Lessons Learned from Medical System Foundation Development for Long-Duration Lunar Orbit and Surface Missions

Human Research Program
Exploration Medical Capability Element

HRP IWS
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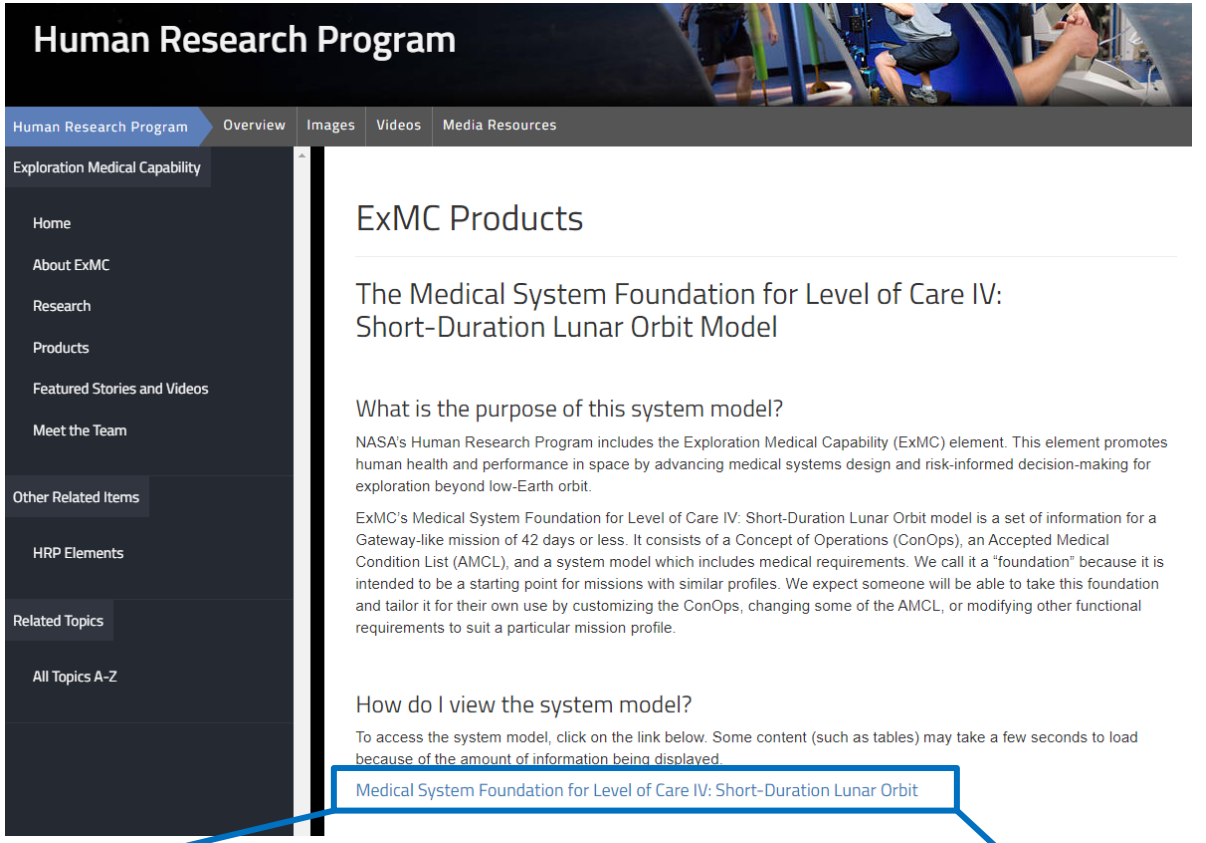
"Expanding the Boundaries of Space Medicine and Technology"

Introduction: ExMC Medical System Foundation Models

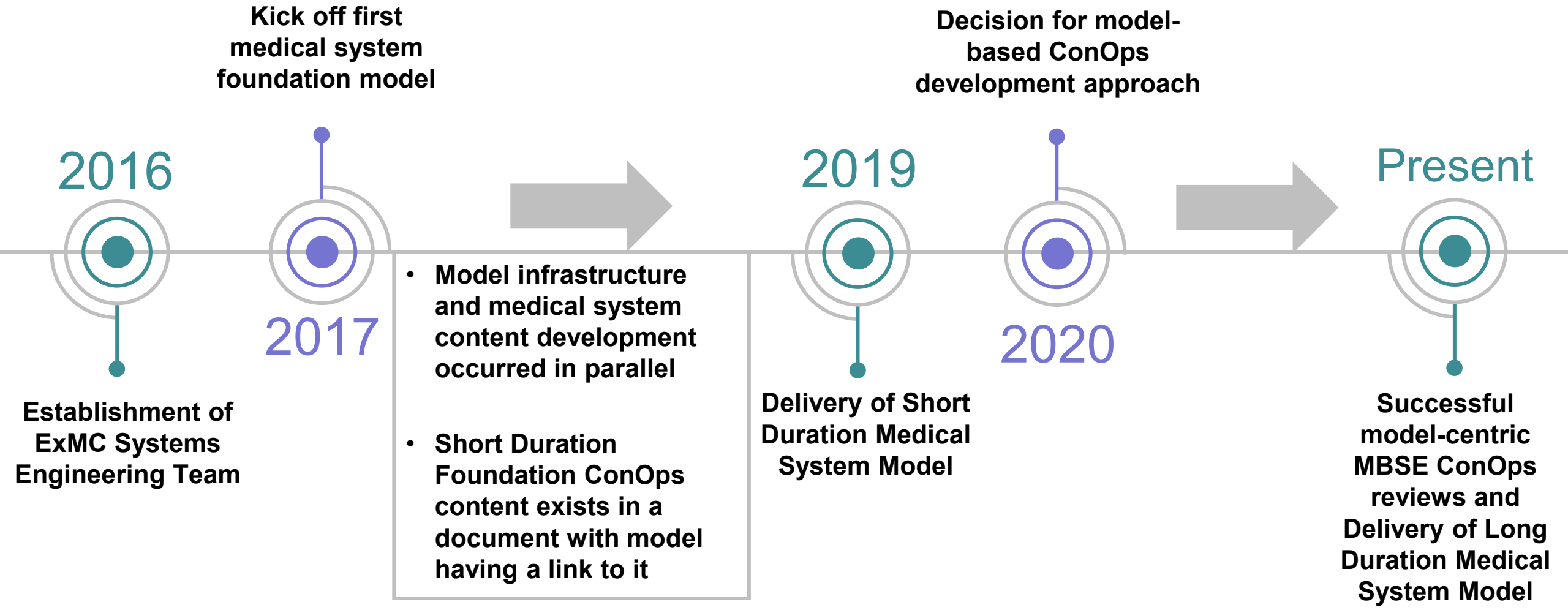
- **Two ExMC Medical System Foundation Projects:**
  - Short-Duration Lunar Orbit – Complete and Available to the Public
  - Long-Duration Lunar Orbit and Lunar Surface – Undergoing Roadshows

