



# Integrating MBSE and MCAD Models in Virtual Reality

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Sandia National Laboratories





# Outline

- Overview (Casey Noll)
  - Sandia National Laboratories
  - Digital Engineering and MBSE at Sandia
- Problem Introduction (Casey Noll)
  - Current Limitations of Visualization
  - RASR MEP
- Integration in VR (Kelsey Wilson)
  - Model Interoperability
  - CAD + MBSE -> Unity
- Conclusions (Kelsey Wilson)

# Overview





# Sandia National Laboratories Overview

**Sandia is a Federally Funded Research and Development Center (FFRDC)  
Managed and Operated by:**

- National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, INC. (NTESS)
- Government owned, contractor operated
- FFRDCs are long-term strategic partners to the federal government, operating in the public interest with objectivity and independence and maintaining core competencies in missions of national significance



**Sandia  
National  
Laboratories**





# Nuclear Deterrence Overview



## NUCLEAR DETERRENCE

Responsibilities form a critical mandate

**Warhead systems  
engineering &  
integration**

**Design agency  
for nonnuclear  
components**

- Gas transfer systems
- Radar
- Safety systems
- Arming, fuzing & firing systems
- Neutron generators

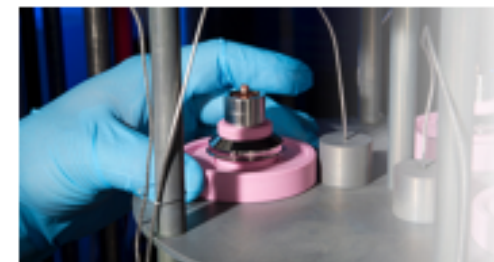
Sandia's Mission Assurance organization proactively prevents defects and ensures mission success.



**Multidisciplinary  
capabilities**

Required for design, qualification, production, surveillance, computation/experimentation

- Major environmental test facilities & diagnostics
- Materials sciences
- Light-initiated high explosives
- Computational analytics

