</td>
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<td>Control Plan</td>
<td>R</td>
<td>R</td>
<td>R</td>
<td>R</td>
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<tr>
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<td>Measurement System Analysis Studies (MSA)</td>
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<td>R</td>
<td>R</td>
<td>R</td>
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<td>Dimensional Results</td>
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<tr>
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<td>S</td>
<td>S</td>
<td>S</td>
<td>R</td>
</tr>
</tbody>
</table>

10 Material Test Results & Records

![Image of a table showing PPAP requirements with highlighted material test results and records]

**Bill of Characteristics (BoC)**

- Characteristic requirements
- Characteristic requirements
Can the Meta Data Record expand beyond ‘Management information’
Manufacturing Process Must Ensure Predictable Outcomes

To Achieve Needed Functionality

- In the world of IoT - Information ‘Packets’ regarding Product conformance will need to be at a Feature-by Feature ‘Granularity’
Model Based Enterprise Quality use-case

"All Characteristics Are Special…"

"….Some Are Just More Special Than Others"*

Originate from different types of Requirements:
- Customer
- Regulatory
- Market
- Sustainability

Fulfill different Purposes:
- Safety
- Function
- Coordination
- Interchangeability
- Life

Ordered in a similar Hierarchy:
- Critical
- Major
- Minor

* - apologies to George Orwell’s ‘Animal Farm’
Although Special Characteristics are designated differently by different organizations, they all follow a similar hierarchy of rationale for:

Collection > Analysis = Reporting (APQP)

- potentially hazardous or unsafe conditions
- effects on performance, not safety
- requiring exceptional test or inspection not covered by standard sampling
- vital [at part level] for interchangeability but diminished significance after assembly
- requiring verification prior to assembly
Although Special Characteristics are designated differently by different organizations, they all follow a similar hierarchy of rationale for:

**Collection > Analysis = Reporting (APQP)**

### Characteristics Classifications

- Critical
  - GM: S/C
  - FORD: CC
  - DC: <S>
  - PSA (CTFE): S
  - RSA (HCPP): S
  - VW-Audi: TLD or D

- Major
  - GM: F/F
  - FORD: SC
  - DC: <D>
  - PSA (CTFE): C
  - RSA (HCPP): M1
  - VW-Audi: TLD or D

- Minor

---

**Description von Critical (C) and Initial (I)**

- **CC-CCC**: Designates critical characteristic in Control Plan. Weist auf ein kritisches Merkmal in der Definition im Kontrollplan.
- **SC-SCC**: Designates significant characteristic in Control Plan. Weist auf ein signifikantes Merkmal in der Definition im Kontrollplan.
- **IC-ICC**: Designates initial characteristic in Control Plan. Weist auf zu beobachtendes Merkmal in der Definition im Kontrollplan.

**Fehlende Maße sind der 3D-Geometrie:**

MISSING DIMENSIONS MUST BE TAKEN FROM...
ISO/TS 16949 defines Special Characteristics as:

- **Product** (material, dimension, performance)
- **Process** parameters
- whose variation can affect:
  - compliance with (environment, **safety**) Regulations (**Mandatory**)
  - the **satisfaction** of the final **customer** through Quality, or Durability (**Reliability**) of a function
  - the **impact of using** the product by downstream customer (**Producibility**)
Model Based Enterprise Quality use-case

Measure Characteristics to improve control

- Certain Characteristics require Process parameter monitoring in order to detect & contain defects

1. **Tool Verification** – every feature checked supplier deems important for Tool Buy-off, no on-going measurement (Initial Sample Inspection Report)

2. **Part Verification** – measures of performance for product acceptance until Launch (PPAP)

3. **Product Prove-out** – sub-set of Category 1 & 2 measures, to be re-checked if Category 4 (SPC) measures go out-of-control - until process is stabilized

4. **Process Control** – on-going production, monitor manufacturing, from Production Check Fixture (SPC- Statistical Process Control)
Model Based Enterprise Quality use-case

Measure Characteristics to improve control

- Identified as part of a Product’s Control Plan

1. Tool Verification – Tool Buy-off, no on-going

2. Part Verification – until Launch (PPAP)

3. Product Prove-out – checked if Category 4 (Stabilized)

4. Process Control – or Production Check Fixture

Number of Characteristics

Product Lifecycle Phases

<table>
<thead>
<tr>
<th>Number of Characteristics</th>
<th>Product Lifecycle Phases</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Control Plan</td>
</tr>
</tbody>
</table>
Model Based Enterprise Quality use-case

