Semantic MBD Workflows

How the use of Model Based Definition can help bring about Digital Transformation for the modern manufacturing enterprise

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Overview

- What is MBD?
- QIF – how MBD is implemented
- MBD Workflows
  - Digital FAI with Supply Chain
  - MBD-Based CMM Workflow
- Questions

Model Based Definition (MBD)

What is MBD, and why is it important?

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Model Based Definition (MBD)

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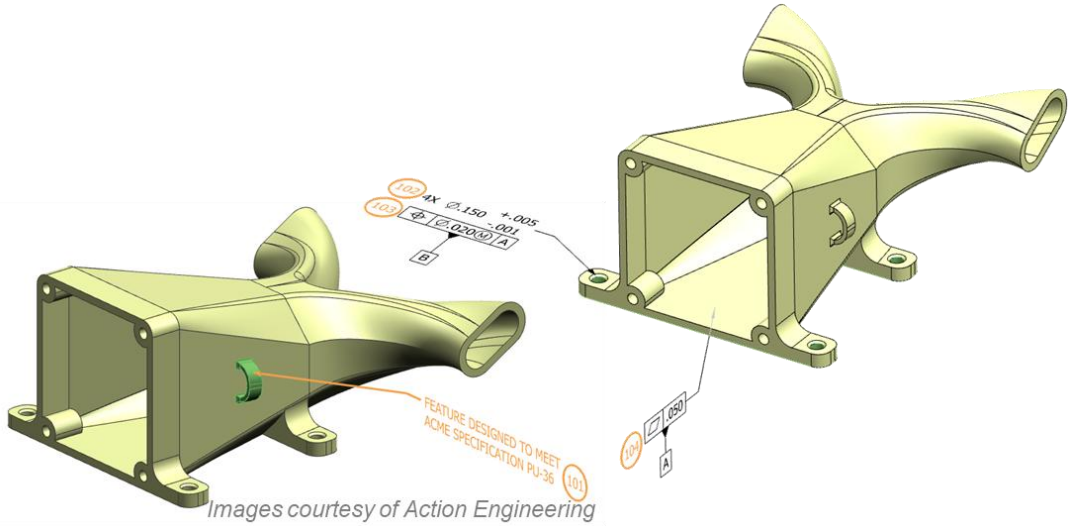
*Using the **3D CAD** model, managed in the context of a PLM workflow, as the "**single source of truth**" for **product and process data***



Images courtesy of Action Engineering

From Wikipedia:

Model-based definition (**MBD**), sometimes **digital product definition**, is the practice of using 3D models (such as solid models, 3D PMI and associated metadata) within 3D CAD software to define (provide specifications for) individual components and product assemblies. The types of information included are geometric dimensioning and tolerancing (GD&T), component level materials, assembly level bills of materials, engineering configurations, design intent, etc. By contrast, other methodologies have historically required accompanying use of 2D engineering drawings to provide such details.[1]

Wikipedia contributors. (2018, October 9). Model-based definition. In Wikipedia, The Free Encyclopedia. Retrieved 19:27, June 8, 2019, from https://en.wikipedia.org/w/index.php?title=Model-based_definition&oldid=863182909

Looking to the Future: What is the Value of MBD?

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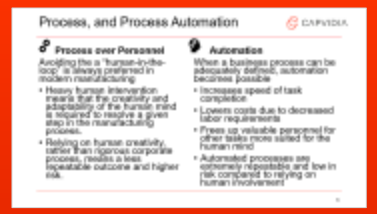
Downstream

Upstream

Process and Automation



Mfg Data for Analytics

Model Based Definition provides a source of value in the downstream direction from design, and in the upstream direction from operations and deployment

Process, and Process Automation

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Process over Personnel

Avoiding the a “human-in-the-loop” is always preferred in modern manufacturing

- Heavy human intervention means that the creativity and adaptability of the human mind is required to resolve a given step in the manufacturing process.
- Relying on human creativity, rather than rigorous corporate process, means a less repeatable outcome and higher risk.

Automation

When a business process can be adequately defined, automation becomes possible

- Increases speed of task completion
- Lowers costs due to decreased labor requirements
- Frees up valuable personnel for other tasks more suited for the human mind
- Automated processes are extremely repeatable and low in risk compared to relying on human involvement

Value of Manufacturing Data

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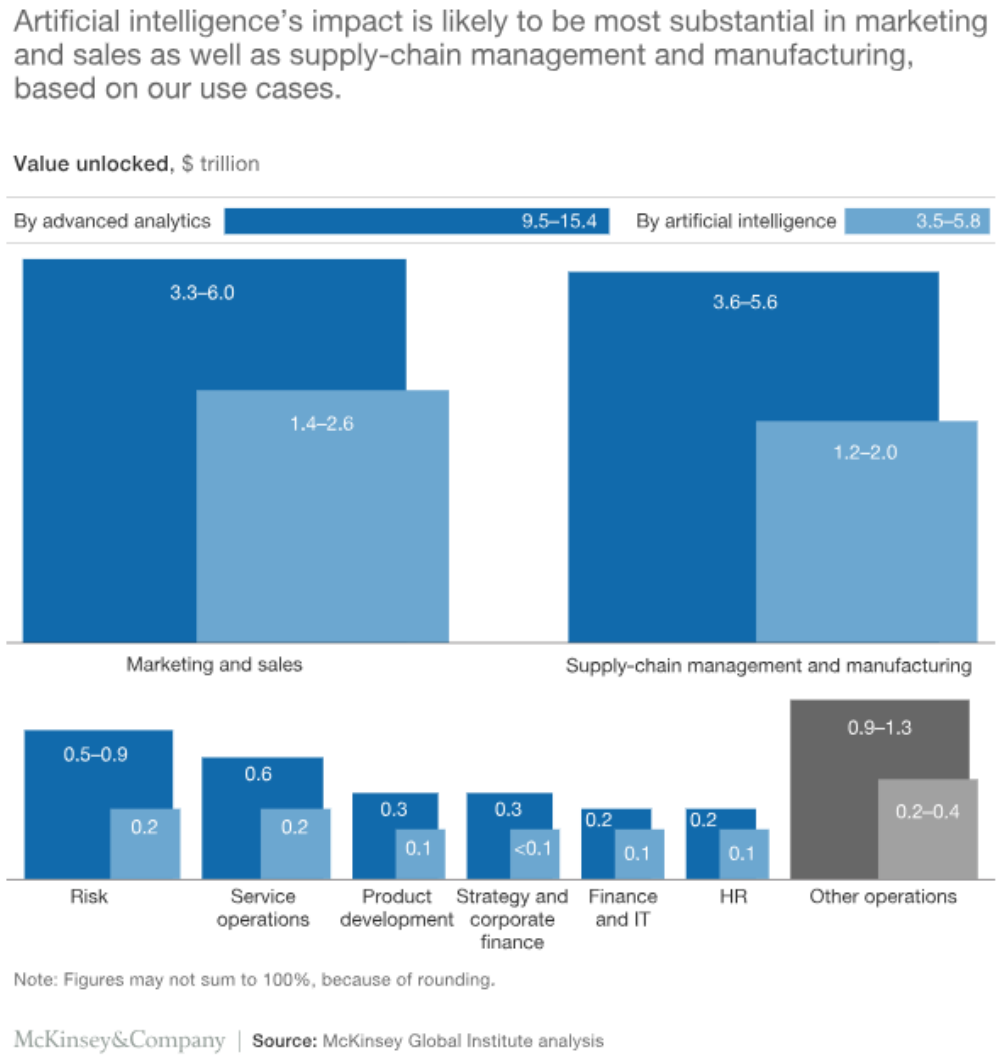
- Currently, manufacturing data is not fully exploited because of lack of structure
- A study by McKinsey & Company states:

