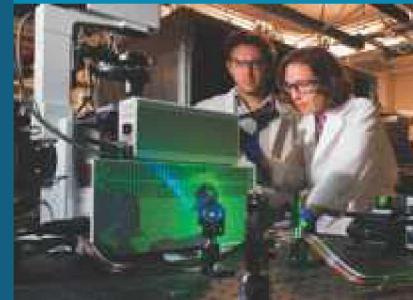




SAND2018-8697R

# Model Authorized Product Realization (MAP-R)



## PRESENTED BY

Adrian Miura – Sandia National Laboratories



Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

# Presenting Today

Adrian S. Miura  
Solution Architect  
Sandia National Laboratories

[asmiura@sandia.gov](mailto:asmiura@sandia.gov)



# Agenda

## Model Authorized Product – Realization (MAP-R)

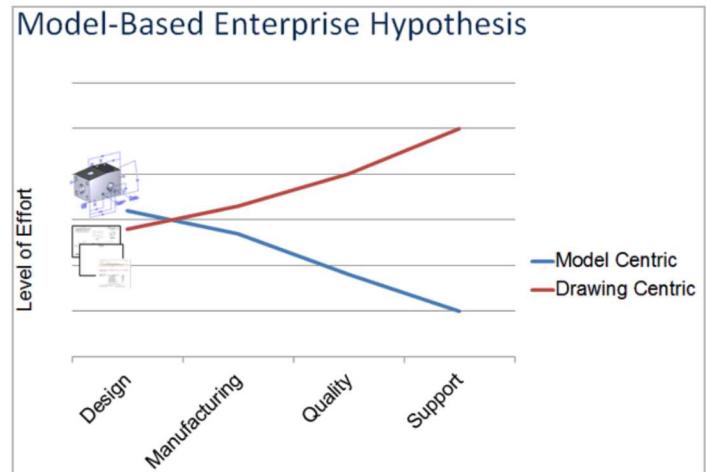
- Project Background
- Data Collected
- Observations & Findings

## Next Steps

- MBE Level 3+
- Research on 3D interactive viewable(s) (3DIV)

# Nuclear Security Enterprise MBE Expected Benefits

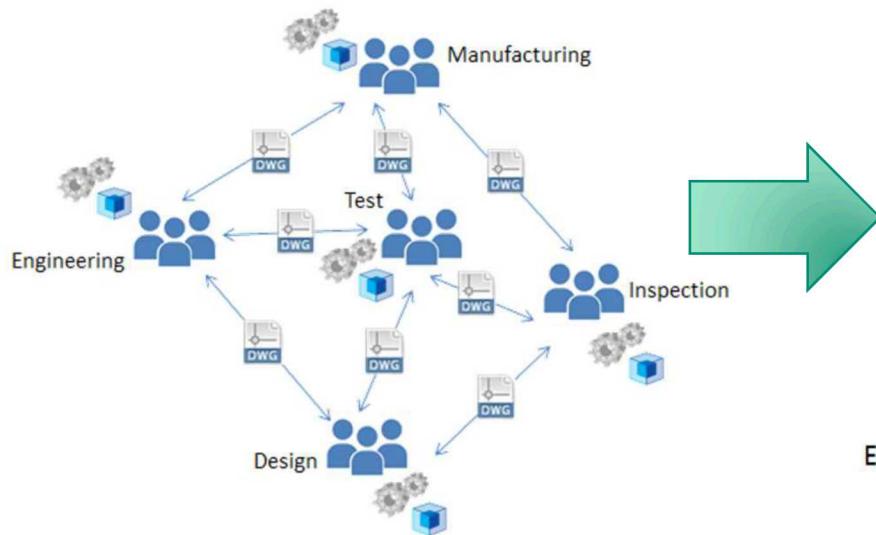
- **New Business Advantages in**
  - **Faster** – through Increasing Velocity of Product Realization & Responsiveness
  - **Smarter** – by easily Incorporating Innovative Ideas & Next Generation Automation
  - **Better** – through Improving both Model and Product Quality
  - **Cheaper** – via Enabling 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



# A trusted model to facilitate accelerated development is at the core of the MBE

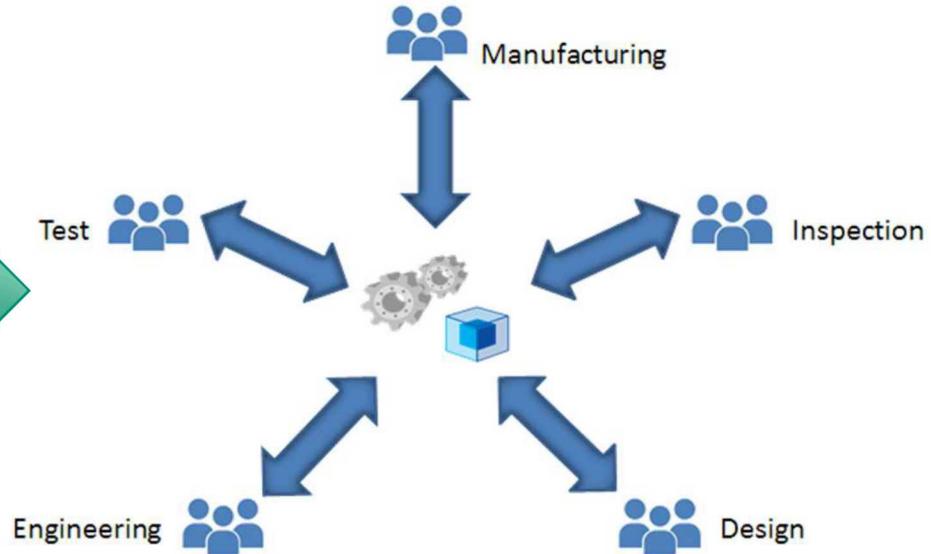


## Today



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

## Tomorrow



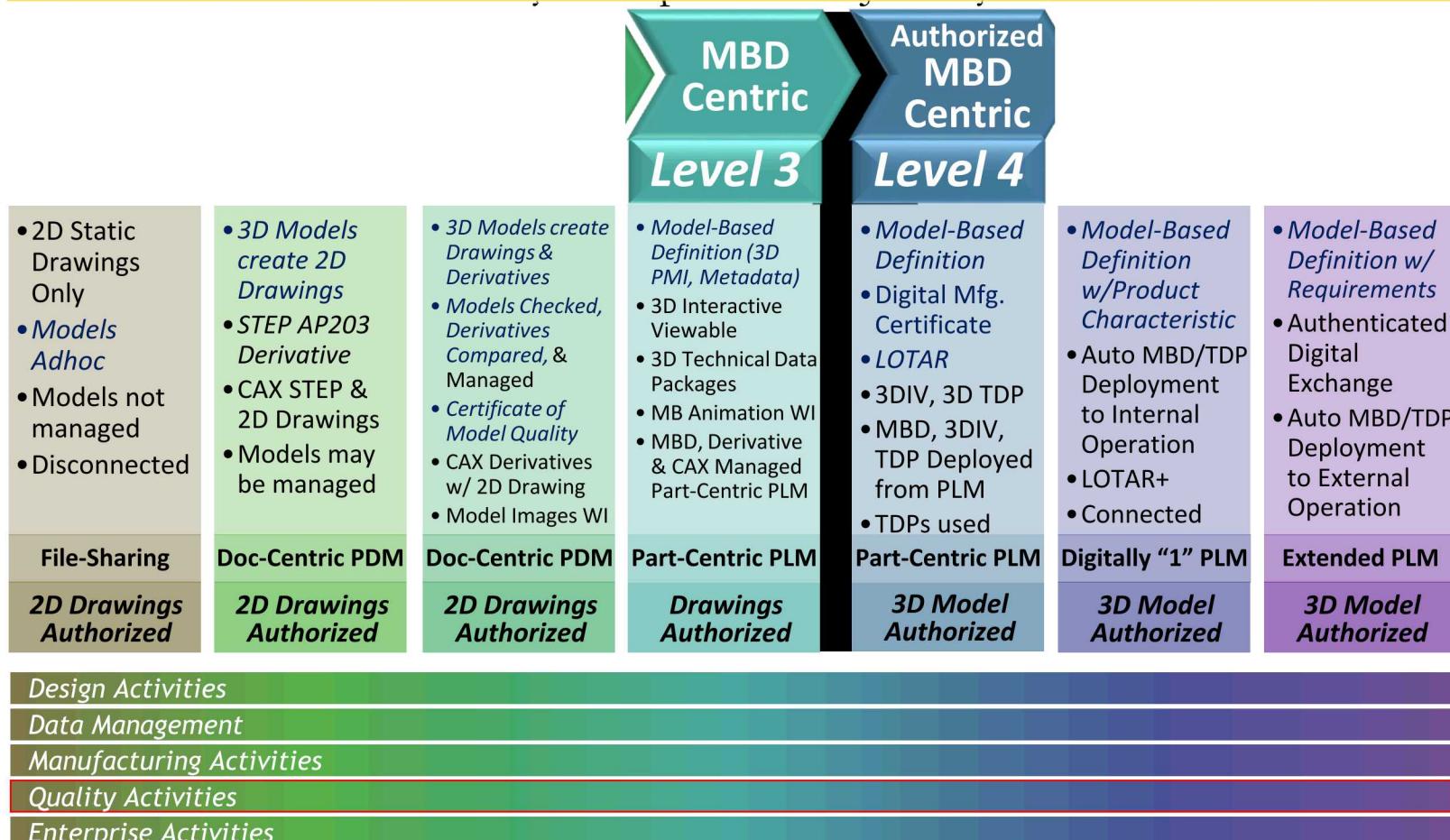
Trusted model that can be reused  
to support collaboration and  
virtual/physical product  
development activities.

