

The background features a network diagram with nodes and connecting lines. The nodes are represented by circles of varying sizes and shades of blue and grey. The lines are thin and light-colored, creating a web-like structure. The overall aesthetic is clean and modern, typical of a technology or data-related brand.

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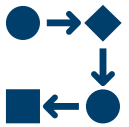
A Modular Digital Engineering Approach to Mission Engineering

MBSE Enabled Decision Making in Defence Symposium
Canberra, 22 August 2024

Overview



Introduction



Mission Engineering Context



A Digital Mission Engineering Framework



Communicating the Model



Broader Applications



Q&A





Introduction

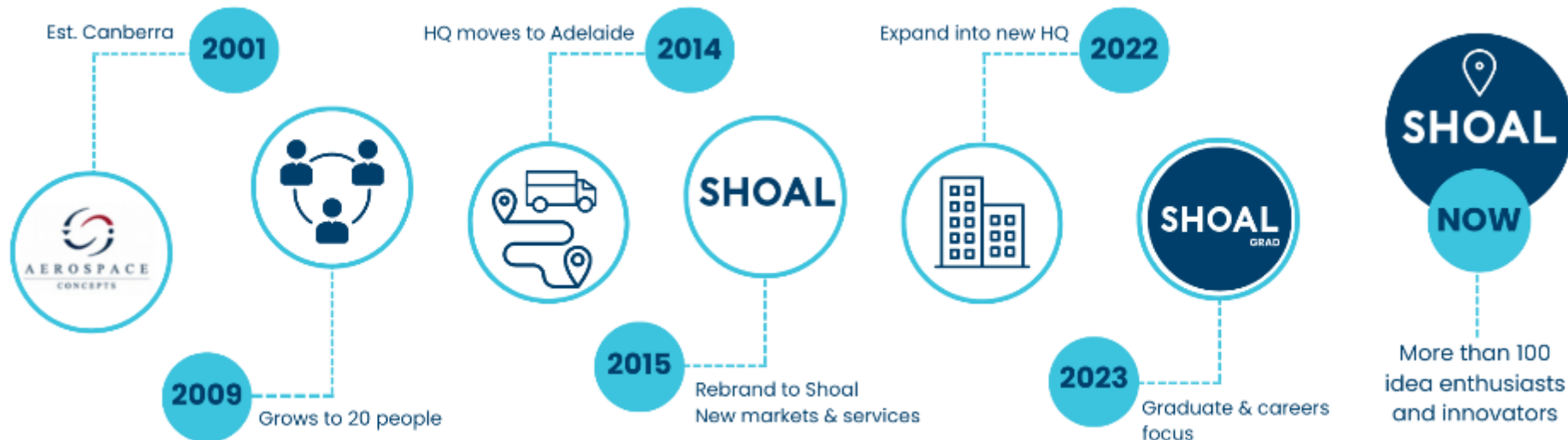
Shoal Group



Shoal Group: Who We Are

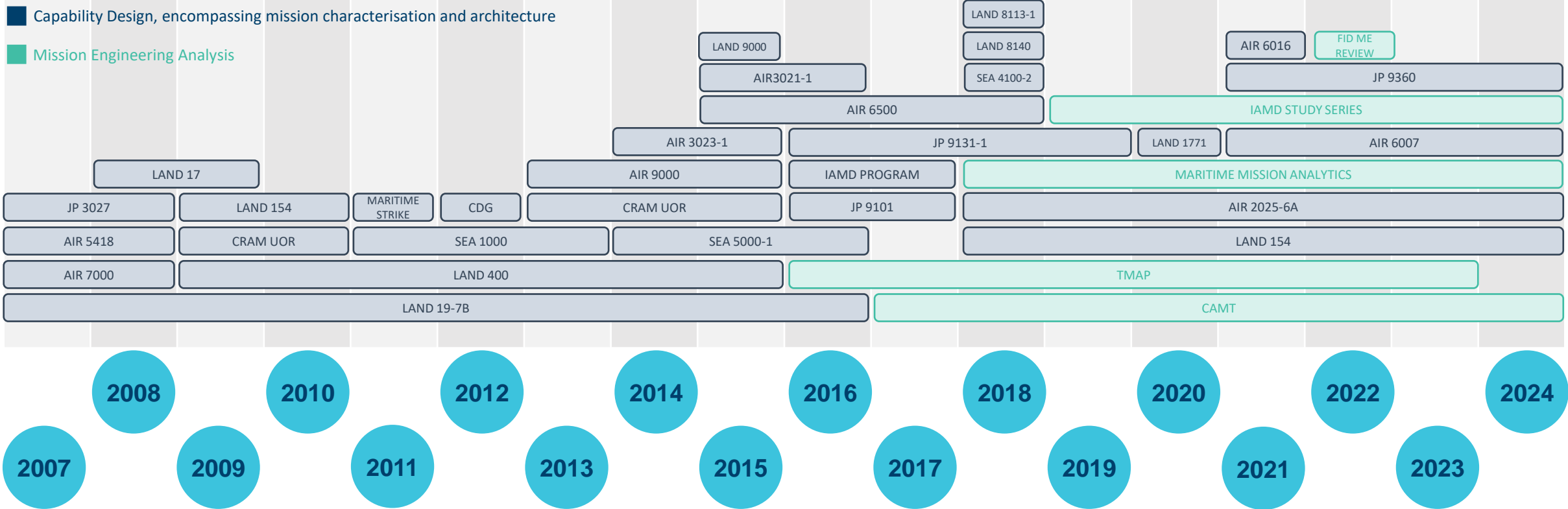
We apply systems thinking to bring about positive change

- Deliver Digital Engineering (DE) based solutions for complex projects in challenging environments for: Defence, Space (civil and military), Transport, Energy, & Infrastructure.
- Shoal has deep, resident Digital Engineering (DE) knowledge, particularly for complex Systems-of-Systems and Mission Engineering analyses, with over 20 years of experience.



Shoal and Mission Engineering

Shoal has organically developed and sustained core Mission Engineering capabilities since 2007, with experience across all major Domains, and their principal Projects and Programs.





Context

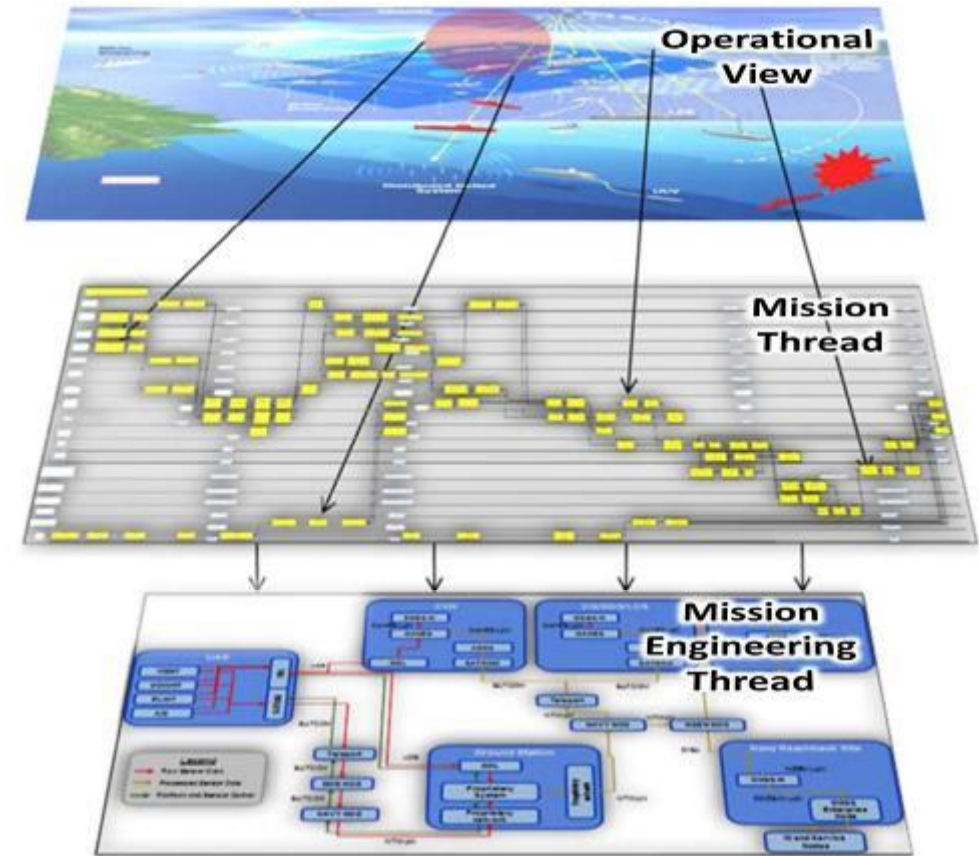
Mission Engineering



Mission Engineering Overview

- *Mission Engineering (ME)*
 - Considers how mission objectives can be delivered by one or more alternative Systems-of-Systems (SoSs)
- Focused on Operational Outcomes
 - Gets engineers and tacticians working more closely together
 - Considers the broad enterprise, while enabling focus on specific missions
- Analysis through
 - Mission Threads
 - Mission Engineering Threads (METs)