  We estimate that the AI techniques we cite in this briefing together have the potential to create between $3.5 trillion and $5.8 trillion in value annually across nine business functions in 19 industries

- The second largest growth area for AI and Big Data is Supply-chain management and manufacturing
- Providing structure and data traceability is required to unlock this potential



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Quality Information Framework – **QIF**

QIF – and ANSI and DIS ISO standard for implementing Model Based Definition workflows

What is QIF?

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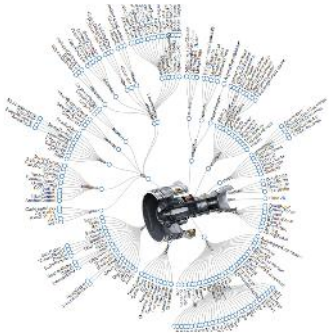
Feature-Based Ontology of Manufacturing Quality Metadata

XML Technology: Simple Implementation and Built-In Code Validation



Data semantically linked to Model for full data traceability to CAD

QIF Application Areas

QIF Application Areas

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Reference a bundle of QIF Results sets and specify a statistical analysis method to be carried out. Can optionally include the results of the statistical analysis as well

Measurement results data, associated with the MBD! This can be just tolerance evaluation results, and can even include all the point cloud data from the features

DMIS is <u>not</u> part of QIF, but it has been updated to harmonize with the data traceability mechanisms in QIF

Create measurement templates—e.g.: *If a Surface Profile tolerance value is less than **x**, use at least **y** number of points/sq. in. for CMM measurement*

QIF MBD is the base for providing traceability to authority CAD data. It is not required for basic QIF use cases. Considered to be the strongest semantic CAD+PMI standard available

Wide range of optional levels of detail for measurement plans:

- Bill of characteristics
- Assign measurement resources
- Specify sampling point locations

Specify basic or highly detailed information about available measurement equipment (e.g., CMMs, probes, calipers, gages, etc.). As always, this data is contextual and semantic

Workflow Example

Process Stage 1:
Search the PMI applied to the QIF MBD model, and identify the necessary measurement tasks.
This list of tasks is called a Bill of Characteristics

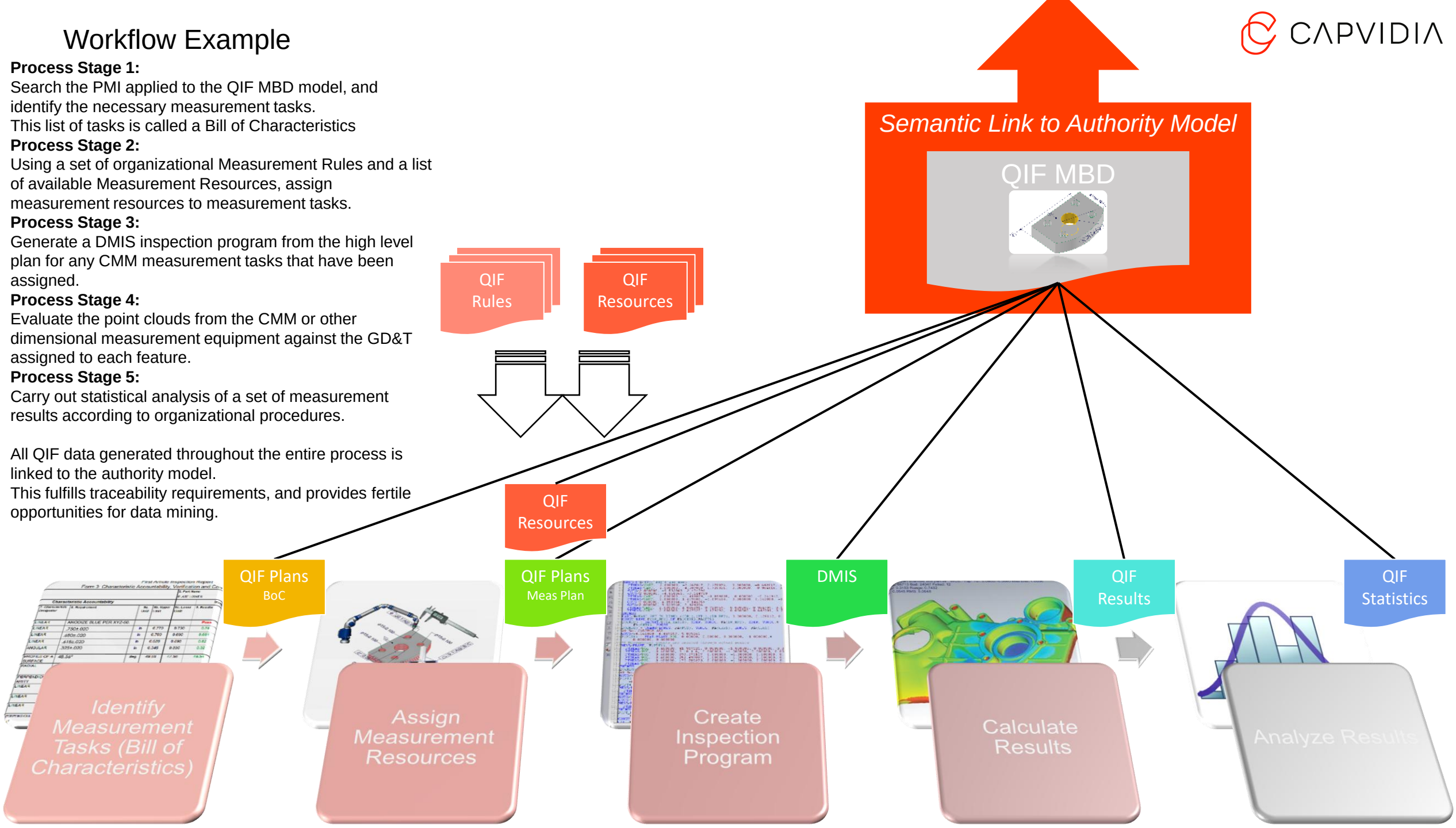
Process Stage 2:
Using a set of organizational Measurement Rules and a list of available Measurement Resources, assign measurement resources to measurement tasks.

Process Stage 3:
Generate a DMIS inspection program from the high level plan for any CMM measurement tasks that have been assigned.

Process Stage 4:
Evaluate the point clouds from the CMM or other dimensional measurement equipment against the GD&T assigned to each feature.

Process Stage 5:
Carry out statistical analysis of a set of measurement results according to organizational procedures.

