CMM Automation from MBD:

A case study of optimized Model Based Inspection

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Model Based Definition, Manufacturing & Inspection

Design

Manufacture

Inspect

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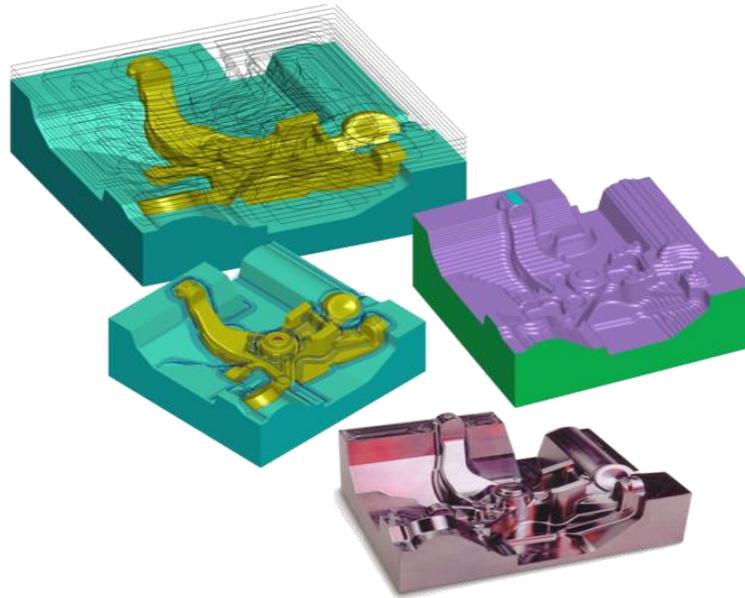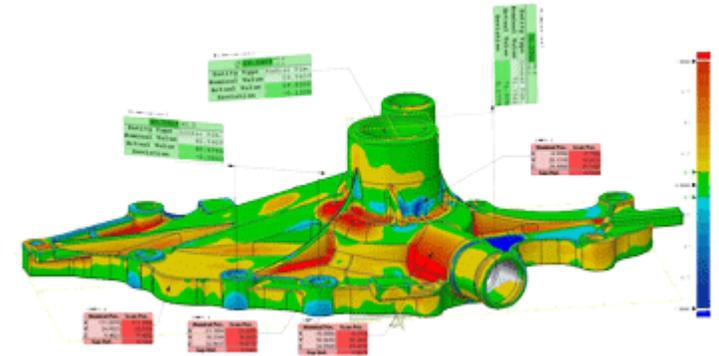
Each Process has been evolving

Design

Manufacture

Inspect

INSPECTED
READY TO USE

CAD

CAM

CAI

Drawing Centric

Model Centric

Model Based Definition

Model Based Enterprise

Manual Machining

CNC: Computer Numerical Control

Feature based machining

Toolpath Strategies

Manual Gauging

CMM: Coordinate Measurement Machines

Non-contact Scanners

MN

Good News / Bad News about CMMs

- **The good news about CMMs:**

  - They are extremely versatile ☺

- **The bad news about CMMs:**

  - They are extremely versatile ☹

  - Many different interdependent measurands

  - Almost unlimited measurement conditions, including:
    - the CMM being used,
    - workpiece location/orientation,
    - probe/stylus type and configuration,
    - environment,
    - sampling strategy,

MN

Overview: Model-Based CMM Measurement

Current CMM processes are highly manual and expensive

- Highly manual process, risking transcription and interpretation errors
- Resulting quality of CMM program depends on skill, experience, and practices of CMM programmer

Automation and optimization are possible with MBE

- Process can be automated, massively decreasing time spent to create the program
- Resulting program can be optimized for the job based on measurement resource availability and measurement uncertainty requirements

Technology is ready and already showing ROI

- Off-the-shelf software applications can carry out this workflow
- Workflow demonstration: how does it work?
- Workflow automation results: time saved

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CMM Programming: Current State

Issues with current Computer Aided Inspection Process

- **Manual transcription** of GD&T / PMI into inspection software can lead to conflicts and inaccuracies

- High risk of CAD **translation or interpretation errors** with GD&T

- Requires a **skilled CMM technician** with expert knowledge of GD&T, CAD and measurement

- Personnel and machine dependent

- **Labor intensive** - can take weeks to program a single part

Enterprise measurement data is siloed:

- Multiple, **proprietary data formats** are used

- **Not** linked to "**single source of truth**" – the design model and PLM

2D Paper Drawing

CMM Software

Over-burdened Engineer!
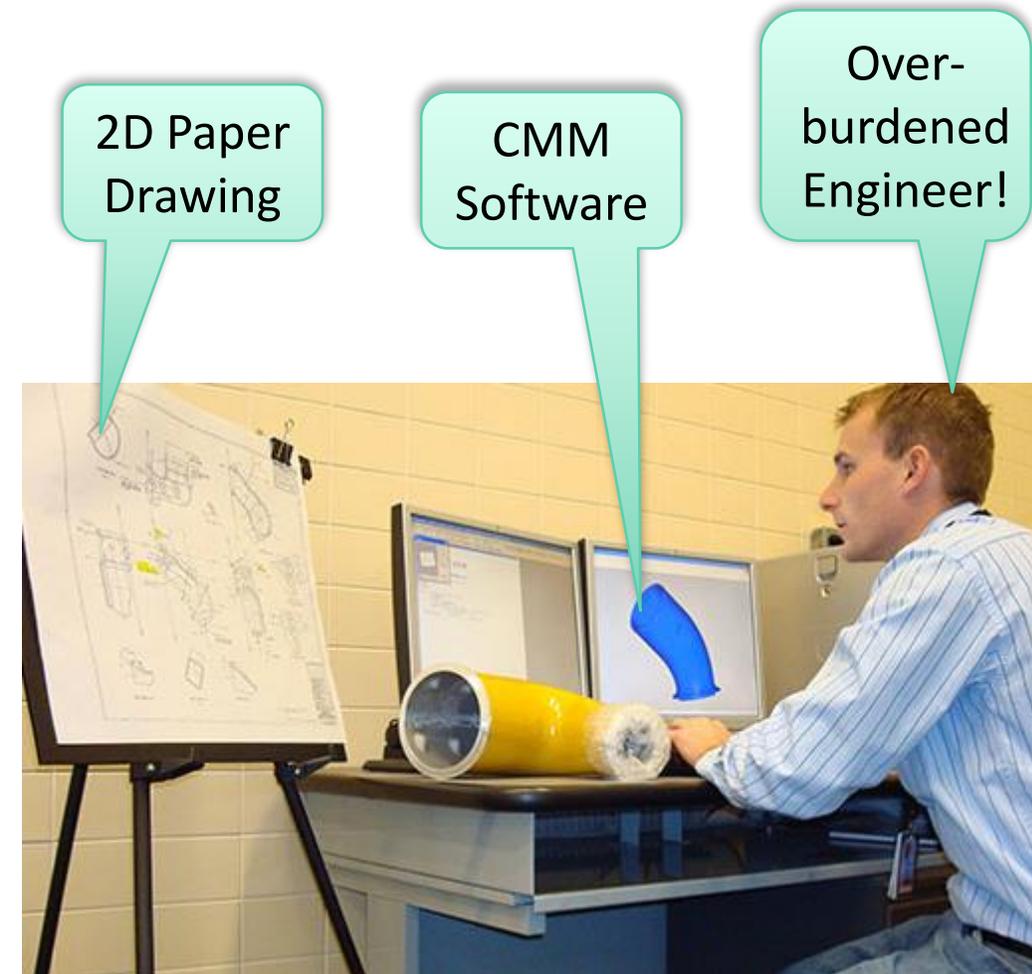
Overall proposed workflow

| Authority Model | Create QIF Data | | Optimize CMM Plan | Run CMM & Analyze Results | Visualize Results on Model |

