In or Out?
Assessing the Impacts of Modeling the System Operator Within the System Boundary using MBSE

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Agenda

- Introduction
- Case Study
- Assessment
- Conclusion and Q&A

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INTRODUCTION

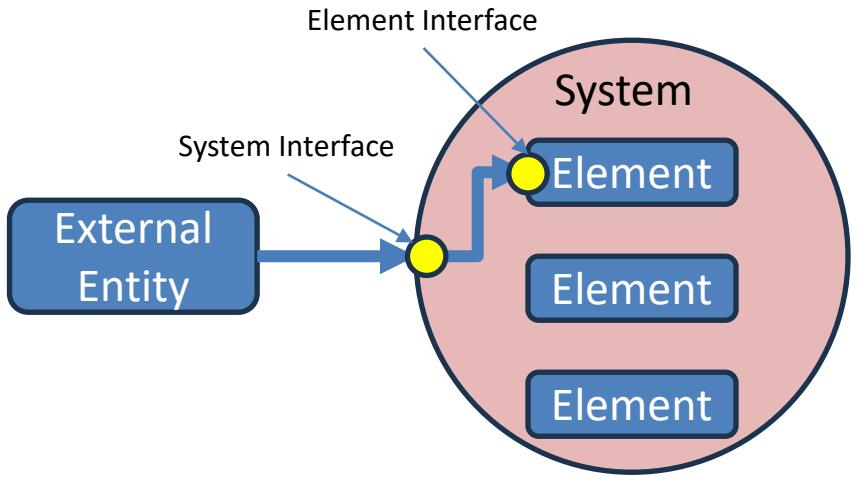
Introduction

MBSE and the System Boundary

- MBSE Practitioners tend to model human interaction with systems to be *external* to the system.
- This approach works on smaller systems but *may* not suffice on larger more complex systems.
  - Coffee maker vs. Air Defense System
- In more complex systems:
  - Human operators play key functional roles in their operational interaction with the system.
  - Modeling human operators external to the system may complicate interface definition.
- A case study using a notional **Main Battle Tank (MBT)** system will evaluate modeling operators of the system in and out of its boundary.

Concept Overview – System Boundary

- **System Boundary**
  - Developed from the analysis and definition of Stakeholder Needs.
  - Set *relative* to external entitles:
    - Enabling systems
    - Interoperating systems
    - Interfacing systems
    - Human actors
  - Setting the system boundary is an early design decision.

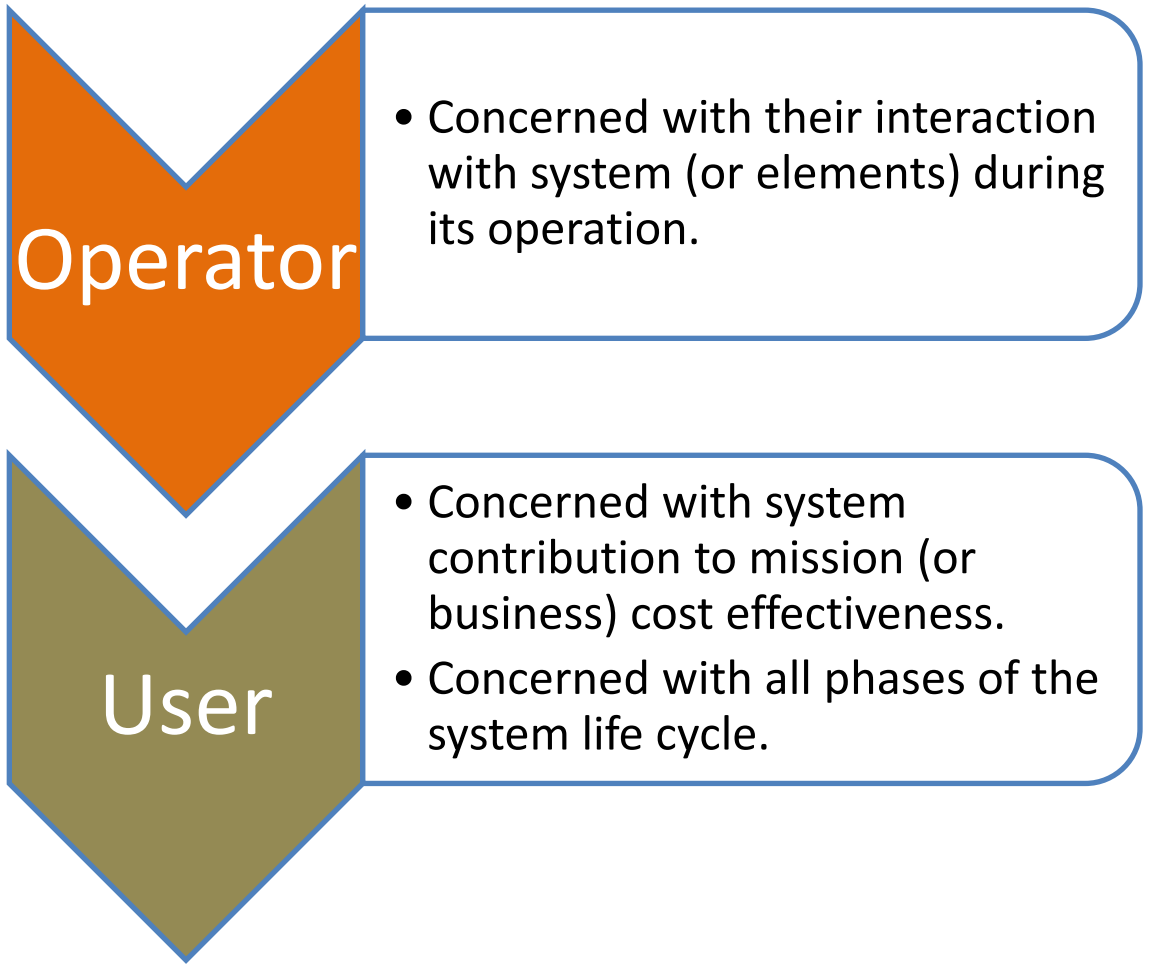


  - Internal Elements may be logical, or physical human operators, hardware, and/or software.