All QIF data generated throughout the entire process is linked to the authority model.
This fulfills traceability requirements, and provides fertile opportunities for data mining.



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MBD Workflows: Digital FAI with Supply Chain

Bridging the data gap between an OEM and its supply chain

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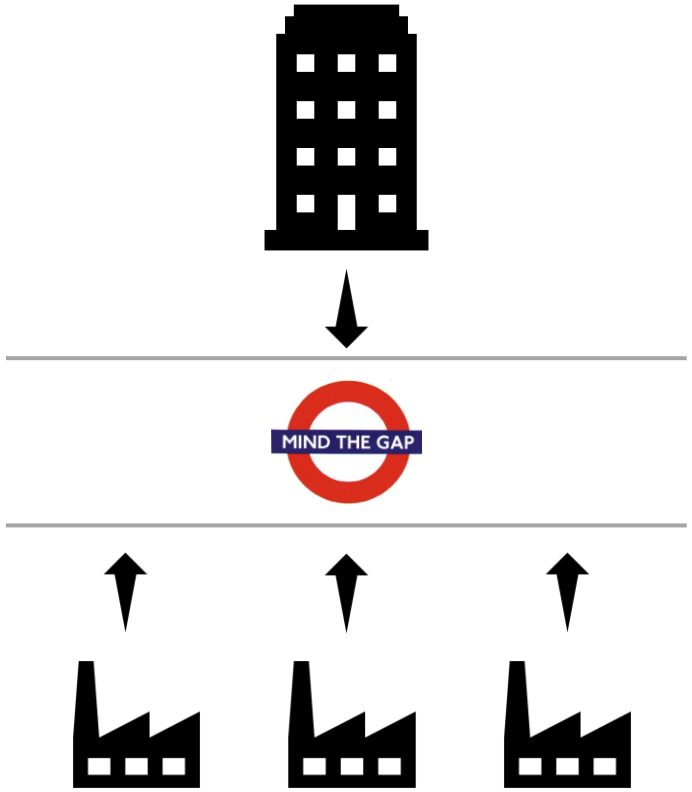
MBD Workflows:
Digital FAI with Supply Chain



- Manufacturing is global and distributed
- **But data is fragmented**
- 70-90% of manufacturing is typically executed outside the walls of an OEM

MBD Workflows:
Digital FAI with Supply Chain

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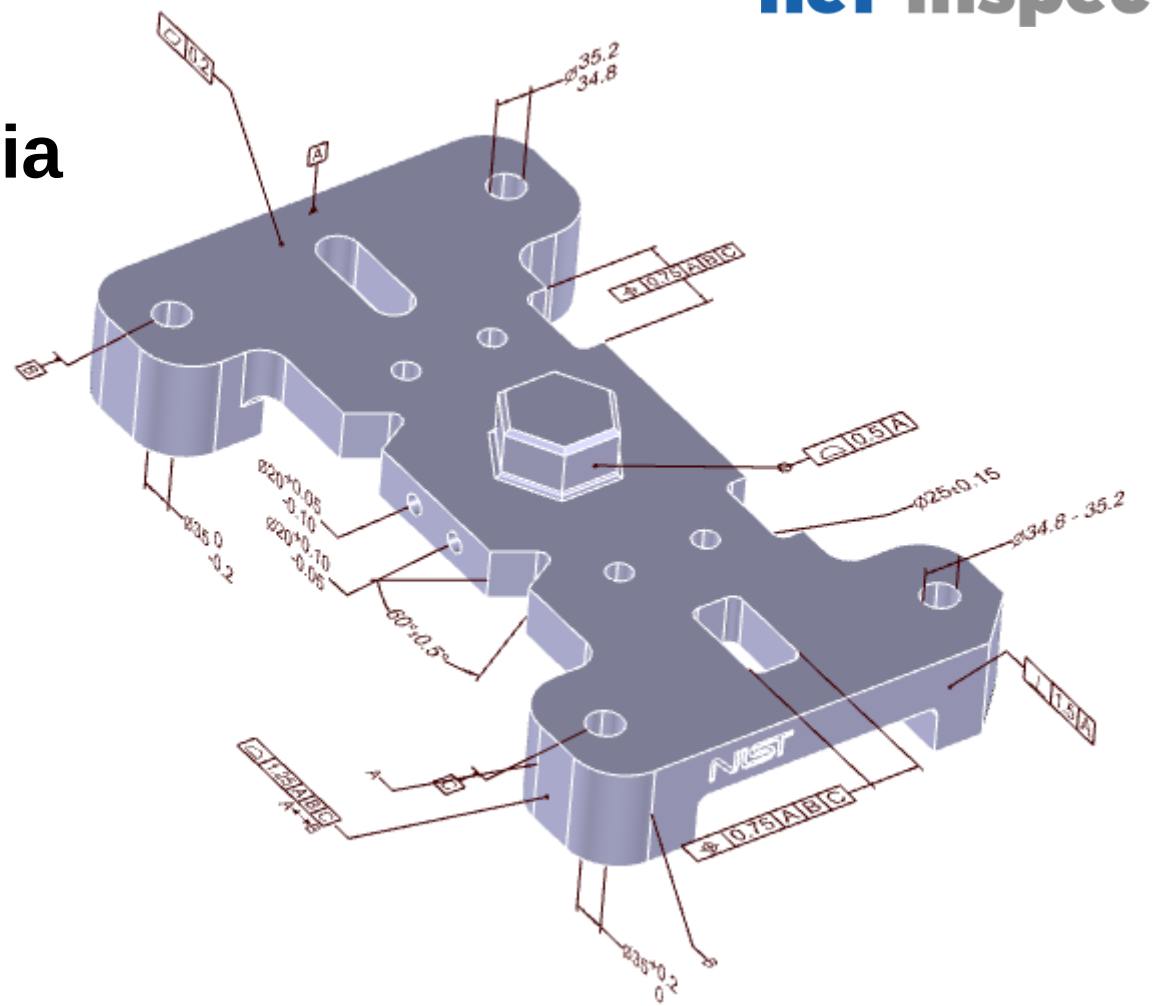
net-inspect