A single source of the truth eliminating waste

# MBE Maturity Index\*



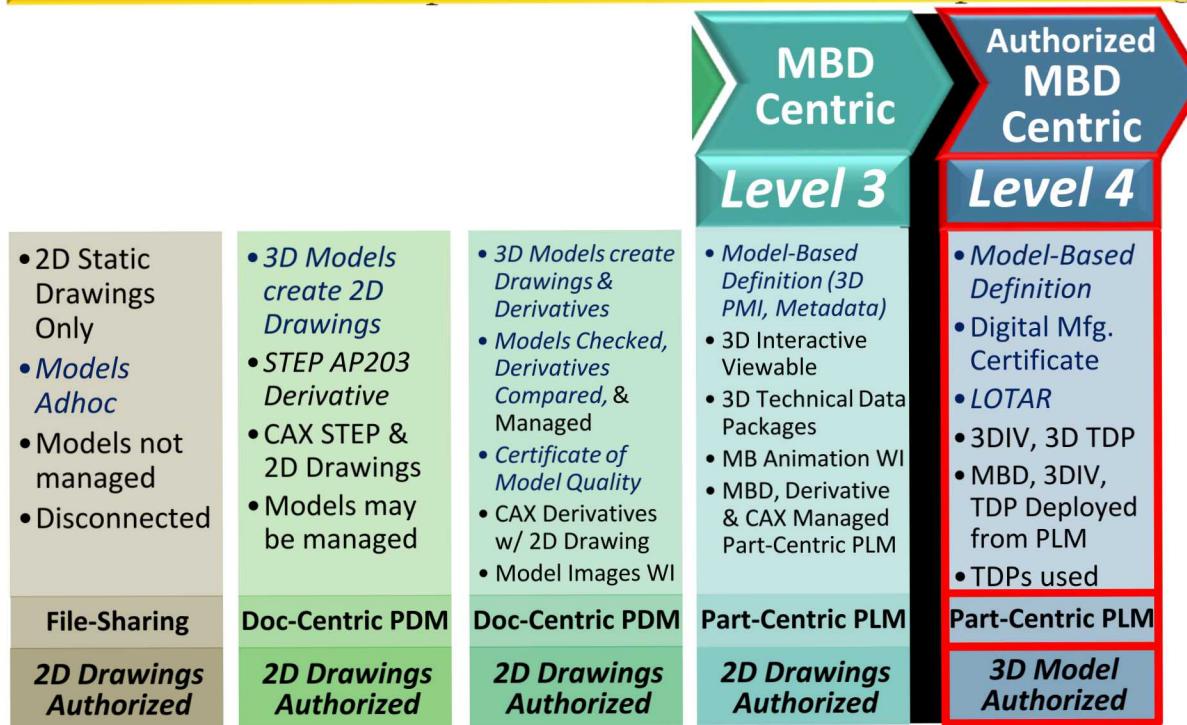
## Model-Based Enterprise Maturity Index



# Future Situation at NSE?



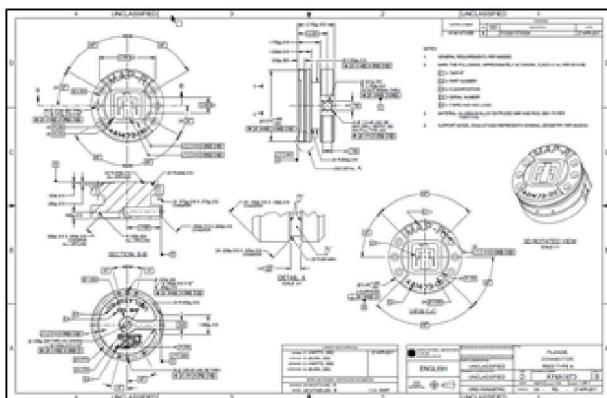
## Model-Based Enterprise Maturity Index



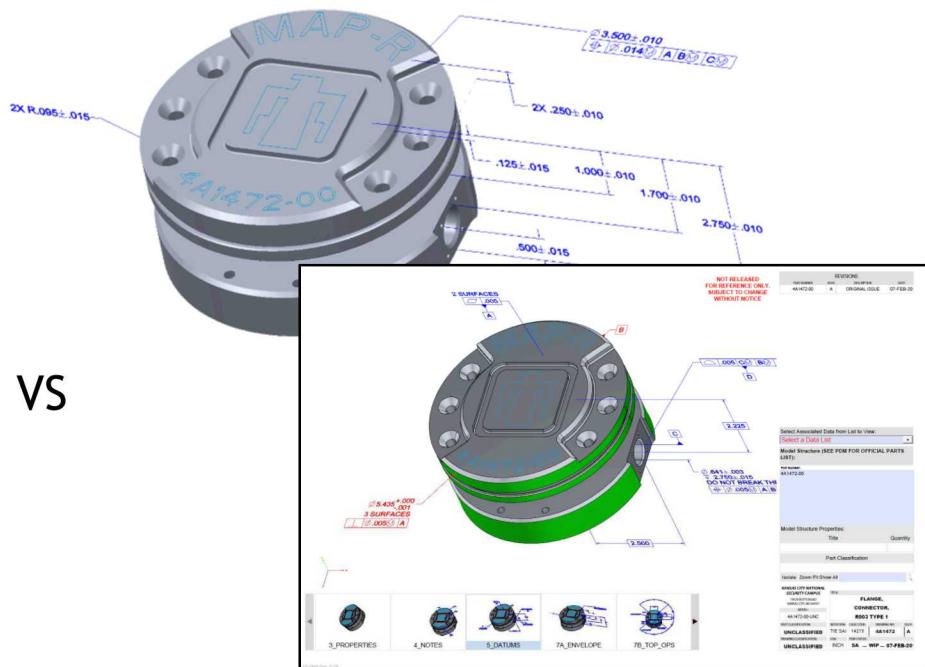
# MBE Collaboration Project

## 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

Thomas Hedberg, Jr.<sup>1</sup>  
National Institute of Standards and Technology,  
Gaithersburg, MD 20899  
e-mail: tdh1@nist.gov