Operators, Users, and Stakeholders

Terminology

- **Operator:**
  - A person (or group) responsible for *controlling* or *managing* a system during its use.
- **User:**
  - The end user or customer who *benefits* from or interacts with the system, but may not directly control, operate or interact with it.
- **Stakeholders:**
  - Have a right, share, claim, or interest in the system to meet their needs/expectations.
  - Operators and Users are Stakeholders.



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CASE STUDY

Case Study Introduction

- **Introduction**
  - Explore impacts of operators relative to boundary using Main Battle Tank (MBT).
  - MBT tend to have two crew configurations:
    - 3-Crew
    - 4-Crew
  - Crew size has implications on cost, size, performance, and weight of an MBT.
    - Crew size is a *major* trade for an MBT.

Crew Roles	Commander	Driver	Gunner	Loader
4-person crew	X	X	X	X
3-person crew	X	X	X	Auto

Typical Crew roles in MBT

K2 Black Panther MBT (SK)

M1A2 Abrams MBT (USA)

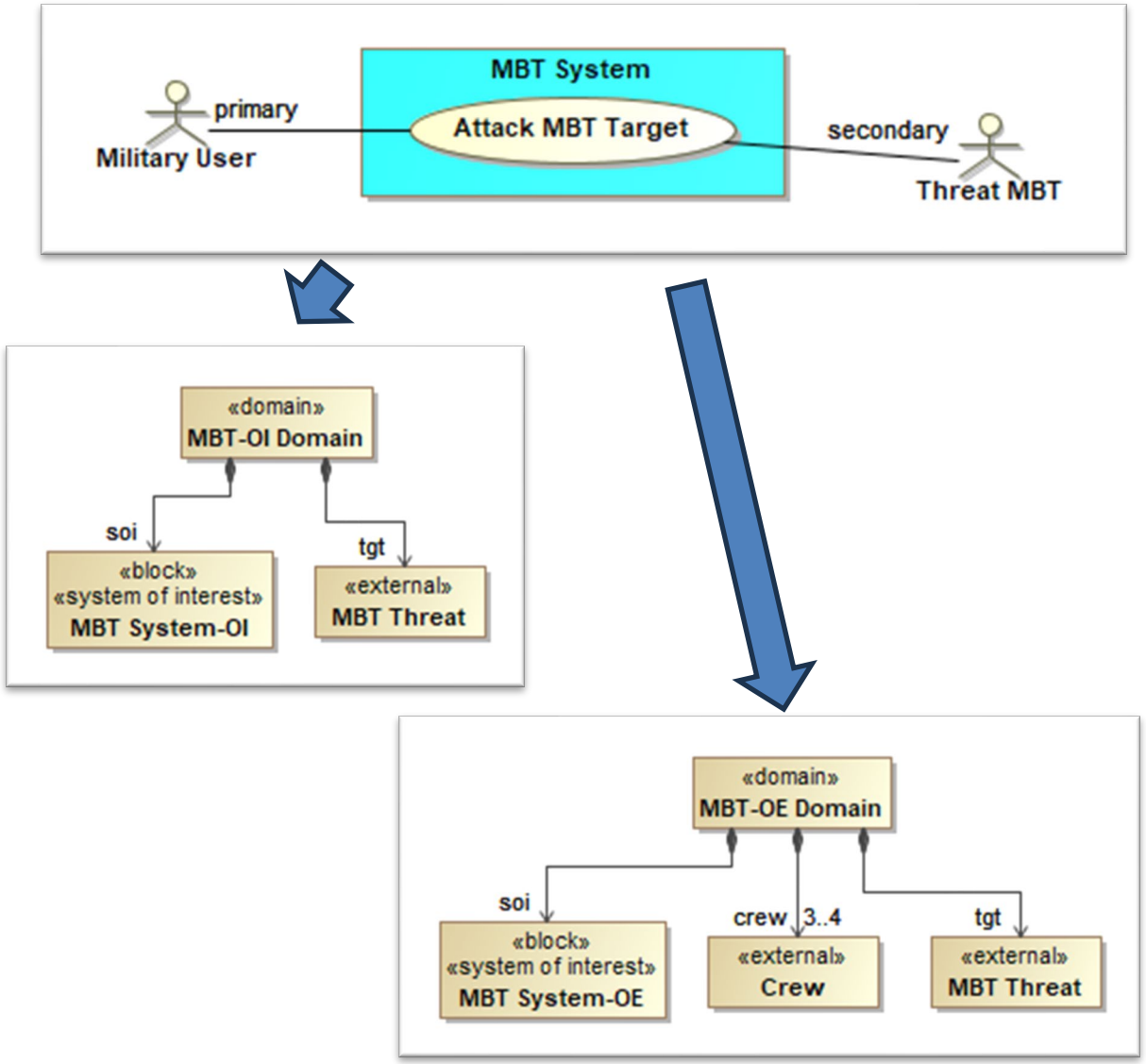
Case Study – Main Battle Tank Crew/Operators

- **Overview**
  - Case Study will approach modeling an MBT in two ways:
    - Crew/Operators **internal** to MBT System
    - Crew/Operators **external** to MBT System
- **Approach**
  - Language: SysML v1.7
  - Method: OOSEM as implemented by Strategic Technology Consulting (STC)
  - Tool: Cameo System Modeler 2022X
  - *Attack MBT Target* scenario will be focus of analysis.
- **Limitations**
  - Limitation 1: System will be partially modeled for brevity relative to *Attack Target*
  - Limitation 2: System will be notionally modeled (No proprietary data used)
  - Limitation 3: Requirements and performance will not be assessed.

