Model Authorized Product Realization (MAP-R)

PRESENTED BY

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Presenting Today

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Agenda

Model Authorized Product – Realization (MAP-R)
  ◦ Project Background
  ◦ Data Collected
  ◦ Observations & Findings

Next Steps
  ◦ MBE Level 3+
  ◦ Research on 3D interactive viewable(s) (3DIV)

Nuclear Security Enterprise MBE Expected Benefits

- **New Business Advantages in**
  - **Faster –** through Increasing Velocity of Product Realization & Responsiveness
  - **Smarter –** by easily Incorporating Innovative Ideas & Next Generation Automation
  - **Better –** through Improving both Model and Product Quality
  - **Cheaper –** via Enabling Cost-Effective Downstream Processes
  - **Safer –** by virtually Simulating First & analyzing Advanced Safing Concepts
  - **Securer -** through Digitally Controlling a Single Source of Truth
- **Major Benefits come from Downstream**
  - **Simulations & Analysis**
  - **Manufacturing (Additive & Subtractive)**
  - **Engineering & Tool Design**
  - **Purchased Products / Procurement**
  - **Quality's Contribution to the Enterprise**
  - **3D Technical Data Packages**
  - **Visualization & Animation**
  - **Automation via Digital Interoperability**
  - **Extends the Enterprise**

Model-Based Enterprise Hypothesis
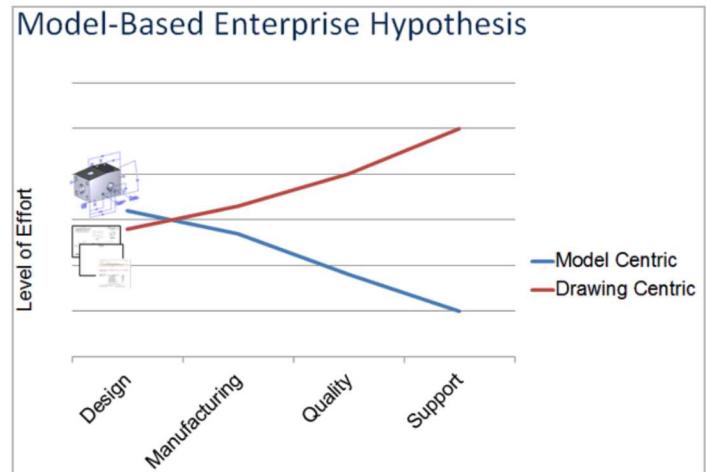
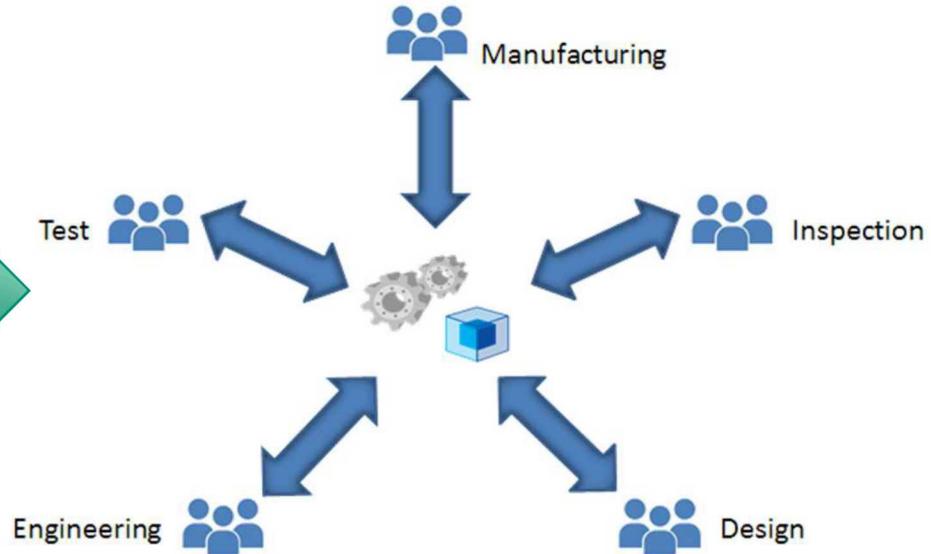# A trusted model to facilitate accelerated development is at the core of the MBE

Today
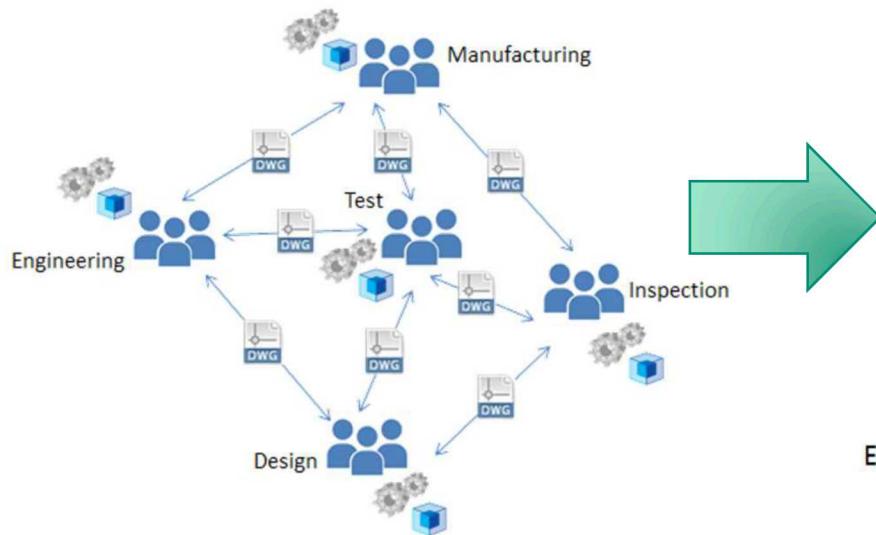
Models are created to make drawings. These drawings are used to create new models for product development activities.
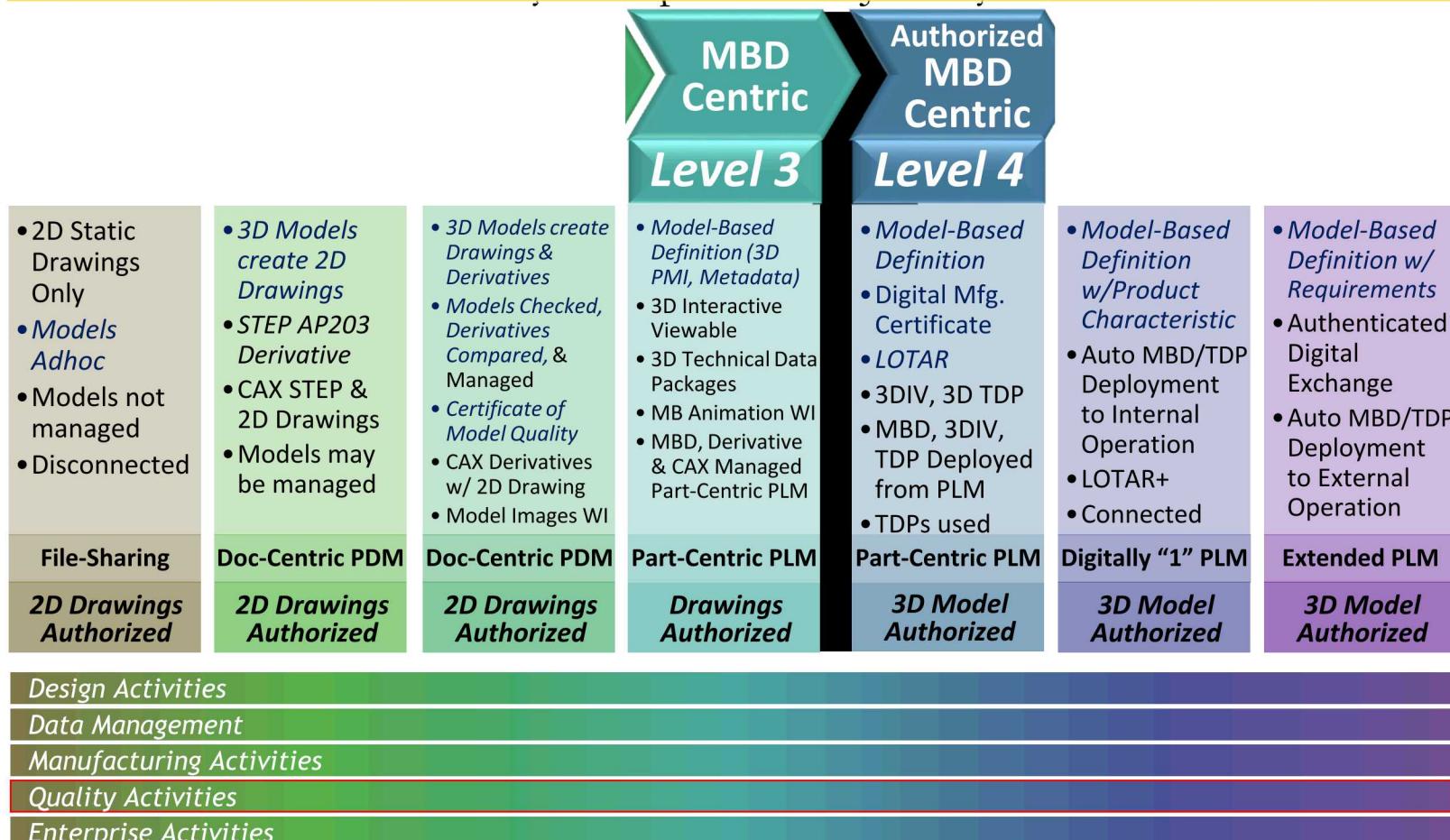
Tomorrow

