A DIGITAL PRODUCT REALIZATION REVOLUTION

Enabled by Persistent Model-Based Product Characteristics

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2017 MBE Summit
Presentation Objective

• Promote an idea for how your company can attain maximum impact from your MBE Efforts.

  - Digital Product Acceptance

Help enable your Manufacturing Quality to Contribute to your Digital Enterprise
Overview

- Opportunity & Objective
- Model-Based Enterprise (MBE)
- Digital Product Realization Enterprise (DPRE)
  - Trusted Product Model
  - Managed with Confident Reuse
  - Throughout our Enterprise
- Model-Based Product Characteristics (MBC)
- Model-Based Quality
  - Model Quality Validation
  - Product Characteristics
  - Digital Product Acceptance
  - Quality Information Framework
- The Persistent Product Characteristic Story
- Challenge
Kansas City National Security Campus (KCNSC)

Government sponsored, multi-mission engineering and manufacturing enterprise delivering trusted national security products and government services

**KCNSC**
- 60+ Years of Continuous Service to Department of Energy
- Relocated in 2014 as a LEED® Gold-Rated Manufacturing Facility
- ~1.5 million sq. ft. facility

**Talented Work Force**
- 2,700 skilled employees in MO & NM
- Engineers, skilled trades workers, and support personnel

**Managed and Operated by Honeywell FM&T**

**Partners**
- Sandia National Laboratories
- Los Alamos National Laboratories
- Lawrence Livermore National Laboratories

**Customers**
- National Nuclear Security Administration
- Department of Energy
- Department of Defense
- Other Federal Agencies

Kansas City National Security Campus (KCNSC)
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The Opportunity

Opportunity Management:
To exploit an event that has not yet happened

Probability – Likelihood of an event occurring.
Impact – Value of benefits that can be realized!

Various Technologies/Standards have arrived or matured to realize a Model-Based Enterprise
The Ultimate Objective!

“Your processes / customer must allow for the acceptance / purchase of product from an authorized and certified part-defining model.”

The bridge for impactful benefits from MBE adoption, drives through Digital Product Acceptance.
MBE Expected Results

- New competitive advantage in
  - Faster – through Increasing Velocity of Product Realization
  - Smarter – by Allowing Next Generation Automation
  - Better – through Improving both Model and Product Quality
  - Cheaper – via Enabling Cost-Effective Downstream Processes
  - Safer – by Incorporating Innovative Ideas
  - Securer - through Digitally Controlling a Single Source of Truth

- Major Benefits come from downstream
  - Analysis & Simulation
  - Manufacturing (Additive & Subtractive)
  - Quality’s Contribution to the Enterprise
  - 3D Technical Data Package
  - Visualization & Animation
  - Automation via Digital Interoperability
  - Extends the Enterprise

Results will benefit product realization and acceptance
MBE Maturity Levels

MBE Solutions lifecycle matures and gains business value through MBE Assessment, Readiness, Adoption & Adaptive
Digital Product Definition Lexicons

• **Source Model:** The initial model, typically a native CAD model but it could be in the form of a derivative model format.

• **3D Annotated Model:** The model that contains associated 3D annotations for PMI (aka Model-Based Definition, Product Model)

• **Certified Model:** A Source model that has been quality certified (e.g., Certificate of model Quality) after performing various model validation checks (aka, Validated Model)

• **Authorized Model:** A Certified model that has been authorized for reuse. (aka, Part Defining Model)

• **Derivative Models:** Models derived or translated, typically from a native format, into a proprietary, public domain, or recognized standards body. Typically needed for downstream model-centric applications.
**MBE Maturity Index***

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### Model-Based Enterprise Maturity Index