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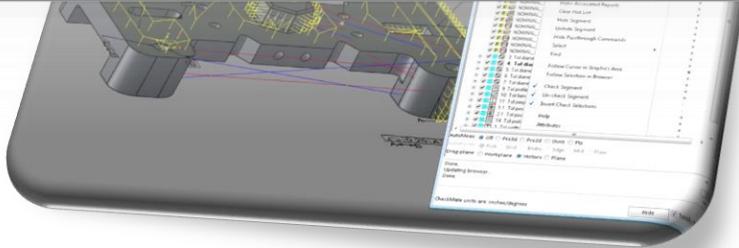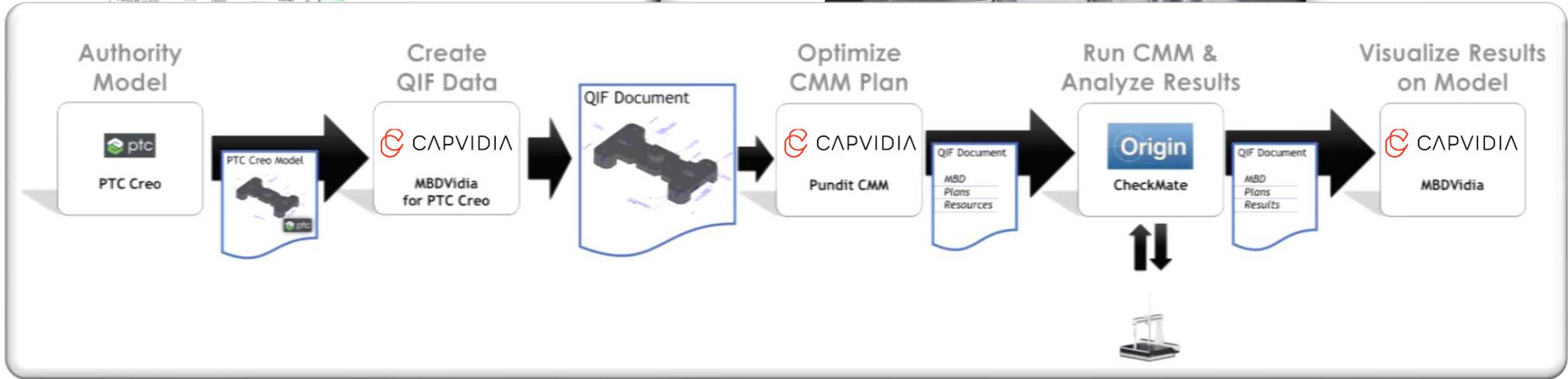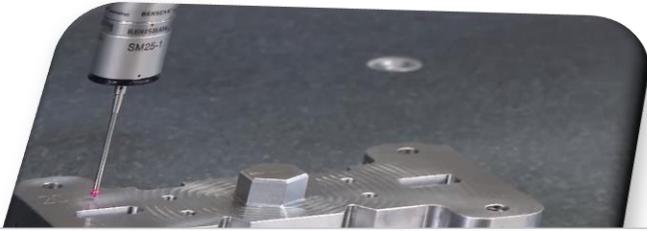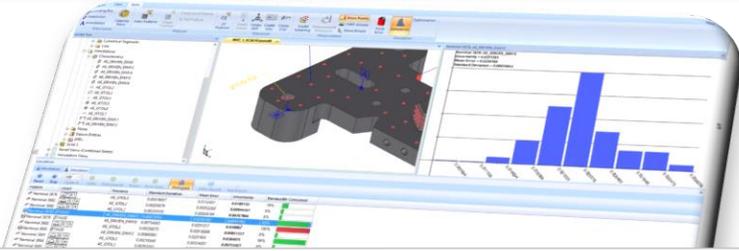
Video of workflow
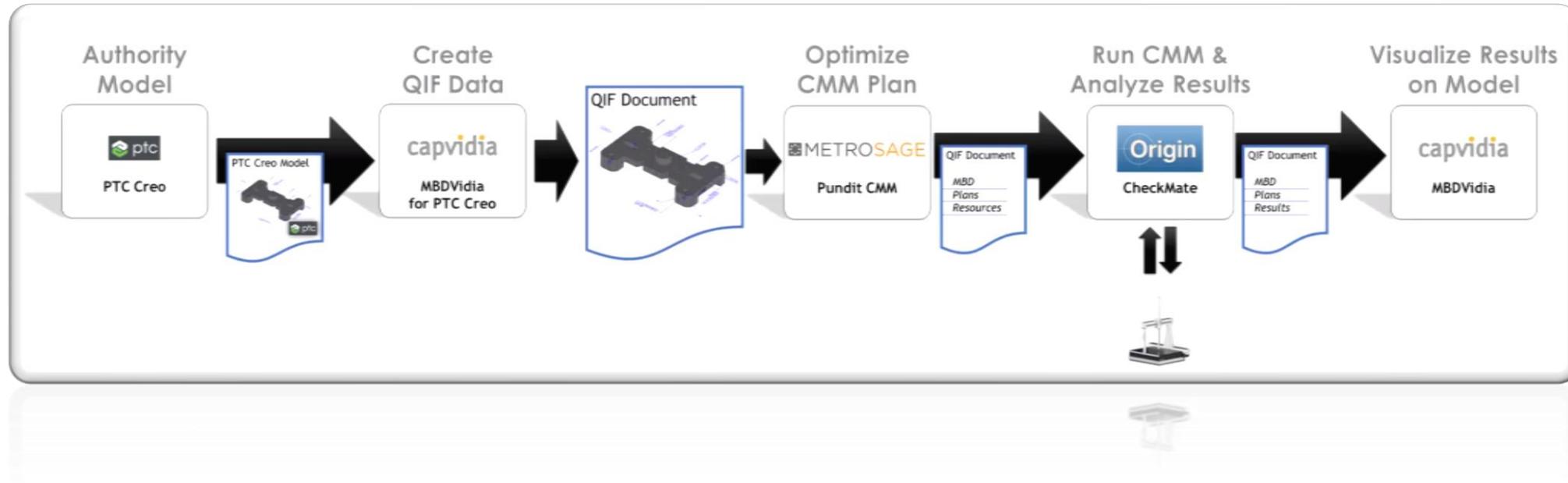
Simplified pilot workflow

Raytheon

PTC Creo
- MBDVidia for Creo Plugin

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

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

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

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Semantic PMI – Machine Readable PMI

Why does **machine-readable PMI** matter?