6.9.5.2

"MBD + Plan + Results + Statistics"

Execute Measurement  |  Define Measurement Process  |  Define Product  |  activity

Plan

MBD PMI nominal products

Results

Post Metrology

PPAP - Design Records

Actual instances - of products

Statistics

SPC - Quality Records

"FeatureActual"  "FeatureItem"  "FeatureNominal"  "FeatureDefinition"

"CharacteristicActual"  "CharacteristicItem"  "CharacteristicNominal"  "CharacteristicDefinition"
Model Based Enterprise Quality use-case

Naming Things for “What they Are…”

# Tolerance Feature Taxonomy

- **Domain**: Class, Type, Attribute
- **Bi-Tolerance**: Feature-of-Size, Axial, Conical
- **Bi-Tolerance**: Feature-of-Size, Axial, Cylindrical
- **Bi-Tolerance**: Feature-of-Size, Axial, Threaded
- **Bi-Tolerance**: Feature-of-Size, Opposed Symmetrical, Radial
- **Bi-Tolerance**: Feature-of-Size, Opposed Symmetrical, Planar
- **Bi-Tolerance**: Feature-of-Size, Opposed Symmetrical, Planar Parallel
- **Bi-Tolerance**: Feature-of-Size, Planar
- **Bi-Tolerance**: Feature-of-Size, Radial Plane
- **Bi-Tolerance**: Feature-of-Size, Radial Segment
- **Bi-Tolerance**: Feature-of-Size, Radial Segment, Cylindrical
- **Bi-Tolerance**: Feature-of-Size, Radial Segment, Spherical
- **Bi-Tolerance**: Revolution
- **Planar Plane**: Axial
- **Planar Plane**: Planar
- **Composite Component**: Axial
- **Composite Component**: Planar
- **Composite Component**: Simple Pattern
- **Composite Component**: Simple Pattern, Axial

## QIF_2.1_Part3 MBE-tbl-DigitalModel 7.4.4.3
- **Data Type**: xs:string
- **Description**: The name of the model
- **File Name**: xs:token
- **File Version**: xs:token
- **Application Name**: xs:token
- **Application Addon Name**: xs:token
- **Application Addon Organization**: xs:string
- **Application Source Name**: xs:token
- **Application Source Organization**: xs:string
- **Units**: OtherUnitType
- **GDT**: GDTNumType
- **Topology**: TopologyType
- **Entities**: EntitiesExteriorType

---

Dimensions: ToleranceFeature

- **Conical**: Cylindrical, Spherical, Planar
- **Cylindrical**: Conical, Spherical, Planar
- **Spherical**: Conical, Cylindrical, Planar
- **Planar**: Conical, Cylindrical, Spherical
- **Radial**: Cylindrical, Spherical, Planar
- **Threaded**: Cylindrical, Spherical, Planar
- **Opposite Symmetrical Plane (Wedge)**
- **Surface of Revolution**: Cylindrical, Spherical, Planar
- **Toroidal Radiation**: Cylindrical, Spherical, Planar
- **Torus**: Cylindrical, Spherical, Planar

---

**Dimensional Metrology Standards Consortium (DNMSC™, Inc.)**
Model Based Enterprise Quality use-case

Naming Things for “What they Are…”

- SASIG – PDQ (Product Data Quality) Criteria Codes

```
X - YY - ZZ
```

Values allowed for the **Domain Identifier**:

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<table>
<thead>
<tr>
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<tr>
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<td>Analysis</td>
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<td>D</td>
<td>Drawing</td>
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<tr>
<td>G</td>
<td>Geometry - CAD data</td>
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<tr>
<td>I</td>
<td>Inspection</td>
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<td>M</td>
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<td>O</td>
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Values allowed for the **Parameter Identifier**:

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<td>AP</td>
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<tr>
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Values allowed for the **Representation Identifier**:

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<td>Layer Usage</td>
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<td>QU</td>
<td>QUadrilateral</td>
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</table>
Additional potential for MBE Quality use-case

Enabling Predictive Analysis

Naming Things for “What they Do…”

“Causa latet, vis est notissima” - Ovid

The cause is hidden, but the effect is clear

- **Requirements** are the conditions needed to solve a problem or achieve an objective. – the Y’s

