

Curtis Brown
2017 MBE Summit

A DIGITAL PRODUCT REALIZATION REVOLUTION

Enabled by Persistent Model-Based Product Characteristics



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

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

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



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!

Public Domain Image, Source Christopher S. Baird

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.”



Category	Definition	Revision	Code	Date
Category	Category	Revision	Code	Date
Document Number	Document Number	Revision	Code	Date
Revision	Revision	Code	Date	
Request Program	Request Program	Code	Date	
Request Authority	Request Authority	Code	Date	
Request Authority	Request Authority	Code	Date	

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

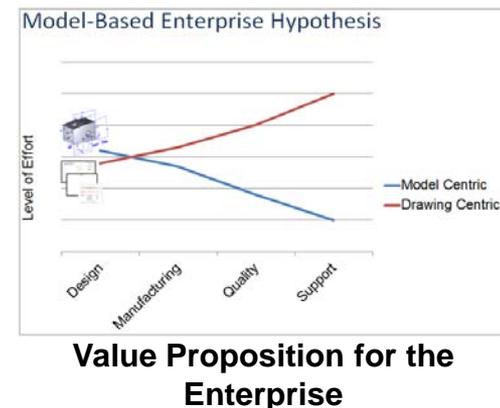
MBE Expected Results

- 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

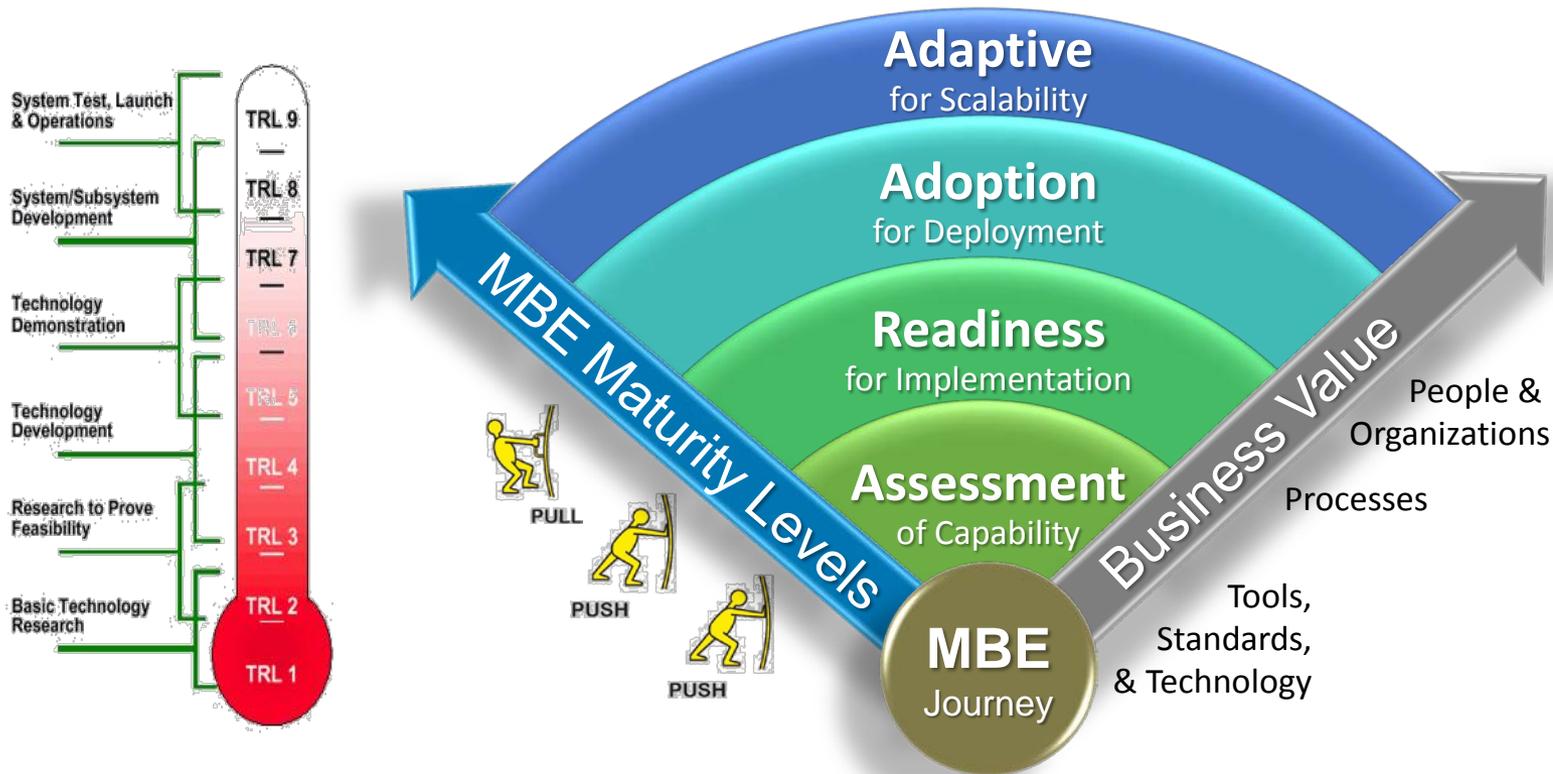
- Major Benefits come from downstream

- **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*

Model-Based Enterprise Maturity Index Assessment, Readiness, Adoption

Drawing Centric	Model Centric	Trusted Model Centric	MBD Centric	Authorized MBD Centric	Internal MBE Centric	Extended MBE Centric
Level 0	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
<ul style="list-style-type: none"> • 2D Static Drawings Only • Models Adhoc • Models not managed 	<ul style="list-style-type: none"> • 3D Models create 2D Drawings • STEP AP203 Derivative • CAX STEP & 2D Drawings • Models may be managed 	<ul style="list-style-type: none"> • 3D Models create Drawings & Derivatives • Model Checked & Managed. • Derivatives Compared • Certificate of Model Quality • CAX Derivatives w/ 2D Drawing 	<ul style="list-style-type: none"> • Model-Based Definition w/ 3D Assoc. PMI • 3D Interactive Viewables • 3D Technical Data Packages • MBD, Derivative & CAX Managed from Part-Centric PLM 	<ul style="list-style-type: none"> • Model-Based Definition • LOTAR • 3DIV, 3D TDP • MBD, 3DIV, TDP Deployed from PLM • TDPs used • Digital Mfg. Certificate 	<ul style="list-style-type: none"> • Model-Based Enterprise • Product Characteristic • Automated MBD & TDP Deployment to Internal Operation • LOTAR+ 	<ul style="list-style-type: none"> • Model-Based Enterprise • Authenticated Digital Exchange • Automated MBD & TDP Deployment to External Operation
Drawing-Centric	Drawing-Centric	Drawing-Centric	Part-Centric	Part-Centric	Part-Centric	Part-Centric
2D Drawings Authorized	2D Drawings Authorized	2D Drawings Authorized	2D Drawings Authorized	3D Model Authorized	3D Model Authorized	3D Model Authorized

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 . . .

Digital Product Realization Enterprise



VISION

Trusted Product Models . . .

. . . Managed with Confident Reuse . . .

