



# System Engineering Leveraging a Commercial Gaming Platform

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# Outline

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- Overview
  - Sandia National Laboratories
  - Digital Engineering and Model Based Systems Engineering (MBSE) at Sandia
- Product Introduction
  - Current Limitations of visualization
  - Research and Sounding Rocket (RASR) Modular Experiments Platform (MEP)
- Integration in Virtual Reality (VR)
  - Model Interoperability
  - Computer Aided Design (CAD) + Model Based Systems Engineering (MBSE) -> Unity
- Conclusions
- Q&A



# 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 owned
- 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



# 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

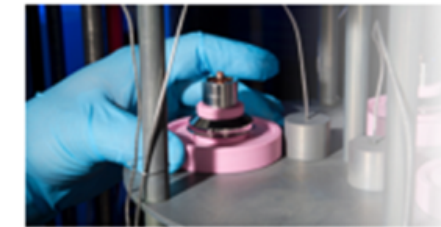
Sandia's Mission Assurance organization proactively prevents defects and ensures mission success.



## Multidisciplinary capabilities

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

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

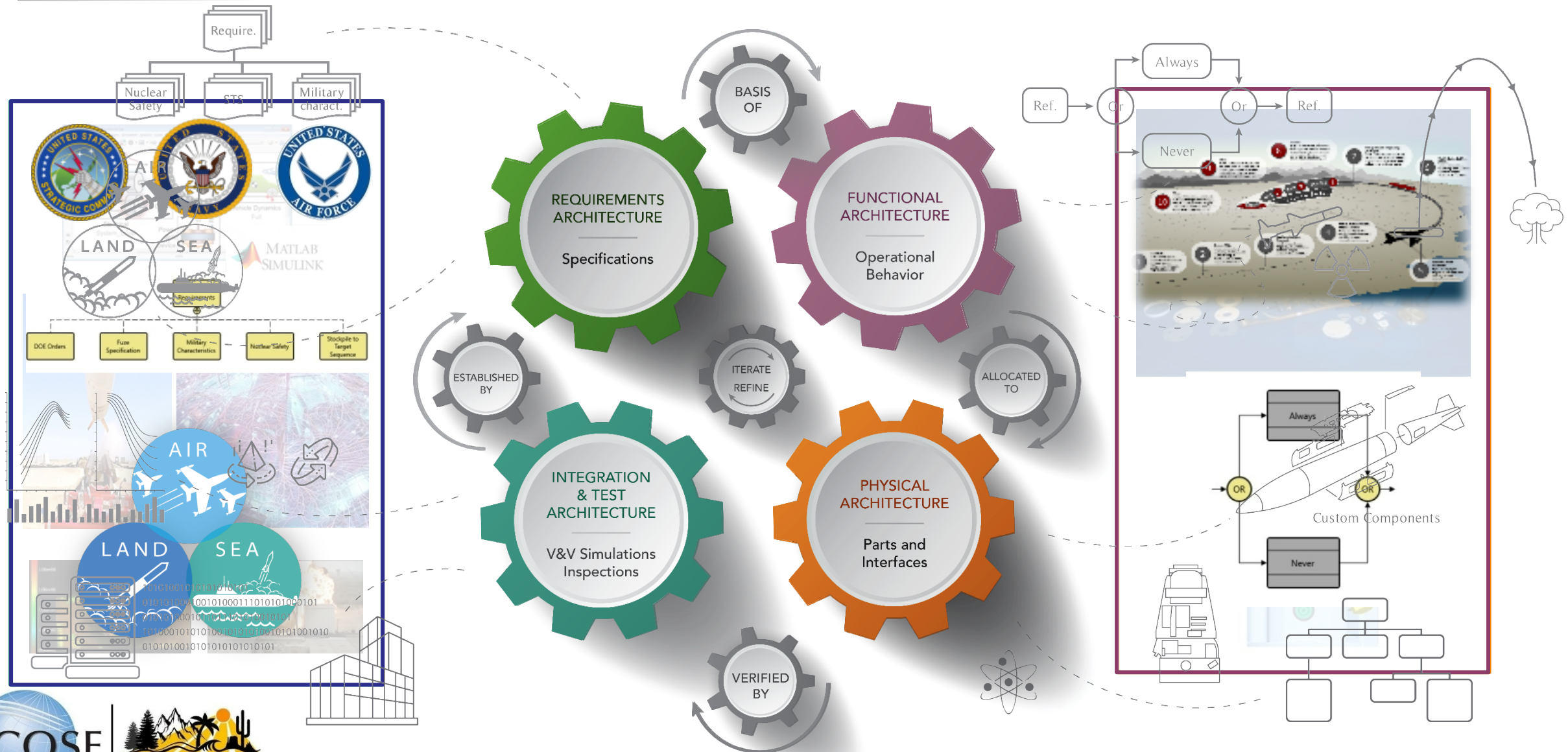


## Production agency

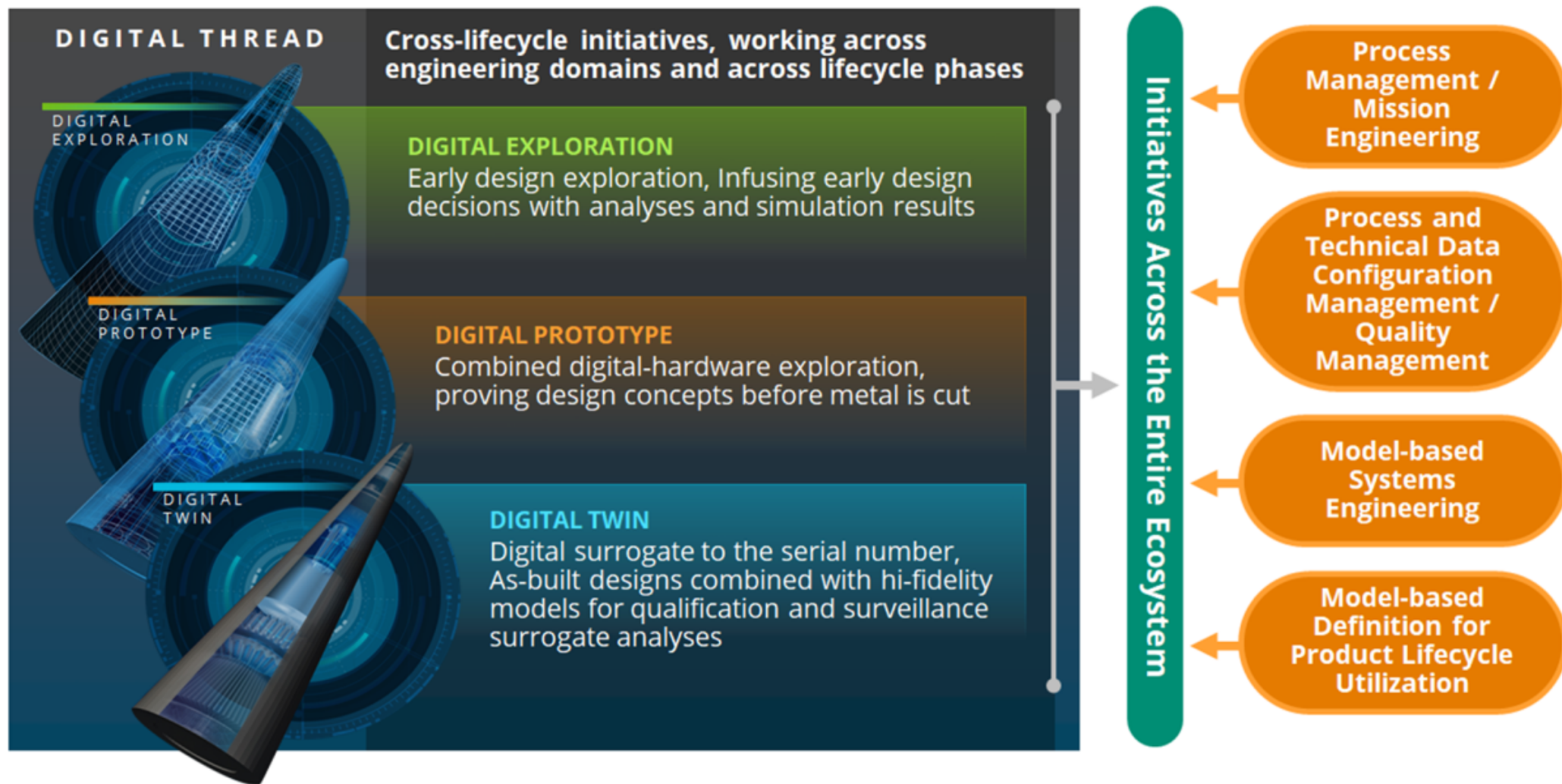
- Neutron generators
- Sandia external production
- Microelectronics
- Thermal battery backup