- **Specifications** are documented - in a complete, precise, verifiable manner - definitions of the characteristics, behaviors, and procedures for determining whether these provisions have been satisfied. – the X’s
Future State - MBSE – REQuirement Management

Using a BoC for …

- Mapping the satisfaction of Functional Requirement (FR) to design parameter s (DP)
Organizing “functional associativity” among elements of an assembly
Enforce associativity between Functional Requirements and Product Characteristics
Organize "functional associativity" among elements of an assembly

<table>
<thead>
<tr>
<th>Domains</th>
<th>Abbr</th>
<th>Characteristic Categories</th>
<th>Description</th>
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<tbody>
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<td>Customer</td>
<td>CN</td>
<td>Customer Needs</td>
<td>elements that the customer seeks in a product or system</td>
</tr>
<tr>
<td>Functional</td>
<td>FR</td>
<td>Functional Requirements</td>
<td>the minimum performance to be met by the Design Alternative (Product)</td>
</tr>
<tr>
<td>Functional</td>
<td>FR</td>
<td>Req Specifications</td>
<td>the documented permissible limits (RS)</td>
</tr>
<tr>
<td>Functional</td>
<td>IC</td>
<td>Input Constraints</td>
<td>specific to overall design goals</td>
</tr>
<tr>
<td>Functional</td>
<td>IC</td>
<td>imposed externally by CNs</td>
<td></td>
</tr>
<tr>
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<td>IC</td>
<td>other constraints that the product has to comply with but not mentioned in the Customer Domain</td>
<td></td>
</tr>
<tr>
<td>Functional</td>
<td>IC</td>
<td>product users</td>
<td></td>
</tr>
<tr>
<td>Functional</td>
<td>IC</td>
<td>conditions of use</td>
<td>such as regulations</td>
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<td>DP</td>
<td>Design Parameters</td>
<td>Those elements of the design solution (physical domain) that satisfy specific FRs</td>
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<td>DP</td>
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<tr>
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<td>DP</td>
<td>Components; for Systems or Subsystems</td>
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</tr>
<tr>
<td>Physical</td>
<td>DP</td>
<td>Attributes; of individual Components</td>
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<tr>
<td>Physical</td>
<td>SC</td>
<td>System Components</td>
<td>categorical hierarchy representing the physical system architecture or product tree</td>
</tr>
<tr>
<td>Physical</td>
<td>SC</td>
<td>Segment</td>
<td>NASA</td>
</tr>
<tr>
<td>Physical</td>
<td>SC</td>
<td>Element</td>
<td>NASA</td>
</tr>
<tr>
<td>Physical</td>
<td>SC</td>
<td>Subsystem</td>
<td>Eppinger &amp; NASA</td>
</tr>
<tr>
<td>Physical</td>
<td>SC</td>
<td>Assembly</td>
<td>NASA</td>
</tr>
<tr>
<td>Physical</td>
<td>SC</td>
<td>Subassembly</td>
<td>NASA</td>
</tr>
<tr>
<td>Physical</td>
<td>SC</td>
<td>Component/Part</td>
<td>Eppinger / NASA</td>
</tr>
<tr>
<td>Process</td>
<td>PV</td>
<td>Process Variables</td>
<td>used to establish System Components SCs (was Design Parameters)</td>
</tr>
<tr>
<td>Process</td>
<td>PV</td>
<td>Dynamic Features (subject to change)</td>
<td>Current state: variable / ideal state: set-point</td>
</tr>
<tr>
<td>Process</td>
<td>PV</td>
<td>Controls</td>
<td>Typically: pressure, temperature, level and flow</td>
</tr>
</tbody>
</table>
Future MBE Quality use-case concerns

Interoperable Classifications for Characteristics

- **STEP AP242 needs calibration/direction**

http://www.ap242.org/ap242ed1
Summary

What are the Potentials for

- Encouraging a disciplined Management & Culture MBD Authoring and Usage
- Enabling Predictive Analysis & Simulation-led Design
- Aligning disparate standards ASME, STEP, etc…
- Commonizing Dimensional Quality Reporting for the IoT

All be embracing:

- Moving the ‘Planning’ activities (forward) into the MBD Authoring Schema

and seeking for Achieving:

Keep Your Eye on the Prize: "Compatibility before Completion"