. . . Throughout our Enterprise®

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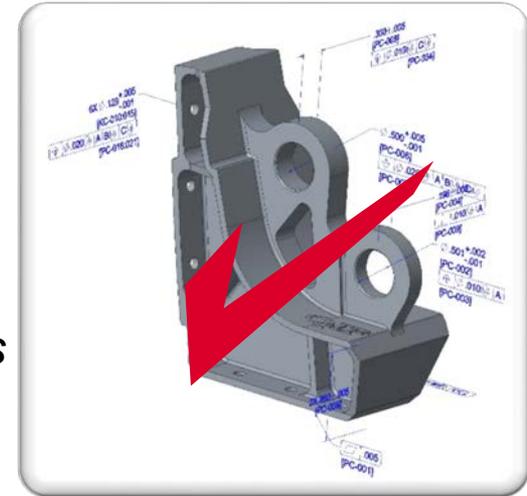
Digital Product Realization Enterprise

Trusted Product Models with Confident Reuse Throughout our Enterprise[©]

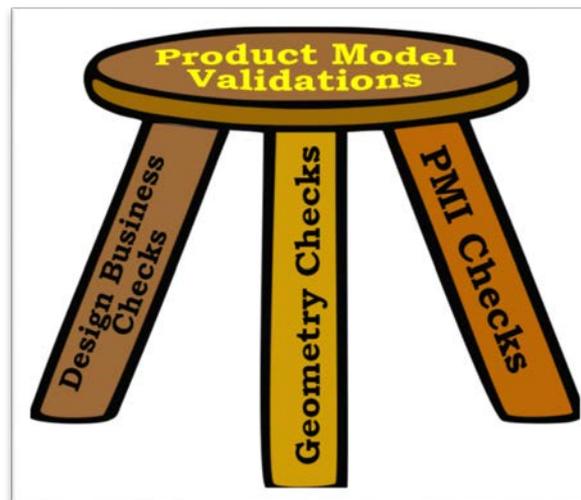
Trusted Product Models . . .

- *Prepare 3D Associative Annotated Models*
- **Certify Model Quality** through Validations
- *Use FBTol to Check & Advise on Tolerancing*
- **Authorize Certified Product Models** for Reuse
- **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.



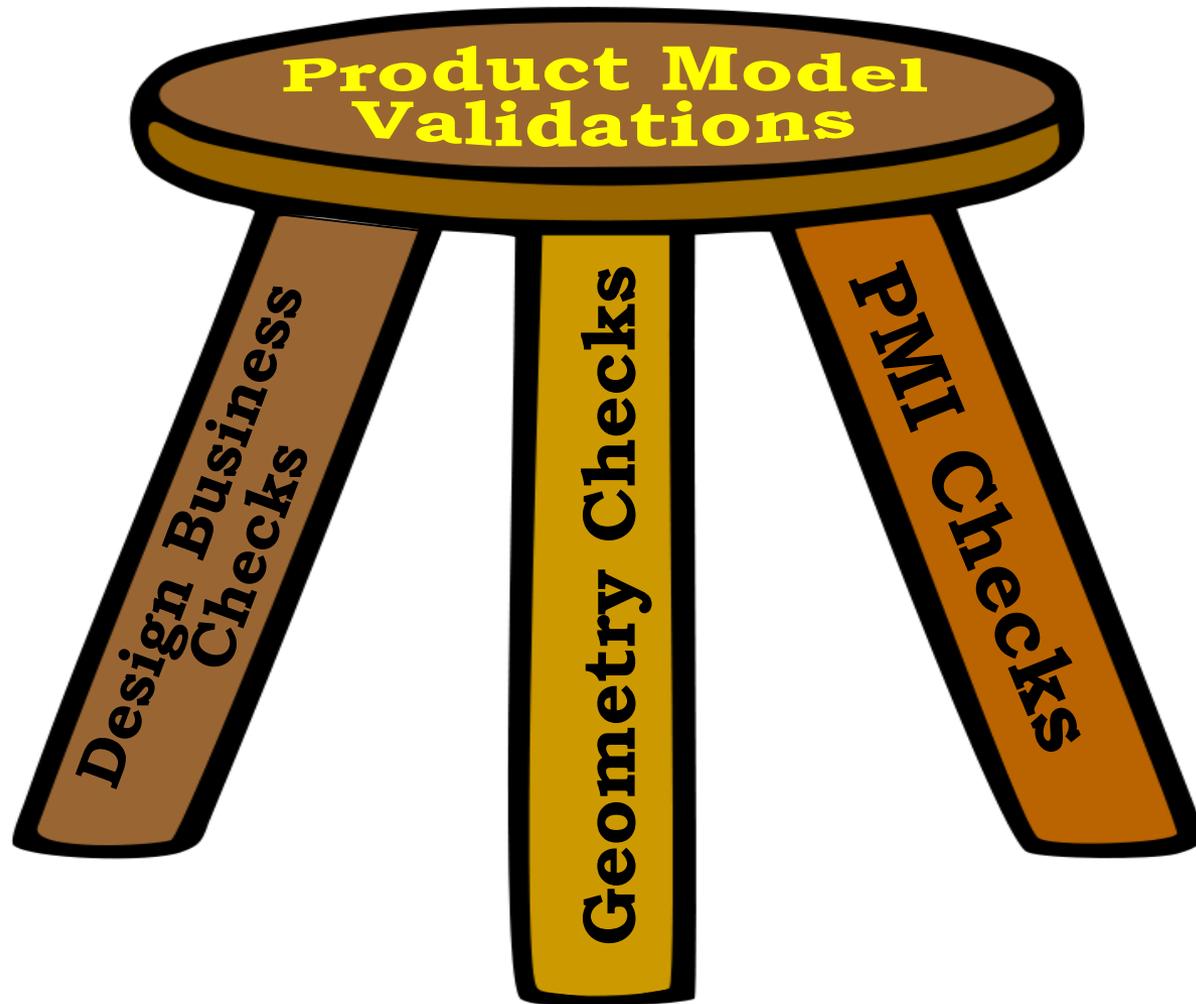
3D Product Models with Associative Annotations



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Trinity of Product Model Validations

