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Darth Vader's Secret Weapon: Implementing Mission Engineering with UAF

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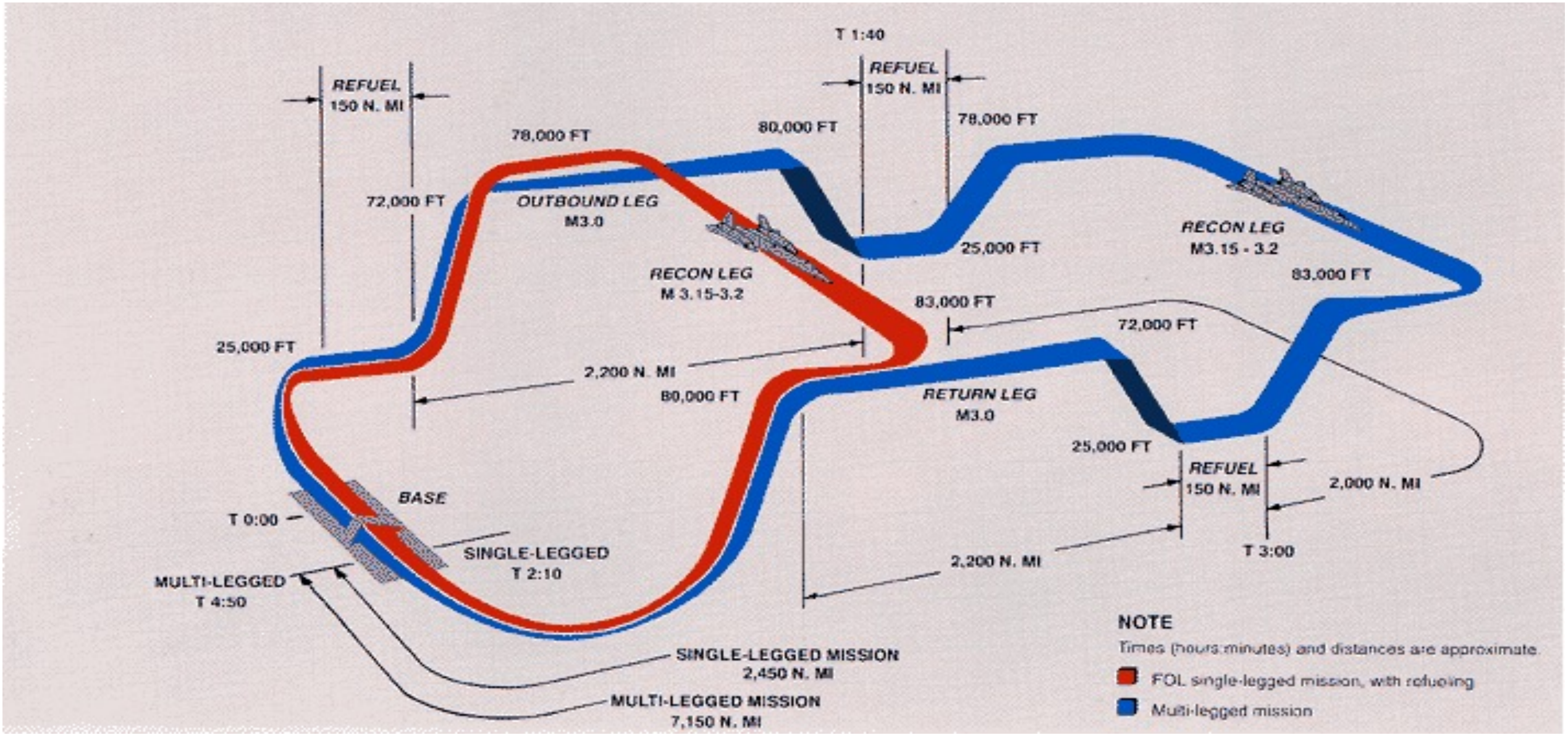
This Presentation is all about:

M.E.

Mission Engineering

SR 71 Mission Profile Diagram

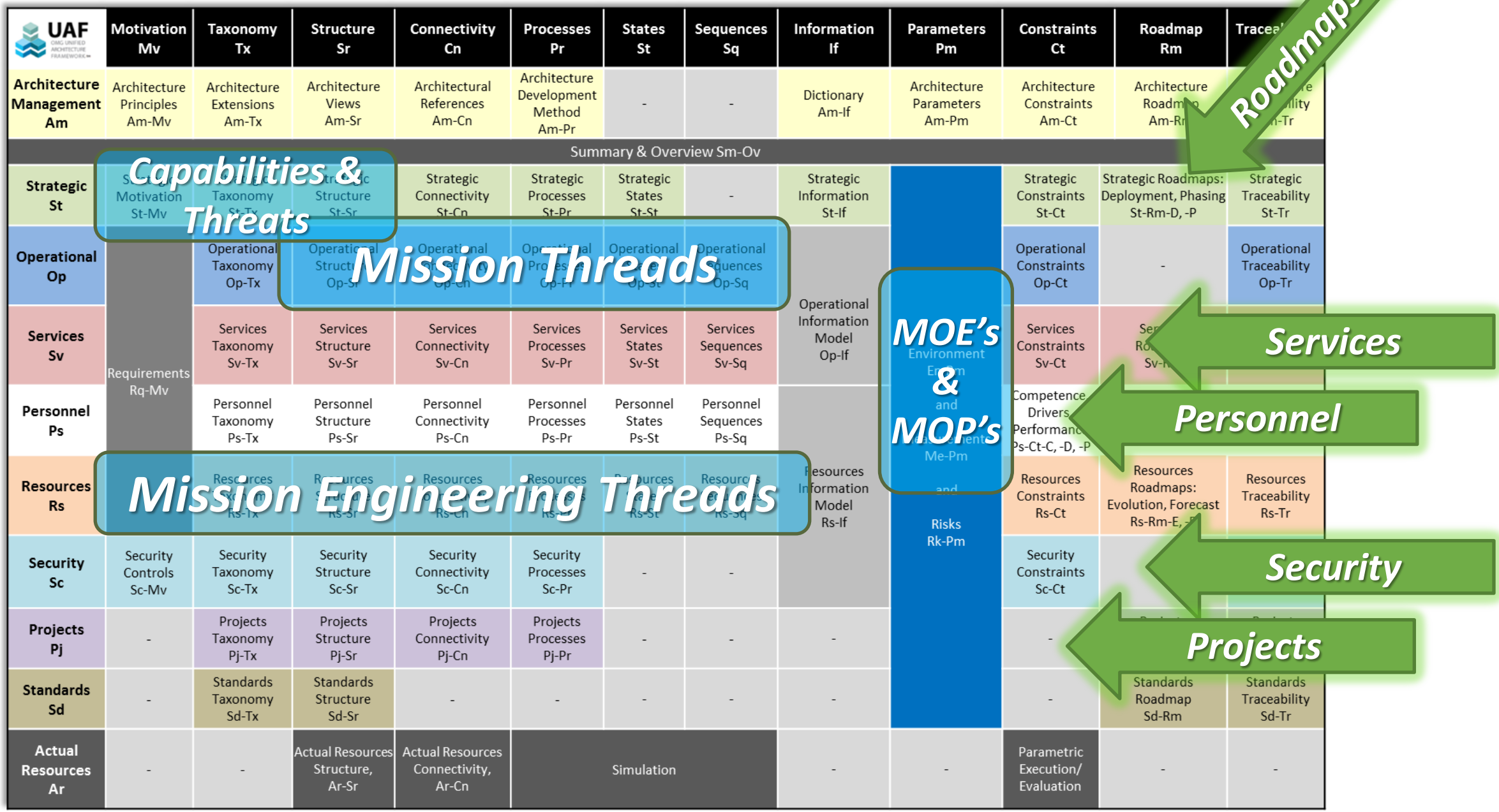


What is Mission Engineering?

- Mission Engineering (ME) is an interdisciplinary process encompassing the entire technical effort to analyze, design, and integrate current and emerging operational needs and capabilities to ***achieve desired mission outcomes***
- ME is a top-down approach that delivers engineering results to identify enhanced capabilities, technologies, system interdependencies, and architectures to guide development, prototypes, experiments, and SoS to ***achieve reference missions*** and ***close mission capability gaps***
- ME uses Systems and Systems of Systems (SoS's) in an operational mission context to inform stakeholders about building the right things, not just building things right, by ***guiding capability maturation*** to address ***warfighter mission needs***

Mission Engineering Guide.
Available online at https://ac.cto.mil/wp-content/uploads/2020/12/MEG-v40_20201130_shm.pdf