Joshua Lubell  
National Institute of Standards and Technology,  
Gaithersburg, MD 20899

Lyle Fischer  
Capvidia NA,  
New Ulm, MN 56073

Larry Maggiano  
Mitutoyo America Corp.,  
Aurora, IL 60502

Allison Barnard Feeney  
National Institute of Standards and Technology,  
Gaithersburg, MD 20899

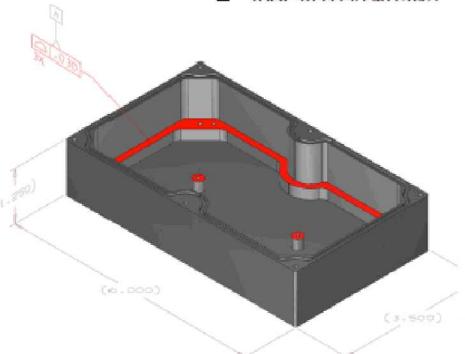


Fig. 3 Three-dimensional model of test case 1

## Testing the Digital Thread in Support of Model-Based Manufacturing and Inspection

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 that inspection defines this digital and analysis, collaborative and full-process traceability in a participants. This paper documents strategies for implementing MBD of data between various man results from a study of model provides evidence to support: DOI-10.1115/1.40326071

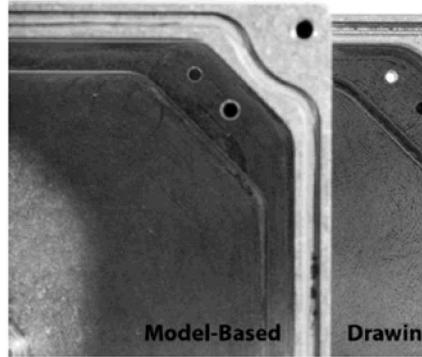
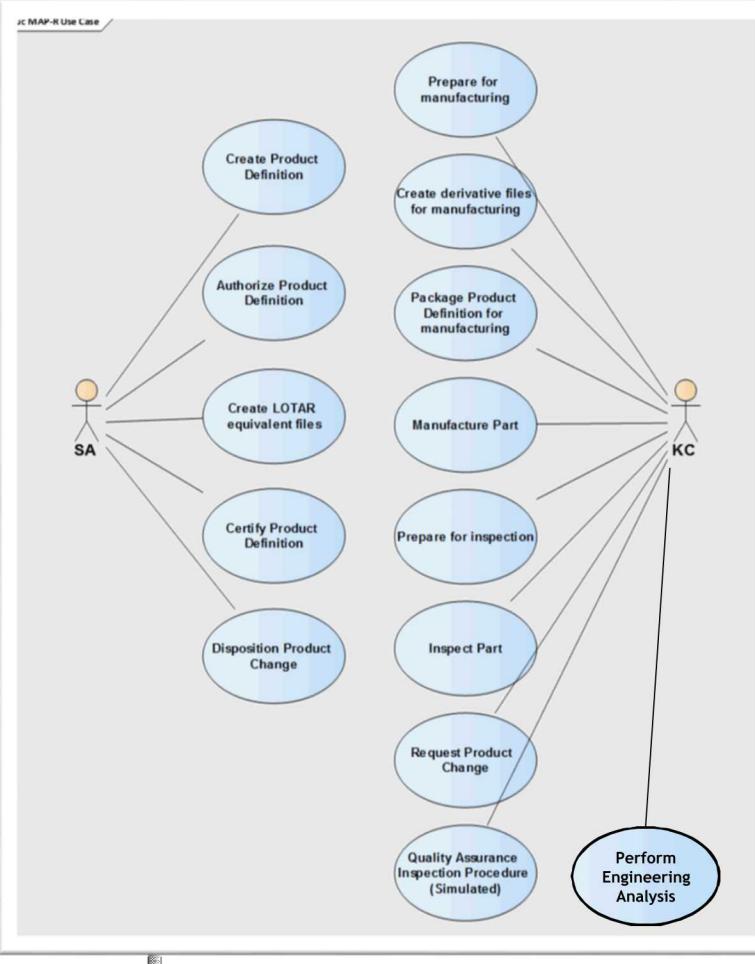


Fig. 7 Comparison of a delivered test case 1 part and addition of an unintended through-hole in the drawing



MAP-R builds upon the findings of NIST studies with NSE unique use cases

\* Permission Granted from NIST and all Authors

# MAP-R Deliverables



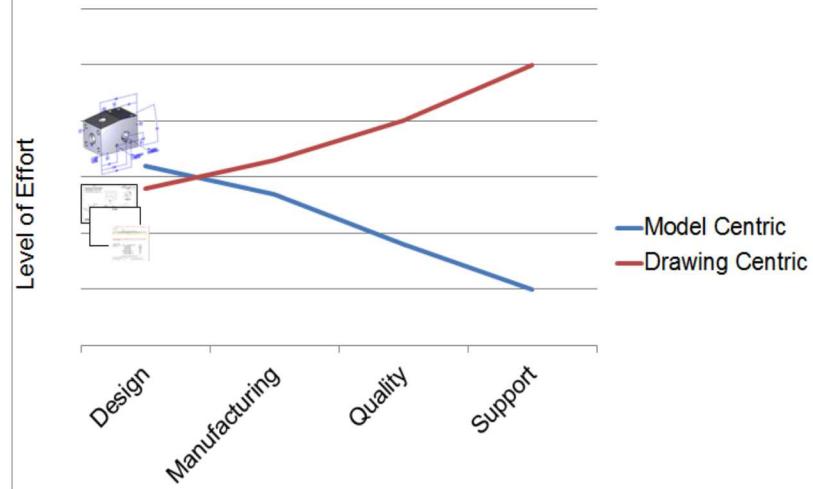
Validate the Model-Based Hypothesis and answer critical questions such as:

- 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)

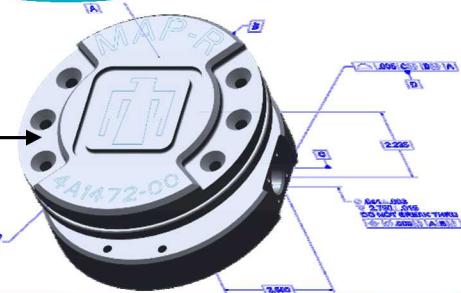
Capture best practices and create new process documents/modify existing documentation

