The New QIF Standard:

What Is It, and Why is it Important to my Organization?

Lyle Fischer

Technical Marketing Director, Capvidia

DMSC

Chair - QIF MBD WG,

Chair - QIF Marketing & Membership

GLOBAL PRODUCT DATA
INTEROPERABILITY
SUMMIT
2015

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CAPSULE

- **Manufacturing Quality digital information *incompatibilities* are costly and affects everyone:**
    - **Vendors**
    - **Suppliers**
    - **Users**
    - **Customers**

  ***And* the digital metrology community lacks an enterprise-wide standard solution, . . . UNTIL NOW, a superior standards-based digital interoperability has been approved.**
- **QIF also enables Manufacturing Quality to Join the Model-Based Enterprise!**

QIF™
Quality Information Framework

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CAPSULE

- **Quality Information Framework (QIF) is a new standard for interoperable manufacturing quality data.**

- **Developed by Metrology Subject Matter Experts and Computer Scientists**

- **The QIF Information Model:**
  - **Scope: developing the digital product verification package with initial emphasis on dimensional metrology; from product design to inspection planning, planning to programming, and inspection execution to results reporting, analysis w/ statistics**
  - **Effects: will be efficient, accurate transfer of self validating manufacturing quality information**
  - **Benefits: improve manufacturing quality; increase product verification velocity; while reducing costs**

The QIF Standard

- **ANSI/QIF 2014 (QIF v2.0)**
- **Dimensional Metrology Standards Consortium (DMSC)**
- *Quality Information Framework (QIF) — An Integrated Model for Manufacturing Quality Information*:
  - *Part 1*: *Overview and Fundamental Principles*
  - *Part 2*: *QIF Library Information Model and XML Schema Files*
  - *Part 3*: *QIF Model Based Definition (MBD) Information Model and XML Schema File*
  - *Part 4*: *QIF Plans Information Model and XML Schema File*
  - *Part 5*: *QIF Resources Information Model and XML Schema File*
  - *Part 6*: *QIF Rules Information Model and XML Schema File*
  - *Part 7*: *QIF Results Information Model and XML Schema File*
  - *Part 8*: *QIF Statistics Information Model and XML Schema File*

Outline

- **Digital Product Verification (DPV)**

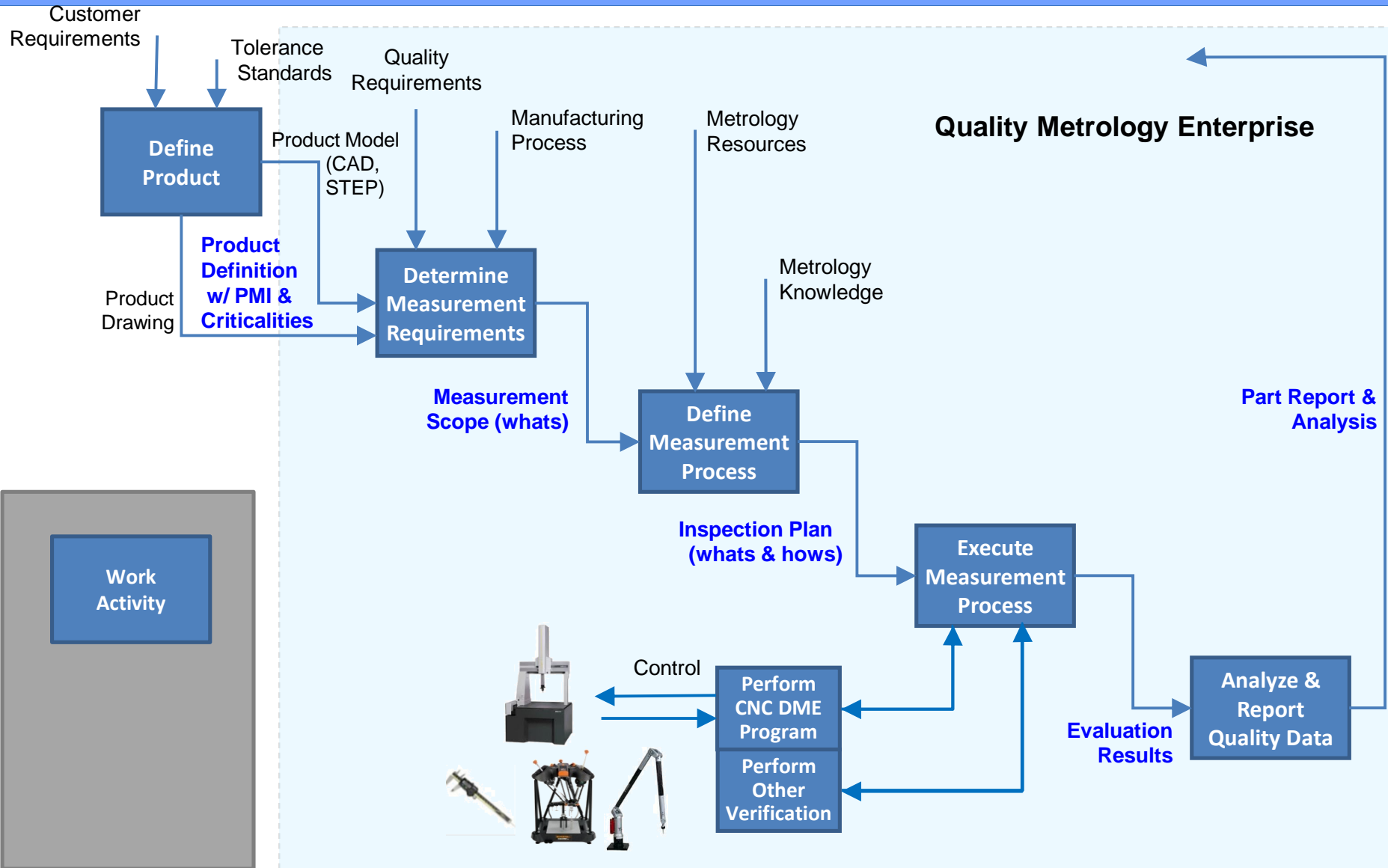- **Digital Interoperability Standards for enabling . . .**

Model Based Enterprise (MBE)

- **Quality Information Framework enables DPV**

  - **Structure of QIF, design principles**

  - **Validation and demos**

  - **Current development status**

- **Dimensional Metrology Standards Consortium**
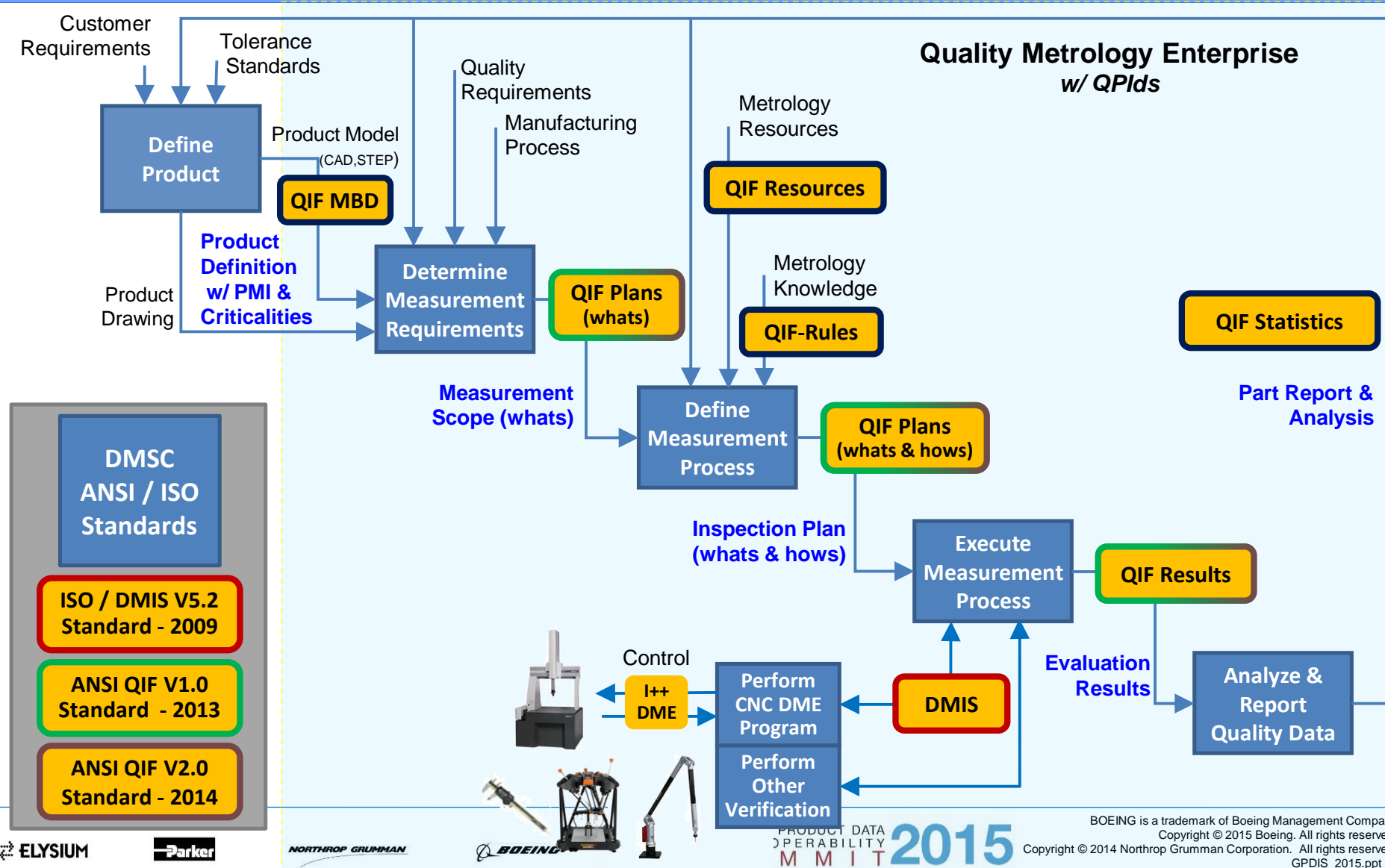
- **Summary and Request for Involvement**