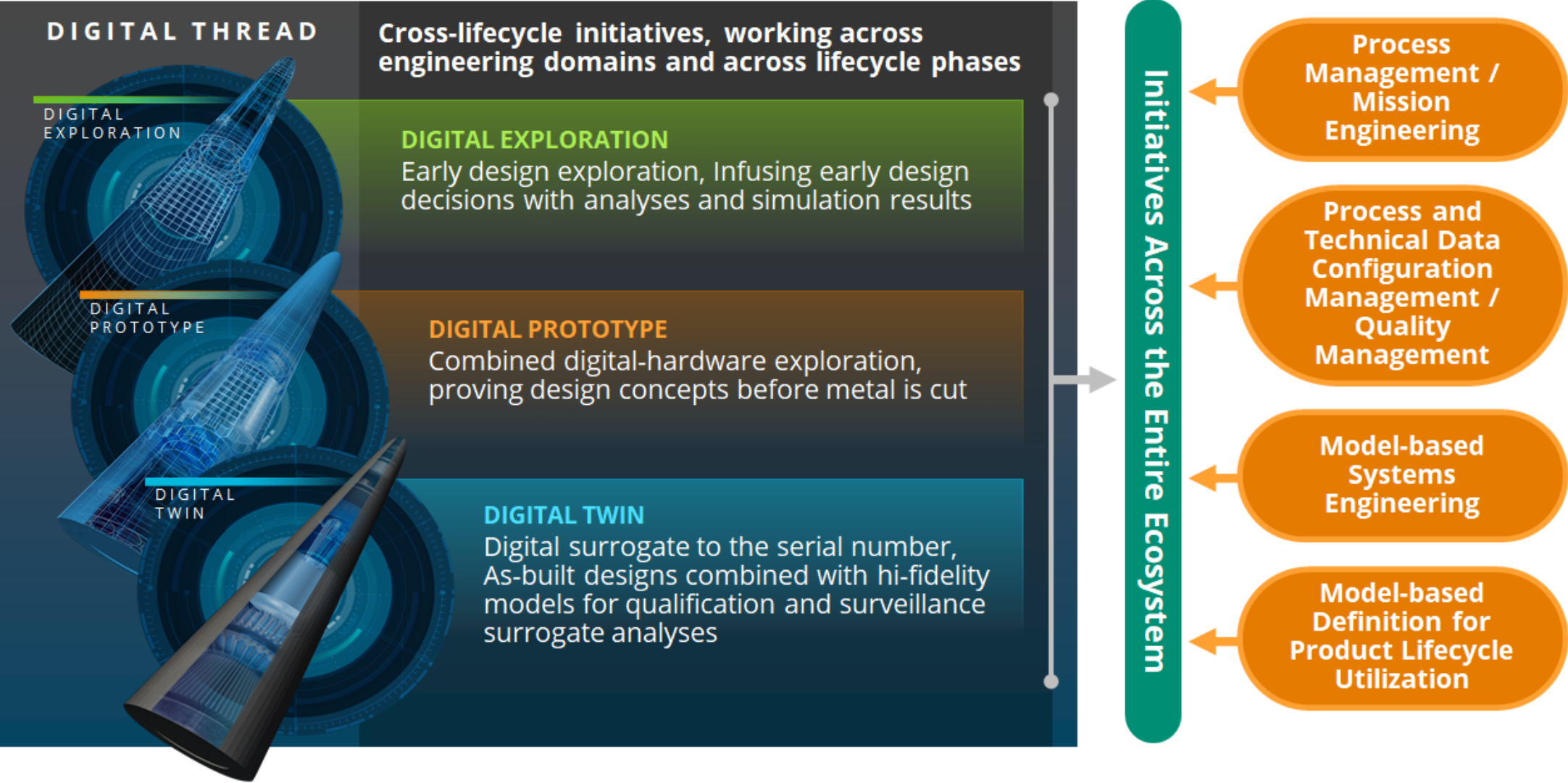


**Production agency**

- Neutron generators
- Sandia external production
- Microelectronics
- Thermal battery backup



# Digital Engineering Transformation at SNL



Sandia National Laboratories is pursuing a digital engineering transformation initiative in support of the strategic vision to enable a resilient and responsive nuclear stockpile





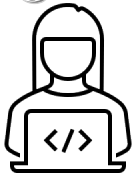


# Problem Introduction

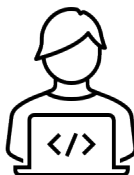
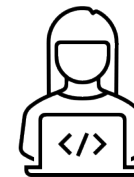


# MBSE + MCAD → VR Overview

Systems Engineer



unity



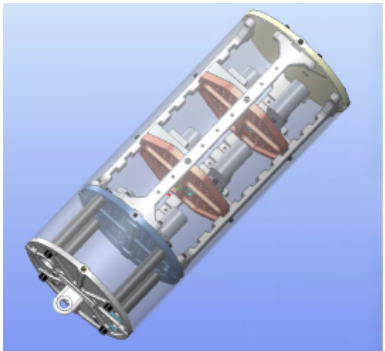
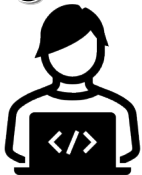
Virtual Reality

Digital Thread

MBSE

MCAD

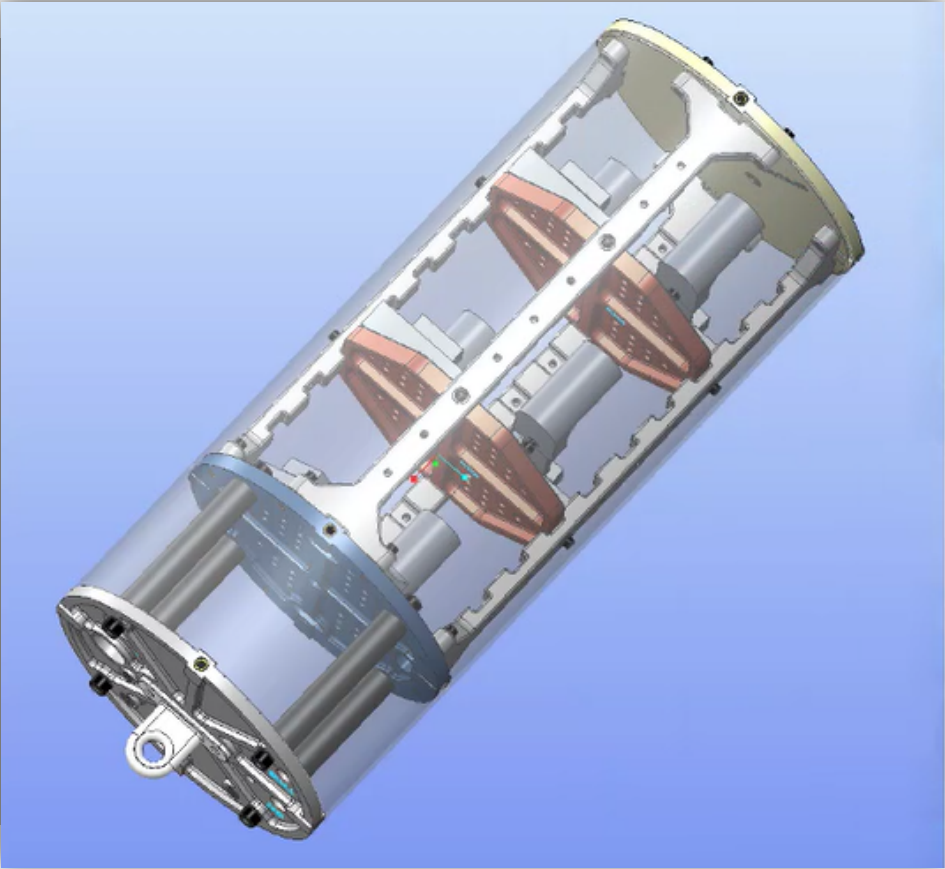
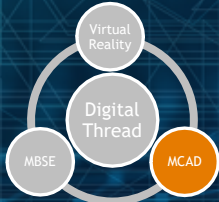
Mechanical Engineer