Mission Engineering Views in UAF



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		Services Constraints Sv-Ct	Services Roadmap Sv-Rm	
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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	Environment and Measurement Me-Pm and Risks Rk-Pm	Resources Constraints Rs-Ct	Resources Roadmaps: Evolution, Forecast Rs-Rm-E, -P	Resources Traceability Rs-Tr
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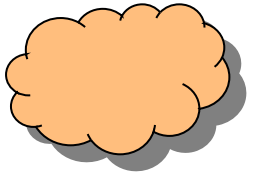
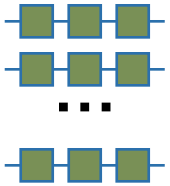
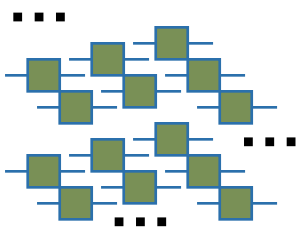
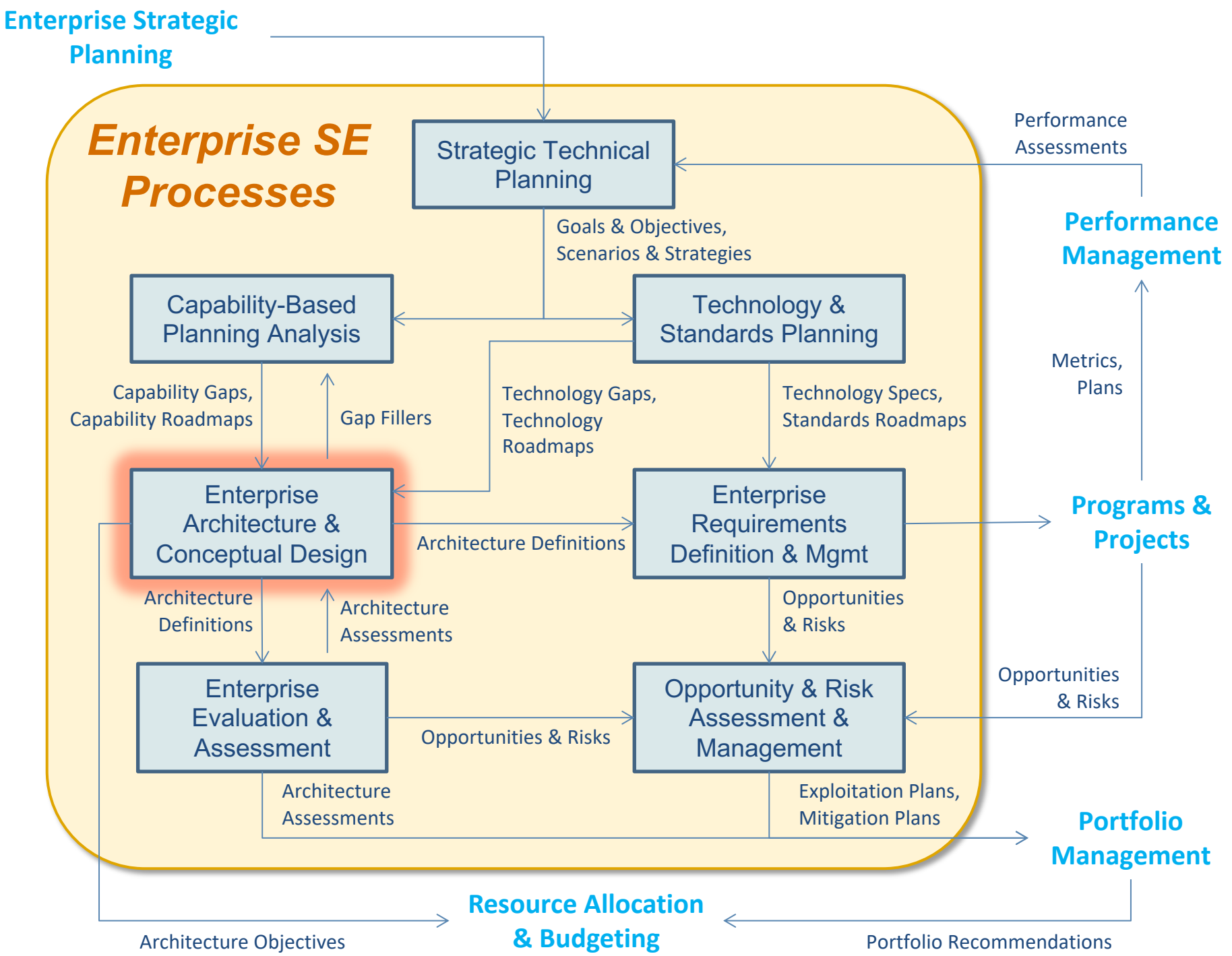
Projects Pj	-	Projects Taxonomy Pj-Tx	Projects Structure Pj-Sr	Projects Connectivity Pj-Cn	Projects Processes Pj-Pr	-	-	-		-		
Standards Sd	-	Standards Taxonomy Sd-Tx	Standards Structure Sd-Sr	-	-	-	-	-		-	Standards Roadmap Sd-Rm	Standards Traceability Sd-Tr
Actual Resources Ar	-	-	Actual Resources Structure, Ar-Sr	Actual Resources Connectivity, Ar-Cn	Simulation			-	-	Parametric Execution/ Evaluation	-	-

Different Groupings and Patterns Revealed at Different Scales

Scales	Groupings	Patterns	Descriptions
Enterprise Systems Engineering	Enterprise & Sub-enterprise		Broad Descriptions Net-centric Capabilities-based Effects Evolutionary Development Emergent Behavior
Capabilities / Constraints			
System of Systems Engineering	Tens of System of Systems (Mission Strings)		Mission Descriptions Mission-based Execution Composition and Structure of Systems and SOS's
Functionality / Constraints			
Systems Engineering	Hundreds of Independent Systems		Functional Descriptions Detailed Specifications Detailed Requirements

Source: DeRosa, Joseph K. 2005., "Enterprise Systems Engineering," Air Force Association, Industry Day, Day 1, Danvers, MA, 4 August 2005, https://www.paulrevereafa.org/IndustryDay/05/presentations/index.asp


Enterprise Strategic Planning
Enterprise SE Processes
Strategic Technical Planning
Goals & Objectives, Scenarios & Strategies
Capability-Based Planning Analysis
Technology & Standards Planning
Capability Gaps, Capability Roadmaps
Gap Fillers
Technology Gaps, Technology Roadmaps
Technology Specs, Standards Roadmaps
Enterprise Architecture & Conceptual Design
Architecture Definitions
Enterprise Requirements Definition & Mgmt
Architecture Definitions
Architecture Assessments
Opportunities & Risks
Enterprise Evaluation & Assessment
Opportunities & Risks
Opportunity & Risk Assessment & Management
Architecture Assessments
Exploitation Plans, Mitigation Plans
Performance Assessments
Performance Management
Metrics, Plans
Programs & Projects
Opportunities & Risks
Portfolio Management
Resource Allocation & Budgeting
Architecture Objectives
Portfolio Recommendations

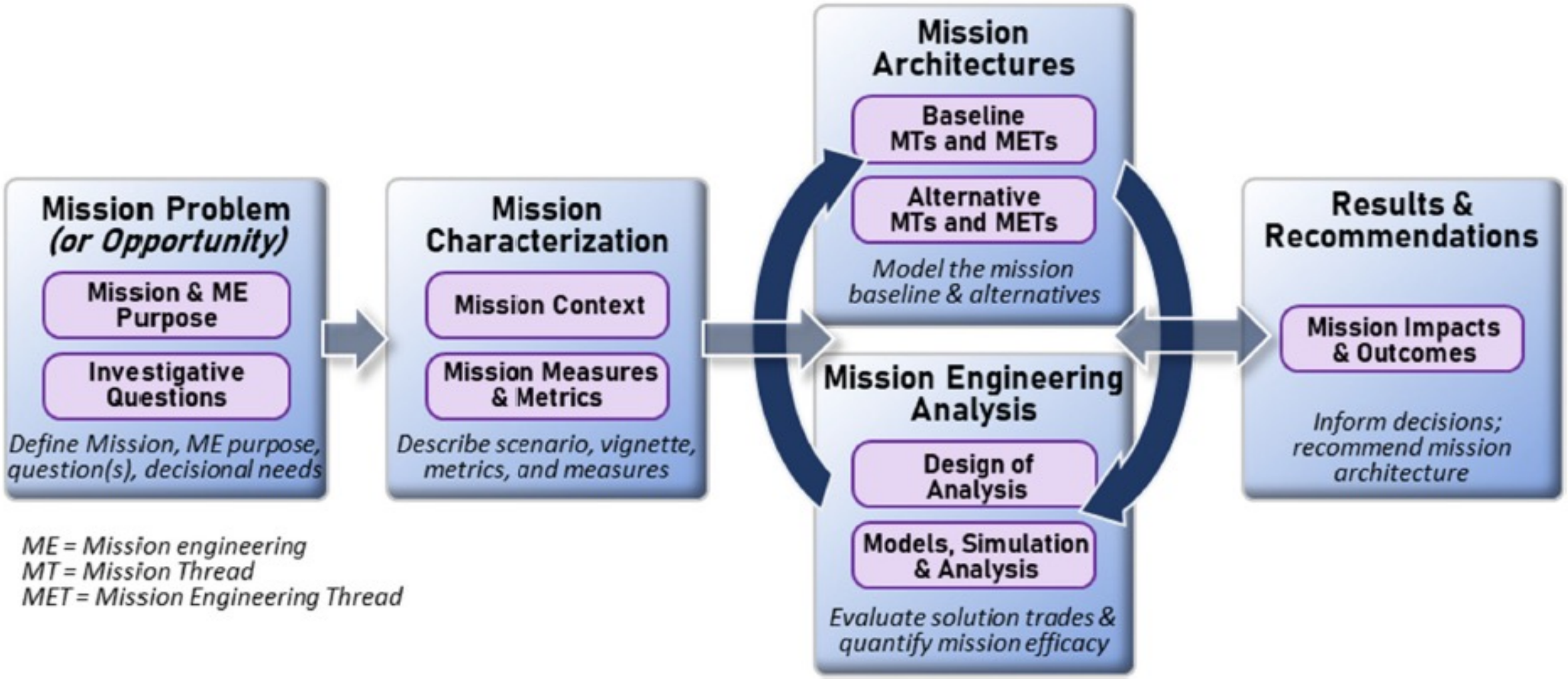
Department of Defense

Mission Engineering Guide

Version 2.0

October 1, 2023

Mission Engineering Process



ME = Mission engineering
MT = Mission Thread
MET = Mission Engineering Thread

A Long Time Ago in a Galaxy Far, Far, Away….