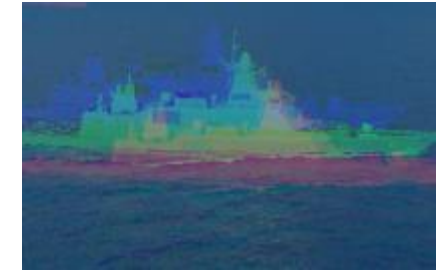
ME combines the tactical insights from operational planning with the structure of SE



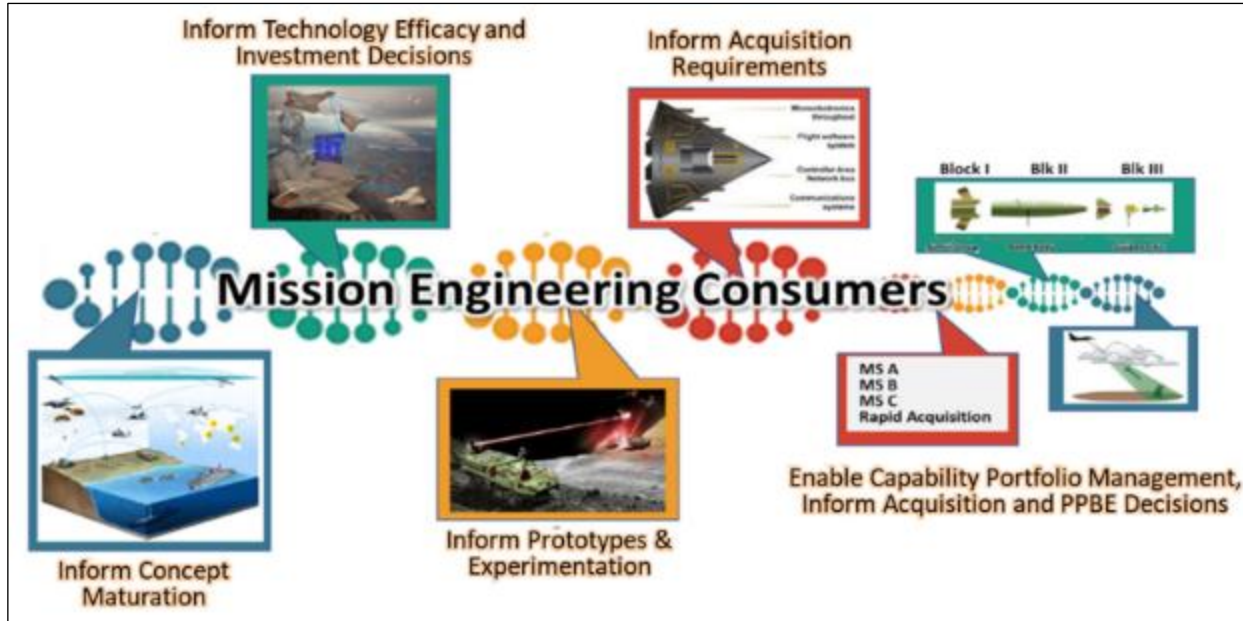
US DoD Mission Engineering Guide – 2023

Mission Engineering Application

- Types of problems
 - Multiple types of systems → SoS
 - SoS to deliver a Mission goal
- Applied from strategic to tactical
 - Force level missions to shape capability
 - Design and analysis of missions with:
 - Current Capability
 - Future Capability and Innovation
 - Far Future



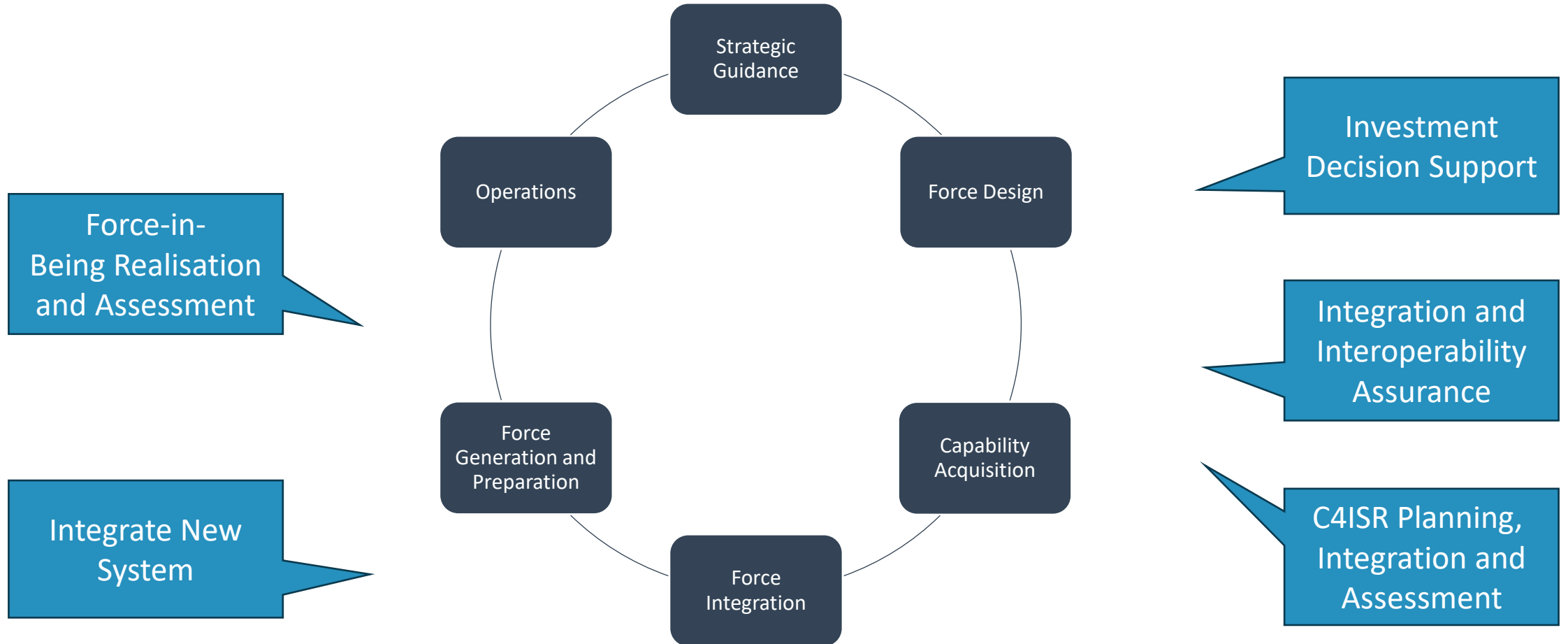
Mission Engineering Purpose and Use Cases



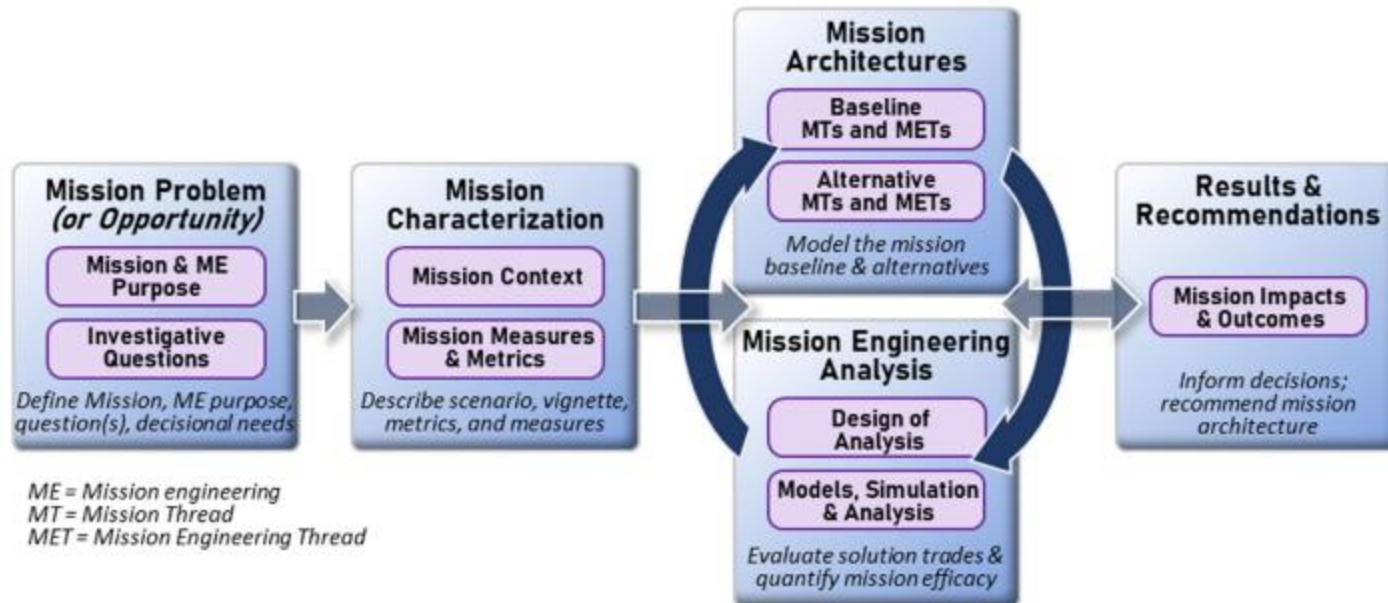
US DoD Mission Engineering Guide – 2023

- Mission Engineering (ME) has many use cases
- Understanding the ME study purpose is key
 - Drives design of the ME study and analysis
 - Ensures focused architecture modelling and analysis
 - Supports later re-use