## Model-Based Enterprise Hypothesis

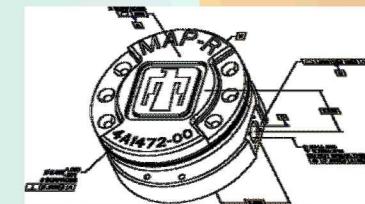


Understanding the value proposition for the Enterprise

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



# Certify Part Defining Model



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Page 1 of 1																																																																	
<p><b>NBC Release Date:</b> 04/01/2014</p> <p><b>Category:</b> Defense Release</p> <p><b>Authoritative Title:</b> Computer Engineering Release</p> <p><b>Document Number:</b> 00000000000000000000000000000000</p> <p><b>Revision:</b> 0</p> <p><b>Request Program:</b> None</p> <p><b>Affected Assemblies:</b> None</p> <p><b>Additional Information:</b> None</p> <p><b>Code (CER):</b> Code (CER)</p> <p><b>ICD:</b> None</p>																																																																	
<p><b>APPROVAL:</b></p> <table border="0"> <tr> <td><b>SPIN:</b></td> <td><b>Name:</b></td> <td><b>Organization:</b></td> <td><b>Date Approved:</b></td> </tr> <tr> <td>SPIN 00000000000000000000000000000000</td> <td>SA - Charles A. Allen, S.</td> <td>SPIN 00000000000000000000000000000000</td> <td>2008-04-01</td> </tr> <tr> <td>SA - Charles T. J.</td> <td></td> <td>SPIN 00000000000000000000000000000000</td> <td>TBC</td> </tr> </table>						<b>SPIN:</b>	<b>Name:</b>	<b>Organization:</b>	<b>Date Approved:</b>	SPIN 00000000000000000000000000000000	SA - Charles A. Allen, S.	SPIN 00000000000000000000000000000000	2008-04-01	SA - Charles T. J.		SPIN 00000000000000000000000000000000	TBC																																																
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<p><b>REASON FOR RELEASE:</b></p> <p>(Rev 04/06)</p> <p>1.0</p> <p>The following use of listed product definition to build product using a part defining modes per (DRAFT) 99012013. This product will be used as a component in a system. The system will be used in a space environment (Earth, Moon, and Mars) and will be used in a harsh environment (vacuum, high heat, and impact resistance capabilities).</p>																																																																	
<p><b>REFERENCE AND REMARKS:</b></p> <p>1.0</p> <p>The drawing section of this NBC specifies the part defining (STD 100-00000000000000000000000000000000) and the location of the hardware file from which it was created.</p>																																																																	
<p>This document has been determined to be UNCLASSIFIED. Reviewed by: <b>Lloyd, Charles H.</b></p> <table border="0"> <tr> <td><b>Initials:</b></td> <td><b>Date:</b></td> </tr> <tr> <td>LCH</td> <td>04/01/2014</td> </tr> <tr> <td><b>Derived From:</b></td> <td><b>Source Data:</b></td> </tr> <tr> <td>N/A</td> <td>N/A</td> </tr> </table>						<b>Initials:</b>	<b>Date:</b>	LCH	04/01/2014	<b>Derived From:</b>	<b>Source Data:</b>	N/A	N/A																																																				
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PA is *authorized* to use the *certified* part defining model and associated baseline for *all* production activities

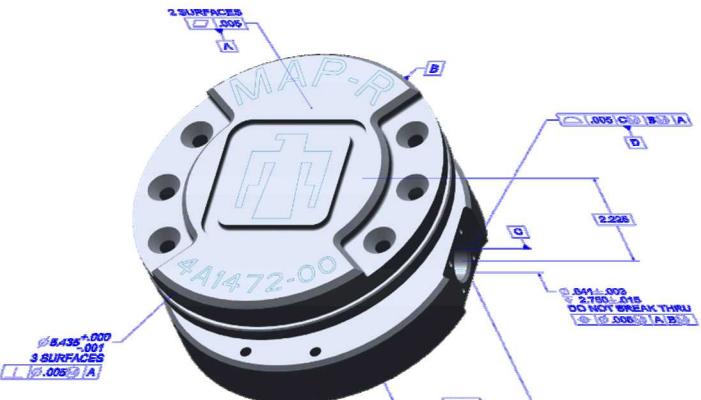


Authorized to use the Certified Part Defining Model for ALL Production Activities

# 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



9925020  
PAGE 1 OF 11

Page 2 of 2

CAGE CODE 14213

UNCLASSIFIED

20163030SA

**DRAWING LIST**

Dwg Dwg Dwg  
Drawing Number  
Drawing Title  
Suf Iss Loc  
4A1472 00 A SA FLANGE, CONNECTOR, R003 TYPE 1

DETAILS

KC is authorized to use the part defining model and its associated baseline referenced in the header to create files needed for production and acceptance of 4A1472-00.

CHANGE HIS

CONTROL NUM 9925020-00

DISTRIBUTION

Callout: PART DEFINITION

(1) Insert "NOM" in the drawing list

**REASON FOR RELEASE**  
/Rev 0/ (2017-02-27)

1.0 Authorize use of listed product definition to build product using a part defining model per DRAFT 9925020.

**SPEC IS AUTHORIZED**

**REFER TO AER FOR**

**REFERENCE AND REMARKS**

1.0 The drawing list section of this EA specifies the part defining STEP file. The STEP (AP242) file is equivalent to the native CREO file containing product manufacturing information. Listed in header of the STEP file is the url to the location of the native/source file from which it was created.

This document has been determined to be UNCLASSIFIED. Reviewed by: [Signature]  
Title: [Signature]  
Date: [Signature]  
Derived From: N/A  
Source Date: N/A

UNCLASSIFIED

# Authorization to Baseline

Sandia PLM asmiura

Submit a Service Request CAD Document Search ... Quick Links

Products > 4A1472 FLANGE-CONNECTOR-R003 TYPE 1 > PDMLink Business Objects Recently Accessed

Actions > Folder - Baselines (/Default)

**Folders** ( 14 objects )

Search in selected folder

Name

- 4A1472 FLANGE-CONNECTOR-...
  - Documents
  - Material Lists
  - Models and Drawings
- Sandia PLM asmiura

**Folder Contents** ( 3 objects )

New Document New Part New Change Request New Folder Copy Add to Workspace

	Number	Name
	0000003810	4A1472-00 ISSUE A

Submit a Service Request CAD Document Search ... Quick Links

Products > 4A1472 FLANGE-CONNECTOR-R003 TYPE 1 > PDMLink Business Objects > Baselines Recently Accessed

Actions > **Managed Baseline - 0000003870 (4A1472-00 ISSUE C)** Released

**Details** **Related Objects** **History**

**Baseline Objects | Contexts**

**Baseline Objects** ( 7 objects )

Add Objects Collect Objects Remove Copy Paste Actions

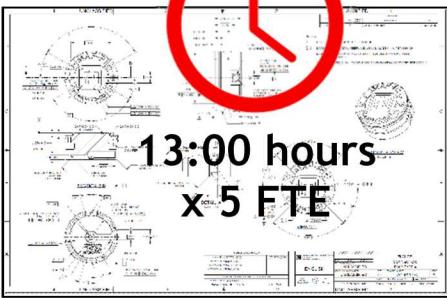
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	FLANGE, CONNECTOR, R003 TYPE 1	4A1472-00-UNC	B.1	REL	2017-04-25 07:40 M
	FLANGE, CONNECTOR, R003 TYPE 1	4A1472-00-UNC.ASM	C.2	REL	2017-04-28 10:39 M
	ALUMINUM ALLOY, 6061-T6 EXTRUDED BAR AN...	7420373-02	A.3 (As-Designed)	REL	2017-02-24 09:23 M
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	FLANGE, CONNECTOR, R003 TYPE 1	4A1472-00	C.1 (As-Designed)	REL	2017-05-01 14:45 M

( 0 objects selected )

**Contexts** ( 0 objects )

Navigator

# Easy and Early detection of defects



13:00 hours  
x 5 FTE

DRAFT - For Demonstrations

DOE's National Security Campus

MODEL QUALITY	
Model ID:	Product Name:
AA1472-00	PLANGE_CONN
Model File Name:	Model Type:
AA1472-00-UNC Rev. A-20-WIP	Creo
Model Design/	
Check Software:	Checked By:
ModelNC	Kevin Knotts
Result:	Comments and
<input checked="" type="checkbox"/> Passed	
<input type="checkbox"/> Issues	
<input type="checkbox"/> Fail	
<input type="checkbox"/> N/A	
Model Product & Manufacturing Information (PMI) Check	
Model:	<input checked="" type="checkbox"/> 3D View <input type="checkbox"/> 2D Static Drawing
Product Name:	AA1472-ModelBased-DRAFT.043
PMI:	Checked By:
Score:	Checked Date:
4.0/5.0	Carlton Brown & Derek Ramsey
PMI Score:	09/09/2017
PMI Count:	11
Result:	Comments and/or Issues:
<input checked="" type="checkbox"/> Passed	See attached PMI Report
<input type="checkbox"/> Issues	
<input type="checkbox"/> Fail	
<input type="checkbox"/> N/A	
Model conforms to NSC's model quality checks.	
<input type="checkbox"/> Disapprove (Explain)	
DERRICK RAMSEY <input checked="" type="checkbox"/> (Affiliate)	
Model Geometry and PMI Issues	

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

Properties:

Item Name - 1 : 0.0108021

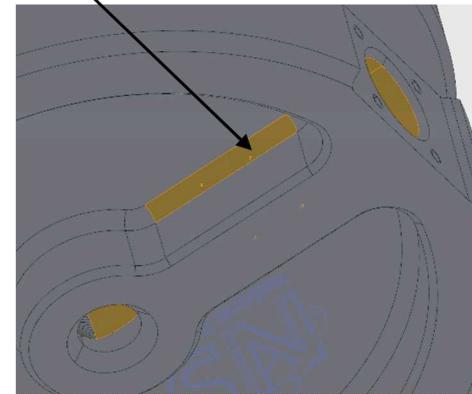
Hot/Warm/Error/Total Thicknesses : 2/0/0/5

Surface Type

Target Faces

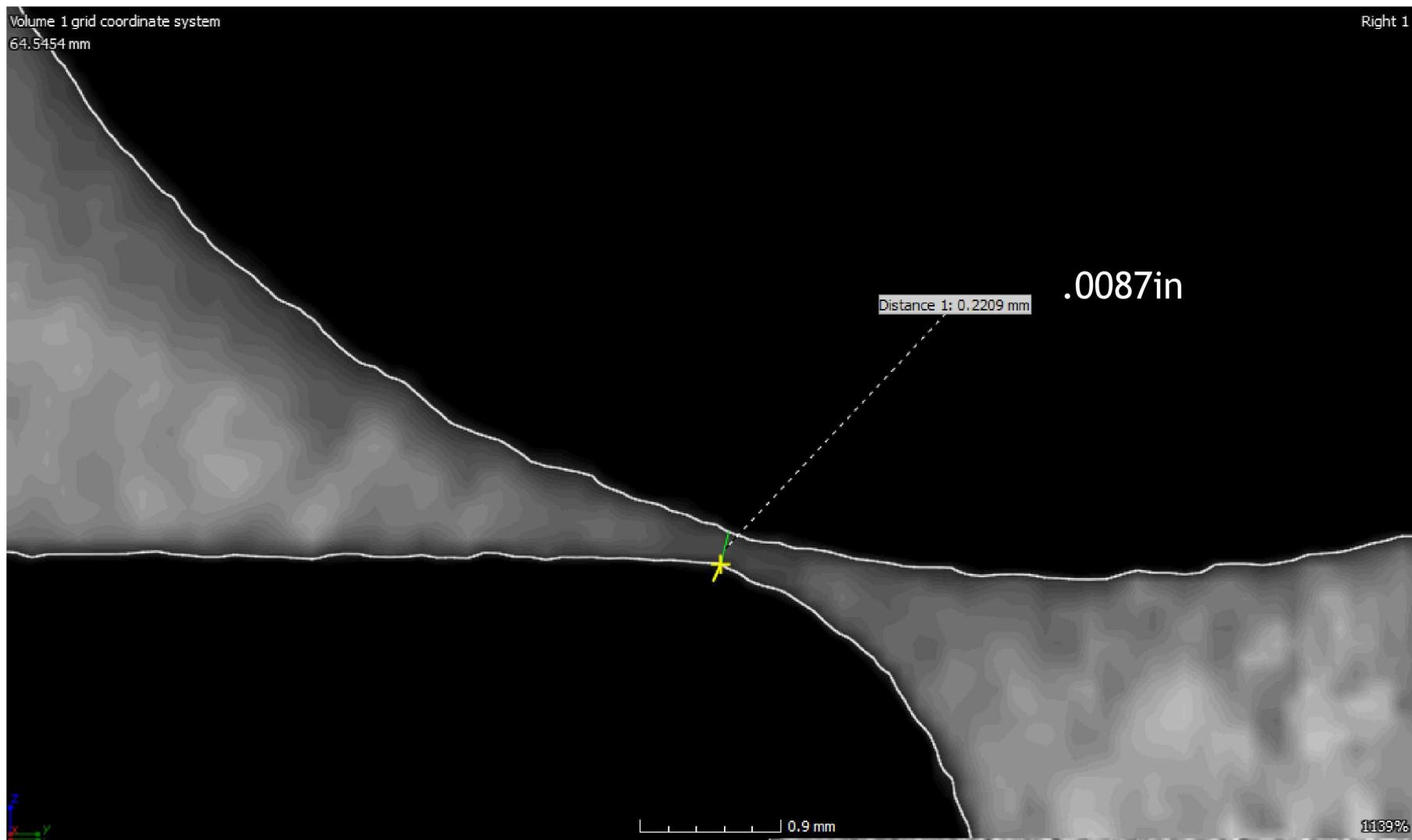
: Cylinder

: 4084-1



Model certification identifies defects  
not identified in drawing reviews

# CT Scan of Interest Area

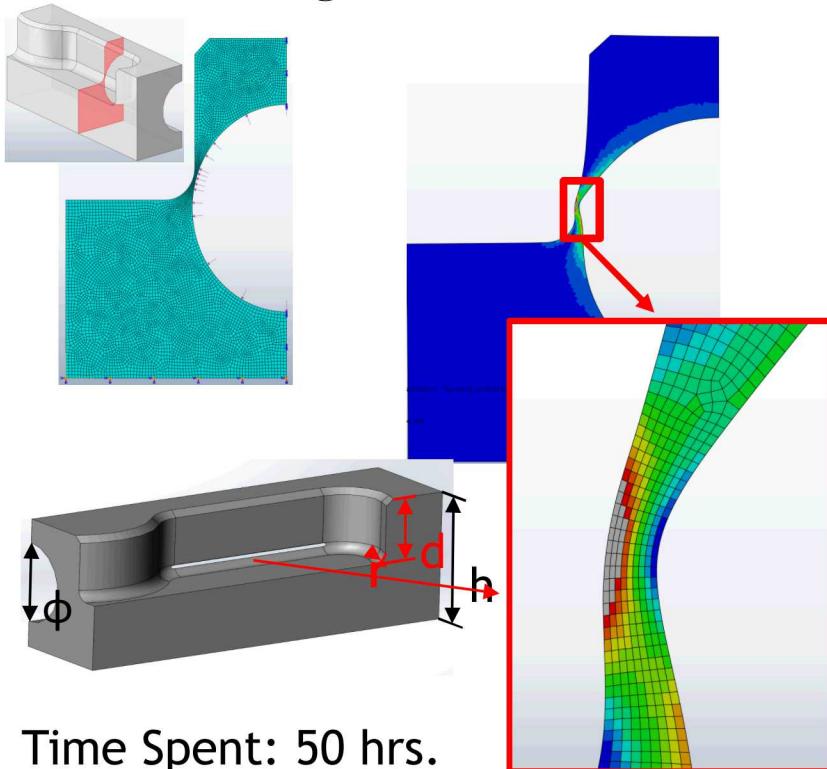


# Perform Engineering Analysis

Drawing-Based MAPR

Analyze thin wall issue

2D Drawing and STEP AP203

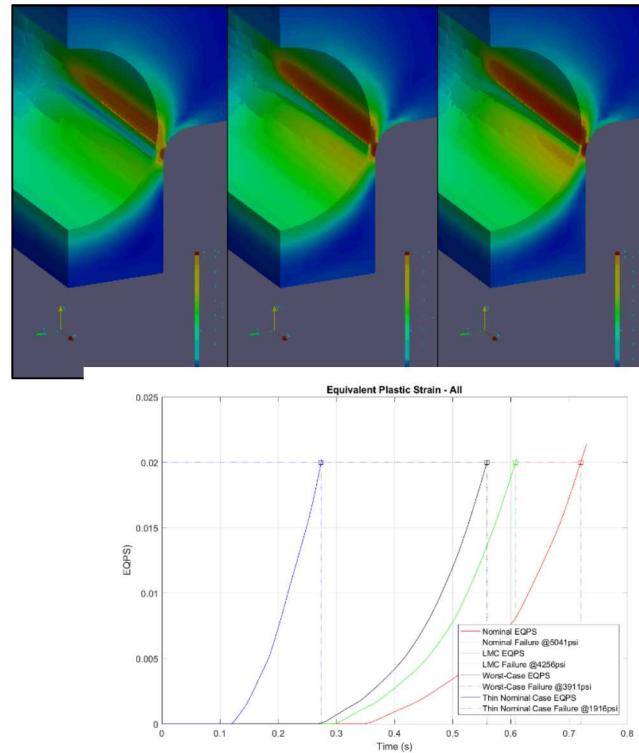


Time Spent: 50 hrs.