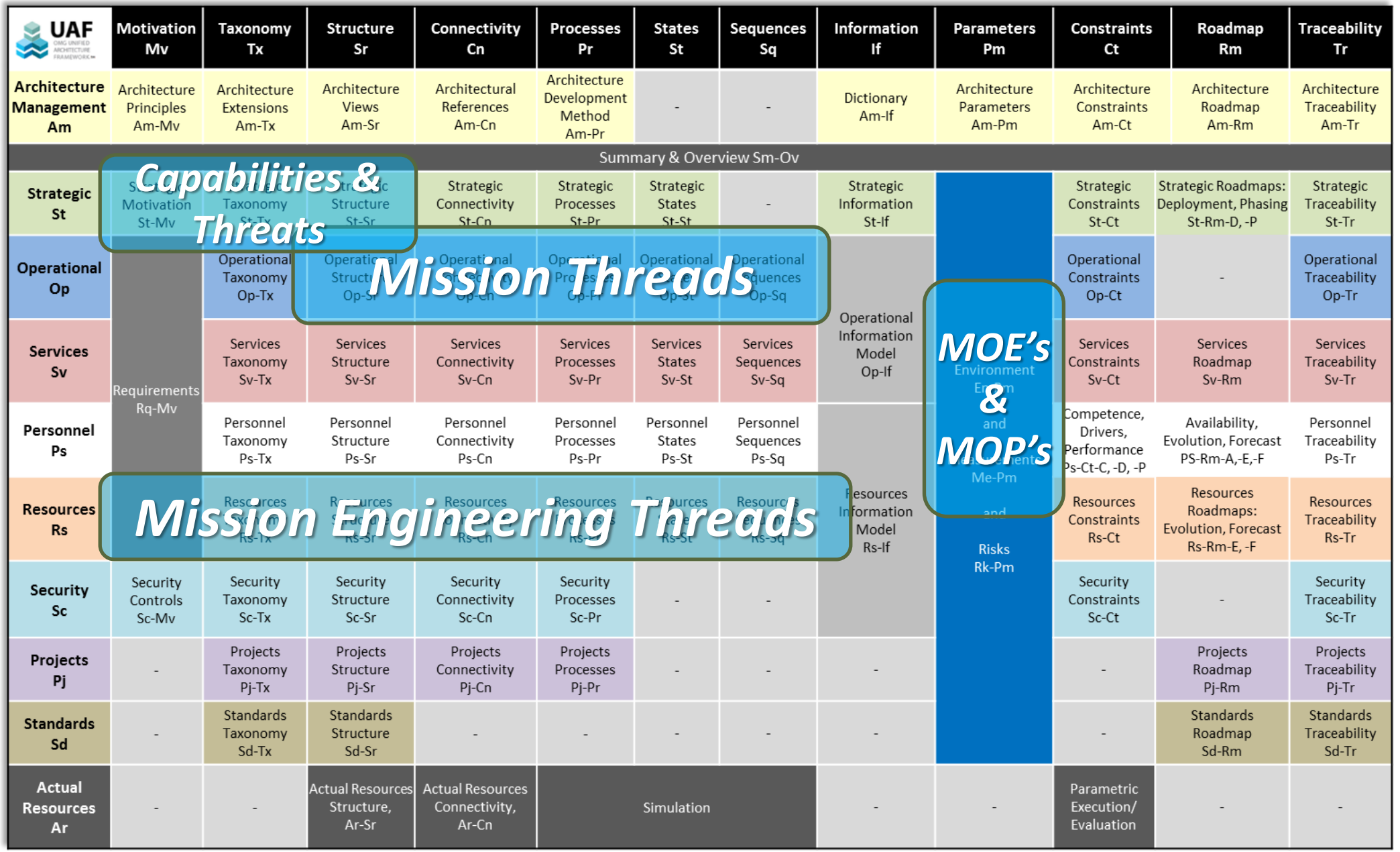
- The Battle of Hoth was a major battle fought in 3 ABY and was considered a major victory for the Galactic Empire and the single worst battlefield defeat suffered by the Rebel Alliance during the Galactic Civil War
  - ❑ The battle was an Imperial invasion led by Darth Vader, aimed at destroying the Rebel Alliance's Echo Base hidden on the remote ice world Hoth and capturing Luke Skywalker
  - ❑ The base's location was discovered when a Viper probe droid, deployed by Darth Vader's Death Squadron, landed on the planet - prompting the Rebels to begin an evacuation of Hoth

https://starwars.fandom.com/wiki/Star_Wars:_Episode_V_The_Empire_Strikes_Back#The_Battle_of_Hoth

Why the Battle of Hoth?

- The example used in this paper is the Battle of Hoth from the second Star Wars movie, “The Empire Strikes Back”
  - ❑ We are using this as an example because it is well known, contains a rich source of systems, strategies, missions, and behavior as well as illustrates joint operations
  - ❑ As it is based on a movie, there are no issues of classified materials or problems relating to the release of information
  - ❑ The actual model created to describe the complete mission would be a large undertaking requiring several diagrams
  - ❑ For reasons of space and time, we have limited this to a set of example diagrams to express the main concepts covered

Mission Engineering Views in UAF



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Stakeholders, Concerns, Goals and Drivers

- Stakeholders of the mission likely have enduring concerns that are independent of the mission but relate to its goals.
- The Legion Commander (a post Admiral Ozzel fills), Darth Sidius, and Darth Vader have Concerns that relate directly to the mission goals, linking to Drivers.

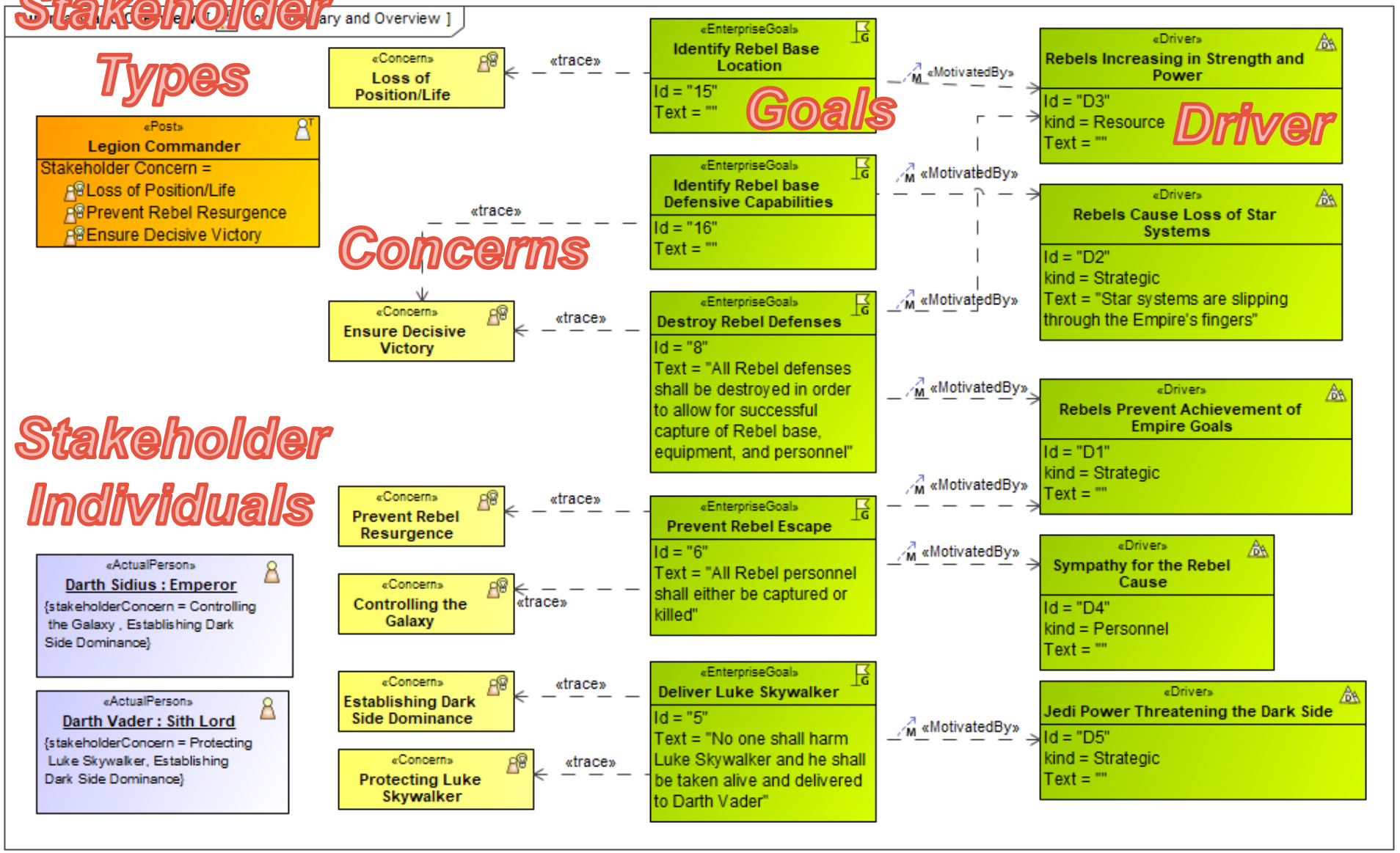
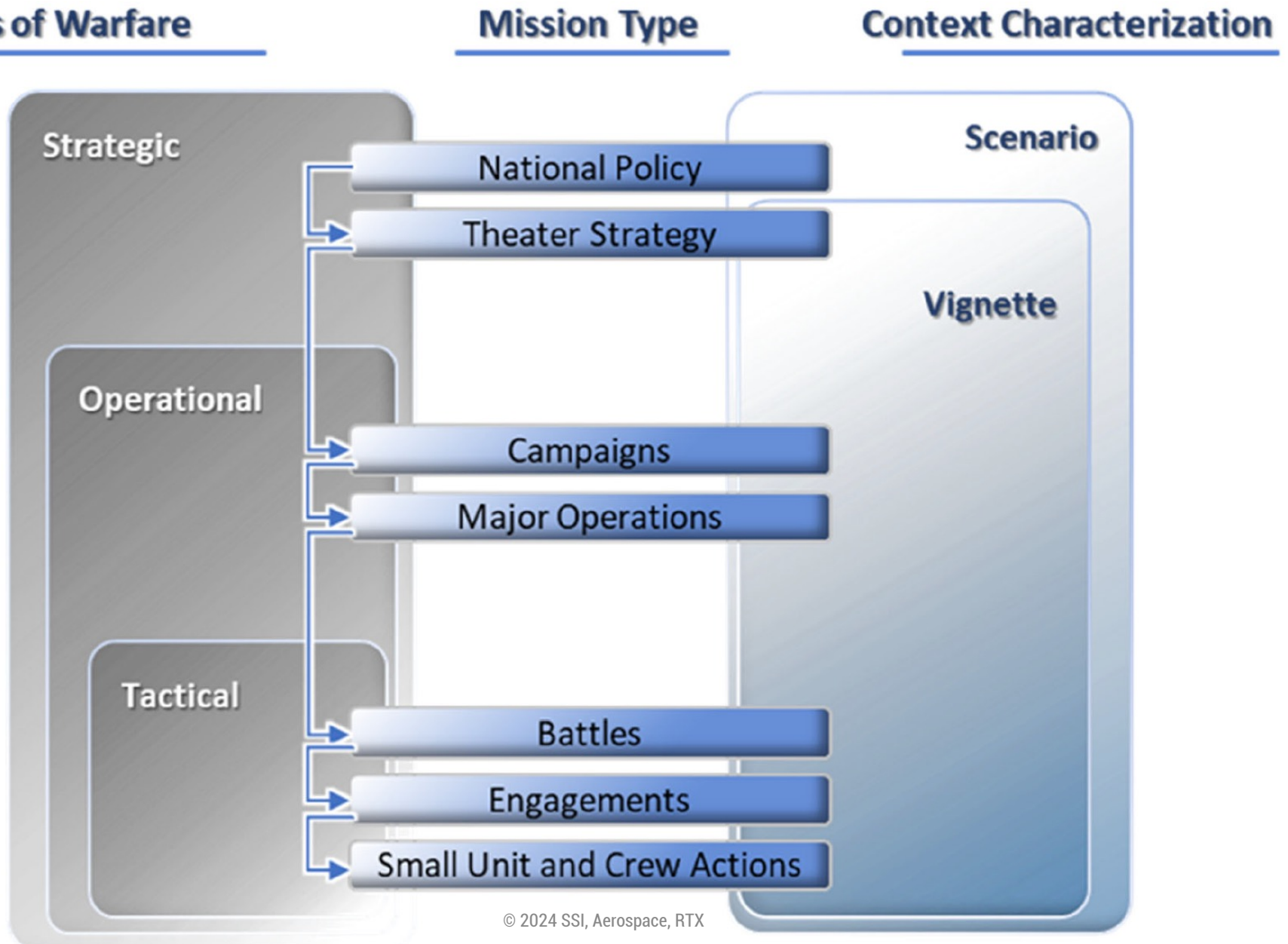