Key Mission Engineering Use Cases for Defence



US DoD Mission Engineering Process Evolution



US DoD Mission Engineering Guide – 2023 (Version 2.0)

Key Changes from v1.0 to v2.0:

- Updated guide (Oct 2023) informed by experience of ME practitioners
- Increased focus on defining purpose
- Benefits & scalability emphasised
- Methodology revised to show applicability beyond studies – inform acquisition, R&D, SoS integration, and evolve ConOps
- Design of analysis activities updated to reflect lessons learned
- MT & MET emphasised in architecture definition process



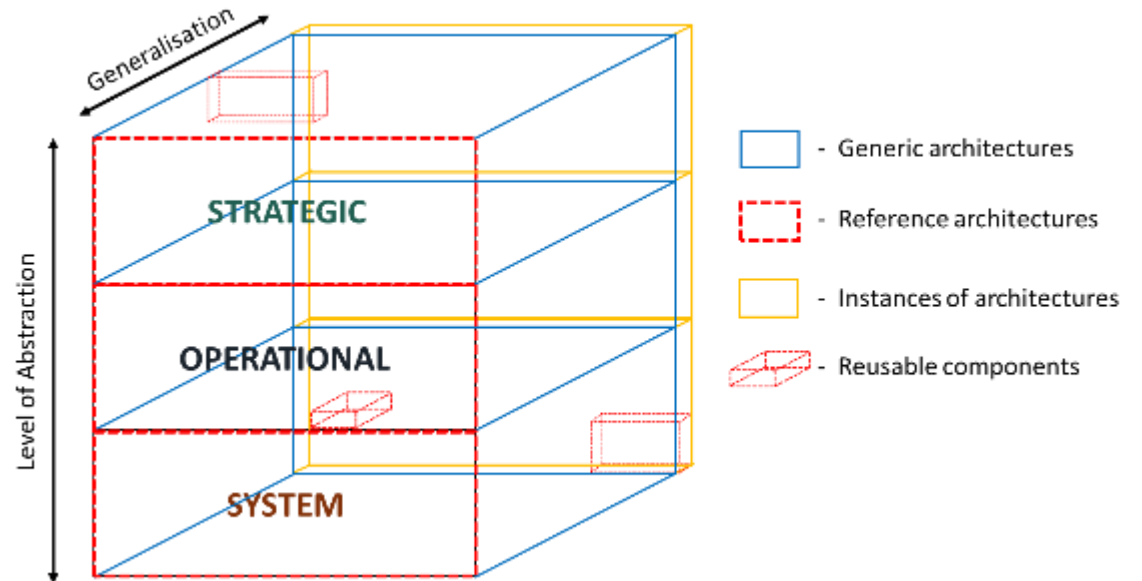
Digital Mission Engineering Framework

Needs, approach and design



Digital ME Framework Needs

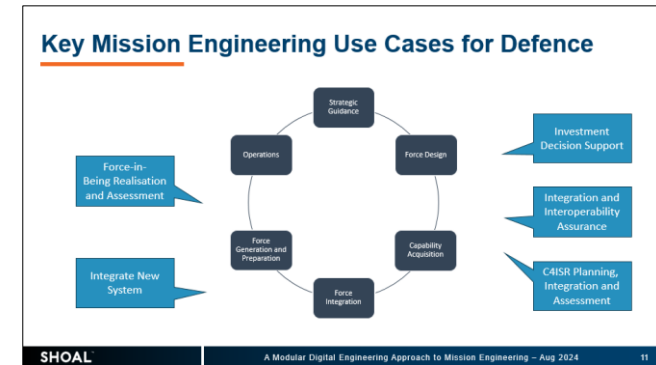
- Suitable for analysis at different levels of Generalisation
 - Force Level
 - Capability Stream
 - Capability (Program/Project)
- Incorporating and tracing between different levels of Abstraction:
 - Strategic
 - Operational
 - System



Adapted from Paternoster 2023

Digital ME Framework Needs

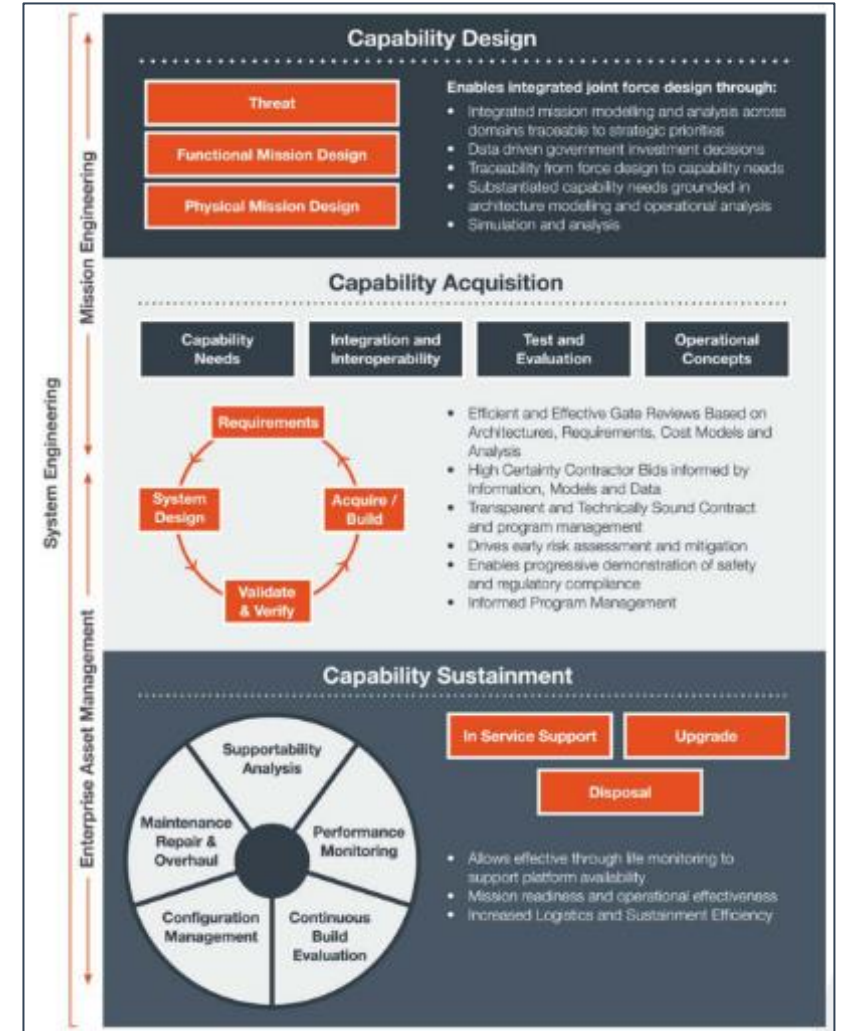
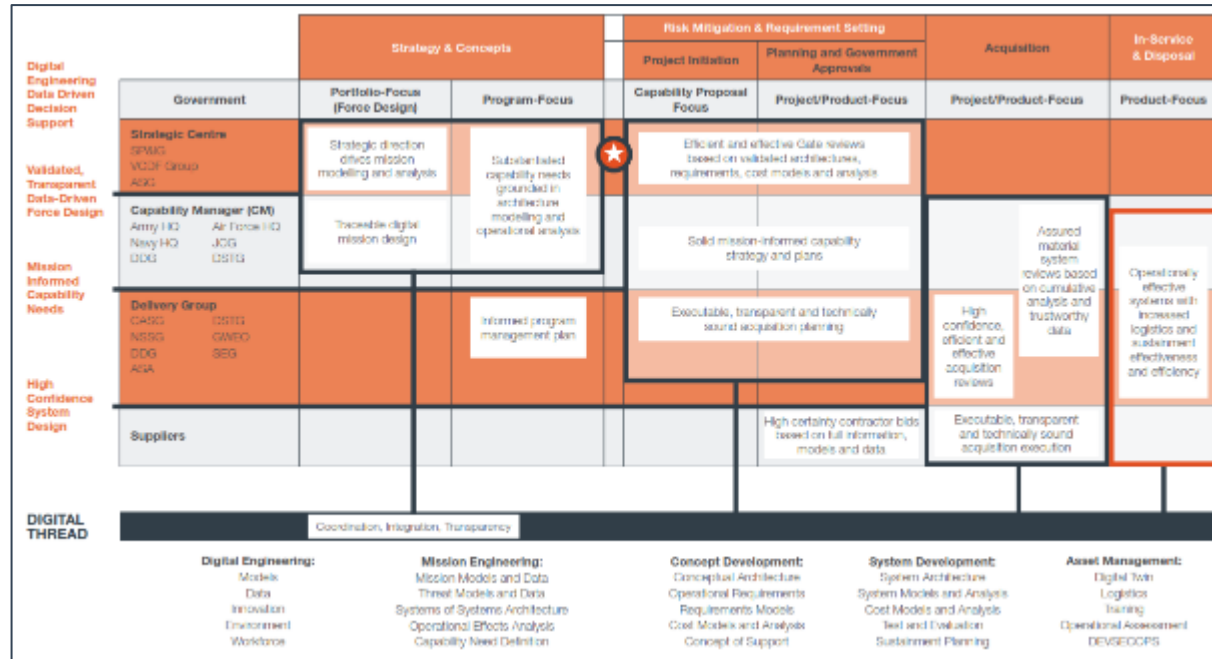
- Scope and flexibility to support different Mission Engineering Use Cases:
 - Investment Decision Support
 - Integration and Interoperability Assurance
 - C4ISR Planning, Integration and Assessment
 - Integrate New System
 - Force-in-Being Realisation and Assessment