- **Major Differences in Process:**
  - Concept of Operations (ConOps) is in Model-Based Systems Engineering (MBSE) format
  - Adopted Agile Project Approach
  - Model infrastructure was already established



Medical System Foundation for Level of Care IV: Short-Duration Lunar Orbit

Introduction: ExMC Modeling History



Difference: Concept of Operations in MBSE Format

Concepts of Operations

Level of Care IV Medical System ConOps (HRP_48012 Baseline)

Level of Care IV CHP ConOps (Not available outside NASA)

Level of Care IV Habitat Medical System Scenarios

HRP-48012

Recommendation for a Medical System Concept of Operations for Gateway Missions

Exploration Medical Capability (ExMC) Element
Human Research Program

Concept of Operations

Concept of Operations

Medical System › Concept of Operations

Purpose & Scope

01 Purpose | 02 Scope | 03 Change Authority | 04 Report Terminology | Applicable Documents | Reference Documents

Mission Descriptions & Assumptions

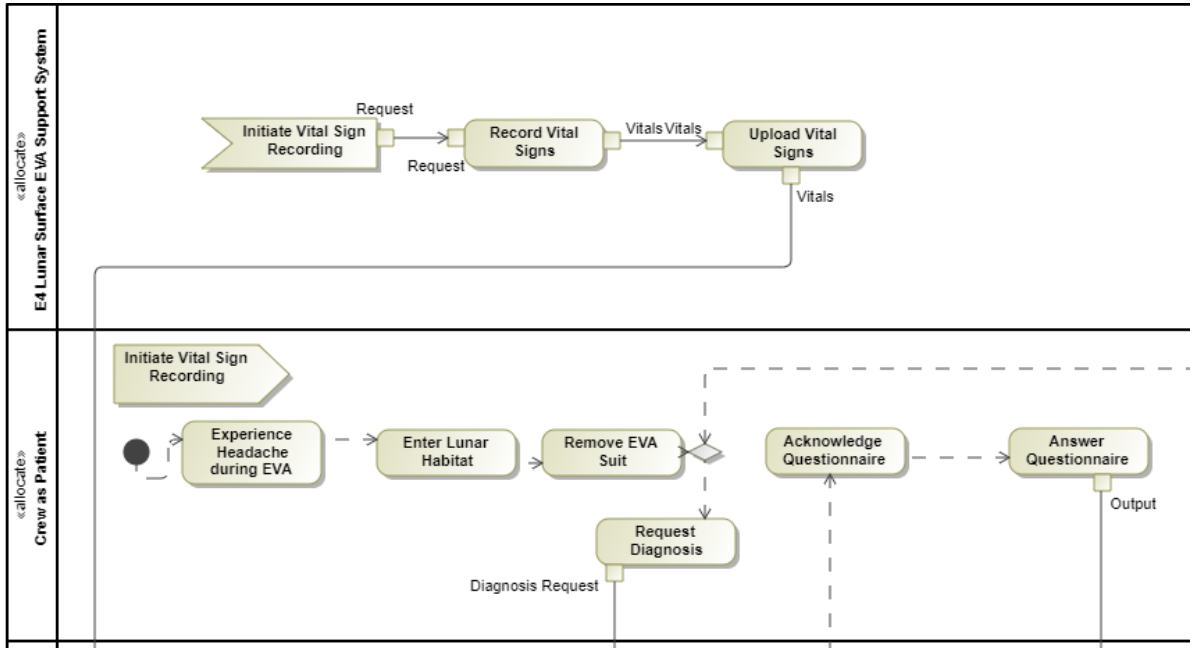
This section identifies the stakeholders, the stakeholder needs, Medical System goals, and assumptions the Systems Engineering team used to define the Medical System specified in this report. Stakeholder needs identify why this Medical System exists from the points of view of those affected by the Medical System. Goals identify the ends the Systems Engineering team works towards while specifying the Medical System. While specifying the Medical System, Systems Engineers and Clinicians identify constraints that limit the system. To address those constraints, the model captures the Assumptions made about the operating and habitat environments, as well as the Medical System itself.

Benefits: Concept of Operations in MBSE Format

- **Ability to hyperlink to references inside and outside of the model**
- **Graphical representation of content allows for better collaboration between team members and stakeholders' understanding**
- **Centralized Source of Truth for the project that follows a consistent format**