Table of Concerns and Stakeholders

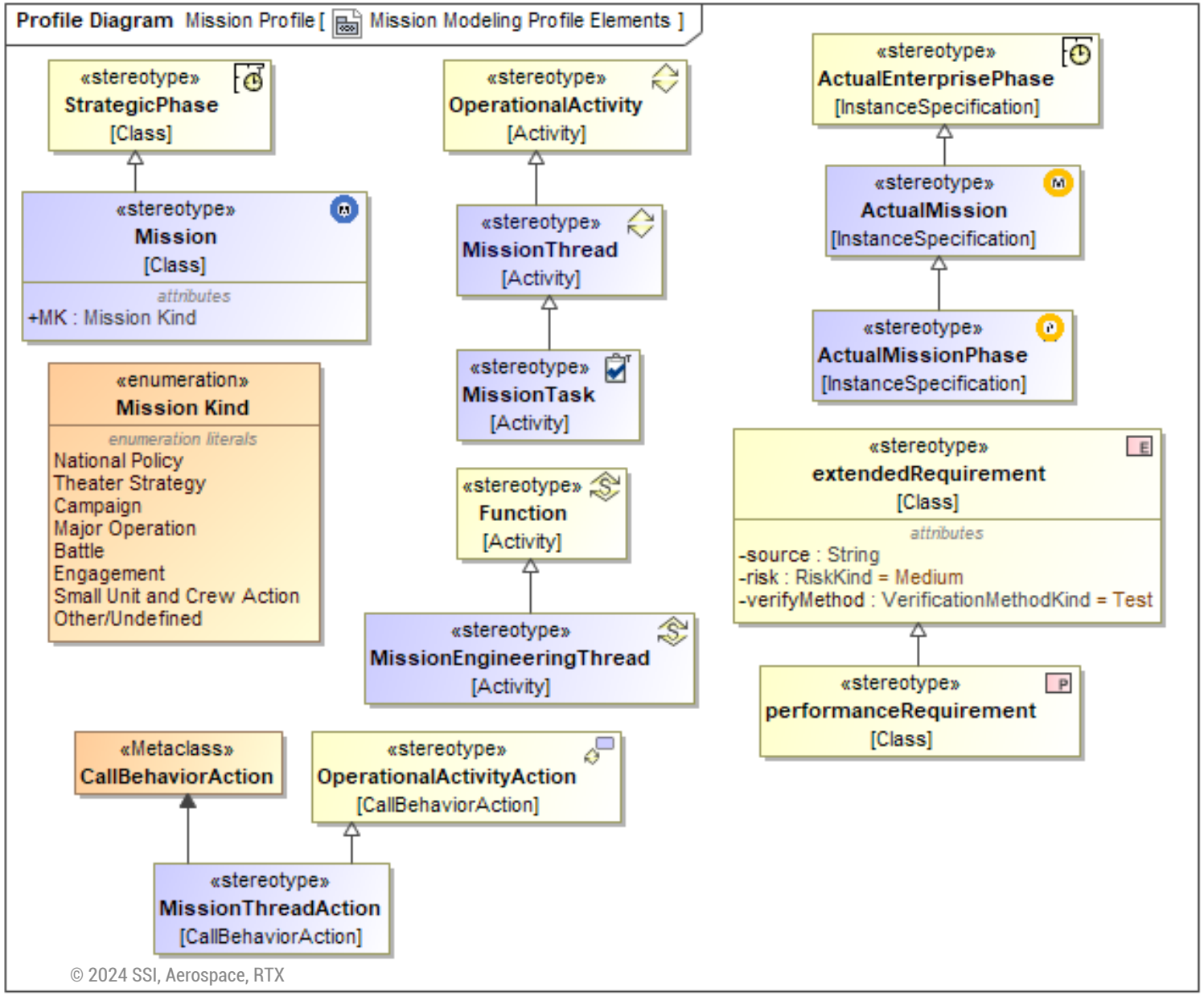
#	Name	Stakeholder Concern	Enterprise Goal	Drivers
1	Brigade Commander			
2	Chief intelligence Operator			
3	Company Commander			
4	Darth Sidius	Controlling the Galaxy Establishing Dark Side Dominance	EG6 Prevent Rebel Escape EG5 Deliver Luke Skywalker	D1 Rebels Prevent Achievement of Empire Goals D4 Sympathy for the Rebel Cause D5 Jedi Power Threatening the Dark Side
5	Darth Vader	Protecting Luke Skywalker Establishing Dark Side Dominance	EG5 Deliver Luke Skywalker	D5 Jedi Power Threatening the Dark Side
6	Division Commander			
7	Emperor			
8	Empire Spy			
9	Hoth Spy			
10	Intelligence Operative			
11	Legion Commander	Loss of Position/Life Prevent Rebel Resurgence Ensure Decisive Victory	EG9 Identify Rebel Base Location EG6 Prevent Rebel Escape EG7 Destroy Rebel Defenses EG10 Identify Rebel base Defensive Capabilities	D3 Rebels Increasing in Strength and Power D1 Rebels Prevent Achievement of Empire Goals D4 Sympathy for the Rebel Cause D2 Rebels Cause Loss of Star Systems
12	Platoon Leader			
13	Section Leader			
14	Sith Lord			
15	Sqd Ldr			
16	Squad Driver			
17	Squad Gunner			
18	Squad Leader			
19	Squad Roles			
20	Squad Trooper			

