Model-Based Quality enabled by Persistent Product Characteristics

Curtis W. Brown
Principal Engineer
Honeywell FM&T
• **Introduction**
  • Kansas City National Security Campus
  • Honeywell FM&T
  • Speaker Information

• **Model-Based Enterprise (MBE) - The Epic Journey**

• **Model-Based Characteristics (MBC) - The Bridge**

• **Model-Based Quality (MBQ) - Our part of the Story**
  • Trusted Product Models
  • Product Characteristics
  • Quality Information Framework

• **IMTS 2016 Demonstration and Message**

• **The Persistent Product Characteristic Story**

• **Way Forward**
Kansas City National Security Campus

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

Core Mission – National Nuclear Security Administration
– A large portion of the Campus is dedicated to NNSA’s mission of keeping our nation’s nuclear stockpile safe, secure and reliable by delivering mission-critical mechanical, electrical and engineered material components.

Global Security – Other Government Agencies
– Our unique expertise extends beyond the nuclear security enterprise to benefit national security and promote nonproliferation with field-ready solutions for other government agencies.

Supply Chain Management Center – Department of Energy
– Using our innovative strategic sourcing processes, we enable DOE and NNSA sites to leverage their annual spend to save millions each year.
Managed and Operated by Honeywell FM&T

Kansas City National Security Campus located in Kansas City, MO

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

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
Speaker information

Curtis W. Brown

- Hired as a Quality Engineer support CMM product inspections
- Currently Principle Mechanical Engineer in Design Services
- FM&T’s Focus Lead for Model-Based Enterprise
- Technology Creator of Feature-Based Tolerancing (FBTol) Advisor
- Volunteer President of the Dimensional Metrology Standards Consortium
What is Model-Based Enterprise (MBE)?

MBD: An 3D annotated model and its associated data elements that fully define the product definition in a manner that can be communicated and used effectively by all downstream customers without a drawing graphic sheet.

Model-Based Enterprise starts with a Trusted MBD
What is Model-Based Enterprise (MBE)?

MBE: A fully integrated and collaborative environment founded on a 3D MBD, validated, authorized, and shared across the enterprise to enable the realization of products from concept through sustainment.

An organization that successfully reuses MBD

Initial Source: SAE Systems

Analyze

Manufacture

Monitor

End Of Life

Requirements

Concept

Design

Production

Sustain

Realization

3DMBD

Model

Inspection

Initial Source: SAE Systems

An organization that successfully reuses MBD

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The Road to MBE Impact

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

The Road to MBE Impact is the MBQ road over the MBC Bridge
KCNSC’s Digital Product Realization Enterprise

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VISION

Trusted Product Models, with Confident Reuse, Throughout Our Enterprise

1. Establish Trusted 3D Annotated Master Models
2. Certify Equivalent Derivative Models
3. Enable Manufacturing & Quality Collaboration
4. Communicate & Release 3D Product Viewables
5. Focus on Preparing 3D Technical Data Package
6. Build “Case Law” Implementation Approach
7. Evaluate Progress against MBE Capability Roadmap

GOALS

From a Trusted 3D Model-Based Definition to a 3D Technical Data Package to the Enterprise
KCNSC’s Digital Product Realization Enterprise

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Trusted Product Models . . .

. . . 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

If you are going to rely on your model, it must be a reliable model… then prove it.
Important Terms and Definitions

- **PMI: Product and Manufacturing Information** – the annotations added to the product definition such as GD&T, notes, symbols, specifications, & tables.
- **DPD: Digital Product Definition** – the digital information needed (e.g., 3D model) to fully describe the geometry and all design requirements for the product:
  - **Geometry (both shape & supplemental)**
  - PMI (product & manufacturing information),
  - Associated metadata, and
  - Presentation states (combination states)
Trinity of Product Model Validations

Multiple Checks for Multiple Purposes, all to gain a Certified Product Model

Design Business Checks
Geometry Checks
PMI Checks
Status: 7% of the 513 model geometry checks had “hot” geometry issues
Status: For parts that are “Geometry Rich”, 80% of model geometry checks identify addressable issues.
Trinity of Product Model Validations - PMI Checks

Make sure your products fit & function by communicating complete & correct PMI
Feature-Based Tolerancing (FBTol) Advisor

- Is your Part’s tolerances complete and correct?

