Shared Modeling Framework

An Approach for System of Systems Modeling Reuse

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Background

- MITRE sponsors are pursuing Mission Engineering (ME) as a means to address their rapidly evolving challenges
- Short cycle times preclude repeated development of models from scratch
- The MITRE Corporation developed a Shared Modeling Framework to mitigate this issue
  - Based on experimentation to determine the appropriate approach to reuse over multiple, real-world mission engineering efforts
- Here we present our approach to constructing the Shared Modeling Framework and our lessons learned

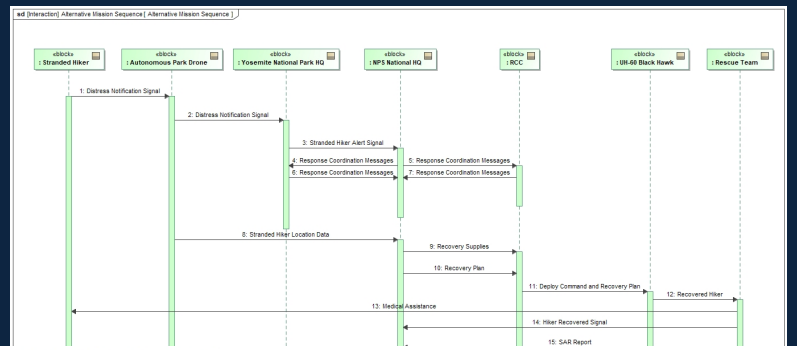
Approach - Mission Engineering (ME) with Digital Engineering (DE)

- Applied Mission Engineering to characterize and evaluate complex system of systems (SoS) behavior and performance in a selected mission scenario.
- Leveraged Digital Engineering processes and tools (Cameo/MagicDraw) to model the SoS, mission activities, and interfaces required to execute a given mission.

System Definitions

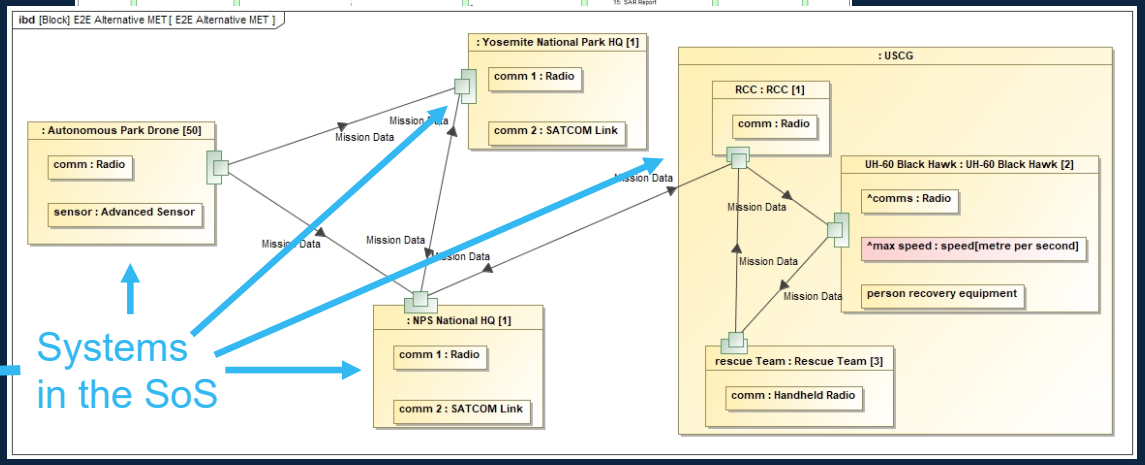
#	Name	Part
1	Advanced Sensor	Azimuth FOV = -90 deg 90 deg Elevation FOV = -90 deg 90 deg
2	Autonomous Park Drone	MissionComms : MissionComms sensor : Advanced Sensor comm : Radio
3	UH-60 Black Hawk	person recovery equipment MissionComms : MissionComms

Mission Sequence for a Selected Scenario



Systems in the SoS

System Exchanges



End-to-End Mission Architecture for a Selected Scenario

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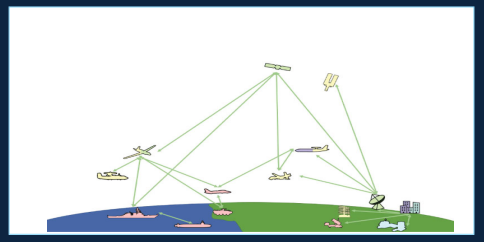
ME with DE Workflow