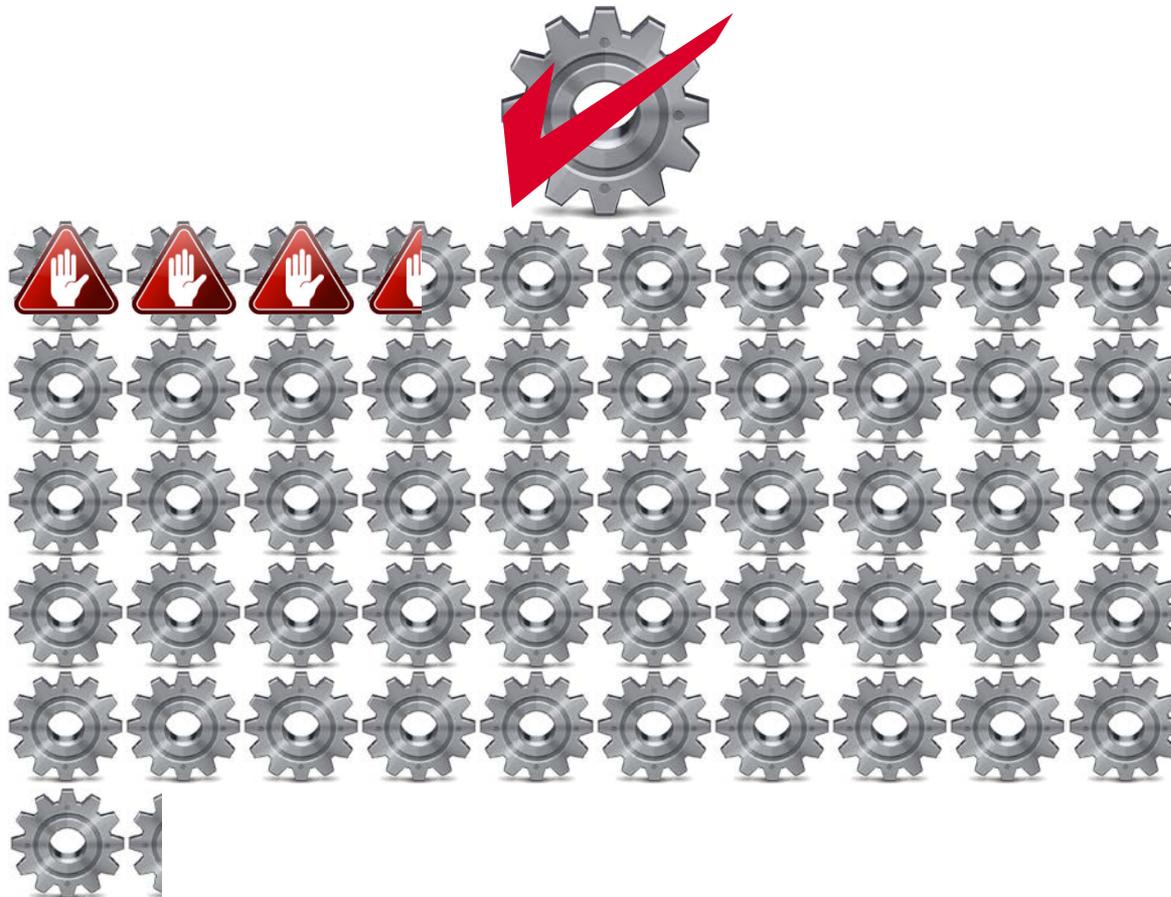


Multiple Checks for Multiple Purposes, all to gain a Certified Product Model

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Trusted Product Models – Geometry Checks

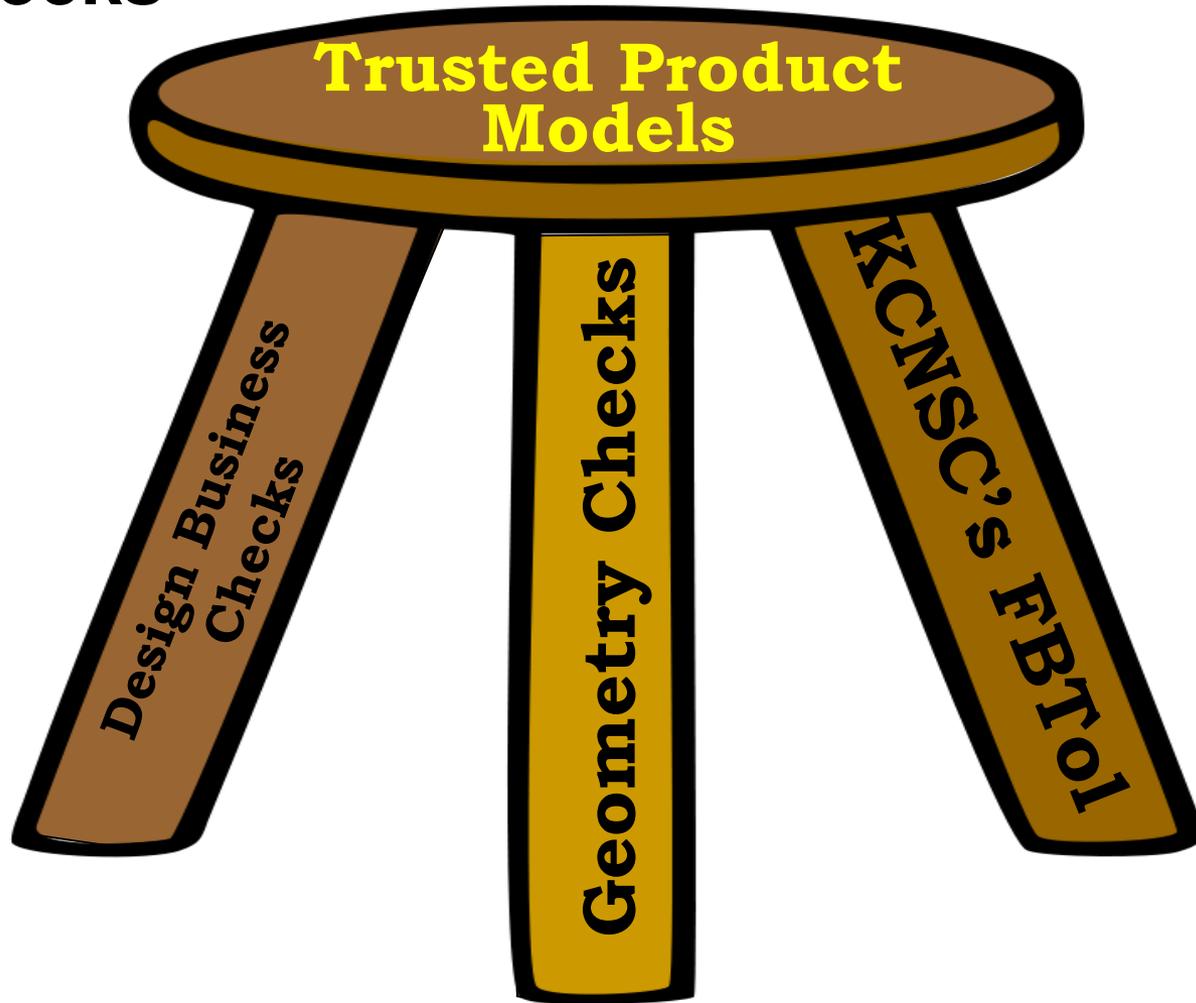
Status: 7% of the 513 model geometry checks had addressable geometry issues.



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Trinity of Product Model Validations

PMI Checks

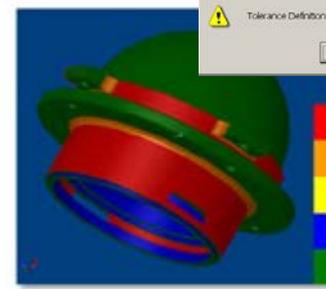
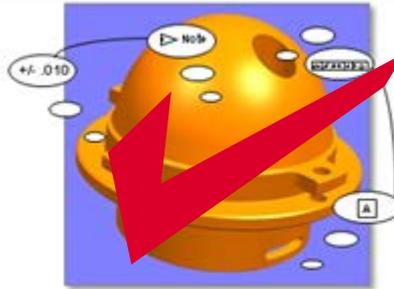
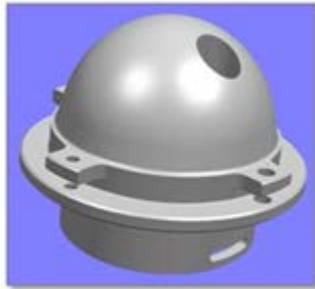


Make sure your products fit & function by communicating complete & correct PMI

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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.