Trusted model that can be reused to support collaboration and virtual/physical product development activities.

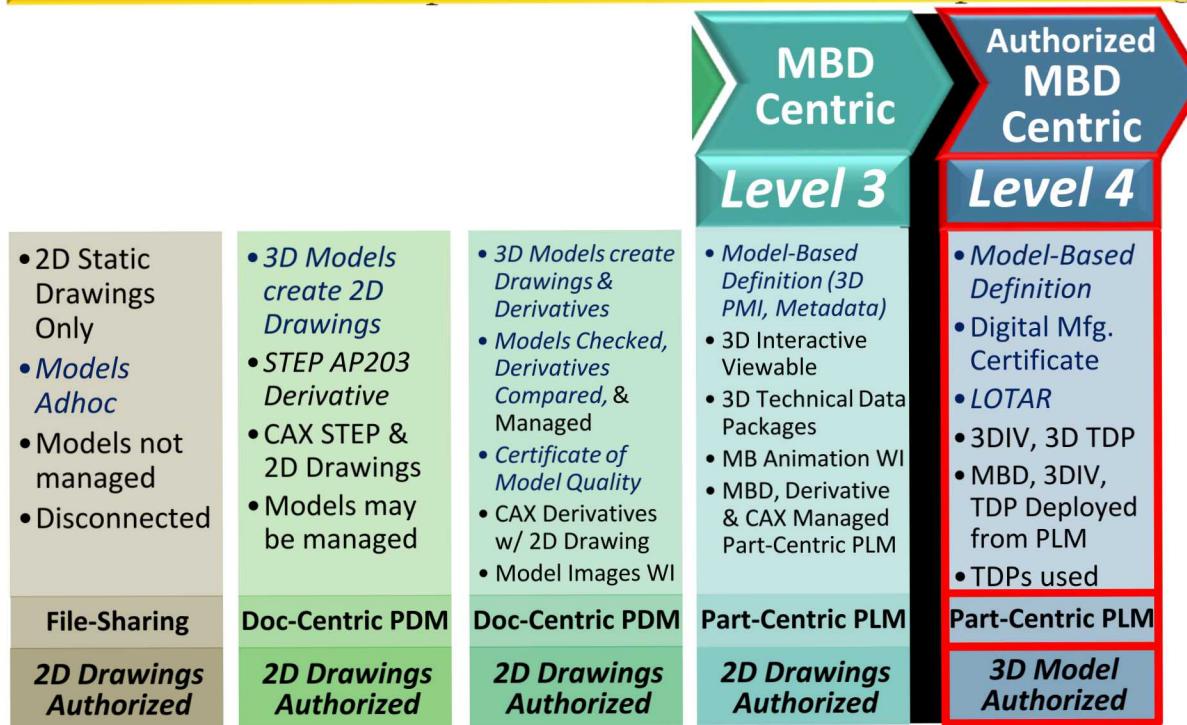A single source of the truth eliminating waste

MBE Maturity Index*
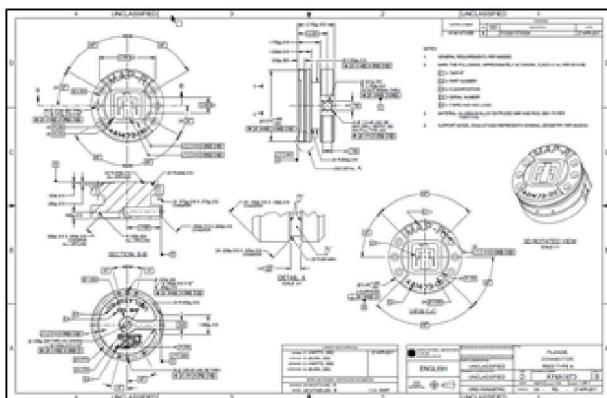
Model-Based Enterprise Maturity Index

			MBD Centric **Level 3**	**Authorized MBD Centric** **Level 4**		
• 2D Static Drawings Only • *Models Adhoc* • Models not managed • Disconnected	• *3D Models create 2D Drawings* • *STEP AP203 Derivative* • CAX STEP & 2D Drawings • Models may be managed	• *3D Models create Drawings & Derivatives* • *Models Checked, Derivatives Compared, & Managed* • *Certificate of Model Quality* • CAX Derivatives w/ 2D Drawing • Model Images WI	• *Model-Based Definition (3D PMI, Metadata)* • 3D Interactive Viewable • 3D Technical Data Packages • MB Animation WI • MBD, Derivative & CAX Managed Part-Centric PLM	• *Model-Based Definition* • Digital Mfg. Certificate • *LOTAR* • 3DIV, 3D TDP • MBD, 3DIV, TDP Deployed from PLM • TDPs used	• *Model-Based Definition w/Product Characteristic* • Auto MBD/TDP Deployment to Internal Operation • LOTAR+ • Connected	• *Model-Based Definition w/ Requirements* • Authenticated Digital Exchange • Auto MBD/TDP Deployment to External Operation
File-Sharing	**Doc-Centric PDM**	**Doc-Centric PDM**	**Part-Centric PLM**	**Part-Centric PLM**	**Digitally "1" PLM**	**Extended PLM**
2D Drawings Authorized	***2D Drawings Authorized***	***2D Drawings Authorized***	***Drawings Authorized***	***3D Model Authorized***	***3D Model Authorized***	***3D Model Authorized***

Design Activities

Data Management

Manufacturing Activities

Quality Activities

Enterprise Activities

Future Situation at NSE?