- Communicate to decision makers
- Reuse

Digital ME Framework Needs

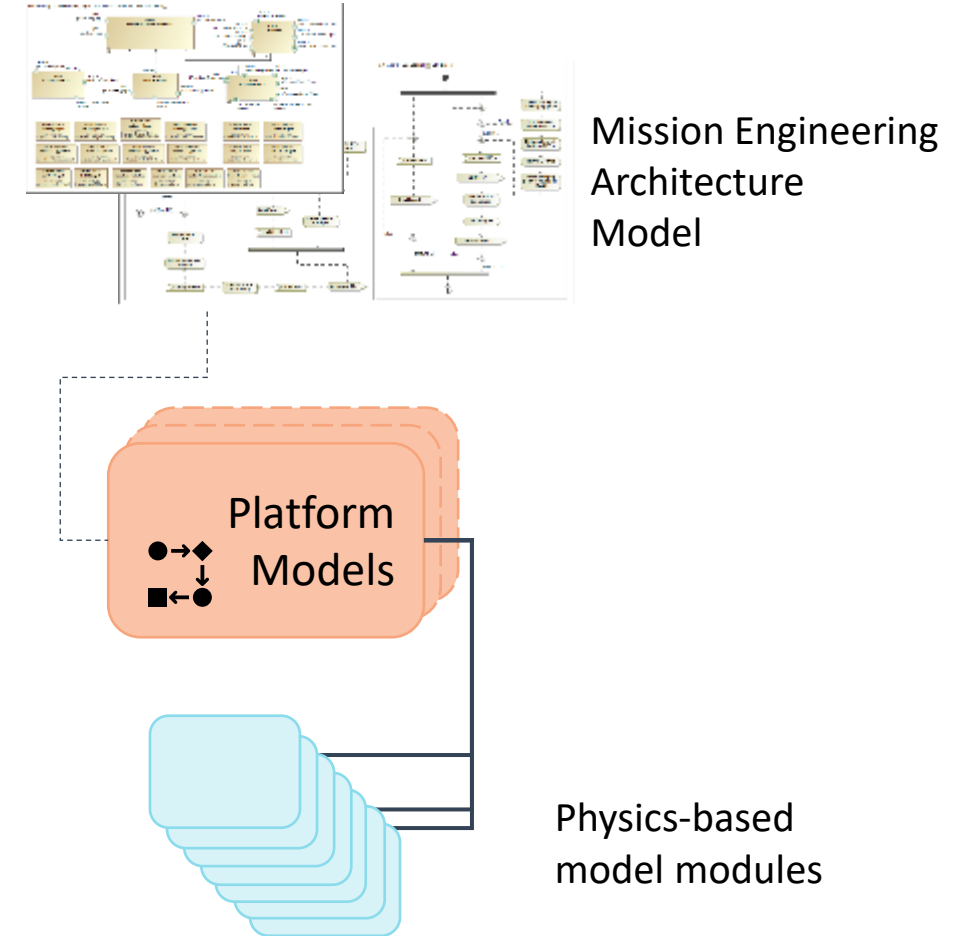
- Support an enterprise view throughout the capability lifecycle



Digital Engineering Strategy 2024

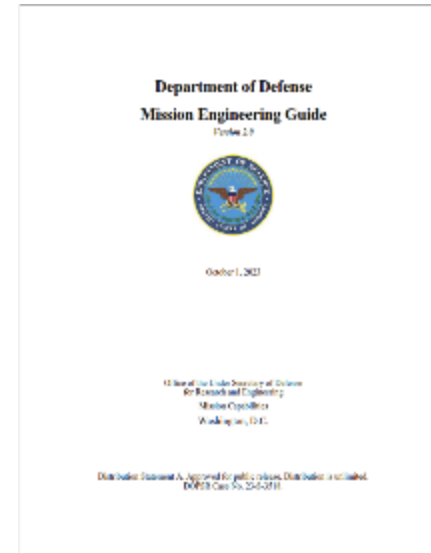
Scalable Approach

- Resources are limited
- Apply learnings from case studies
- Need a rapid and austere approach that
 - Focuses work on the study purpose
 - Focuses on Missions and Mission Threads of interest
 - Enables use of common MBSE tools
 - Based on a reusable library of modules
 - Tailorable, low cost, easily assembled
- Employ a DE environment that supports:
 - Curation and re-use of mission and mission thread libraries, as well as platform behaviour models
 - Rapid assembly and refinement of Mission Engineering Threads for baseline and alternative architecture configurations.

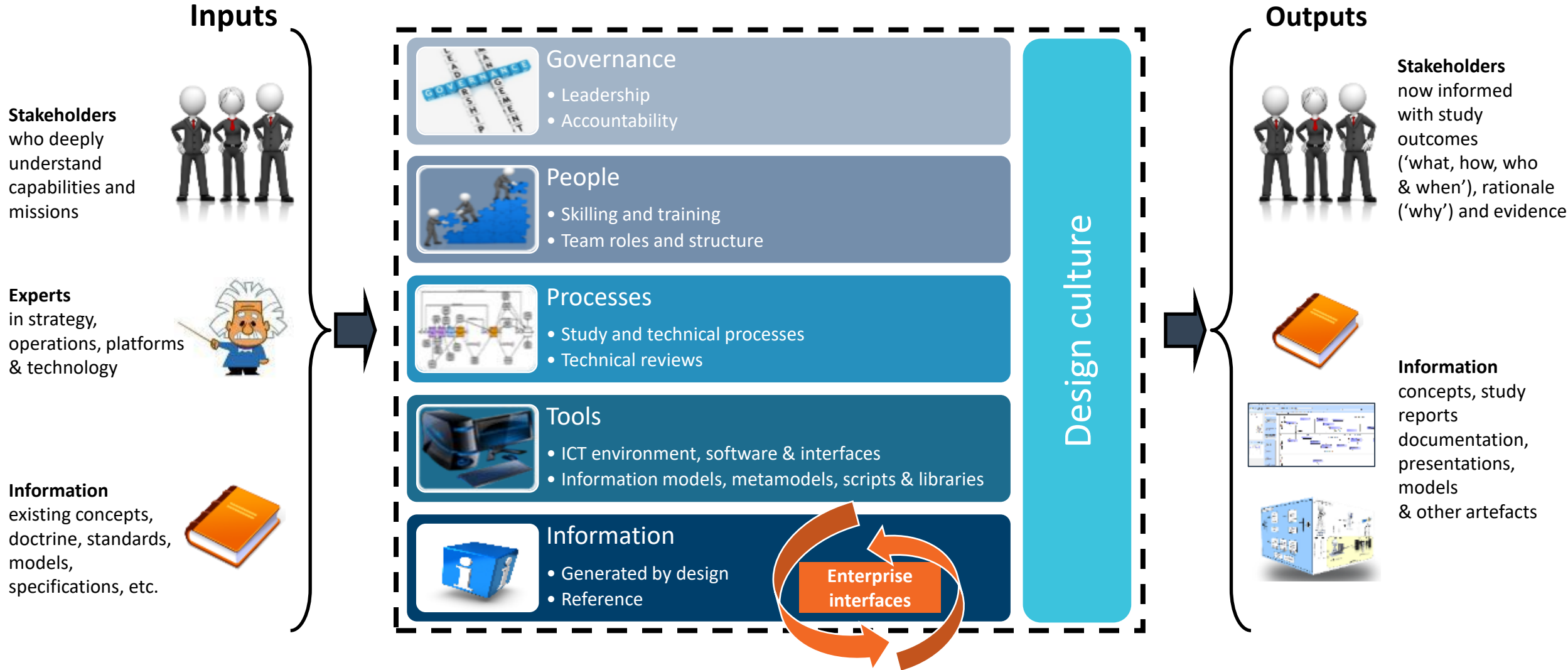


Digital Engineering Environment for Success

- Use common tools and frameworks across Defence and Industry
- Adopt and adapt learnings from US DoD and US DE implementation
- Apply a consistent approach
 - Defined metamodel and process
 - Promote model library curation and reuse
- Build a ME **Capability** ...