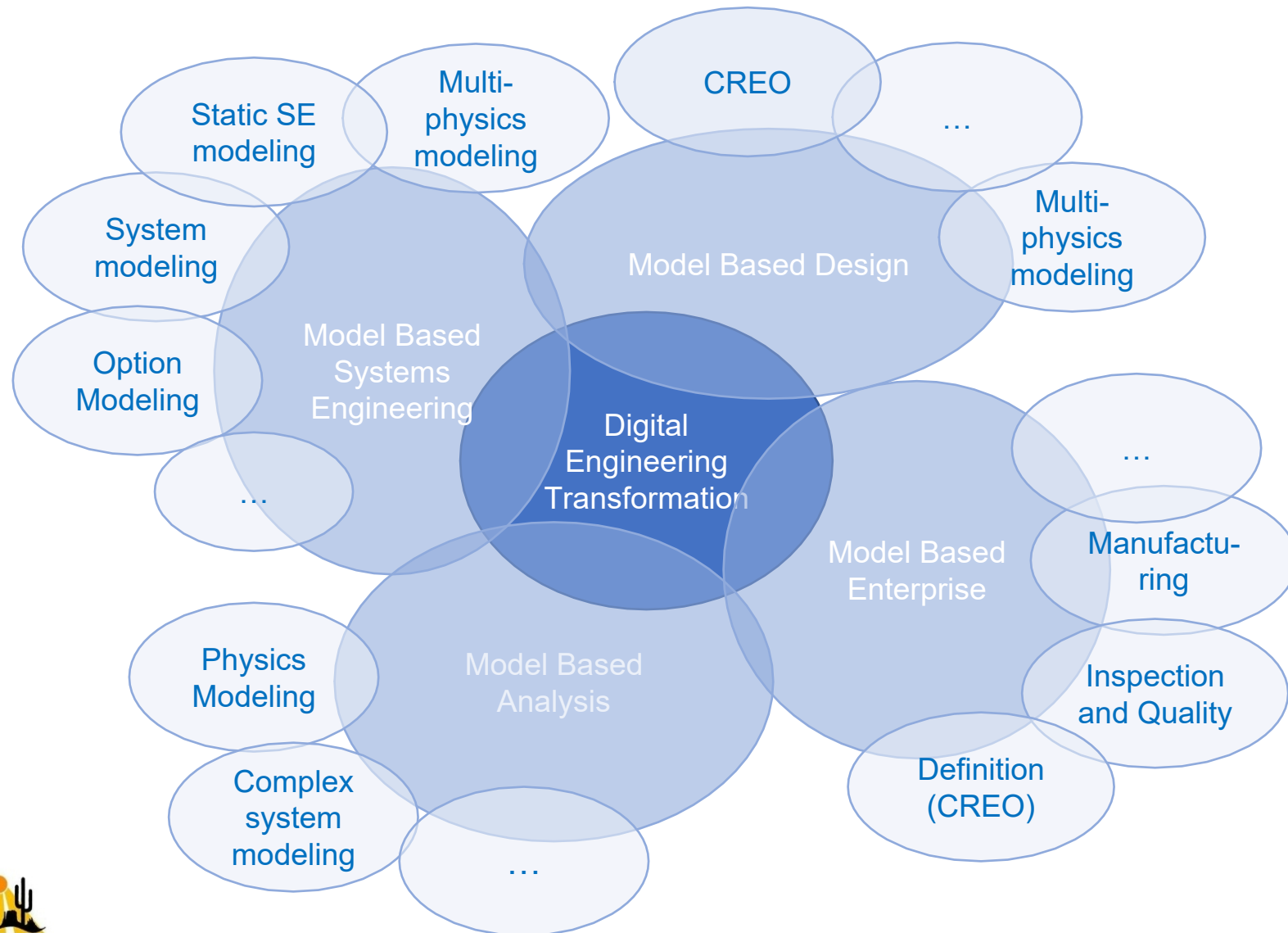
# MBSE for Nuclear Deterrence



# Digital Engineering Transformation at SNL

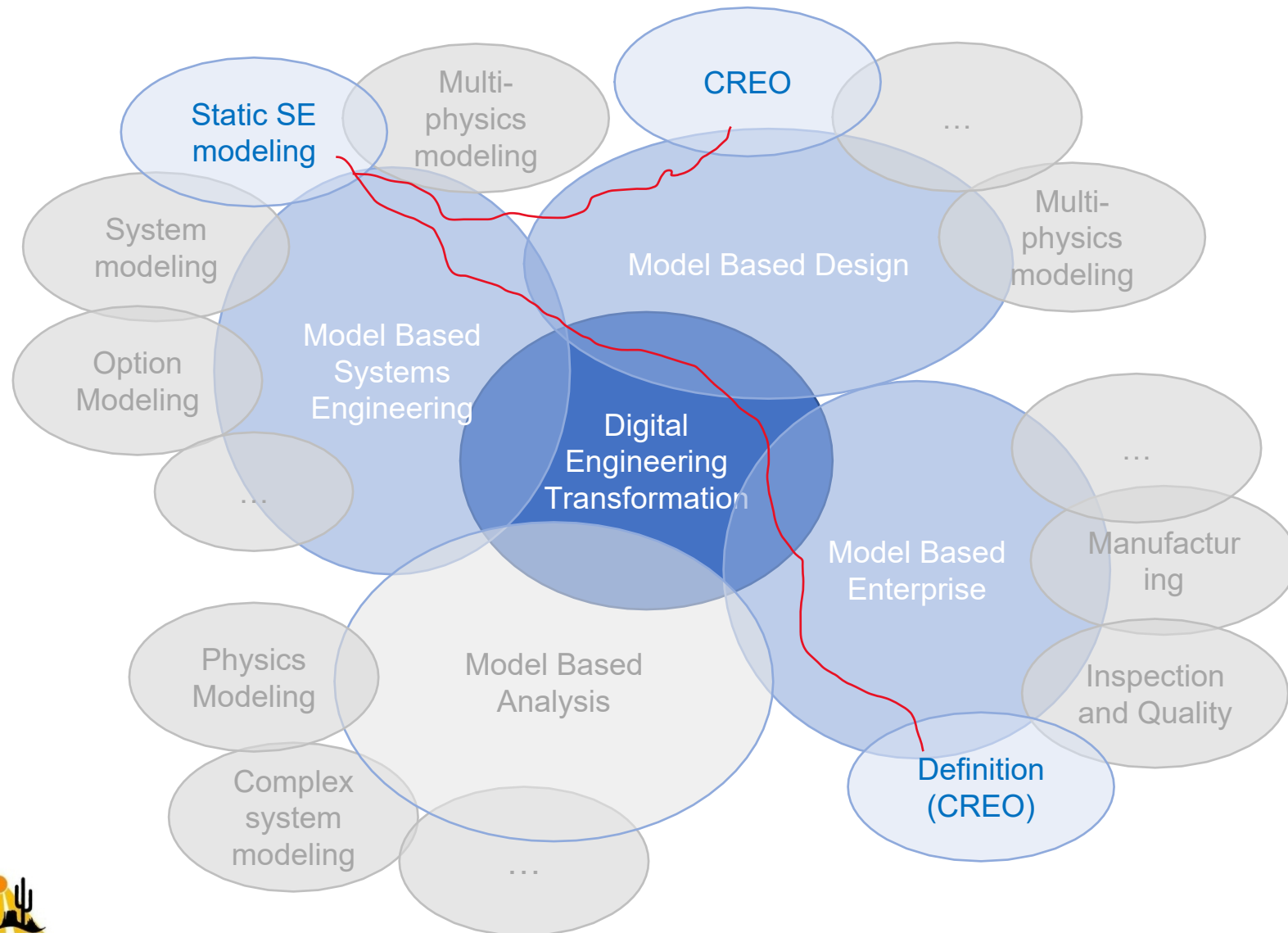


# Digital Engineering Ecosystem at SNL





# Digital Engineering Ecosystem at SNL



# Problem Introduction

# Research and Sounding Rocket (RASR)

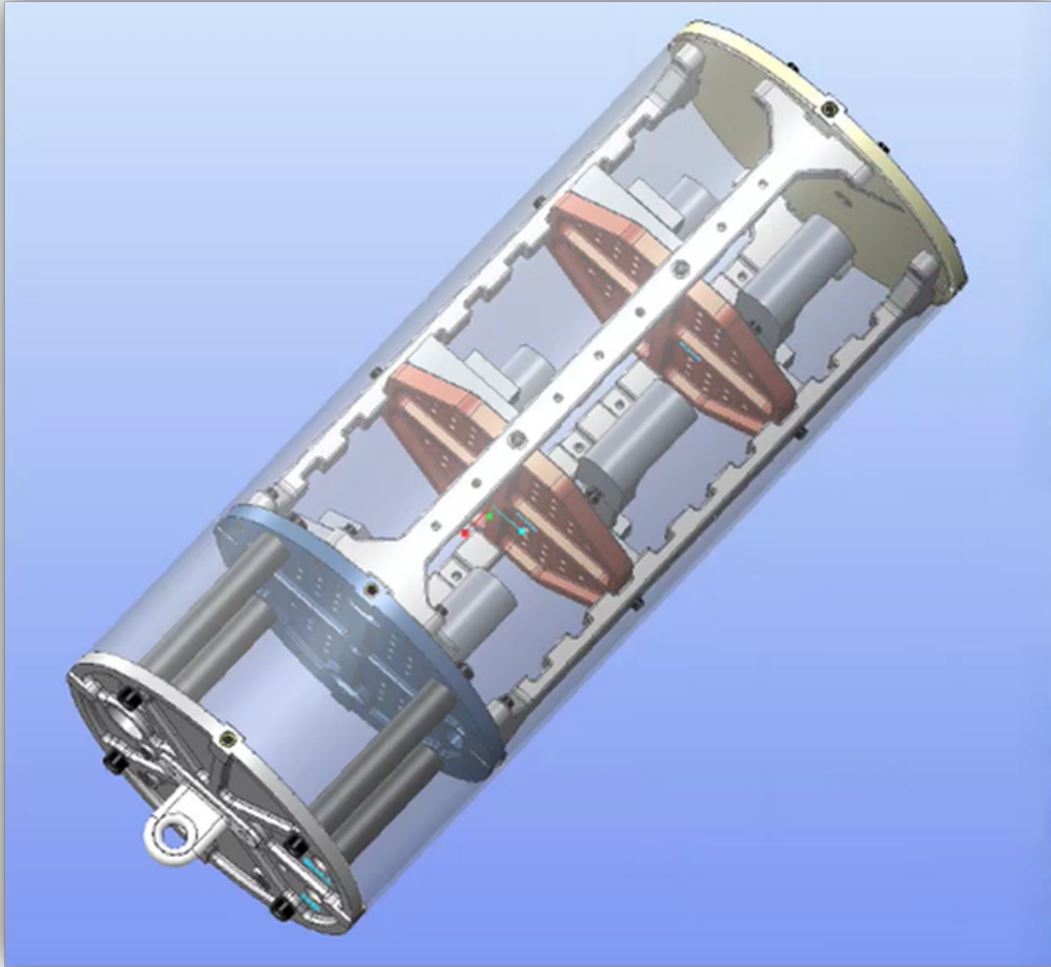
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- **RASR** - Research and Sounding Rocket: an instrument-carrying rocket designed to take measurements and perform scientific experiments during its sub-orbital flight.
  - Experimental flight tests are expensive. Efforts such as RASR enable rapid 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.