Model-Based Enterprise Maturity Index

			MBD Centric	Authorized MBD Centric
			Level 3	**Level 4**
• 2D Static Drawings Only • *Models Adhoc* • Models not managed • Disconnected	• *3D Models create 2D Drawings* • *STEP AP203 Derivative* • CAX STEP & 2D Drawings • Models may be managed	• *3D Models create Drawings & Derivatives* • *Models Checked, Derivatives Compared, & Managed* • *Certificate of Model Quality* • CAX Derivatives w/ 2D Drawing • Model Images WI	• *Model-Based Definition (3D PMI, Metadata)* • 3D Interactive Viewable • 3D Technical Data Packages • MB Animation WI • MBD, Derivative & CAX Managed Part-Centric PLM	• *Model-Based Definition* • Digital Mfg. Certificate • *LOTAR* • 3DIV, 3D TDP • MBD, 3DIV, TDP Deployed from PLM • TDPs used
File-Sharing	**Doc-Centric PDM**	**Doc-Centric PDM**	**Part-Centric PLM**	**Part-Centric PLM**
2D Drawings Authorized	***2D Drawings Authorized***	***2D Drawings Authorized***	***2D Drawings Authorized***	***3D Model Authorized***

MBE Collaboration Project

Model Authorized Product Realization (MAP-R)

◦ MBE Collaborative SNL-NM and KCNSC Project

◦ Exercised an Authorized Part Defining Model (MBE Level 4)

◦ 9925020 addressed Identification of a Part Defining Model

◦ Help Quantify MBE Benefits and Identify Challenges

◦ Quantify the differences and business practices for design, manufacturing, inspection, & QAIP

  ◦ Traditional *drawing-based* processes

  ◦ Responsive *model-based* paradigm

VS

MAP-R Methodology

Testing the Digital Thread in Support of Model-Based Manufacturing and Inspection
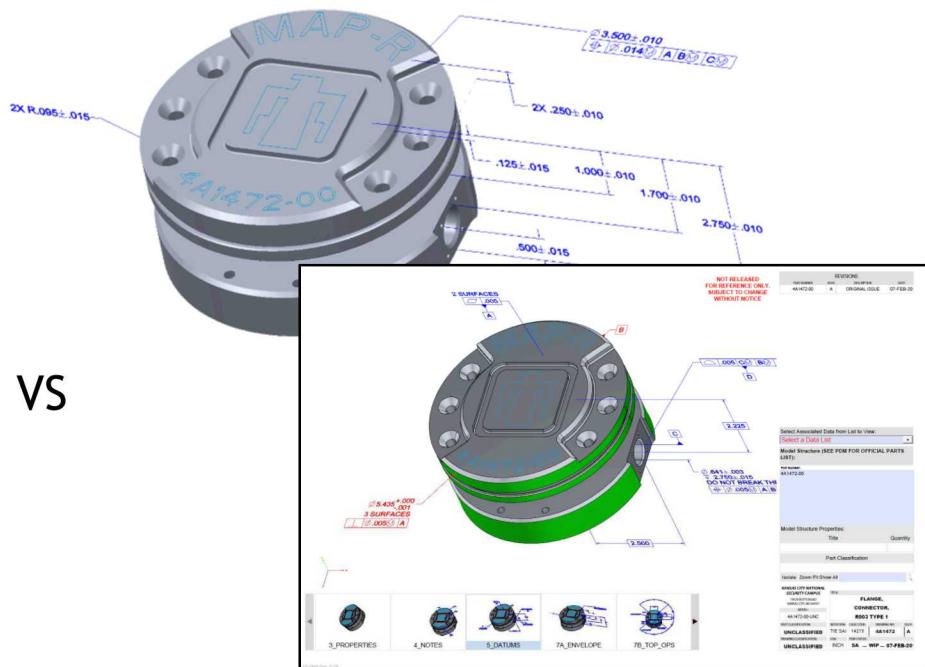
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A number of manufacturing companies have reported anecdotal evidence describing the benefits of model-based enterprise (MBE). Based on this evidence, major players in industry have embraced a vision to deploy MBE. In our view, the best chance of realizing this vision is the creation of a single "digital thread." Under MBE, there exists a model-based definition (MBD), created by the Engineering function, which downstream functions reuse to complete model-based manufacturing and model-based inspection activities. The ensemble of data ... inspection defines this digital ... and analysis, collaborative p... full-process traceability in a ... participants. This paper docu... strategies for implementing M... of data between various man... results from a study of model-... provides evidence to support ... [DOI: 10.1115/1.4032697]
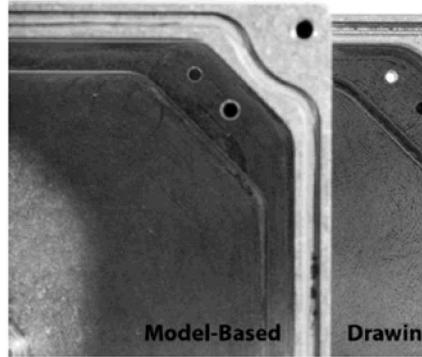
Fig. 7 Comparison of a delivered test case 1 par... addition of an unintended through-hole in the d... part

Model-Based **Drawing**

Fig. 3 Three-dimensional model of test case 1

* Permission Granted from NIST and all Authors
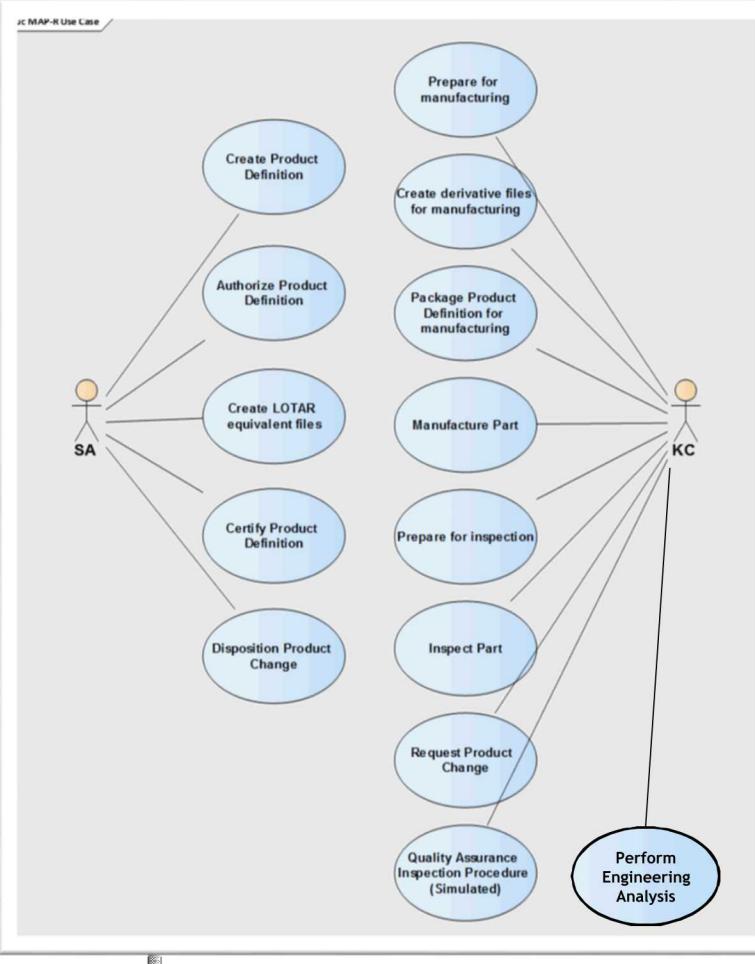
MAP-R builds upon the findings of NIST studies with NSE unique use cases

MAP-R Deliverables

Validate the Model-Based Hypothesis and answer critical questions such as:

◦ Is there a quantifiable business benefit?
◦ What Product Manufacturing Information (PMI) should be included?
◦ What is a Trusted Model?
◦ Does a 3D annotated model save time and improve quality?
◦ What are our capabilities (people, processes, tools) and maturity to use models?