Case Study Products and Assessment

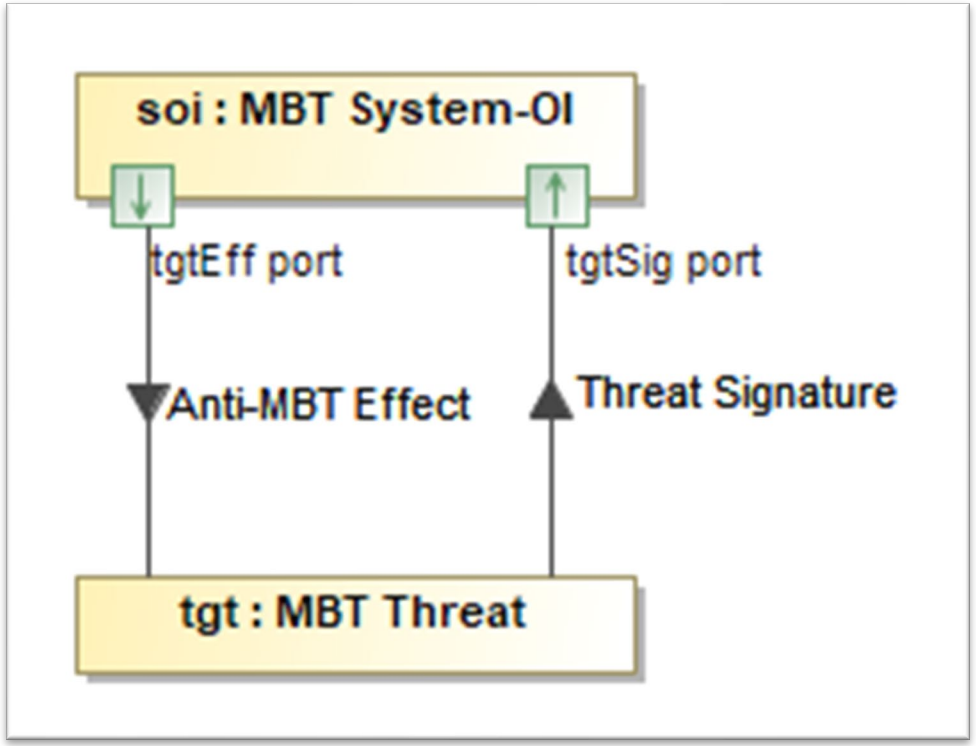
- **Assessment Areas:**
  - Behavior modeling impacts
  - Structural modeling impacts
  - Abstraction modeling impacts
  - Model organization and federation impacts
  - Design flexibility impacts

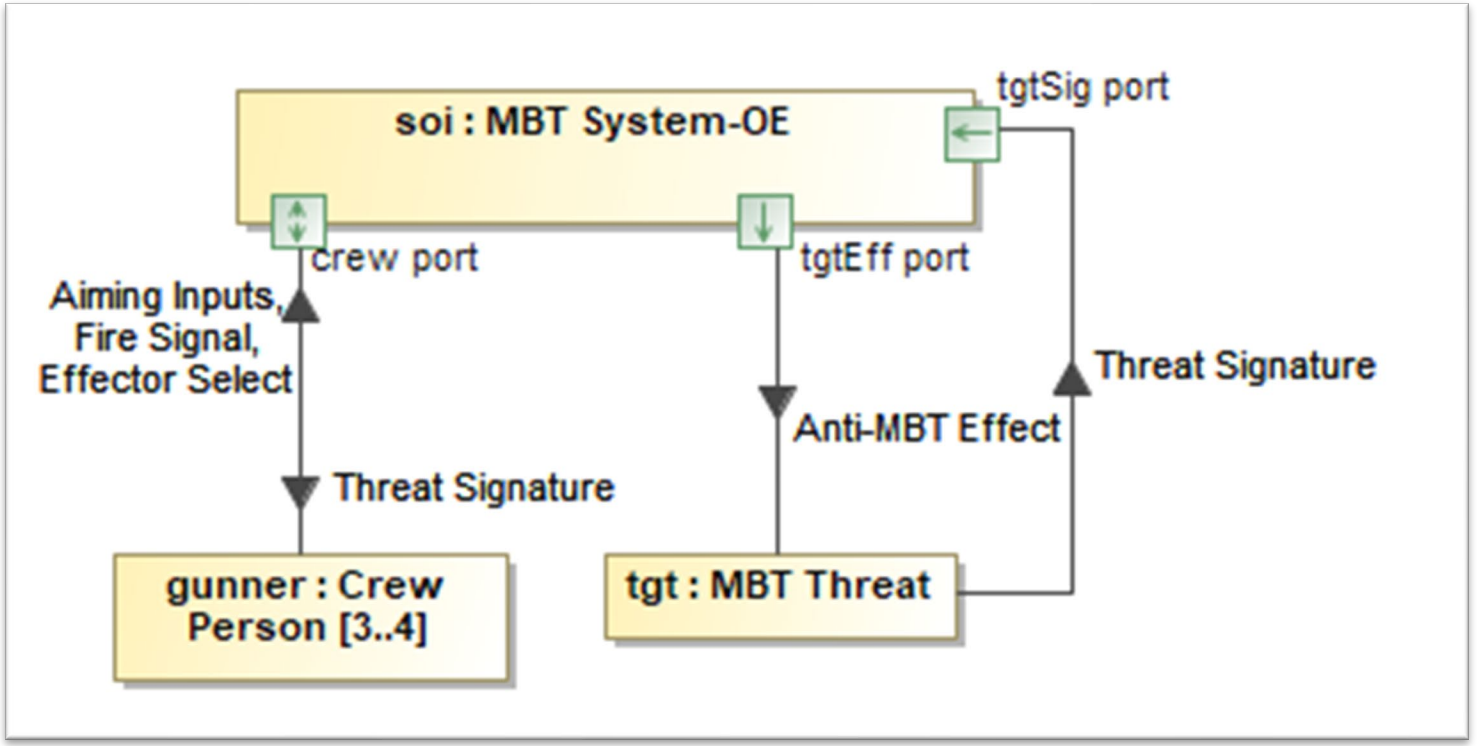
Use Case and Domain – *Attack MBT Target*



