CMM Automation from MBD:
A case study of optimized Model Based Inspection

Mark Nielsen
TechAzul
310-729-6275
mark@techazul.com

Bryan Bergsma
Raytheon MS
520-794-0021
bergsma@raytheon.com

Daniel Campbell
Capvidia
415-738-7366
dc@capvidia.com
Model Based Definition, Manufacturing & Inspection

Design

Manufacture

Inspect
Each Process has been evolving

**Design**
- Drawing Centric
- Model Centric
- Model Based Definition
- Model Based Enterprise

**Manufacture**
- Manual Machining
- CNC: Computer Numerical Control
- Feature based machining
- Toolpath Strategies

**Inspect**
- Manual Gauging
- CMM: Coordinate Measurement Machines
- Non-contact Scanners
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,
## Overview: Model-Based CMM Measurement

<table>
<thead>
<tr>
<th>Current CMM processes are highly manual and expensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Highly manual process, risking transcription and interpretation errors</td>
</tr>
<tr>
<td>• Resulting quality of CMM program depends on skill, experience, and practices of CMM programmer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Automation and optimization are possible with MBE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Process can be automated, massively decreasing time spent to create the program</td>
</tr>
<tr>
<td>• Resulting program can be optimized for the job based on measurement resource availability and measurement uncertainty requirements</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technology is ready and already showing ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Off-the-shelf software applications can carry out this workflow</td>
</tr>
<tr>
<td>• Workflow demonstration: how does it work?</td>
</tr>
<tr>
<td>• Workflow automation results: time saved</td>
</tr>
</tbody>
</table>
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
Overall proposed workflow
Video of workflow
Simplified pilot workflow

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

PTC Creo
• MBDVidia for Creo Plugin

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

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 1 minute

5 minutes (but can be automated)

Less than 3 hours – pilot processed can be drastically streamlined from this baseline effort
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.
## Value of MBD Measurement

<table>
<thead>
<tr>
<th>Reduce inspection costs</th>
<th>Faster time-to-inspection</th>
<th>Increase inspection quality</th>
<th>Bring measurement data into the digital thread</th>
<th>Lower risk for transcription &amp; interpretation errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection planning is a laborious task involving skilled technicians – automation decreases its cost significantly</td>
<td>Faster product delivery. Inspection is typically a bottleneck in production – this approach can streamline manufacturing processes</td>
<td>• Utilize measurement uncertainty simulation • Implement organizational guidelines — rely on corporate process, not personnel</td>
<td>Measurement data has immense value – don’t use it for PASS/FAIL inspection and then discard. MBD traceable data is ready for analytics</td>
<td>Software automation lowers the risk of transcription or interpretation errors of data, and creates opportunities for validation of data</td>
</tr>
</tbody>
</table>
Today’s traditional, manual workflow for this part is estimated at about 16 hours.

The MBD pilot workflow took less than 3 hours.

### Current Workflow

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total hours, existing manual workflow</td>
<td>16 Hours</td>
</tr>
</tbody>
</table>

### New MBD Workflow

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>MBDVidia</td>
<td>5 Minutes</td>
</tr>
<tr>
<td>FormatWorks import of Creo file</td>
<td>5 Minutes</td>
</tr>
<tr>
<td>Checkmate Setup Parameters</td>
<td>5 Minutes</td>
</tr>
<tr>
<td>Checkmate Auto Programming</td>
<td></td>
</tr>
<tr>
<td>Accessibility</td>
<td>15 Minutes</td>
</tr>
<tr>
<td>Sorting for dependencies</td>
<td>1 Minute</td>
</tr>
<tr>
<td>Auto Coordinate Systems</td>
<td>1 Minute</td>
</tr>
<tr>
<td>Probe moves/rotations</td>
<td>1 Minute</td>
</tr>
<tr>
<td>Collision detection</td>
<td>20 Minutes</td>
</tr>
<tr>
<td>Manual editing (estimate)</td>
<td>120 Minutes</td>
</tr>
<tr>
<td>Post process program</td>
<td>5 Minutes</td>
</tr>
<tr>
<td>Total, New MBD Workflow</td>
<td>178 Minutes</td>
</tr>
</tbody>
</table>

**Total, New MBD Workflow**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.0 Hours</td>
</tr>
</tbody>
</table>

**81% Reduction in Time**

### 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
Comments,
thoughts?
• fin