Identify gaps in current processes, tools, training, and policies to effectively implement MBE (inputs for MBE Roadmap)

Capture best practices and create new process documents/modify existing documentation

Model-Based Enterprise Hypothesis

- Model Centric
- Drawing Centric

Level of Effort

Design   Manufacturing   Quality   Support
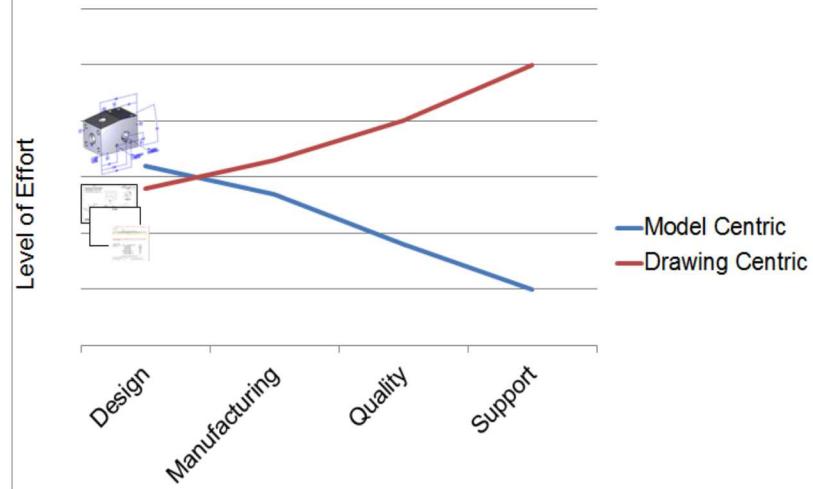
Understanding the value proposition for the Enterprise

From Design Agency (DA) To Production Agency (PA)

Authorize Part Defining Model

PA is *authorized* to use the *certified* part defining model and associated baseline for *all* production activities
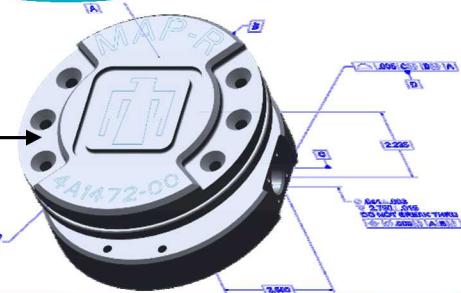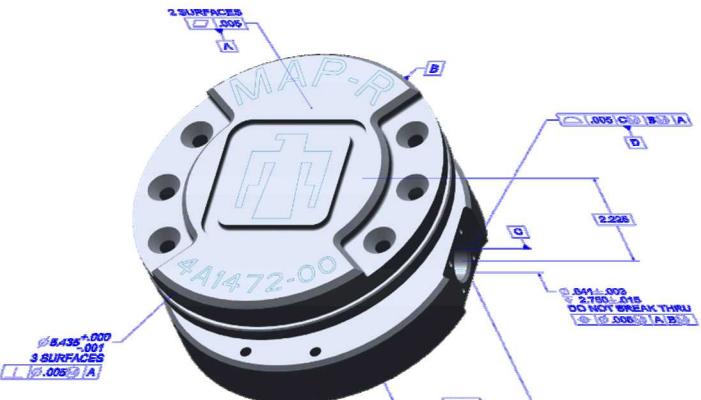
Certify Part Defining Model

Authorized to use the Certified Part Defining Model for ALL Production Activities

Authorizing models as product definition is required for MBE

Part Defining Model specification 9925020 defines a method to certify and authorize native CAD and derived STEP files for use as product definition

Current EA system only recognizes drawings

Authorization to Baseline

Easy and Early detection of defects

View Description: The minimum thickness of a solid is too thin

:58 seconds

Properties:
Item Name - 1 : 0.0108021
Hot/Warm/Error/Total Thicknesses : 2/0/0/5
Surface Type : Cylinder
Target Faces : 4084-1

**13:00 hours
x 5 FTE**
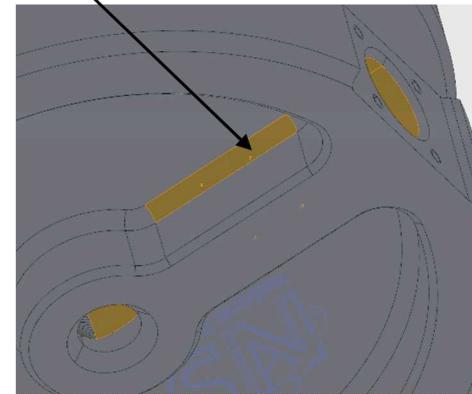
Model certification identifies defects
not identified in drawing reviews

CT Scan of Interest Area
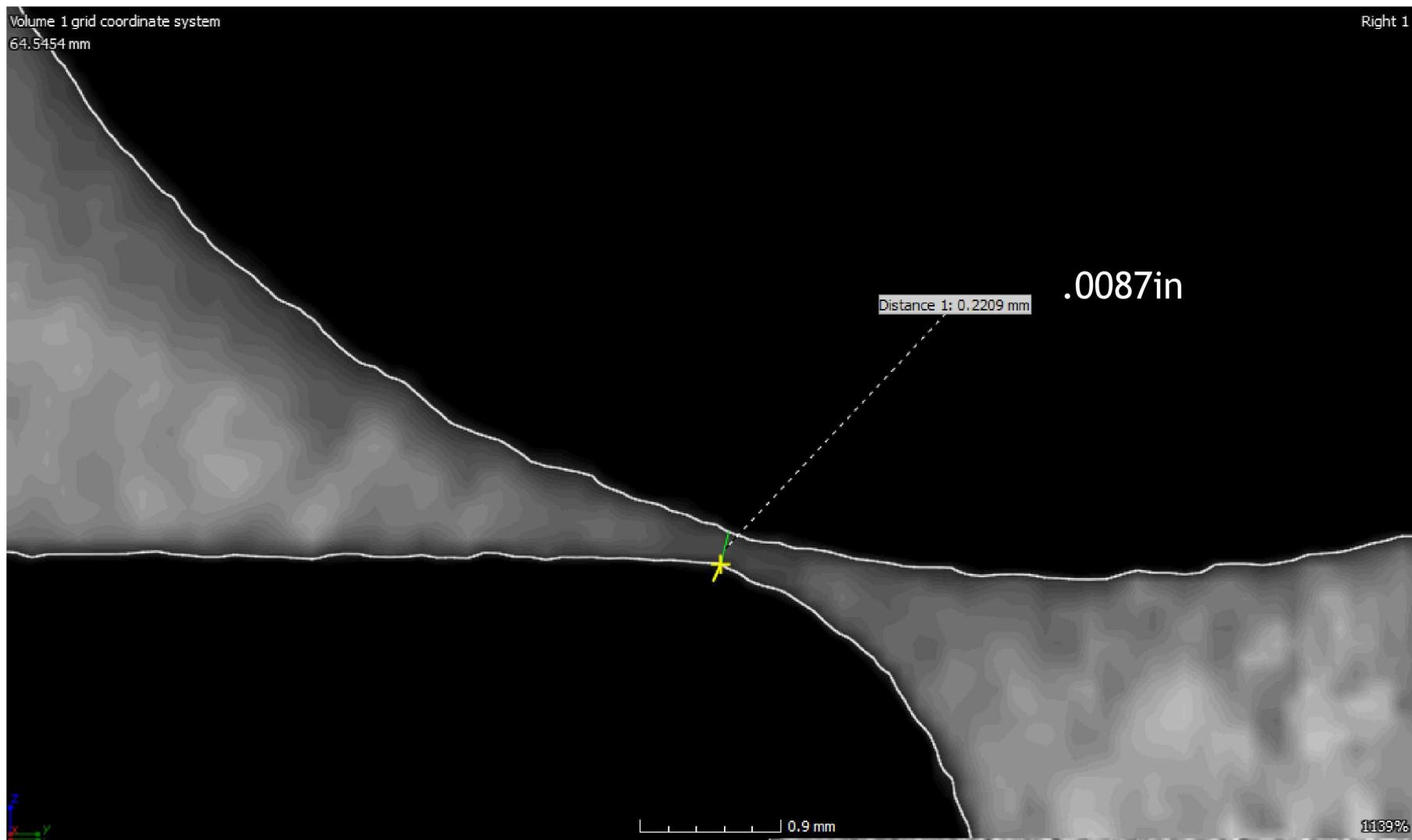
Perform Engineering Analysis

