



# Integrating MBSE and MCAD Models in Virtual Reality

Casey Noll  
*R&D S&E Systems Engineer*  
Sandia National Laboratories

Kelsey Wilson  
*R&D S&E Systems Engineer*  
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)

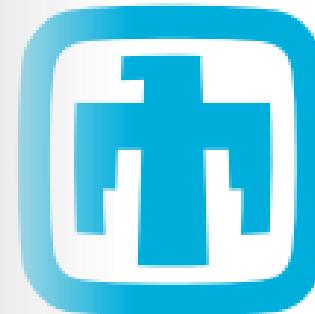
# Overview



# 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

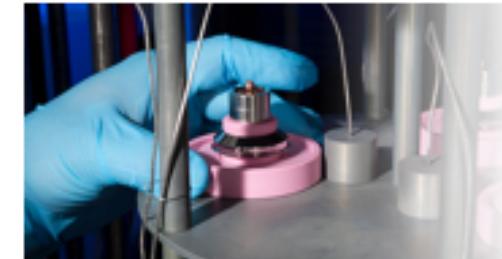
Sandia's Mission Assurance organization proactively  
prevents defects and ensures mission success.



## Multidisciplinary capabilities

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

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

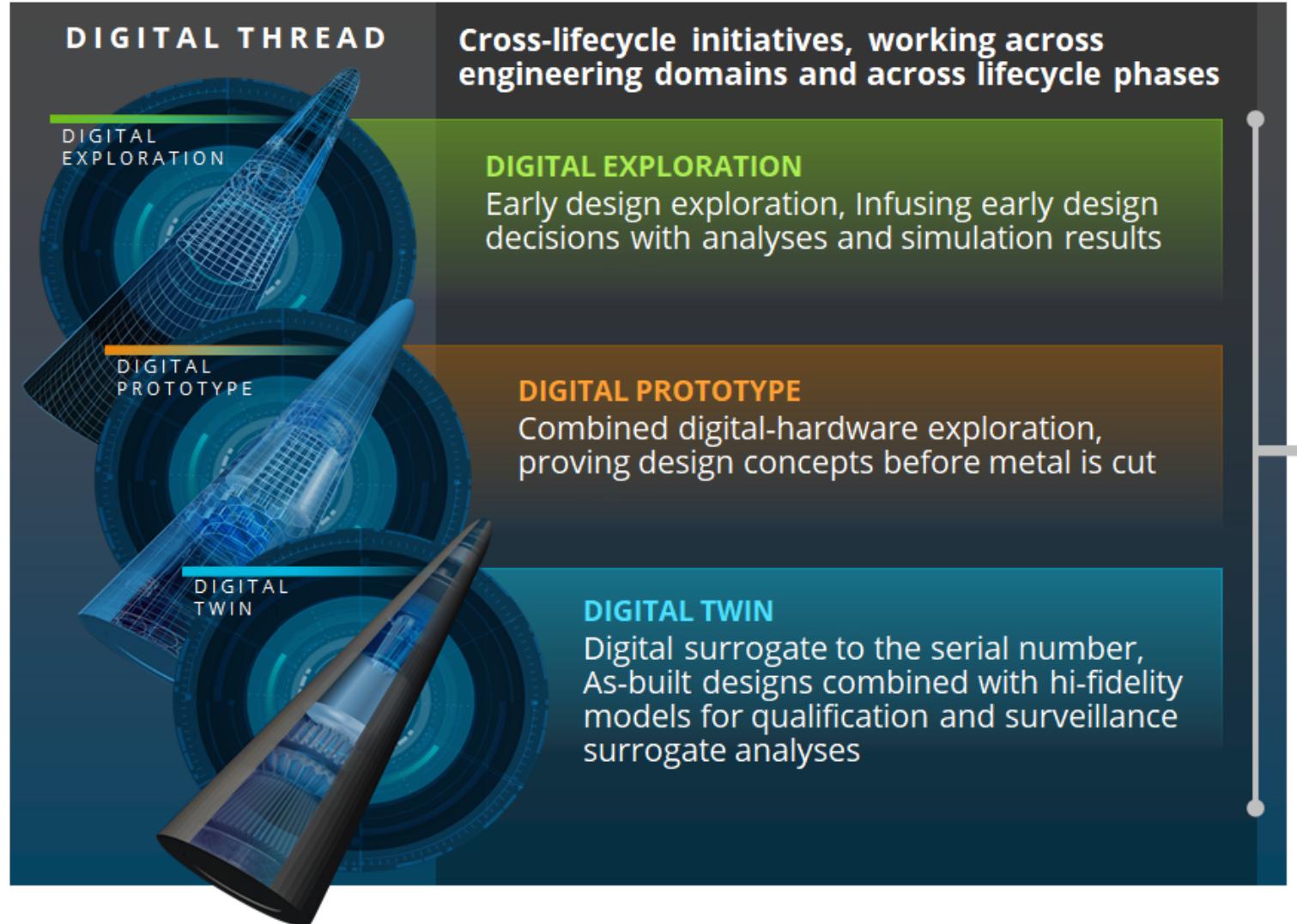


## Production agency

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



# Digital Engineering Transformation at SNL



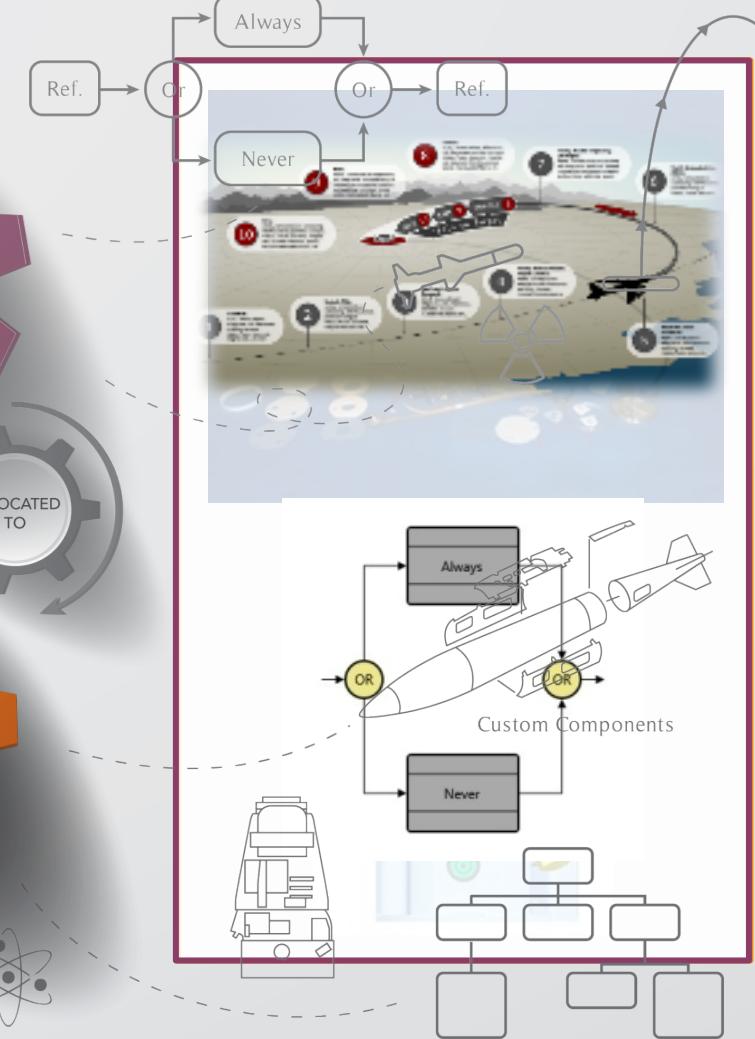
- Process Management / Mission Engineering
- Process and Technical Data Configuration Management / Quality Management
- Model-based Systems Engineering
- Model-based Definition for Product Lifecycle Utilization



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



# MBSE for Nuclear Deterrence

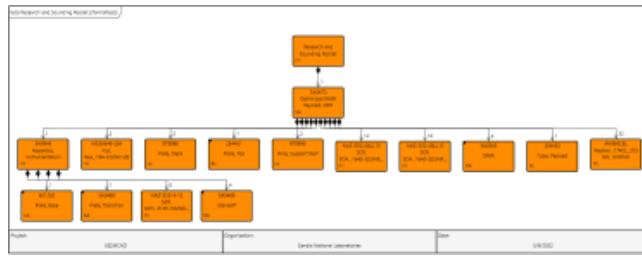
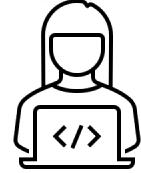


