QIF 2.0:
A New Digital Interoperability Standard for Manufacturing Quality Data

GLOBAL PRODUCT DATA
INTEROPERABILITY
SUMMIT
2014

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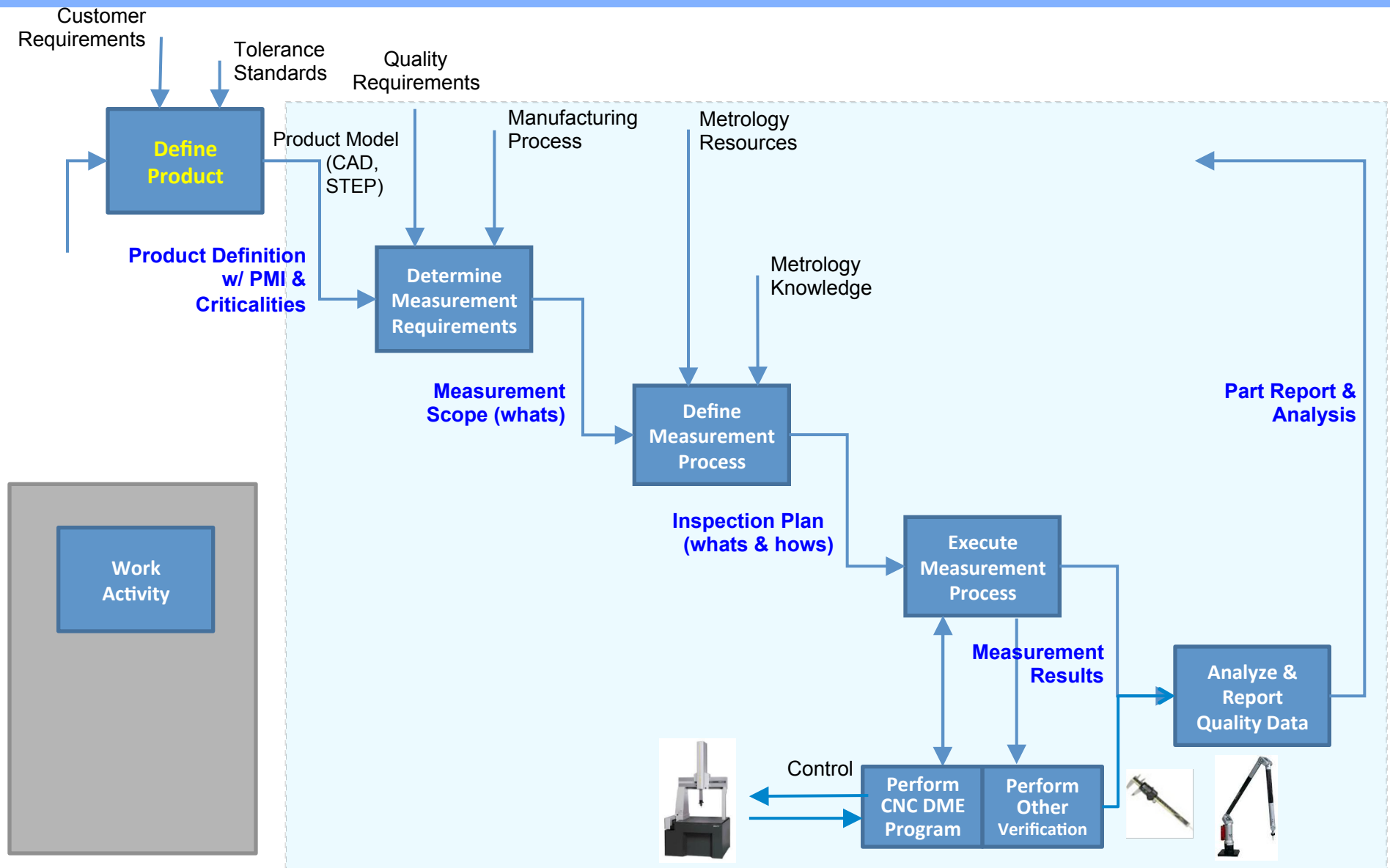
John Horst
Project Manager
NIST

ANSI Standard
Quality Information Framework (QIF™) Standard
New QIF™ v2.0 Standard: A significant Breakthrough for the Metrology Industry

- **Burleson, Texas, USA – September 3, 2014 – The Dimensional Metrology Standards Consortium, Inc. (DMSC) will hold a special event daily during the IMTS show September 8-13, 2014 at the McCormick Place in Chicago, IL.**

- **A demonstration of QIF (Quality Information Framework) version 2.0 draft standard will be held Tuesday-Friday Sept 9 – 12 at the Daily Demonstrations: 10AM – 2PM**

- **DMSC President Curtis Brown of Honeywell FM&T, Lockheed Martin, NIST, John Deere, Capvidia, Metrosage, Origin International, IPI Solutions, Mitutoyo America Corporation, Innovalia Metrology, MTConnect Institute, InfinityQS, Kotem Ltd, Renishaw, and PAS Technology, will demonstrate QIF version 2.0 as published in the September 5th, 2014 ANSI Standards Action publication.**

Product Verification Activity Workflow

Customer
Requirements

Tolerance
Standards

Quality
Requirements

Manufacturing
Process

Metrology
Resources

Define Product

Product Model
(CAD, STEP)

**Product Definition
w/ PMI &
Criticalities**

Metrology
Knowledge

**Determine
Measurement
Requirements**

**Measurement
Scope (whats)**

**Define
Measurement
Process**

**Part Report &
Analysis**

**Work
Activity**

**Inspection Plan
(whats & hows)**

**Execute
Measurement
Process**

**Measurement
Results**

**Analyze &
Report
Quality Data**

Control

**Perform
CNC DME
Program**

**Perform
Other
Verification**

QIF v2.0 Digital Product Verification Process

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Customer Requirements

Tolerance Standards

Quality Requirements

Define Product

Product Model (CAD,STEP)

QIF MBD

Manufacturing Process

Metrology Resources

QIF-Resources

Quality Metrology Enterprise

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

Inspection Plan (whats & hows)

Execute Measurement Process

QIF-Results

Work Activity

DMSC Standard Current

DMSC Standard QIF v1.0

DMSC Standard QIF v2.0

Measurement Results

DMIS

Analyze & Report Quality Data

Control

I++ DME

Perform CNC DME Program

Perform Other Verification

Outline

- **Digital Product Verification (DPV)**

- **Standards for Interoperability enable the**
  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**

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*

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
    - Attribute
    - Real-Valued
  - 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*

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- 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**)

QIF v2.0 Metrology 'Life Saver' Architecture
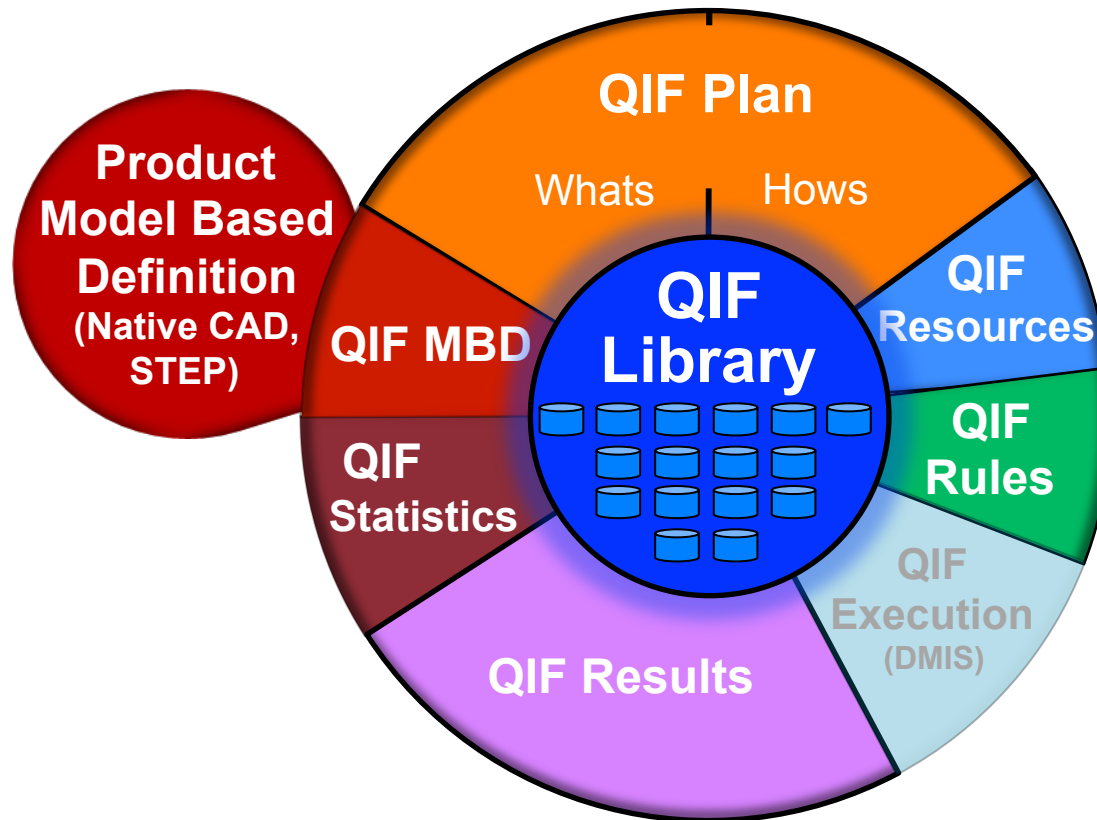
Planned QIF v2.0