Applicable Documents Table

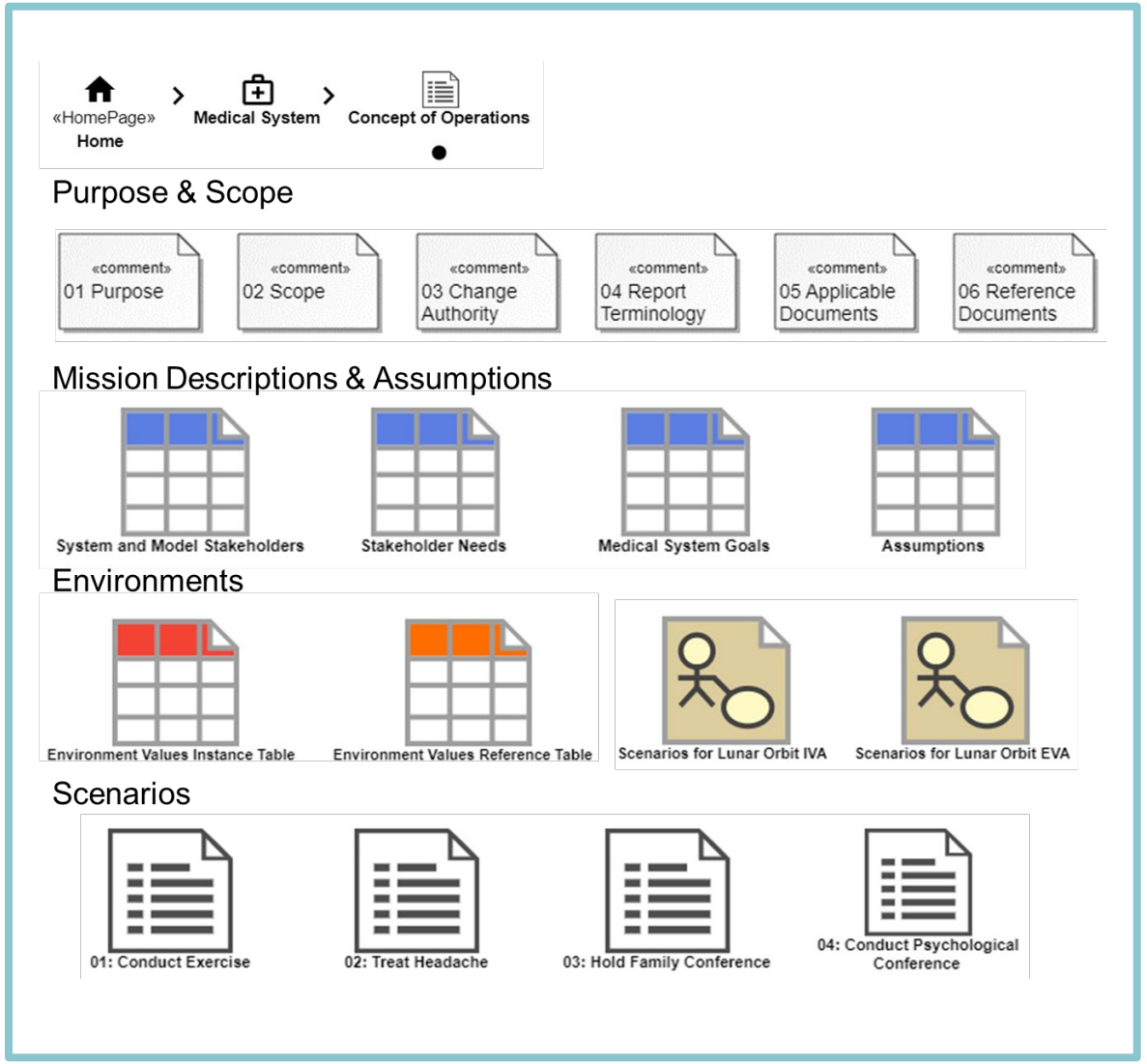
#	Document Reference with Hyperlink
1	ExMC-SE-001 SEMP (Not available outside of NASA)
2	HRP-47067 Rev C (Not available outside of NASA)



Lessons Learned: Concept of Operations in MBSE Format

Standardize Organization of Concept of Operation

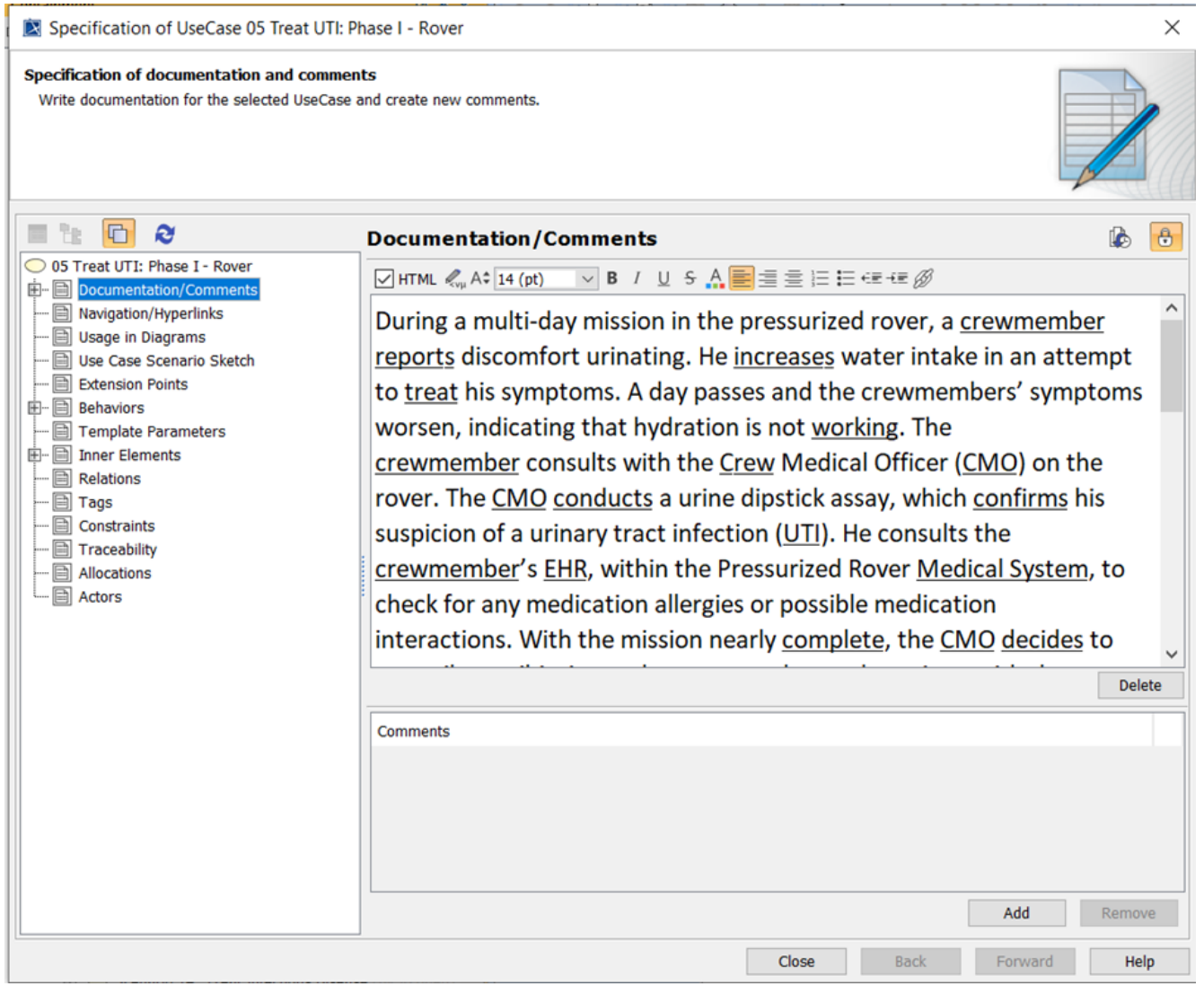
- Originally did not impose a standard model report format
- Follow the structure of a document-based Concept of Operations
- Commonality between projects and emulating the traditional document-format facilitates stakeholders' review