Obtain Kill Chain Source Information (i.e., OPLAN) For selected Scenario



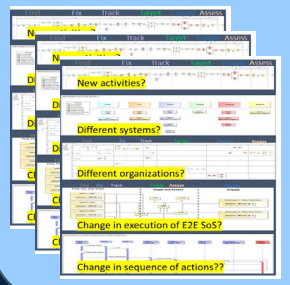
Informs

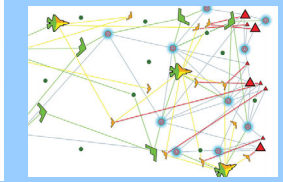
Baseline METS

Baseline Kill Web

Provides basis for

Alternatives Represented as Changes in the METs

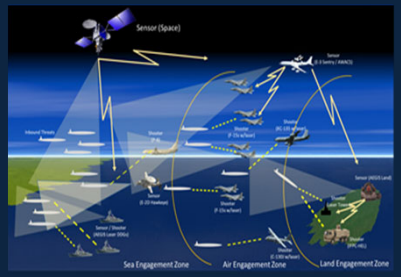




Represented in AFSIM

Represented in AFSIM

Alignment with Scenario Documentation (i.e., JFOS)



Informs

Analysis of Baseline Compared to Concept on Mission Outcome Metrics In Selected Scenario

Baseline

Alternative

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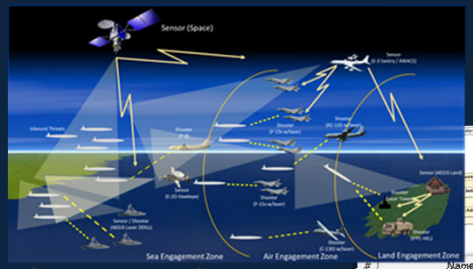
Challenges with Reusing Digital Mission Models

Digital Engineering tools enable reuse of mission model elements, but mission engineering practitioners need to consider the following challenges…

- Characterization of systems depends on the selected mission scenario.
  - *What system data can be leveraged across different mission engineering efforts?*
  - *What modeling abstractions can be leveraged to rapidly model new mission systems?*
- Mission activities and sequence of execution depends on SoS configuration used in a selected mission scenario.
  - *How can sequences of mission activities (i.e., mission threads) be leveraged in different mission scenarios with different sets of SoS implementations?*
- Reused model elements need to be configuration managed such that changes are propagated.
  - *How can we streamline model reuse so that configuration management is not a heavy burden?*

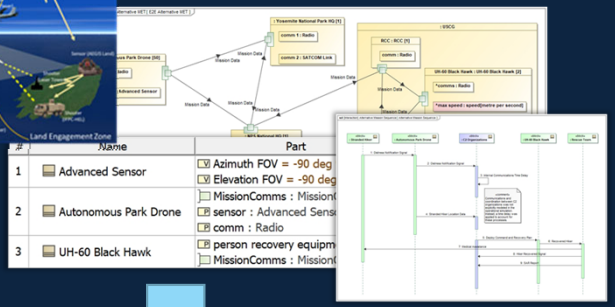
Approach to Effectively Reuse Digital Mission Models

Developed a detailed digital Mission Model in Cameo/MagicDraw for ME study in a selected scenario.



Selected Scenario

Digital Mission Model



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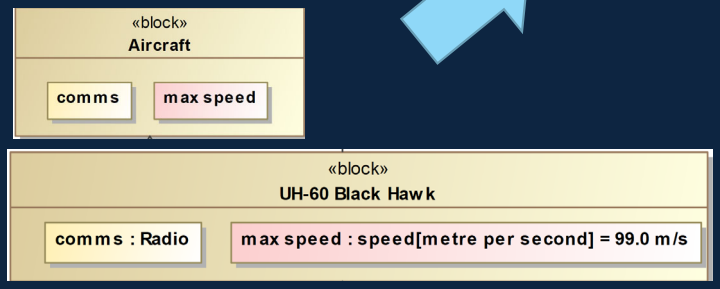
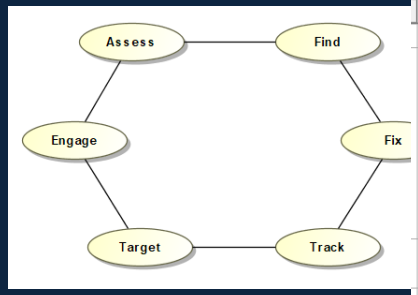
Abstracted common classifiers and defined these in a Seed Model.