Common QIF Library
   Eight Information Models
QIF Application Information Models (use the QIF Library)
- **QIF MBD (Product Definition w/PMI)**
- **QIF Plans**
- **QIF Resources**
- **QIF Rules**
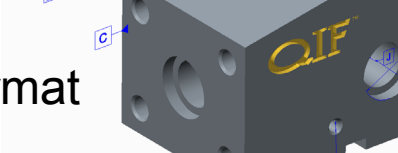- *QIF Execution (next generation DMIS)*
- **QIF Results**
- **QIF Statistics**
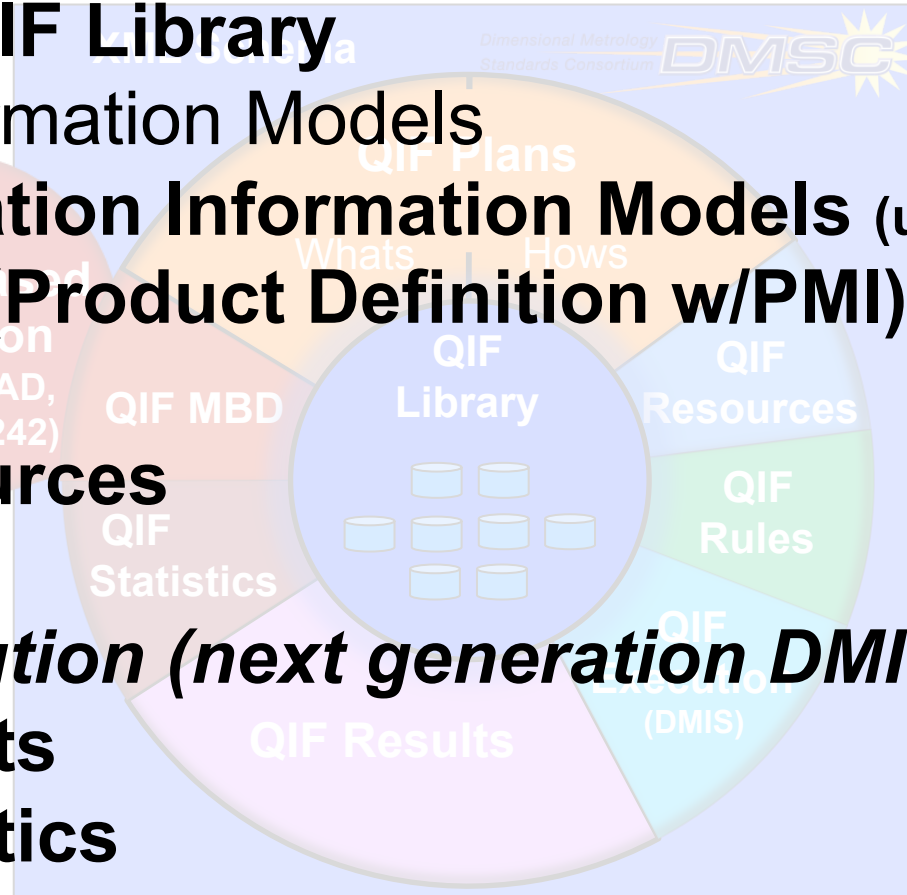
QIF MBD

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 PMI
- Native CAD + PMI
- STEP AP242
- INCLUDES PMI!
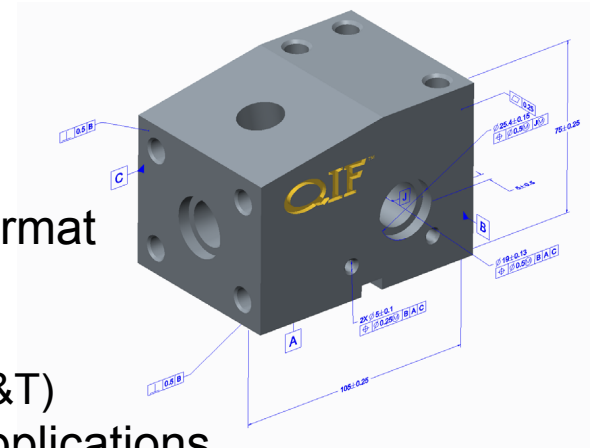
- XML Schema (Initiated by DMSC/Capvidia MoU)
  - Expose the Product Definition w/ PMI in the QIF format
  - Model Based Product Definition
    - Model Based Definition (e.g., Solid Model)
    - Various Conformance Levels of Semantic PMI (GD&T)
  - Easier Use and Implementation for downstream applications
  - Satisfy Native CAD to Model Based Metrology Use Case and more….
  - Satisfy STEP to Model Based Metrology Use Case and more….

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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
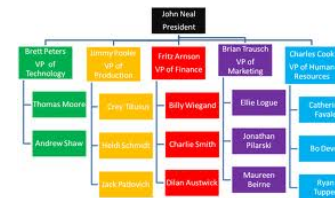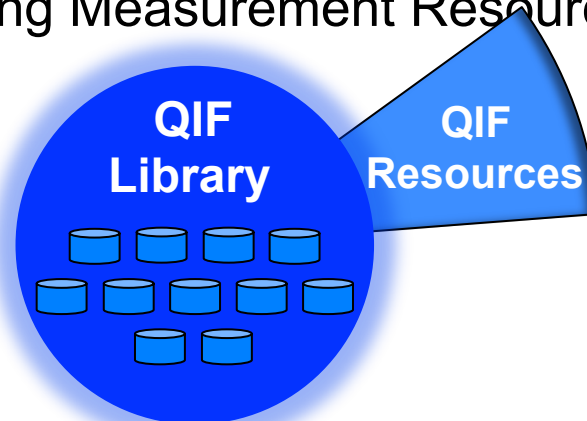
QIF Library

QIF Resources

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
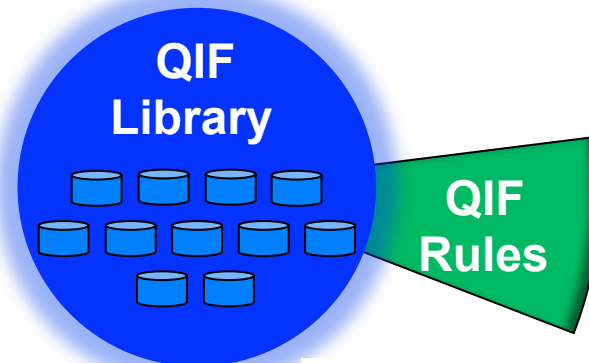
Actions /
Methods /
Rules /
Resources

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

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Bill of Characteristics with QIF Plans

Product
Model Based Definition Source

QIF MBD

QIF Plans

Whats

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

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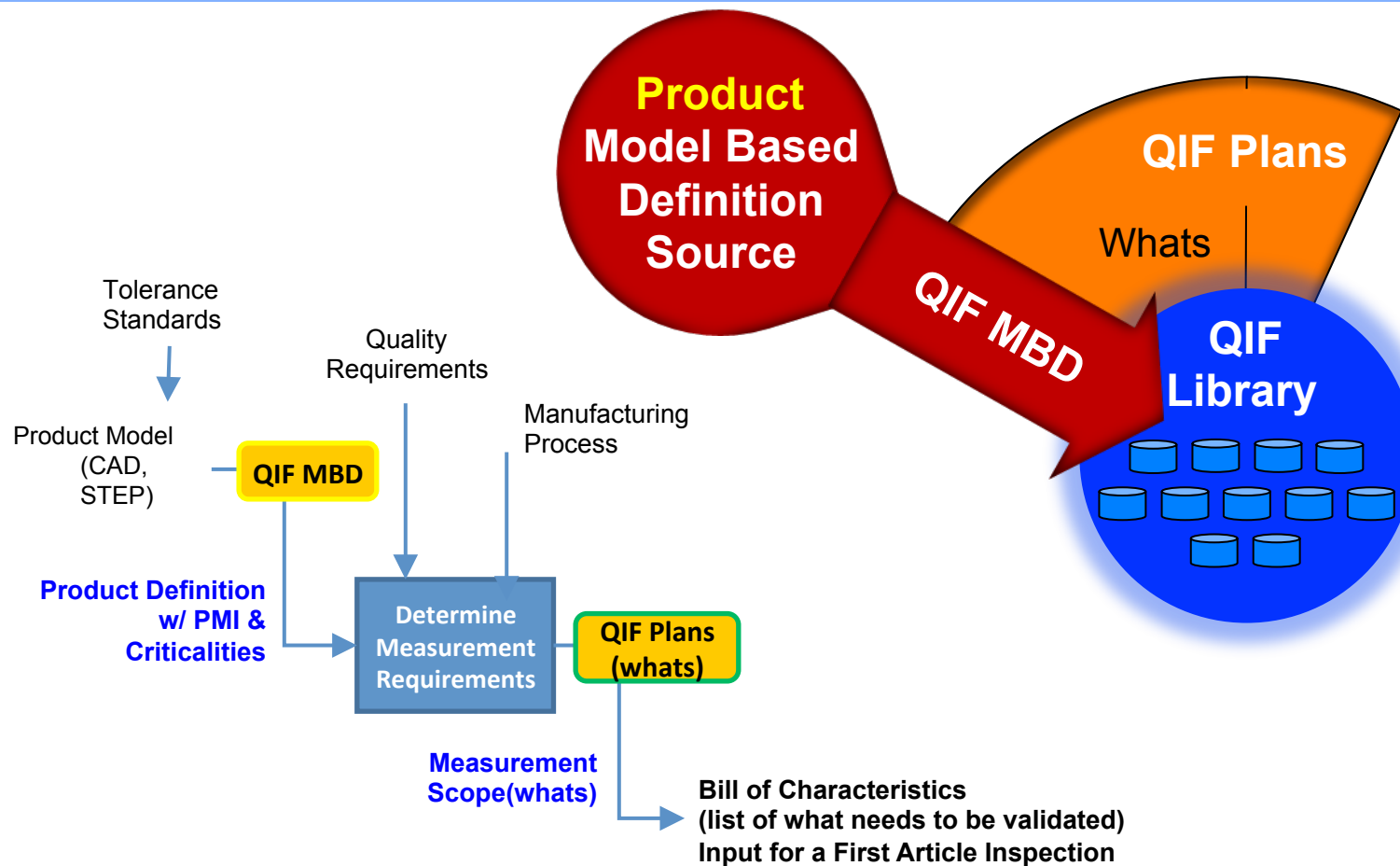
Inspection Process Planning with QIF Plans

Tolerance Standards

Product Model (CAD, STEP)

QIF MBD

Quality Requirements

Product Definition w/ PMI & Criticalities

Manufacturing Process

Product Model Based Definition Source

QIF MBD

QIF MBD

QIF Plans

Whats | Hows

QIF Library

QIF Resources

QIF Rules

Metrology Resources

QIF Resources

Determine Measurement Requirements

QIF Plans (whats)

Measurement Scope(whats)

Metrology Knowledge

QIF Rules

Define Measurement Process

QIF Plans (hows)

Inspection Plan (whats & hows)

Inspection Plans on what to measure and any how(s) (i.e., resources, processes) to perform the measurement