Technology that Represents Fully Semantically Part Tolerances on solid models and Check for Completeness and Correctness
Trusted Product Model – PMI Checks

• Part Tolerance Definition Checking w/ FBToI

• Documented FBToI Tolerance Definition Analysis this period
  • 40 Analysis
  • FBToI Averages (low-high)
    – 78.2% FBToI Score (30% - 99.76%)
    – 24.1 Issues Identified (1 – 75)
  • Tolerance Definition Complexity Average (low-high)
    – 83.7 Characteristics (5 - 1199)
• Master Models: Certify Quality then Authorized for Reuse

• Derivative Models: Certified back to Master Model

• Model Certification: Certify Model Quality
  • Manual Certificate: via Separate Accompanying Documentation
  • Digital Manufacturing Certificate: Extension with Model File
    – Considering widely accepted X.509 Digital Certificate Standard
    – Investigations with NIST’s Thomas Hedberg – EngrLab

If you are going to rely on your model, it must be a reliable model. . . and then make it known.
with Confident Reuse

- Create **Certified Derivatives** w.r.t. the Master
- Generate 3D Interactive Viewables (**3DIV**)  
- Extend **Product-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
Interoperability with Derivatives

- Derivative Models Certified as Functionally Equivalent to Authorized Model
- STEP is always an *Intermediary* Derivative Model

Downstream Applications are Enabled by Derivatives
Interoperability with Derivatives

- Derivative Models Certified as Functionally Equivalent to Authorized Model
- STEP is always an Intermediary Derivative Model
- Other Derivatives: Scrubbed Models; In-Process Models, AM Models, Physics Models
- Also Consider Direct Derivative Models, and prepare for:
  - ANSI / QIF MBD – Quality Information Framework (has PMI, Metadata, Presentation States)
  - ISO 10303-AP242 – Managed Model-Based 3D Engineering (has PMI, but modular and …)
- Adopting Orphaned Models back into CAD Assemblies

Downstream Applications are Enabled by Derivatives
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 Definitions
- Measure our Progress with the **MBE Capability 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
Model-Based Quality (MBQ)

- MBQ is the conformance to the requirements of the product using measurement planning, execution, and evaluating in combination with a 3D model, \textit{PMI (characteristics)}, and associated data.
- MBQ is validating the quality of your product models and defining the quality process definition necessary for digital product realization.
- MBQ takes advantage of product characteristics grouped as a Bill of Characteristics.
- MBQ starts with a Quality Model and Results in a Quality Product.

The Quality of your Products will Reflect the Quality of your Models.
Model-Based Quality Activity Workflow

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Business Practices

Tolerance Standards

Quality Requirements

Product Definition w/ PMI & Criticalities

Manufacturing Process

Design Product

Determine Measurement Requirements

Measurement Scope (whats)
a.k.a. BoC

Define Measurement Process

Inspection Plan (whats & hows)

Execute Measurement Process

Perform CNC CMM Program

Perform Other Measures

Part Results Report w/ Analysis

Quality Metrology Enterprise

Work Activity

Metrology Resources

Metrology Knowledge

Analyze & Report Quality Data

Evaluation Results

Control

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Model-Based Quality Activity Workflow

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Design Product → Certified QIF MBD → Determine Measurement Requirements → Define Measurement Process → Execute Measurement Process → QIF Results

Business Practices → Tolerance Standards → Quality Requirements → Manufacturing Process → Metrology Resources → Quality Metrology Enterprise

Part Results Report w/ Analysis

DMSC ANSI / ISO Standards
- ISO / DMIS V5.2 Standard - 2009
- ANSI QIF V1.0 Standard - 2013
- ANSI QIF V2.0 Standard - 2014
- ANSI QIF v2.1 DMIS V5.3 Standard - 2016