**Assessment, Readiness, Adoption**

<table>
<thead>
<tr>
<th>Drawing-Centric</th>
<th>Model-Centric</th>
<th>Trusted Model Centric</th>
<th>MBD Centric</th>
<th>Authorized MBD Centric</th>
<th>Internal MBE Centric</th>
<th>Extended MBE Centric</th>
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<tr>
<td><strong>Level 0</strong></td>
<td><strong>Level 1</strong></td>
<td><strong>Level 2</strong></td>
<td><strong>Level 3</strong></td>
<td><strong>Level 4</strong></td>
<td><strong>Level 5</strong></td>
<td><strong>Level 6</strong></td>
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<tr>
<td>2D Drawings Only</td>
<td>3D Models create 2D Drawings &amp; Derivatives</td>
<td>3D Models create Drawings &amp; Derivatives &amp; Model Checked &amp; Managed. &amp; Derivatives Compared &amp; Certificate of Model Quality &amp; CAX Derivatives w/ 2D Drawing</td>
<td>Model-Based Definition w/ 3D Assoc. PMI &amp; 3D Interactive Viewables &amp; 3D Technical Data Packages &amp; MBD, Derivative &amp; CAX Managed from Part-Centric PLM</td>
<td>Model-Based Definition &amp; LOTAR &amp; 3DIV, 3D TDP &amp; MBD, 3DIV, TDP Deployed from PLM &amp; TDPs used &amp; Digital Mfg. Certificate</td>
<td>Model-Based Enterprise &amp; Product Characteristic &amp; Automated MBD &amp; TDP Deployment to Internal Operation &amp; LOTAR+ &amp; Model-Based Enterprise &amp; Authenticated Digital Exchange &amp; Automated MBD &amp; TDP Deployment to External Operation</td>
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<td>Models Adhoc</td>
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<td>Part-Centric</td>
<td>3D Model Authorized</td>
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<td>2D Drawings Authorized</td>
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<td>3D Model Authorized</td>
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</tbody>
</table>

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Apply the MBE Index for each Maturity Level

*Details are modified from original. Maintains the published MBE Capability Index baseline but Flavored for MBE at NSE*
MBE – The Epic Journey

Which Road are you on for MBE Impact?

The Road to MBE Impact is . . .
Trusted Product Models . . .

. . . Managed with Confident Reuse . . .

. . . Throughout our Enterprise©
Trusted Product Models . . .

- Prepare 3D Associative Annotated Models
- Certify Model Quality through Validations
- Use FBTol to Check & Advise on Tolerancing
- Authorize Certified Product Models for Reuse
- Product Characteristic designations with criticalities
- Authenticate Models with Digital Certificates

If you are going to rely on your model, it must be a reliable model… then prove it.
Trinity of Product Model Validations

Multiple Checks for Multiple Purposes, all to gain a Certified Product Model
Trusted Product Models – Geometry Checks

Status: 7% of the 513 model geometry checks had addressable geometry issues.
Trinity of Product Model Validations
PMI Checks

Trusted Product Models

Design Business Checks

Geometry Checks

KCNSe’s FBTo1

Make sure your products fit & function by communicating complete & correct PMI
Trusted Product Models – PMI Checks

Part Tolerance Definition Checking w/ Feature-Based Tolerancing (FBTol) Advisor

• Documented FBTol Tolerance Definition Analysis from period
  - FBTol Averages (low-high)
    ▪ 78.2% FBTol Score (30% - 99.76%)
    ▪ 24.1 Issues Identified (1 – 75)
  - Tolerance Definition Complexity Average (low-high)
    ▪ 83.7 Product Characteristics (5 - 1199)

Is your part’s tolerances complete and correct? Most likely not.
Trusted Product Model - Certified

Digital Manufacturing Certificate

• An Extension within Model File
  - A Digital Signature on Model file with Metadata
    ▪ NIST DMC Toolkit
  - Quality Digital Certificate of model (CoQ)
    ▪ Certificate of Model Quality
      – Source Models: Check Quality
      – Derivative Models: Functionally Equivalent w.r.t. Source
  - Authorization Digital Certificate for reuse
  - Authenticity Digital Certificate
    ▪ Genuine, it is still what it is.