Abstracted specific systems and top-level mission threads for reuse across different scenarios and defined these in a Base Model.



Reused and tailored model elements to rapidly build Mission Models for subsequent ME studies. Expanded Seed Model and Base Model with new classifiers, systems, and mission activities as needed with each study.



Name	Part
AWACS	
B-52	wingspan : length[metre] = 56.4 m length : length[metre] = 48.5 m height : height[metre] = 12.4 m empty_mass : mass[kilogram] = 83250.0 kg payload_mass : mass[kilogram] = 31500.0 kg maximum_speed : speed [mph] = 650.0 mph maximum_altitude : height[metre] = 15151.5 m engine : TF33-P-3/103 turbofan [8]
BCT	human Eye : Human Eye BCT Comms : BCT Comms
BSG	sensor : BSG EO/IR Sensor [0..*]
Destroyer	
F-15	maximum_speed : speed [kph] = 3017.0 length : length[metre] = 19.45 m height : height[metre] = 5.65 m wingspan : length[metre] = 13.05 m empty_mass : mass[kilogram] = 20411.0 kg sensor : APG-70 [1]

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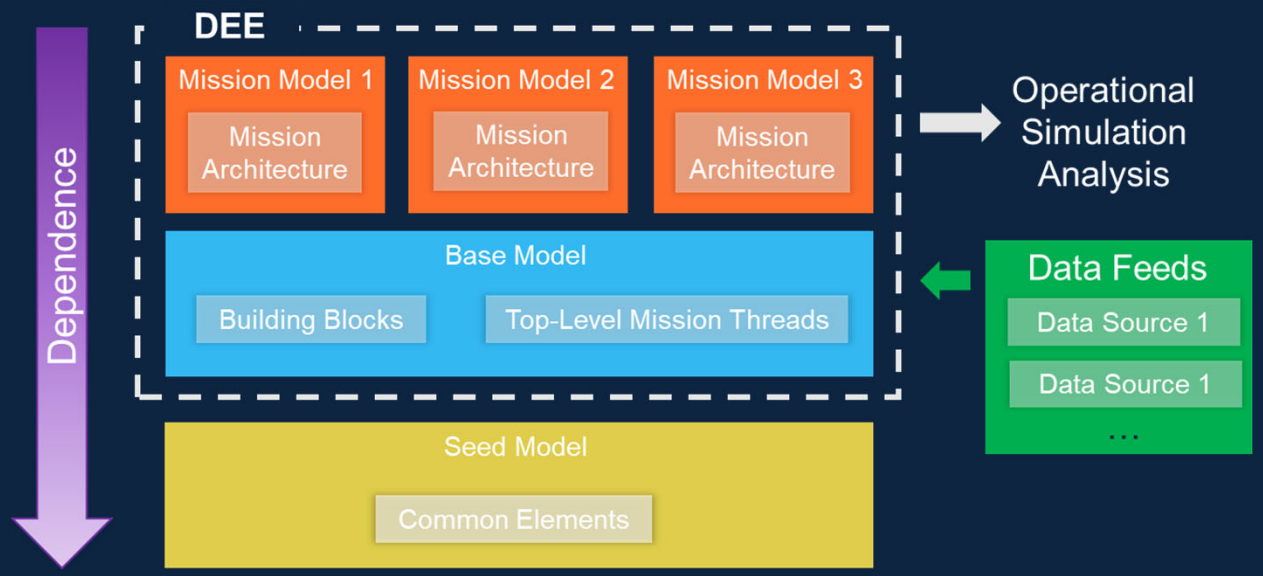
Shared Modeling Framework

- The Digital Engineering Environment (DEE) is a set of SySML models developed in the Model-Based Systems Engineering (MBSE) tool Cameo built on the MITRE Enterprise Shared Modeling Framework
- Reusable model elements are maintained in the base model as building blocks and top-level mission threads
- Mission models use the base model and other data to address different ME studies
- The framework supports data feeds to operational simulations and tools for specific analyses



- The object-oriented nature of MBSE tools like Magic Systems of Systems Architect / Cameo / MagicDraw is key to enabling reuse in the Shared Modeling Framework
- Objects (i.e., “Blocks” in SysML) and inheritance relationships are leveraged to reuse elements from the Seed and Base Models
- The same Block can be instantiated in various mission architectures across different mission scenarios