Product Verification Activity Workflow

Digital Product Verification Process with QIF

Customer Requirements
Tolerance Standards

Define Product

Product Model (CAD,STEP)

QIF MBD

Quality Requirements
Manufacturing Process

Metrology Resources

QIF Resources

Quality Metrology Enterprise
w/ QPIds

Product Drawing

Product Definition w/ PMI & Criticalities

Determine Measurement Requirements

QIF Plans (whats)

Metrology Knowledge

QIF-Rules

QIF Statistics

Measurement Scope (whats)

Define Measurement Process

QIF Plans (whats & hows)

Part Report & Analysis

DMSC ANSI / ISO Standards

ISO / DMIS V5.2 Standard - 2009

ANSI QIF V1.0 Standard - 2013

ANSI QIF V2.0 Standard - 2014

Inspection Plan (whats & hows)

Execute Measurement Process

QIF Results

Control

I++ DME

Perform CNC DME Program

DMIS

Evaluation Results

Analyze & Report Quality Data

Perform Other Verification

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Digital Product Verification - Issue Statement

- **Metrology Community** is digital and model centric, unfortunately, even with the **successful emergence of CAD**, we have **not realized the benefits** promised by this investment.
- **Two primary needs:**
  1. Full end to end **Digital Metrology Interoperability**
     - *DMSC Response: via QIF Working Groups*
  2. Metrology applications, as well as other downstream applications, need complete, accurate, and cost effective **model-based product definitions** with **smarter semantic PMI**
     - Native CAD w/PMI
     - STEP AP242 w/PMI
     - *DMSC Response: DMSC/Capvidia MOU via QIF CAMBD Working Group*

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MBM Critical Requirements

- ## Model Based Definition for Metrology / Manufacturing
  - Complete, Accurate, & Cost Effective Product Definition
  - Common, Domain-Specific Features Manages Complexity
  - Smarter Model Based Semantic PMI (e.g., Product Tolerances)
- ## Quality Digital Interoperability Requirements
  - Measurement Process Planning
    - Measurement Scope (i.e., Bill of Characteristics)
    - Inspection Planning
  - Measurement Results & Process Analysis
    - Dimensional
    - Real-Valued
    - Attribute
  - Supports Standards
    - ASME Y14.5, *Dimensioning and Tolerancing (Similar to ISO TC213 Suite)*
    - ASME Y14.41, *Digital Product Data Definition*
    - ISO/DMSC 22093 DMIS 5.2, *Dimensional Measuring Interface Standard*
    - AS9102a, *Aerospace First Article Inspection Requirement*

- QIF™ is a standard integrated information model for the **efficient exchange** of data between software and equipment modules for discrete product measurement
  - **Standard:** Open development, free-to-implement, free tools
  - **Integrated:** No overlap, harmonized upstream & downstream
  - **Modern/Affordable:** World Wide Web Consortium's (W3C) XML
  - **Information model:** W3C's XSD
  - **Implementation/data verification:** W3C XSLT
  - **XML Application Data Files:** Conform to QIF data model
  - **Measurement process modules:** Plan, Program, Execute, Report/Analyze
- QIF is developed within the Dimensional Metrology Standards Consortium (**DMSC**)

- XML (Extensible Markup Language)
  - A modern, state of art file format technology
  - Human and machine readable
  - Emphasis on **simplicity, generality, usability**
- XSD (XML Schema Definition)
  - Description of how XML is used (e.g. QIF)
  - Verifies sender & receiver can **communicate**
- XSLT (Extensible Stylesheet Language Transformations)
  - Encodes logical rules enabling **self-validation**
- XML/XSD/XSLT Software tools are
  - Often available free or at a moderate price.
  - Known and used by many
- **Easy to implement, quicker** & **lower cost investment** for application implementers

QIF Metrology 'Life Saver' Architecture
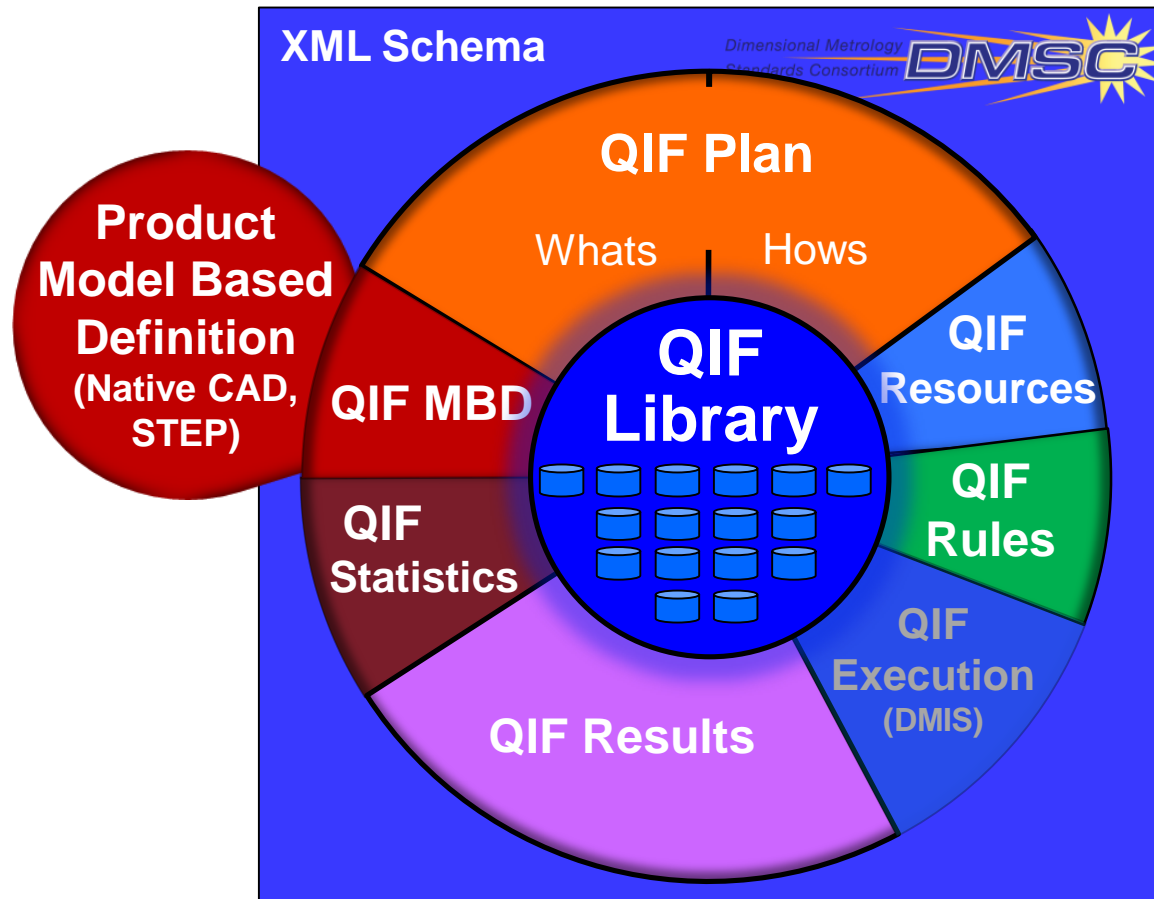
Complete QIF Roadmap