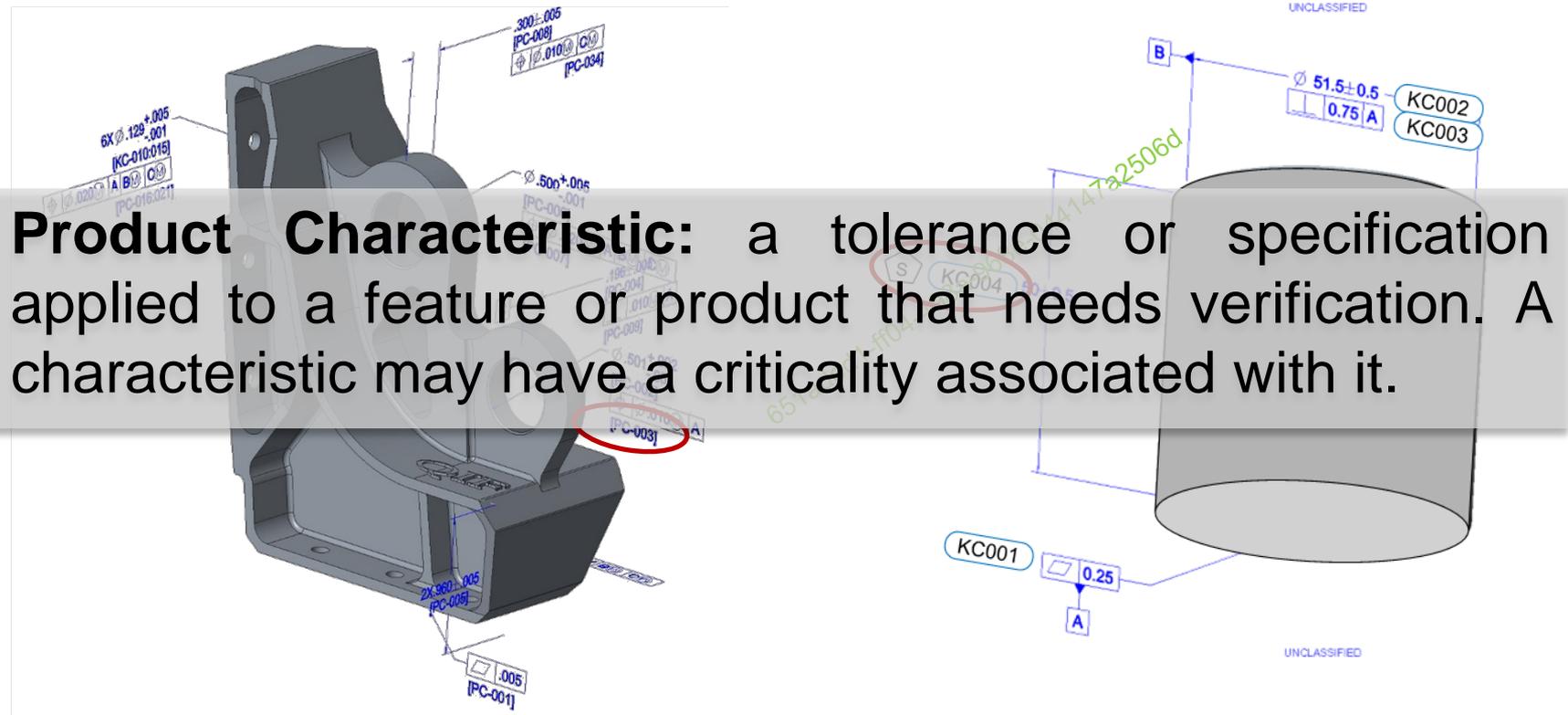


Indicates that the model is legitimate and verified
... and **then make it known.**

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Trusted Product Model – Product Characteristics

MBD w/ Product Characteristic Designators and Criticalities



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

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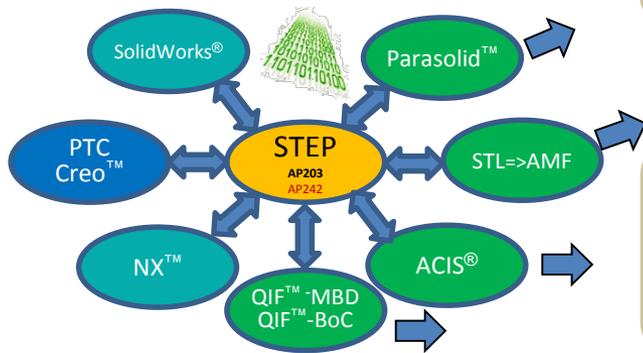
More Lexicons

- **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***,

Digital Product Realization Enterprise

Trusted Product Models with Confident Reuse Throughout our Enterprise[©]

... Managed with Confident Reuse ...



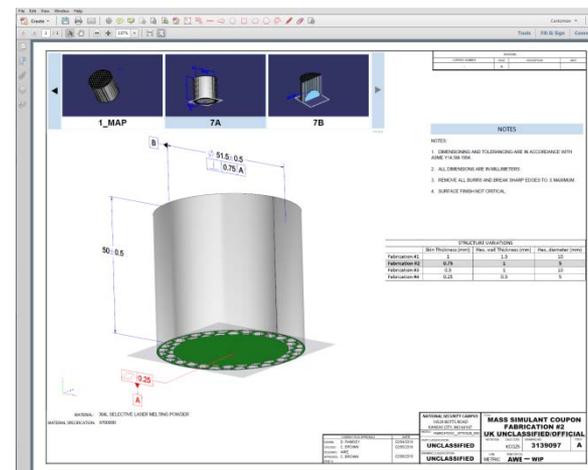
Derivatives Contribute to Analysis, Manufacturing, and Verifications

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.

Part-Centric
Product Lifecycle
Management

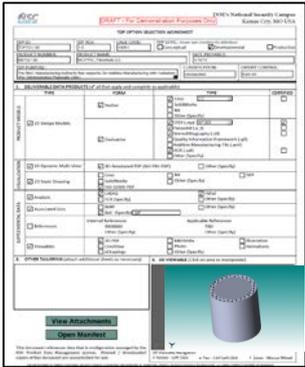


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Digital Product Realization Enterprise

Trusted Product Models with Confident Reuse Throughout our Enterprise[©]

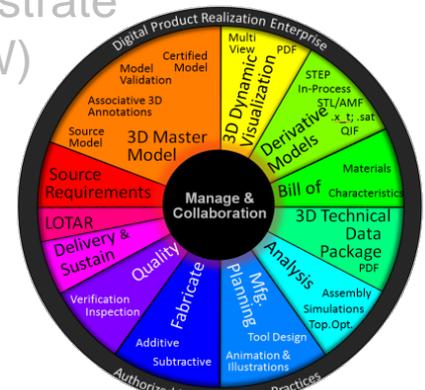
... Throughout our Enterprise



Digital TDP

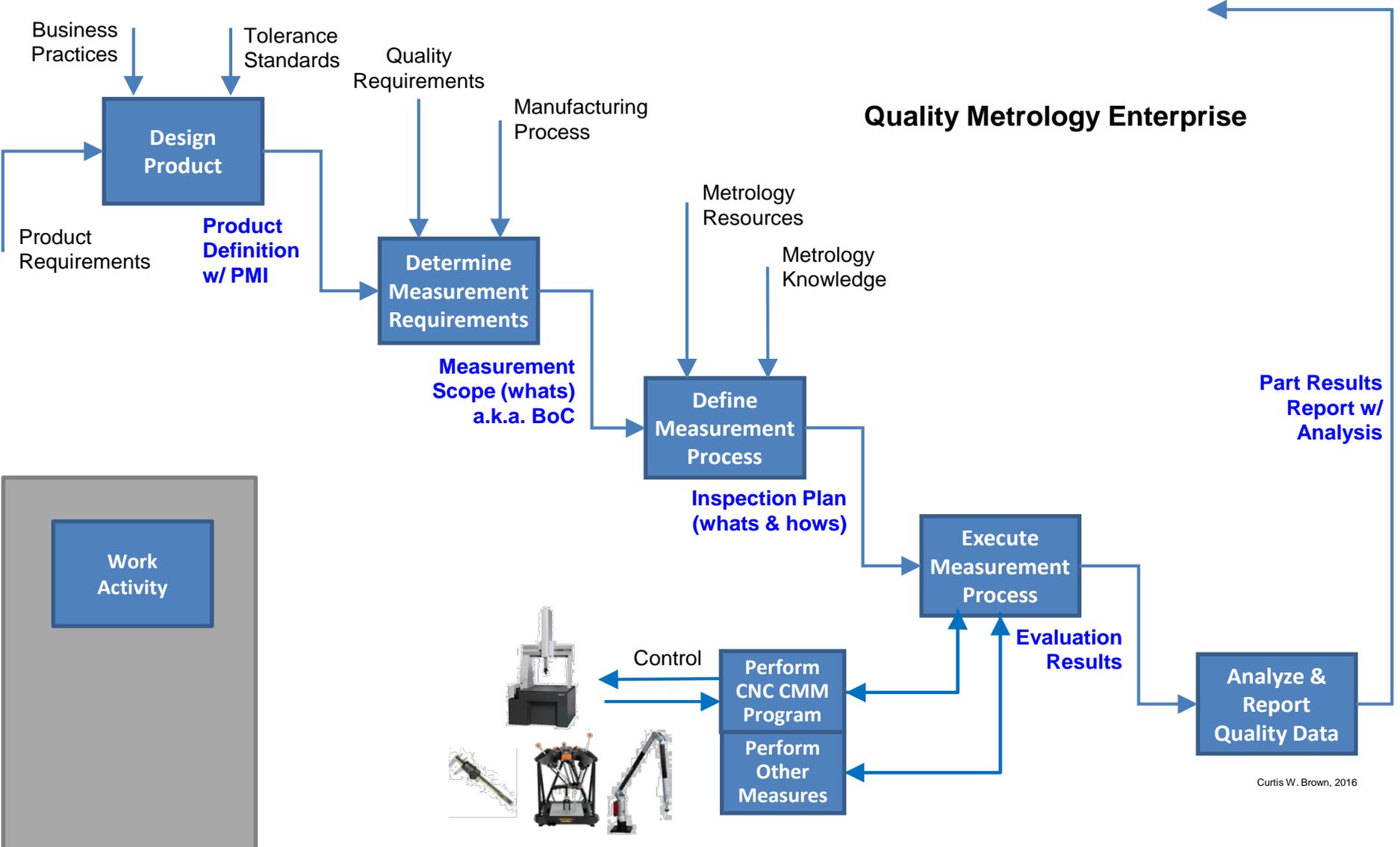
- **Empower Manufacturing & Quality with Trusted Models**
- **Product Characteristic designations with criticalities**
- **Digital Bill of Characteristics (BoC)**
- **QIF Enables Quality to Digitally Contribute to the Enterprise**
- *Prepare 3D Technical Data Package (TDP)*
- *Model-Based Animations 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