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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
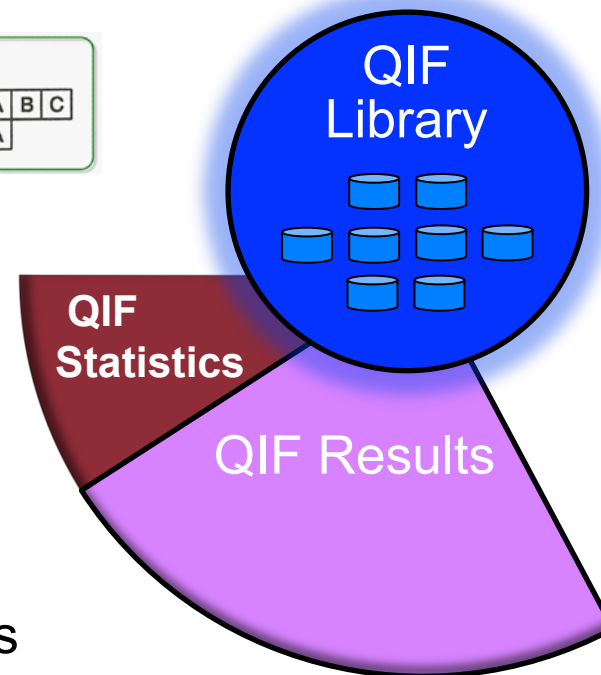
PTC – Creo Parametric

- Create precise geometry, regardless of model complexity
  - With a comprehensive library of CAD, CAID, CAM, and CAE extensions
- Create Product Definition w/ PMI & Criticalities
  - QIF MBD compliant
- Create 2D and 3D drawings according to international standards, including ASME, ISO, and JIS

PTC Creo® Parametric™

PTC Creo Parametric provides the broadest range of powerful yet flexible 3D CAD capabilities to accelerate the product development process
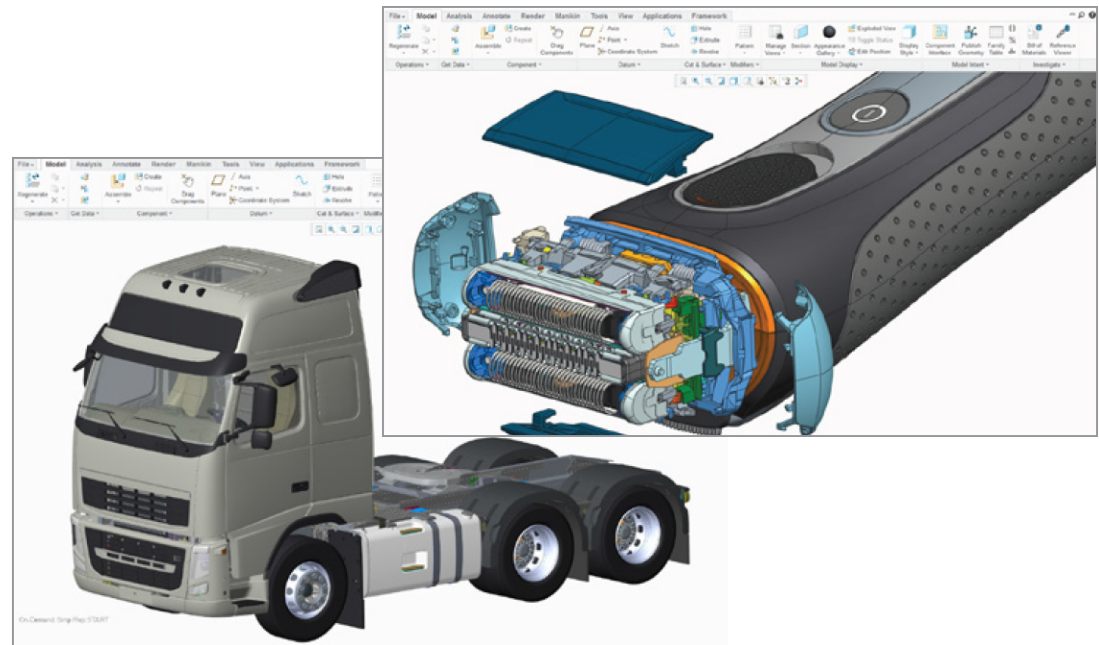
QIF v2.0. PTC – Creo Parametric
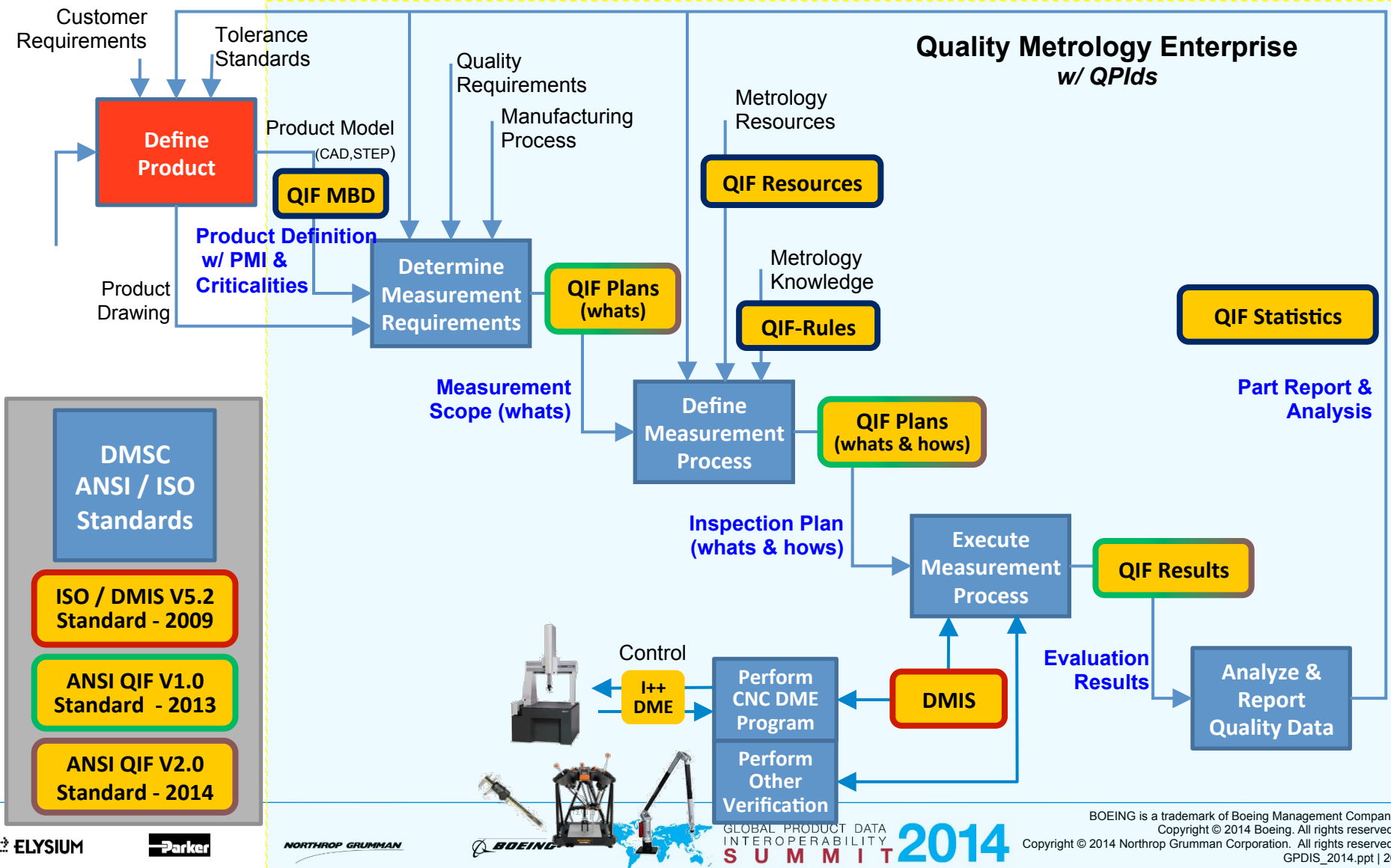
Quality Metrology Enterprise
w/ QPIds

Customer Requirements

Tolerance Standards

Quality Requirements

Manufacturing Process

Metrology Resources

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Execute Measurement Process

QIF Results

Control

I++ DME

Perform CNC DME Program

DMIS

Evaluation Results

Analyze & Report Quality Data

Perform Other Verification

DMSC ANSI / ISO Standards

ISO / DMIS V5.2 Standard - 2009

ANSI QIF V1.0 Standard - 2013

ANSI QIF V2.0 Standard - 2014

Capvidia – CreoVidia, CompareVidia, & MBDVidia

CreoVidia – Produce QIF

- **Converts 3D Model + PMI into QIF**
- **Automatic QIF Feature Recognition**
- **Export to QIF:**
  - **3D Model**
  - **Semantic PMI**
  - **Saved Views, Annotations**
  - **QIF Features & Characteristics**

MBDVidia - View/Analyze QIF

- **QIF Import**
- **View 3D Model & Semantic PMI**
- **Investigate QIF Features & Characteristics**