Common QIF Library
  Information Models
## QIF Application Information Models (use the QIF Library)
- **QIF Document (Parent structure)**
- **QIF MBD (Product Definition w/Feature-Based PMI)**
- **QIF Plans**
- **QIF Resources**
- **QIF Rules**
- **QIF Results**
- **QIF Statistics**
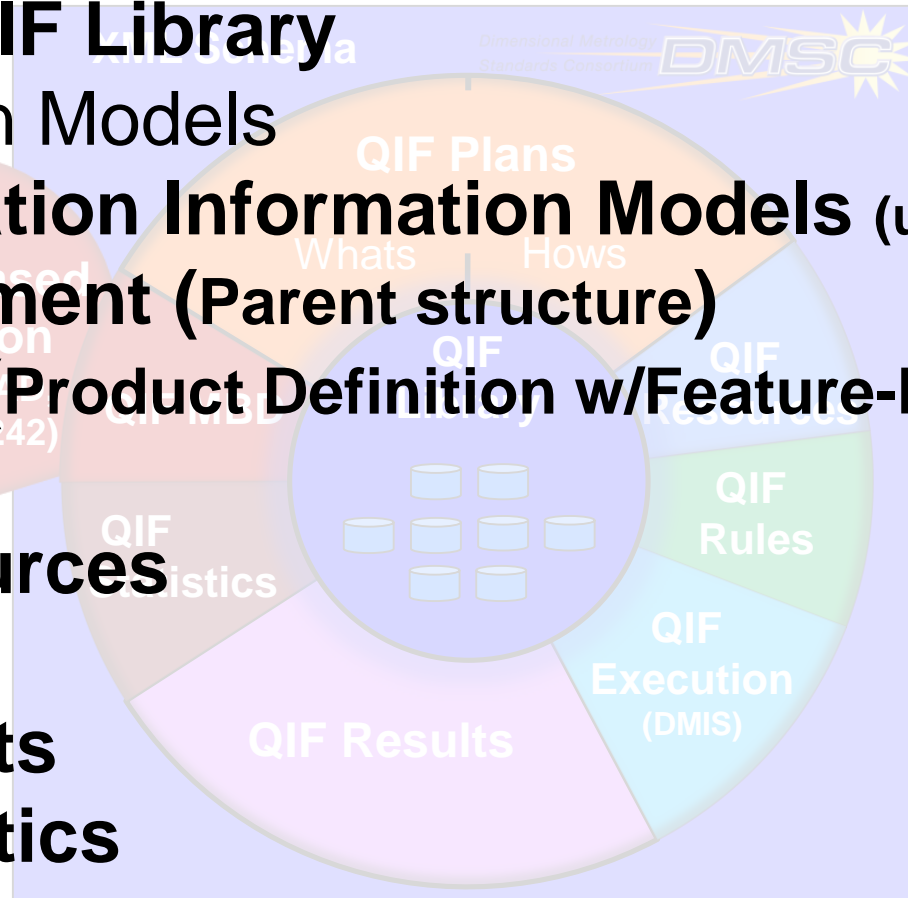
QIF Library

- **Common Data Framework assures Interoperability**
- **XSD Schemas Files for**
    - **Auxiliary**
    - **Characteristics (e.g., Tolerances)**
    - **Expressions**
    - **Feature Types (Metrology/Measurement)**
    - **Generic Expressions**
    - **Geometry**
    - **IntermediatesPMI**
    - **Primitives**
    - **PrimitivesPD**
    - **PrimitivesPMI**
    - **Statistics**
    - **Topology**
    - **Traceability Information**
    - **Units**
    - **Visualization**
- **Supports all QIF Application Models**
- **Benefits**
    - **Avoid Multiple and Conflicting Definitions**
    - **Reuse of common / shared data elements**
   - **Eliminate Point-to-Point Harmonization and Mapping with other specs.**
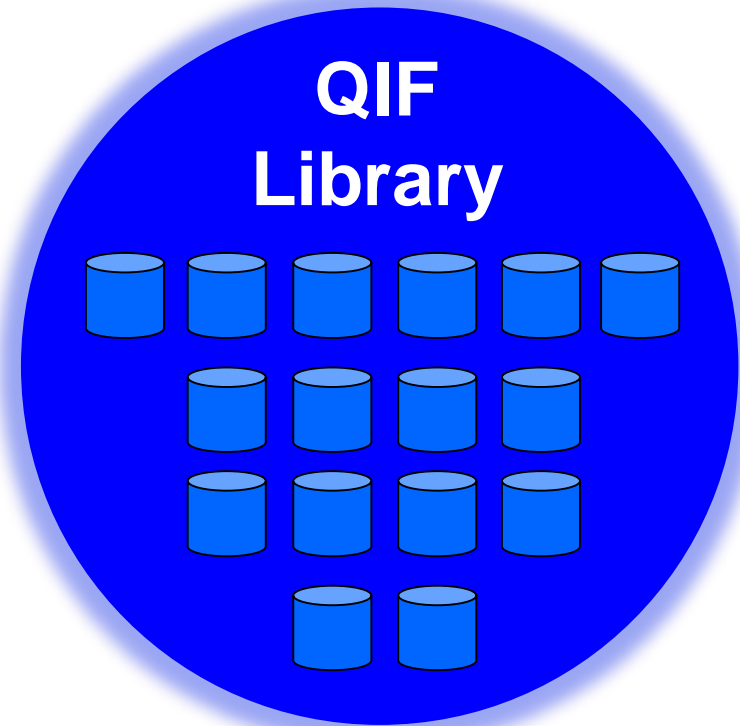
QIF Library

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- DimensionalCharacteristicBaseType
  - CoordinateCharacteristicBaseType …
  - AngularCharacteristicBaseType …
  - LinearCharacteristicBaseType …

  +/-

- GeometricCharacteristicBaseType
  - FormCharacteristicBaseType …
  - LocationCharacteristicBaseType …
  - OrientationCharacteristicBaseType …
  - ProfileCharacteristicBaseType …
  - RunoutCharacteristicBaseType …

▱	0.01			
⌖	0.05 Ⓜ	A	B	C
⊥	0.02	A		
⌒	0.05	A	B	C
⌰	0.05	A	B	

- UserDefinedAttributeCharacteristicType

- UserDefinedVariableCharacteristicType

- SurfaceTextureCharacteristicType   √

- ThreadCharacteristicType
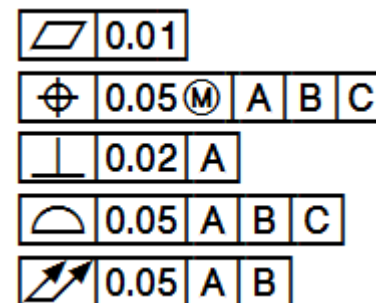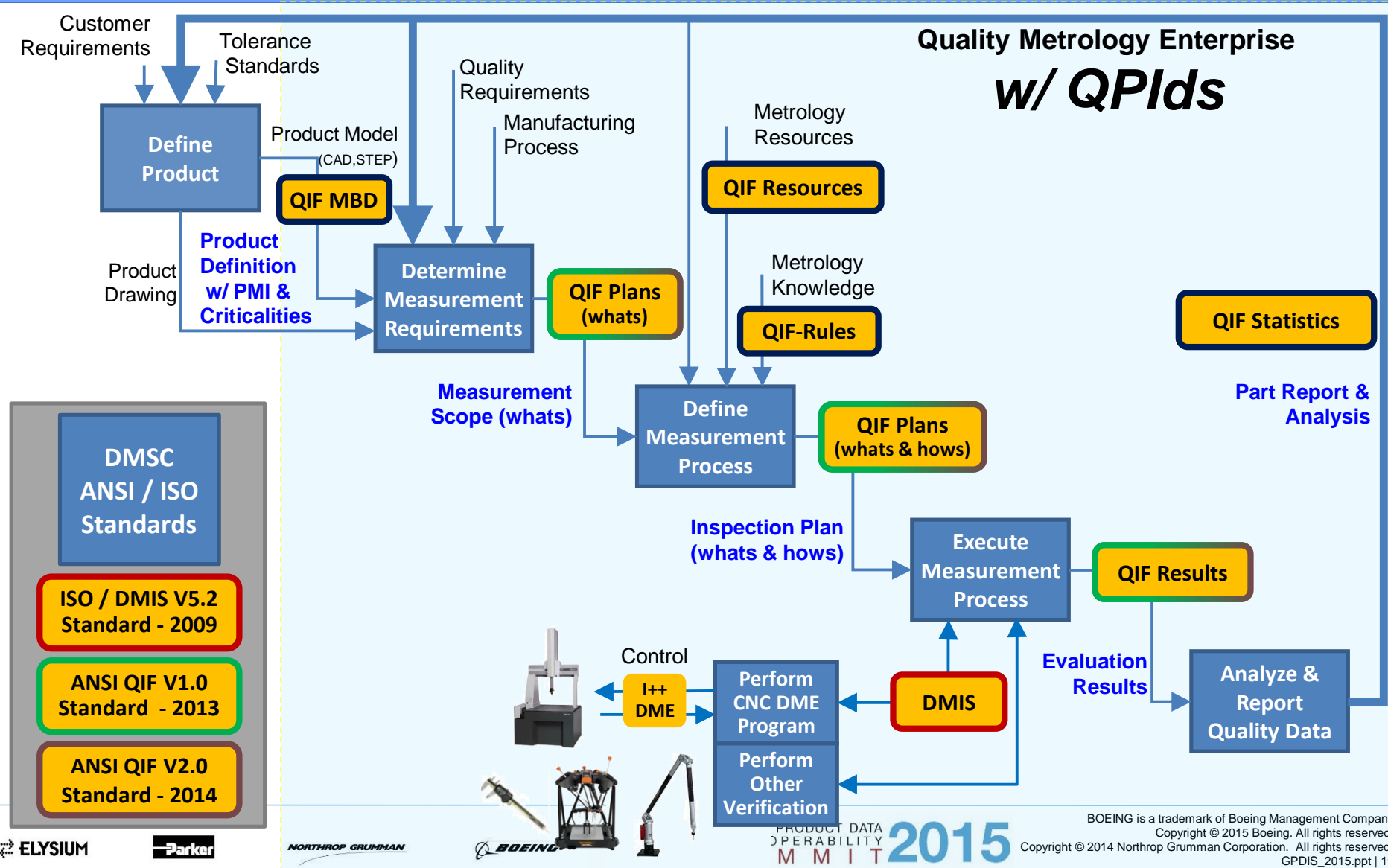
QPIds – A Persistent UUID used within the QIF