# Problem Introduction



# MBSE + MCAD → VR Overview

Systems  
Engineer



**Vitech**



MBSE

Digital  
Thread

MCAD

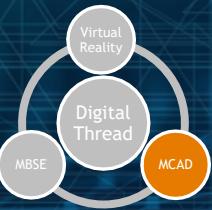
Mechanical  
Engineer



**ptc**



# System Overview of the RASR MEP - MCAD

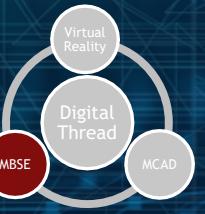


The Paradox: “We need Revolutionary Change in an Evolutionary Environment”

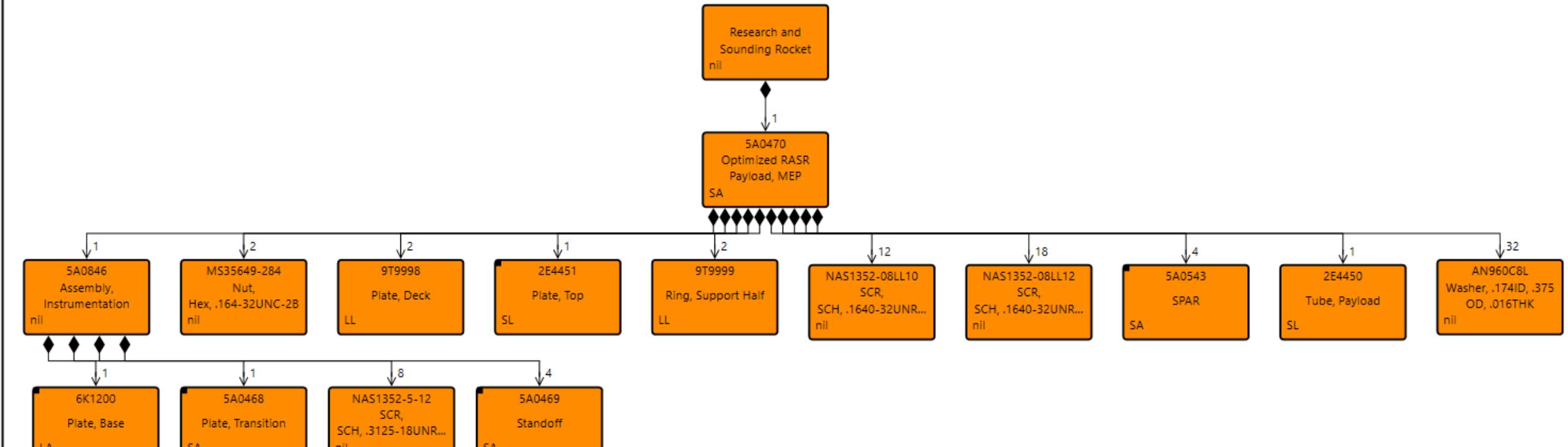
- Don Cook, Former Deputy Administrator for NNSA’s Office of Defense Programs



# System Overview of the RASR MEP - MBSE



bdd Research and Sounding Rocket [(formatted)]



Project:

SE2MCAD

Organization:

Sandia National Laboratories

Date:

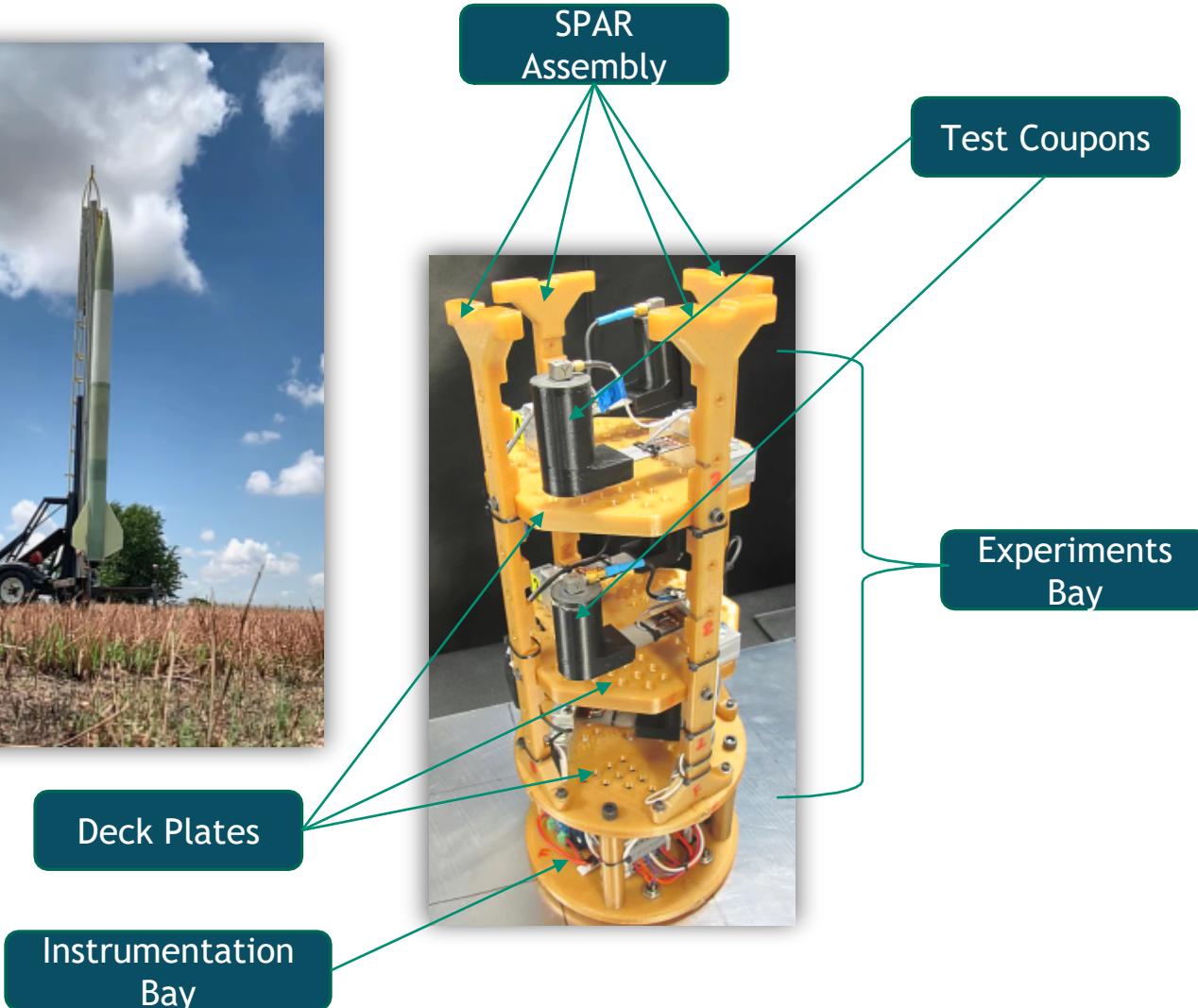
5/9/2022



# 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



The screenshot displays the Creo Parametric software interface with the following components:

- Top Bar:** File, Model, Analysis, Live Simulation, Annotate, Tools, View, Flexible Modeling, Applications, MBPC Tools, DFMPro.
- Left Sidebar:** Model Tree, Folder Browser, Favorites. The Model Tree shows the part name: SA0543D01-M00-UNC\_MPBCS\_PRA.PRT.
- Bottom Left:** A callout box labeled "tech" with the following text:
  - ment
  - Length
  - have a maximum
  - n and a
  - of 13.62 in.

Associated with this text is a dashed arrow pointing to a "VerificationRequirement" box.

**VerificationRequirement**  
Part Inspection  
  
Verifies the associated component meets all released product definition requirements.