DMIS ANSI QIF v2.1
- DMIS V5.3 Standard - 2016
- ANSI QIF V1.0 Standard - 2014
- ANSI QIF V2.0 Standard - 2013
- ISO / DMIS V5.2 Standard - 2009

Certified QIF MBD
- Product Definition w/ PMI & Criticalities
- Quality Requirements
- Measurement Scope (whats) a.k.a. BoC
- Inspection Plan (whats & hows)

QIF Plans (whats & hows)
- QIF-Rules
- QIF Knowledge
- QIF Resources

Define Measurement Process
- Measurement Resources
- Metrology Knowledge
- Inspection Plan (whats & hows)

Part Results Report w/ Analysis

Evaluate Results

QIF Statistics

Perform CNC CMM Program
- Perform Other Measures
- DMIS

Control

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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 – A Persistent UUID used within the QIF

QIF Persistent Identifier (QPID) noun Cu·pid \\ˈkə-pəd\\
- Universally Unique Identifier (UUID) (adopted by Microsoft as GUID)
  - ISO/IEC 9834-8
  - 550e8400-e29b-41d4-a716-446655440000
  - 340000000000000000000000000000000000000 (3.4x10^{38}) possible UUIDs
- Chances of generating two that are the same within the universe are practically nil.
- Many software development libraries generate UUIDs
- Allows information to be combined later without resolving identifier conflicts
- 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
Important Terms and Definitions

- **Product Characteristic**: a tolerance or specification applied to a feature or product that requires verification. A characteristic has designation identifier(s) and may have a criticality associated with it. A product characteristic may exist because of a product requirement.

- **Bill of Characteristics (BoC)**: the complete listing of characteristics required for verifying that a part meets requirements. A BoC can be represented via DMSC/QIF standard.

- **Model-Based Characteristics (MBQ)**: the use of a Model-Based Definition with product characteristics designated.

- **Quality Information Framework (QIF)**: a new American National Standard (ANSI) for the digital interoperability of information supporting model-based definition, manufacturing quality processes, and measurement results.
Quality Plan BoC QPlId Use Case

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Business Practices

Design Product

Certified QIF MBD

Quality Requirements

Tolerance Standards

Determine Measurement Requirements

QIF Plans (whats)

Metrology Resources

Manufacturing Process

QIF Rules

Define Measurement Process

QIF Plans (whats & hows)

Metrology Knowledge

Inspection Plan (whats & hows)

QIF Resources

QIF Results

QIF Statistics

Part Results Report w/ Analysis

Perform CNC CMM Program

Perform Other Measures

DMIS

Evaluate Results

Analyze & Report Quality Data

QIF w/ QPlId BoC enables Quality to add Value to the Enterprise

DMSC ANSI / ISO Standards

ISO / DMIS V5.2 Standard - 2009

ANSI QIF V1.0 Standard - 2013

ANSI QIF V2.0 Standard - 2014

ANSI QIF v2.1 DMIS V5.3 Standard - 2016

Certified QIF MBD

Measurement Scope (whats) a.k.a. BoC

Perform CNC CMM Program

Perform Other Measures

DMIS

Evaluation Results

Analyze & Report Quality Data

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**Bill of Characteristics**

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<table>
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<tr>
<th>Char No.</th>
<th>Criticality</th>
<th>Characteristic</th>
<th>Feature</th>
<th>Requirement</th>
<th>Plus</th>
<th>Minus</th>
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<td>Minor</td>
<td>Size +/- 0.1</td>
<td>Hole #9</td>
<td>12</td>
<td>0.1</td>
<td>-0.1</td>
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<td></td>
<td></td>
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<tr>
<td>KC0099</td>
<td>Major</td>
<td>Paint color</td>
<td>Product</td>
<td>JohnDeere Green</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Human-Readable BoCs

### Machine-Read/Writeable QIF/BoC

DMSC/QIF ANSI Standard allow BoCs to be Digitally Consumed, Enabling Closed-Loop Automation

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Product Characteristics can be Designated for Human Consumption
And QIF Allows for Digital Consumption!

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QIF w/ QPIIds BoC enables Quality to directly influence Product Design
QIF is not just a data structure but includes formal rules for data interaction within that structure.