# System Overview of the RASR MEP - MCAD



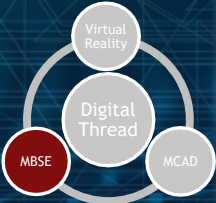
The Paradox: “We need Revolutionary Change in an Evolutionary Environment”

- Don Cook, Former Deputy Administrator for NNSA’s Office of Defense Programs

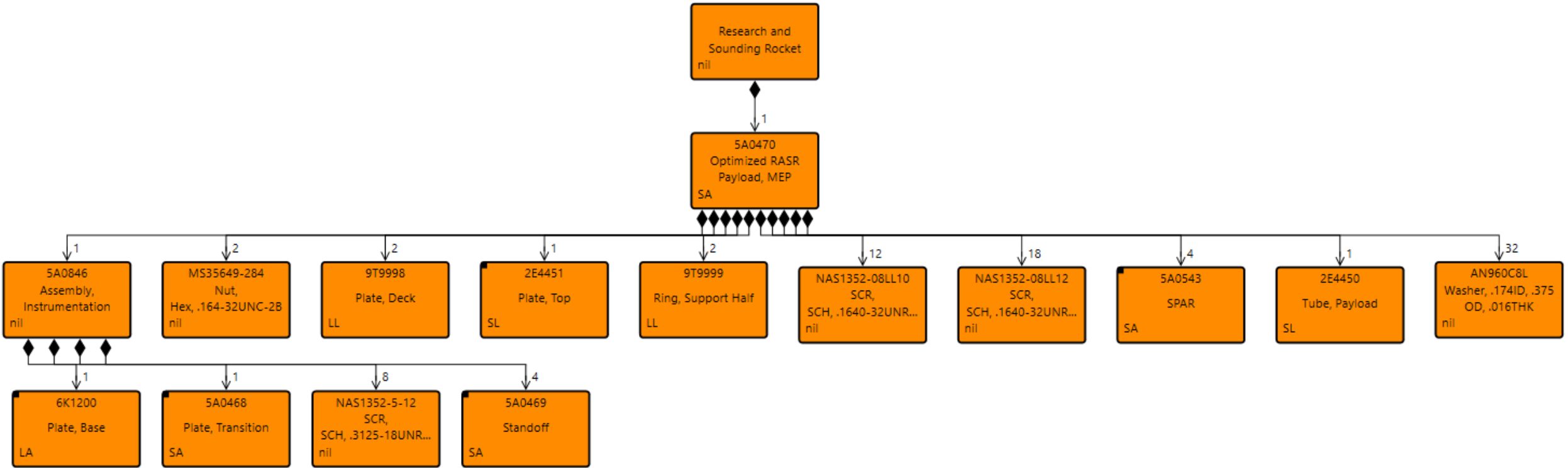




# System Overview of the RASR MEP - MBSE



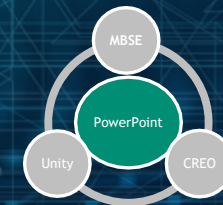
bdd Research and Sounding Rocket [(formatted)]