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How to Leverage the Shared Modeling Framework to Rapidly Develop Mission Models

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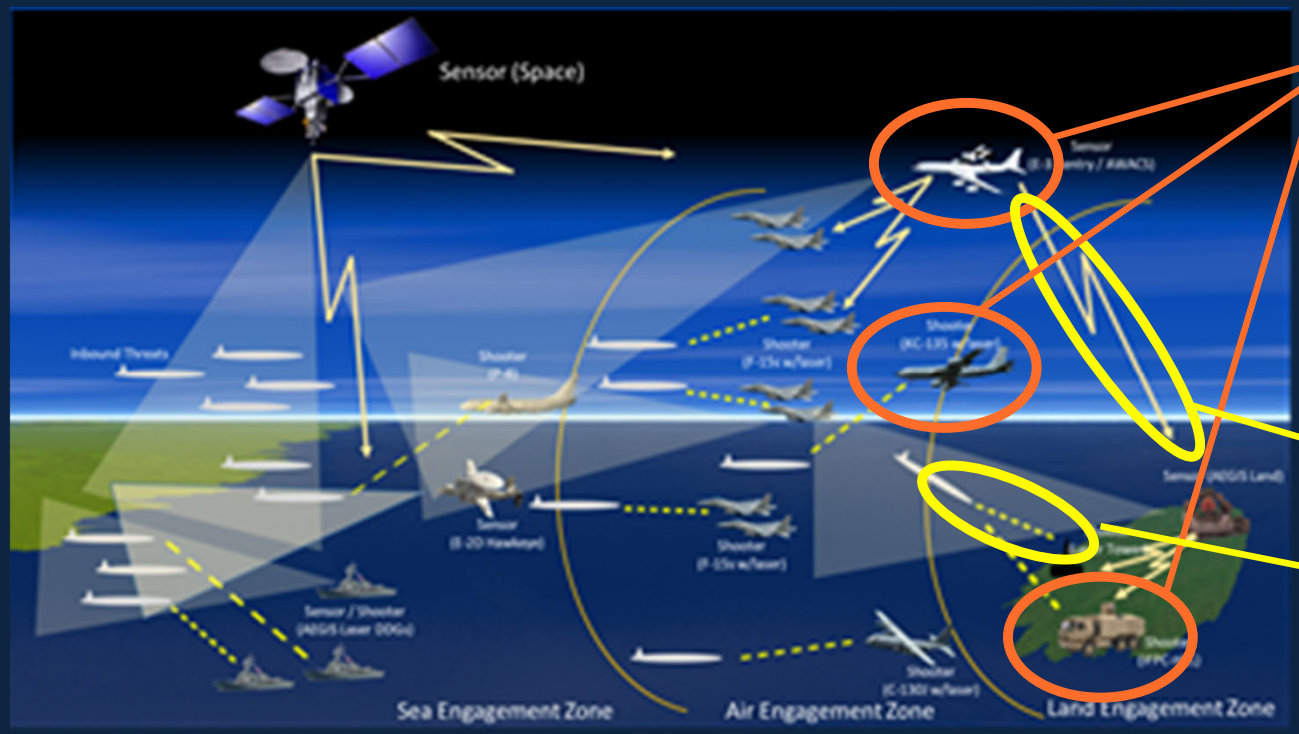
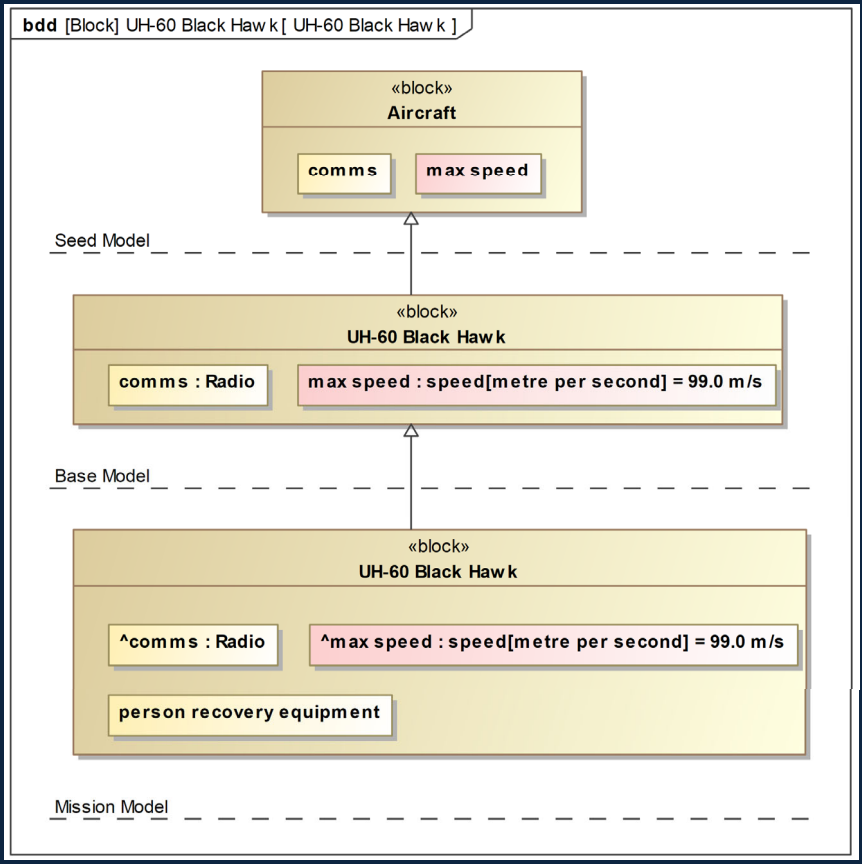
Examine the Selected Scenario