QIF standard transfers the burden of data quality from the application developer to the standard itself.
IMTS 2016 – ANSI QIF Interoperability Demonstration

ANSI QIF Interoperability Demonstration
IMTS 2016
IMTS 2016 – The Message

Quality is a Requirement .. Make it Easier with the QIF

Manufacturers want:

- **Freedom of choice** in selection of value and performance based metrology solutions.
- Quality solutions that **communicate** the **value** of their inspections back to design & manufacturing.
- **Interoperability** between current software & equipment solutions.

DMSC Announces:

- New **Business Model** for Manufacturing Quality.
- Digital information exchange standard DMSC/QIF 2.1.
- QIF is **powerful** and relatively quick and easy to implement.

Business Model:

- **Mandate** the use of QIF within your enterprise
- **Join the DMSC** with your preferred suppliers to progress change
- Both organizations **Reap Cost Savings.**
Quality is a Requirement .. Make it Easier with the QIF

QIF offers:

- **Mature** ANSI Standard (v2.1)
- Solution providers that have **Implemented** QIF
- Results from Software Scientists and Dimensional Metrology Experts
- Reflects the **state-of-the-art**
  - Model-Based Definition
  - Feature-Based Tolerancing
  - Quality Planning with Bill of Characteristics (BoC)
  - Robust Measurement Results with Persistent IDs
  - Modern Software Development Techniques
- **500 Years of Experience** in Metrology, GD&T, & Software Development
- **Value-Added** proposition to Manufacturing and Design
- Energized the dimensional metrology development community
IMTS 2016 – ANSI QIF Interoperability Demonstration

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IMTS 2016 – ANSI QIF Interoperability Demonstration

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3D Technical Data Package (TDP)

- Recognized as the Digital Manufacturing Authority
- A collection of all product data elements needed to Acquire, Manufacture, and/or Sustain the product
- Viewed as a competitive advantage but likely to become a requirement.
- Regulated – DoD’s MIL-STD-31000A
TDP is a package containing Technical Data Elements.

For Example:

- Models
  - Native
  - Derivatives
  - Model Check Report
  - Model Certificates
- Viewables
  - 3D Interactive Views
  - 2D Static Drawings
- References
  - Included
  - Hyperlinked
  - External
  - External
- Quality Support
  - Bill of Characteristics

...Throughout our Enterprise
3D Technical Data Package

- Manufacturing Authority
- PDF Container

... Throughout our Enterprise

KCNSC’s Inspection Request 3D Technical Data Package
The QIF advances the OEM/Supplier Relationship

Use Case Measurement Scope (BoC)

OEM

3D Master Product Model

Certified QIF MBD

Product Definition w/ PMI & Criticalities

Determine Measurement Requirements

QIF Plans (BoC)

Part Report & Analysis

Analyze & Report Quality Data

OEM / Supplier Relationship w/ QPIds

Supplier1

QIF Results

Supplier2

QIF Results

Supplier3

QIF Results

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Certified QIF MBD

QIF Statistics

3D Technical Data Package

• Derivative Models
• Certified QIF MBD
• QIF Plan (BoC)
• QIF Rules
• ...

OEM Metrology Knowledge

QIF Rules

3D Master Product Model

Determine Measurement Requirements

Measurement Scope (whats)
The QIF advances the OEM/Supplier Relationship

Use Case Inspection Plans

OEM

- Determine Measurement Requirements
  - Product Definition w/ PMI & Criticalities

- Define Measurement Process
  - Measurement Scope (whats)

- Inspect Plan (whats & hows)

- 3D Technical Data Package
  - Derivative Models
  - Certified QIF MBD
  - QIF Plan (BoC)
  - QIF Plan
  - ...

