RT-168: Transforming Systems Engineering through Model Centric Engineering

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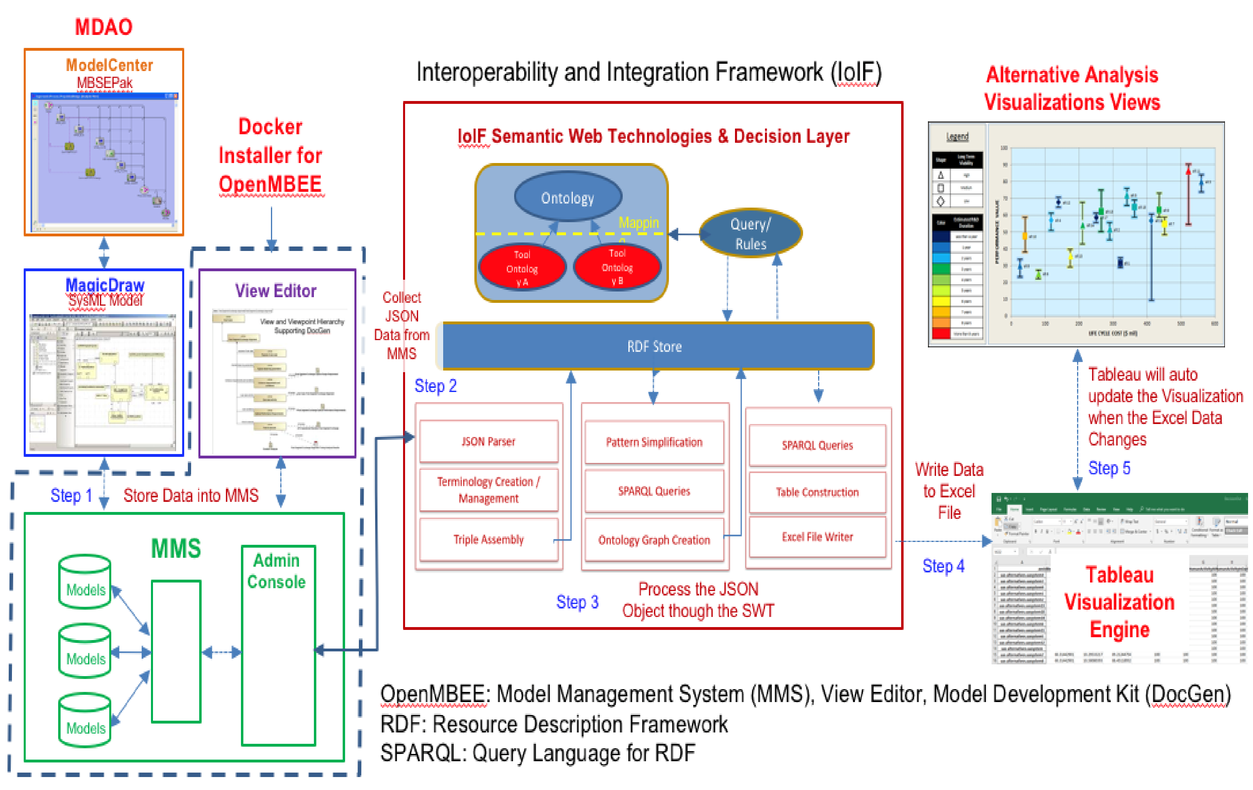
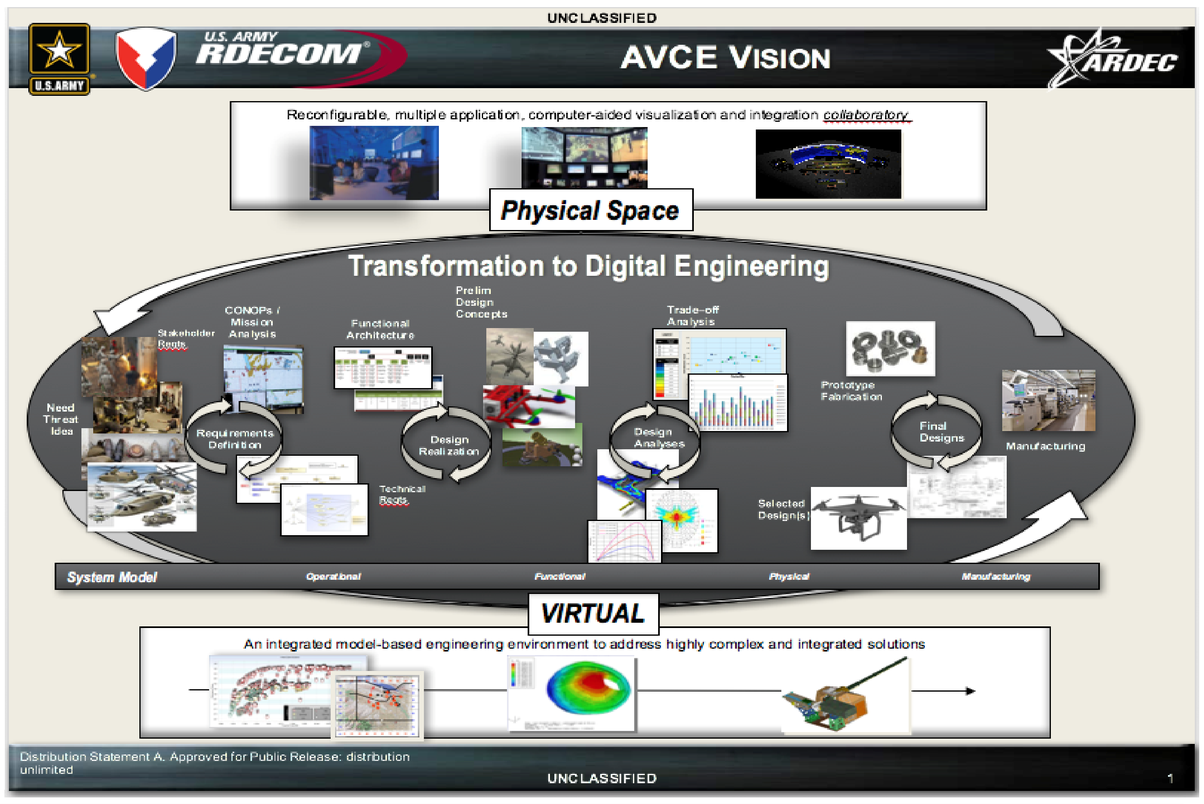
Overview of Research Task