Mission Types, Levels, and Context



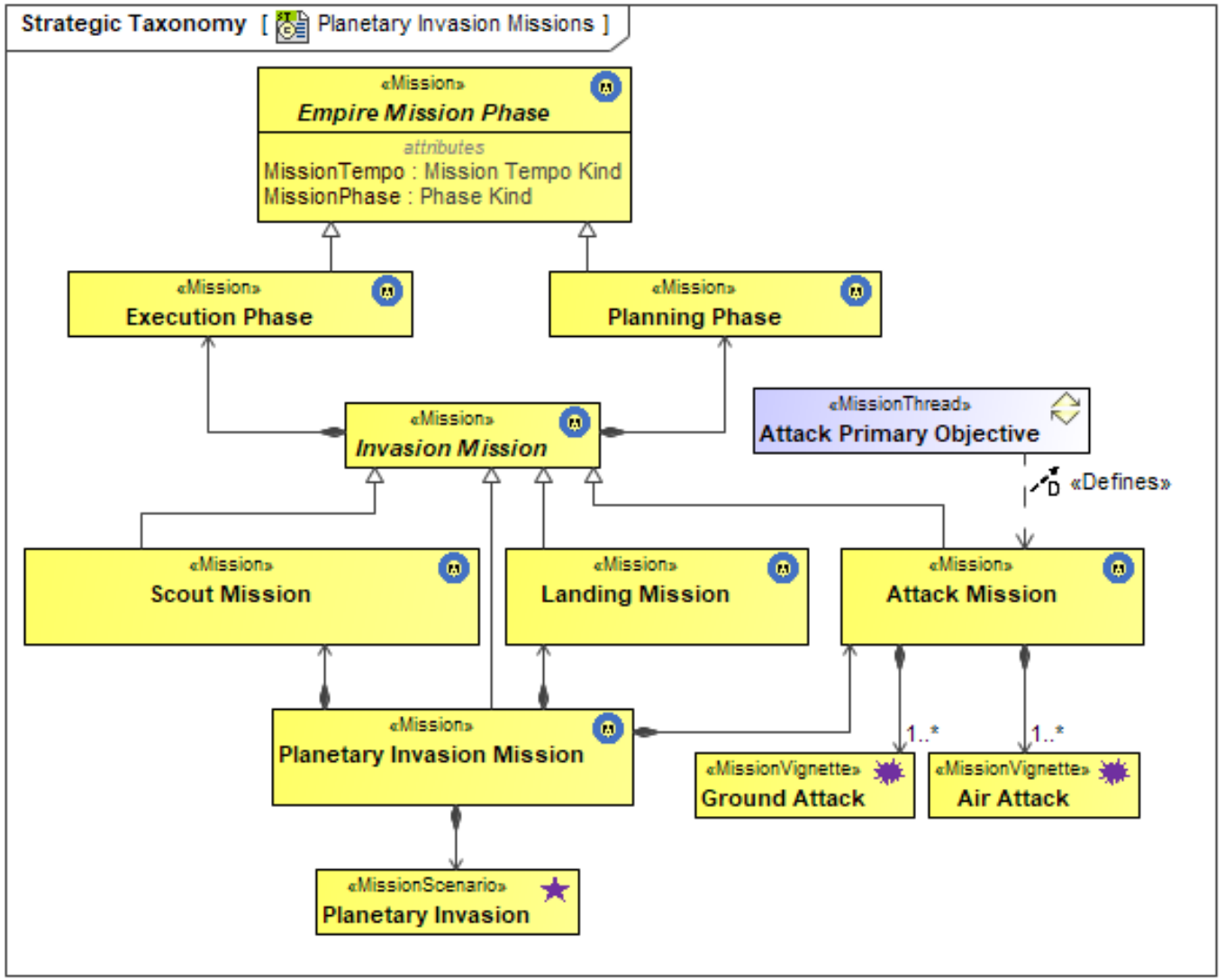
Mission Modeling Profile Elements View

- We took a minimalist approach: only add what was necessary
- Simple extensions to add some of the concepts to be implemented in UAF 1.3
  - Mission
  - Actual Mission
  - Mission Kind
  - Actual Mission Phase
  - Mission Thread
  - Mission Thread Action
  - Mission Task
  - Mission Engineering Thread
  - Extensions to the UAF diagrams.
- Performance requirement is a standard SysML construct

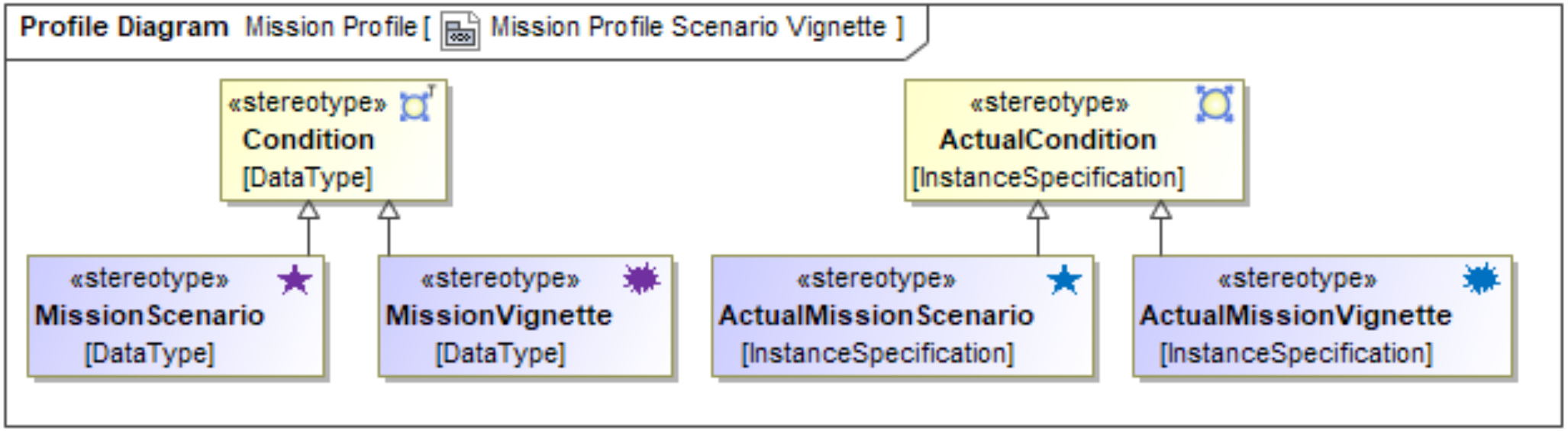


Planetary Invasion Missions for the Evil Empire

- The Empire Mission structure shown illustrates the complexity required to model missions
- Empire doctrine proscribes that every military mission has two phases to it: Planning and Execution
- A Planetary Invasion Mission is comprised of separate Scout, Landing, and Attack Missions, each with their own Planning and Execution Phases
- These are all types of Invasion Missions. Each of these have a defined Mission Type
- The Execution and Planning Phases both inherit Mission Tempo and Phase attributes



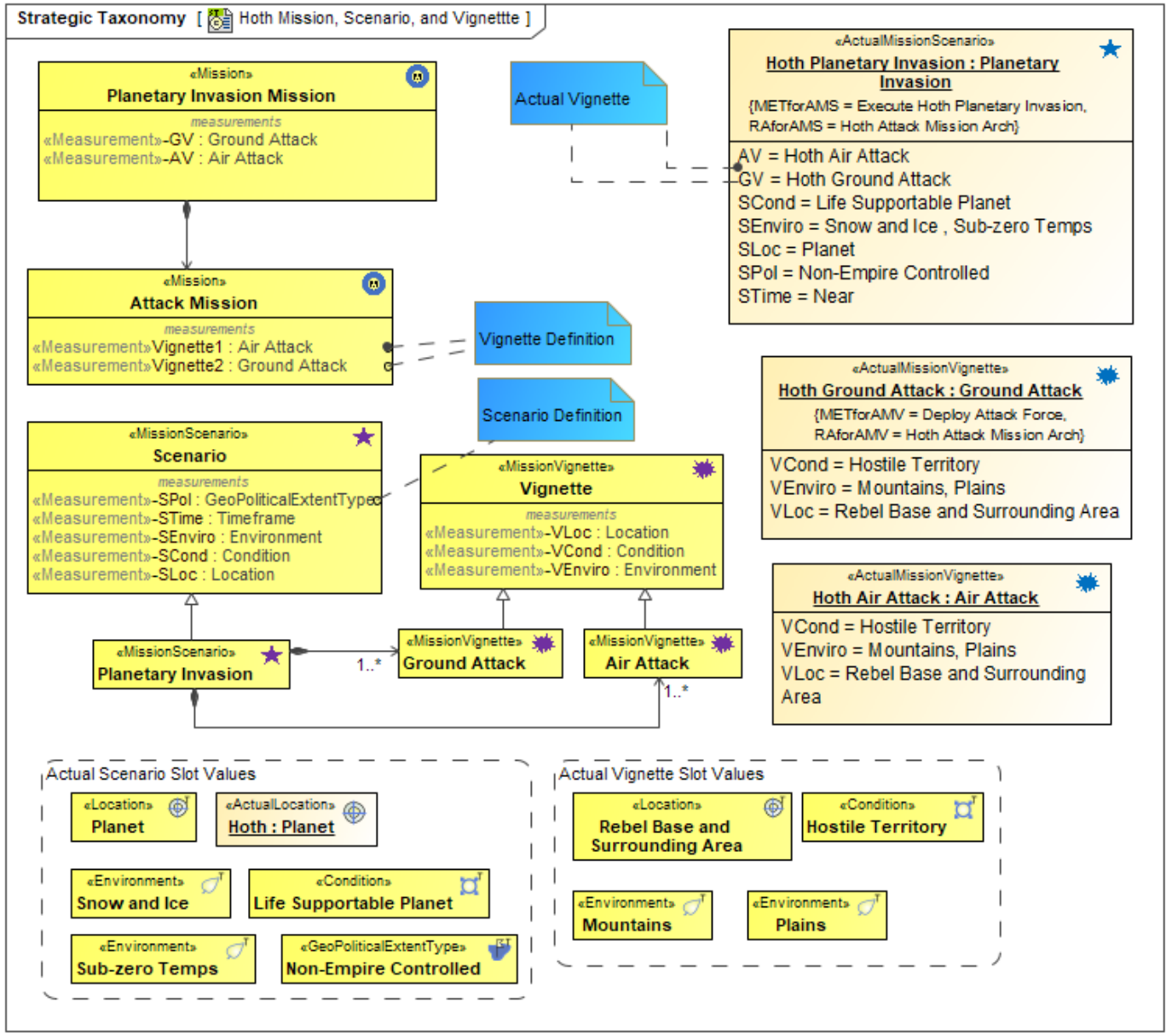
Vignettes and Scenarios



- **Scenario** – Description of the geographical location and time frame of the overall conflict. It should include information such as threat and friendly politico-military contexts and backgrounds, assumptions, constraints, limitations, strategic objectives, and other planning considerations. (ME Guide)
- **Vignette** – A narrow and specific ordered set of events, and behaviors and interactions for a specific set of systems to include blue capabilities and red threats within the operational environment. Vignettes can represent small, ideally self-contained parts of a scenario (ME Guide)
- For the UAF, the actuals are the ones that contain the specific information – **Actual Mission Scenario** and **Actual Mission Vignette**