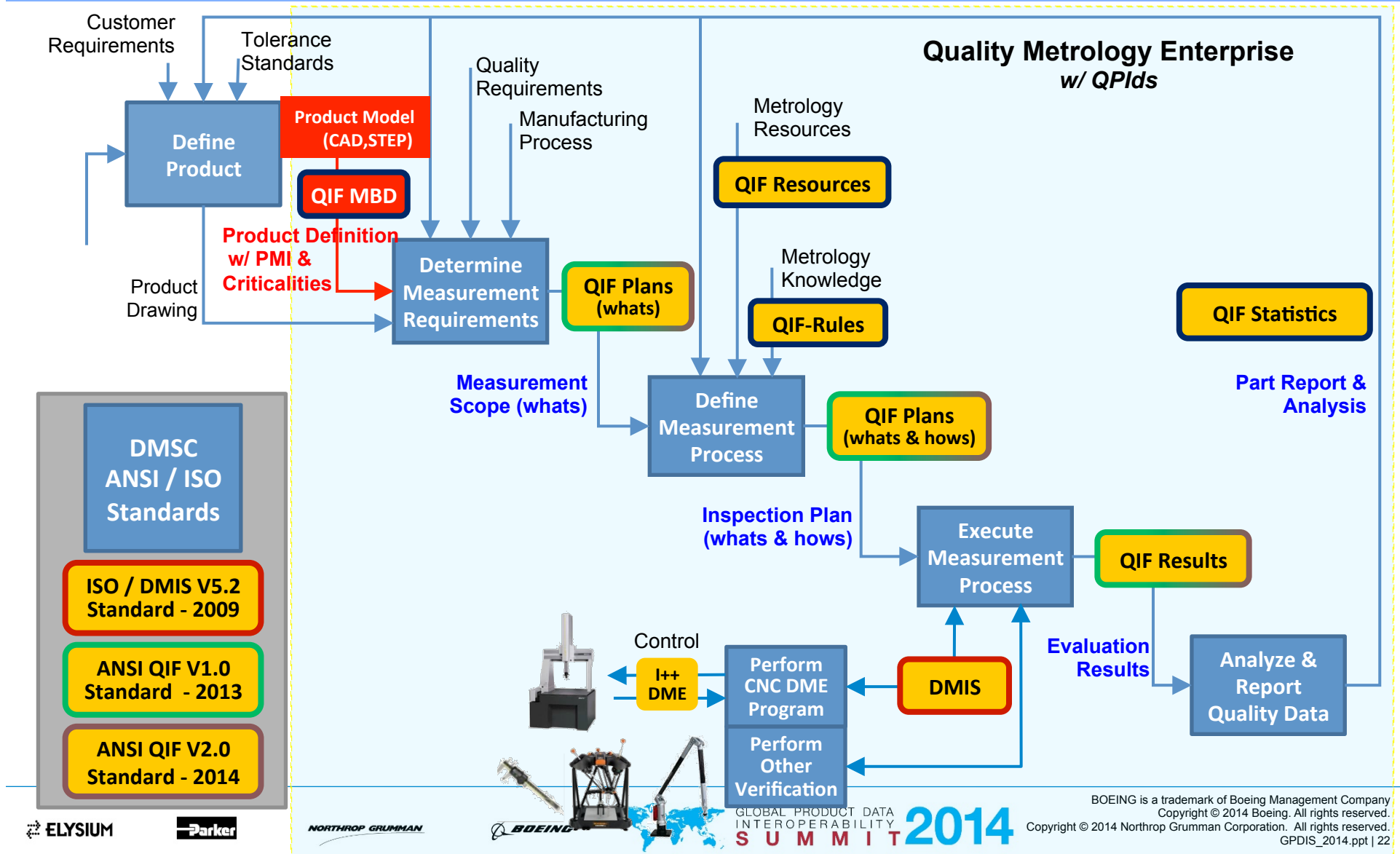## CompareVidia - Validate QIF

- **Compares CAD/STEP with QIF:**
  - **Geometry**
  - **Semantic PMI**
- **Pass/Fail Report**
- **Ensures Integrity of QIF Model**

CreoVidia – Capvidia Auxiliary PTC Creo Application to create QIF files

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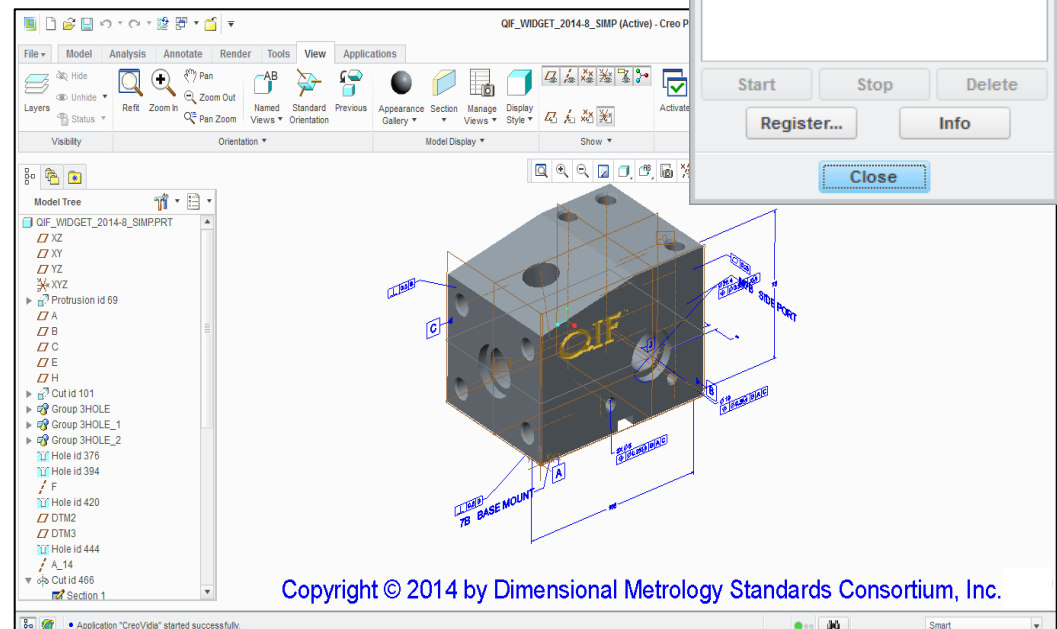
QIF v2.0 – Capvidia CreoVidia, CompareVidia & MBDVidia

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Honeywell FM&T's Feature-Based Tolerancing

Enriches Model Based Definitions with 3D Functional Tolerance Information

- **Represents Fully Semantic Tolerances**
- **Recognizes Tolerance Features Automatically**
- **Infers Correct Tolerances**
- **Checks & Grades Part Tolerance Definition**
- **Provides Downstream Model Based Applications with Explicit Tolerance Data**
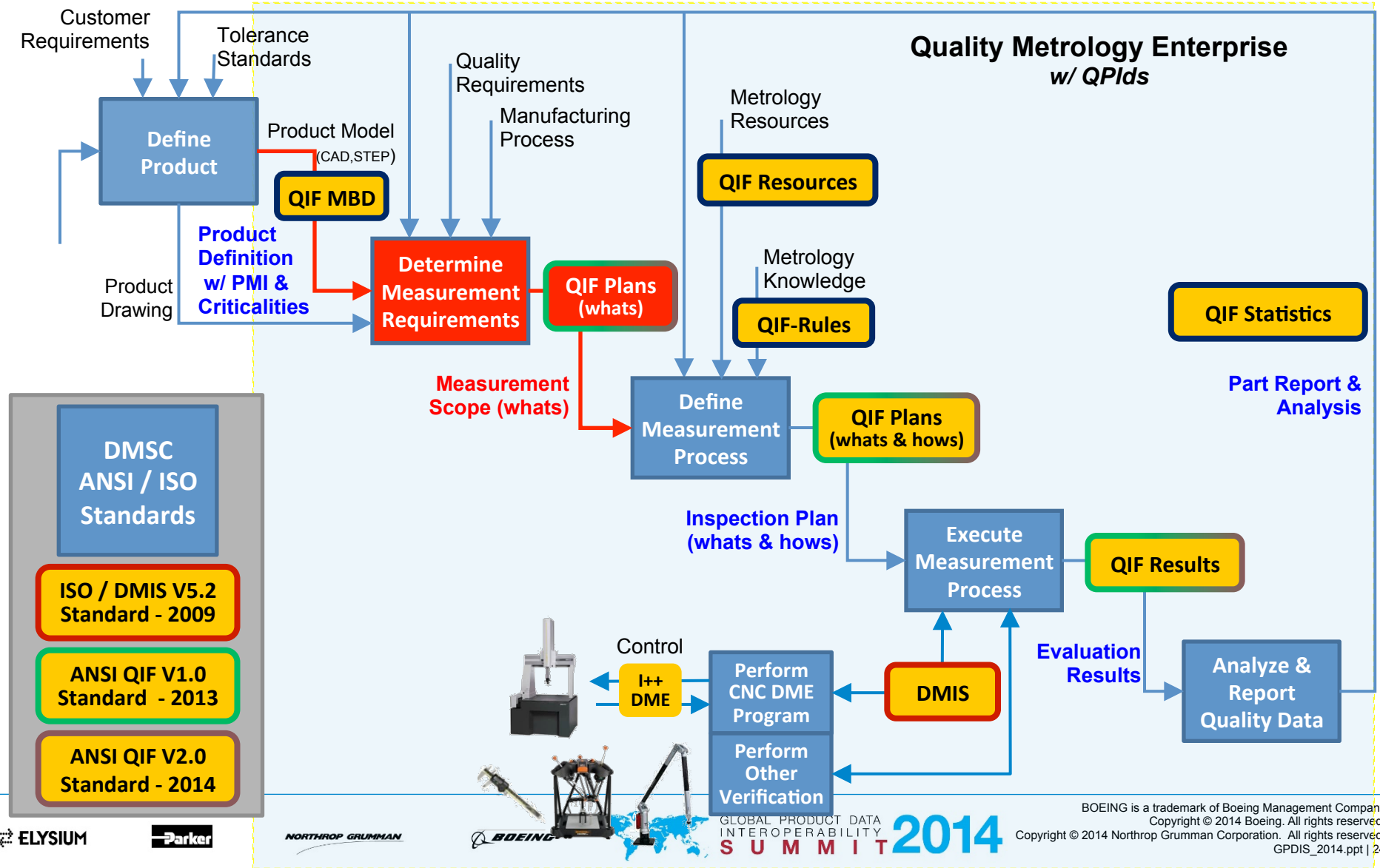- **Generates Model-Based Quality Plans (BoC) in QIF format**

SolidWorks

Tolerance Definition Check returns with an FBTol Score of 87.0.

FBTol Score 100%

+/- 0.010

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GPDIS_2014.ppt | 23

QIF v2.0 – Honeywell FM&T with FBTol

Honeywell

Origin – **CheckMate** and **CheckMateRT**

- Consume QIF MBD or QIF Plan
- Produce DMIS program (.DMI)
- Consume DMIS results (.DMO)
- Produce QIF Results

CheckMate – offline programming, reporting and analysis for both CMM and point cloud systems
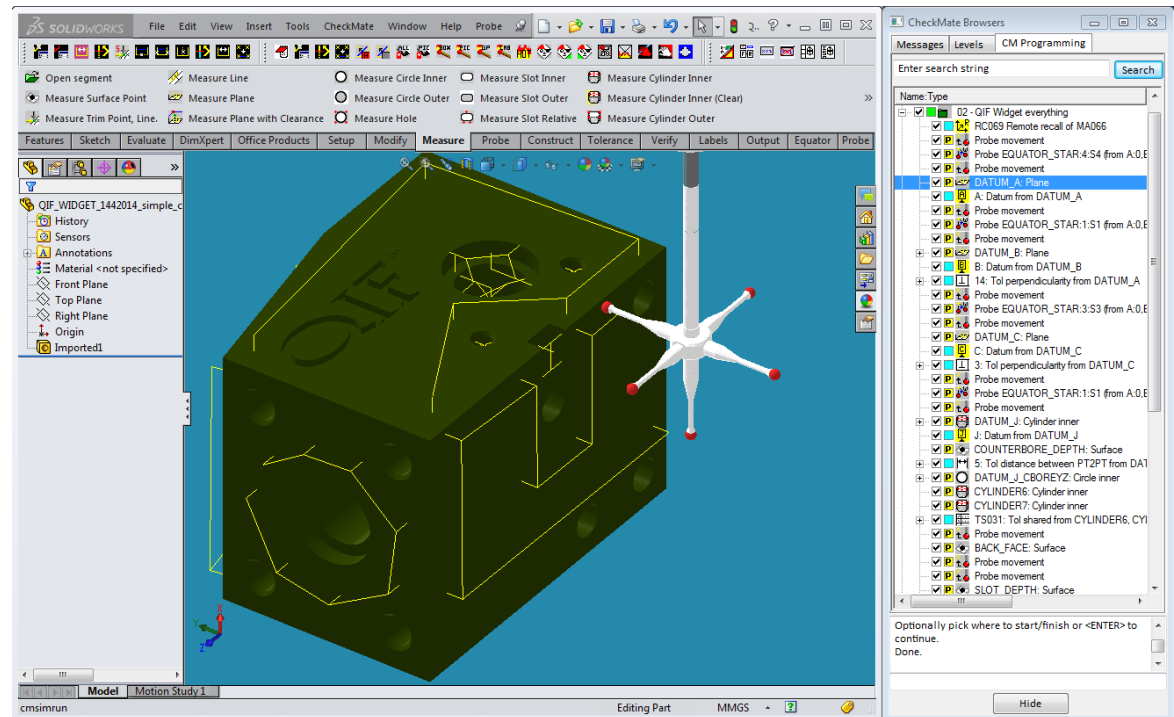
QIF v2.0 – Origin – CheckMate and CheckMateRT