Date: 5/9/2022
- Product Requirement Association (PRA) Information Dialog:** Shows two entries:
  - REQ-0009: Description: MAPR-4Ds SPAR Length, URL: >product%3A940562177&oid=VR%3Acom.ptc.windchill.enterprise.requirement.Requirement%3A1548434349&u=1
  - REQ-0013: Description: SPAR: Interface with Plate, Top, URL: >product%3A940562177&oid=VR%3Acom.ptc.windchill.enterprise.requirement.Requirement%3A1602138521&u=1
- 3D Model View:** The model shows various dimensions and annotations, including:
  - PC0010: R.050±.010 TYP
  - PC0011: 2X 2.500
  - PC0012: 2X .500±.005
  - PC0014: 8X .111
  - PC0016: 2X 13.625
  - PC0018: 2X .002
- Bottom Right:** A browser window showing the Windchill Requirements database, and a separate table showing a list of requirements with columns: Name, Status, and Last Modified.



# 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>



The FXC-001's rotor-less tail uses an internal thrust system to generate the necessary force to counteract torque from the main rotor. Bell says it's a safer approach that also requires less maintenance. | Image courtesy Bell Helicopter

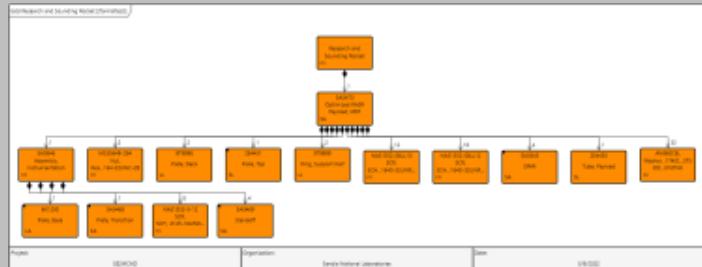


# Application of AR/VR as a Type of Digital Thread

*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”