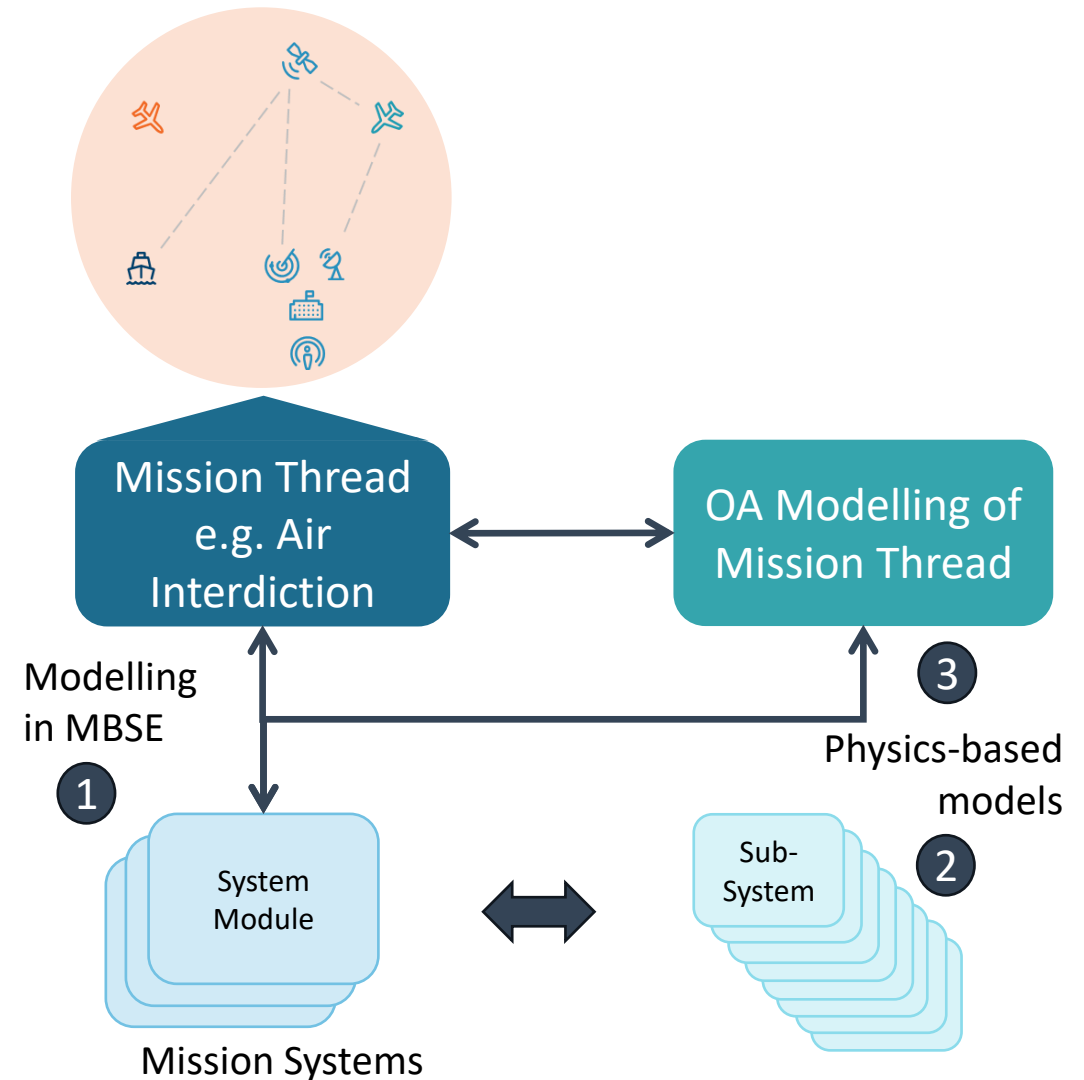


Digital Mission Engineering Capability



ME Implementation Using Digital Engineering

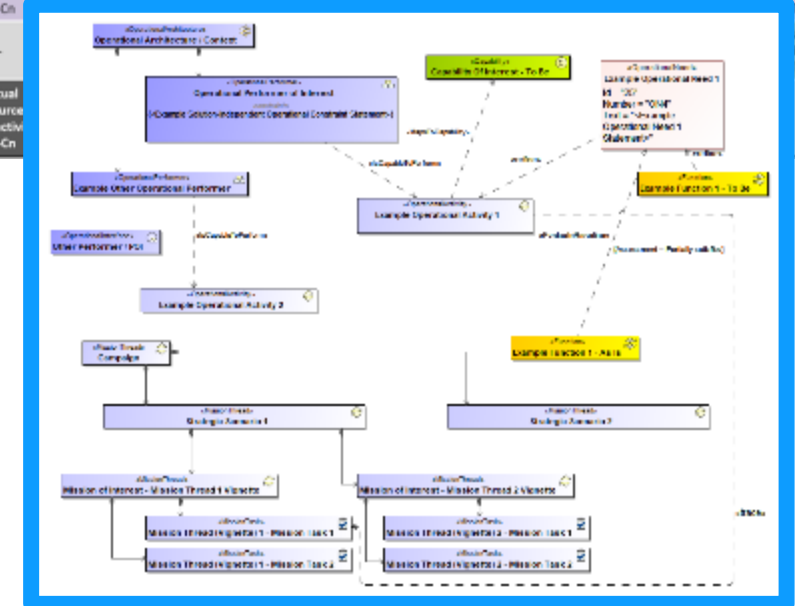
1. Mission behavioural and structural architecture
2. Mission Engineering Analysis
3. Operations Analysis (OA)



UAF Implementation

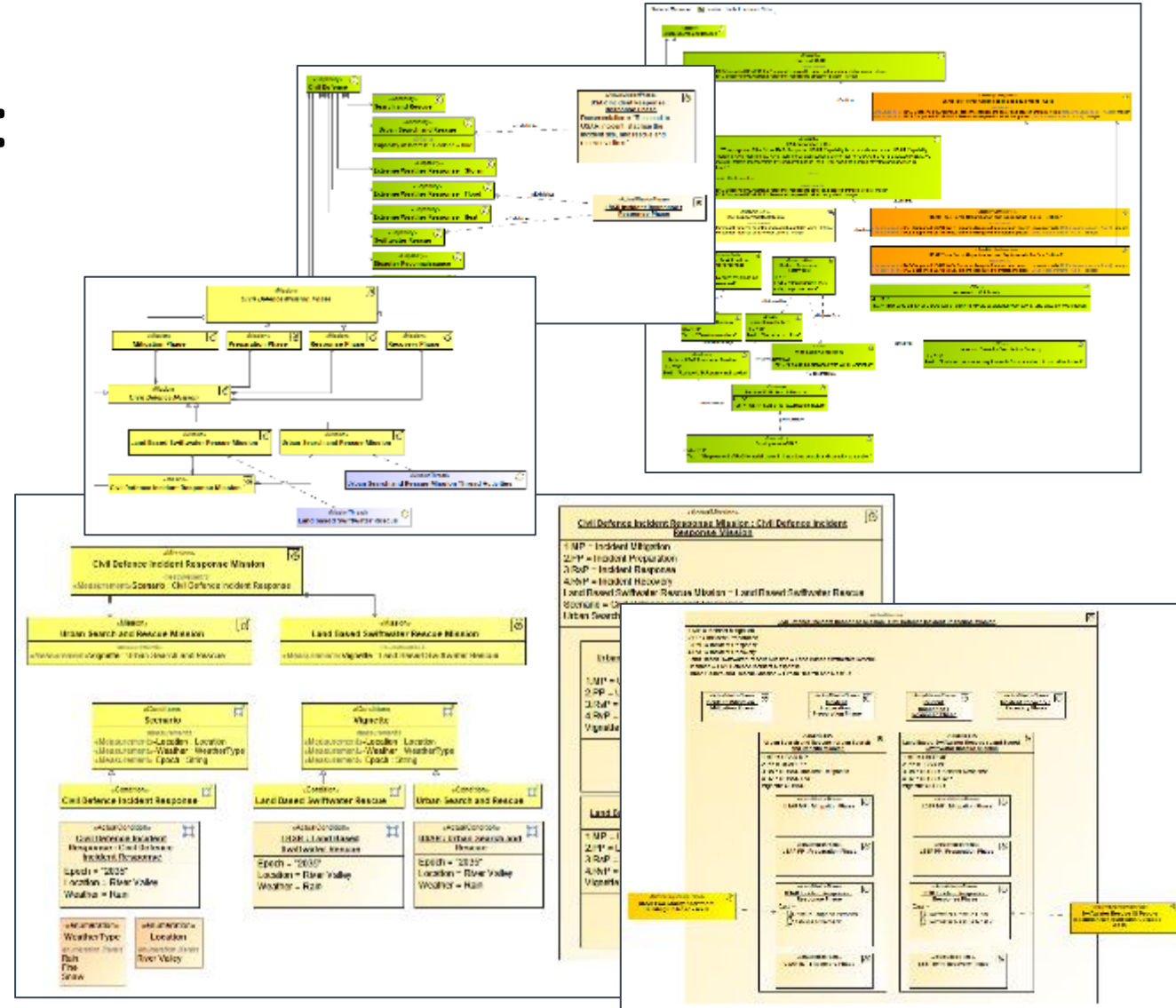
- Select Domains and Viewpoints
- Defined profile, metamodel
- Defined template, adaptable to different levels of generalisation
- Package structure to promote modular, reusable model elements.