QIF Persistent Identifier (QPId)

- **Important Mechanism that helps facilitate full lifecycle MBE**
- **Universally Unique Identifier (UUID) (aka GUID within Microsoft)**
  - **ISO/IEC 9834-8**
  - **550e8400-e29b-41d4-a716-446655440000**
  - **3.4×10^{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 Plan**
  - **QIF Result**
  - **QIF Rule Set**
  - **Feature Item**
  - **Characteristic Item**
  - **Product Item**
  - **Resource Item**

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Digital Product Verification Process with QIF QPIds

Quality Metrology Enterprise

w/ QPIds

Customer Requirements

Tolerance Standards

Quality Requirements

Manufacturing Process

Metrology Resources

Define Product

Product Model (CAD,STEP)

QIF MBD

QIF Resources

Product Definition w/ PMI & Criticalities

Product Drawing

Metrology Knowledge

QIF Statistics

Determine Measurement Requirements

QIF Plans (whats)

QIF-Rules

Measurement Scope (whats)

Part Report & Analysis

Define Measurement Process

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DMSC ANSI / ISO Standards

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QIF Results

ISO / DMIS V5.2 Standard - 2009

ANSI QIF V1.0 Standard - 2013

ANSI QIF V2.0 Standard - 2014

Control

I++ DME

Perform CNC DME Program

DMIS

Evaluation Results

Analyze & Report Quality Data

Perform Other Verification

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QIF MBD

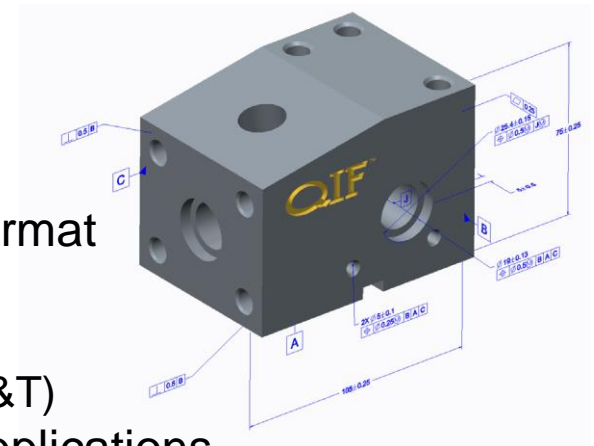**Product Model Based Definition Source**

QIF MBD

QIF Library
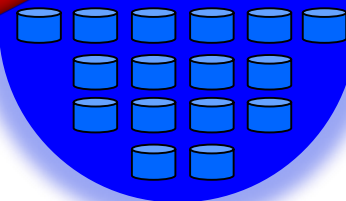
Complete & Accurate Model Based Definition
Product Definition w/ Product Manufacturing Information
Motivated to support Model Based Metrology/Manufacturing
- QIF Library
- Includes **Feature-Based PMI**
- Native CAD + PMI
- **Harmonized with STEP AP242**
- INCLUDES PMI!

- XML Schema (Initiated by DMSC/Capvidia MoU)
  - Expose the Product Definition w/ PMI in the QIF format
  - Model Based Product Definition
    - Model Based Definition (e.g., Solid Model)
    - Various Conformance Levels of Semantic PMI (GD&T)
  - Easier Use and Implementation for downstream applications
  - Satisfy Native CAD to Model Based Metrology Use Case and more….
  - Satisfy STEP to Model Based Metrology Use Case and more….
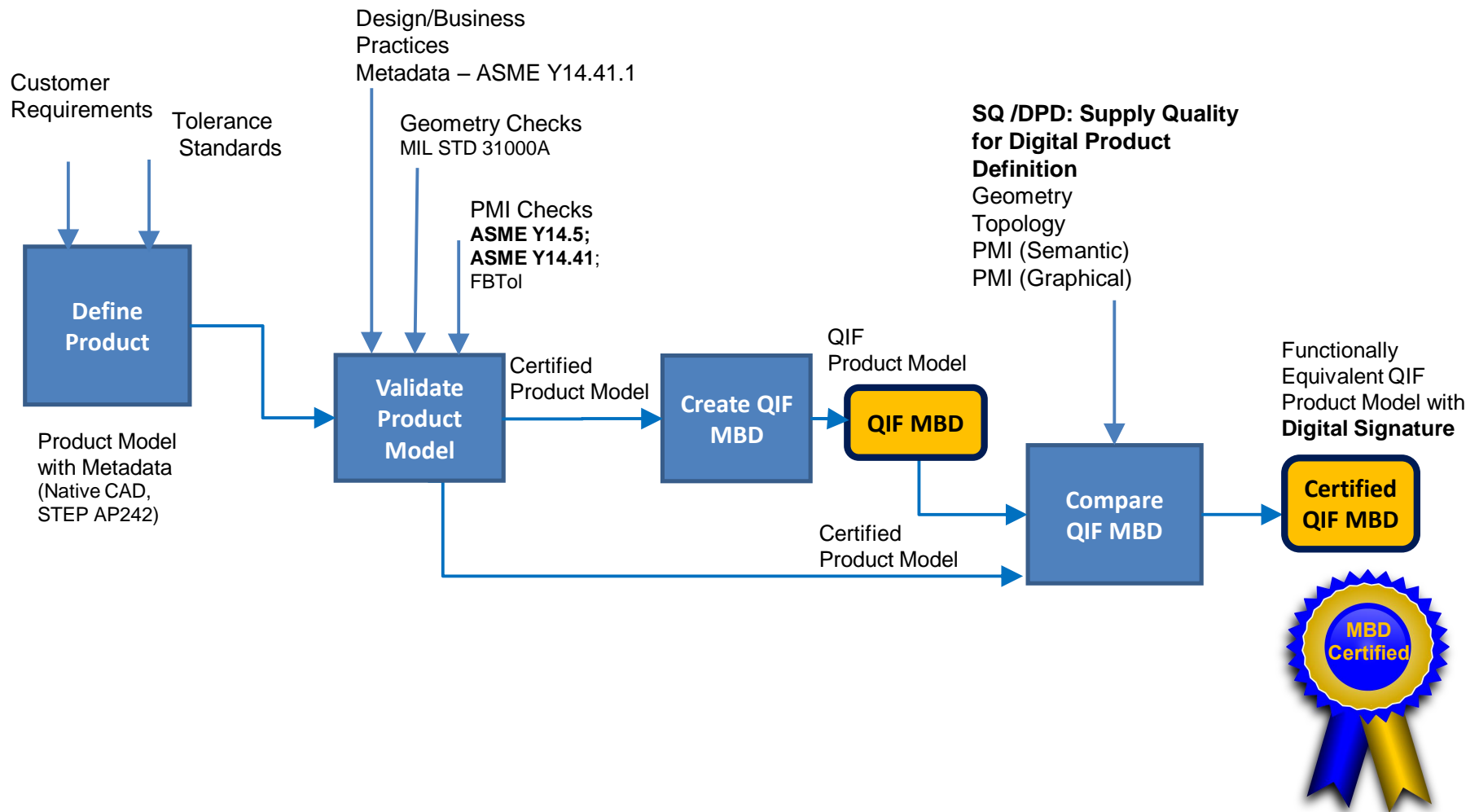
QIF MBD Quality Certification

Enables "Certification" of QIF models for downstream use.