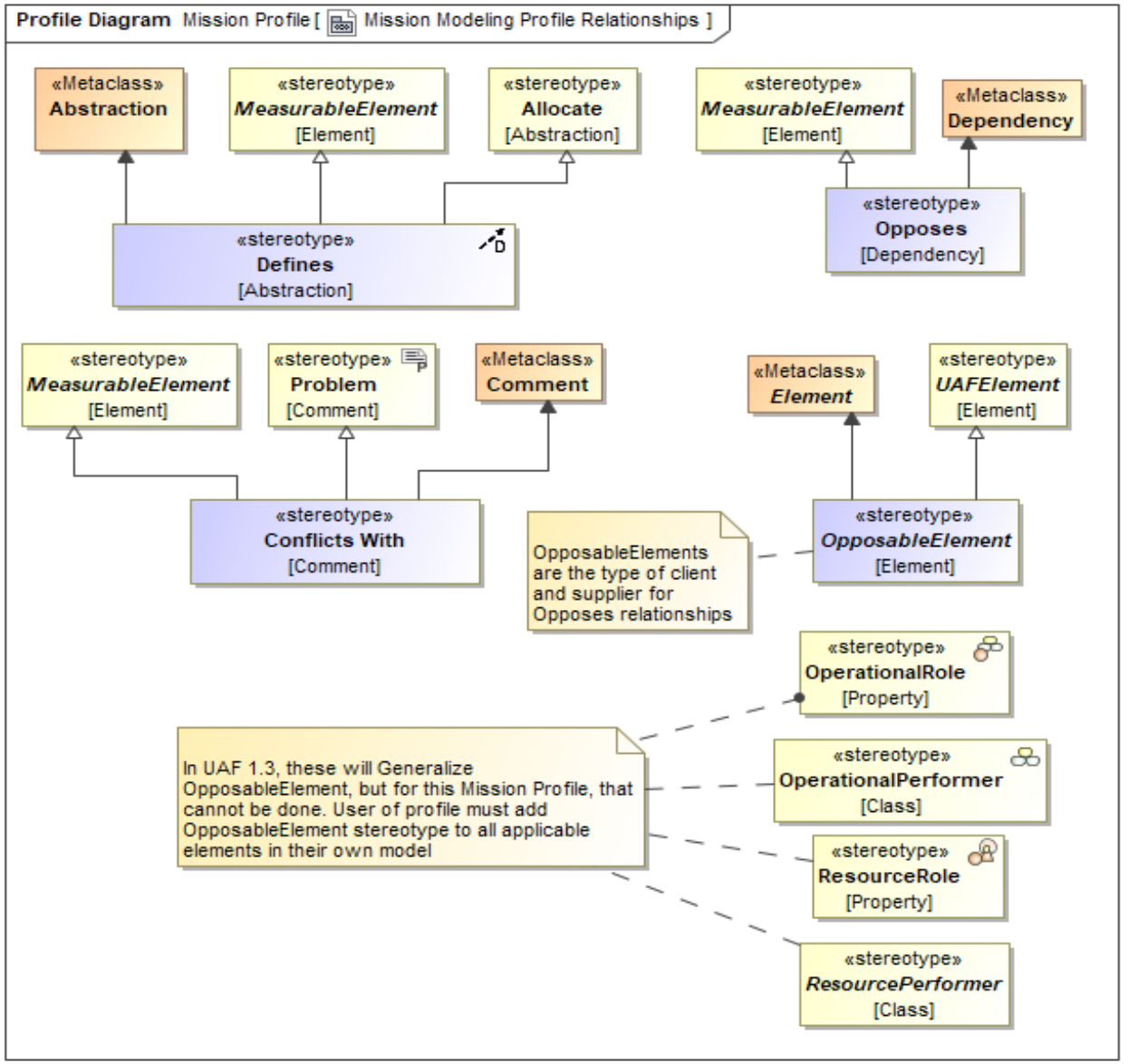
Vignettes and Scenarios Linked to Mission Types & Mission Instances

- On the left are a default Mission Scenario and Vignette Definitions. These will be included in the profile as examples
- These have been extended for the Hoth Battle
- Along the bottom are a set of conditions that can be used throughout the model
- These are used by the instances of scenario and vignette on the right.
- These are then linked to the Mission definitions so that the Mission actuals can reference the Vignette and Scenario actuals



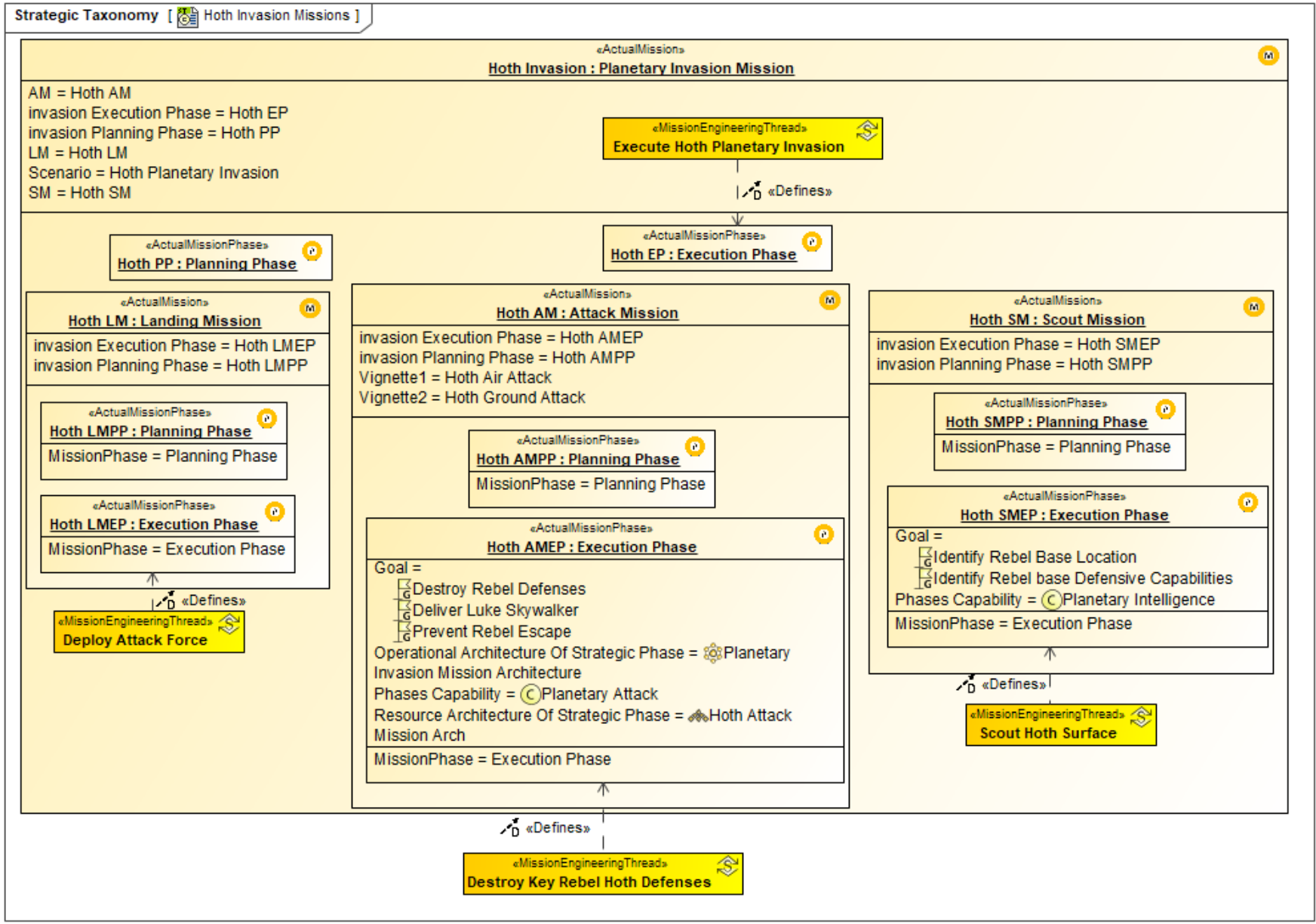
Mission Modeling Profile Relationships

- Relationships were added to allow traceability between functional and structural elements
- Mission Threads map to Missions via the Process Defines Initiative relationship
- Mission Engineering Thread maps to the Actual Mission via the Process Adapts to Actual Initiative
- The Opposes Dependency provides a means of indicating elements in the model that conflict with one another such as opposing goals