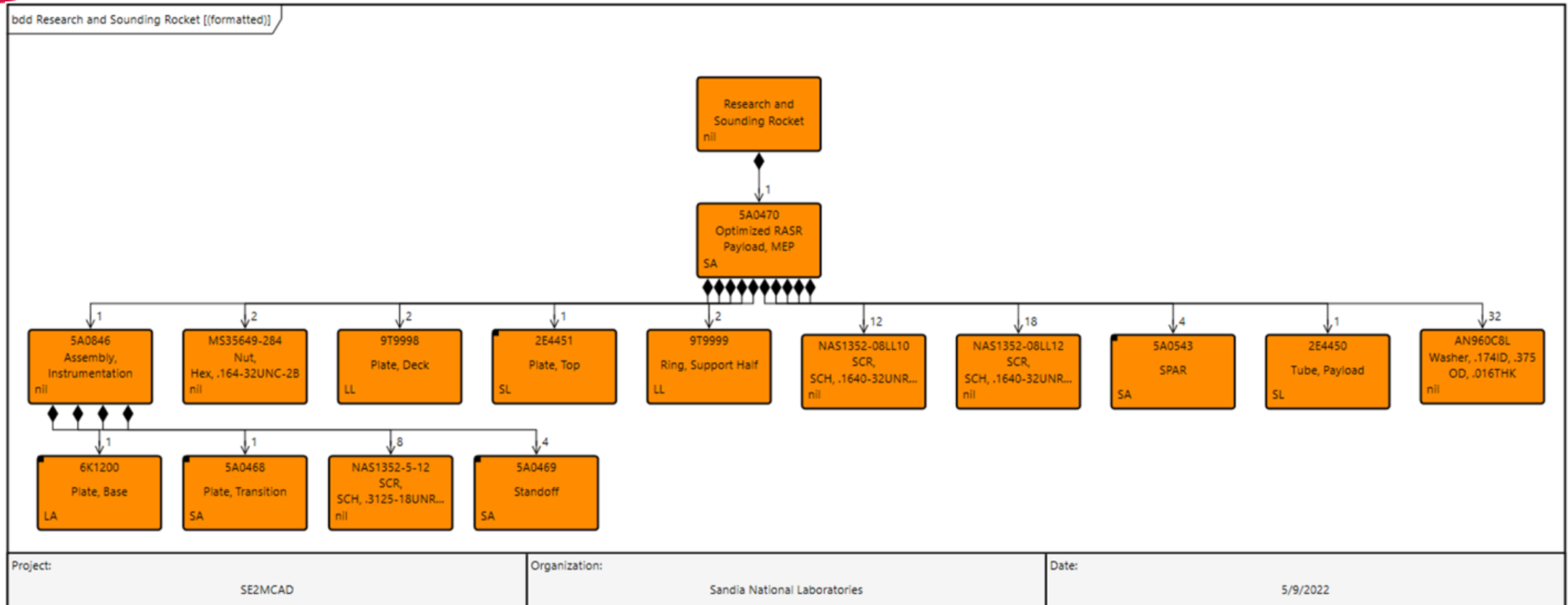
# System Overview of the RASR MEP - MCAD

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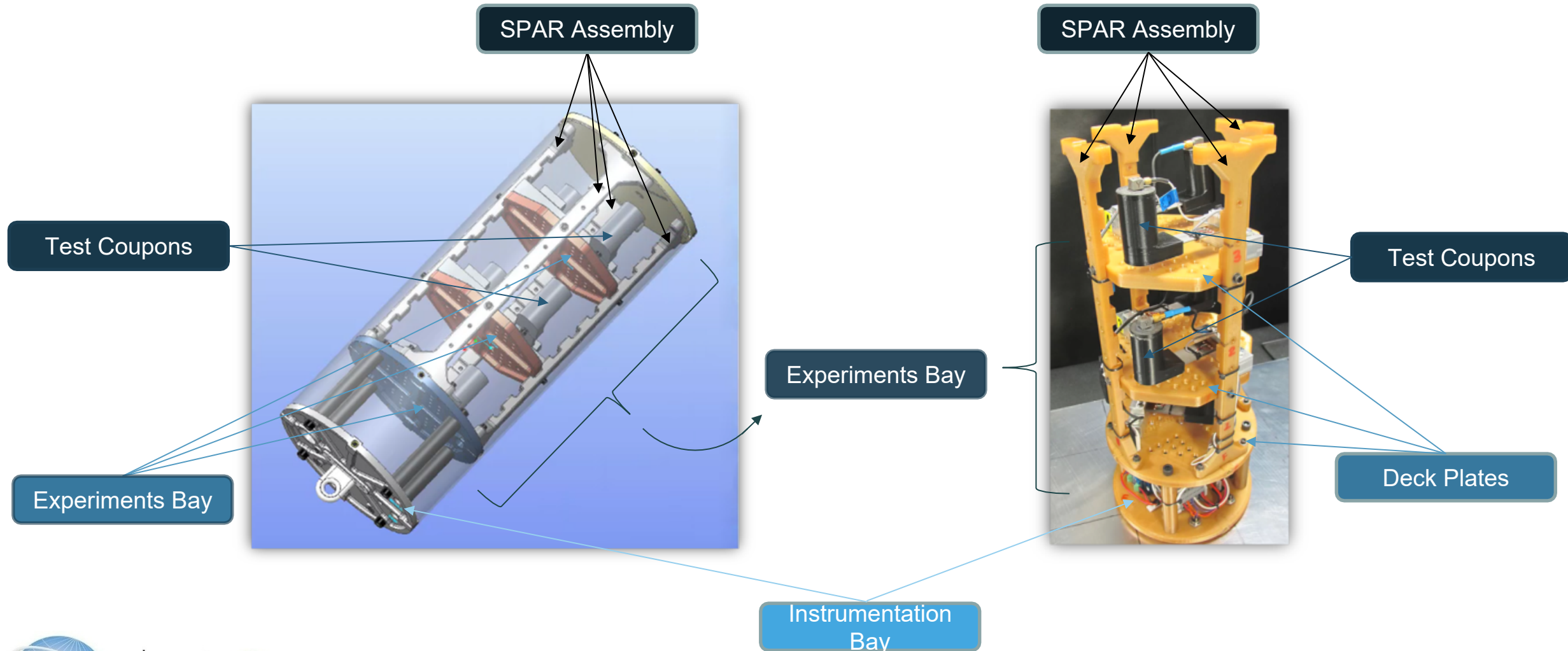