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w/ QPIds

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QIF v2.0 – PAS TECHNOLOGY – PAS CMM & Inspection Manager

Automatically extracting manufacturing and inspection requirements from 3D file and 2D blueprint and convert it automatically to inspection plan, inspection CMM program and reporting.
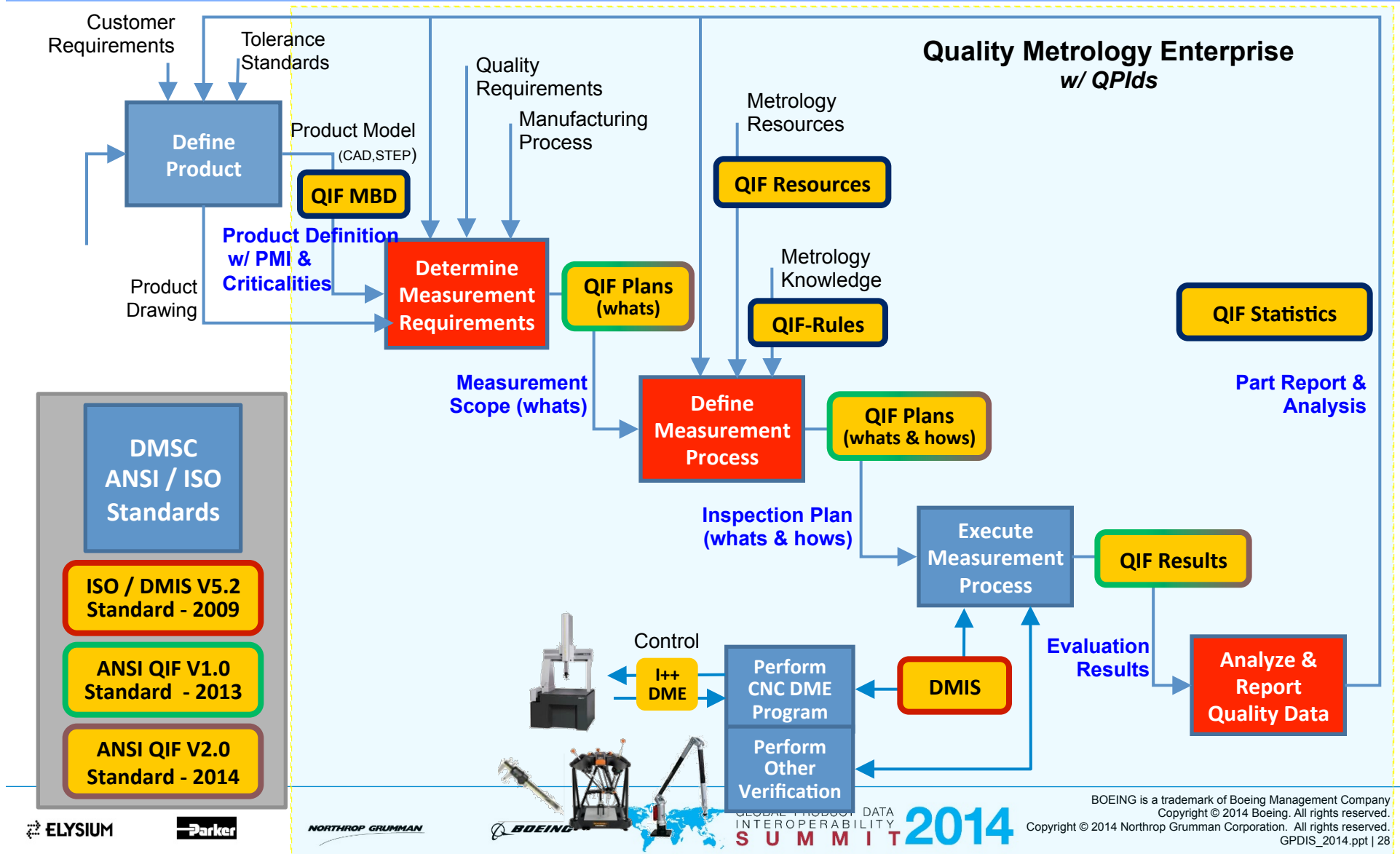
- Consume QIF 2D file and\or 2D blueprint.
- Produce QIF Inspection requirements
- Acquire data from any Measurement Resource and generate QIF reporting

QIF v2.0 – PAS TECHNOLOGY – PAS CMM & Inspection Manager

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w/ QPIds

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ANSI QIF V1.0 Standard - 2013

Analyze & Report Quality Data

ANSI QIF V2.0 Standard - 2014

Perform Other Verification

- **Consume** any CAD model (**QIF MBD**)
- **Consume** measured point data (**QIF Results**)
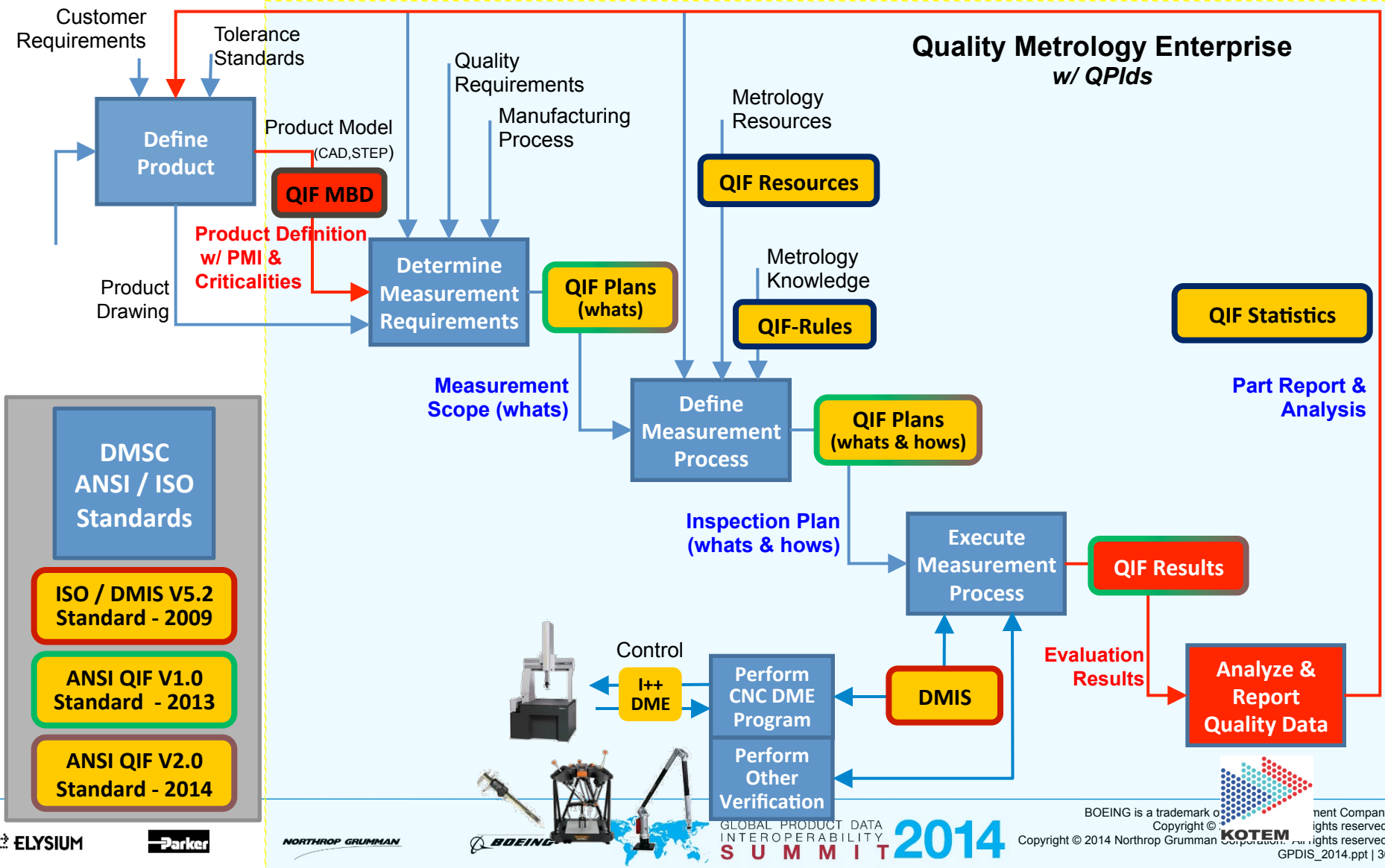- **Produce** QIF measurement results for relevant characteristics (**QIF Results**)