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

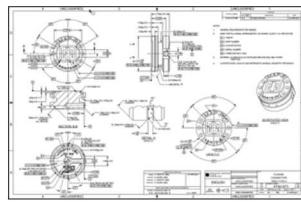


Used ACIS Model from 3DTDP  
Time Spent: 12.2 hrs.

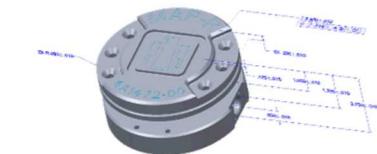
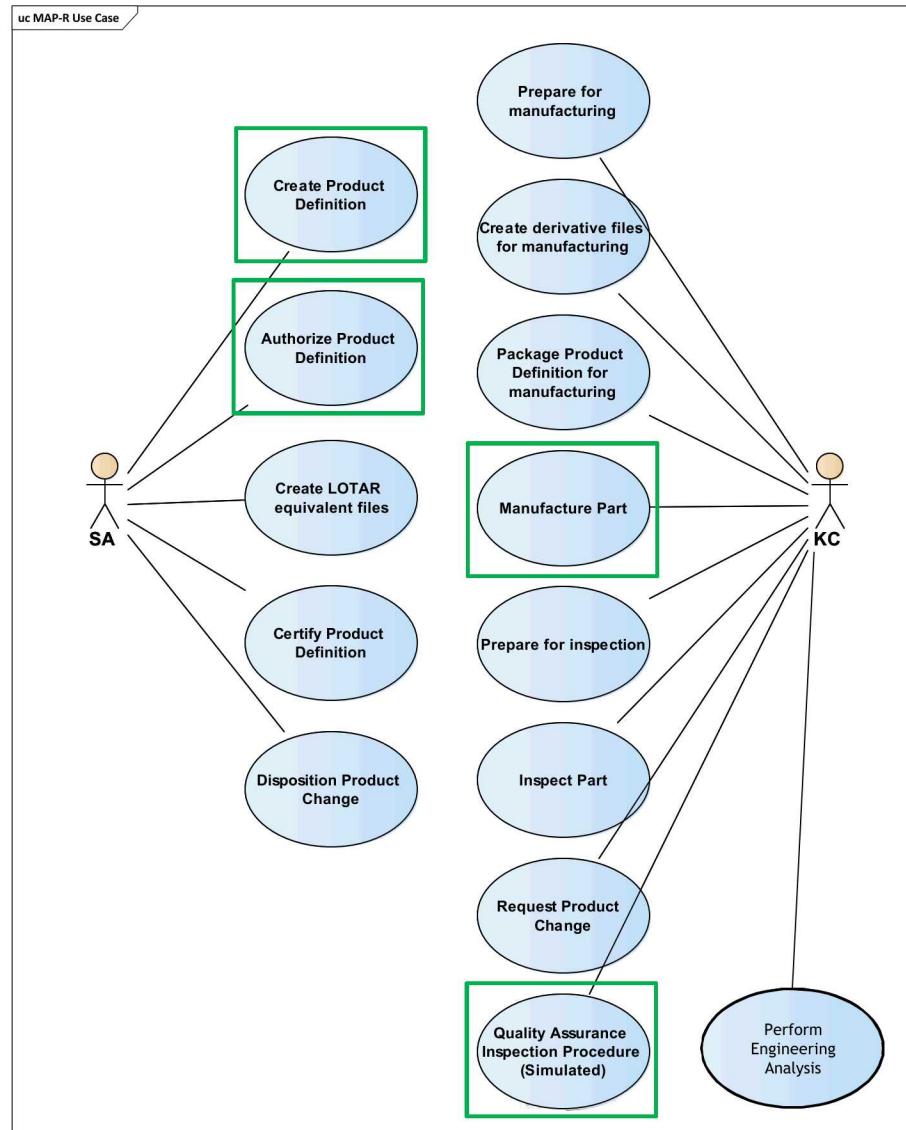
# Drawing Based - NC Programming



# 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:

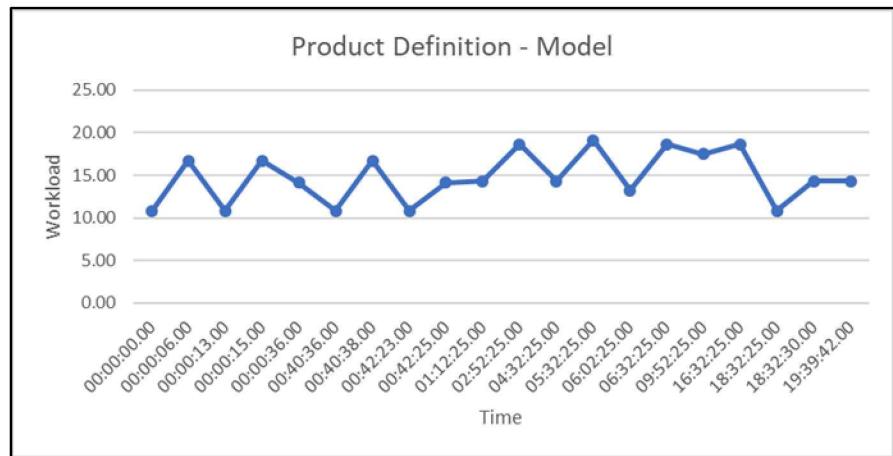
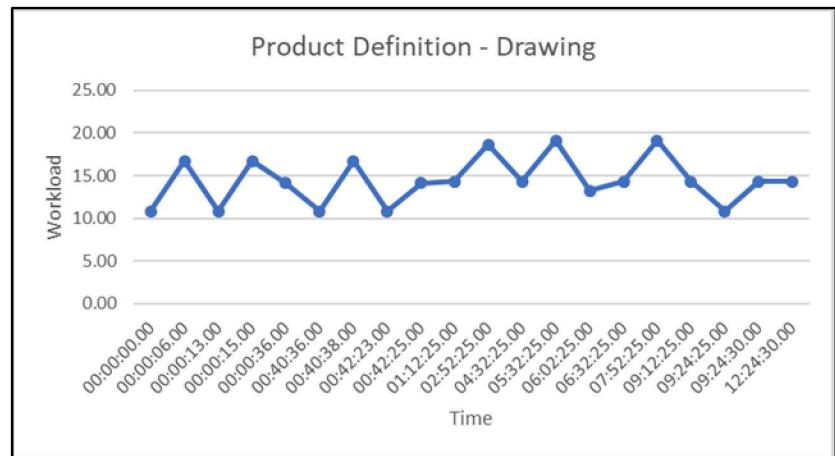
The **low, medium and high** workload levels were assigned based on the aggregate workload score for each task for both processes. Low = 0-14.9, medium 15 to 18.9, high 19-21. These determinations were based on Multiple Resource Theory scores for task types, where 21 is the maximum of possible workload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