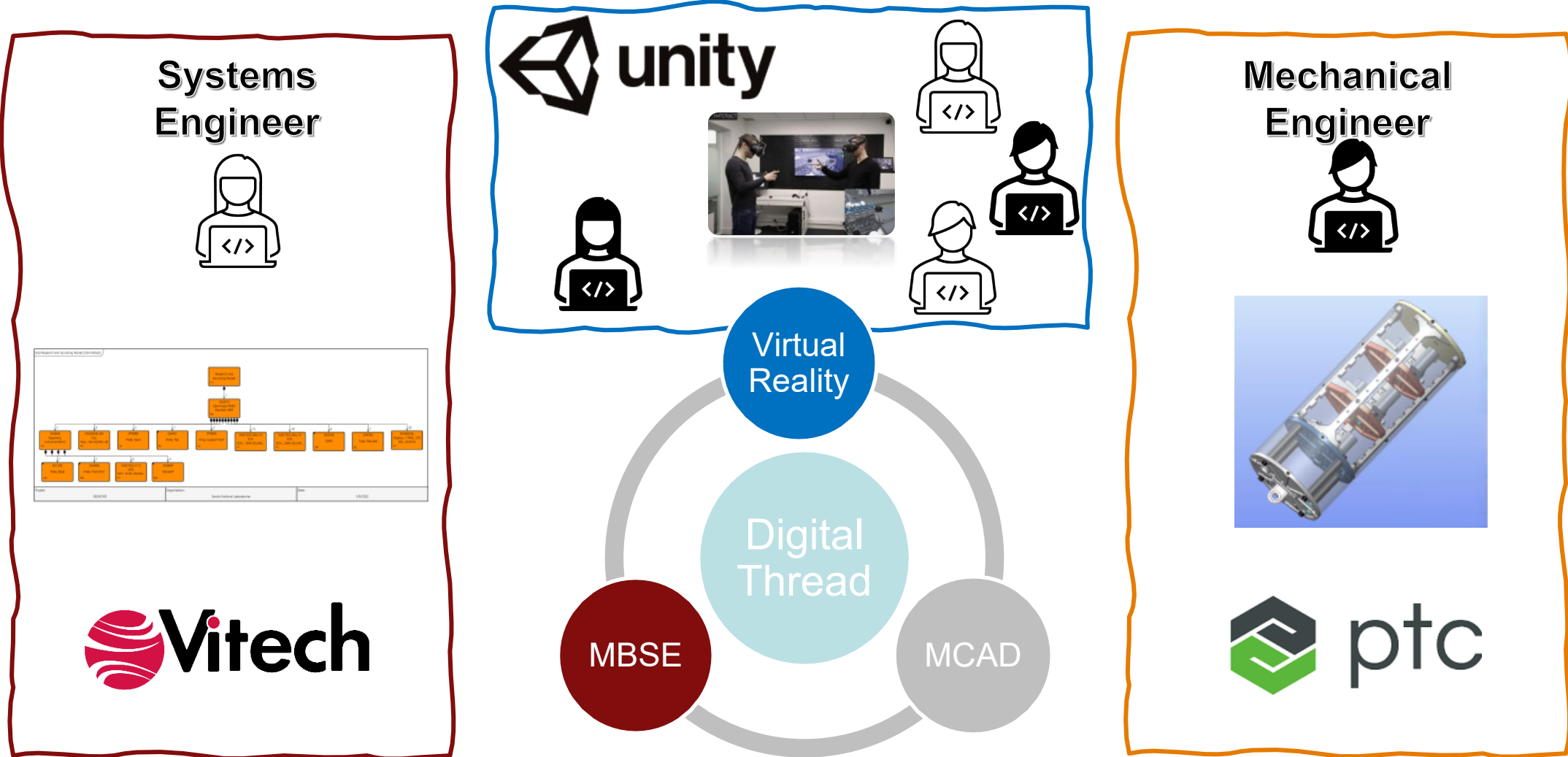
# System Overview of the RASR MEP - MBSE



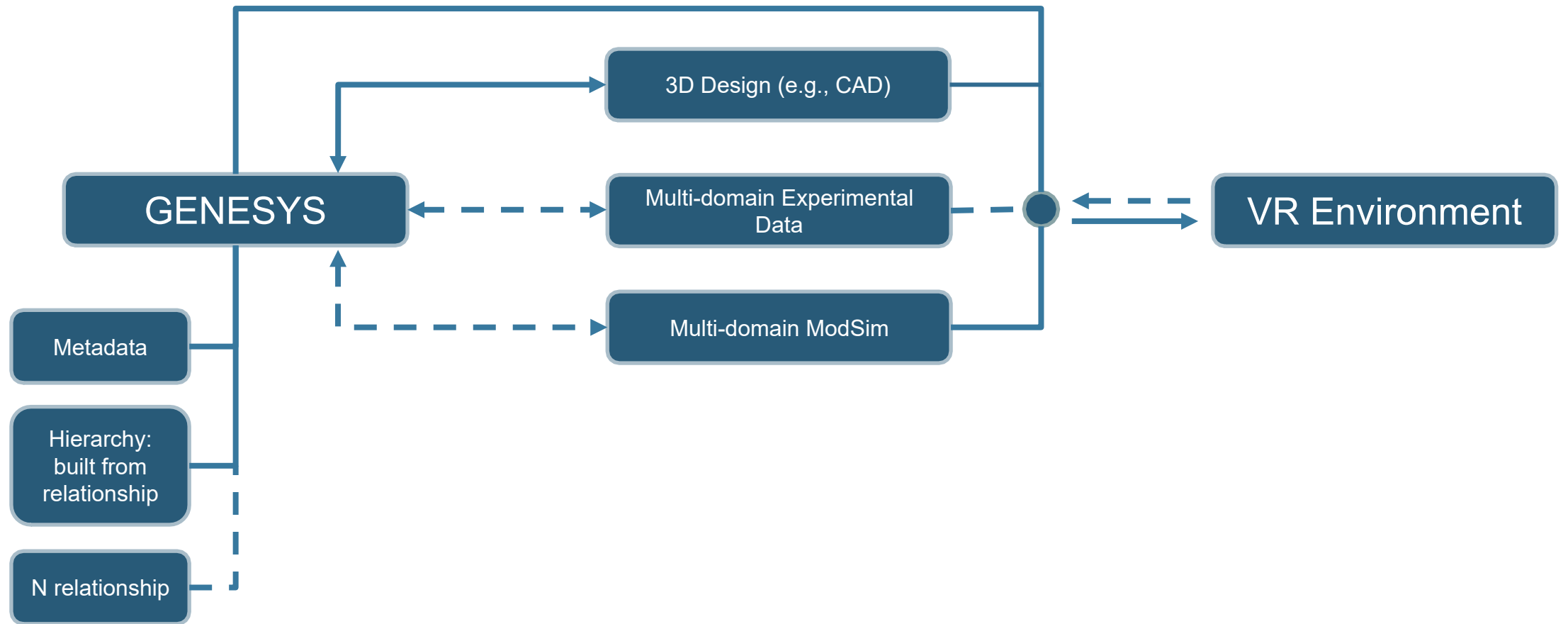
# System Overview of the RASR MEP - PowerPoint



# MBSE + MCAD -> VR Overview



# Data Connectivity





# Integration into VR

# Unity Game Engine

- **Unity Game Engine**

- “Unity is a cross-platform game engine developed by Unity Technologies”