1 2 3 4 5

Load the model into MBDVidia

- Fully annotated MBD model



MBD Workflows:
Digital FAI with Supply Chain

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1 2 3 4 5

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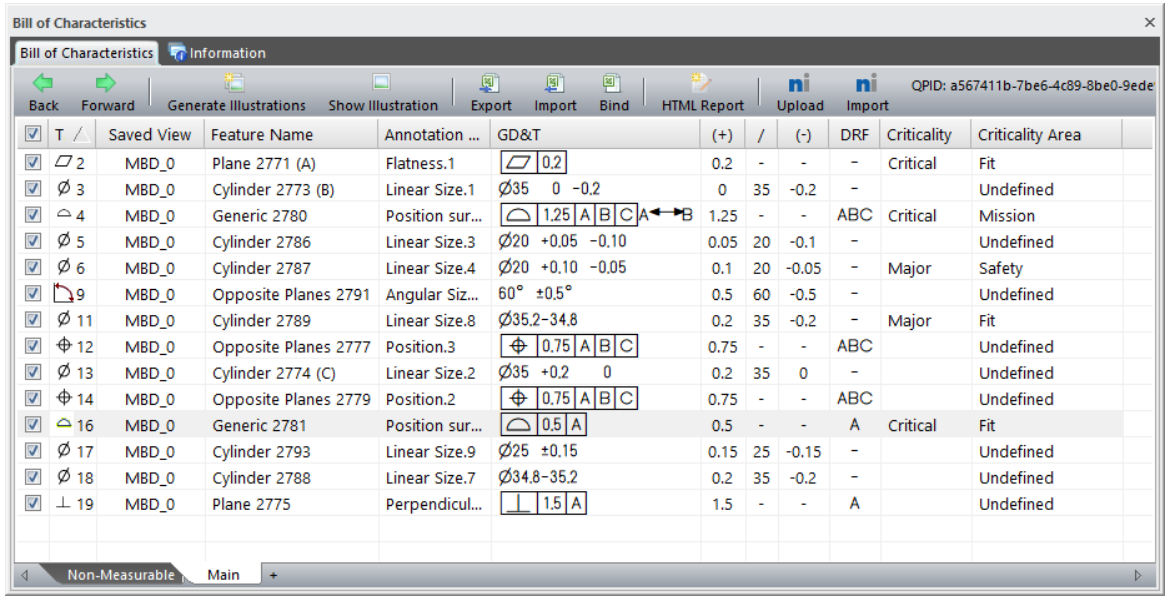
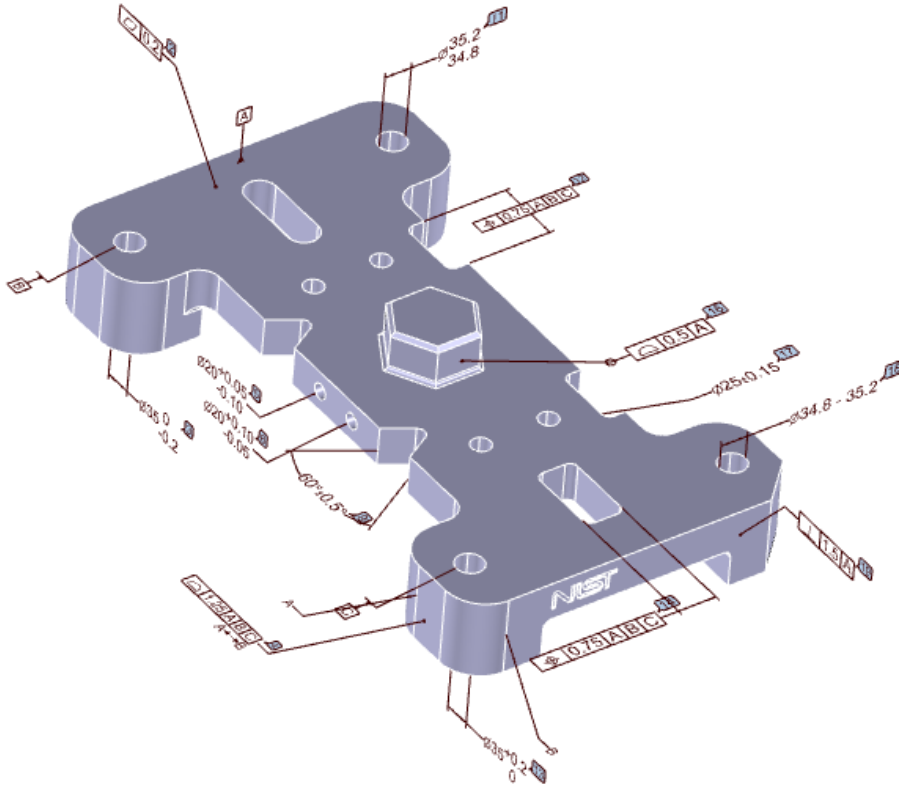
Generate Bill of Characteristics

- Automatic ballooning
- Data sorted into organized Bill of Characteristics



T	Saved View	Feature Name	Annotation ...	GD&T	(+)	/	(-)	DRF	Criticality	Criticality Area
2	MBD_0	Plane 2771 (A)	Flatness.1	⏥ 0.2	0.2	-	-	-	Critical	Fit
3	MBD_0	Cylinder 2773 (B)	Linear Size.1	Ø35 0 -0.2	0	35	-0.2	-		Undefined
4	MBD_0	Generic 2780	Position sur...	⌓ 1.25 A B C A↔B	1.25	-	-	ABC	Critical	Mission
5	MBD_0	Cylinder 2786	Linear Size.3	Ø20 +0.05 -0.10	0.05	20	-0.1	-		Undefined
6	MBD_0	Cylinder 2787	Linear Size.4	Ø20 +0.10 -0.05	0.1	20	-0.05	-	Major	Safety
9	MBD_0	Opposite Planes 2791	Angular Siz...	60° ±0.5°	0.5	60	-0.5	-		Undefined
11	MBD_0	Cylinder 2789	Linear Size.8	Ø35.2-34.8	0.2	35	-0.2	-	Major	Fit
12	MBD_0	Opposite Planes 2777	Position.3	⌖ 0.75 A B C	0.75	-	-	ABC		Undefined
13	MBD_0	Cylinder 2774 (C)	Linear Size.2	Ø35 +0.2 0	0.2	35	0	-		Undefined
14	MBD_0	Opposite Planes 2779	Position.2	⌖ 0.75 A B C	0.75	-	-	ABC		Undefined
16	MBD_0	Generic 2781	Position sur...	⌓ 0.5 A	0.5	-	-	A	Critical	Fit
17	MBD_0	Cylinder 2793	Linear Size.9	Ø25 ±0.15	0.15	25	-0.15	-		Undefined
18	MBD_0	Cylinder 2788	Linear Size.7	Ø34.8-35.2	0.2	35	-0.2	-		Undefined
19	MBD_0	Plane 2775	Perpendicul...	⊥ 1.5 A	1.5	-	-	A		Undefined