- **Overview:**
  - Military User reflects the perspective of an *acquiring* military agency procuring an MBT.
  - Use Case defines a general mission the user needs the system to perform.
  - Domain BDD reflects the two variations:
    - Operator Internal (OI)
    - Operator External (OE)

System Context (ibd) – *Attack MBT Target*

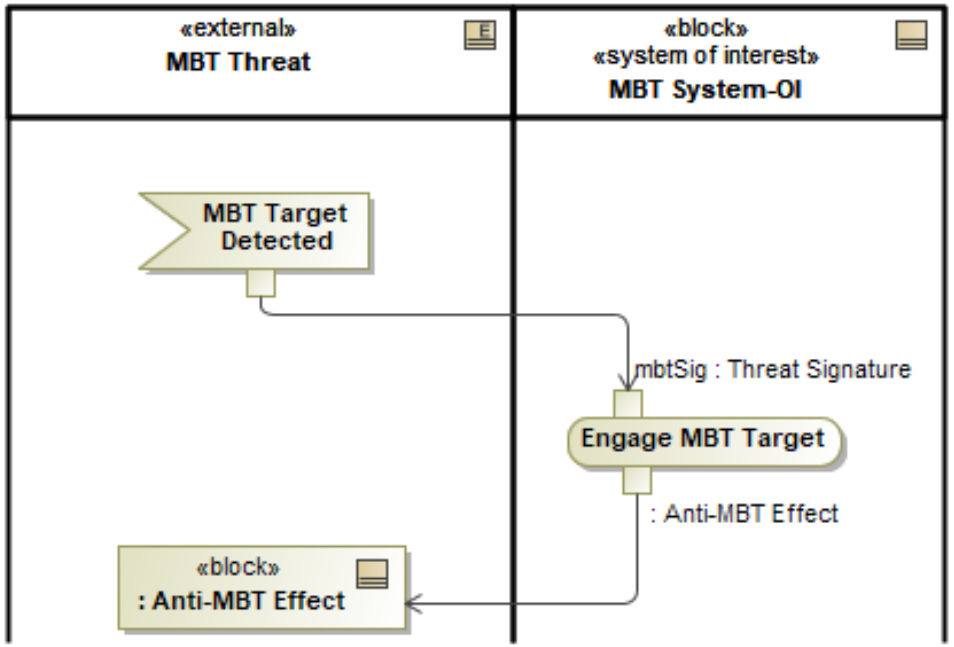




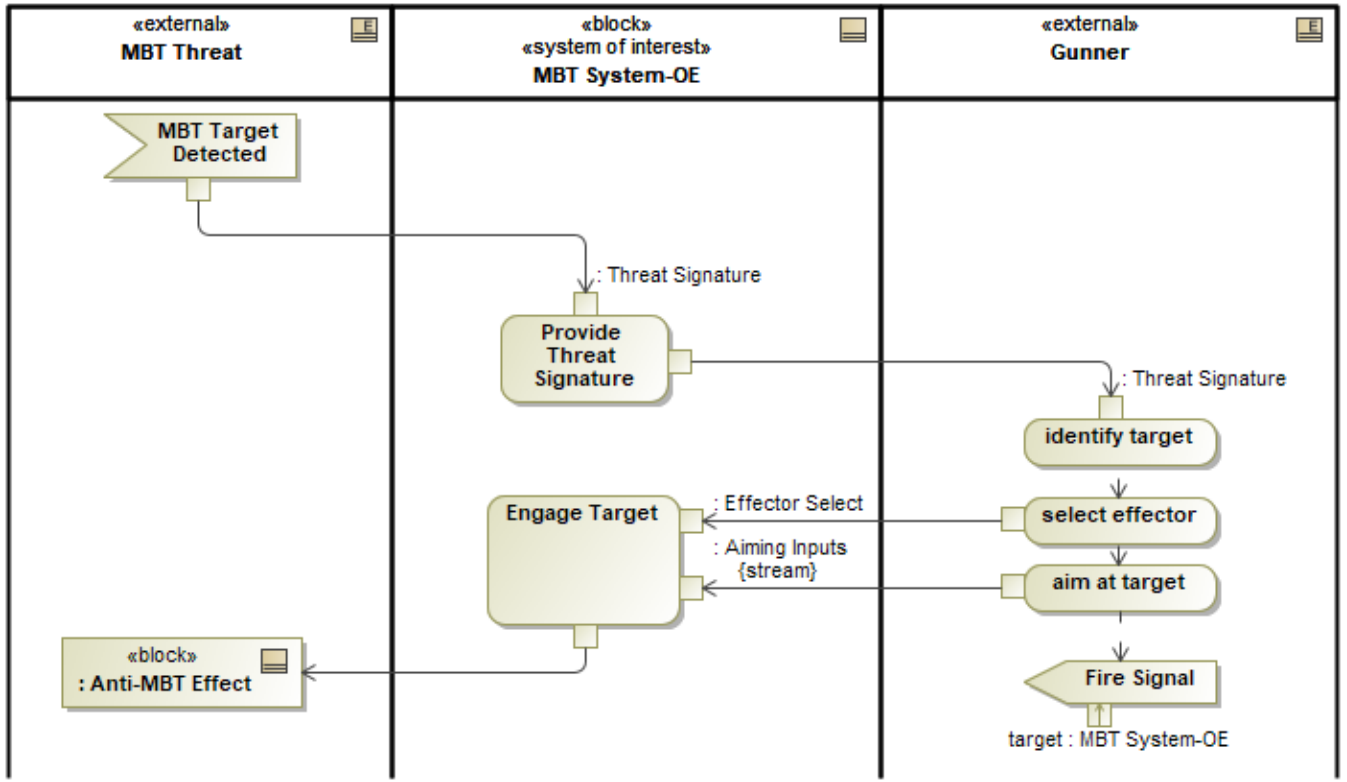
With the crew *external* to the SOI, an additional interface (or more) is needed to handle the flow of items across the boundary. What flows across the interface depends on the crew interactions.