- Identify mission systems
- Determine what mission(s) are included in the scenario
  - Define mission activities and sequence of execution
  - Identify system-to-system interactions and exchanges

- Determine what systems and mission activities can be reused from the Base Model
- Must validate that the identified systems and activities in the Base Model are fit for purpose in the Mission Model

Reuse Systems from the Shared Modeling Framework



Seed Model – Element Classifier

- Contains generic properties for a class of systems and serves as “blueprints.”

Base Model – Baseline System Definition

- Specifies properties inherited from the Seed Model classifier for specific systems.
- Properties are independent of scenario context.

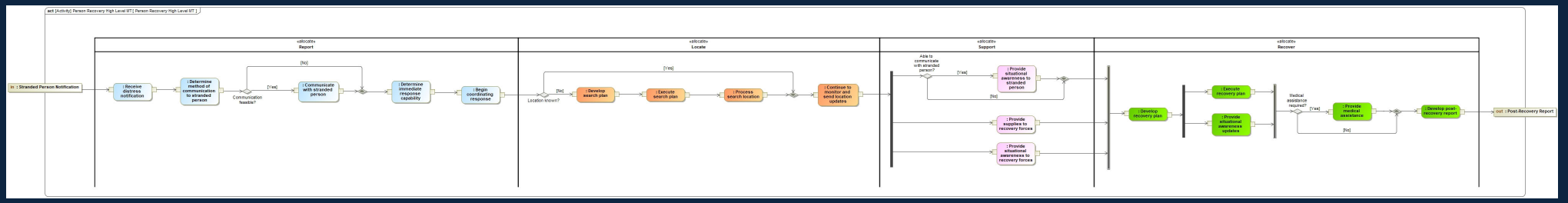
Mission Model – Mission System Definition

- Redefines properties inherited from the Base Model system to reflect changes for the scenario context.
- Adds new properties as needed for the scenario context.

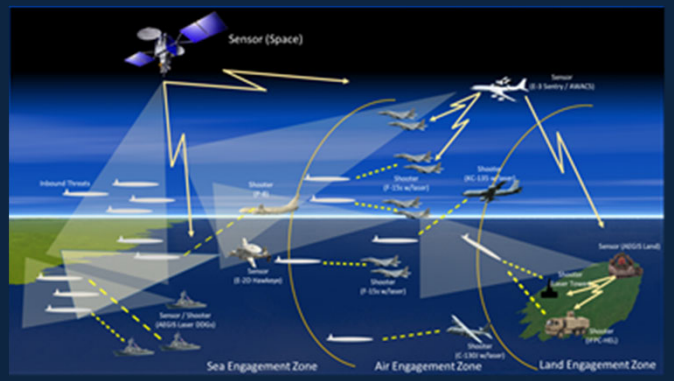
Reuse Mission Threads from the Shared Modeling Framework