- Communicates Product Data Quality (PDQ) Criteria
- PDQ Check Performed
- PDQ Check Approved
- PDQ Check Declaration
- PDQ Checks
  - Name
  - Description
  - Type (Design/Business Practice; Model Geometry; PMI; Compare; Other
  - Application Tool
  - Results
    - Pass/Fail
    - Statement
- Authorization of Product Model for Downstream Use
  - Digital Signature

MBD Quality Certification with QIF

Design/Business
Practices
Metadata – ASME Y14.41.1

Geometry Checks
MIL STD 31000A

PMI Checks
ASME Y14.5;
ASME Y14.41;
FBTol

SQ /DPD: Supply Quality
for Digital Product
Definition
Geometry
Topology
PMI (Semantic)
PMI (Graphical)

Customer
Requirements

Tolerance
Standards

Define
Product

Product Model
with Metadata
(Native CAD,
STEP AP242)

Validate
Product
Model

Certified
Product Model

Create QIF
MBD

QIF
Product Model

QIF MBD

Certified
Product Model

Compare
QIF MBD

Functionally
Equivalent QIF
Product Model with
Digital Signature

Certified
QIF MBD

MBD
Certified

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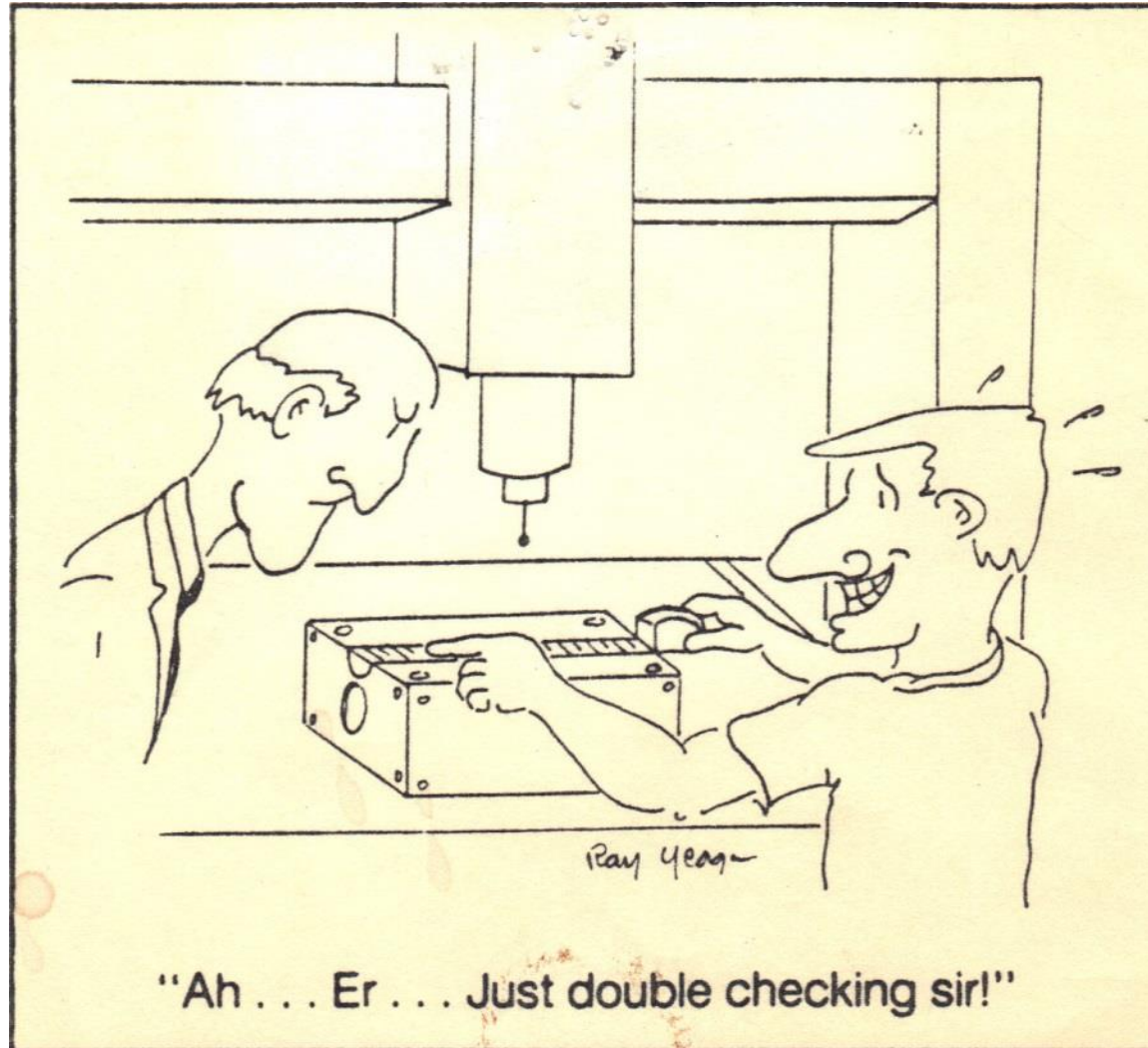
QIF Plans

Quality Measurement Plans
- **XML Schema File**
- **QPIDs (Universal Unique IDs)**

- **Measurement Features**
  - **Linked with Product**
- **Characteristics (e.g., Tolerances)**
- **Enabler for end-to-end Automation**
- **Standard format for Defining:**
  - **Measurement Scope (i.e., "what" needs to be inspected, BoC)**
  - **Inspection Plan (i.e., "what & how" to be inspected)**
- **Key Characteristic**
  - **Designators (i.e., 2D balloon labeling)**
  - **Criticality Classes**
- **Measuring Action Sequence**
- **Scalable & Extensible**
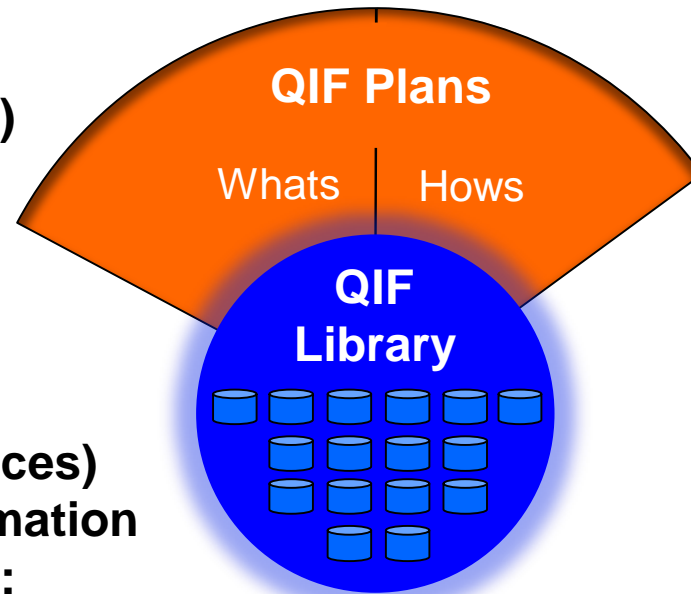
QIF Plans

Whats | Hows

QIF Library

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"Ah . . . Er . . . Just double checking sir!"

QIF Resources

Quality Measurement Resources
- XML Schema
- Supports QIF Plans w/Methods (i.e., hows)
- Standard format for Defining Measurement Resources
  - Measuring Equipment
  - Measure Devices
    - Accuracy
    - Calibration
  - Sensors
  - Rotary Tables
  - Work Centers

- Define Resources by
  - Company
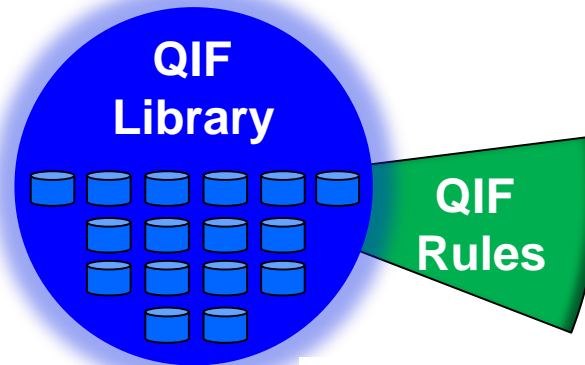 - Factory
  - Department
  - Supplier
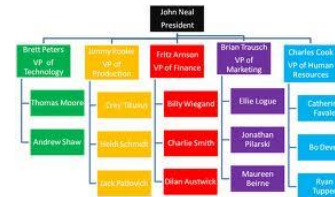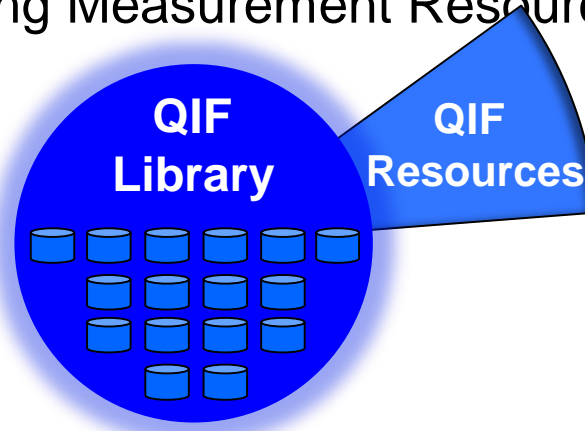
QIF Library