This research task addressed the research needs defined by the United States (US) Army RDECOM-ARDEC in Picatinny, NJ. These needs are characterized as overarching objectives and goals to **elicit requirements for the Armament Virtual Collaboratory Environment** (**AVCE**). The AVCE is ARDEC's envisioned concept of an integrated modeling environment - "***the system for designing future ARDEC systems or systems-of-systems.***" With an intent to understand the relationships between Systems Engineering (SE) activities in the context of a Digital Thread concept for understanding the requirements and methods for analysis workflows for the **AVCE integrated Model-based Engineering** (**iMBE**) environment. iMBE is comprised of: CAD, augmented virtual reality, gaming technology, behavioral techniques, physics-based/engineering simulations, decision analytics, CAM, system architecting, prototyping, embedded in an knowledge management environment, and Interoperable with distributed interactive simulation capabilities.

Research focused around Model Centric Engineering enablers (conducted 12 working sessions, four special session and 32 virtual meetings/webinars)

- Products: Technical reports, demonstrations, prototypes, working session highlighting research and identification of promising enablers to ARDEC iMBE goals, including Interoperability and Integration Framework (IoIF), Decision Framework, Decision Ontology, and Review of iMBE draft requirements
- Create instantiation of demonstration environment using NASA/JPL OpenMBEE with extensions focused on achieving cross-domain model integration through data interoperability supported by semantic technologies and ontologies, Multidisciplinary Design, Analysis and Optimization (MDAO)





Evolving Research Approach

Using a Model Based System Engineering (MBSE) to model our project, we have elaborated the research tasks using high-level use cases, and associating them with researchers, and show a non-exhaustive set of relationships between the different use case. Every use case has produced results that have been presented to the ARDEC sponsors.

UC00 Develop Information Model using semantic technologies and ontologies that characterize the underlying information and relationships to "everything" that might need to be produced by the tools of AVCE.

❖**UC01** Research Graphical CONOPS using technologies such as gaming environments. This information would be mapped to UC00 and be provided as input to UC02, and driven by MDAO technologies.

❖**UC02** Investigate the methodological and relevant technologies for mapping the Graphical CONOPS into Mission and System modeling and simulation capabilities.