Lessons Learned: Concept of Operations in MBSE Format

Start Somethings Outside of the Model

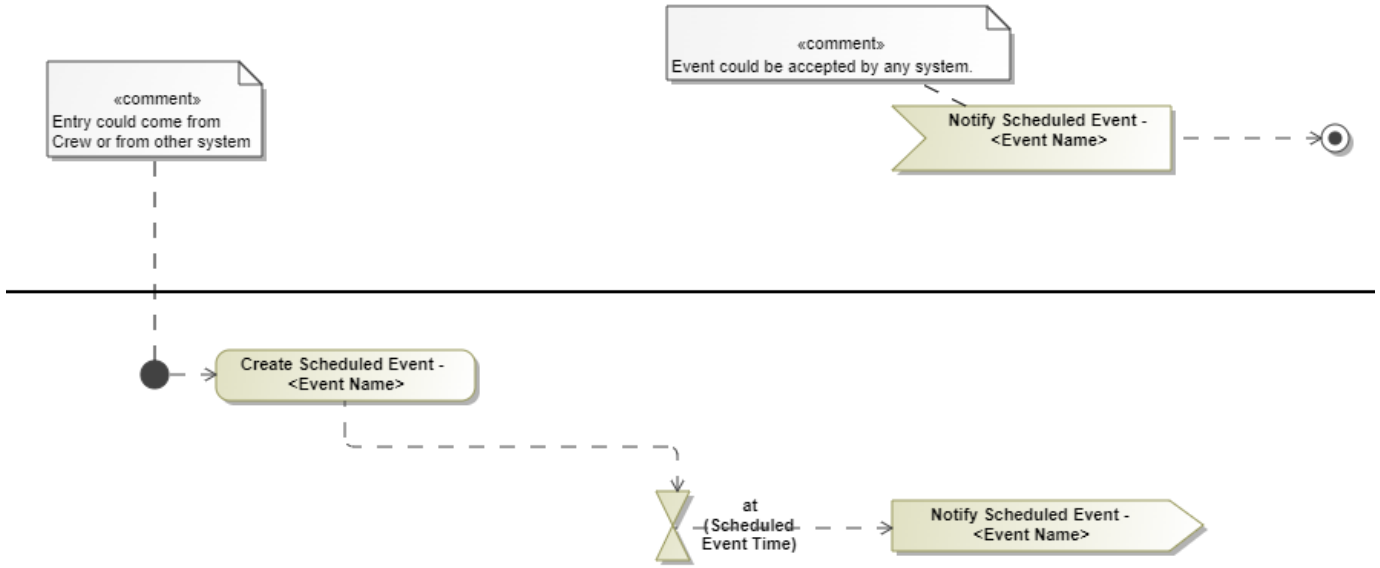
- ConOps content can have a significant amount of text
- Subject Matter Experts are not trained MBSE practitioners
- Starting content outside of the model allows for early and frequent reviews without extra training
- Content added to model after reviews



Implementation of Patterns

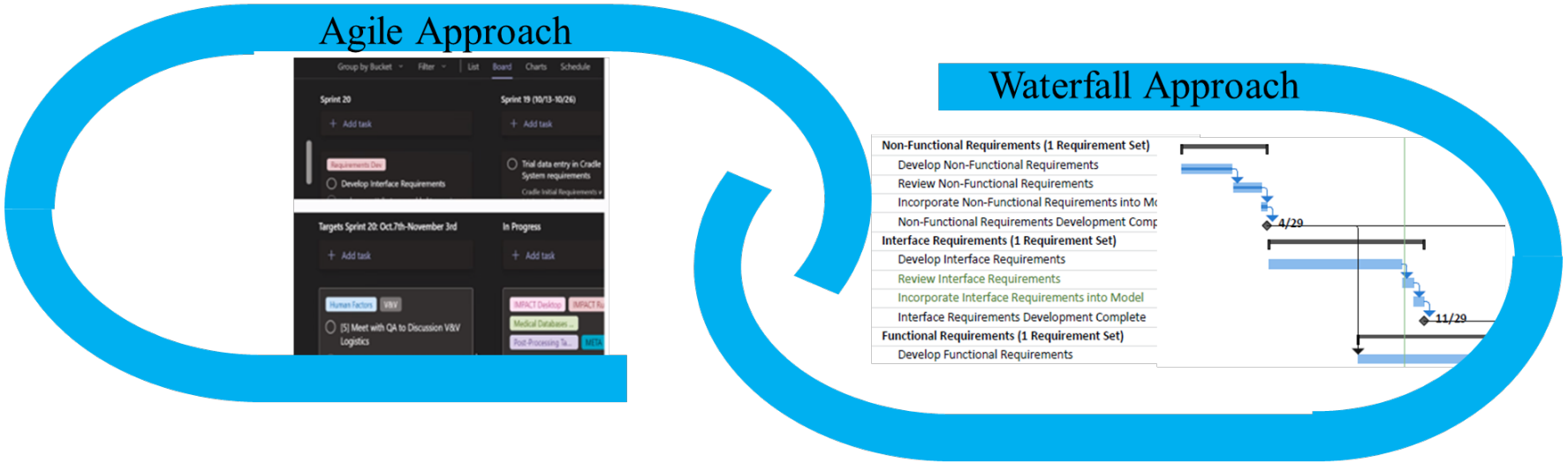
- **Originally each SE team member drafted activity diagrams independently**
- **Common functionality was implemented differently**
- **Design patterns allowed for harmonization of the activity diagrams**
  - Scenario Activity Diagrams were easier to understand
  - Team identified missing functionality of the system
- **Future projects will implement patterns before drafting activity diagrams**