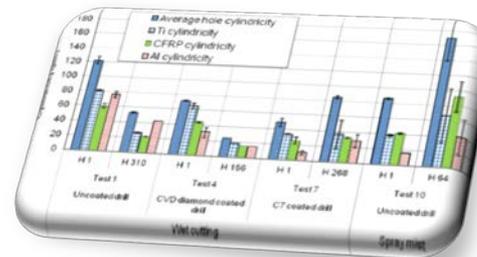
Digital Product Realization Enterprise Architecture © Curtis W. Brown, 2016

Digital Product Acceptance Activity Workflow



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/QPIDs*
 - *Measurement Results*
 - *Piece Part*
 - *Statistical*
 - *Enterprise Connectivity for Quality Feedback*
 - *Quality Persistent ID (QPId) (i.e., universal unique ID)*
 - *651aded1-ff04-498a-968e-044147a2506d*



QPIs – Persistent UUID within the QIF

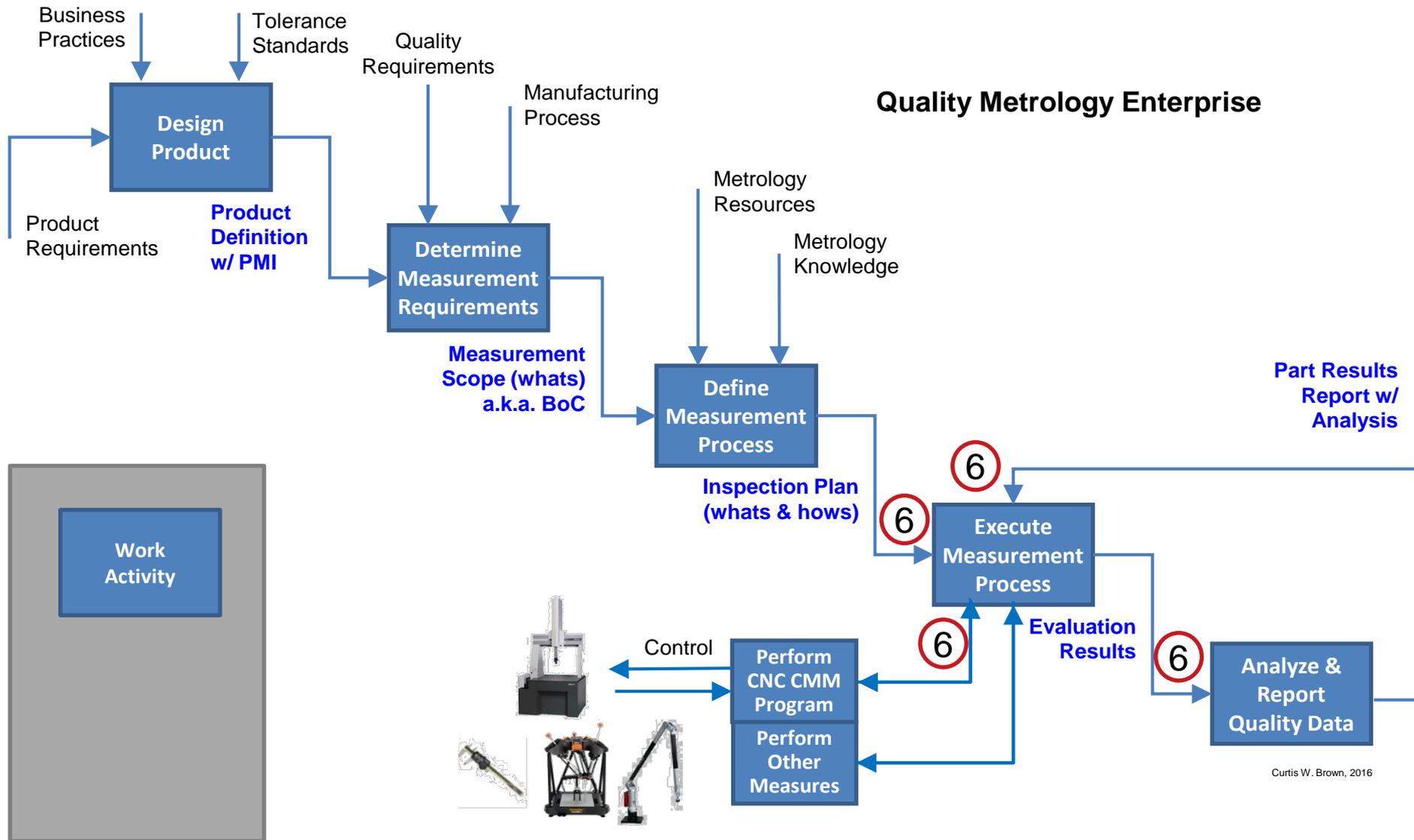
QIF Persistent Identifier (QPI) *noun* Cu·pid \ˈkyü-pəd\

- 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.
 - 3400 (3.4x10³⁸) possible UUIDs
- Allows information to be combined later without resolving identifier conflicts
- Many software development libraries generate UUIDs
- QPIs uniquely identify
 - QIF Document
 - QIF Plan
 - QIF Result
 - QIF Rule Set
 - Feature Item
 - Characteristic Item 
 - Product Item
 - Resource Item

