‘The Cost of Enabling the Digital Thread’

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Agenda

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  - Data Normalization Synopsis
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- Conclusion
- Future Research
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Background - Definitions

**MBE** – “an organization and/or an operation that uses model-based definitions (MBD) for the purpose of commissioning, operating, servicing, and decommissioning a product.” (Hedberg et al, 2017)

**MBD** – “The practice of using 3D datasets containing the exact solid representation, associated 3D geometry and 3D annotations of a product’s dimensions, tolerances, materials, finishes and other notes to specify a complete product definition.” (MIL-STD-31000; ASME Y14.41)

**Digital Thread** – a method “to convey the data flows between engineering, manufacturing, business processes, and across supply chains.” (Hedberg et al, 2016)
Background – MBD/MBE

2D Drawing vs. 3D MBD

(A)

(B)

Graphics obtained from Hedberg et al, 2016
Background – MBD/MBE

MBD

For Human Consumption

For Computer Consumption

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  <Node Name="DIM">
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    <Property Name="gt1_isOverallTolerance" Value="true"/>
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    <Property Name="gt1_overallToleranceValue" Value="0.250000"/>
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    <Property Name="gt1_secondaryBasic DatumName" Value="B"/>
    <Property Name="gt1_showAllAroundSymbol" Value="false"/>
    <Property Name="gt1_showDiameterSymbol" Value="true"/>
  </Node>
</ModelTree3D>

Graphics obtained from Hedberg et al, 2016
Background – Existing Research

‘Testing the Digital Thread in Support of Model-Based Manufacturing and Inspection’
(Hedberg et al, 2016)

• Compared 2D DWG processes vs 3D MBD processes
  – Design -> Manufacture -> Inspect (for mechanical components)

• Three different test cases of varying level of annotations
  – Full, hybrid, and reduced annotations

• Findings: 3D MBD more efficient overall, but can be more labor some during design phase
Background – Existing Research

Graphic obtained from Hedberg et al, 2016

Fig. 8. Comparison of drawing-based and model-based processes
### Background – Existing Research

Table 2. Observed time to annotate the design definition

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</table>

Graphic obtained from Hedberg et al, 2016
Purpose

• Fill literature gaps
  – Findings supported by **quantitative evidence** are limited
  – Findings supported by **real-world/non-piloted evidence** are limited
  – Quantitative analysis from a **Systems Engineering use case/viewpoint**

• Validate/Extend existing work

• Focus on **ROI & potential counterproductiveness**
Assumptions

- model organization schema for MBD data include annotations and no attributes (as defined by ASME Y14.47)
- the data sets best compare to the full annotations test case of Hedberg et al.’s 2016 [2] study
- model organization schema for the MBD data sets are for human consumption
- the scope of all data sets is inclusive of annotating the design definition only
- learning curves are non-existent as both the 2D DWG and 3D MBD are not new to the designers/engineers
- both the 2D DWGs and 3D MBD geometric models were created in the same CAD environment using the same business rules
- both the 2D DWGs and 3D MBD have dimensions and tolerances in accordance with ASME Y14.5
Method

Stepped approach conducted in three parts:

1) Validation of existing research on MBD
   - Comparison of 2D vs 3D Design Effort for Mechanical Components using real-world data (raw and normalized data)

2) Extending the existing research...
   - Comparison of 2D vs 3D Design Effort for Varying Types of Drawing Formats using real-world data (raw and normalized data)

3) Extending the existing research...
   - Comparison of the trends between Part 1 and Part 2
Data Synopsis

The data being used is suitable for the comparison as...

• products for the 2D DWG and 3D MBD practices are of similar content, size and complexity

• 2D DWG data were annotated using MIL-STD-100G and ASME Y14.5

• 3D MBD data were annotated using MIL-STD-31000A and ASME Y14.5
Data Normalization Synopsis

• Part 1 & 3
  – Normalized for number of views

• Part 2
  – Normalized for number of views
  – Normalized for number of parts

• Using ASME Y14.47 it was determined that the MBD was ...
  – maturity states of M3 (i.e. production)
  – geometry states of G3 (full)
  – annotation and attribute states of A3 (full)
Analysis

Part I – Validate Hedberg et al, 2016 findings

Comparison of 2D DWG and 3D MBD Design Efforts for Components
Analysis

Part 2 – Extending existing research

Comparison of 2D DWG and 3D MBD Design Efforts for Assemblies
Part 3 – Comparison of the trends between Part 1 and Part 2a

Comparison of 2D vs 3D Proportion Trends Between Components and Assemblies
Conclusion

• Part 1
  – Partially validates Hedberg et al, 2016’s work
  – Sets a benchmark for the study and validates data

• Part 2
  – Suggests the trends found by Hedberg et al, 2016 are consistent at the assembly level

• Part 3
  – Inconclusive due to affects of unknown variables
Future Research

• Compare 2D DWG vs 3D MBD assemblies in a controlled environment
• Compare 2D DWG vs 3D MBD for varying engineering disciplines
• Extend the research of this paper to the manufacturing and inspection phases to calculate ROI
• Investigate the benefits of MBD throughout the change process
QUESTIONS?
References