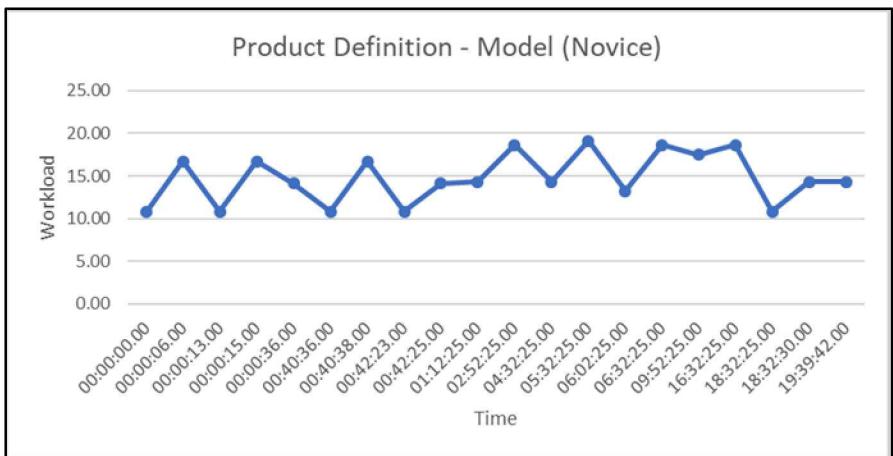
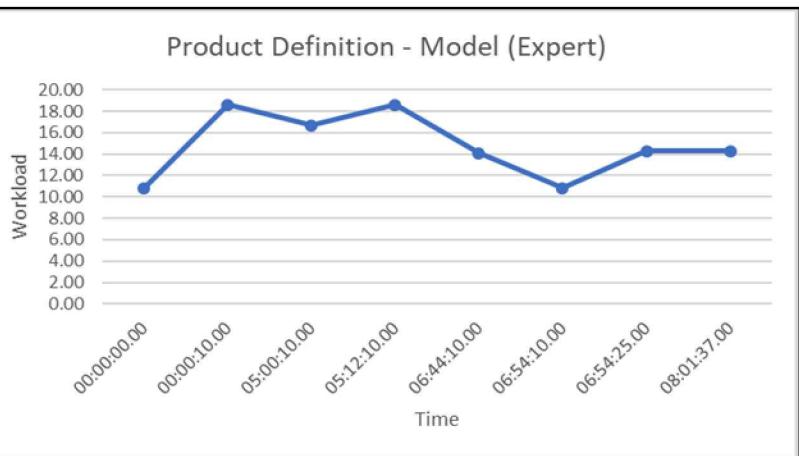
Time at Load		
Low 0-14	Med 15-18	High 19-21
8:52:17	0:02:13	3:30:00

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)



Time at Load

Low 0-14	Med 15-18	High 19-21
1:17:37	0:12:00	6:32:00

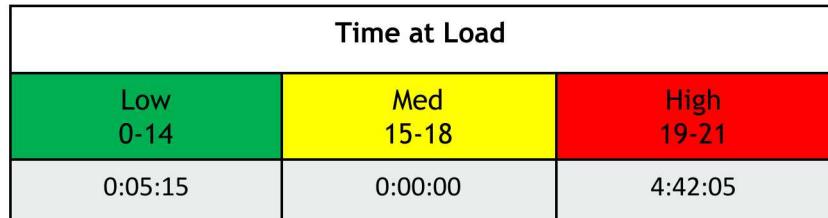
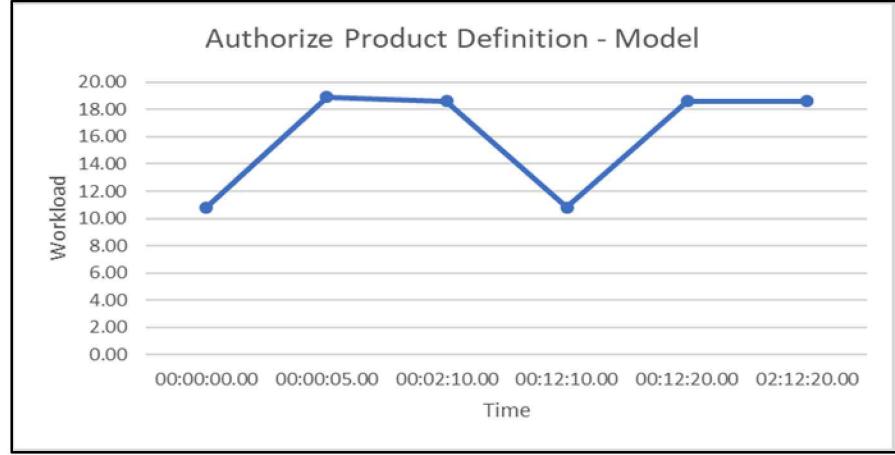
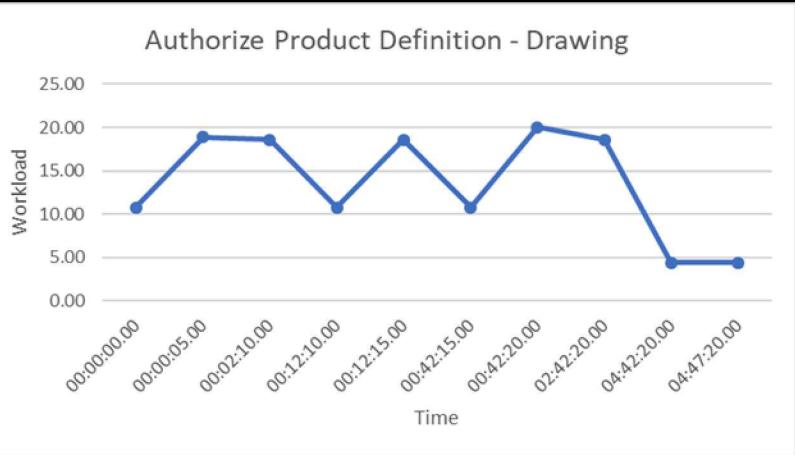
**Total Time 8:01:37**

Time at Load

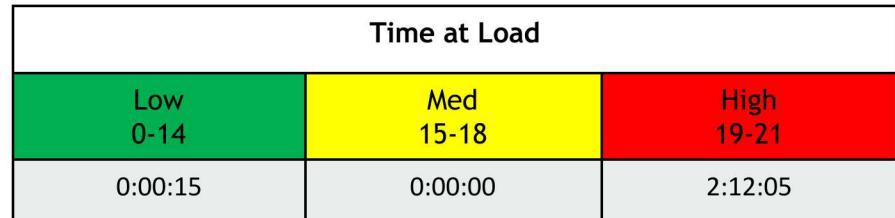
Low 0-14	Med 15-18	High 19-21
5:27:29	6:42:13	7:30:00

**Total Time 19:39:42**

# Authorize Product Definition

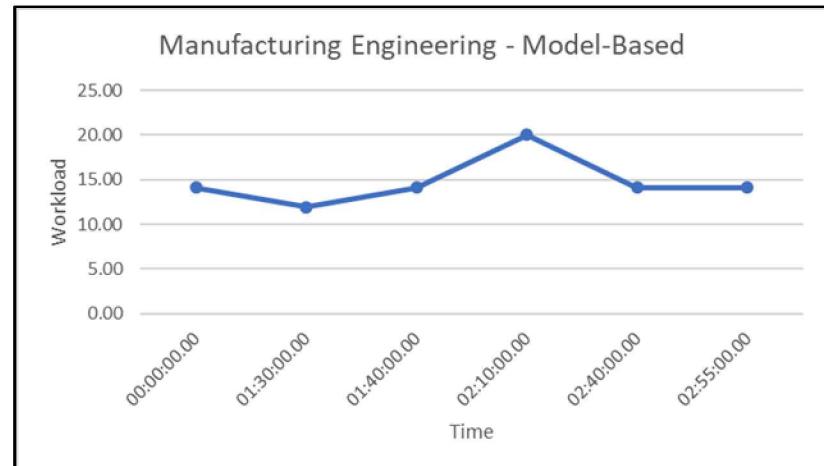
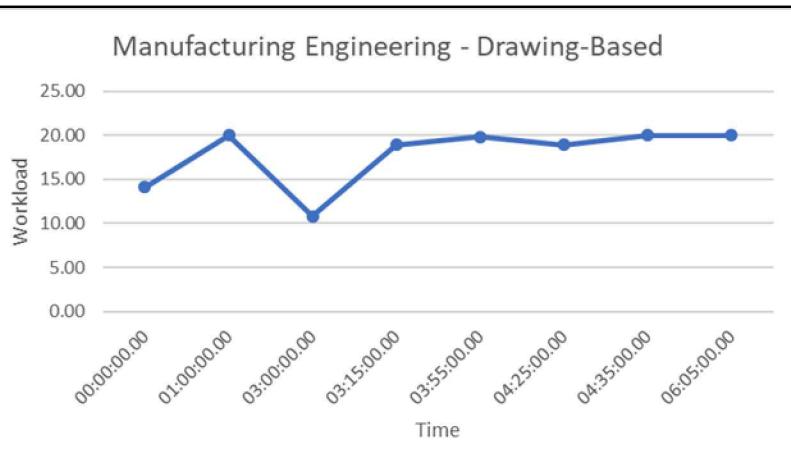