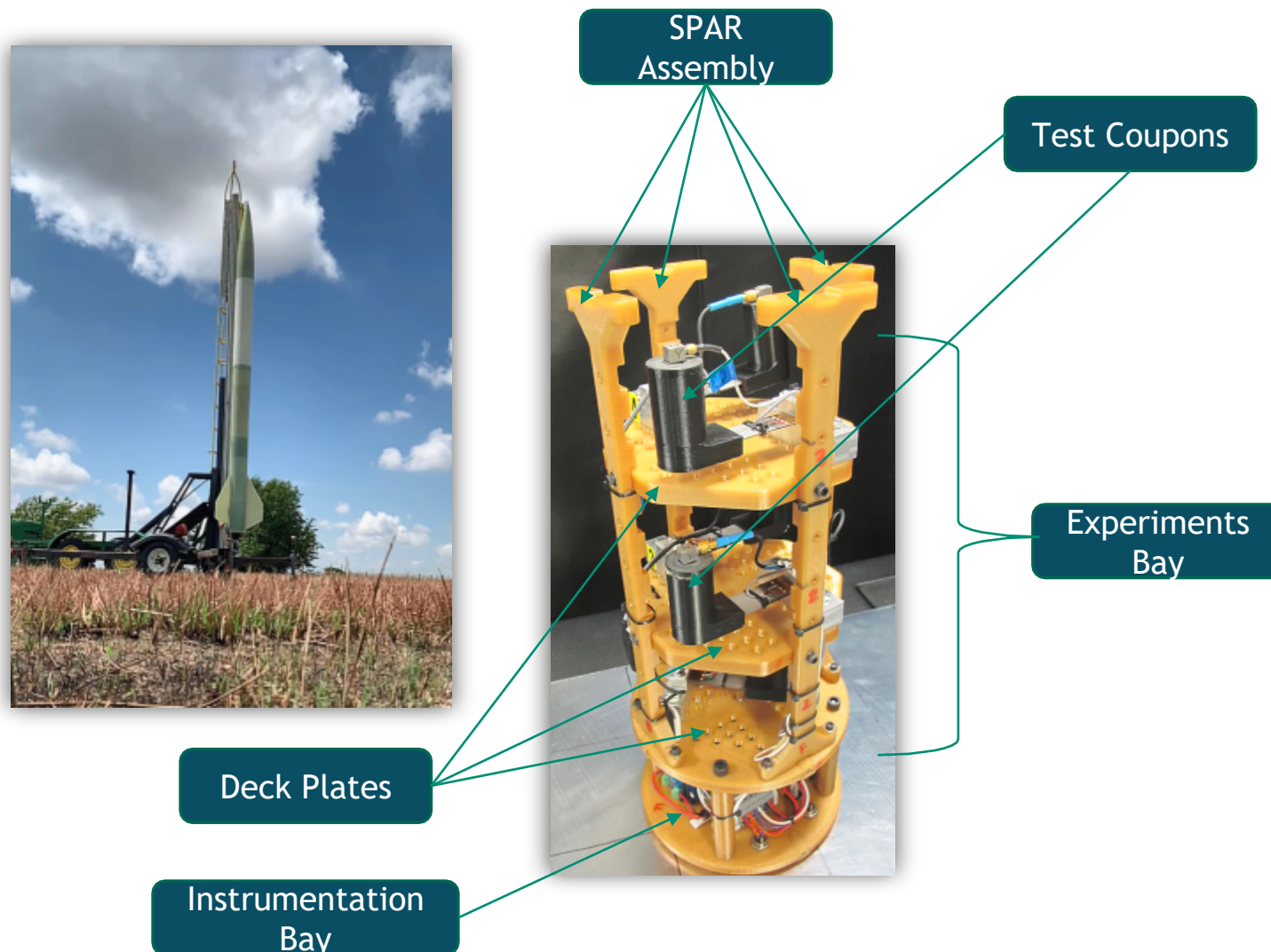
Project:	SE2MCAD	Organization:	Sandia National Laboratories	Date:	5/9/2022
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# System Overview of the RASR MEP - PowerPoint



- **RASR** - Research and Sounding Rocket: an instrument-carrying rocket designed to take measurements and perform scientific experiments during its sub-orbital flight.
  - Experimental flight tests are expensive. Efforts such as RASR enable rapid component design and system integration.
  - Initiative that provides a service to launch experiments on low-cost, low-altitude, high-power research rockets.
- **The payloads for these research rockets are provided by HONEYWELL FM&T**
  - Enables avenue for connectivity between Design and Production
- **MEP** - Modular Experiments Platform: a subsystem of Payload Assembly designed to be modular and provide the structure to mount experiments in the experiments bay.