UAF	Motivation Mv	Taxonomy Tx	Structure Sr	Connectivity Cn	Processes Pr	States St	Sequences Sq	Information If	Parameters Pm	Constraints Ct	Roadmap Rm	Traceability Tr
Architecture Management Am	Architecture Principles Am-Mv	Architecture Extensions Am-Tx	Architecture Views Am-Sr	Architectural References Am-Cn	Architecture Development Method Am-Pr	-	-	Dictionary Am-If	Architecture Parameters Am-Pm	Architecture Constraints Am-Ct	Architecture Roadmap Am-Rm	Architecture Traceability Am-Tr
Summary & Overview Sm-Ov												
Strategic St	Strategic Motivation St-Mv	Strategic Taxonomy St-Tx	Strategic Structure St-Sr	Strategic Connectivity St-Cn	Strategic Processes St-Pr	Strategic States St-St	-	Strategic Information St-If	-	Strategic Constraints St-Ct	Strategic Roadmaps: Deployment, Phasing St-Rm-D, -P	Strategic Traceability St-Tr
Operational Op	-	Operational Taxonomy Op-Tx	Operational Structure Op-Sr	Operational Connectivity Op-Cn	Operational Processes Op-Pr	Operational States Op-St	Operational Sequences Op-Sq	-	-	Operational Constraints Op-Ct	-	Operational Traceability Op-Tr
Services Sv	Requirements Rq-Mv	Services Taxonomy Sv-Tx	Services Structure Sv-Sr	Services Connectivity Sv-Cn	Services Processes Sv-Pr	Services States Sv-St	Services Sequences Sv-Sq	Operational Information Model Op-If	Environment En-Pm	Services Constraints Sv-Ct	Services Roadmap Sv-Rm	Services Traceability Sv-Tr
Personnel Ps	-	Personnel Taxonomy Ps-Tx	Personnel Structure Ps-Sr	Personnel Connectivity Ps-Cn	Personnel Processes Ps-Pr	Personnel States Ps-St	Personnel Sequences Ps-Sq	-	and Measurements Me-Pm	Competence, Drivers, Performance Ps-Ct-C, -D, -P	Availability, Evolution, Forecast PS-Rm-A, -E, -F	Personnel Traceability Ps-Tr
Resources Rs	-	Resources Taxonomy Rs-Tx	Resources Structure Rs-Sr	Resources Connectivity Rs-Cn	Resources Processes Rs-Pr	Resources States Rs-St	Resources Sequences Rs-Sq	Resources Information Model Rs-If	and Risks Ri-Pm	Resources Constraints Rs-Ct	Resources Roadmaps: Evolution, Forecast Rs-Rm-E, -F	Resources Traceability Rs-Tr
Security Sc	Security Controls Sc-Mv	Security Taxonomy Sc-Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr	-	-	-	-	Security Constraints Sc-Ct	-	Security Traceability Sc-Tr
Projects PJ	-	Projects Taxonomy PJ-Tx	Projects Structure PJ-Sr	Projects Connectivity PJ-Cn	Projects Processes	-	-	-	-	-	Projects Roadmap	Projects Traceability PJ-Tr
Standards Sd	-	Standards Taxonomy Sd-Tx	Standards Structure Sd-Sr	-	-	-	-	-	-	-	-	Standards Traceability Sd-Tr
Actual Resources Ar	-	-	Actual Resources Structure Ar-Sr	Actual Resources Connectivity Ar-Cn	-	-	-	-	-	-	-	Actual Resources Traceability Ar-Tr



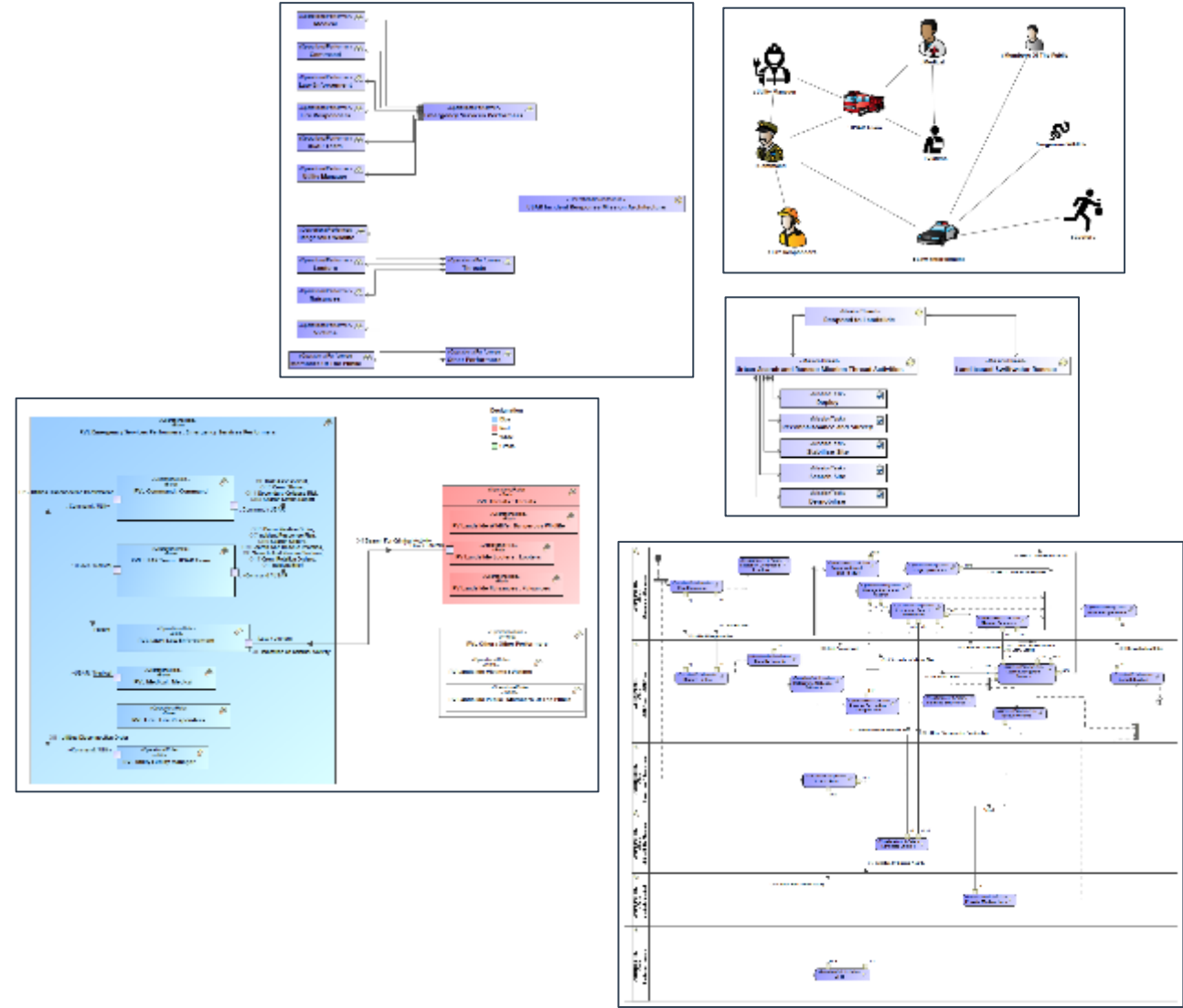
Capability and Mission Definition

- Strategic viewpoints define:
 - Capabilities
 - Strategic Goals, Challenges and Motivation
 - Measures (Cols, MoEs)
 - Missions
 - Location
 - Epoch
 - Conditions



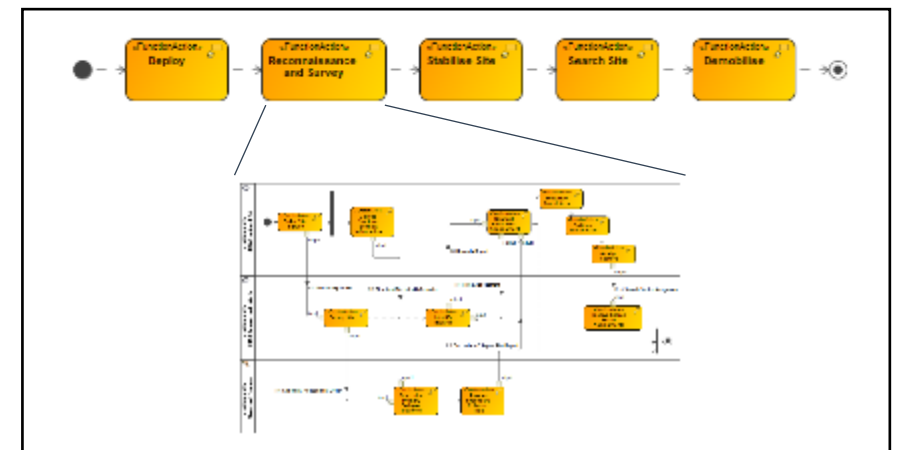
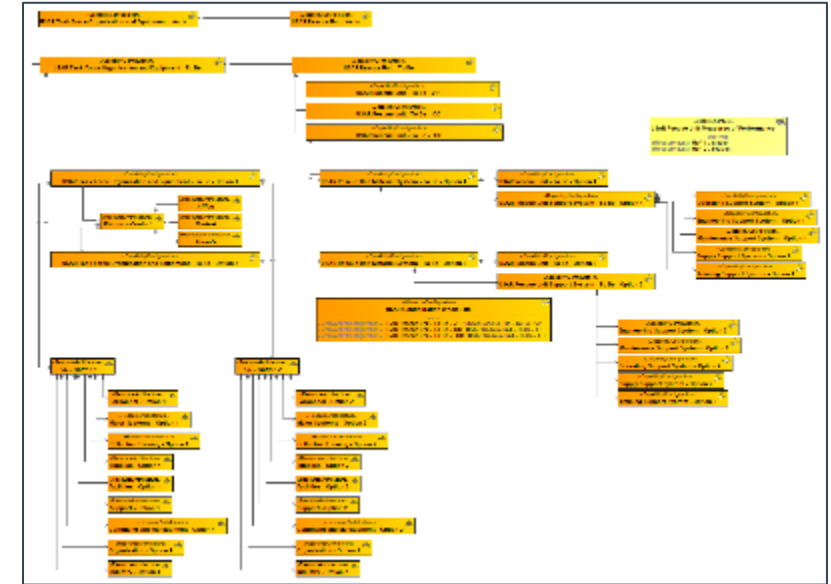
Operational Mission Architecture