Evaluates part conformance to all geometrical dimensioning and tolerancing (GD&T) callouts using point data collected on any measurement system.
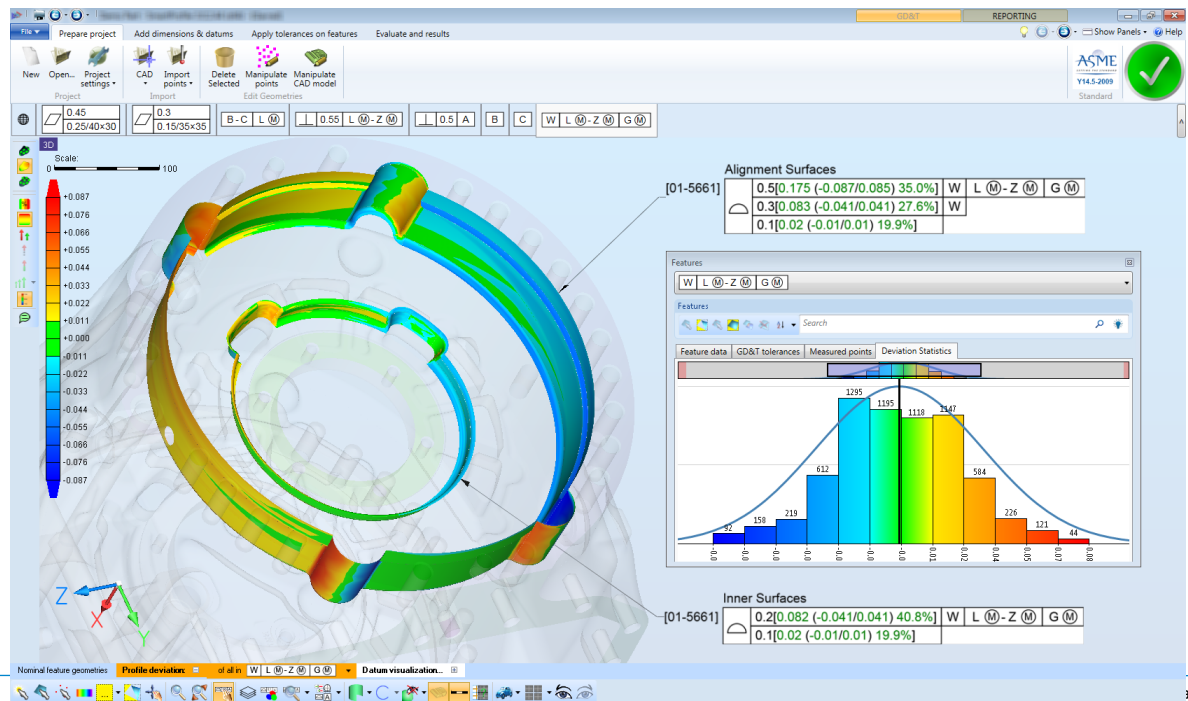
QIF v2.0 – Kotem SmartProfile
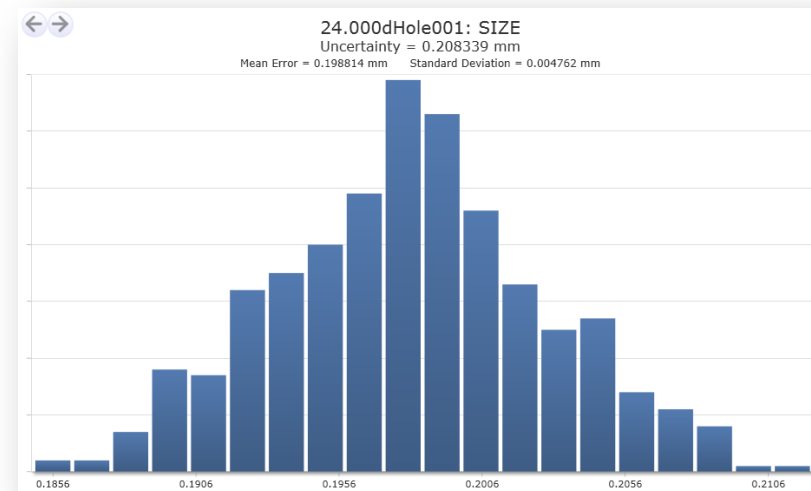
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- Calculate *task-specific measurement uncertainty* for all characteristics on part
- Knowledge of measurement uncertainty required to conform to international traceability requirements and to optimize measurement strategy
- Required information:
    - Feature geometry
    - Bill of characteristics
    - Point sampling locations
    - Measurement equipment information
    - Known manufacturing errors
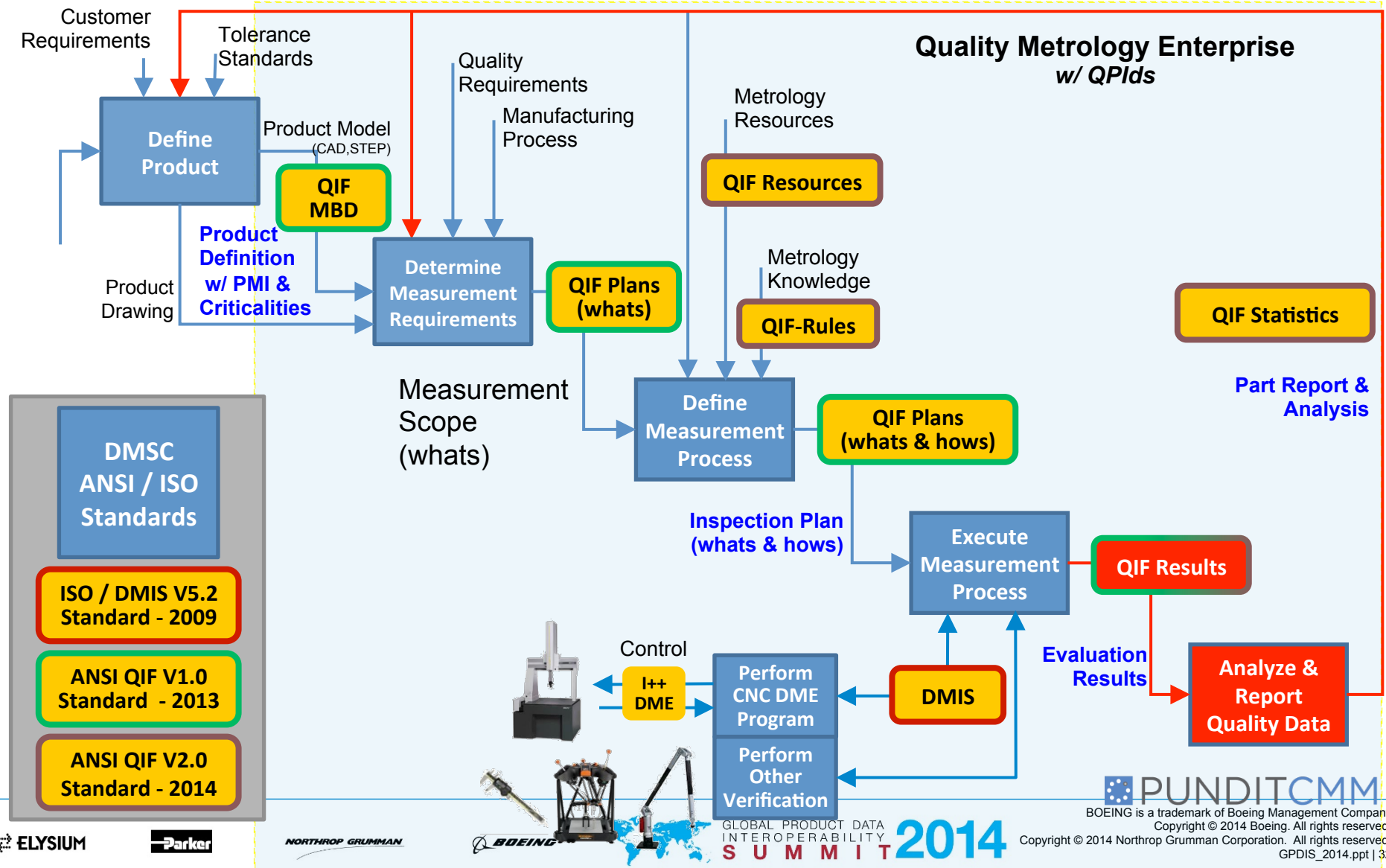
PUNDITCMM
Measurement Uncertainty

24.000dHole001: SIZE
Uncertainty = 0.208339 mm
Mean Error = 0.198814 mm   Standard Deviation = 0.004762 mm

0.1856   0.1906   0.1956   0.2006   0.2056   0.2106

www.metrosage.com

QIF v2.0 Metrosage Pundit CMM

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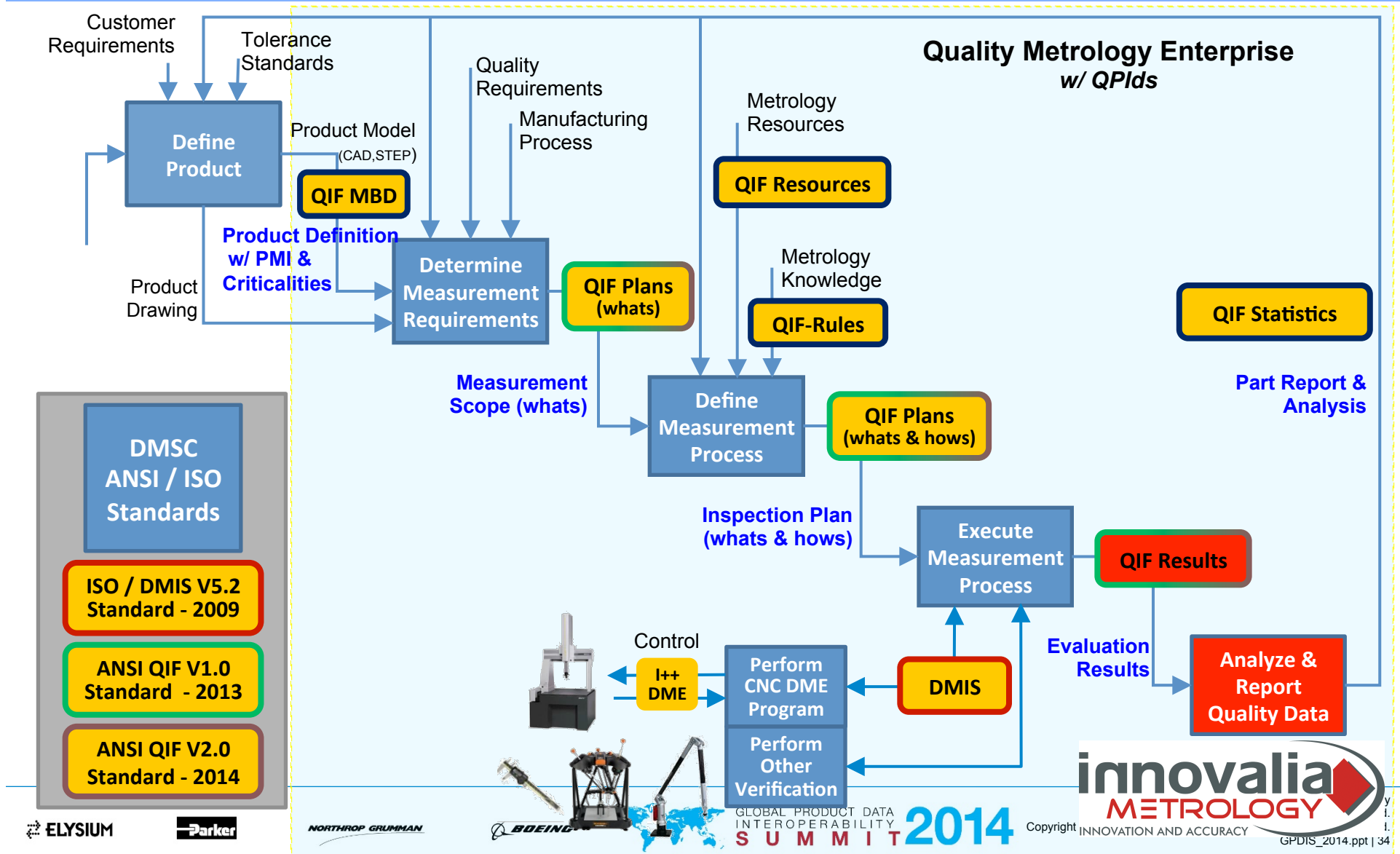
PUNDITCMM