# Integration in VR





req SPAR: Length

Requirement  
SPAR: Length

The SPAR shall have a maximum length of 13.63 in and a minimum length of 13.62 in.

Component  
SPAR

Note: DTER from SA to KC

VerificationRequirement  
Part Inspection

Verifies the associated component meets all released product definition requirements.

<<specified by>>

<<verify>>

Project: SE2MCAD

Organization: Sandia Nation...

Date: 5/9/2022

SA0543D01-M00-UNC\_MPBCS\_PRA (Active) - Creo Parametric

FileModelAnalysisLive SimulationAnnotateToolsViewFlexible ModelingApplicationsMBPC ToolsDFMPro

PC ID PCs SinglyID View PCsAuto ID PCsCreate PCsPC OptionsDelete PCsHide/Show PCs

Delete Single PCDelete All PCSHide/Show PCs in ViewHide/Show PCs in Model

Reposition Single PCReposition View PCsSearch for PC

Highlight PC AssociationReAssociate Symbol

Export to XLSXExport PC Info

Import DataToggle ColorsShow Meas Data

Show PRA InfoPRA Info

Model TreeFolder BrowserFavorites

Model TreeSA0543D01-M00-UNC\_MPBCS\_PRA.PRTMaterialsCSYS

Product Requirement Association (PRA) Information

Viewing 's Product Requirement Associations (PRAs)

REQ-0005UID: 57c00d12-0ba3-481e-8f44-35db17df2464

Description: MAPR-4Ds SPAR Length

URL: Product%3A940562177&oid=VR%3Acom.ptc.windchill.enterprise.requirement.Requirement%3A1548434349&u8=1

Launch URL

REQ-0013UID: ed4171ee-c4c6-456c-bad5-68611b4e9177

Description: SPAR: Interface with Plate, Top

URL: Product%3A940562177&oid=VR%3Acom.ptc.windchill.enterprise.requirement.Requirement%3A1602138521&u8=1

Launch URL

PC00188X

REQ-00122X .005

PC00162X

REQ-00052X 13.625

PC00142X .500

PC0010177+.002

PC00111010

PC00102X 2.500

R.050+.010 TYP

PC0010

Address: MBPCs

Product Requirements

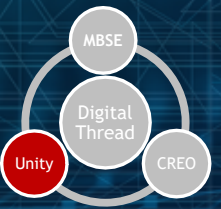
Table with 5 columns: Item, Description, Status, Date, and Location

Found. Retrieved symbol definition file MBPC\_QUALITY\_PLAN\_V2 from the path specified by the Creo config option 'pro\_symbol\_dir'.

Select a MBPC\_Symbol symbol:



# Unity Game Engine



- **Unity Game Engine**
  - “Unity is a cross-platform game engine developed by Unity Technologies”
- **Direct benefits of AR/VR:**
  - Provides physical context, pushing a different type of visualization via graphical integration
  - Driving decisions is better done visually
  - Enables experts to convey complexities to decision makers
  - Enables virtual tradeoffs and integration before cutting material



<https://www.roadtovr.com/bell-says-latest-helicopter-was-designed-10-times-faster-with-vr/amp>

<https://www.defense.gov/Explore/Inside-DOD/Blog/Article/2079205/how-virtual-augmented-reality-are-moving-warfighting-forward/>

<https://unity3d.com/unity/system-requirements>



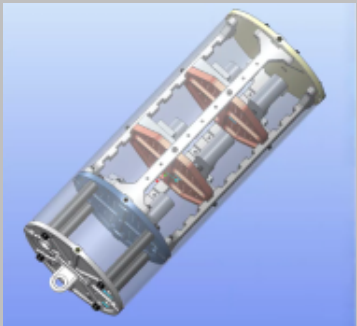


# Application of AR/VR as a Type of Digital Thread

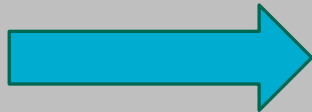
## *CAD Model + Genesys Model → Unity (VR)*



- **BLUF:** Need to identify a multidisciplinary connection between MBSE and physical information that can help decision makers become “experts”