- Operational viewpoints define:
 - Operational Performers
 - Mission Threads, Tasks and Operational Activities
 - Operational Needs and Constraints
 - Operational interfaces and information exchange



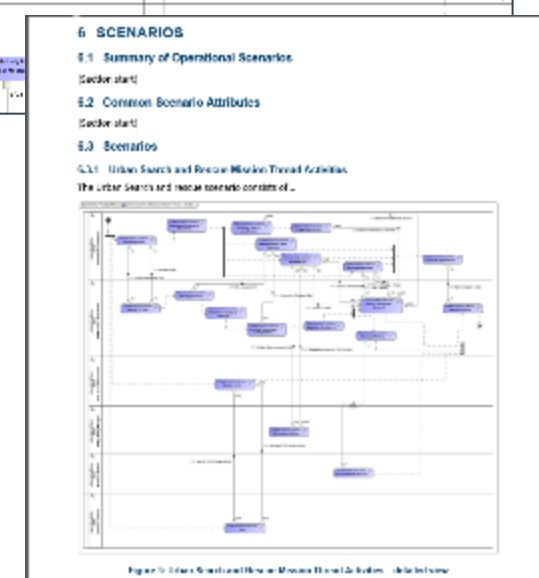
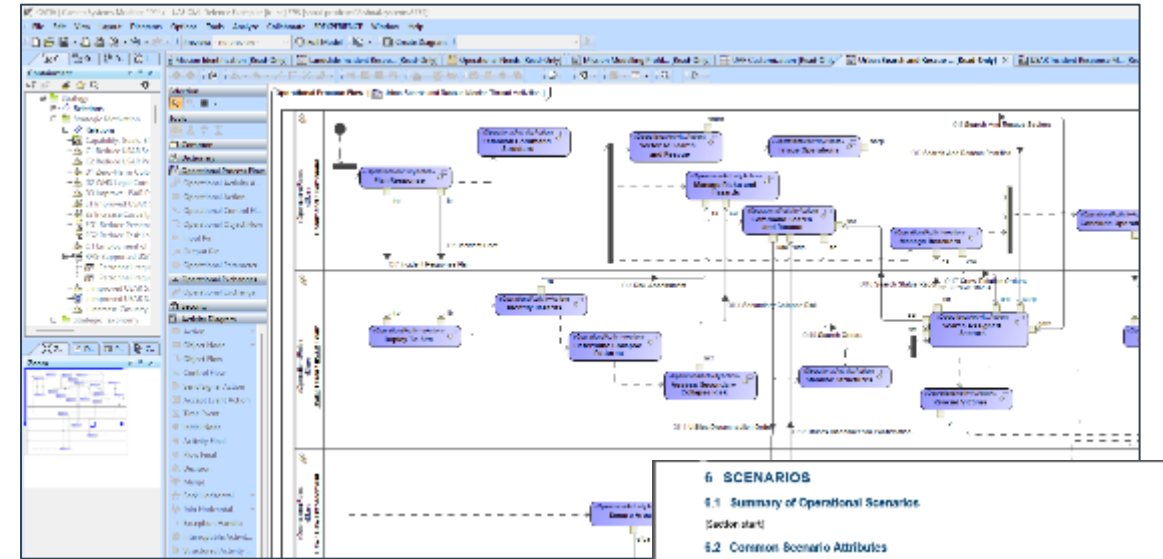
Systems/Resources Mission Architecture

- Resources/Systems, Services and Personnel viewpoints define:
 - Systems of Systems
 - Configurations of interest
 - As Is / To Be (multiple alternatives)
 - Mission Engineering Threads
 - System, FIC, support requirements and constraints
 - System interfaces and information exchange



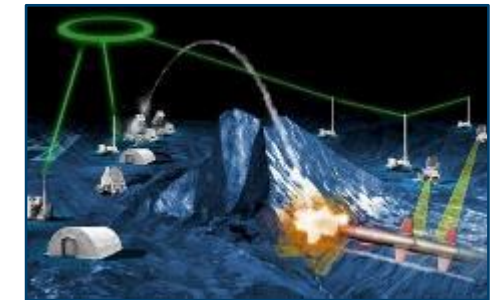
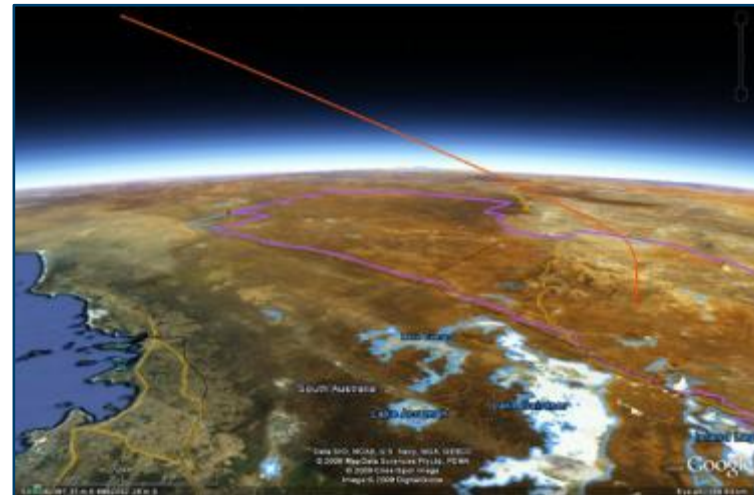
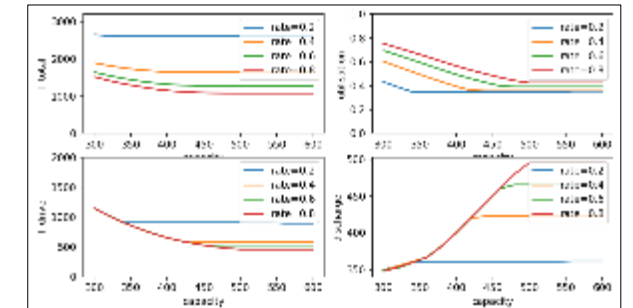
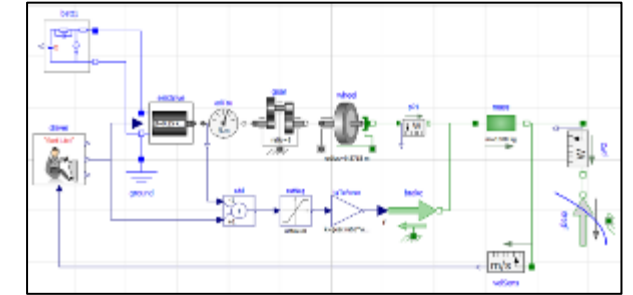
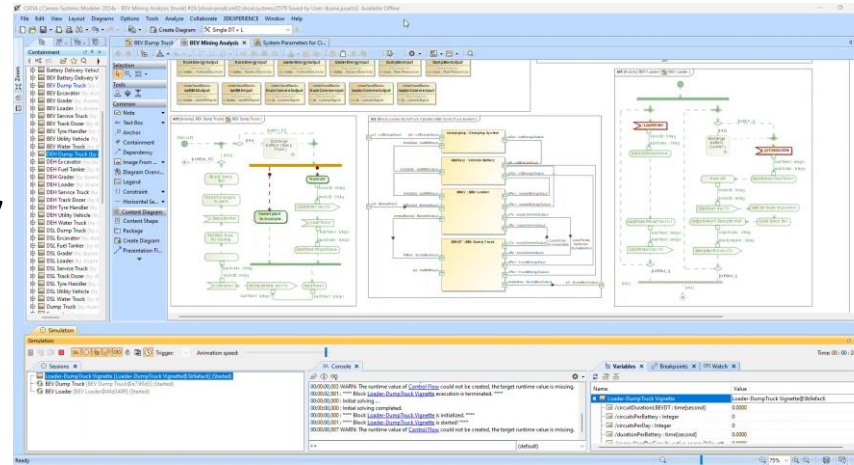
Artefact Generation from the Model

- Document-centric information cannot be consistently maintained
- Documents should be automated reports of modelled information
- Tailored outputs for different stakeholders and decision makers



Mission Engineering Analysis DE Environment

- Analysis tools and methods fit-for-purpose for the study
 - Cameo/Catia Magic
 - OpenModelica
 - MathCAD
 - AFSIM
 - DAPSIM
 - STK
 - ...