MBD Workflows:
Digital FAI with Supply Chain

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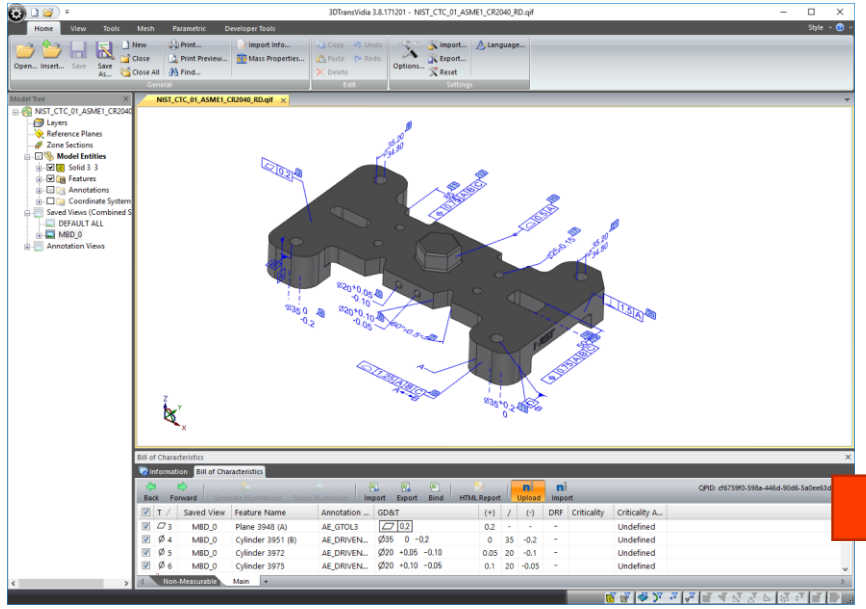
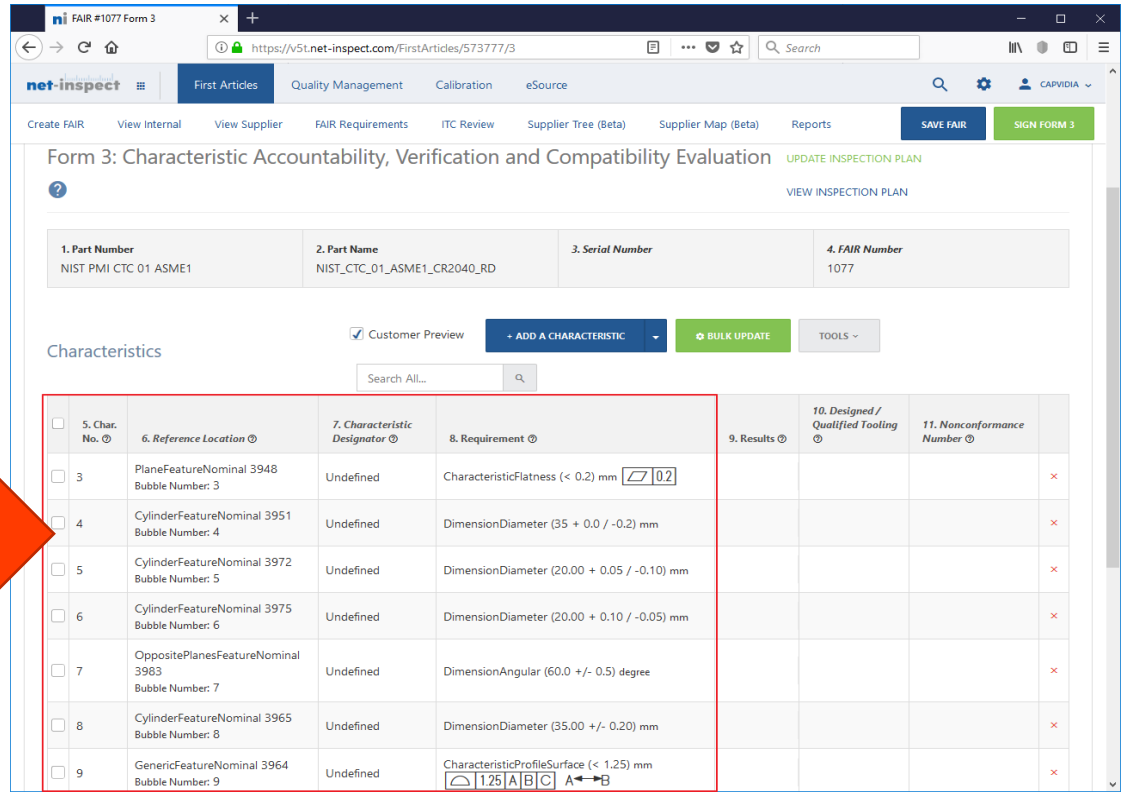
1 2 **3** 4 5

Publish

- FAIR automatically generated/filled
- Linked to MBD





MBD Workflows:
Digital FAI with Supply Chain

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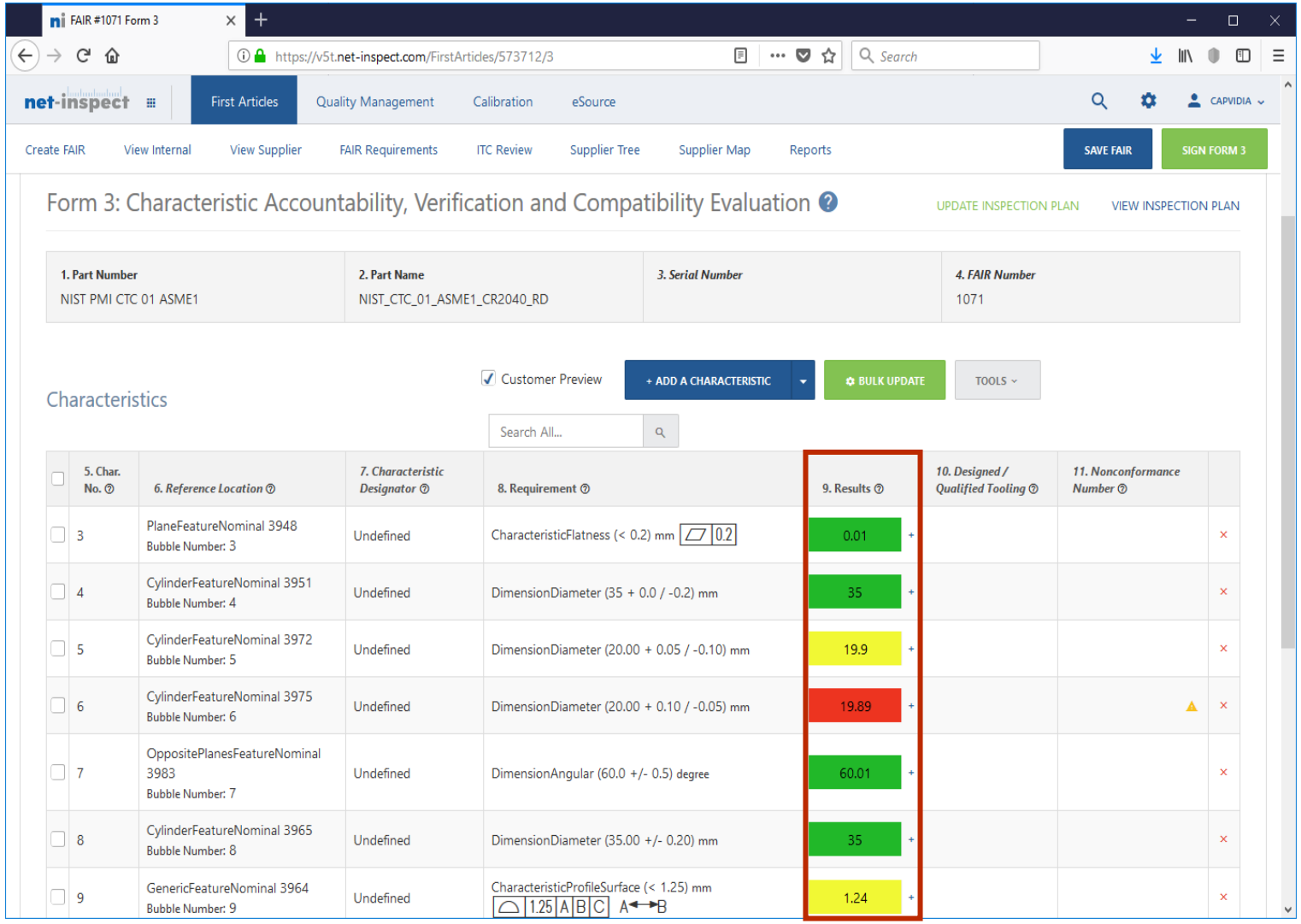
1 2 3 **4** 5