- **Direct benefits of AR/VR:**

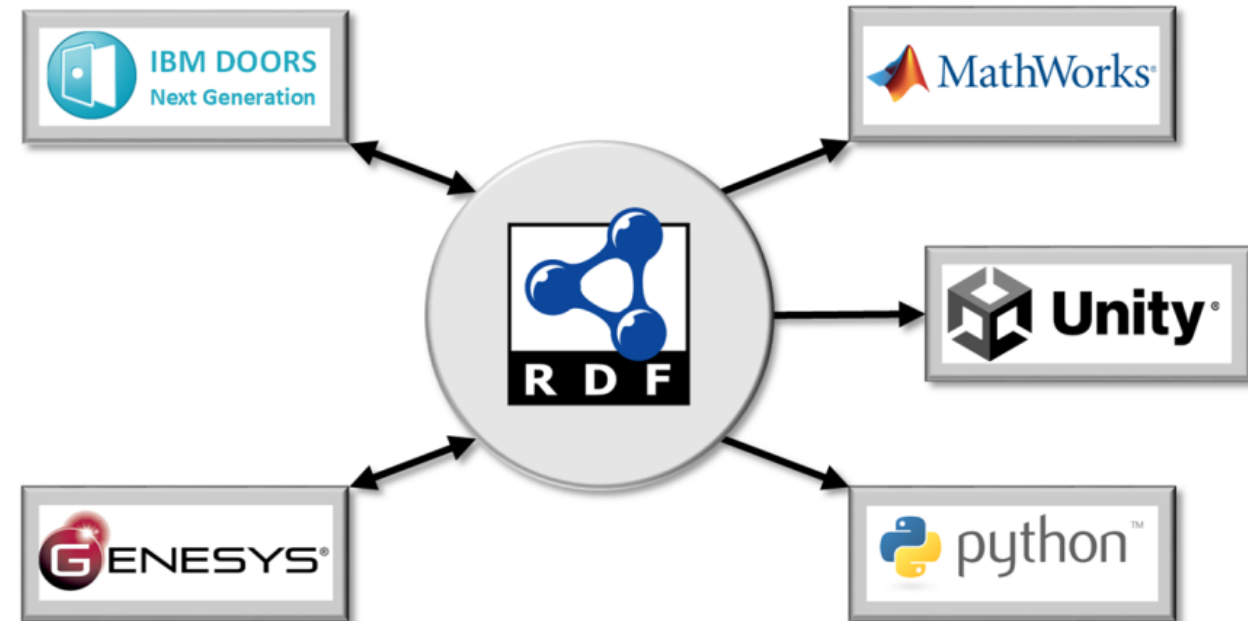
- Provides physical context, pushing a different type of visualization via graphical integration
- Driving decisions is better done visually
- Enables experts to convey complexities to decision makers
- Enables virtual tradeoffs and integration before cutting material



# Model Interoperability

## *Resource Description Framework*

- •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 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



# RDF in Unity

## Work completed to date:

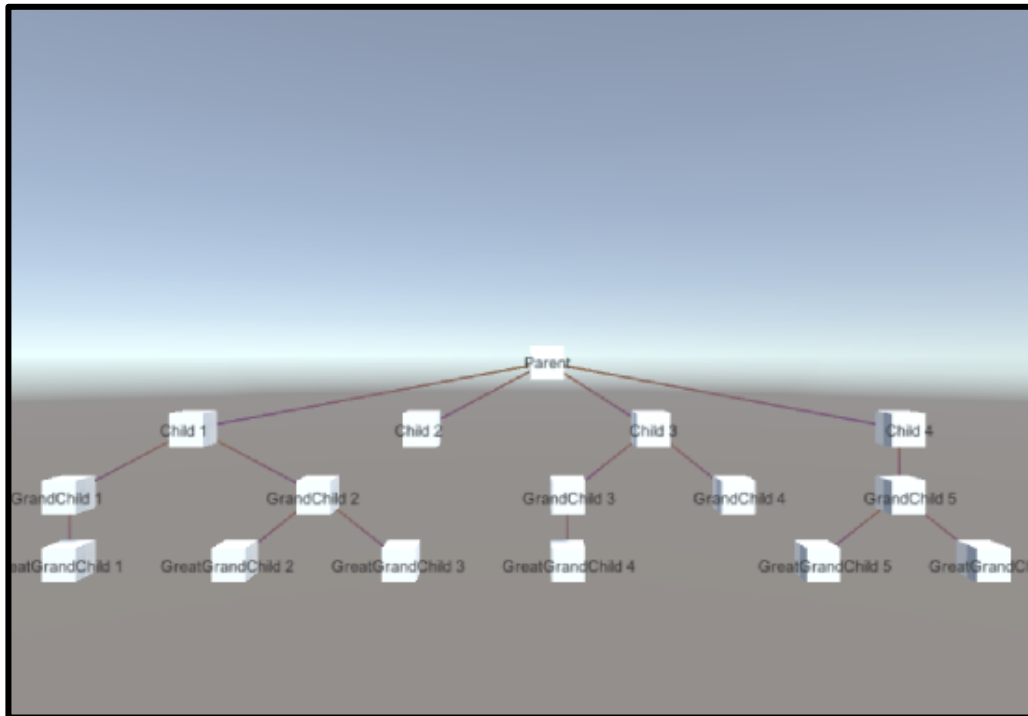
- Leverage RDF to import GENESYS component name and description into Unity
- Create digital thread between CAD and GENESYS requirements
- Implement interactive VR application



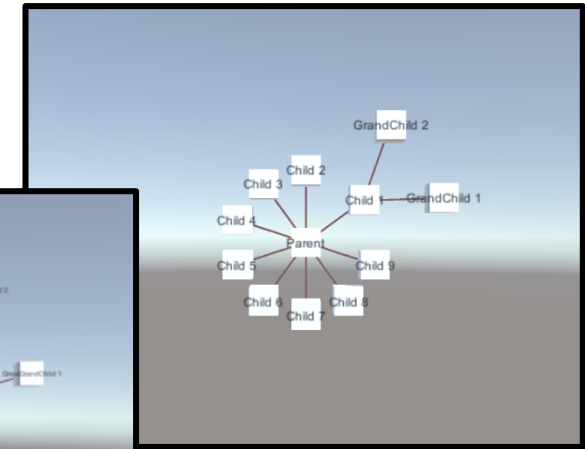
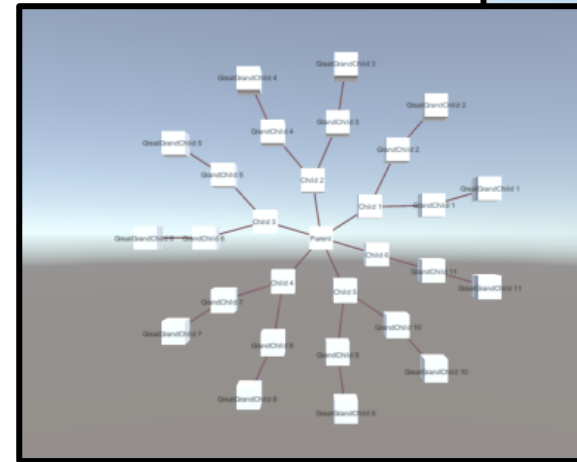


# Hierarchical Diagrams

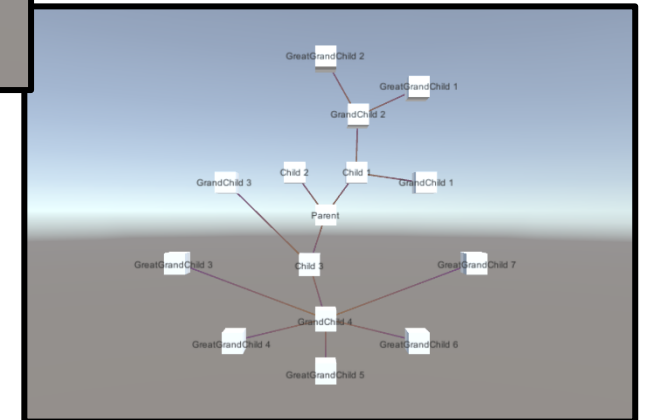
- Implement hierarchy node positioning graphs to visualize GENESYS diagrams