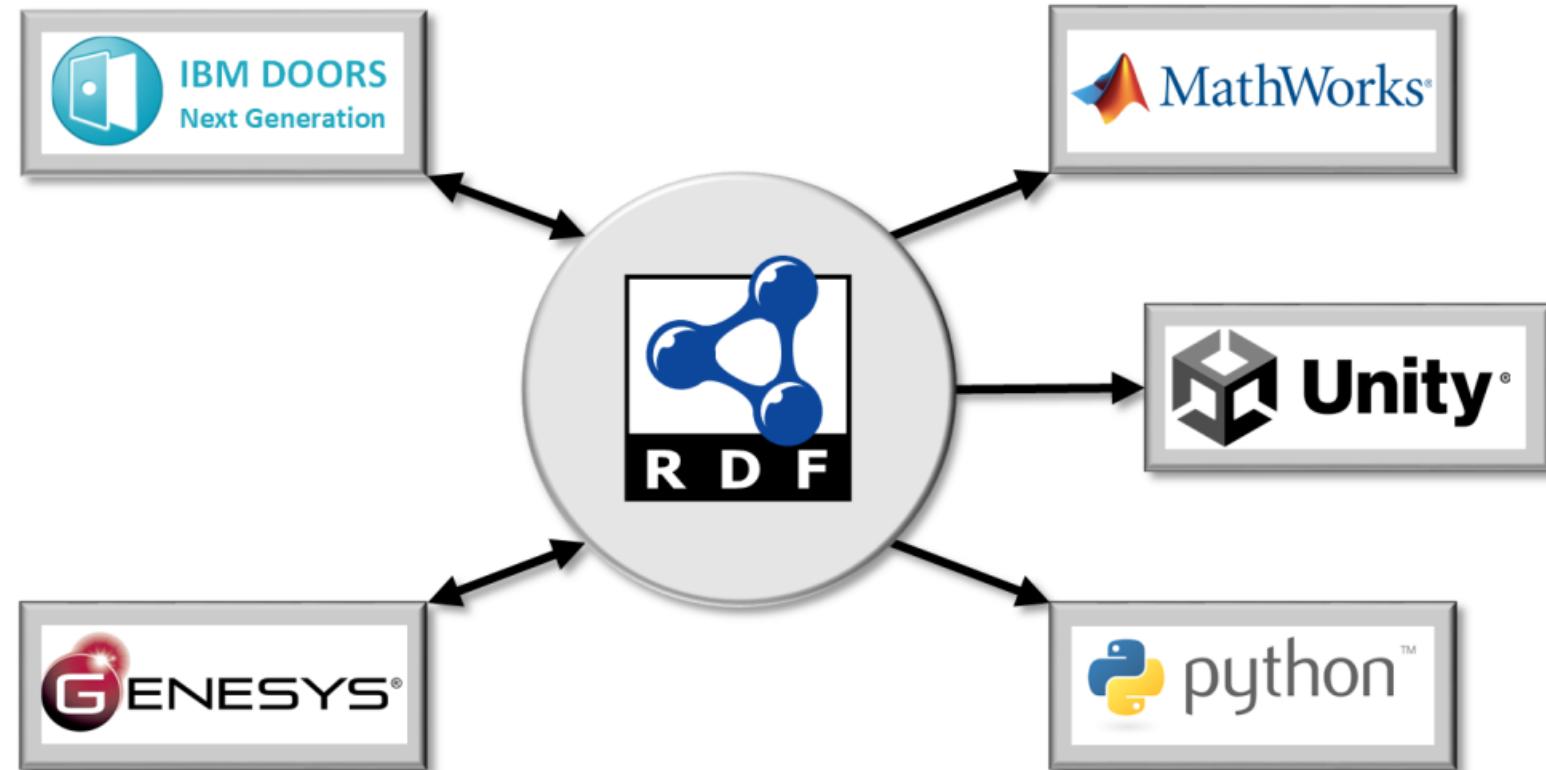


Information  
Overlay  
Graphically



## 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

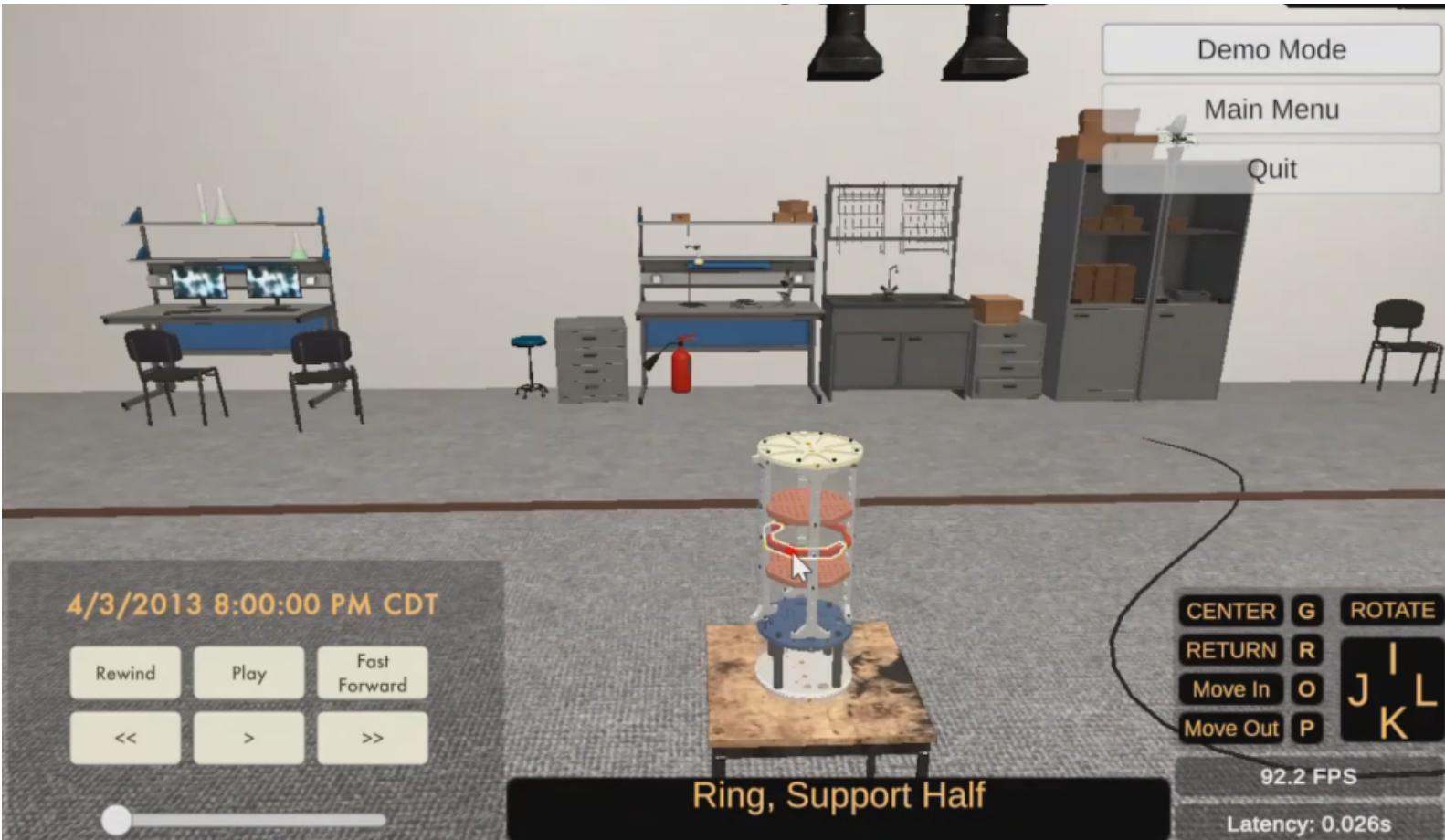
*CAD Model + GENESYS Model → Unity (VR)*