Drawing-Based MAPR

Analyze thin wall issue

2D Drawing and STEP AP203
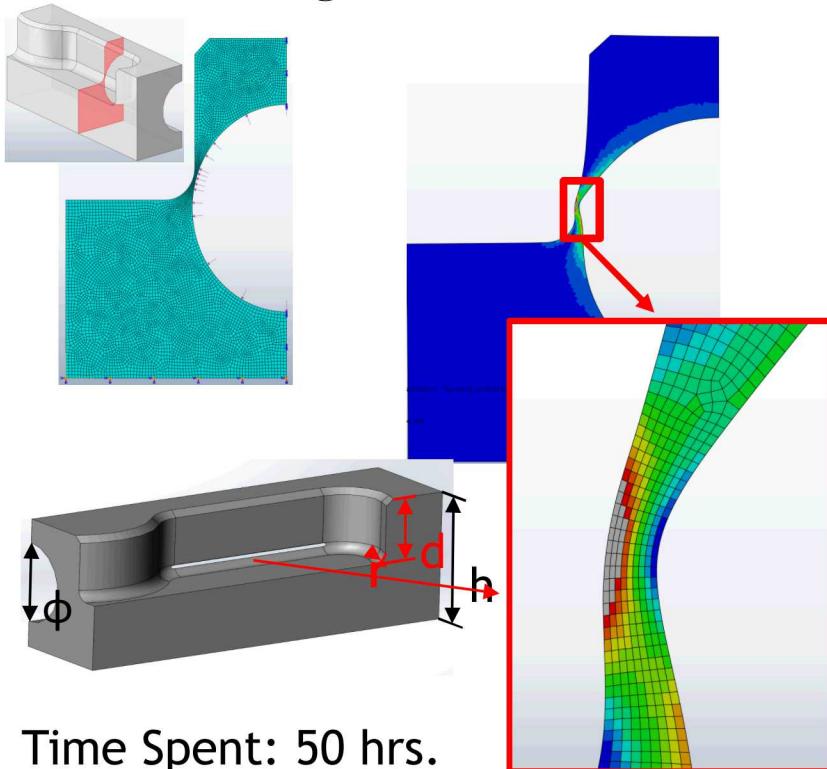
Time Spent: 50 hrs.
Time Spent on Model Prep: 31.5 hrs.
Time Spent Analyzing: 18.5 hrs.

- Model-Based MAPR
- Analyze thickened channel
- 3DTDP w/3D Derivatives Models & 3DIV
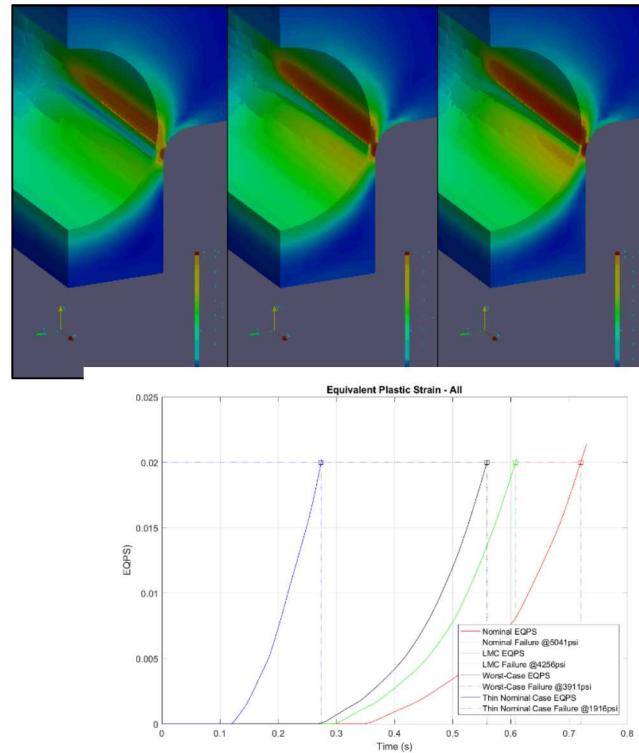
Used ACIS Model from 3DTDP
Time Spent: 12.2 hrs.

Drawing Based – NC Programming

MAP-R Project Analytics
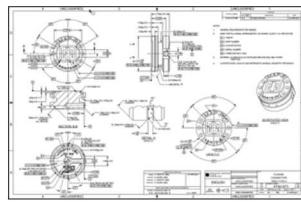
Drawing-Based
All Use Cases
Completed
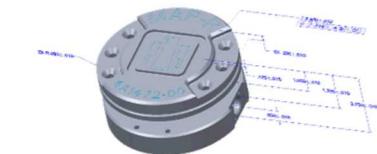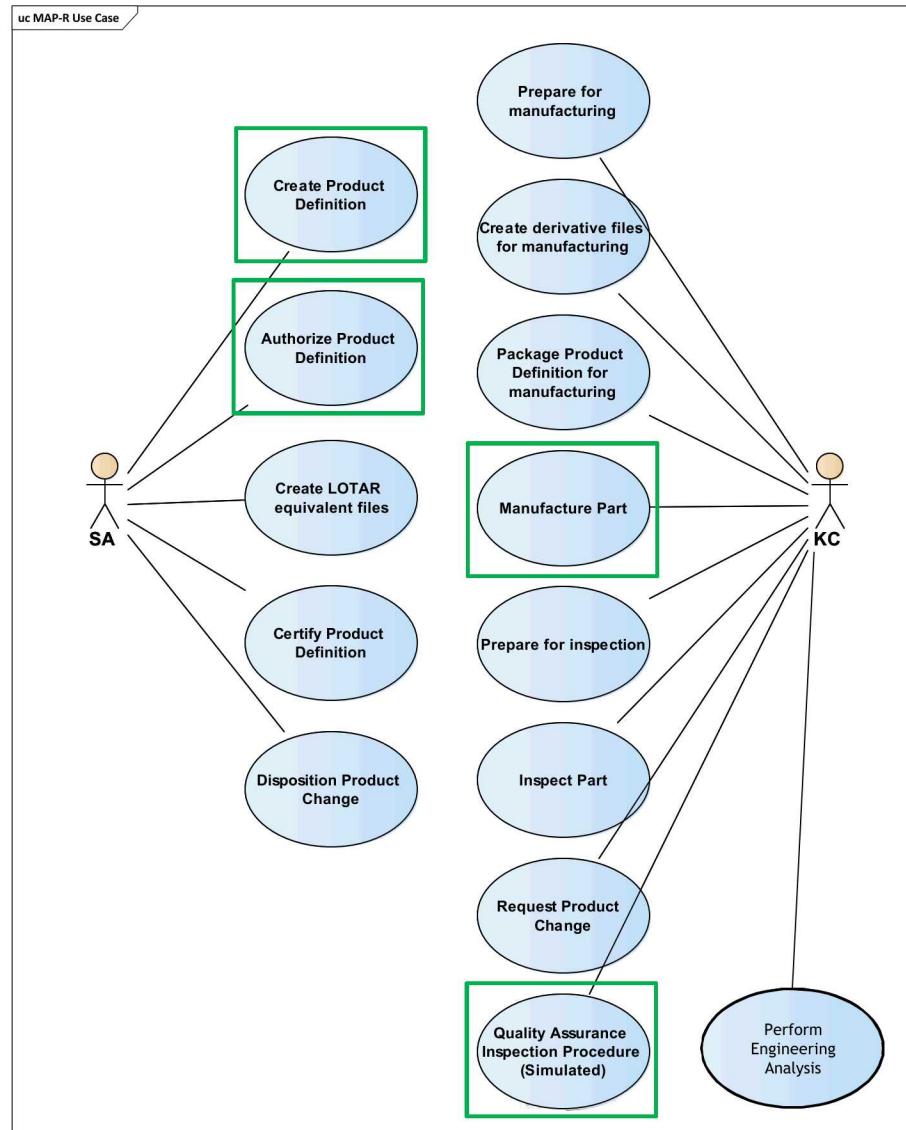
Model-Based
All Use Cases
Completed

MAP-R Data Analysis

Methods

◦ **Workload:** The workload scores were generated based on the Multiple Resource Theory of workload (Wickens and Yeh, 1986). Each **score represents** an aggregate of the modeled **Cognitive** (C), **Fine Motor** (FM) and **Visual** (V) channels, summed and multiplied by subtask time to denote magnitude, and then divided by overall task time (summed time of all tasks).