Information  
Overlay  
Graphically

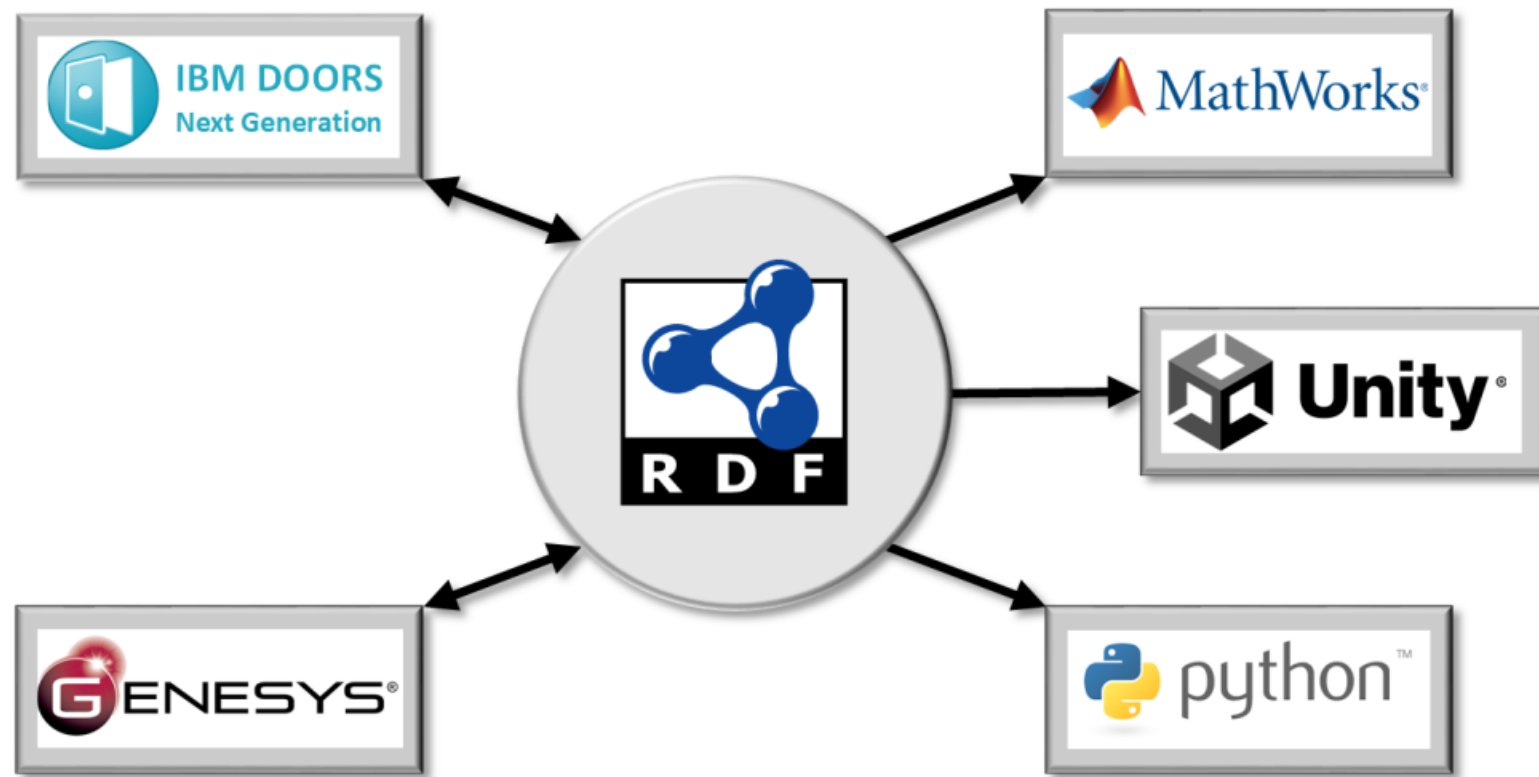






## How do we connect many different languages/tools?

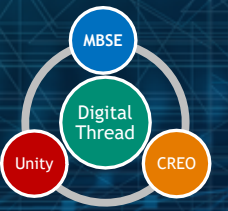
- MBSE model extracted from GENESYS and placed into format called Resource Description Framework (RDF)
  - Open-source, standards-compliant format that acts as the central point of contact between all of the applications shown in diagram
  - Terse RDF Triple Language (Turtle) format
- SNL is building a Digital Engineering Ecosystem (DEE) with an emphasis on model interoperability