QIF Resources

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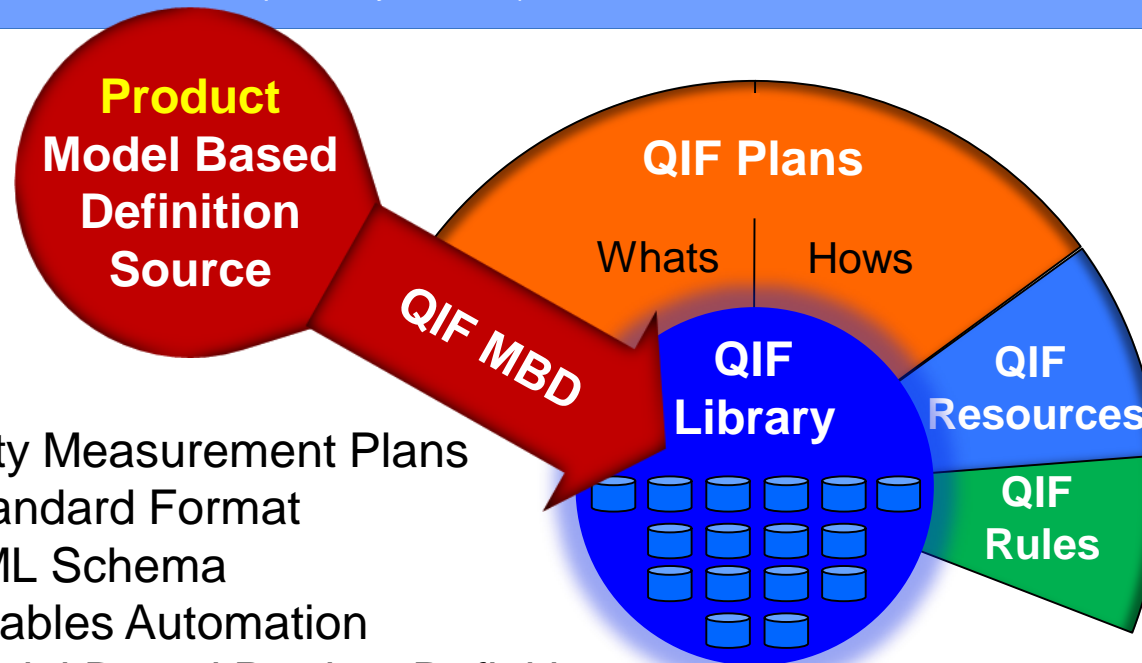
QIF Rules

Quality Measurement Rules
- XML Schema
- Supports QIF Plans w/Methods
- Standard format for Representing Measurement Rules
  - Point Measures
  - Resource Selections
  - Sampling Techniques
  - Algorithm Selection
  - . . .

QIF Library

QIF Rules

- Enables Defining Rules by
  - Company
  - Part Family
  - Quality Level

Part Families

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Enhanced QIF Plans

Product Model Based Definition Source

QIF MBD

QIF Plans

Whats | Hows

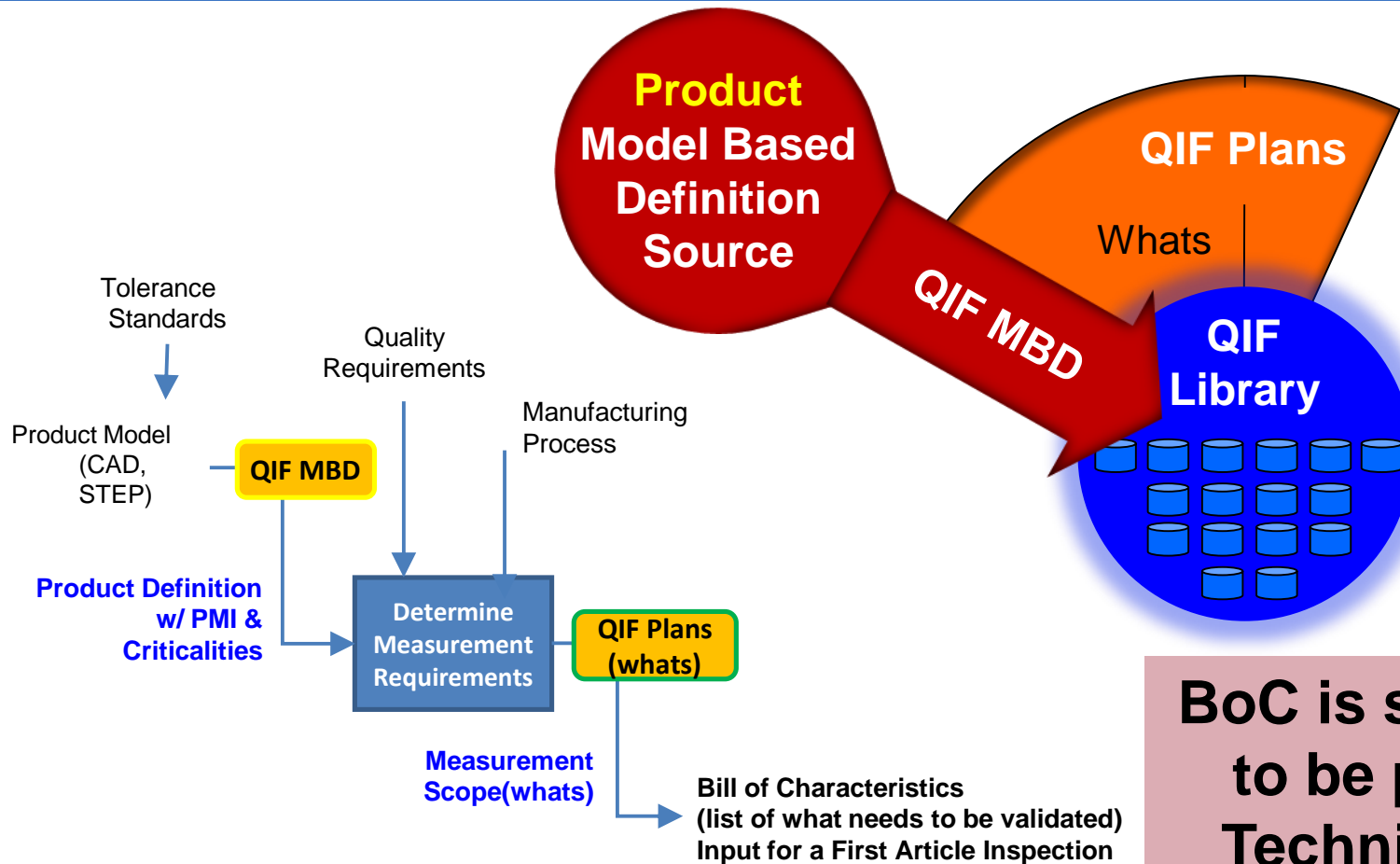**QIF Library**

QIF Resources

QIF Rules

Actions / Methods / Rules / Resources

Quality Measurement Plans
- Standard Format
- XML Schema
- Enables Automation
- Model Based Product Definitions
- Features / Characteristics
- Resource-Based
- Rules-Based
  - Applies Rules (by Company, by Part Family)
  - Assigns Resources (by Department, by Supplier)
- Hierarchical Ordered Measuring Sequence
- Dimensional & Non-Dimensional

Bill of Characteristics with QIF Plans

Product Model Based Definition Source

QIF Plans

Whats

QIF MBD

QIF Library

Tolerance Standards

Quality Requirements

Manufacturing Process

Product Model (CAD, STEP)

QIF MBD

Product Definition w/ PMI & Criticalities

Determine Measurement Requirements

QIF Plans (whats)

Measurement Scope(whats)

Bill of Characteristics (list of what needs to be validated) Input for a First Article Inspection

Example QIF PLAN_BOC_XML

BoC is suggested to be part of a Technical Data Package (TDP)

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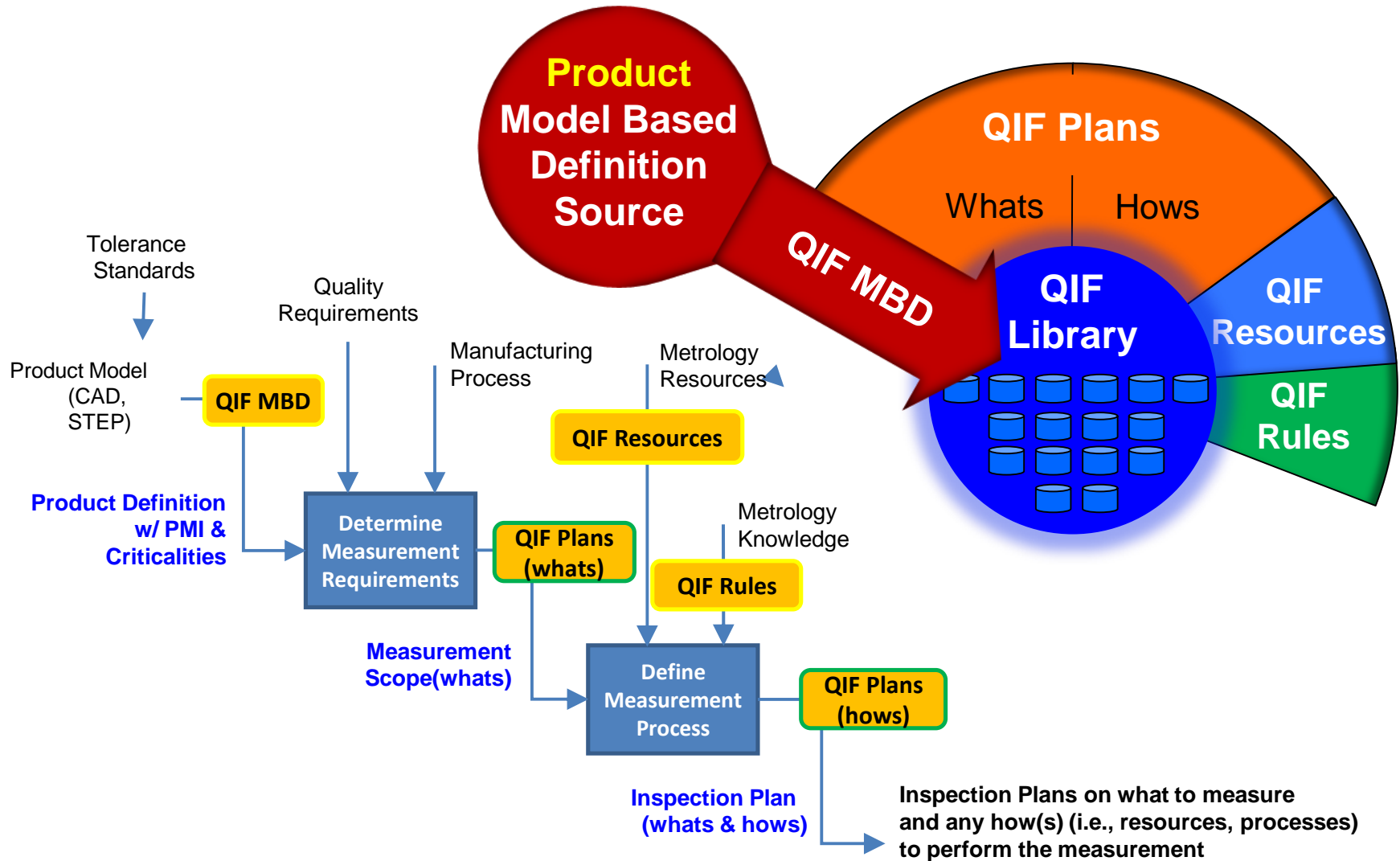
QIF Results and Statistics