Digital Mission Engineering Framework

Broader application

Other Industrial Energy Transition Applications

- Transport decarbonisation
 - Heavy road transport (EV & Hydrogen)
 - Rail electrification
 - Air (Hydrogen and Sustainable Aviation Fuels (SAF))
- Agricultural & Forestry equipment
- Green energy generation and distribution
 - Solar, wind, nuclear
 - Hydrogen
- Green chemicals: ammonia, methanol
- Decarbonising energy-intensive heavy industry – e.g. smelting/refining resources such as iron and aluminium



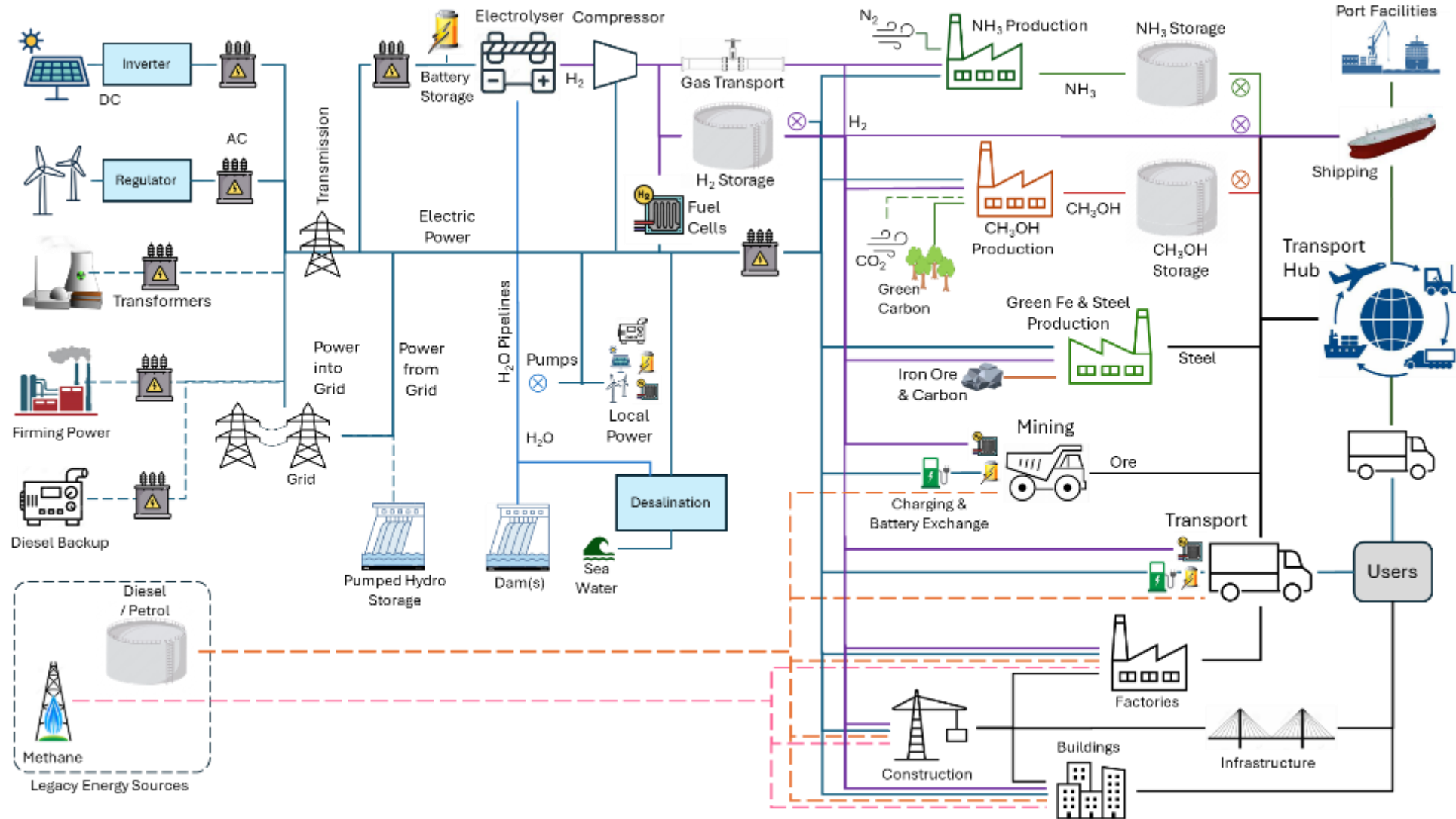
Example: Energy Decarbonisation in Mining

- Transition to green energy is accelerating
 - Increased regulation & compliance
 - Increased focus on sustainability
- Mining industry is moving to electrification
 - Diesel powered to electric powered vehicles
- How to accelerate effective selection of future mining battery electric vehicles (MBEVs)?



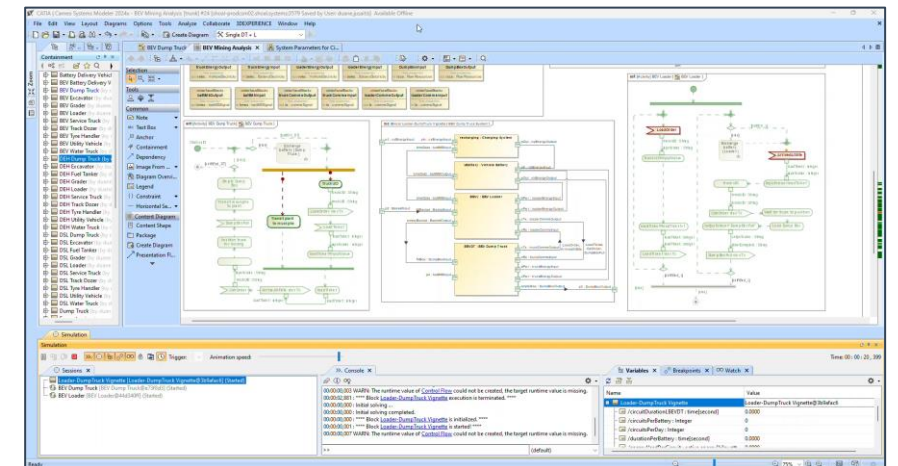
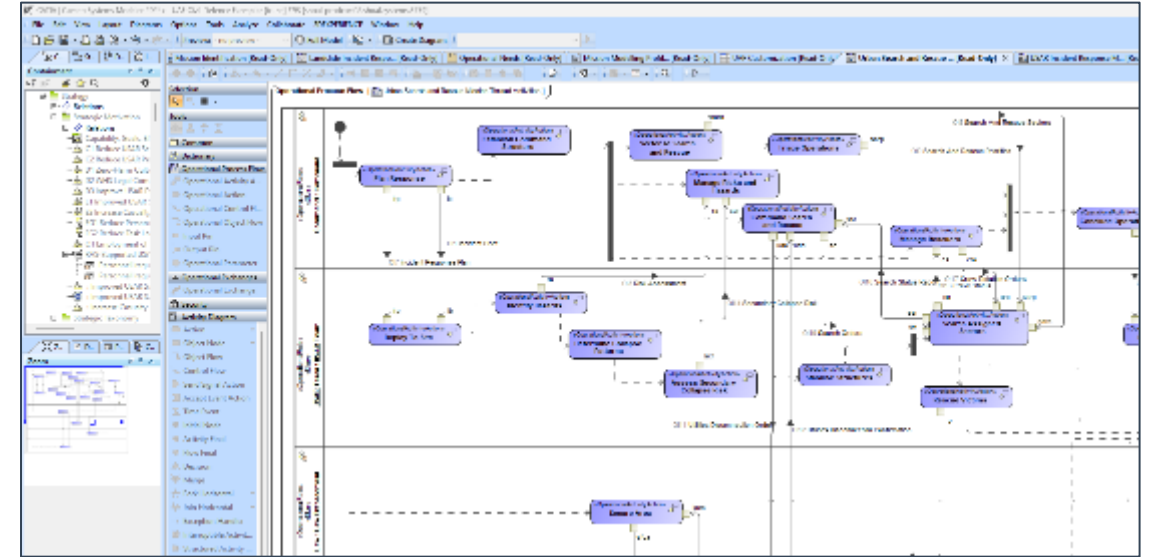
➔ *FastSEAT: Fast Selection of EVs for Accelerated Transition*

Example: Energy Decarbonisation SoS Analysis



Summary

- Key considerations
 - Focus on purpose
 - Design for broad Mission Engineering use cases
 - Scalable, modular approach
 - Use of common industry tools and standards
 - Consistent modelling and reporting



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Questions and comments



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