Company - Product

- Multisensor measurement platform
- GD&T Point cloud analysis
- Produce/Import QIF results
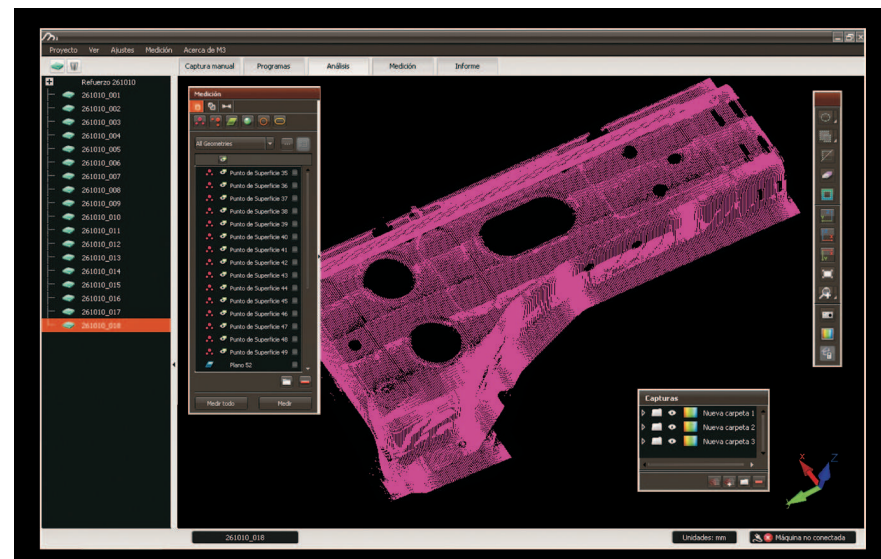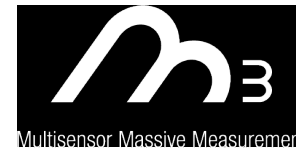
QIF v2.0 – Innovalia M3

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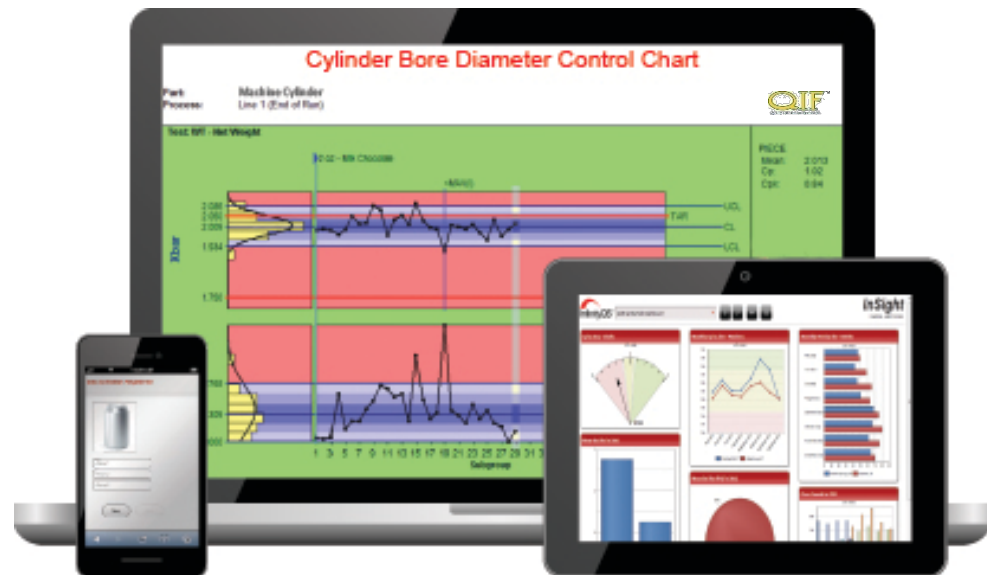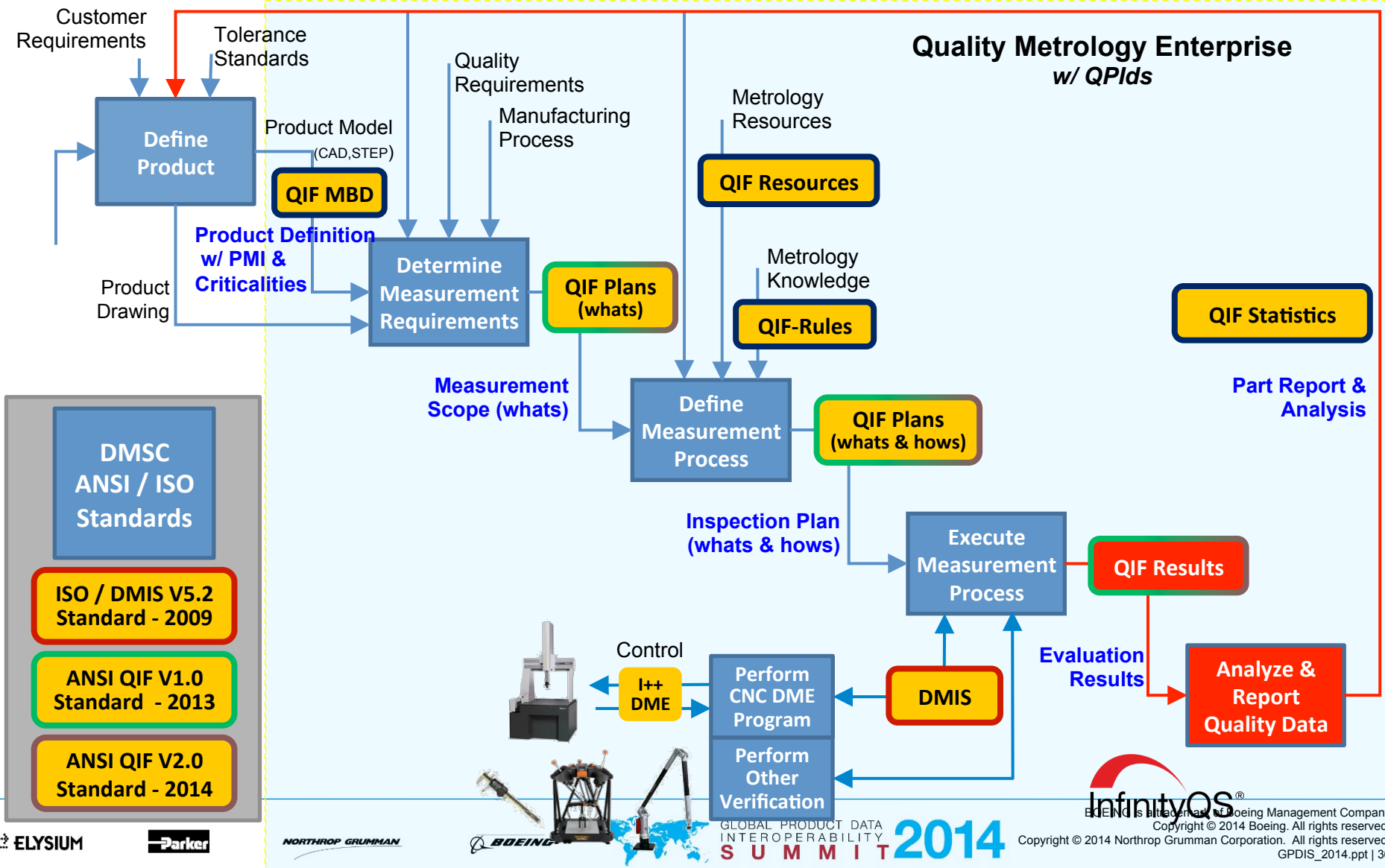
InfinityQS ProFicient

- Consume QIF Results

- **Reporting and analysis of results**

- Easily acquire data from virtually any data source

ProFicient is a proven quality software platform that gives manufacturers a complete, real-time view of manufacturing operations, allowing them to control quality at each point of the product lifecycle.