## 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!

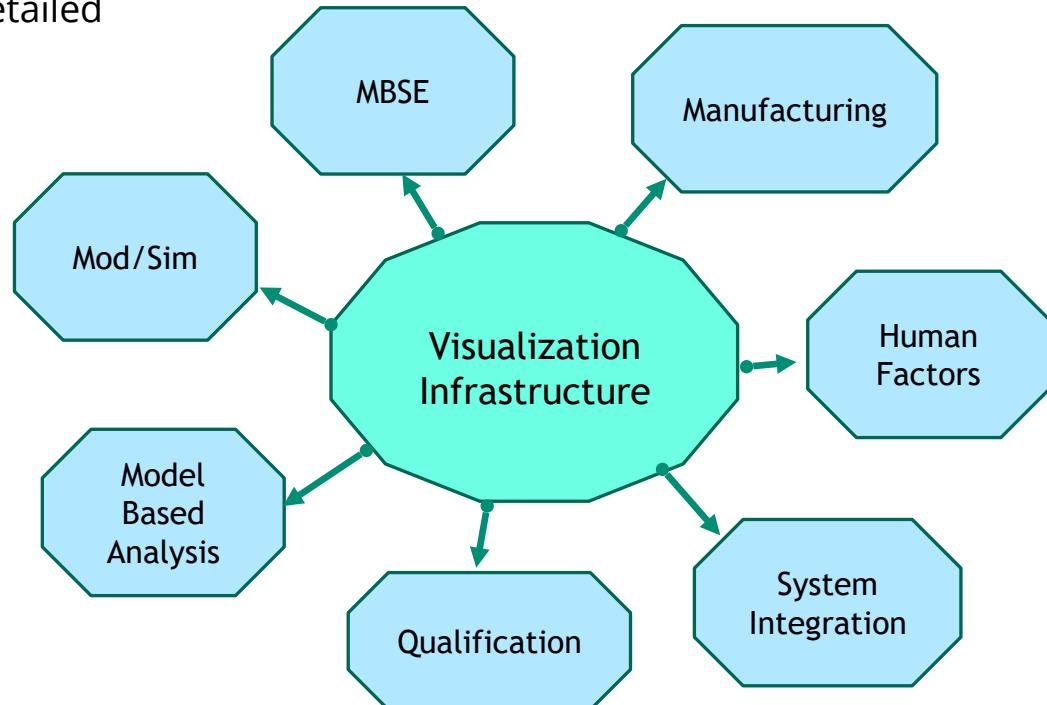




# Additional Applications Being Explored – Digital Thread



- **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

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- Ed Carroll
- Ben Peterson
- Kevin Clark
- Timothy Navickas
- ...and many more!



# Thank You Q&A Time!