◦ **Success Rate:** Success rates were determined through applying known error rates from pre-existing research (Melchers & Harrington, 1982; Grudin, 1983; Swain & Guttman, 1983; Dhillon, 1986) and then providing a product of all error rates for the entire task.

Overall Underlying Theory:

Workload can affect performance and be a predictor of possible error rates (Yerkes, Dodson, 1908; Swain, 1964; Paas, 1992). We hypothesize that the model-based process will show less time in the high-workload condition than the drawing-based process. This can be used as a predictor for possible error rate of the task(s) in question and could result in less errors over time through implementing the process.

Cognitive Workload Levels:

The **low, medium and high** workload levels were assigned based on the aggregate workload score for each task for both processes. Low = 0-14.9, medium 15 to 18.9, high 19-21. These determinations were based on Multiple Resource Theory scores for task types, where 21 is the maximum of possible workload to be experienced for the three channels modeled, and the concept of stress-based workload levels and predicted performance.

MAP-R Data Analysis Summary

Total Execution Time	
Drawing	Model
89:15:14	83:42:11

Time in Low Workload	
Drawing	Model
19:48:31	18:14:28

Time in Med Workload	
Drawing	Model
5:24:38	12:08:38

Time in High Workload	
Drawing	Model
64:02:05	53:19:05

Create Product Definition
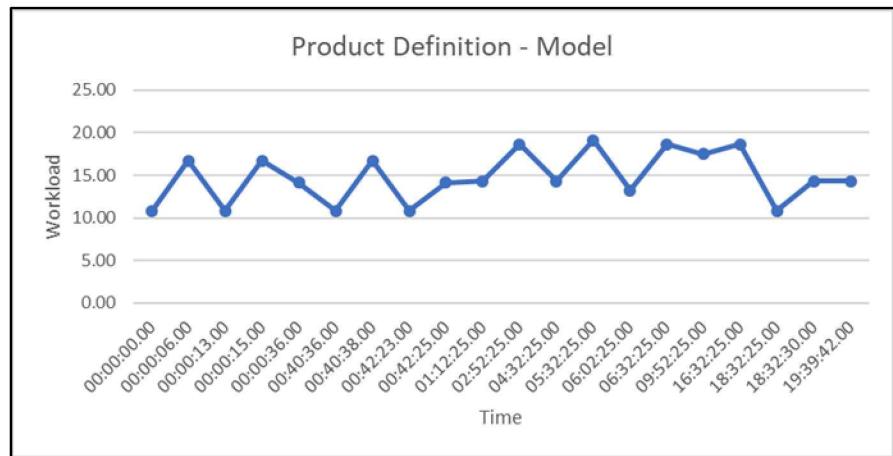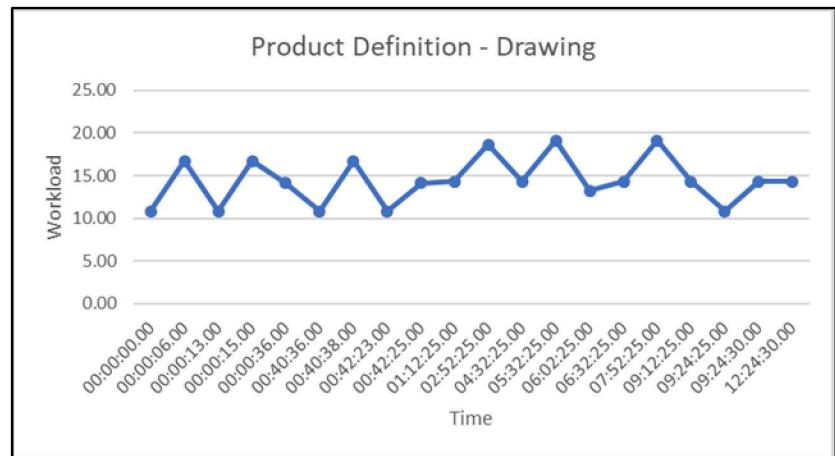
Time at Load		
Low 0-14	Med 15-18	High 19-21
8:52:17	0:02:13	3:30:00

Total Time 12:24:05

Time at Load		
Low 0-14	Med 15-18	High 19-21
5:27:29	6:42:13	7:30:00

Total Time 19:39:42

Create Product Definition (Expert vs Novice)

Product Definition - Model (Expert)

Product Definition - Model (Novice)
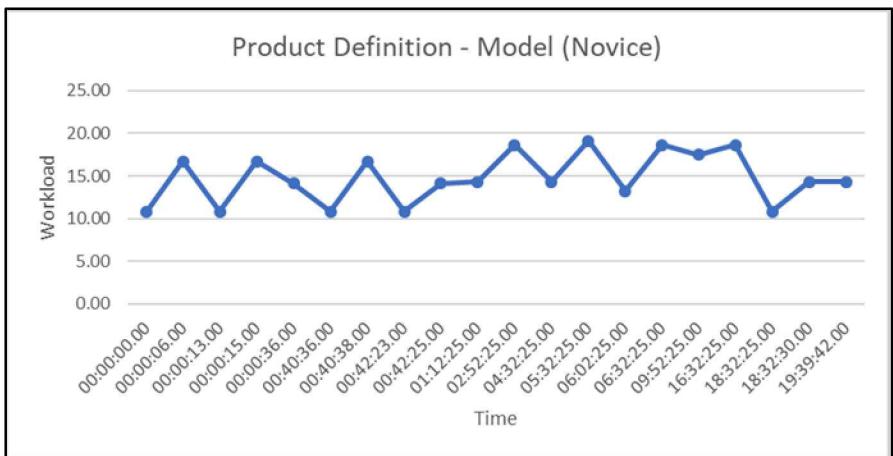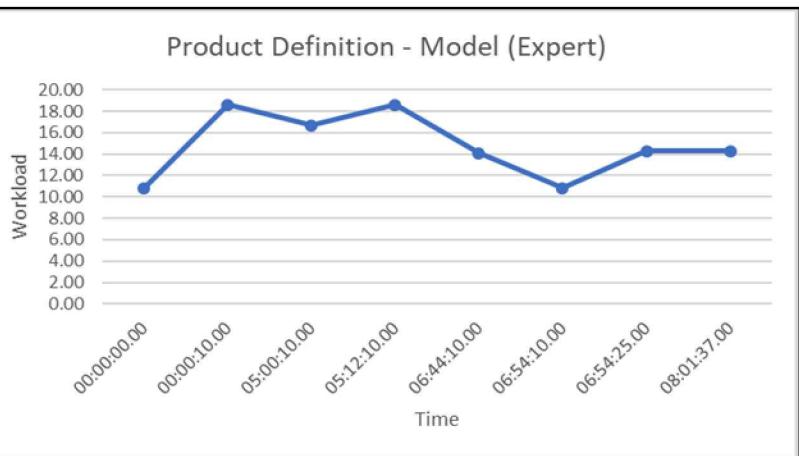
Time at Load		
Low 0-14	Med 15-18	High 19-21
1:17:37	0:12:00	6:32:00