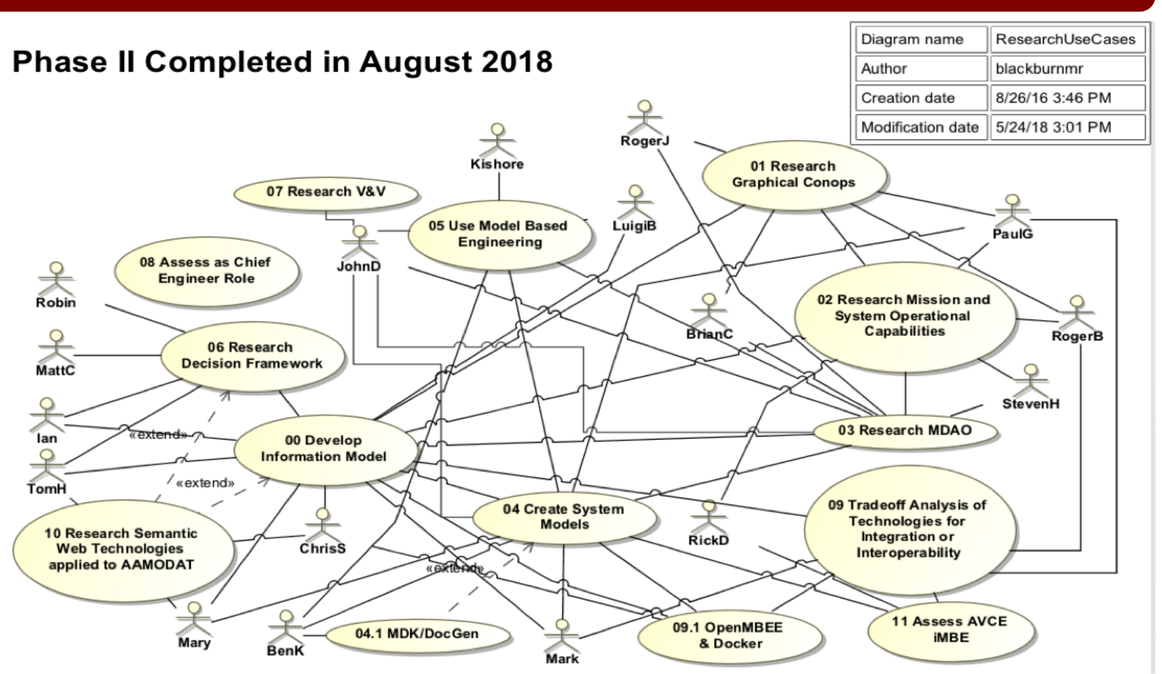
❖**UC03** Investigate the method to trace capabilities to the relevant design disciplines and perform cross-domain analyses through MDAO for problem and design tradespace analyses.

❖**UC04** Create System Models, applying MBSE to the case study examples and looking at how metamodels or metadata is represented in the Information Model to provide traceability through the other forms of modeling for UC01, UC02, UC03 and UC05. This also includes the extension use of OpneMBEE DocGen.

❖**UC05** Apply Model-Based Engineering (MBE) typically associated with the different design disciplines (e.g., electrical, mechanical, controls).

❖**UC06** Research Decision Framework, to capture information across the life cycle that can be used to provide input to the Decision Framework tool and associated methodology for assessing Key Performance Parameters. This would provide the type of information needed to consider technology capability tradeoff using Performance, Cost, Time and Risk. If a particular answer is unacceptable, we could trace linkages through the Information model back to all other related perspectives on the system (UC01, UC02, UC03, UC04, UC05).

❖**UC07** Research Verification and Validation (V&V). Rigorously defined models can directly support V&V, and this could both subsume cost and risks.



❖ **UC08** Assess as Chief Engineering Role, to provide some level of assessment of our overarching approach and contribute to the requirements for AVCE.

❖ **UC09** research of Integration or Interoperability Framework (IoIF) as a way for representing and analyzing the architecture trades across domains, including the use and integration with OpenMBEE and Docker.

❖ **UC10** research the use of Semantic Web Technologies applied to Decision Framework (UC06).

❖ **UC11** use case for assessing the AVCE iMBE requirements and model using INCOSE's Agile Systems Engineering Life Cycle Model (ASELCM) Pattern of Three Concurrent Systems.

Contacts/References

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