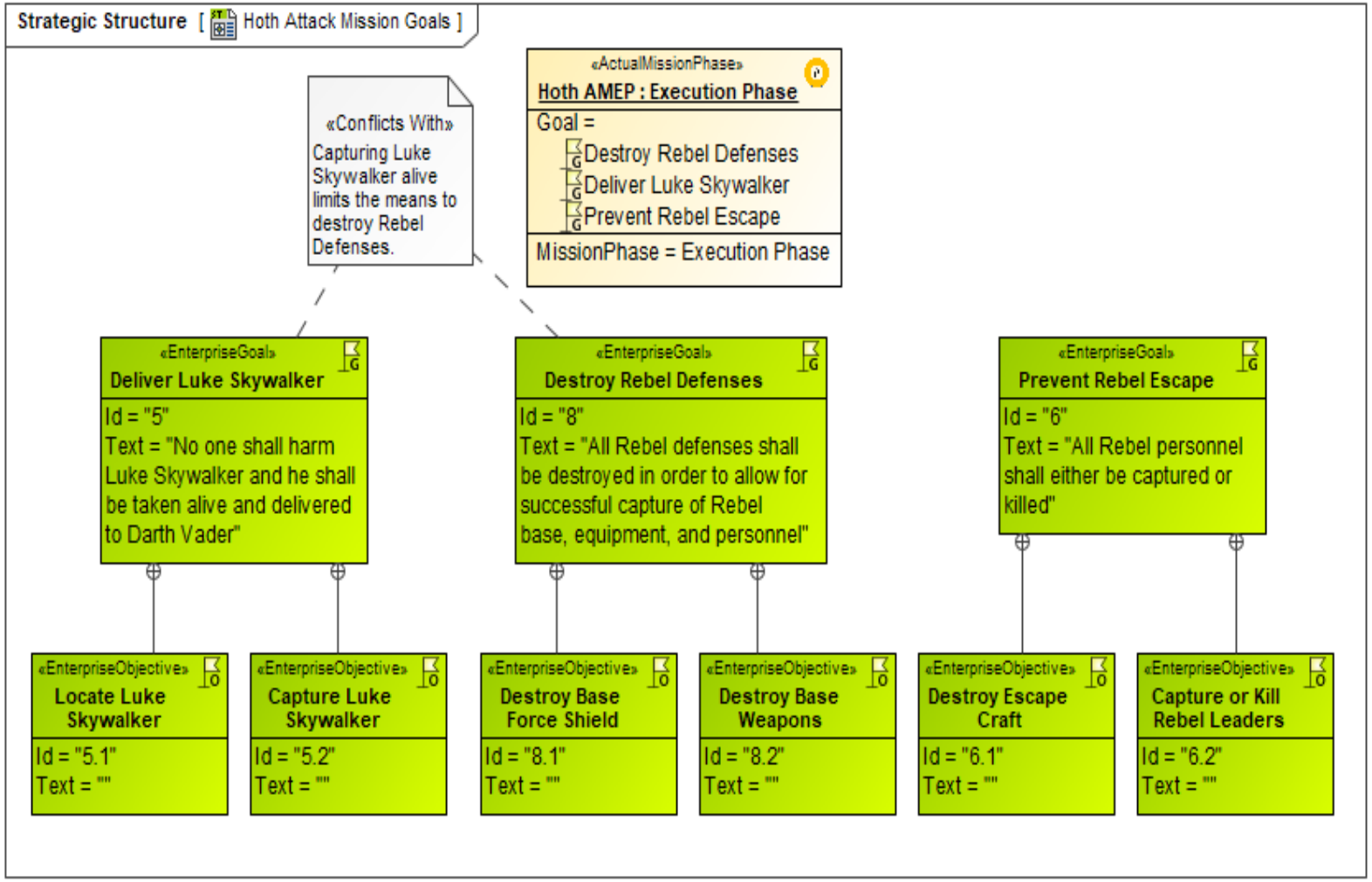
Invasion Missions on the Planet Hoth

- The Hoth Invasion is an instance of the Planetary Invasion Mission
- This Actual Mission is made up of the Planning and Execution Phase as well as the Landing Mission, Attack Mission, and Scout mission
- These Missions each have Planning and Execution Phases
- The Execution phases all have Mission Engineering Threads mapped to them
- The Hoth AMEP Execution Phase has defined goals as well as Operational and Resource Architecture



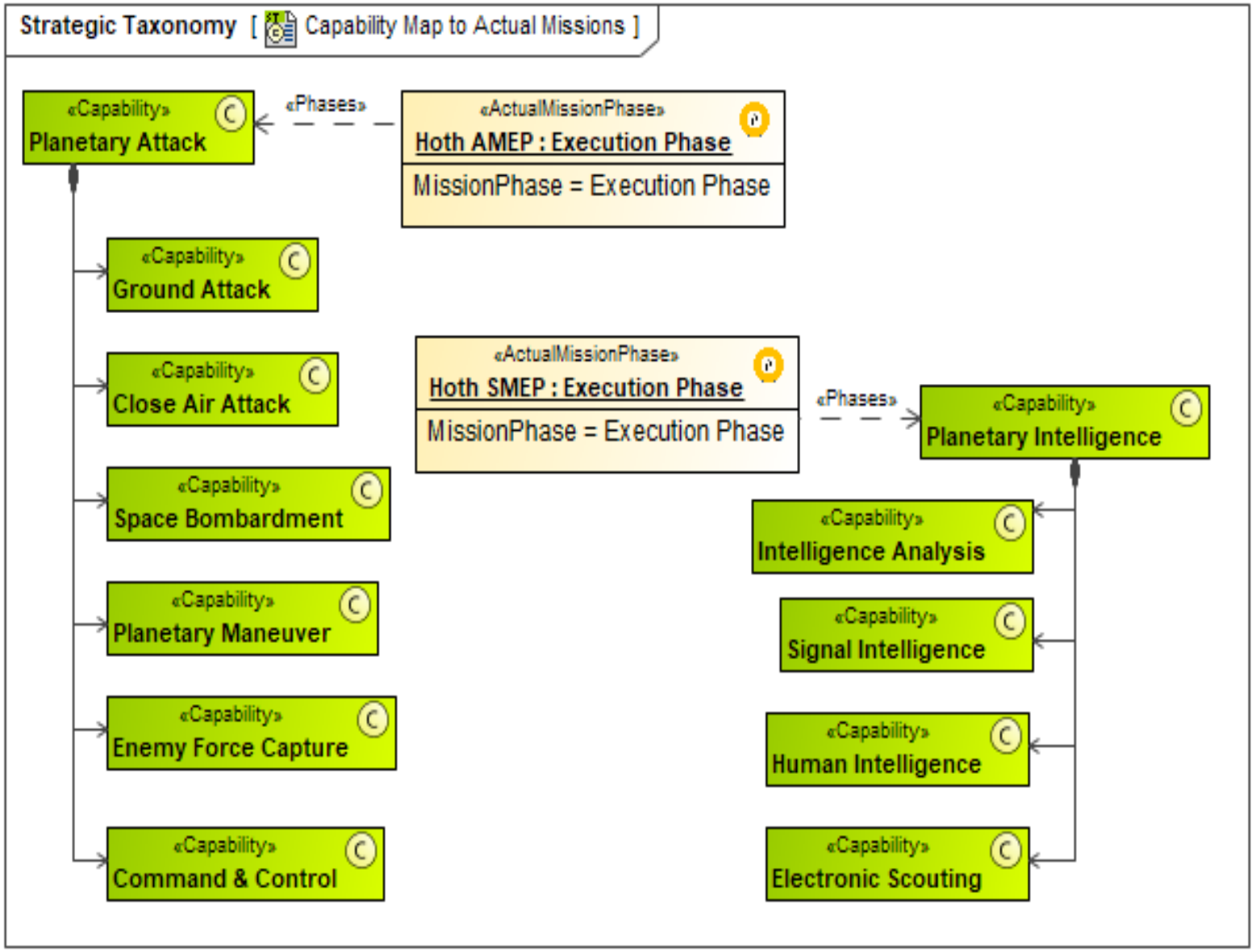
Hoth Battle Execution Phase – Specific Mission Goals

- Prior to planning the Mission Thread and Mission Engineering Thread, the Goals of the Mission are defined
- These are to Destroy Rebel Defenses, Prevent Rebel Escape, and Capture Luke Skywalker
- The constraint imposed by Capturing Luke Skywalker alive and unharmed is one of the causes that lead to Attack Mission failure
- The Empire normally executes their missions with extreme violence. This constraint, prevented this hence the “Conflicts With” relationship
- Objectives or sub-goals are also defined for each goal using the containment relationship



Capability Map to Mission Phases

- The Planetary Attack capability hierarchy is shown on the left
- This includes Ground Attack, Close Air Attack, etc.
- Planetary Intelligence is shown on the right
- Linking the mission to the highest-level capability reduces the coupling of the two structures
- These capabilities along with the associated metrics will form the basis for trade-off analysis of the candidate architectures and systems