Total Time 8:01:37

Time at Load		
Low 0-14	Med 15-18	High 19-21
5:27:29	6:42:13	7:30:00

Total Time 19:39:42

Authorize Product Definition

Authorize Product Definition - Drawing

Authorize Product Definition - Model

Time at Load		
Low 0-14	Med 15-18	High 19-21
0:05:15	0:00:00	4:42:05

Total Time 4:47:20

Time at Load		
Low 0-14	Med 15-18	High 19-21
0:00:15	0:00:00	2:12:05
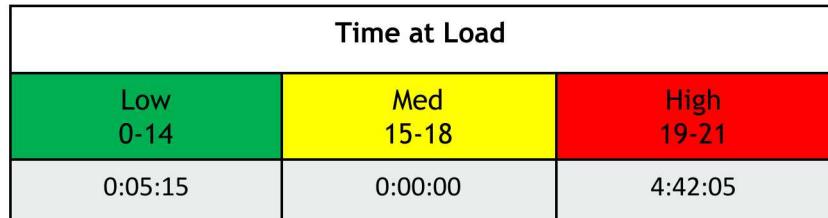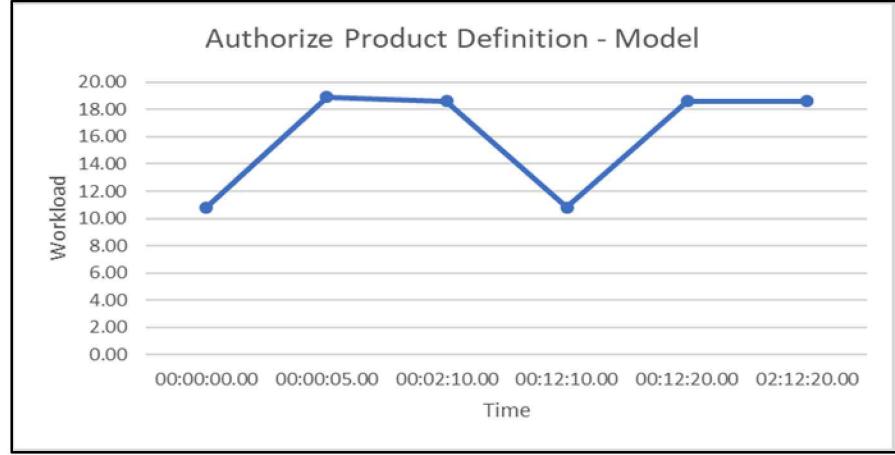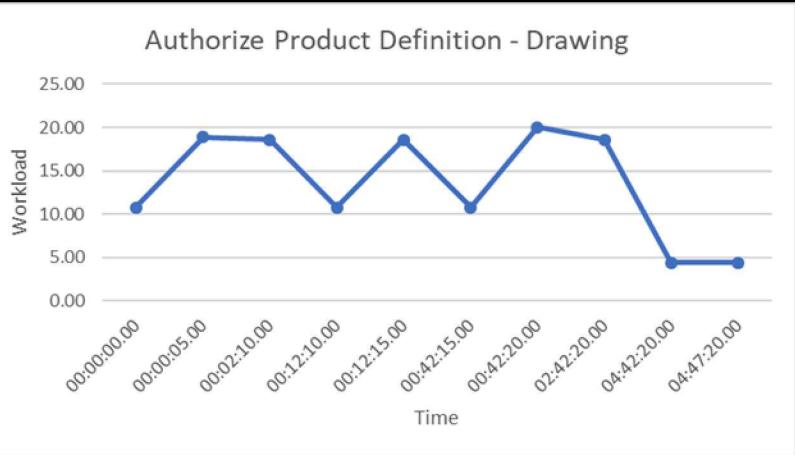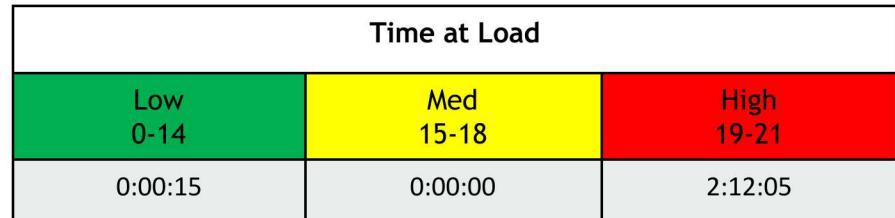
Total Time 2:12:20

Manufacture Part (Engineering)

Manufacturing Engineering - Drawing-Based
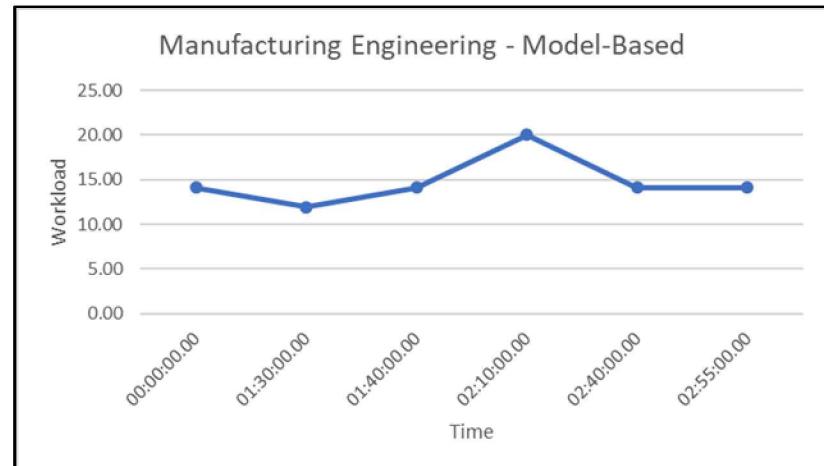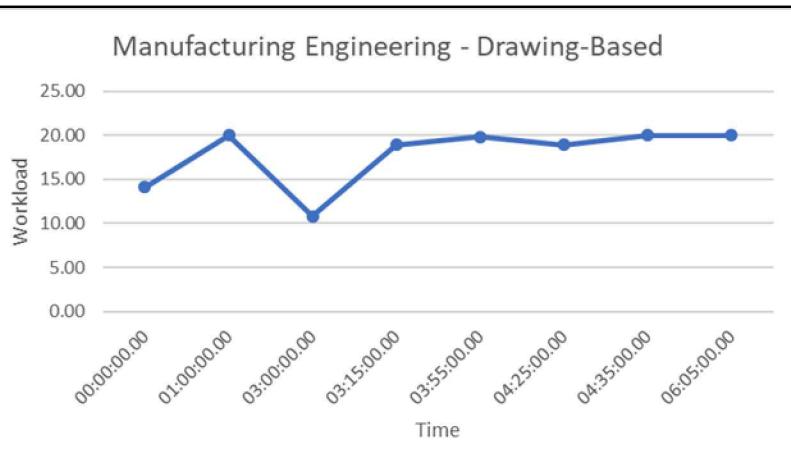
Time at Load		
Low 0-14	Med 15-18	High 19-21
1:15:00	0:00:00	4:50:00