Example: Scheduling



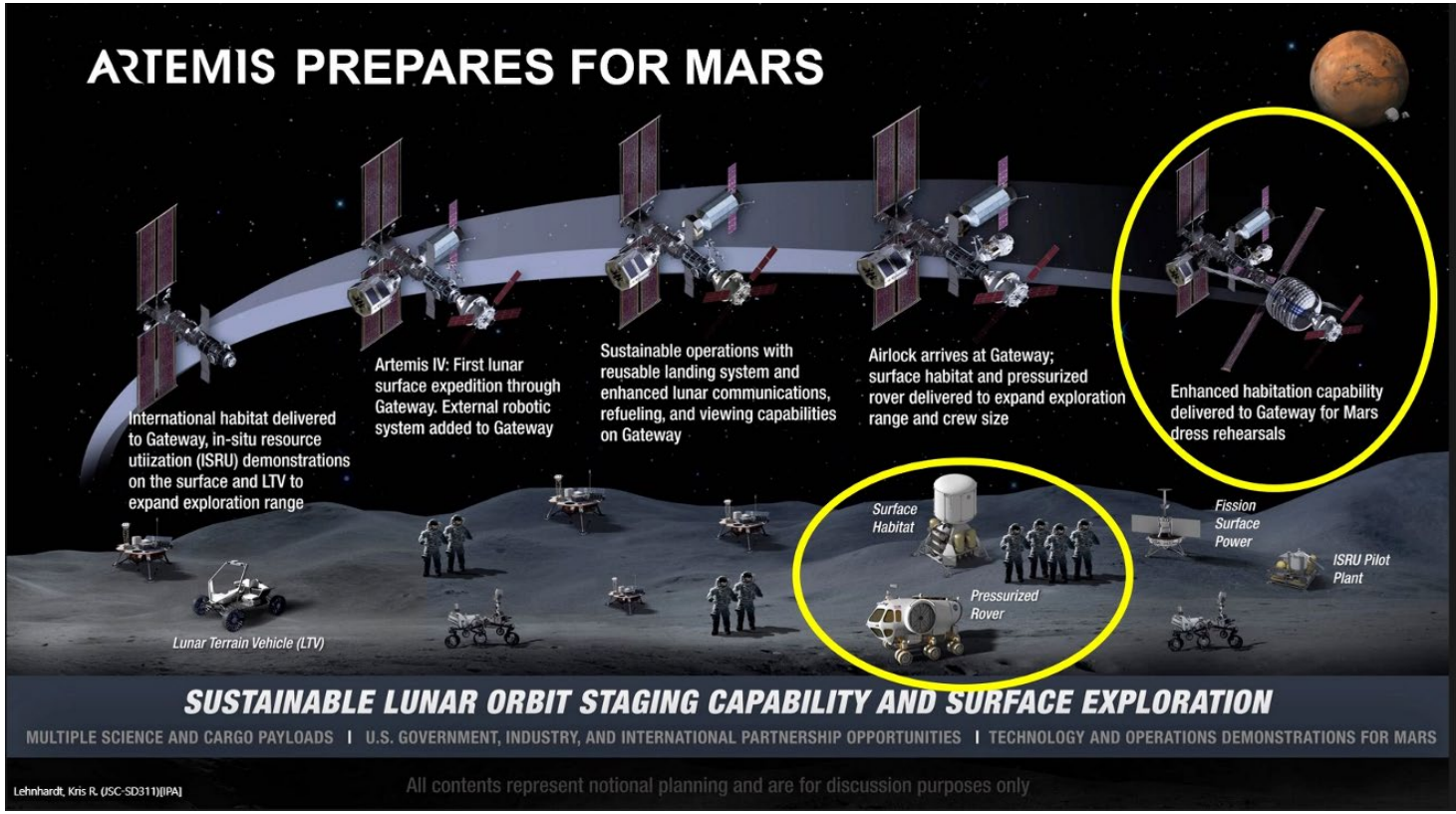
Difference: Adopt Agile Approach

- **Waterfall Schedule Approach**
  - Used to track competing milestones and deliverable timelines across the SE team and non-SE system stakeholders (e.g., clinicians and management)
  - Integrated schedule lists tasks granularly and in a prescribed order
- **Agile Development Approach**
  - Uses Sprints: fixed time period for performing a set of tasks
  - Facilitates iterations with stakeholders to verify that the SE understanding of functionality meets the stakeholders' expectations