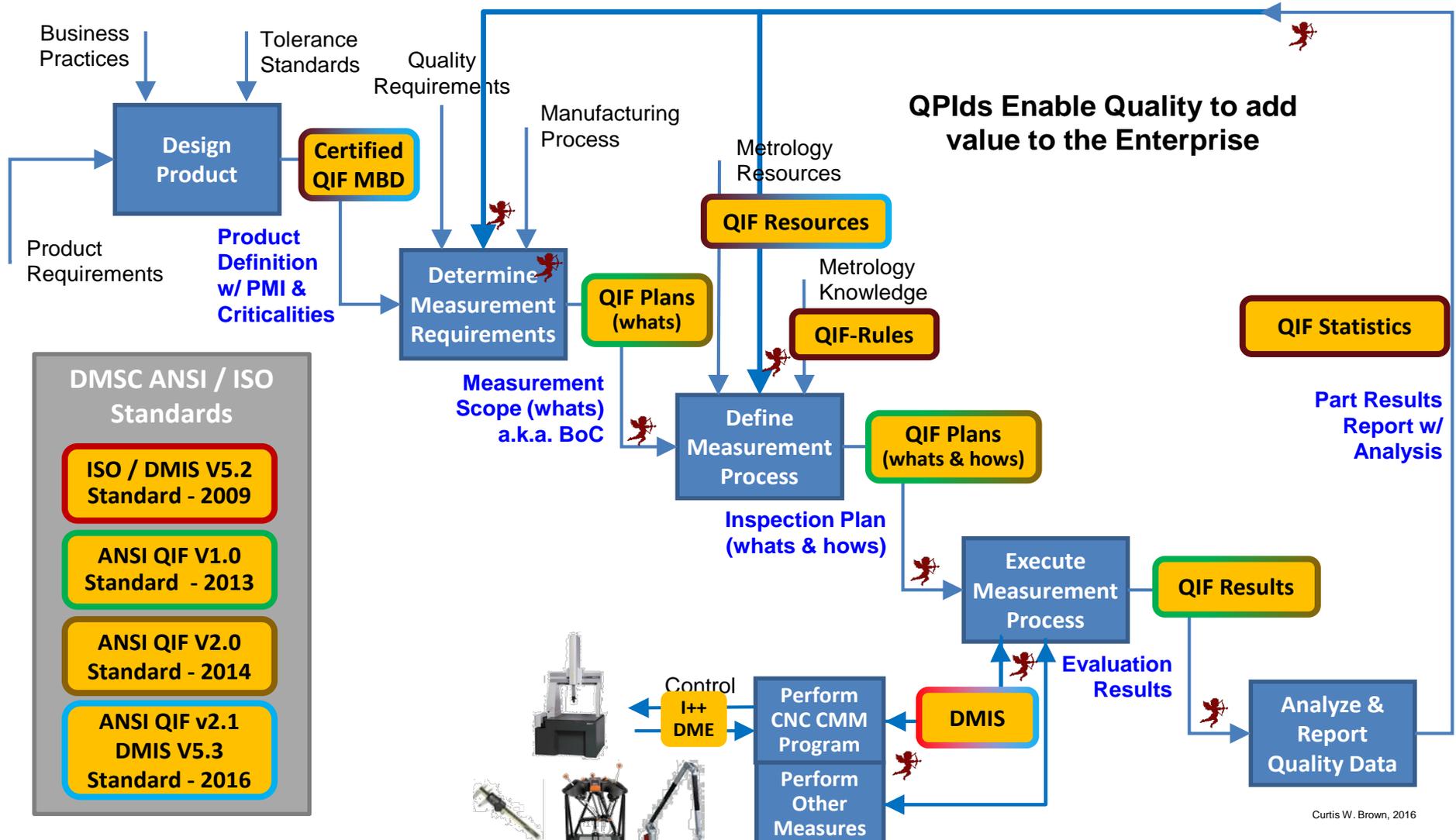
An Important Mechanism that facilitates Lifecycle Connectivity

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Use Case: Document-Base BoC – “Ballooning the Drawing” (Just in Time)



Use Case: QIF Plan BoC QPId



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

Bill of Characteristics

Ballon #	Char #	Char Z...	▲ Qty	Type	Sub-Type	Units	Upper Limit	Lower Limit
10	10			1 Dimension	Linear Dimension	in	0.270	0.230
11	11			1 Dimension	Linear Dimension	in	2.895	2.855
12	12			1 Dimension	Linear Dimension	in	3.209	3.202

5. Char No	6. Reference Location	7. Characteristic Designator	8. Requirement	8a. UoM	8b. Upper Limit	8c. Lower Limit
3	A2.PDF pg.1					
5	LOWER PLATE -	LINEAR	3.750	in	3.870	0.230
10	LOWER PLATE -	LINEAR	2.50	in	0.270	0.230
11	A2.PDF pg.1		3.75			
13	LOWER PLATE -	LINEAR	3.503 / 3.496	in	3.503	3.496
	A2.PDF pg.1					

<Characteristics>

<CharacteristicDefinitions>

<DiameterCharacteristicDefinition id="10">

<Tolerance>

<MaxValue>0.1</MaxValue>

<MinValue>-0.1</MinValue>

</Tolerance>

</DiameterCharacteristicDefinition>

</CharacteristicDefinitions>

<CharacteristicItems>

<DiameterCharacteristicItem id="12">

<Name>Size 12</Name>

<QId>151aded1-ff04-498a-968e-044147a2506d</QId>

<Qty>1</Qty>

<Designator>PC0024</Designator>

<Requirement>3.75</Requirement>

</KeyCharacteristic>

<FeatureItemIds N="1">

<Id>9</Id>

</FeatureItemIds>

<CharacteristicNominalId>11</CharacteristicNominalId>

<LocationOnDrawing>

<DrawingId>3</DrawingId>

<SheetNumber>NA</SheetNumber>

<DrawingZone>NA</DrawingZone>

</LocationOnDrawing>

</DiameterCharacteristicItem>

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.

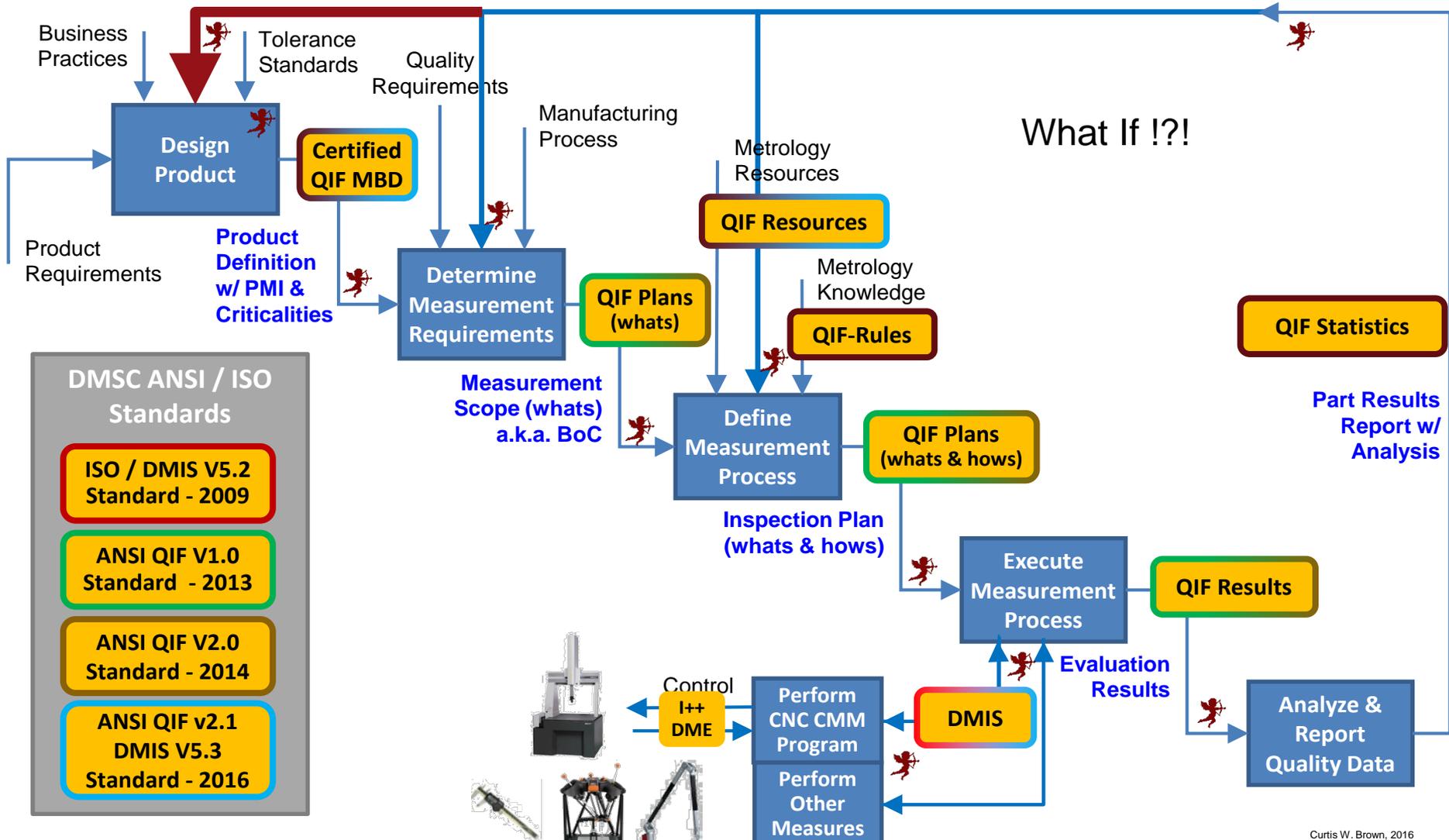
Char No.	Criticality	Characteristic	Feature	Requirement	Plus	Minus
KC0019	Minor	Size +/- 0.1	Hole #9		12	0.1 -0.1
KC0020	Minor	Size +/- 0.1	Hole #10		12	0.1 -0.1
KC0016	Minor	Flat.005	Datum A		0	0.005
KC0014	Minor	Prof.010wABm	Pocket 192			0.01
KC0099	Major	Paint color	Product	JohnDeere Green		