QIF v2.0 – InfinityQS ProFicient

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w/ QPIds

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Perform Other Verification

- Consume QIF Measurement Plans
- Acquire data from any Measurement Resource
- Produce QIF Measurement Results and Statistics
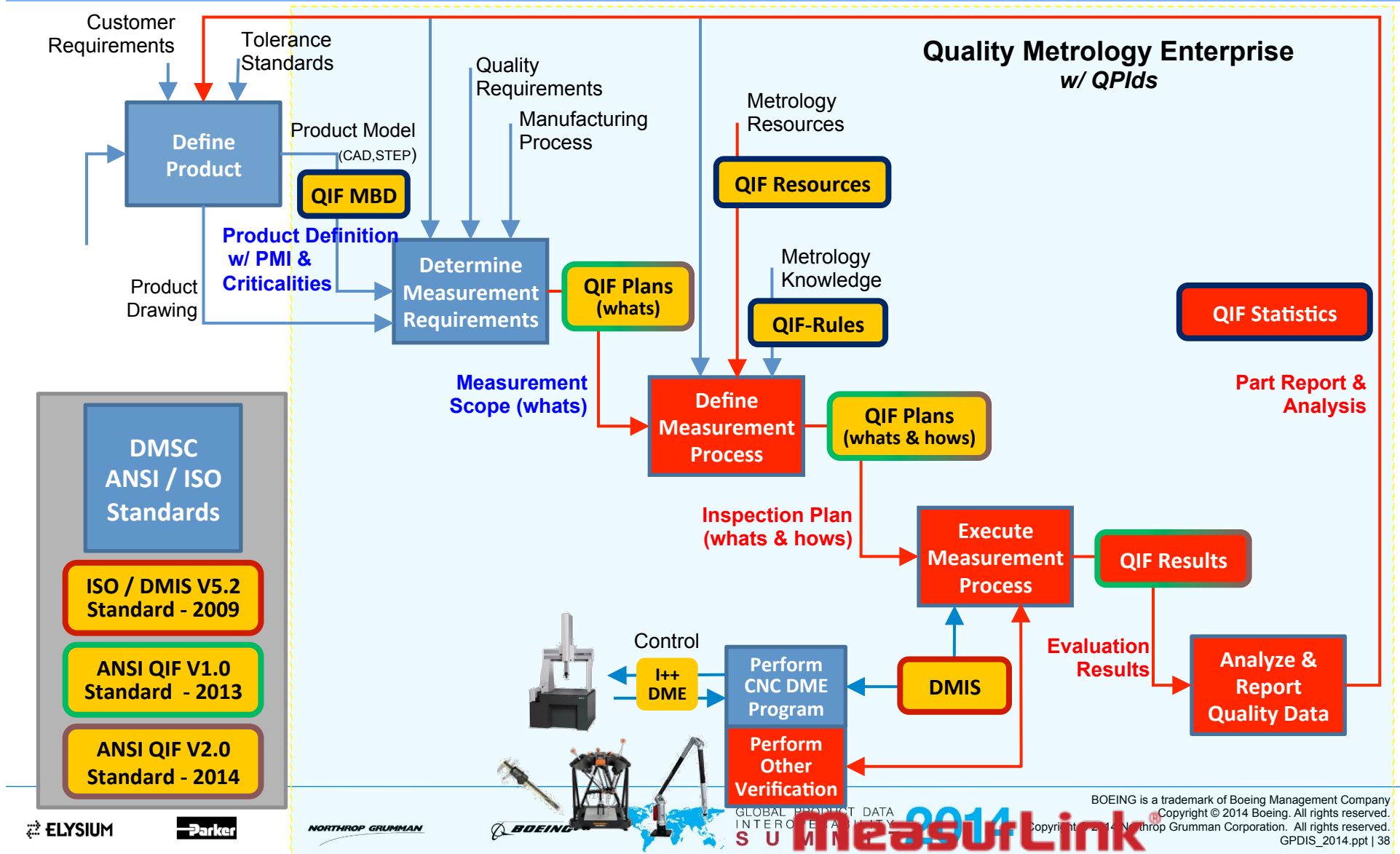
Enterprise Data Collection, Management and Analysis for Statistical Process Control and Measurement Systems Analysis
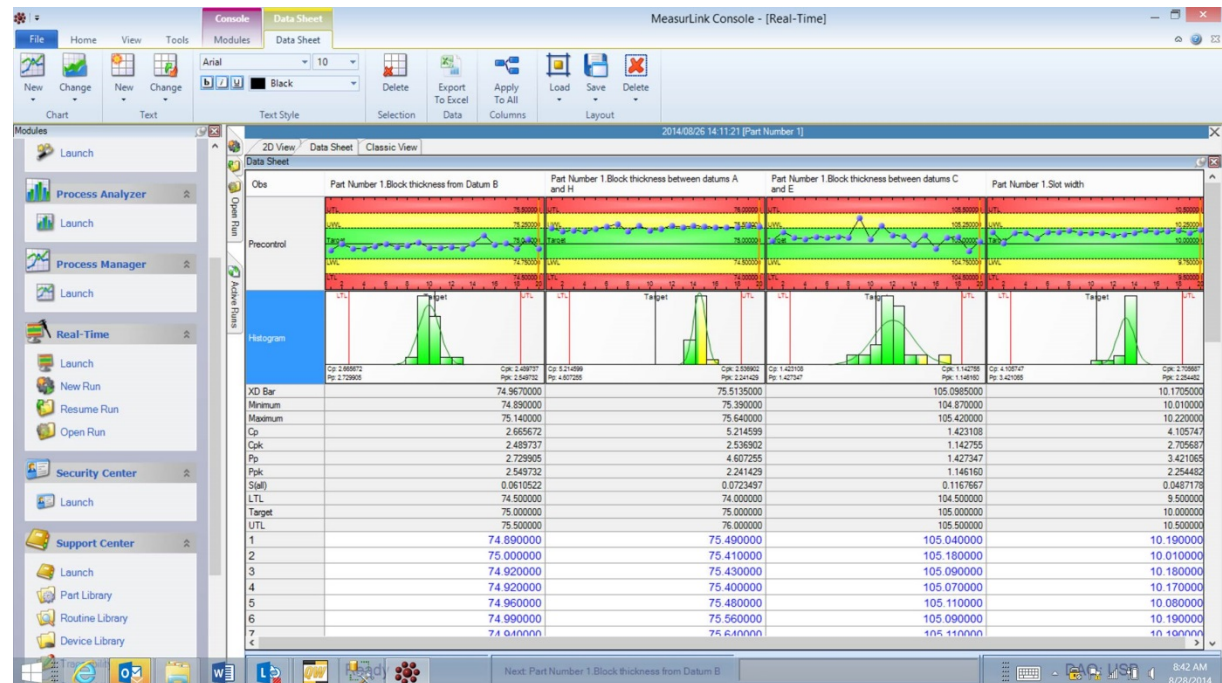
QIF v2.0 – Mitutoyo MeasurLink

NIST – Smart Manufacturing Operations Planning and Control Program

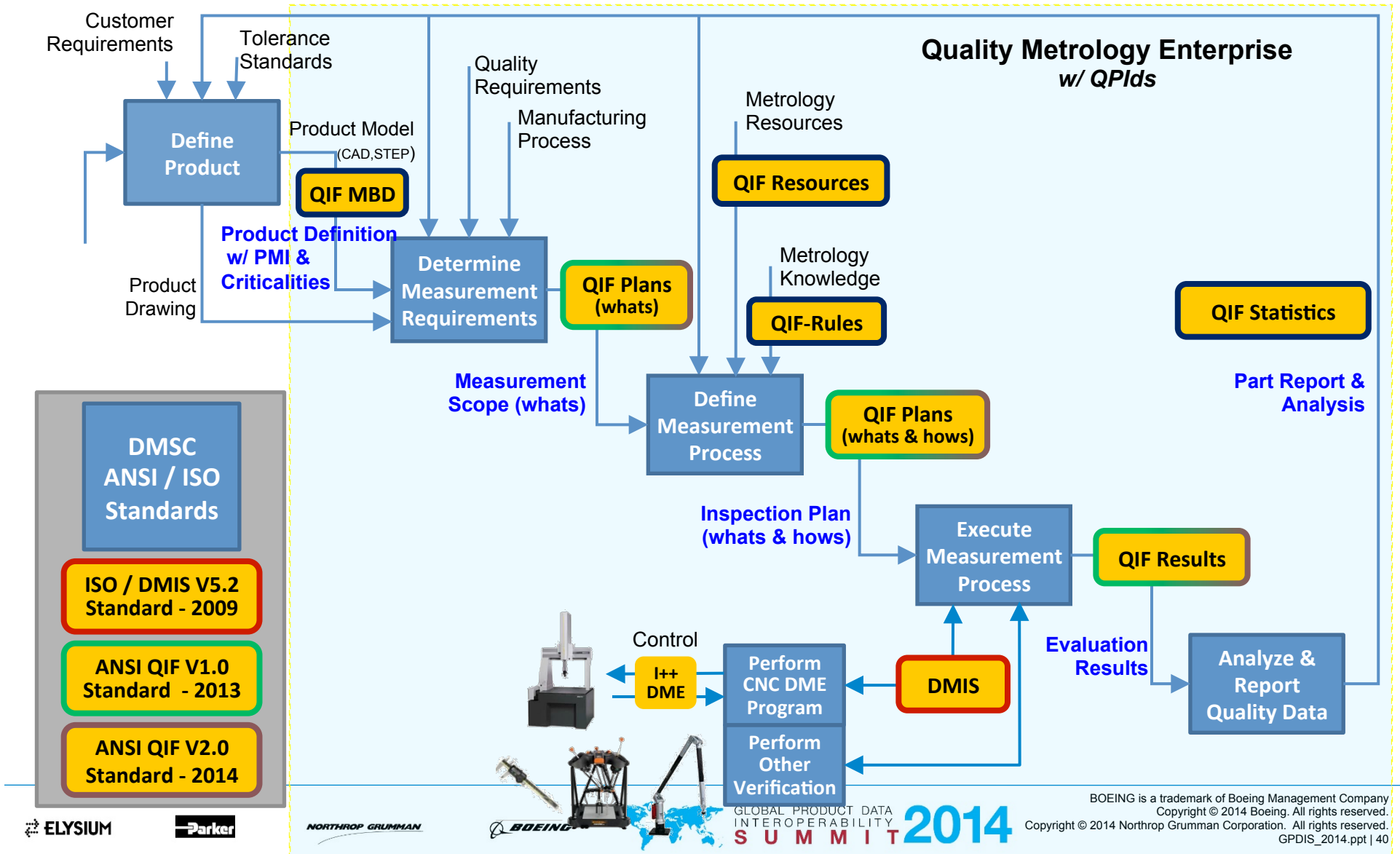NIST is a member of the DMSC and participates in all aspects of the QIF standard development efforts:

- 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

QIF v2.0 – NIST Smart Manufacturing Operations Planning and Control Program

Global Product Data Interoperability Summit | **2014**

Quality Metrology Enterprise
w/ QPIds

Customer Requirements

Tolerance Standards

Quality Requirements

Manufacturing Process

Metrology Resources

QIF Resources

Product Model (CAD,STEP)

Define Product

QIF MBD

Product Definition w/ PMI & Criticalities

Metrology Knowledge

Product Drawing

Determine Measurement Requirements

QIF Plans (whats)

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

ELYSIUM   Parker   NORTHROP GRUMMAN   BOEING

GLOBAL PRODUCT DATA INTEROPERABILITY SUMMIT **2014**

- 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 Consortia Members

  - Applied Automation Technologies
  - Capvidia
  - Deere & Company
  - Hexagon Metrology
  - Honeywell FM&T
  - Lockheed Martin

  - Origin International, Inc.

  - MetroSage LLC
  - Metrology Integrators
  - Mitutoyo America Corp
  - Nikon Metrology
  - NIST
  - PAS Technology

- ## Working Groups

  Open to all who have a Direct and Material Interest
  - Renishaw

  - Rolls Royce
  - Pratt Whitney
  - GE Aviation

  - Boeing
  - DISCUS Software
  - Zeiss

  - Siemens PLM Software
  - Re-Sistance Services
  - Validation Technologies
  - IPI Solutions

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**
  - **Join us directly, we would value your involvement!**
- **Collaborative Partnership**
- **Membership (www.DMSC-Inc.com)**
  - **bsquire@dmsc-inc.com to Request an Application**
- **QIF Involvement (www.QIFStandards.com)**
  - QIF Plans Working Group
  - QIF Results Working Group
  - QIF MBD (PDPMI) Working Group
  - QIF Resources Working Group
  - QIF Rules Working Group
  - QIF Statistics Working Group