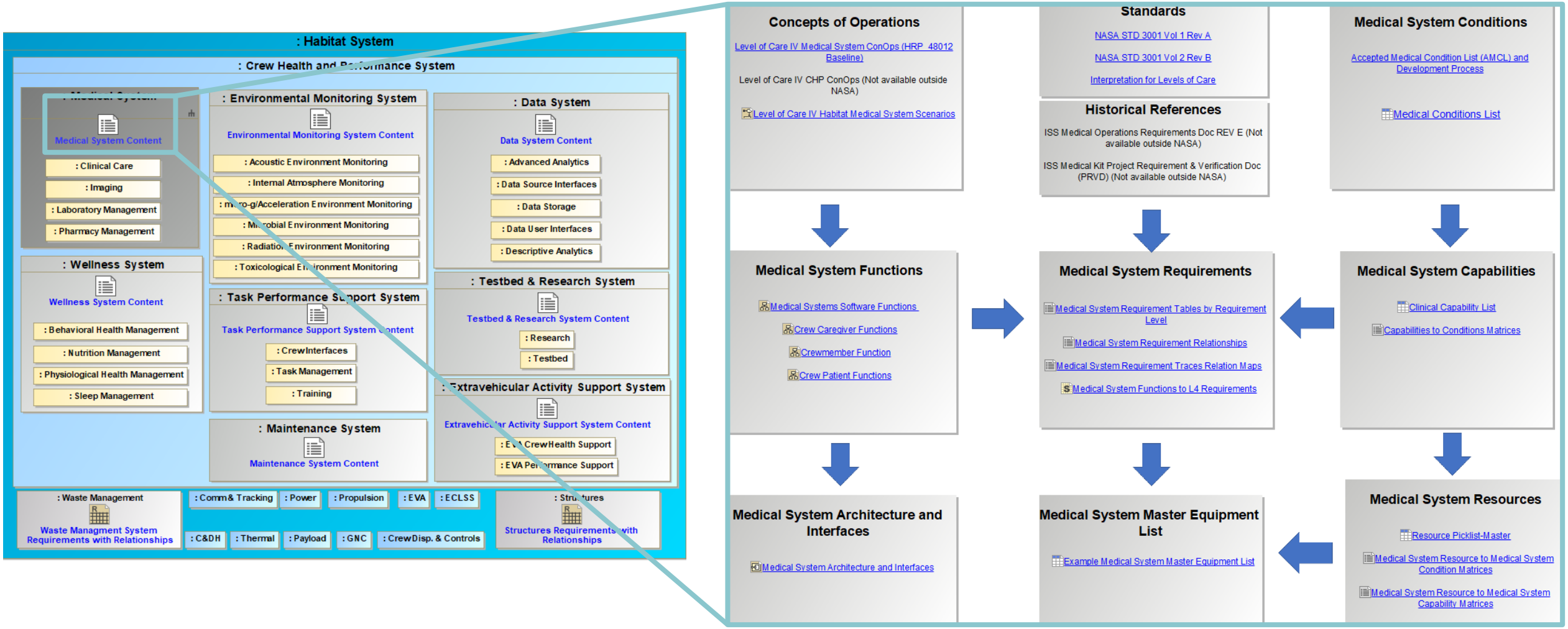
Benefits: Adopt Agile Approach

- **Synergistic with MBSE because portions of model can be updated as information becomes available**
- **Artemis program information incorporated**
- **Human Factors Feedback incorporated**