QIF Results and Statistics

- Analyzing Single and Multiple Part Inspection

- First Article, Capability, SPC, MSA

- Explicit Statistical Tolerances

- Identify Trends

- Trace Anomalies

- Provide Feedback

- Improve Production

- Assess Performance

- Judge Quality & Efficiency of Processes
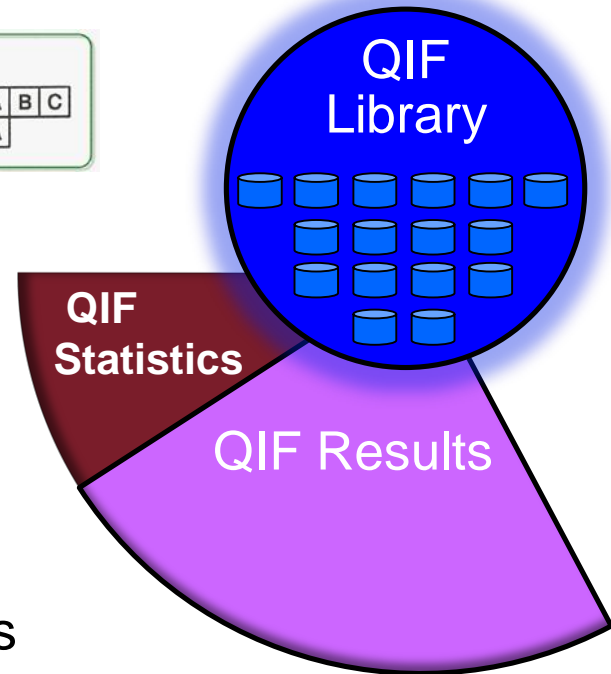
Manufacturing PLM Workflow

Current commercial product landscape:
- Fully associative master-model driven technical package
- Supports complex NC processes
- Promotes data re-use

CAM Process Verification

Post Processor

Tool Path

Machine Setup

Tooling

Fixturing

Master Model
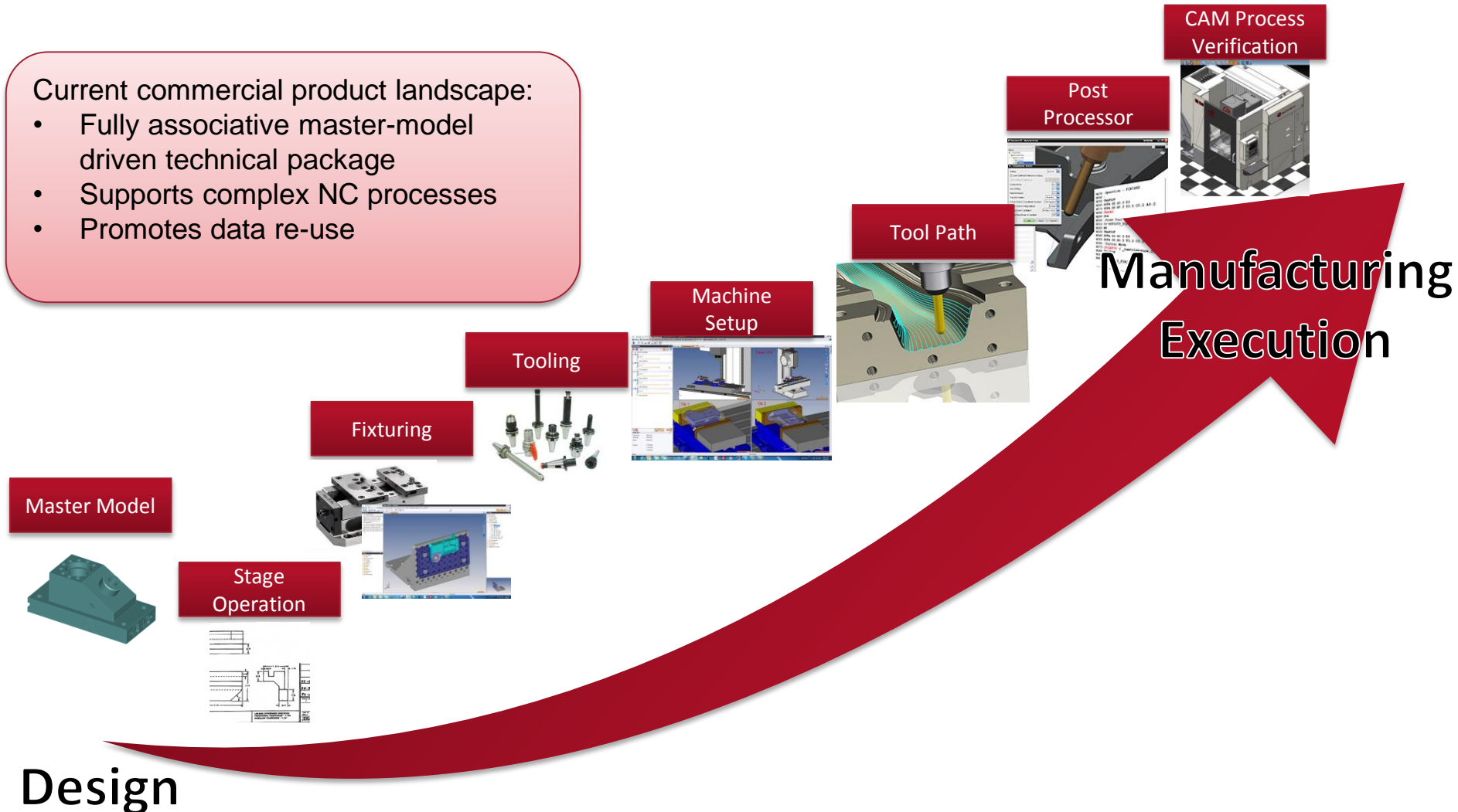
Stage Operation

Manufacturing Execution

Design

Measurement PLM Workflow

Current commercial product landscape without QIF:
- Adequate GD&T representation not available: robust, semantic PMI required
- Downstream metrological applications exist, but lacking GD&T cannot associate back to master model

CMM Program Generation

Measurement Optimization

$$F = a^2 \left[w_s \oint \frac{\partial F}{\partial r} \left(\frac{\partial F}{\partial r} \right)^2 + w_c \oint \nabla^2 F \ \nabla^2 F^2 \right] a$$
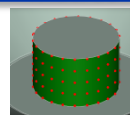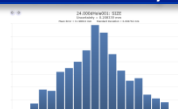
Fixturing