Indicates that the model is legitimate and verified . . . and then make it known.
Product Characteristic: a tolerance or specification applied to a feature or product that needs verification. A characteristic may have a criticality associated with it.

Product Characteristics can be Designated for Human Consumption And Persist for Digital Consumption!
More Lexicons

- **PMI: Product & Manufacturing Information** – the annotations added to the product definition such as GD&T, notes, symbols, specifications, & tables.

- **PMII: Product, Manufacturing, & Inspection Information** – PMI extended with *product characteristic designators* and *criticalities* that directly support quality.

- **DPD: Digital Product Definition** – the digital information needed that fully describes the geometry (e.g., 3D model) and all associated data elements for defining the product:
  - Geometry (both shape & supplemental)
  - Associated PMI (product & manufacturing information),
  - Associated metadata/parameters (e.g., material, classification),
  - Presentation states (i.e., combination states), and
  - *Product Characteristic designations w/ criticalities*,

Curtis W. Brown, 2016
Create Certified Derivatives w.r.t. Authorized Model

- Scrubbed Native Models for extended Reuse
- Extend Partr-Centric LifeCycle Management

3D Interactive Viewable (3DIV)
Succeeds the 2D Static Drawing as the preferred human consumption format.

Derivatives Contribute to Analysis, Manufacturing, and Verifications

Part-Centric
Product Lifecycle Management
Throughout our Enterprise

- **Empower Manufacturing & Quality** with Trusted Models
- **Product Characteristic** designations with criticalities
- **Digital Bill of Characteristics** (BoC)
- **QIF** Enables Quality to Digitally Contribute to the Enterprise
- Prepare **3D Technical Data Package (TDP)**
- Model-Based Animations for Process Instructions
- Measure our Progress with the **MBE Maturity Index**
- **Functional Pilots** to prove-in and demonstrate
- Model-Based Business Workshop (MBBW)
- **Enable Additive Manufacturing**
- **Digital Exchange with External Suppliers**

3D TDP becomes the Manufacturing Authorization
Digital Product Acceptance Activity Workflow

Design Product

Determine Measurement Requirements

Define Measurement Process

Execute Measurement Process

Analyze & Report Quality Data

Part Results Report w/ Analysis

Quality Metrology Enterprise

Business Practices

Tolerance Standards

Quality Requirements

Manufacturing Process

Metrology Resources

Metrology Knowledge

Metrology Resources

Performance Measurements

Metrology Knowledge

Perform CNC CMM Program

Perform Other Measures

Evaluation Results
The QIF Standard – What does it do?

- **Quality Information Framework (QIF) – DMSC/QIF 2016 (v2.1)**
- **An Integrated Model for Manufacturing Quality Information**
- ** Defines, Constrains, and Exchanges:**
  - Model-Based Definition
    - Feature-Based Semantic PMI
  - Quality Planning
    - Bill of Characteristics (BoC)
    - Inspection Plan
  - Measurement Execution
    - DMIS 5.3 w/QPIIds
  - Measurement Results
    - Piece Part
    - Statistical
  - Enterprise Connectivity for Quality Feedback
    - Quality Persistent ID (QPId) (i.e., universal unique ID)
    - 651aded1-ff04-498a-968e-044147a2506d
QPIds – Persistent UUID within the QIF

QIF Persistent Identifier (QPId) noun Cu·pid \ˈkyü-pəd\  
- Universally Unique Identifier (UUID) (adopted by Microsoft as GUID)  
  - ISO/IEC 9834-8  
  - 550e8400-e29b-41d4-a716-446655440000  
- Chances of generating two that are the same within the universe are practically nil.  
  - $3.4 \times 10^{38}$ possible UUIDs  
- Allows information to be combined later without resolving identifier conflicts  
- Many software development libraries generate UUIDs  
- QPIds uniquely identify  
  - QIF Document  
  - QIF Plan  
  - QIF Result  
  - QIF Rule Set  
  - Feature Item  
  - Characteristic Item  
  - Product Item  
  - Resource Item