*Attack Target** – Crew Internal vs. External

Crew internal



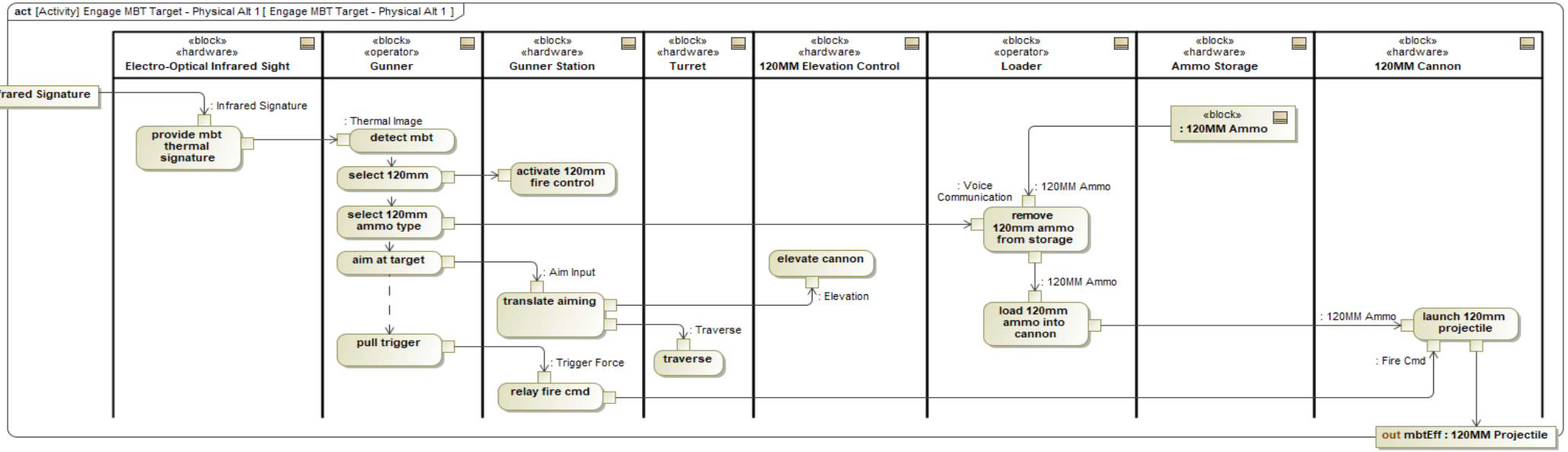
Crew external



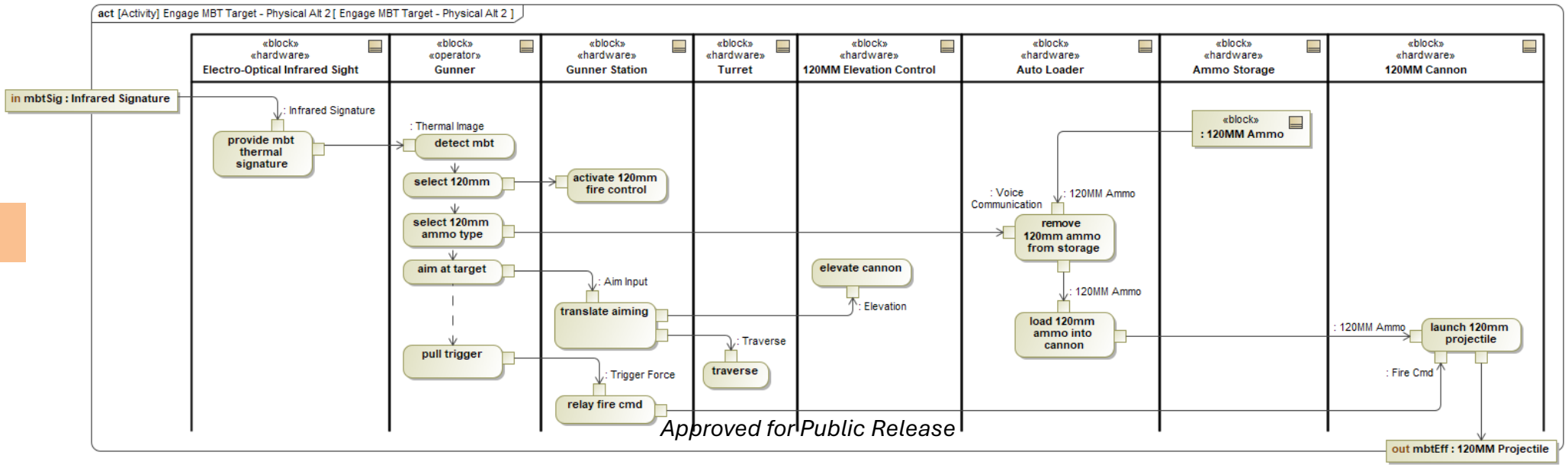
With the crew *external* to the SOI, the system behaviors need to accommodate the crew interactions with it. How the modeler intends for the crew to interact with the system constitutes additional design decisions.