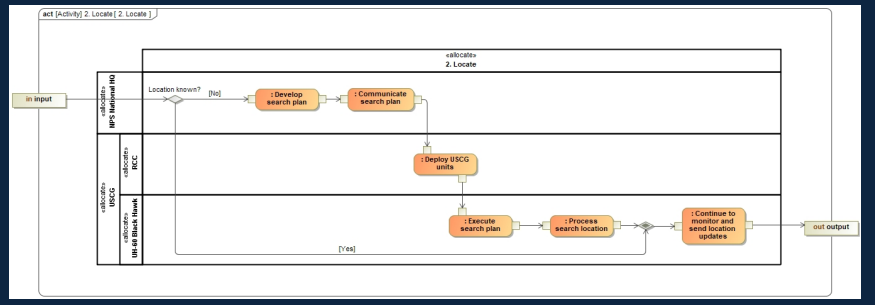
Mission Thread – lays out the set of actions needed to accomplish the mission

Report | Locate | Support | Recover



Insert mission thread into selected scenario





Tailor the thread for the selected scenario context and allocate mission activities to systems to create a Mission Engineering Thread

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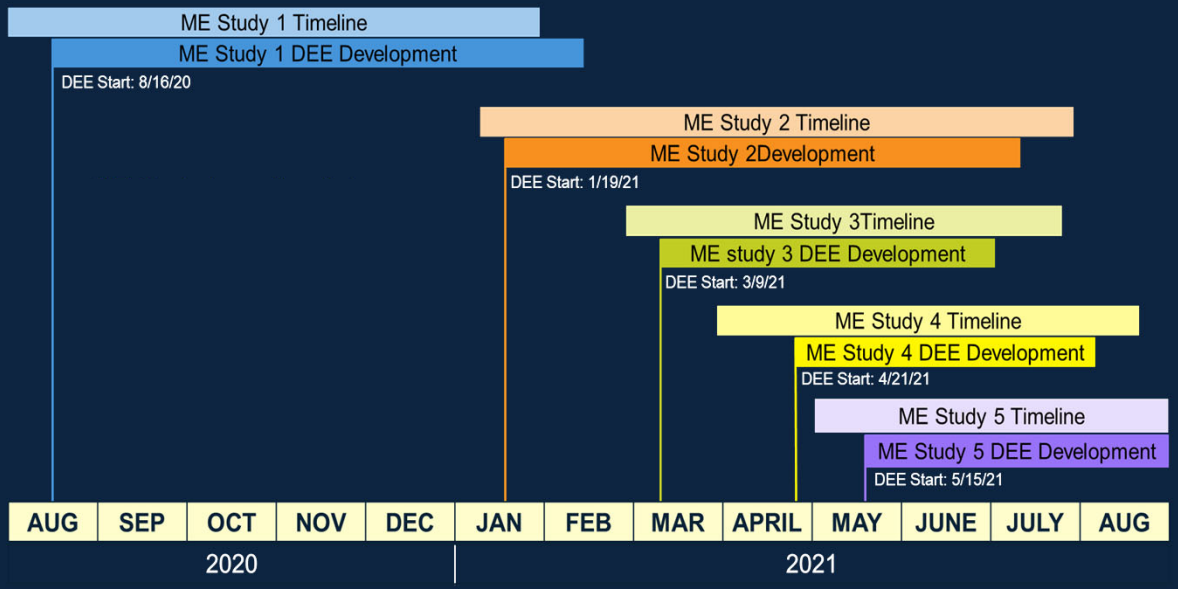
Iterate and Expand the Shared Modeling Framework

- Determine if any new systems developed for the Mission Model should be added to the Seed or Base Models.
- Determine if any new mission engineering threads developed for the Mission Model can be abstracted into top-level mission threads for reuse in other scenario contexts.

Lessons Learned

High Level Timeline for Shared Modeling Framework Development



- Substantially reduced cycle time with each subsequent study
  - Time to create a first draft version of a mission model decreased from months to days
- Reusing system behaviors from study to study required significant tailoring
  - Activities may never be performed the same way twice as actors adapt to the context and circumstances
  - Behaviors were abstracted differently depending on the question of interest

Future Work

- The team is holding technical exchanges with other organizations across the DoD to inform evolution of the Shared Modeling Framework
  - Need the framework to enable data exchange across the DoD enterprise
- The team must develop a configuration management process to incorporate changes/updates to the Shared Modeling Framework from users outside the immediate team
  - Configuration management of the Shared Modeling Framework was previously not an issue due to the small nature of the team and the co-location of team members
  - Driven by current and future mission engineering efforts across multiple mission spaces, the team is expanding use of the Shared Modeling Framework to other stakeholders