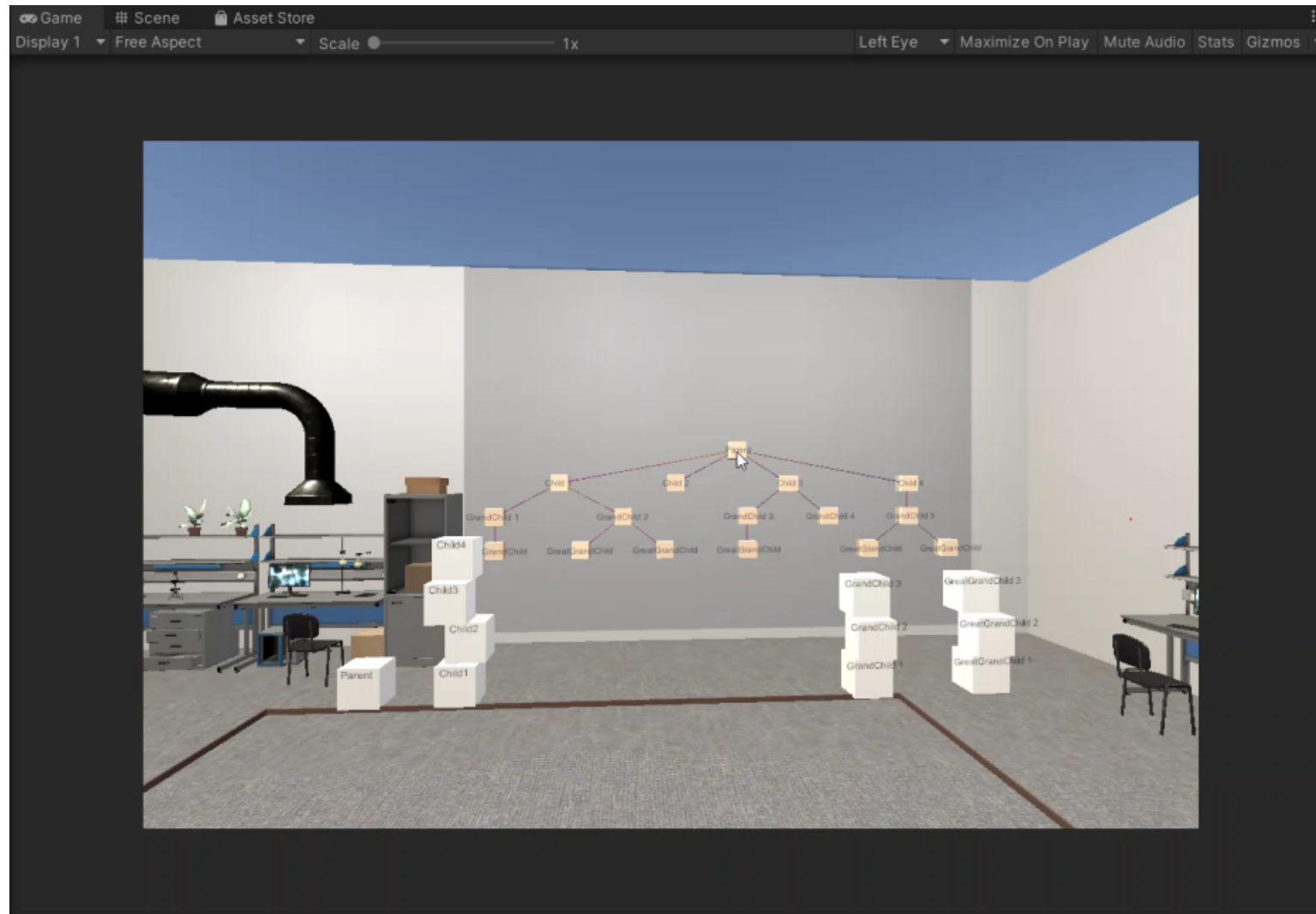
Traditional Hierarchical Diagram



Radial Hierarchical Diagram



# Interactive Hierarchy Diagram using Made-up Data



# Conclusion

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- Connections between MBSE and MBE data were visualized leveraging a video game engine.
- Use of the Game Engine capability enables 3D viewing of complex and disparate datasets without requiring access to each tool.
- AR/VR tools provides an additional layer of intuitiveness and physical context when a user is immersed in a 3D environment.
  - Better understanding leads to more informed decision making.
- Networking to allow users from different sites to collaborate
- Adaptability and connecting complex systems.

# Future Works

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- Create diagrams using the actual GENESYS data.
- Connect diagrams' nodes and CAD, enable user to interact with nodes and CAD models.
- Integrate of human factors aspects (e.g., step-by-step tutorials, manufacturing, training).
- Bring in Simulink and PSPICE models.
- Explore visualizing different relationship-type data from static MBSE tools to build functional-flow architectures of the different datasets.