Engage MBT Target – Crew Internal - Physical

4-Crew

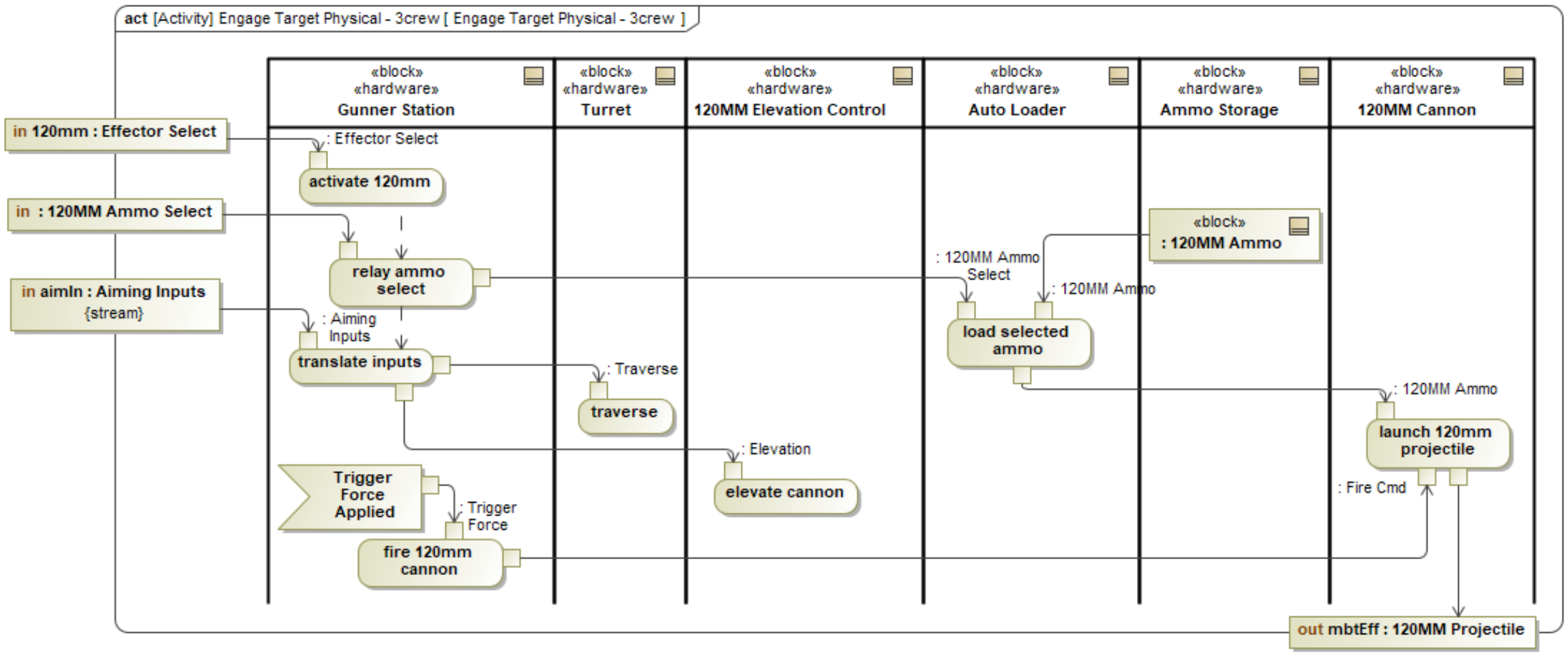


3-Crew



Engage MBT Target – Crew External - Physical

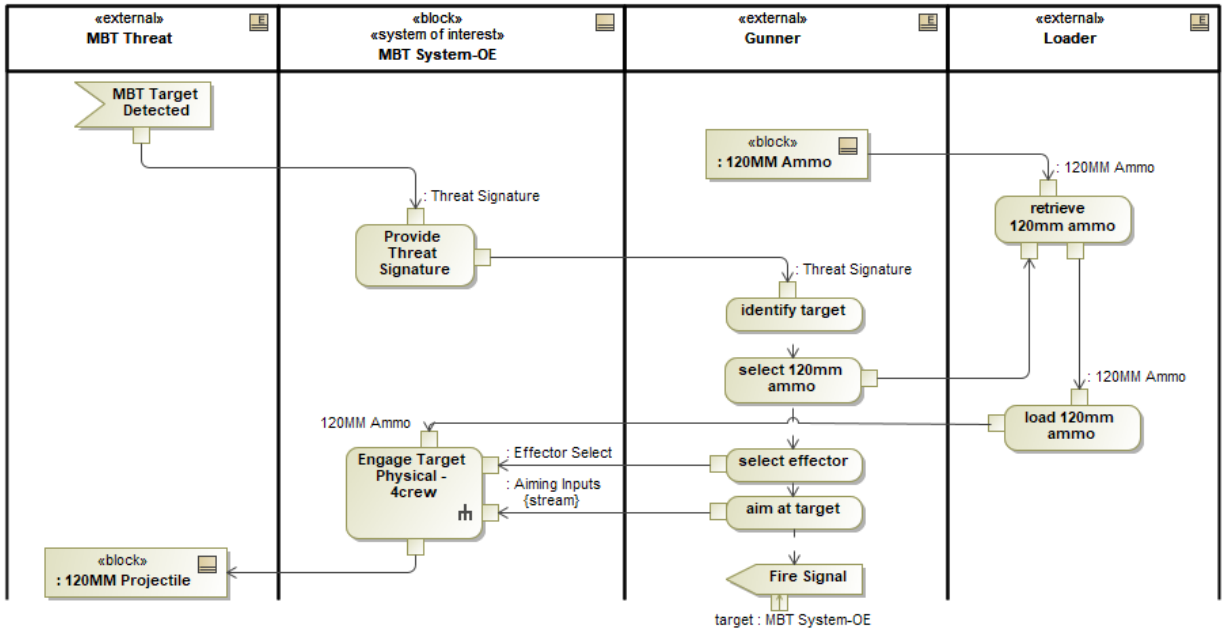
3-Crew