The human eye can understand complex annotations in the context of 3D. Software needs more explicit information:

- What surface needs to be measured?
- If this is a pattern, which features?
- What type of tolerance?
- Tolerance value?
- Datums?
- Material condition modifiers?
- Other GD&T flags?
- Etc., etc.

This dimension is associated with a model edge

ø6 TYP. AT 4 LOCATIONS
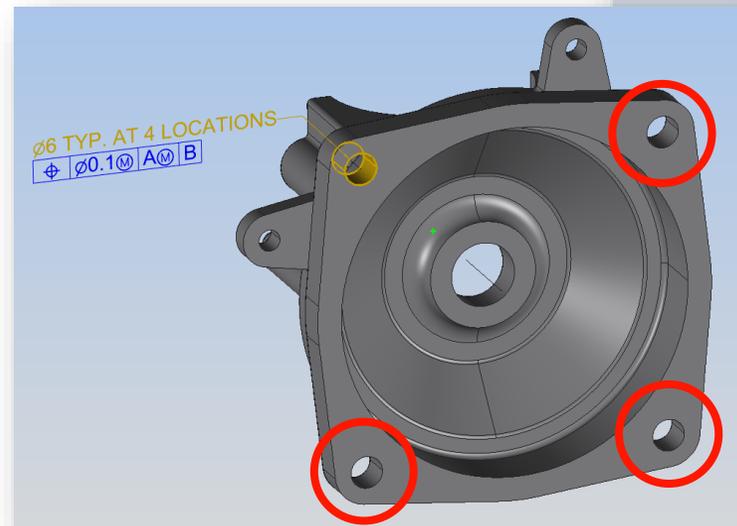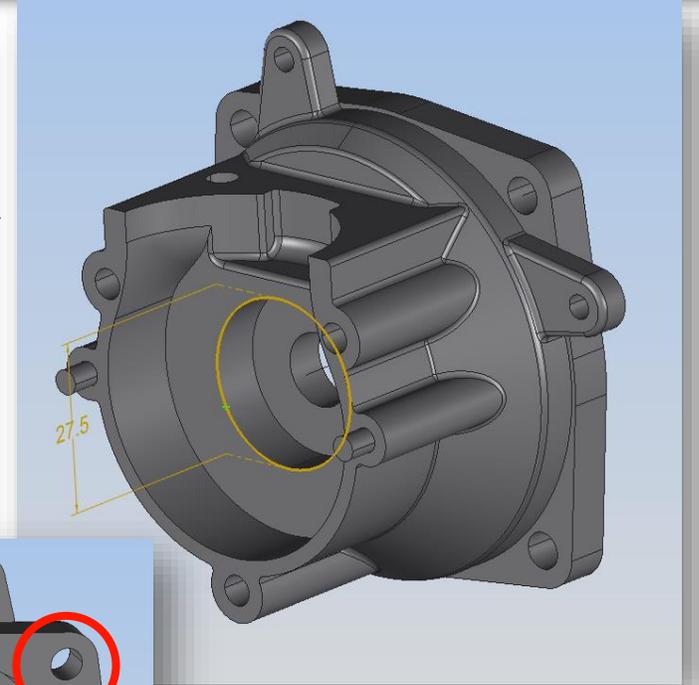
These tolerances apply "AT 4 LOCATIONS", but only 1 hole is associated

Value of MBD Measurement

Reduce inspection costs	**Faster time-to-inspection**	**Increase inspection quality**	**Bring measurement data into the digital thread**	**Lower risk for transcription & interpretation errors**
Inspection planning is a laborious task involving skilled technicians – automation decreases its cost significantly	Faster product delivery. Inspection is typically a bottleneck in production – this approach can streamline manufacturing processes	• Utilize measurement uncertainty simulation • Implement organizational guidelines — rely on corporate process, not personnel	Measurement data has immense value – don't use it for PASS/FAIL inspection and then discard. MBD traceable data is ready for analytics	Software automation lowers the risk of transcription or interpretation errors of data, and creates opportunities for validation of data

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Simple ROI Analysis

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	**3.0 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

Engineer fully burdened cost per hour	$ 150
Hours saved on MBD Workflow	13.0
Labor cost saved per part program	$ 1,955
Number of parts programmed per year	52
Cost savings per year, labor	**$101,660**

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Comments, thoughts?

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