# Acknowledgements

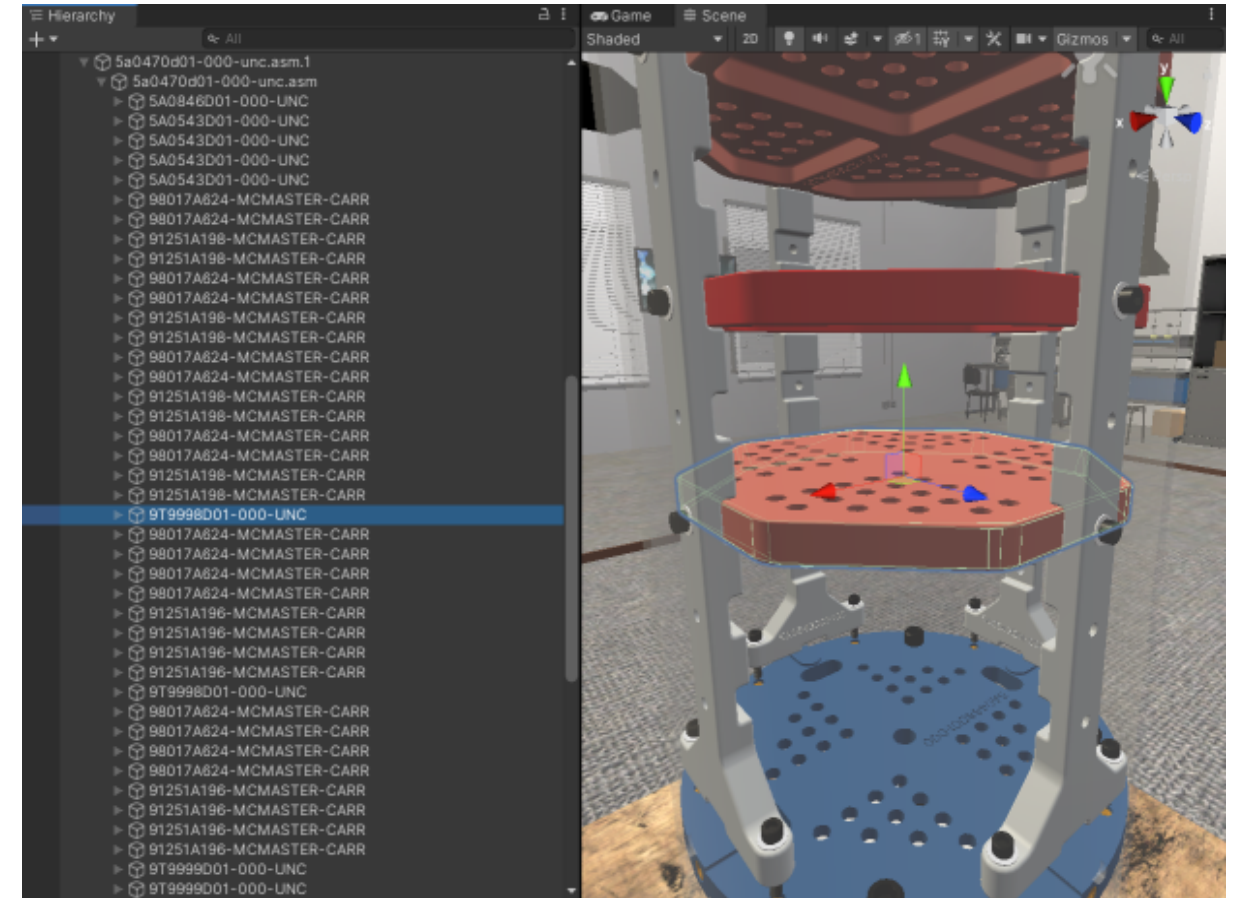
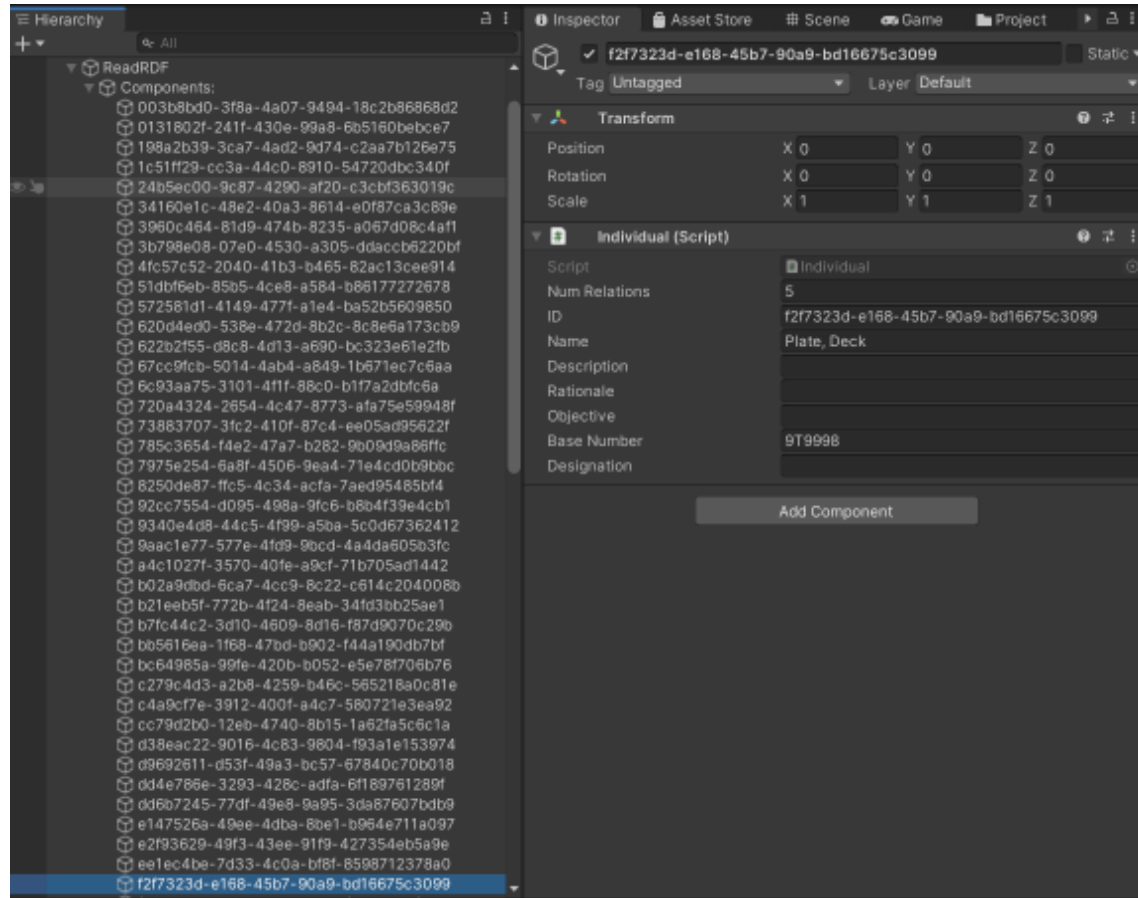
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# RDF - Resource Description Framework



# Querying RDF Data

SQUID - The SPARQL Query Interpreter and Designer

**Ontology**

**RDF Model**

**Query Text**

```
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#>
@prefix xsd: <http://www.w3.org/2001/XMLSchema#>
@prefix : <https://cee-gitlab.sandia.gov/mbse/tester-mbd/test-for-knowledge/dee-team/genesys-api/genesys-rdf-exports/SignalProcessor#>
@prefix owl: <http://www.w3.org/2002/07/owl#>
@prefix xml: <http://www.w3.org/XML/1998/namespace>
@prefix genesys: <https://cee-gitlab.sandia.gov/mbse/ontologies/-/blob/master/T4K%20GENESYS%202021%20SP2.ttl#>

select * where {
  ?entity a genesys:Item.
  ?entity genesys:name ?name.
  ?entity genesys:output_from ?output
```

**Query Results : 7 Results**

entity	name	output
120f5a0d-6fc0-4532-9b4e-dd307c0b6129	Output Signal 1	711e50ca-ab54-4cb5-ae43-32cfb362105d
61f52c8c-1b0d-4042-a673-d45bc0e76898	Processed Signal 2	23071af7-f0e3-4e71-9ed9-1db95ff4554a
6f5dd49f-442f-432e-8f32-5561b00b5161	Output Signal 2	95acfece-56b2-4647-a157-94c40048a8d6
cb16157b-2b1c-45bb-b145-ae32e7e11ca5	Signal	12fee1f5-1efc-487a-8987-2374684110ab
88fe53c4-593f-4913-938c-1eae98b39156	Raw Signal 2	d35f4a4e-620f-4c78-87fb-c36040d4d54c
bcbdc2b0-4888-4245-bf96-fd759bc9127d	Processed Signal 1	caa9c546-7e31-4384-86a9-ba8b4f0f6593
e92306d1-3828-4d19-8e8d-d8d5fe9c7090	Raw Signal 1	ac7907b5-6fc1-4980-860d-9efe183034b4

Run Query