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 QPIs

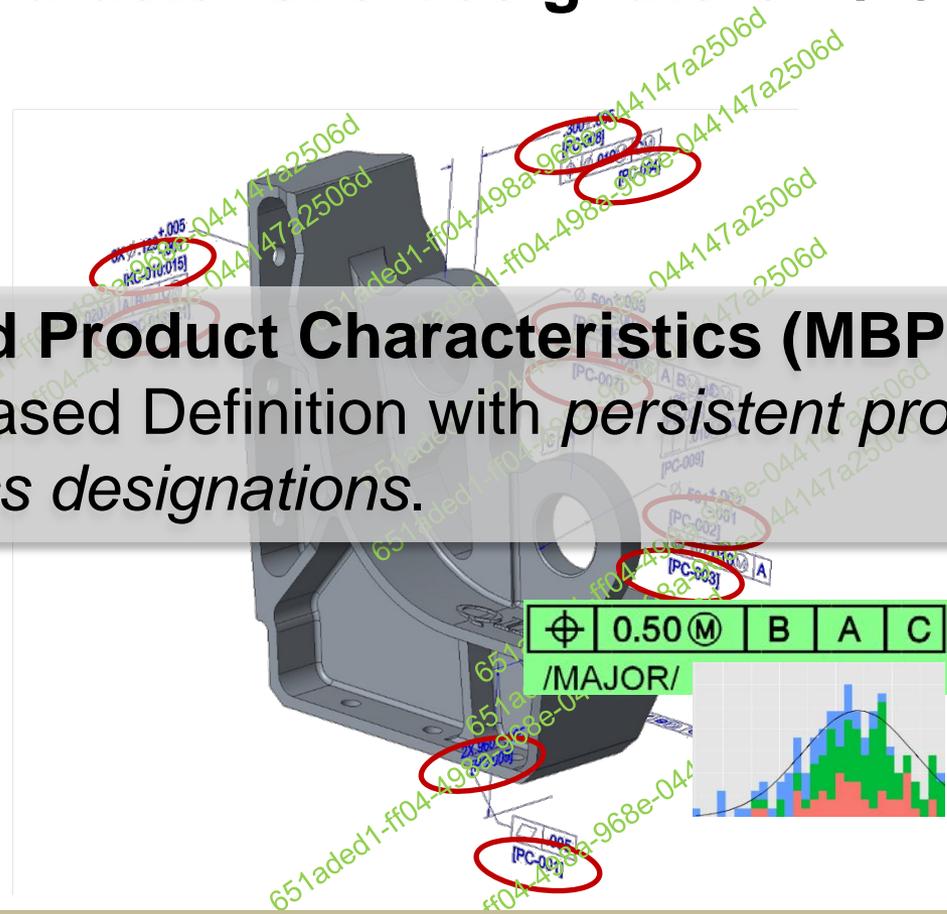


QIF w/ QPIs BoC enables Quality to directly influence Product Design

PMII Investment Returns Value to the Investor

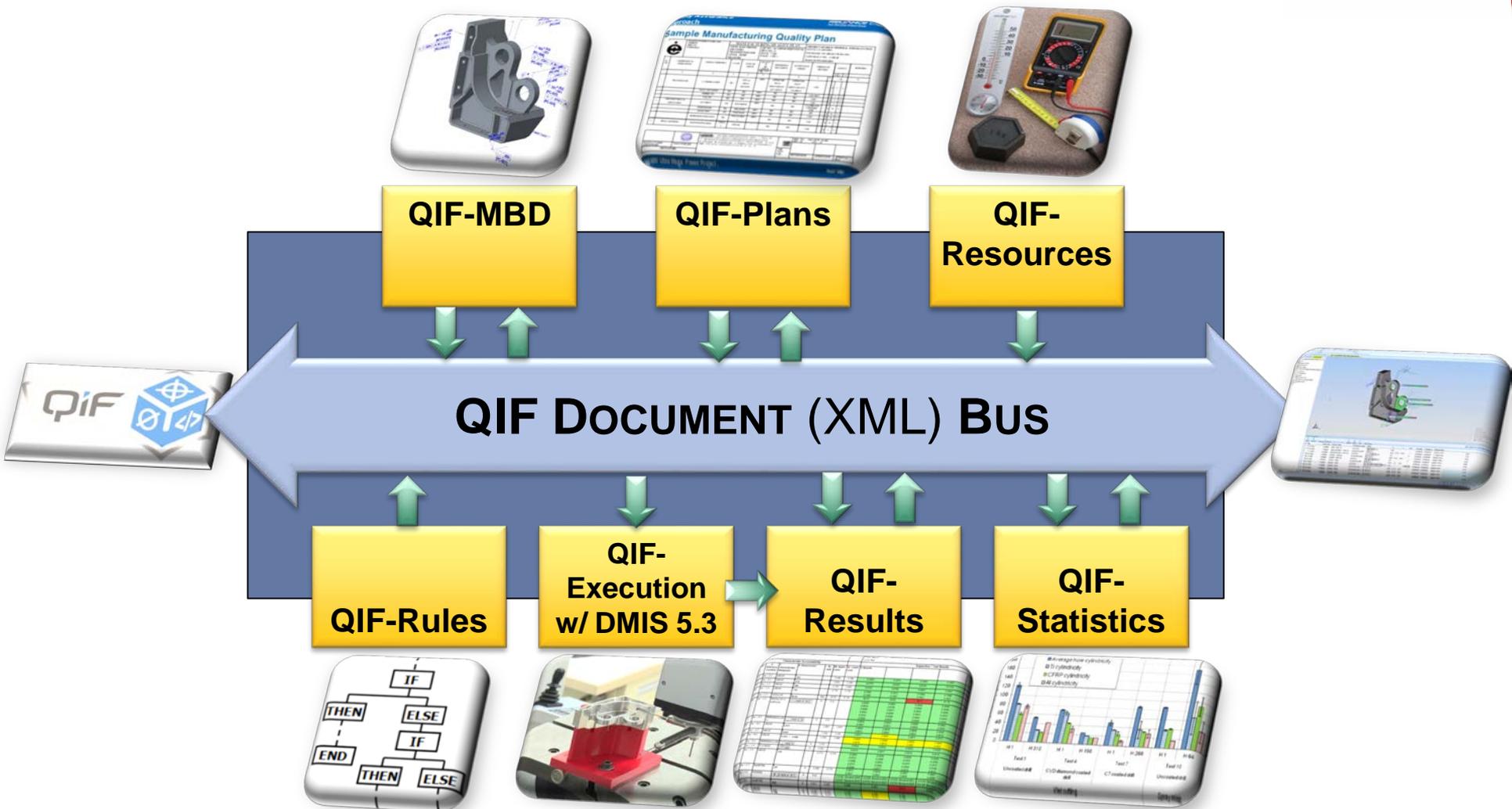
Product Characteristic Designators w/ Criticalities