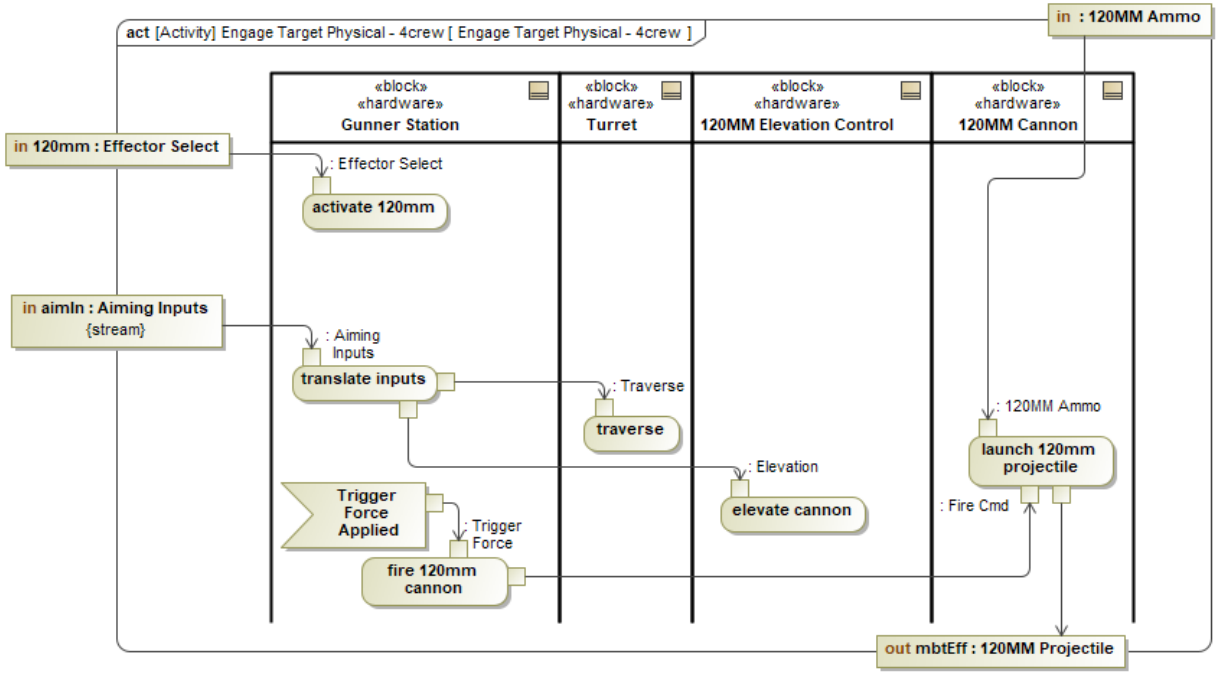


Physically, modeling 3 crew with an auto loader is feasible as the interactions across the system boundary are managed by the *Gunner Station* to the *Auto Loader*.