Benefits: Adopt Agile Approach

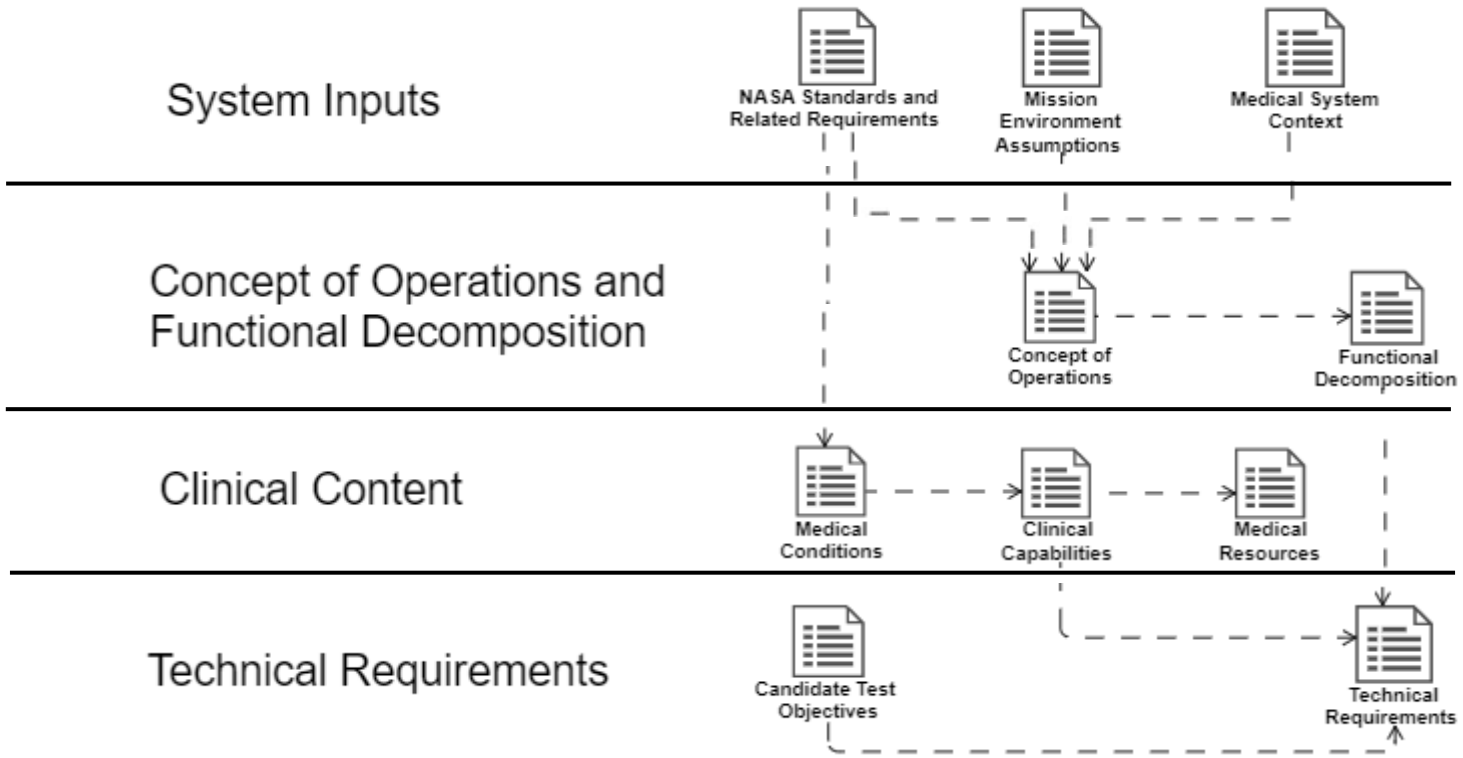
Short Duration Layout



Benefits: Adopt Agile Approach

Medical System Foundation for Level of Care IV: Long Duration Lunar Orbit and Lunar Surface

Information about the Medical System Foundation



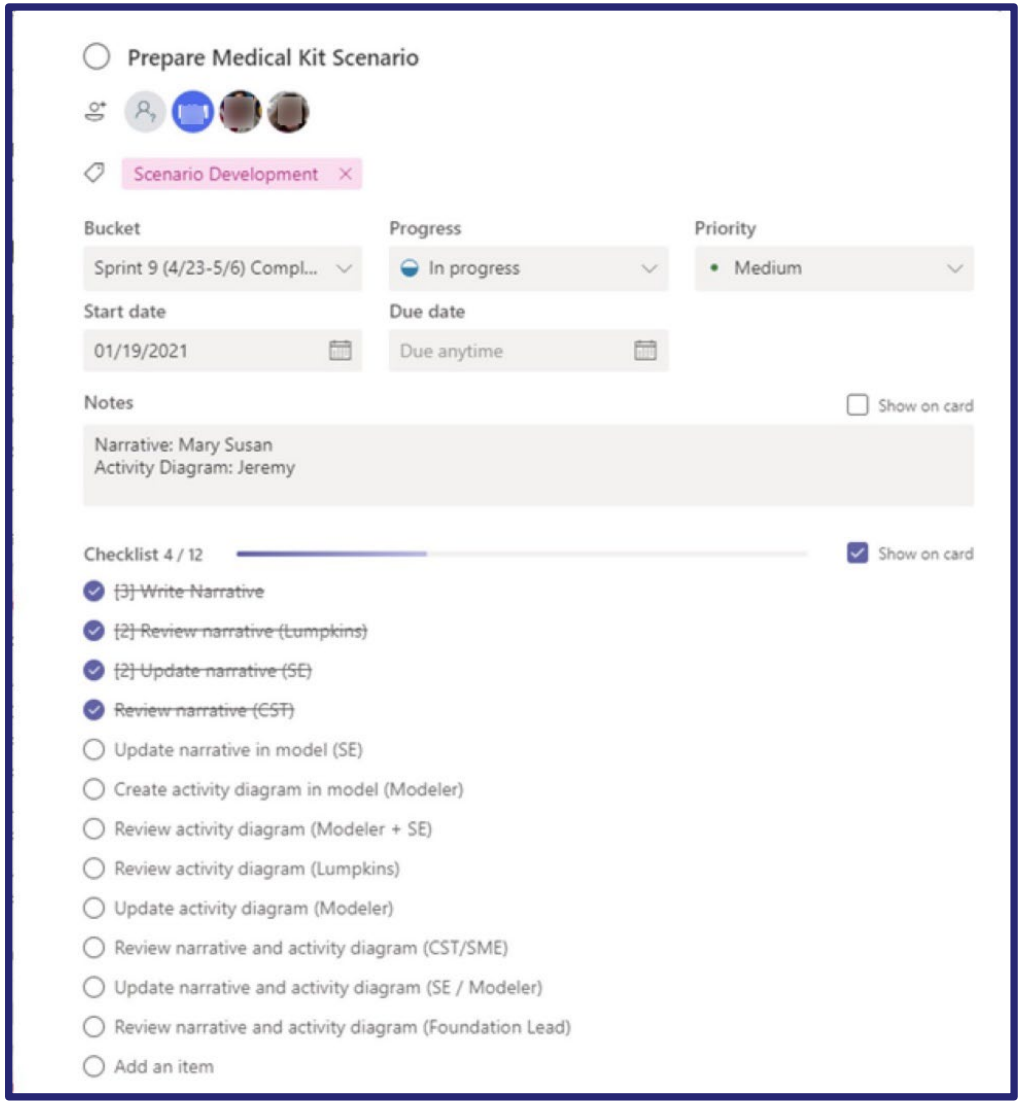
Lesson Learned: Adopt Agile Approach

Implementation of Sprints

Initial process included one planner board for the project with each task including checklist feature to document all steps to complete task