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



The MBPC Impact to the MBE

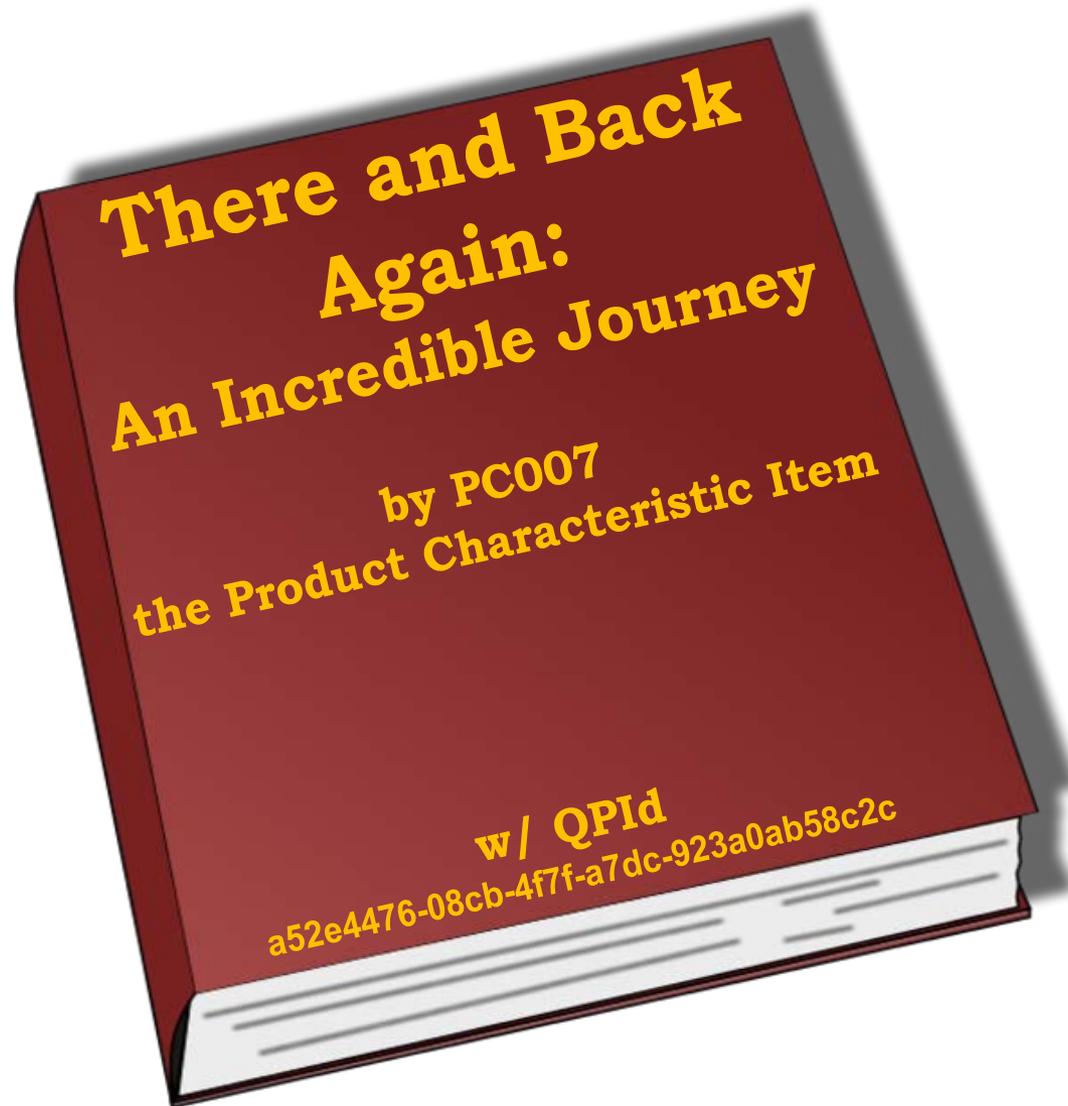
- QIF Product Characteristics with QPIs (MBPC) enables feedback of measurement results back to the MBD.

The screenshot displays a CAD application window with a 3D model of a bracket. The model is annotated with various dimensions and measurement results. The 'Bill of Characteristics' table at the bottom provides a detailed view of these characteristics.

Tag	Saved View	Feature Name	Annotation Name	GD&T	(+)	/	(-)	DRF	Criticality	Criticality A...	Measurement...	Value
1.0.10951		* multiple Plane 10951 (A)	AE_GTOL0	[0.005][KC]	0.005	-	-	-	Undefined	Undefined	equator-cmm...	0.007
2.0.10958		* multiple Opposite Planes 10958 (C)	AE_DRIVEN_DIM9	.196[KC]	0.005	0.196	-0.005	-	Undefined	Undefined	6" Digital Cali...	0.197
3.1.10958		* multiple Opposite Planes 10958 (C)	AE_GTOL4	[0.010][A][KC]	0.01	-	-	A	Undefined	Undefined	equator-cmm...	0.002
3.0.10956		* multiple Opposite Planes 10956 (C)	AE_DRIVEN_DIM10	[0.501][KC]	0.002	0.501	-0.001	-	Undefined	Undefined	equator-cmm...	0.500
3.1.10956		* multiple Opposite Planes 10956 (C)	AE_DRIVEN_DIM8	[0.501][KC]	0.002	0.501	-0.001	A	Undefined	Undefined	equator-cmm...	0.004
4.0.10960		* multiple Cylinder 10960	AE_DRIVEN_DIM8	Ø500[KC]	0.005	0.5	-0.001	-	Undefined	Undefined	equator-cmm...	0.499
4.1.10960		* multiple Cylinder 10960	AE_DRIVEN_DIM8	Ø500[KC]	0.005	0.5	-0.001	-	Undefined	Undefined	equator-cmm...	0.003
5.0.10936		* multiple Cylinder 10936	AE_DRIVEN_DIM13	Ø129[KC]	0.005	0.129	-0.001	-	Undefined	Undefined	equator-cmm...	0.125
5.0.10938		* multiple Cylinder 10938	AE_DRIVEN_DIM13	Ø129[KC]	0.005	0.129	-0.001	-	Undefined	Undefined	equator-cmm...	0.125
5.0.10940		* multiple Cylinder 10940	AE_DRIVEN_DIM13	Ø129[KC]	0.005	0.129	-0.001	-	Undefined	Undefined	equator-cmm...	0.125

We can also observe the Characteristic Actual data from the QIF document.

The Incredible Journey of PC007 the QPId



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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



3D Collaboration & Interoperability Congress

3D Collaboration & Interoperability Congress + Quality Information Framework Summit

October 2-6, 2017 >> Golden, Colorado >> **REGISTER NOW**

<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 QPIs
- 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.”

Model Quality Check Certificate

Model Information

Model Name: MAP-R

Model Number: 441472-00

Model Design/Revision Class: 1.000

Model Geometry Check

Model Product & Manufacturing Information (PMI) Check



UNCLASSIFIED

Page 1 of 1

UNCLASSIFIED

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

Thank you

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