Engage MBT Target – Crew External - Physical

4-Crew

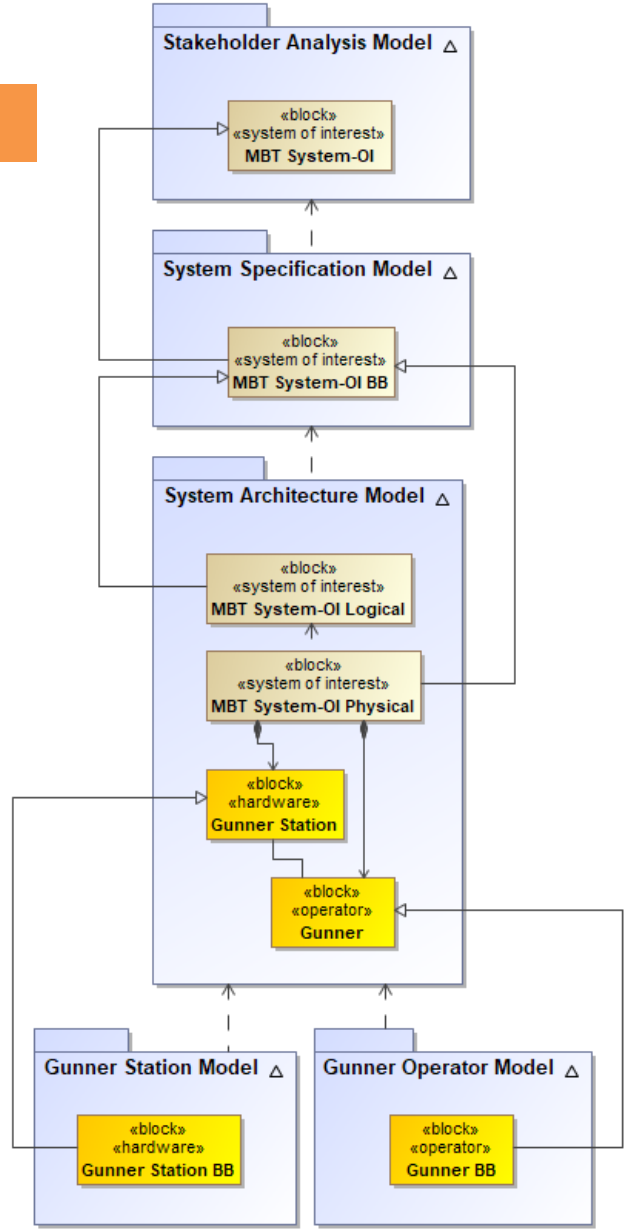




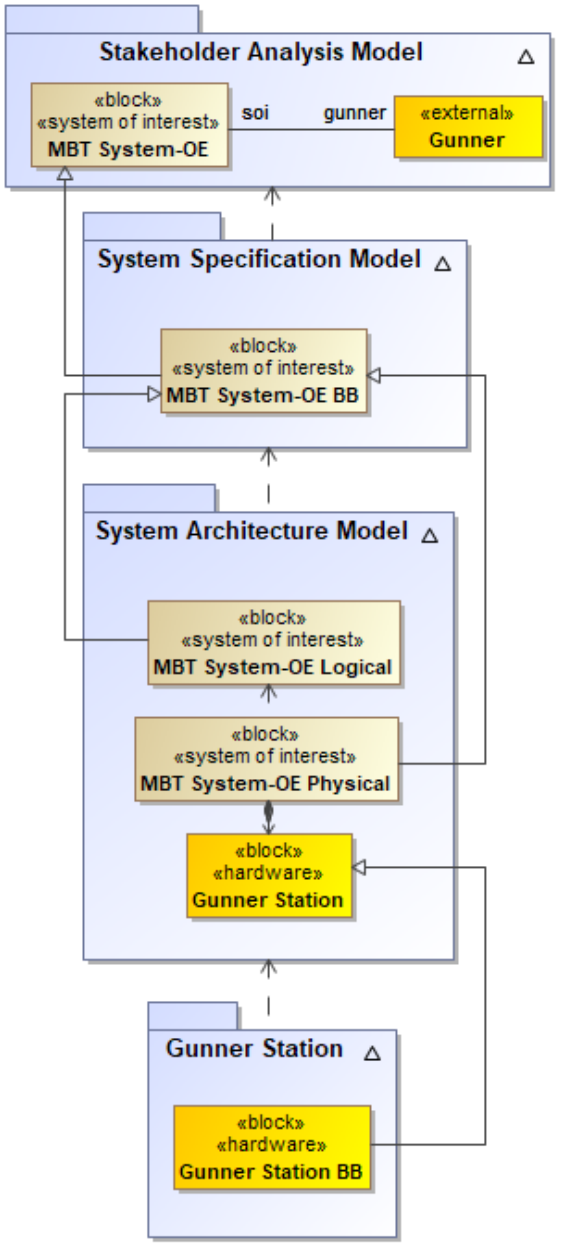
Modeling a human ammo loader (4 crew config) where operators are external to the SOI requires a revisit to the black box perspective. Interactions between the external gunner and loader require definition.

Model Organization / Federation

Crew Internal



Crew External



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ASSESSMENT AND CONCLUSION

Assessment – OI vs OE Impacts

Category	Operator Internal (OI)	Operator External (OE)
Stakeholder Considerations	• While stakeholder considerations would be captured the same as before, the omission of the operator from the use case may reduce their inclusion in stakeholder discussions. **(Potential Negative Impact)**	• With the operator external, the perspective of the system must balance the needs of the acquirer and of those who will operate the system. **(Neutral Impact)**
Design Considerations	• Design decisions surrounding crew layout, roles, and interactions are clearer as the system is viewed more holistically. **(Potential Positive Impact)** • System model supports wider range of design options for physical trades, including increasing autonomy. **(Potential Positive Impact)**	• Re-work of the model becomes a necessity as system design choices are made and revisited. **(Potential Negative Impact)**
Behavioral Considerations	• Operator interactions are internally modeled into system behaviors and reflect planned use. **(Potential Positive Impact)**	• Operator interactions are externally modeled into system behaviors based on intended use. **(Potential Negative Impact)**
Modeling Considerations	• Complex behaviors are modeled within SysML compliance **(Potential Positive Impact)** • Model federation is easier as individual system elements can be turned into their own models later. **(Neutral Impact)** • More elements in diagrams is technically more complicated/complex, however the improved fidelity would be welcomed. **(Neutral Impact)**	• Modeling complex behaviors at high abstraction is difficult while maintaining compliance with SysML. **(Potential Negative Impact)**
Operational Considerations	• Operational procedures are easier to write as operators interact with individual system elements. **(Potential Positive Impact)**	• Status Quo. **(Neutral Impact)**

Takeaways

- **Setting the system boundary is a design decision.**
- **Choosing what is outside the boundary has a larger impact than what is inside.**
- **Large, complex systems *may* benefit from wider system boundary scopes.**
- **Important to distinguish between *acquiring* stakeholders (user) and the stakeholders operating the system (operator) and respective needs.**
- **Perspective on the system and its elements matters.**

Conclusion + Q&A

Thank you!

Questions?

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