net-inspect

Enter Results

- Save FAIR



MBD Workflows:
Digital FAI with Supply Chain

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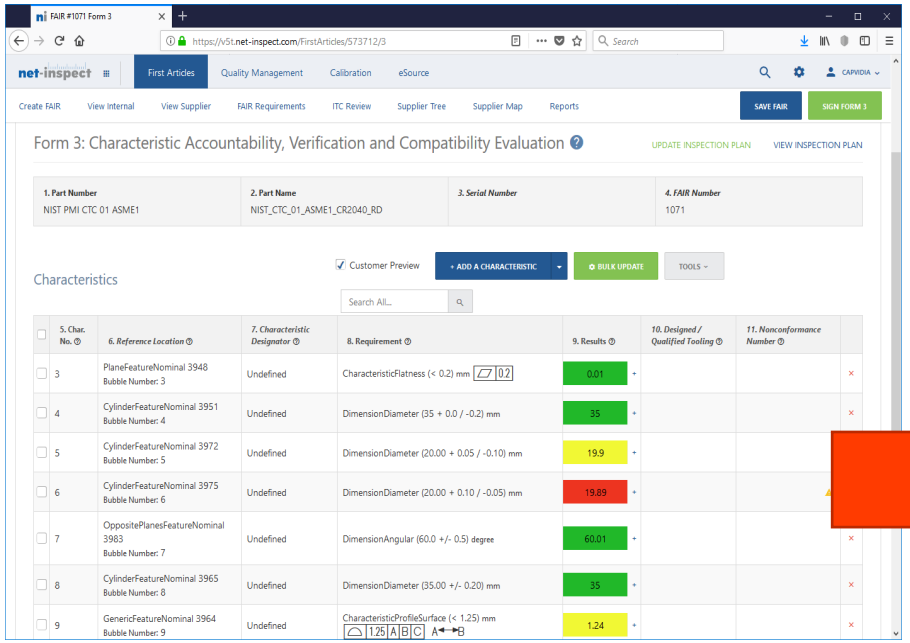
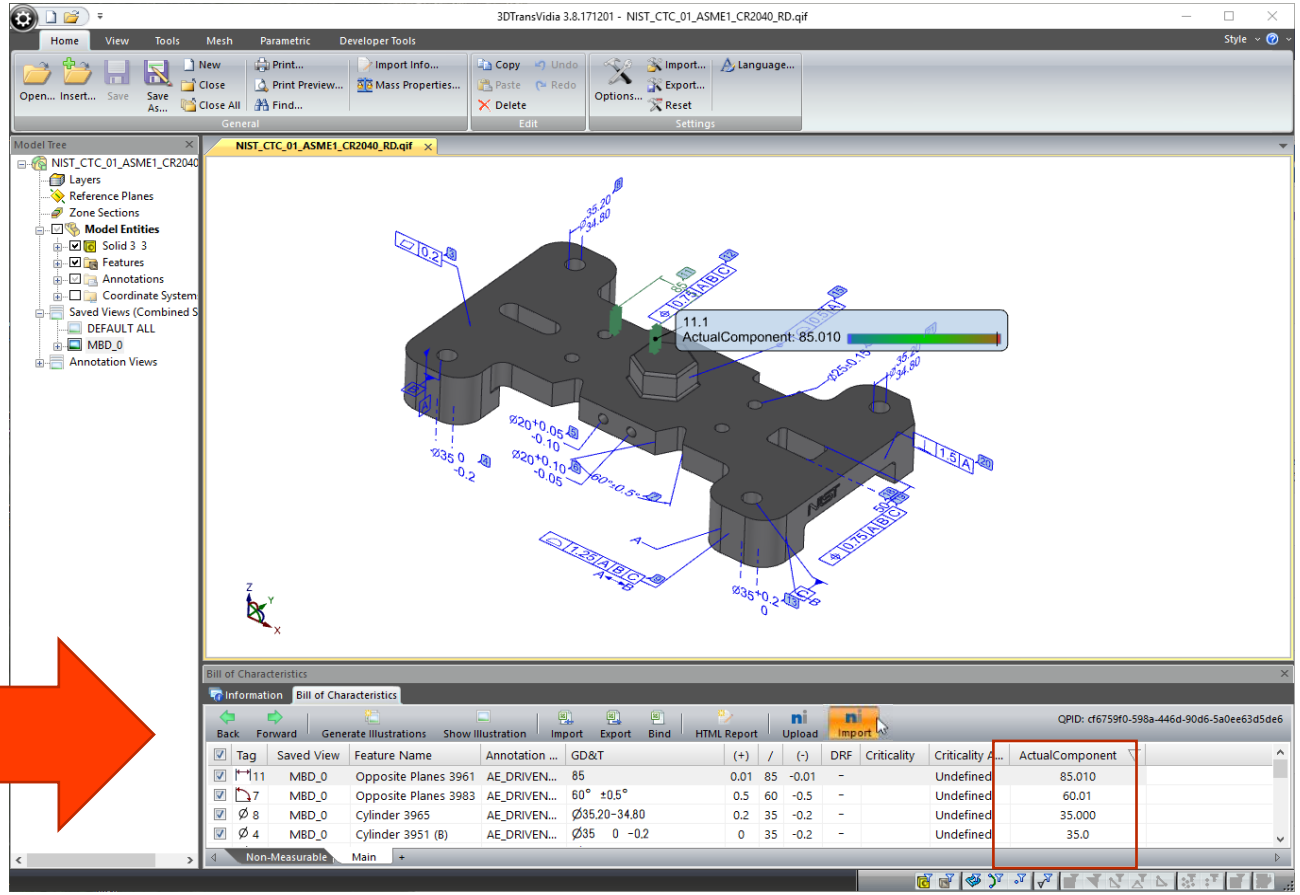
net-inspect

1 2 3 4 **5**

Import FAIR number

- See Net-Inspect data on model
- Net-Inspect data now traceable to authority MBD dataset