Measurement Execution

Measurement Resources

Probing Macros

Measurement Uncertainty

Master Model

GD&T Representation

Inspection Planning

Design

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Measurement PLM Workflow with QIF
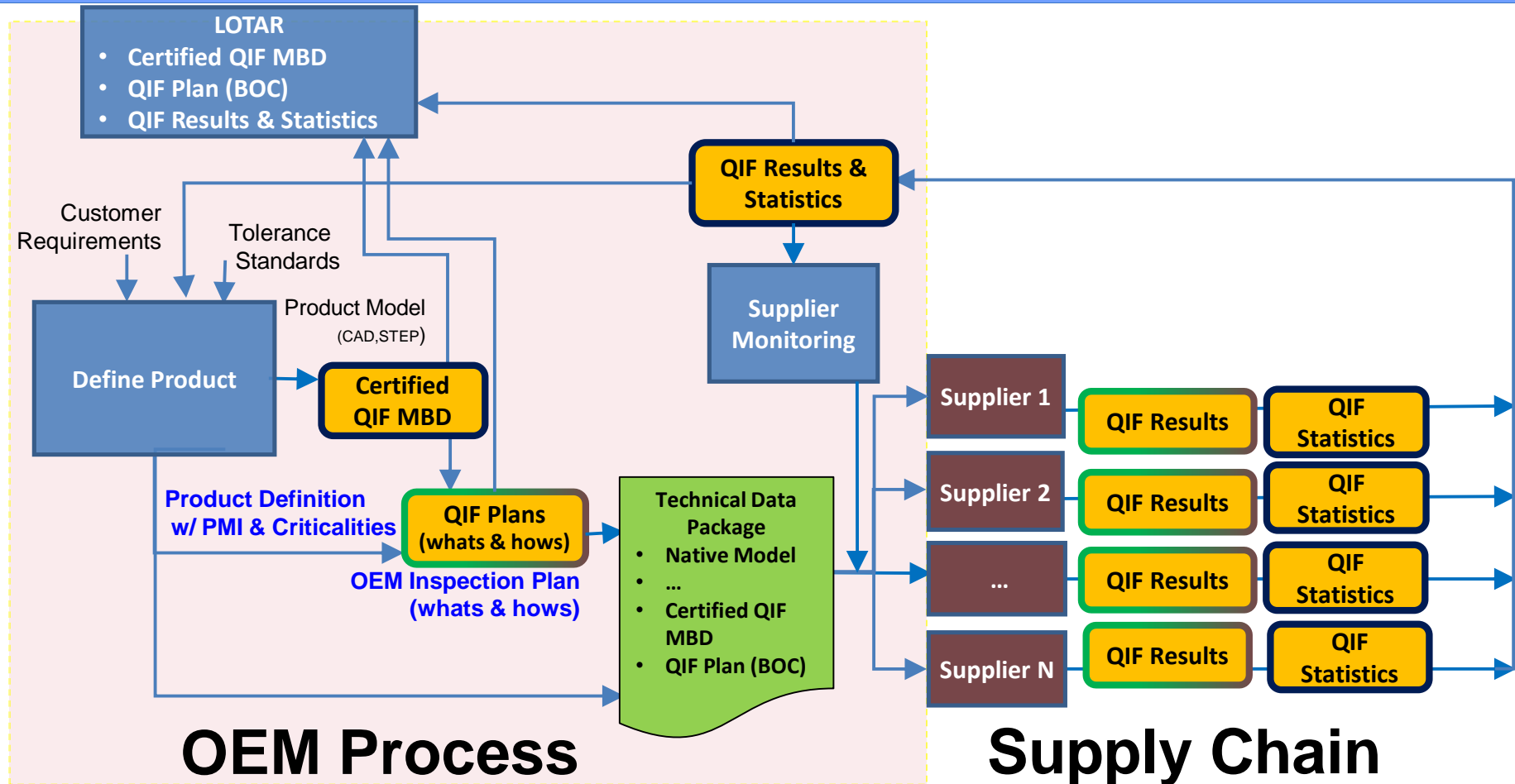
OEM Process

LOTAR
- **Certified QIF MBD**
- **QIF Plan (BOC)**
- **QIF Results & Statistics**

Customer Requirements

Tolerance Standards

Product Model (CAD,STEP)

Define Product

Certified QIF MBD

Product Definition w/ PMI & Criticalities

QIF Plans (whats & hows)

OEM Inspection Plan (whats & hows)

Technical Data Package
- **Native Model**
- **...**
- **Certified QIF MBD**
- **QIF Plan (BOC)**

QIF Results & Statistics

Supplier Monitoring

Supply Chain

Supplier 1 — **QIF Results** — **QIF Statistics**

Supplier 2 — **QIF Results** — **QIF Statistics**

... — **QIF Results** — **QIF Statistics**

Supplier N — **QIF Results** — **QIF Statistics**

QIF offers the following benefits:
- Better control of supply chain
  - Possible to now monitor suppliers in real time
- Smooth flow of information to and from supply chain
- Increase overall quality of the process
- Minimize costs
- Elimination of human errors
- Eliminate information loss due to translations

Multi-Vendor QIF Demonstration at IMTS 2014

The IMTS 2014 QIF v2.0 Interoperability Demonstration video is now available on YouTube.
http://www.youtube.com/watch?v=TgeVfgYX3PA&feature=youtu.be

Quality Digest Interview on QIF
http://youtu.be/Fajp5nVL5bo?list=UUCX2JacnZmLQ7_mwXk2HUaw

QIF INTEROPERABILITY DEMO PARTICIPATING ORGANIZATIONS

Info Producing

PTC

Capvidia

| QIF MBD | QIF Plan | QIF Resources | QIF Results | QIF Statistics |

Honeywell FM&T
IPI Solutions
Origin International
PAS Technology

Innovalia Metrology
IPI Solutions
Kotem
Mitutoyo America
Origin International

Mitutoyo America

Capvidia
Metrosage

IPI Solutions
Metrosage
Mitutoyo America
Origin International
PAS Technology

Honeywell FM&T
Metrosage

InfinityQS
IPI Solutions
Metrosage
MTConnect Institute
PAS Technology

MTConnect Institute

Info Consuming

Equator
Renishaw

Facilitation Testbed → John Deere   Lockheed Martin   NIST

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QIF Widget – Product Model

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- Standards are in general, paper based documents
- QIF is **fully XML based**
- QIF is described by the **XSD Schema (QIF Library of files)** and in-line documentation
- QIF **data model** is completely and explicitly **expressed by XSD schema**
- QIF XSD schema **eliminates ambiguous implementations** (no flavors as in IGES, STEP, PDF, DMIS, etc.)
- QIF includes (build-in) **data validation mechanisms** (XSD, XSLT)
- QIF is a **"new generation" standard** for MBD/MBE and CAx data interoperability

NIST is a member of the DMSC and participates in all aspects of the QIF standard development efforts:

- Maintains the XML schema files
- Prepares data dictionaries
- Leads two subgroups
- Oversees preparation of testing artifacts and provides test files
- Collaborates with industry and establishes test bed to support verification tests and demos
- Researches its integration in the manufacturing enterprise
- Ensures its overall high quality

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

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- 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

- Ensure that **metrology standards fill gaps** and do not overlap

DMSC Consortium Members

- **Advanced Dimensional Management**
- **Applied Automation Technologies**
- **Capvidia**
- **Deere & Company**
- **Honeywell FM&T**
- **Innovalia Metrology**
- **Kotem**
- **Lockheed Martin**
- **MBD360 LLC**
- **MetroSage LLC**

- **Mitutoyo America Corp**
- **Nikon Metrology**
- **NIST**
- **Origin International, Inc**
- **PAS Technology**
- **PS DMIS**
- **Renishaw**
- **Siemens PLM Software**
- **UNC Charlotte**

* November, 2014

Associated Organizations

Open to all who have a Direct and Material Interest

- **Rolls Royce**
- **Pratt Whitney**
- **GE Aviation**
- **Boeing**
- **DISCUS Software**
- **MTConnect**
- **Renaissance Services**
- **IPI Solutions**
- **Infinity QS**

- **Manufacturing Technology Centre**
- **UNC Charlotte**
- **TE Connectivity**
- **Action Engineering**
- **Validation Technologies**
- **PTC**

* November, 2014

DMSC Organization

Dimensional Metrology Standards Consortium **DMSC**

Legal and Finance Committee (Board Only) - LF

Testing, Conformance and Certification Committee (TCC)

DMSC Board of Directors

Quality Measurement Standards Committee (QMS)

Membership, Marketing and Shows Committee (MMS)

DMSC Executive Director

ANSI — American National Standards Institute

Quality Measurement Directives Working Group

Quality Information Framework Working Group (QIF)

Quality Measurement OnMachine Working Group

Working Groups

- **Quality Measurement Plans (QIF Plans)**
- **Quality Measurement Results (QIF Results)**
- **Complete & Accurate Model Based Definition (QIF MBD)**
- **Quality Measurement Resources (QIF Resources)**
- **Quality Measurement Rules (QIF Rules)**
- **Quality Measurement Statistics (QIF Statistics)**
- **Quality Measurement Execution (DMIS) (QIF Execution)**

Driving Technology and Innovation through Standards

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 Capvidia Booth*
  - *Join us, we would value your involvement!*
- **DMSC Membership (www.DMSC-Inc.com)**
  - **bsquier@dmsc-inc.com to Request an Application**
- **DMSC's 2015 QIF SUMMIT *October 5-9, 2015***
  - **Hosted at UTARI, University of Texas at Arlington Research Institute**
  - **DMSC Meeting**
  - **QIF Symposium (14 Speakers)**
  - **QIF Workshop (QIF v2.1)**
- **QIF Involvement (www.QIFStandards.com)**
  - **One or Many Working Groups**
- **Download ANSI/QIF 2014**

  http://qifstandards.org/download-qif/