- Analyze & Report Quality Data

- Part Report & Analysis
  - Supplier N Metrology Resources

- QIF Rules

- QIF Resources

- OEM Metrology Knowledge

- QIF Plans (Insp. Plan)

- QIF Plans (BoC)

Supplier 1
  - QIF Results

Supplier 2
  - QIF Results

Supplier 3
  - QIF Results

OEM / Supplier Relationship w/ QPIs

Certified QIF MBD

3D Master Product Model
The QIF advances the OEM Fabrication
Use Case: Internal

OEM

3D Master Product Model

Product Model

Certified QIF MBD

Determine Measurement Requirements

QIF Statistics

Part Report & Analysis

Analyze & Report Quality Data

OEM w/ QPIds

QIF Plans
(BoC)

QIF Rules

QIF Plans
(Insp. Plan)

3D Technical Data Package
- Master Model
- Derivative Models
- Certified QIF MBD
- QIF Plan (BoC)
- QIF Rules
- ...

3D Master Product Model w/ PMI & Criticalities

Measurement Scope (whats)

OEM Metrology Knowledge

QIF Statistics

OEM w/ QPIds

Evaluation Results

Internal Fabrication / Verification

QIF Rules

Certified QIF MBD

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The Incredible Journey of KC007 the QPId

There and Back Again: An Incredible Journey by KC007 the Product Characteristic Item w/ QPId

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A “major” Product Characteristic Item was conceived during a QIF process when a positional tolerance: `[Pos|0.50m|B|A|C]` was applied to the cylindrical feature: `J_19.0dHole001`.

He was born on the digital product definition: QIF Widget IMTS 2014, known universally has: `<QPlid>c4c8e922-e8c2-45cd-ad75-9995e2ad578d</QPlid>`
The incredible journey of KC007 the QPId

The universe gave this Product Characteristic Item the unique identity of: 

<QPId>a52e4476-08cb-4f7f-a7dc-923a0ab58c2c</QPId>

His friends and family called him: “KC007”.

Define Product Model

Certified QIF MBD
His closest friend was a Cylinder Feature Item known as J_19.00dHole001. This feature was known universally as: `<QPId>aac45384-6573-4684-ad34-15c9c04a4321</QPId>`.

Interestingly, this feature obtained a Datum J status and pointed to a face known within the product as: Face-15.
The Incredible Journey of KC007 the QPIId

His conception in the QIF v2.0 could be written as:

```xml
<PositionCharacteristicItem id="99">
  <Name>Pos0.5mBAC</Name>
  <QPIId>
    a52e4476-08cb-4f7f-a7dc-923a0ab58c2c
  </QPIId>
  <KeyCharacteristic>
    <Designator>KC007</Designator>
    <Criticality>MAJOR</Criticality>
  </KeyCharacteristic>
  <FeatureItemIds N="1">
    <Id>95</Id>
  </FeatureItemIds>
  <CharacteristicNominalId>98</CharacteristicNominalId>
  <LocationOnDrawing>
    <DrawingId>3</DrawingId>
  </LocationOnDrawing>
</PositionCharacteristicItem>
```
The Incredible Journey of KC007 the QPId

Later he was collected with a group of other Product CIs and teamed together as a Bill of Characteristics (BoC). They were assigned to a QIF Plan.

<QIFPlanAsInstanceQPIId>3dfa570f-bf56-4635-bcd2-5d01224b36d8</QIFPlanAsInstanceQPIId>
Soon he was matched from a list of measurement resources with a measurement method for how he could be verified.

Define Measurement Process

Then his team of BoCs was sequentially ordered as an Inspection Plan for verification by Manufacturing Quality.
Interestingly, his product, QIF Widget, was to be realized by multiple suppliers at different location throughout the universe. Therefore, his BoC and Inspection Plan was packaged within a digital Technical Data Package (TDP).

And the TDP was delivered to three suppliers. Each supplier realized a lot of QIF Widgets.
The Incredible Journey of KC007 the QPIId

After the products were realized, they were all shipped home for verification on a coordinate measuring machine (CMM).