# Model Interoperability

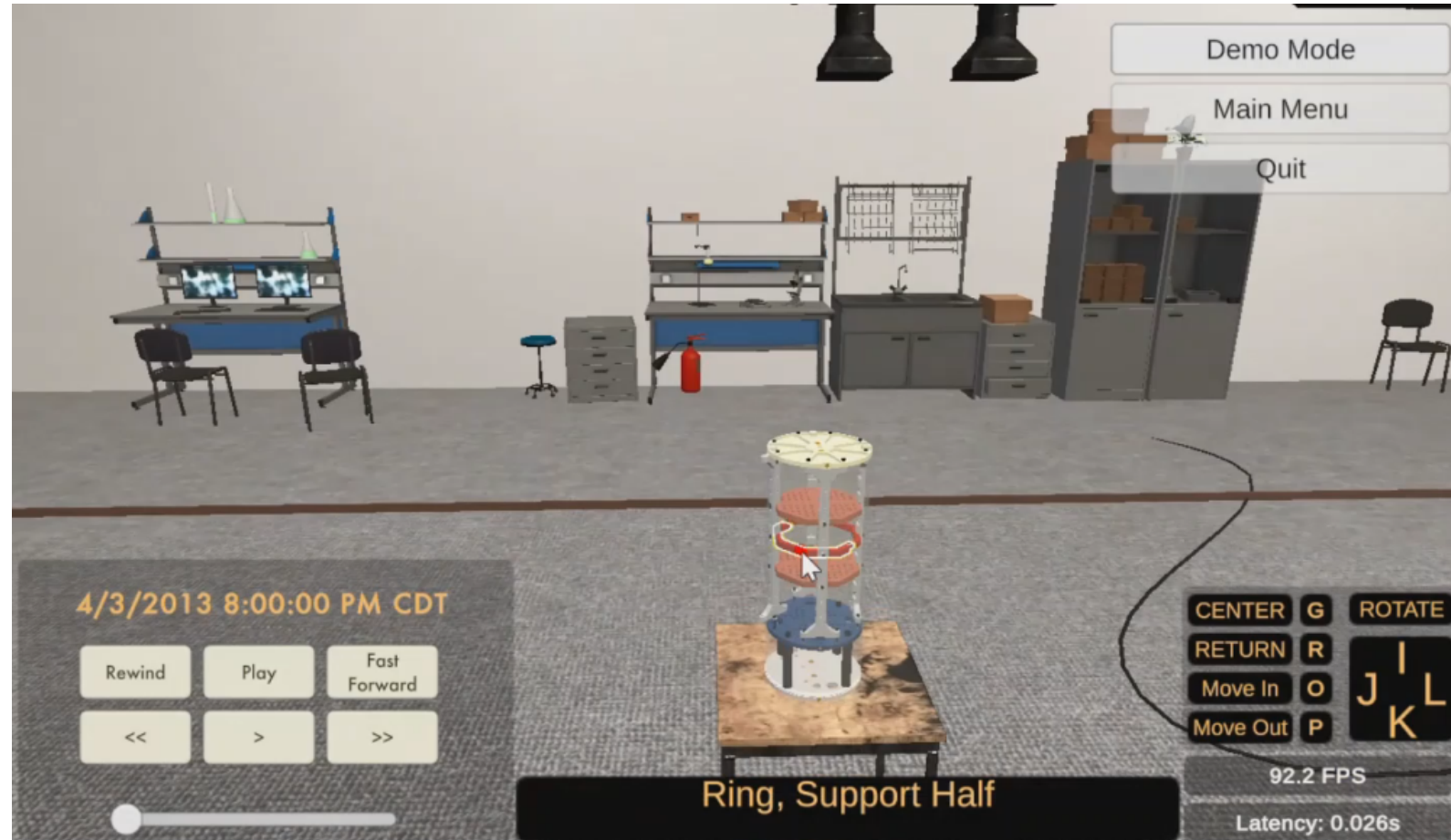
## *CAD Model + GENESYS Model → Unity (VR)*



### Work completed to date:

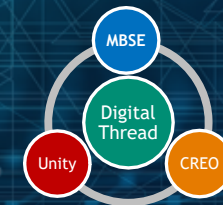
- Leverage RDF to import GENESYS component name and description metadata into Unity
- Create digital thread between CAD and GENESYS requirements
- Implement interactive VR application

Note: VR demo will be available in the afternoon to experience the interactions!