MBD Workflows:
Digital FAI with Supply Chain

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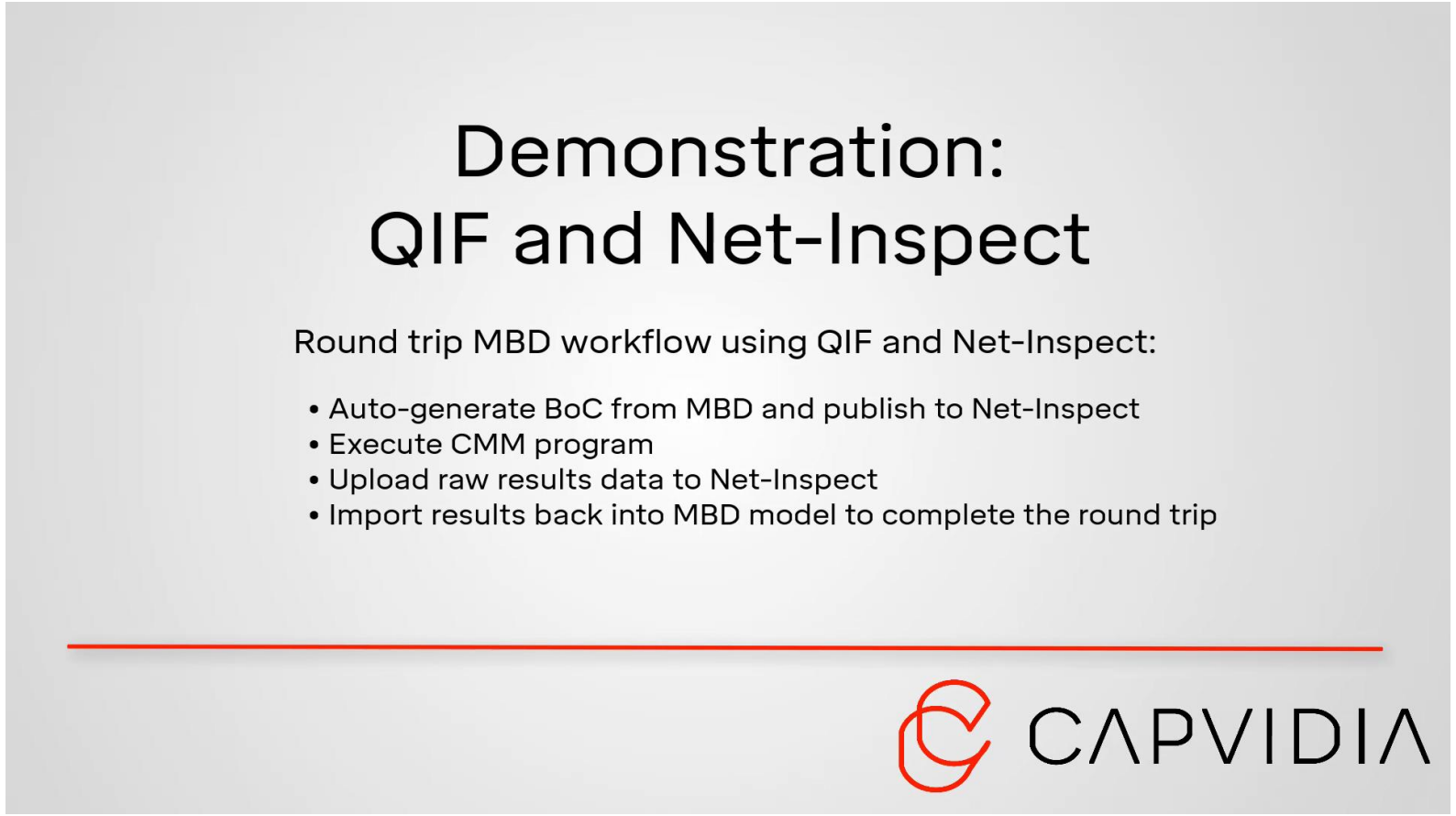

Click here to watch video online

MBD Workflows:
Digital FAI with Supply Chain

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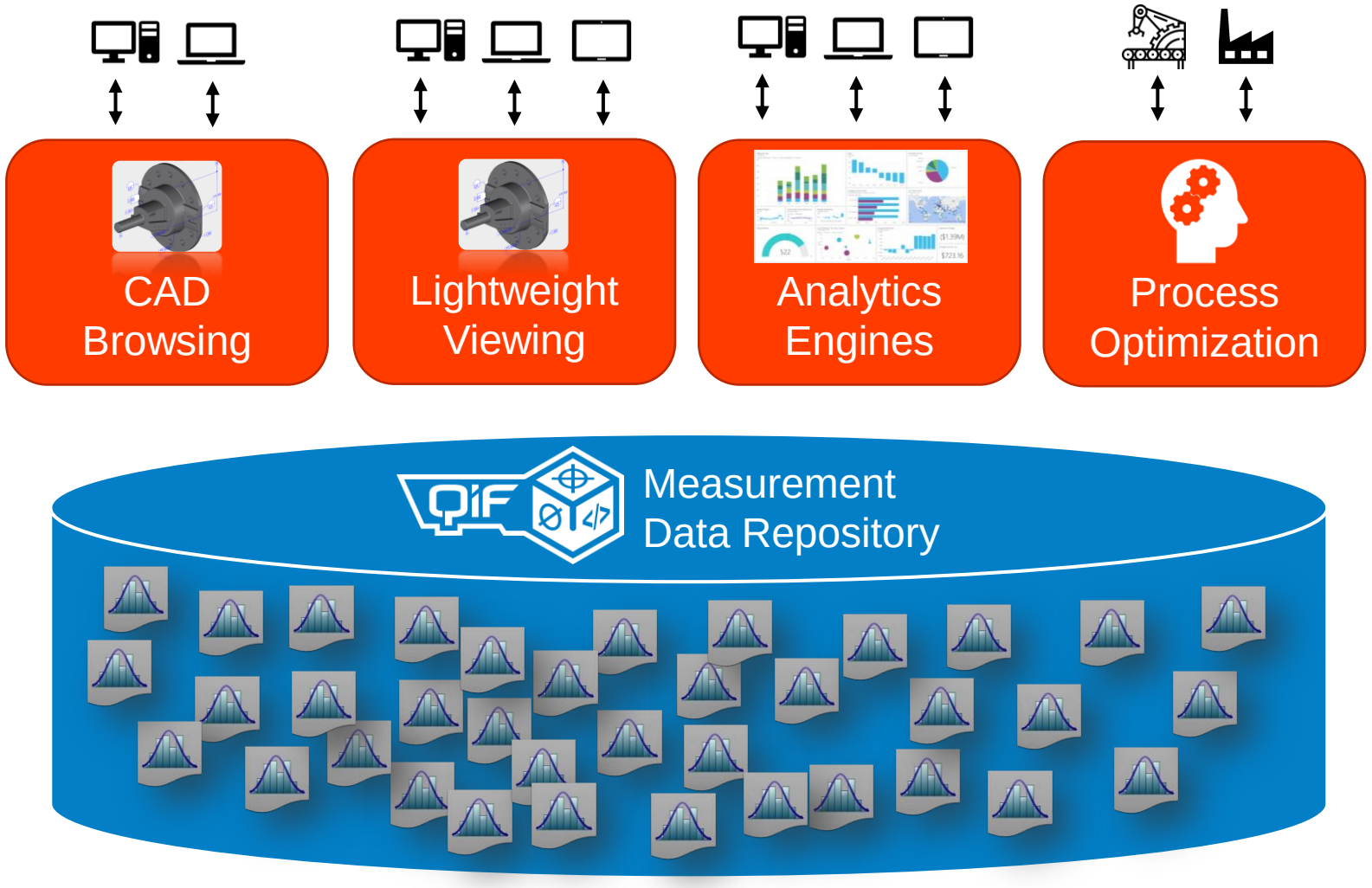
What's the end game?