Total Time 6:05:00

Manufacturing Engineering - Model-Based

Time at Load		
Low 0-14	Med 15-18	High 19-21
2:25:00	0:00:00	0:30:00

Total Time 2:55:00

Quality Assurance Inspection Procedure (QAIP)
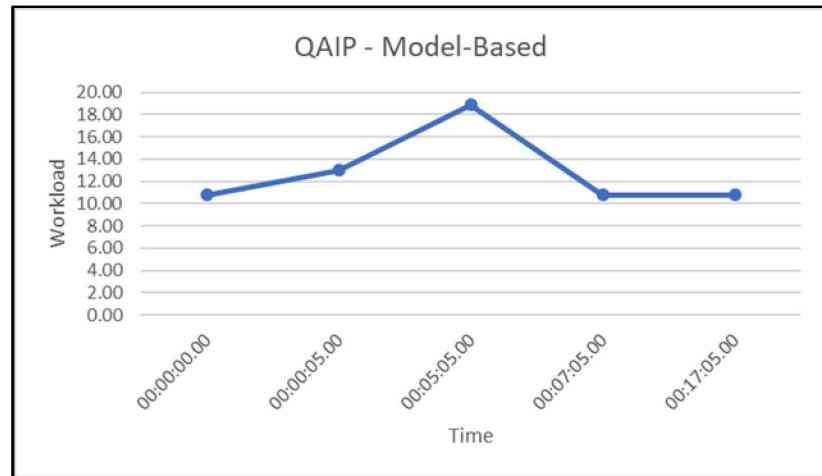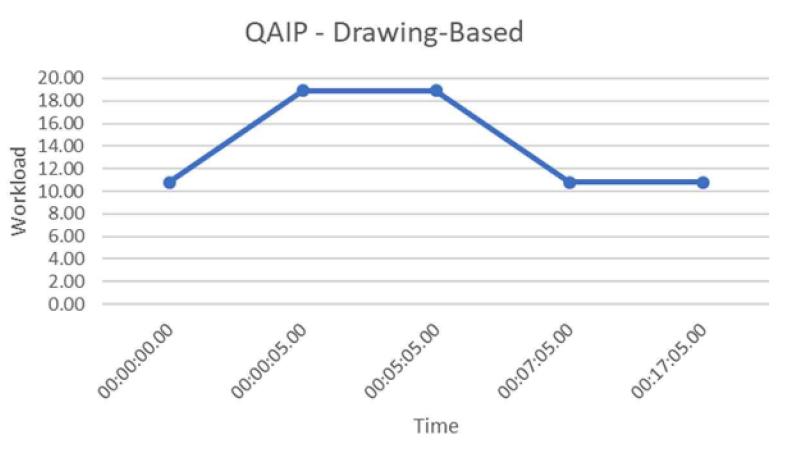
	Time at Load		
Low **0-14**	**Med** **15-18**	**High** **19-21**
0:10:00	0:00:00	0:07:00

Total Time 0:17:05

	Time at Load		
Low **0-14**	**Med** **15-18**	**High** **19-21**
0:15:05	0:00:00	0:02:00

Total Time 0:17:05

QAIP Comments

During the Authorized Part Defining Model QAIP Process:

What did you like?
"I liked how the 3D model area *(i.e., 3DIV face)* was highlighted when you clicked on the drawing requirement *(i.e., tolerance annotation).* It made it very obvious what feature was to be measured."

Concerns?
"The lack of computer access in *KCNSC's* receiving inspection area."

Was there any difference?
"I felt like the 3D drawing *(i.e., 3DIV)* gave you more detail."

Mark B.
Weapons Quality Assurance
Engineer
Kansas City Field Office -
DOE/NNSA

W80-4 Life Extension Program (LEP)

# Model-Based Definition (MBD)"Same but different" Level 3+

- **AY/ML from the start**
  - Eliminates RML "hand-jamming" of IPL (BOM) metadata into PDMLink for Product Structure
  - Enables "early" metadata exchange with KC

- **Designers and Engineers building Product Structure (PS) in PDMLink**
  - PS created from Creo model (CAD driven PS)
  - PS built on the same network as the product (unclassified and classified)
  - Engineers and Designers will have the support of the PS Team in creating and managing ML

- **AY will be 3D Interactive Viewable (3DIV)**
  - 3D PRC format requires only Adobe Acrobat reader for downstream users
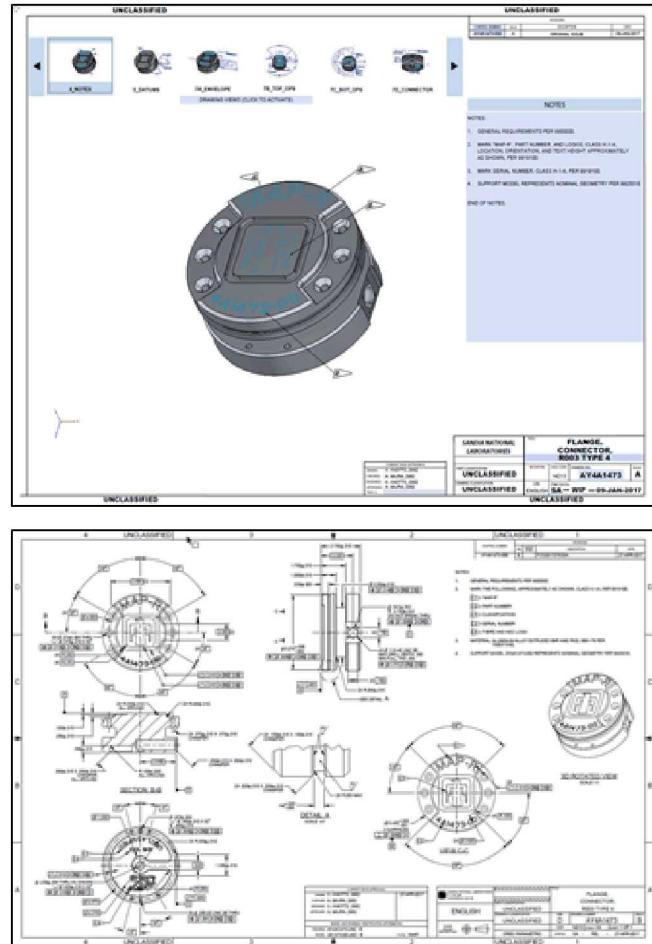 - Released in to PRIME-IMS
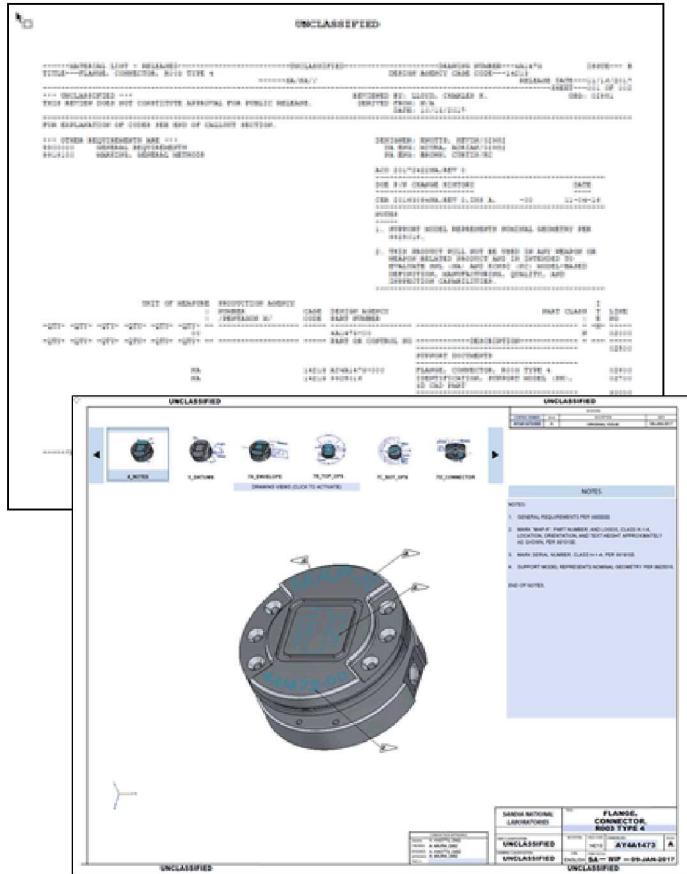
All the benefits of Model-Based Definition without changing KC's IT Systems or NSE Processes

3D Interactive Viewable (3DIV) Human Factors Experiment

This experiment aims to directly compare and quantify the differences between 2D and 3D reference materials with respect to operators performing tasks requiring use of these reference materials. Factors that will be measured to assess reference material use are performance (based on success of task completion and time-to-complete), cognitive workload, and usability.

Participant factors that will be considered are age, gender, education, length of work experience, experience with spatially referenced materials (i.e. engineering drawings), and preferences between 2D and 3D reference materials.

Thank You

Questions