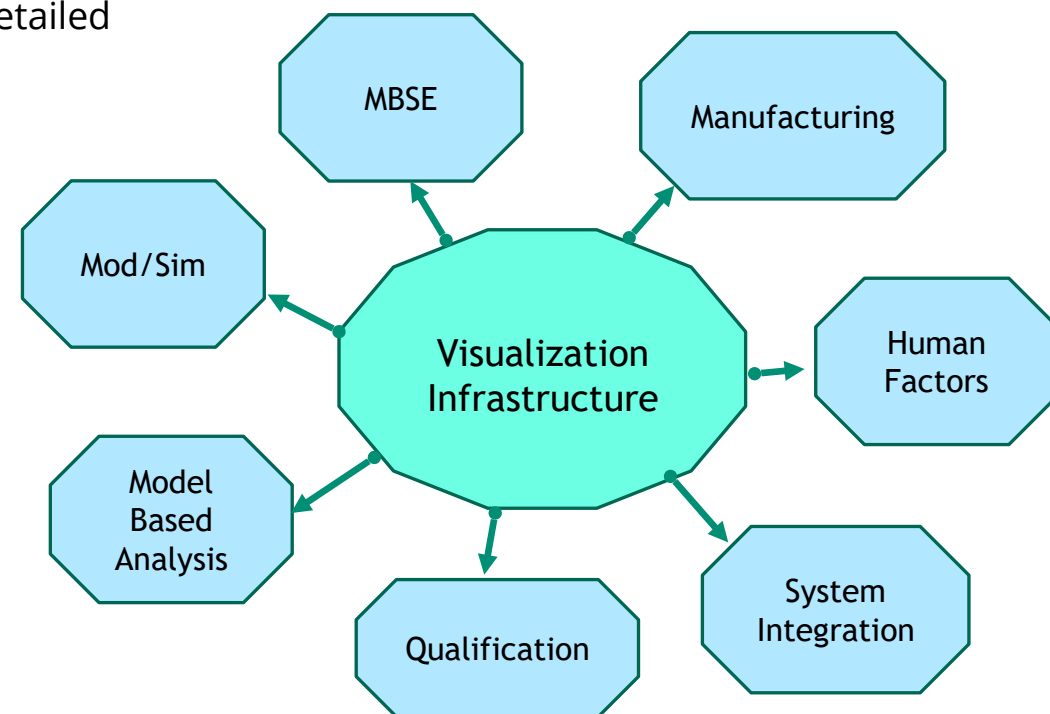




# Additional Applications Being Explored – Digital Thread



- **Model Based Systems Engineering/Model Based Design**
  - Fuze project – visualization similar to RASR model shown, but much more detailed
- **Model Based Manufacturing**
  - Interfacing with external agencies (design and production)
  - Design for manufacturability – identify mistakes virtually, human factors
  - Training
- **Cross-Domain Integration**
  - Visualization of modeling & simulation results of electrical, mechanical, radiation models, etc.
  - Visualization of experimental data
  - Overlay of modeled and experimental data onto physical hardware
- **Networking**
  - Cross-site collaborations



Information and rationale must survive across multiple decades and generations. This, coupled with retention challenges, dictates the need for a transition to a more comprehensive digital environment.



# Conclusions



## Results and Finding

### **Leveraging visualization tools as a digital thread qualitatively enables:**

- More accurately communicated and better distributed information
- Enhanced communication, adaptability, agility, ... etc.
- Customization to specific and disparate tools
- Increased efficiency accomplished by effective tool integration



# Model Interoperability Unity Future Work

## CAD Model + *GENESYS Model* → *Unity (VR)*

### Next steps:

- Visualize additional MBSE type requirements
  - Develop intuitive and interactive views of diagrams/connections in relation to CAD, physical phenomena, etc.
- Requirements verification
- Interface with additional Digital Engineering tools/efforts
- Identify opportunities to expand capabilities to other areas, including collaborative development, training, and production

Sandia is continuously exploring capabilities and collaboration opportunities.

Note: VR demo  
will be available in  
the afternoon  
to experience the  
interactions!





# Acknowledgements

- Justin Serrano
- Anthony Matta
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- Sita Mani
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- Tim Wiseley
- Ruby Ta
- Jake Gonzales
- Andrew McFarland
- Bill Gruner
- Wes Krueger
- Richard Streit
- Ed Carroll
- Ben Peterson
- Kevin Clark
- Timothy Navickas
- ...and many more!

The background is a dark blue gradient with a complex pattern of thin, light blue lines and dots. These elements form a network-like structure, with some lines intersecting to create star-like or geometric shapes. The dots are small and scattered throughout the composition, adding to the digital or technological feel of the slide.

**Thank You  
Q&A Time!**