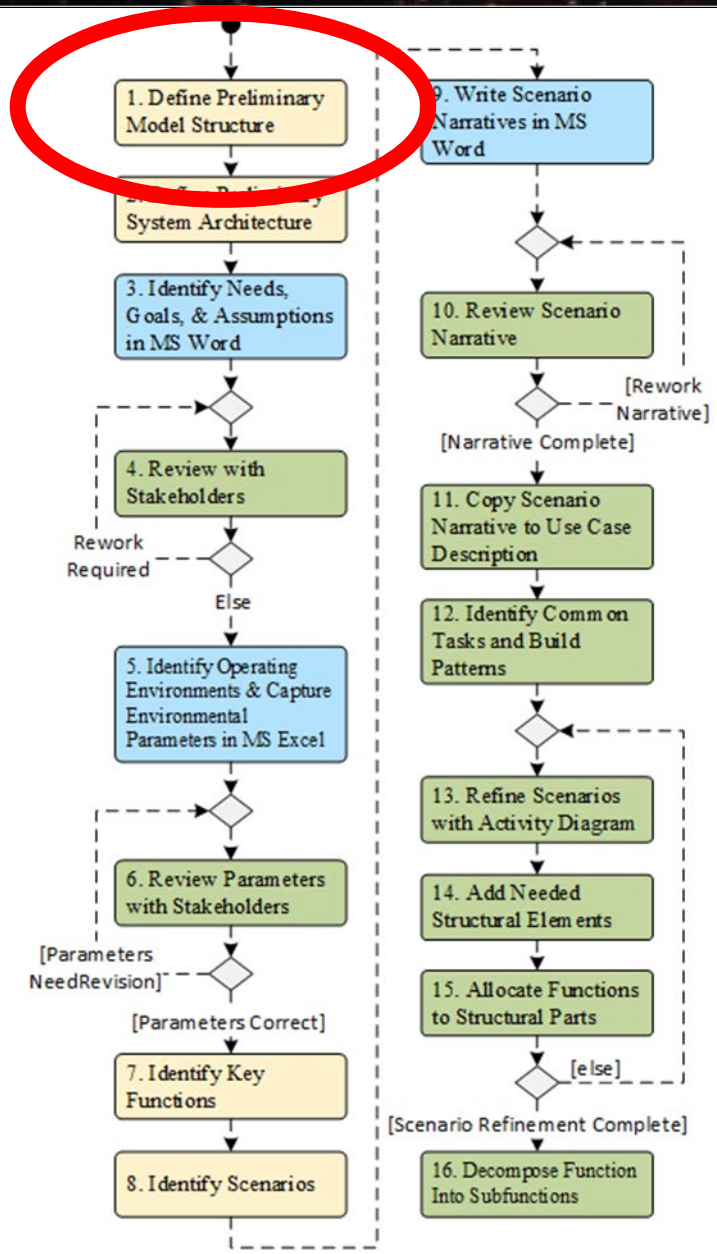
Issues resolved:

- **All the task steps generally couldn't be completed in a single sprint (e.g., reviews by non-SE team stakeholders)**
- **Task cards did not provide sufficient detail to track daily progress of the project's various teams**



Difference: Model Infrastructure was Established

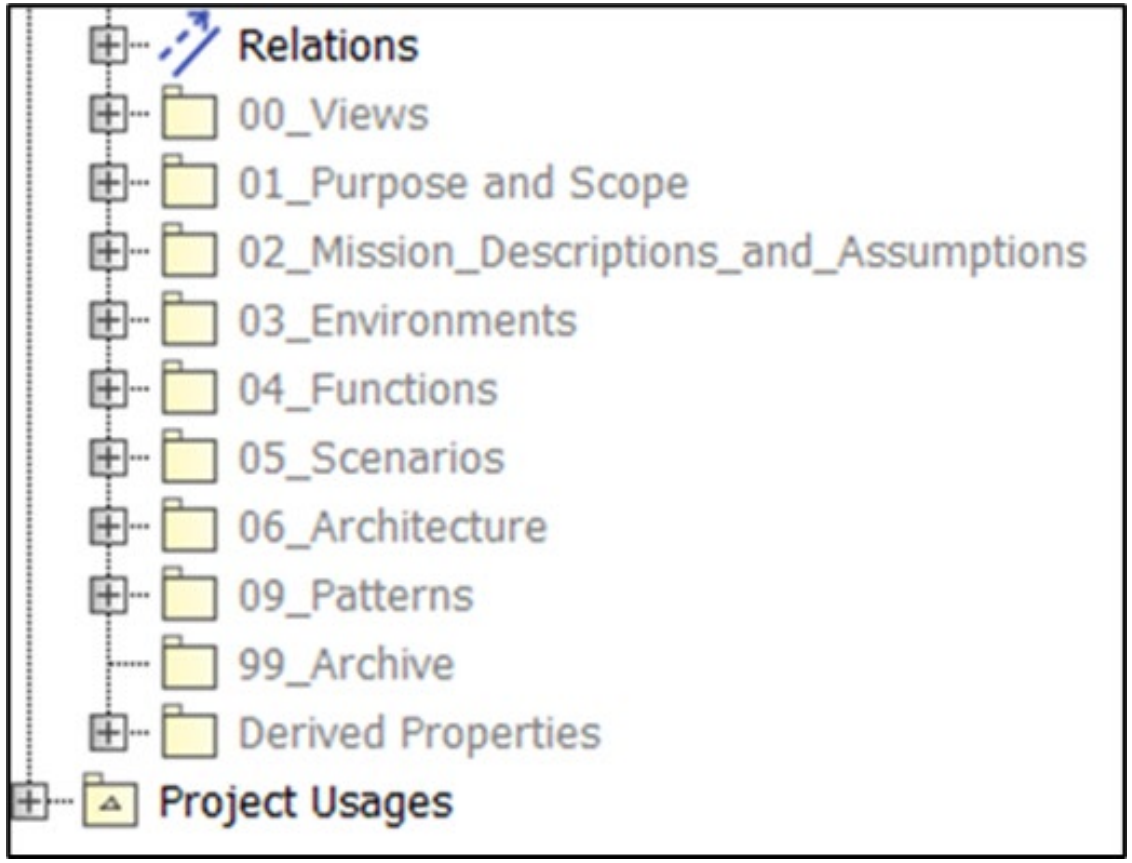
- **First step of ExMC Model Development is to Define Preliminary Model Structure**
- **Model Infrastructure was Established**



Lessons Learned: Model Infrastructure was Established

Standardize Model Layout

- All ExMC products adopt a similar model organization
- Facilitates cross-project work and large teams
- Benefit for both team members and stakeholders



Conclusion

- Developing Medical System Foundations within ExMC is an ongoing journey
- Lessons learned along the way will continue to guide our development process
- Emphasis is on iterative reviews in order to have a useful product for our stakeholders
- Next steps are to update the Long Duration Lunar Orbit and Lunar Surface Medical System Foundation to follow the latest version of NASA Standard 3001, and make the foundation publicly available

https://www.nasa.gov/hrp/elements/exmc/products