Measurement process and results data, mapped to the "single source of truth": the MBD model.

This creates a continuous digital thread from design to inspection.

Bringing your supply chain into the digital thread can be accomplished using ubiquitous software: Excel.

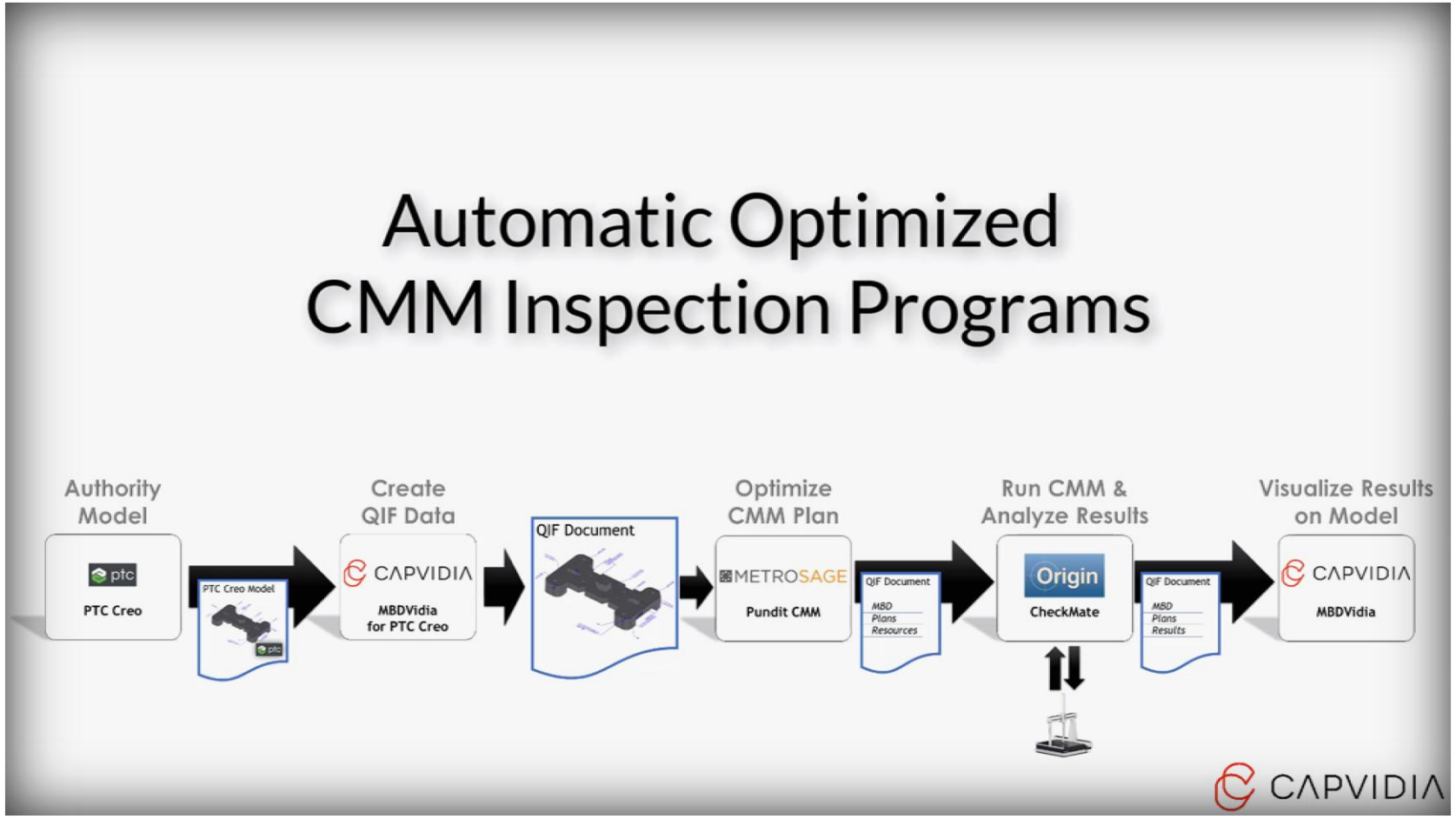


MBD Workflows: MBD-Based CMM Workflow

Using MBD to drive automation and optimization in CMM measurements

MBD-Based CMM Workflow

Video demonstration



[Watch the workflow here]

Raytheon Pilot Workflow

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Raytheon

Creo: MBDVidia for Creo Plugin

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1. Starting point: MBD model in Creo
2. Export to Quality Information Framework (QIF) standard using “MBDVidia for Creo” plugin (Capvidia)

Less than 1 minute

MBDVidia

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1. Load the QIF MBD model
2. Check and heal the PMI – make sure that it is *machine readable*

5 minutes (but can be automated)

CheckMate

Origin

1. Import the machine-readable QIF MBD model
2. Enter essential information: probe configurations, CMM setup, etc.
3. Auto-generate the CMM program
4. Clean up and verify

Less than 3 hours – pilot processed can be drastically streamlined from this baseline effort

Simple ROI Analysis

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Current Workflow		
Total hours, existing manual workflow	**16**	**Hours**

New MBD Workflow		
MBDVidia	5	Minutes
FormatWorks import of Creo file	5	Minutes
Checkmate Setup Parameters	5	Minutes
Checkmate Auto Programming		
Accessibility	15	Minutes
Sorting for dependencies	1	Minutes
Auto Coordinate Systems	1	Minutes
Probe moves/rotations	1	Minutes
Collision detection	20	Minutes
Manual editing (estimate)	120	Minutes
Post process program	5	Minutes
Total, New MBD Workflow	178	Minutes
Total, New MBD Workflow	**2.97**	**Hours**

81% Reduction in Time

Today's traditional, manual workflow for this part is estimated at about 16 hours.

The MBD pilot workflow took less than 3 hours.

ROI Analysis

Time reduction	
MBD Workflow time vs. Manual Workflow Time	19%
MBD Workflow decreases total time by:	**81%**

ROI Analysis	
Hours saved on MBD Workflow	13.03
Number of parts programmed per year	80
Total yearly labor reduction	**1,042 hours**

Value of MBD Measurement

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Reduce inspection costs

Inspection planning is a laborious task involving skilled technicians – automation decreases its cost significantly

Faster time-to-inspection

Faster product delivery. Inspection is typically a bottleneck in production – this approach can streamline manufacturing processes

Increase inspection quality

- Utilize measurement uncertainty simulation
- Implement organizational guidelines — rely on corporate process, not personnel

Bring measurement data into the digital thread

Measurement data has immense value – don't use it for PASS/FAIL inspection and then discard. MBD traceable data is ready for analytics

Lower risk for transcription & interpretation errors

Software automation lowers the risk of transcription or interpretation errors of data, and creates opportunities for validation of data

Thanks!

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