Execution of the measurement process involves the creation of a DMIS (dimensional measuring interface standard) CMM part program. With the new DMIS major word REFID for QPIId reference ID:

```
DMISMN/'QIF Widget', 5.3
... F(FCY95) = FEAT/CYLNDR,
      INNER,CART,x,y,z,i,j,k,19.0
T(TPS99) = TOL/POS,
      3D,0.050,MMC,DAT(B),DATA),DAT(C)
KC(KC007) = KEYCHAR,F((FCY95),T(TPS99)
REFID/KC(KC007), NAME, 'QPIId',
'a52e4476-08cb-4f7f-a7dc-923a0ab58c2c'
MEAS/CYLNDR,F(FCY95),33
EVAL/KC(KC007)
... ENDFIL
```
Performing the CNC DME part program, verifies the KC007 for each actual part by probing the measurement feature.
The Incredible Journey of KC007 the QPId

Measurements from each KC007 produced QIF Results

No matter where the inspection was performed, the QPId allows us to group each piece-part’s KC007 and perform QIF Statistics.
The Incredible Journey of KC007 the QPId

Returning home to KC007’s digital product definition, KC007’s can communicate about his actual results …

… and through QPIIds, he can provide feedback on his feature relationship with J_19.0dHole001

What a incredible journey:
• from digital product definition
• to product realization,
• to product verification,
• to reporting, and
• back to digital product definition.
The Incredible Journey of KC007 the QPlId

And it does not end there. KC007 and his digital product definition, inspection plan, and measurement actuals can be long term archived for future retrieval!

KC007, through his QPlId connects, lived long and happily ever after and was remembered when called upon.

The End

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The Road to MBE Impact

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

Our MBQ Story has Progress Across MBC Bridge
Our Interest in the QIF

Quality is a customer requirement
It is neither free nor optional;
However, it can be achieved
  • Faster
  • Better,
  • Cheaper,
  • Smarter

with Innovation and Standards-Based Digital Interoperability

QIF is a effective standards solutions since:
  • Contains inherent validations for data correctness
  • XML-Based Implementation
  • Cost efficient to implement and use
  • Complete but extensible
  • Enables the Model-Based Enterprise
• A not-for-profit, cooperative sponsorship organization with members Large and Small

• Focused on or relating to Digital Dimensional Metrology

• Dedicated to identifying, promoting, fostering, and encouraging the Development and Interoperability of Standards that benefit the dimensional metrology community.

• An ANSI accredited Standards Making organization with ISO fast-track international presence

• Brought you the DMIS ISO Standard, the most influential standard in the industry

• Developed and ANSI standardized the Quality Information Framework (QIF), a full end-to-end Digital Metrology Interoperability solution
Participants

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DMSC Consortium Members

- Action Engineering
- Advanced Dimensional Management
- Applied Automation Technologies
- Capvidia
- Deere & Company
- Honeywell FM&T
- Innovalia Metrology
- InspectionXpert
- Kotem Technologies
- Lockheed Martin
- MBD360 LLC
- MetroSage LLC
- Mitutoyo America Corp
- Nikon Metrology
- NIST
- Origin International, Inc.
- PAS Technology
- QIF Solutions
- Renishaw
- Siemens PLM Software
- UNC-Charlotte

Associated Organizations

Open to all who have a Direct and Material Interest

- Rolls Royce
- Pratt Whitney
- GE Aviation
- Boeing
- DISCUS Software
- Lockheed Martin
- Hexagon Metrology
- MTCconneXt
- Renaissance Services
- Validation Technologies
- IPI Solutions
- Manufacturing Technology Centre
- PTC
- Net-Inspect
We value your Involvement

- **Encourage:**
  - Your Favorite Vendor to Investigate the Benefits of QIF
  - Your Metrology Department to Plan for the Use of the QIF
  - Your MBE Strategy Team to Plan for the Use of the QIF
  - Visit the DMSC Booth at IMTS 2016
  - Present or Attend the QIF Summit, 2017
  - Join us, we would value your involvement!

- DMSC Membership ([www.DMSC-Inc.com](http://www.DMSC-Inc.com))
  - bsquier@dmsc-inc.com to Request an Application

- QIF Involvement ([www.QIFStandards.org](http://www.QIFStandards.org))
  - One or Many Working Groups

- Download DMSC/QIF 2016
  - [www.QIFStandards.org/download-qif/](http://www.QIFStandards.org/download-qif/)