An Important Mechanism that facilitates Lifecycle Connectivity
Use Case: Document-Base BoC – “Ballooning the Drawing” (Just in Time)

1. Design Product
2. Determine Measurement Requirements
3. Define Measurement Process
4. Execute Measurement Process
5. Analyze & Report Quality Data

- Business Practices
- Tolerance Standards
- Quality Requirements
- Manufacturing Process
- Metrology Resources
- Metrology Knowledge

Product Requirements
Product Definition w/ PMI

Work Activity

Part Results Report w/ Analysis

Curtis W. Brown, 2016
Use Case: QIF Plan BoC QPIId

QIF w/ QPIId BoC enables Quality to add Value to the Enterprise
Bill of Characteristics

BoC: Bill of Characteristics – the complete listing of characteristics required for verifying that a product meets requirements. A BoC can be represented via ANSI/QIF.

<table>
<thead>
<tr>
<th>Char No.</th>
<th>Criticality</th>
<th>Characteristic</th>
<th>Feature</th>
<th>Requirement</th>
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<th>Minus</th>
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</table>

**Human-Readable BoCs**

**Machine-Read/Writeable QIF/BoC**

DMSC/QIF ANSI Standard allow BoCs to be Digitally Consumed, Enabling Closed-Loop Automation.
Use Case: QIF MBPC BoC QPIIds

QIF w/ QPIIds BoC enables Quality to directly influence Product Design
PMII Investment Returns Value to the Investor

Product Characteristic Designators w/ Criticalities

Model-Based Product Characteristics (MBPC): the use of a Model-Based Definition with *persistent product characteristics designations*.

Persistent Model-Based Product Characteristics: Enables Measurement Results to be Return Back to the Model
QIF Document Bus Enables Quality

QIF Document (XML) Bus

QIF-MBD
QIF-Plans
QIF-Resources
QIF-Rules
QIF-Execution w/ DMIS 5.3
QIF-Results
QIF-Statistics
The MBPC Impact to the MBE

• QIF Product Characteristics with QPIIds (MBPC) enables feedback of measurement results back to the MBD.

We can also observe the Characteristic Actual data from the QIF document.
The Incredible Journey of PC007 the QPlId

There and Back Again:
An Incredible Journey
by PC007
the Product Characteristic Item

w/ QPlId
a52e4476-08cb-4f7f-a7dc-923a0ab58c2c
The Road to MBE Impact

• MBE - The Epic Journey
• MBPC - The Bridge
• MBQ - Our Part of the Story

The Road to MBE Impact is on the DPA road over the MBPC Bridge
The DMSC progresses and maintains the QIF and values your Involvement

- **Now is the time, get involved by:**
  - **Notify Your Favorite Vendor about the Benefits of the QIF**
  - **Have Your Metrology Department Plan for the Use of the QIF**
  - **Inform Your MBE Team the Impact of the QIF to MBE**
  - **Present or Attend the 2017 QIF Summit**
  - **Joining the DMSC along with your Favorite Vendor**

- **DMSC Membership (www.DMSC-Inc.com)**
  - bsquier@dmsc-inc.com to Request an Application

- **QIF Involvement (www.QIFStandards.org)**
  - One or Many Working Groups

- **Download DMSC/QIF 2016**
  - www.QIFStandards.org/download-qif/
The DMSC values your Participation

https://www.action-engineering.com/3dcic

- Presentation
- Sponsorship
Promote the Use and Advantages of:

Persistent Model-Based Product Characteristics

- Digitally Produced Early in the Product Lifecycle
- Digitally Consumed throughout the Enterprise
- Human-Readable
- Computer-Interoperable through QPIIs
- Exchange via Quality Information Framework (QIF)
Remember The Challenge!

“Your customer / processes must allow for the acceptance / purchase of product from an authorized and certified part-defining model.”

The Bridge for impactful benefits from MBE adoption, drives through **Digital Product Acceptance**.
Thank you

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