**Total Time 4:47:20**



**Total Time 2:12:20**

# Manufacture Part (Engineering)



Time at Load

Low 0-14	Med 15-18	High 19-21
1:15:00	0:00:00	4:50:00

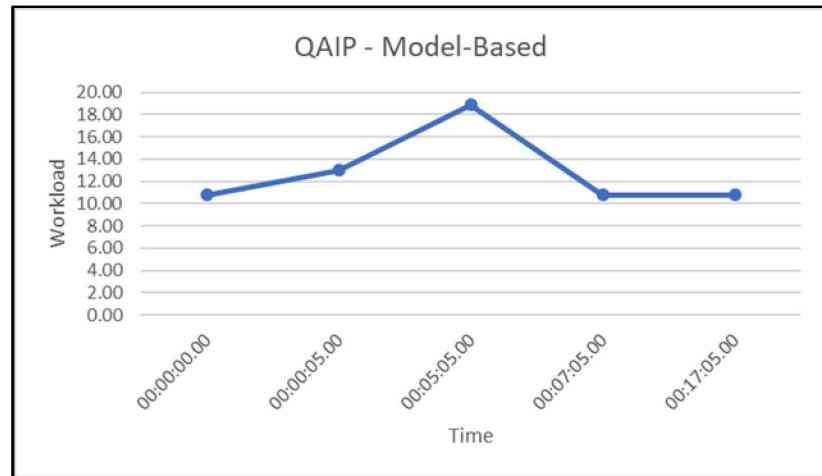
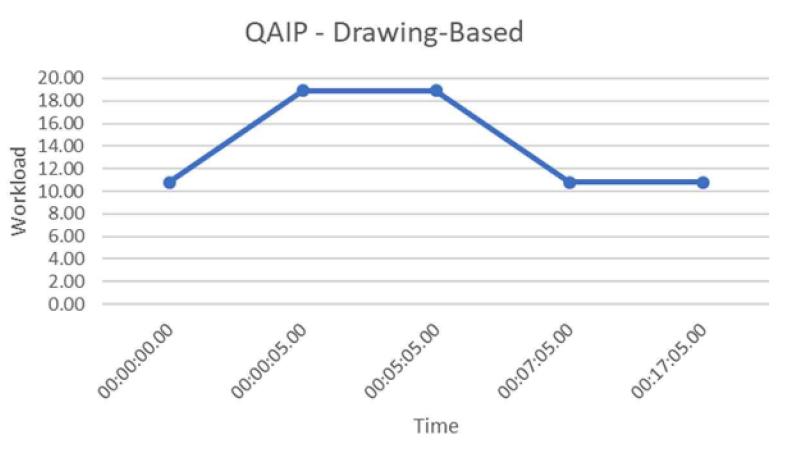
**Total Time 6:05:00**

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

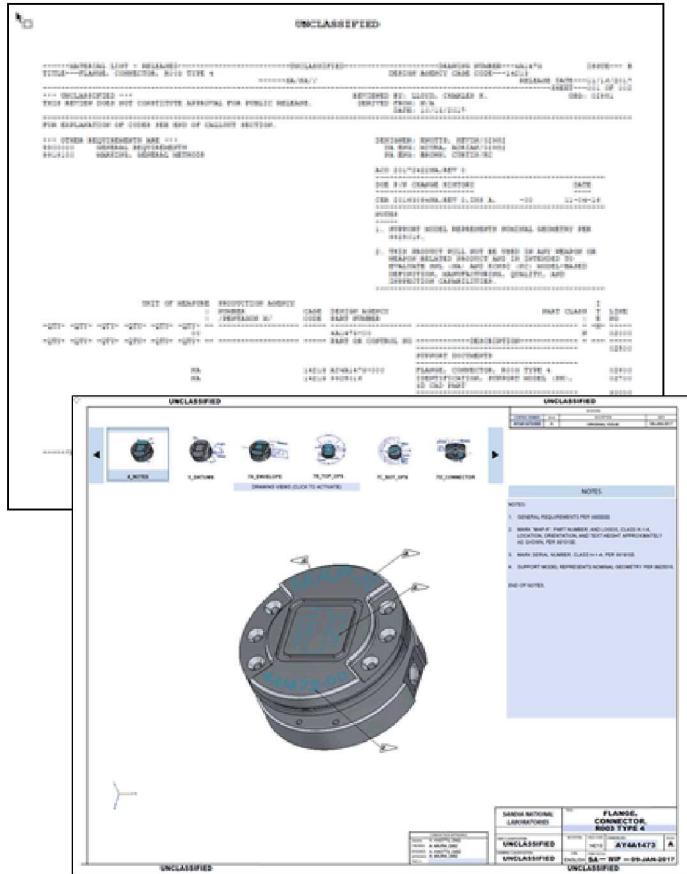


# W80-4 Life Extension Program (LEP)



# 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

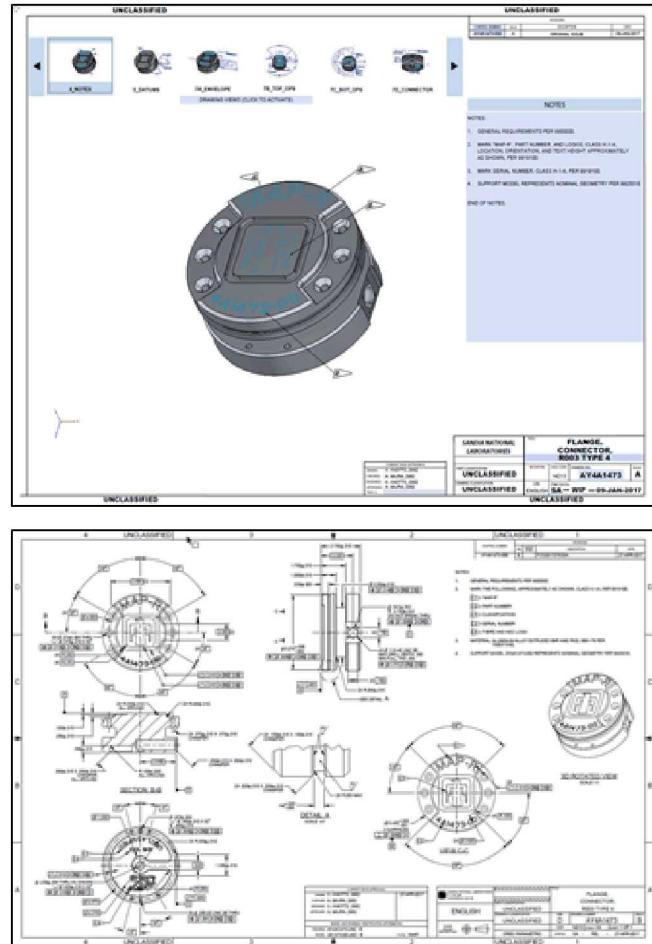


All the benefits of Model-Based Definition without changing KC's IT Systems or NSE Processes

## 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