Strategic Actual Enterprise Phase Taxonomy Table

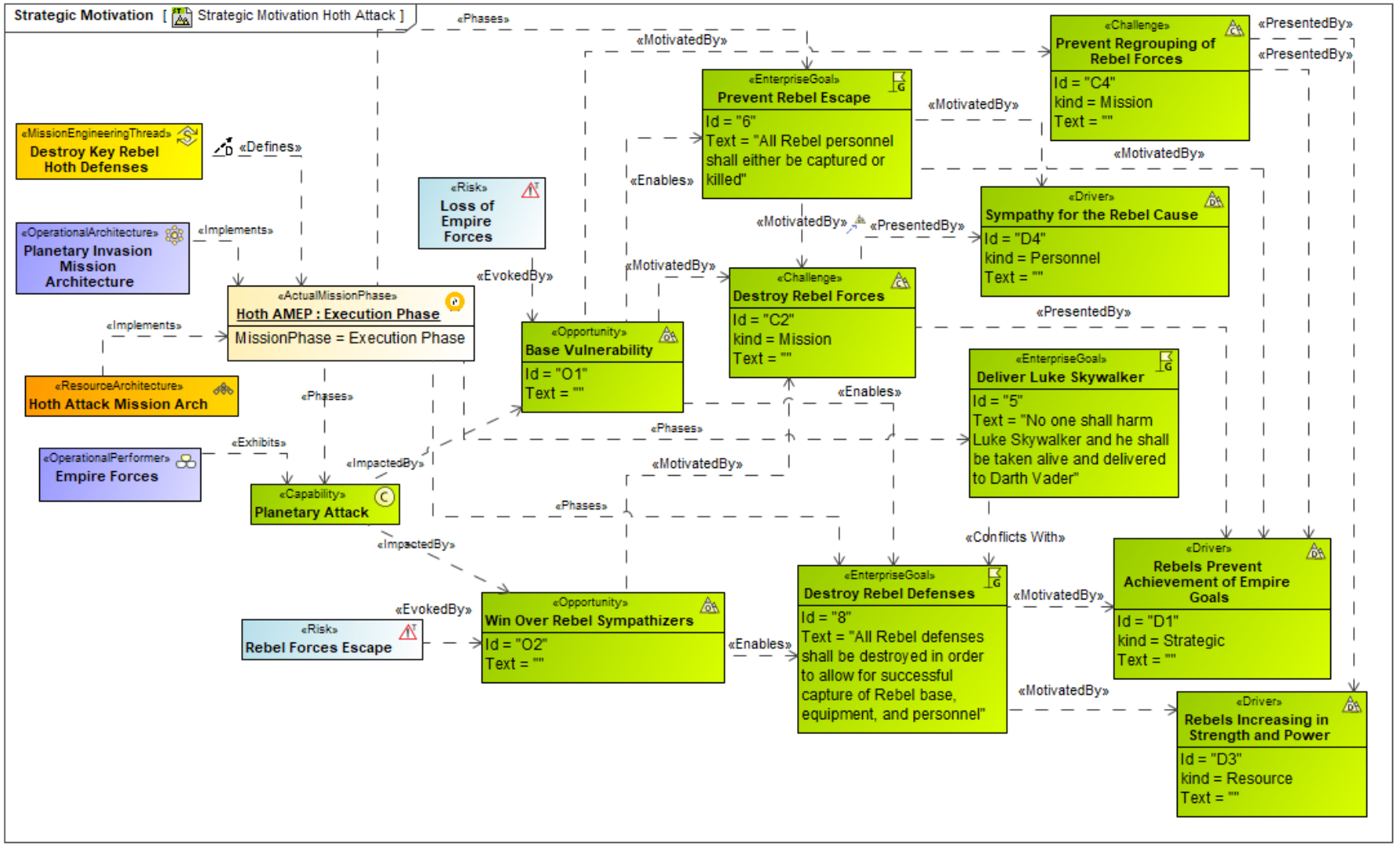
- Automatically generated table showing details of the Actual Missions and Phases

#	Name	Type	Goal	Operational Architecture Of Strategic Phase	Resource Architecture Of Strategic Phase	Phases Capability	Slot
1	Execute Hoth Invasion	Execution Phase					MissionTempo = Rapid and Forceful MissionPhase = Execution Phase
2	Hoth AM	Attack Mission					invasion Planning Phase = Hoth AMPP invasion Execution Phase = Hoth AMEP Vignette1 = Hoth Air Attack Vignette2 = Hoth Ground Attack
3	Hoth AMEP	Execution Phase	EG7 Destroy Rebel Defense EG5 Deliver Luke Skywalker EG6 Prevent Rebel Escape	Planetary Invasion Missi	Hoth Attack Mission Ar	Planetary Attack	MissionPhase = Execution Phase
4	Hoth AMPP	Planning Phase					MissionPhase = Planning Phase
5	Hoth Attack Mission	Attack Mission					
6	Hoth EP	Execution Phase					
7	Hoth Invasion	Planetary Invasion Mission					LM = Hoth LM AM = Hoth AM SM = Hoth SM invasion Planning Phase = Hoth PP invasion Execution Phase = Hoth EP Scenario = Hoth Planetary Invasion
8	Hoth Landing Mission	Landing Mission					
9	Hoth LM	Landing Mission					invasion Execution Phase = Hoth LMEP invasion Planning Phase = Hoth LMPP
10	Hoth LMEP	Execution Phase					MissionPhase = Execution Phase
11	Hoth LMPP	Planning Phase					MissionPhase = Planning Phase
12	Hoth PP	Planning Phase					
13	Hoth Screen Mission	Scout Mission					
14	Hoth SM	Scout Mission					invasion Planning Phase = Hoth SMPP invasion Execution Phase = Hoth SMEP
15	Hoth SMEP	Execution Phase	EG9 Identify Rebel Base Lo EG10 Identify Rebel base D			Planetary Intelligence	MissionPhase = Execution Phase
16	Hoth SMPP	Planning Phase					MissionPhase = Planning Phase
17	Plan Hoth Invasion Mis	Planning Phase					

Hoth Battle – Attack Strategy

Key Strategic Relationships for Hoth Attack Mission Execution Phase

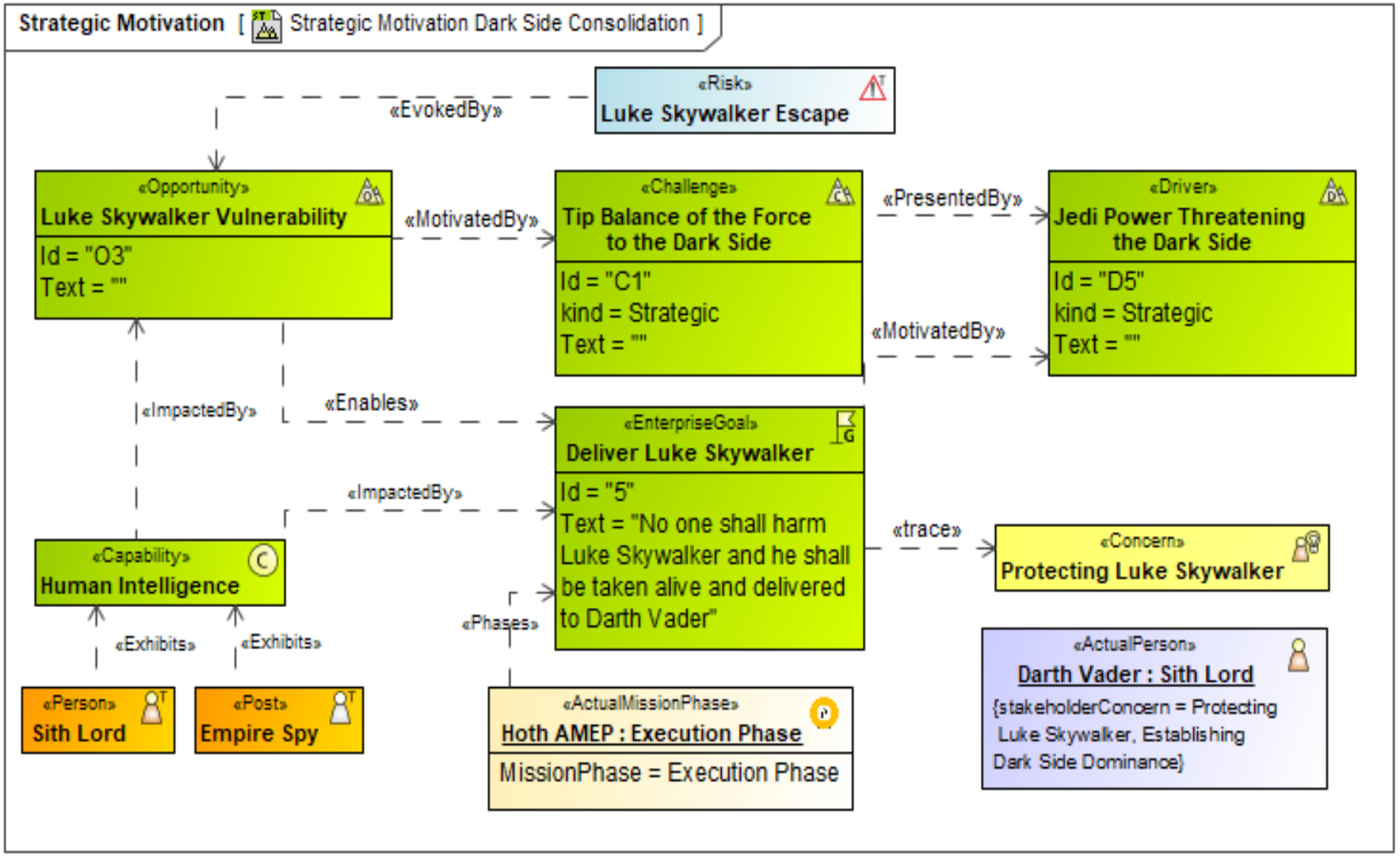
- Drivers, Challenges, Opportunities, Goals and Risks are all shown here
- The Operational and Resource elements are linked to the Capabilities to demonstrate how they will be realized
- Several elements are linked to the Actual Mission Phase showing when they will be deployed



Strategy for the Scouting Phase of the Mission

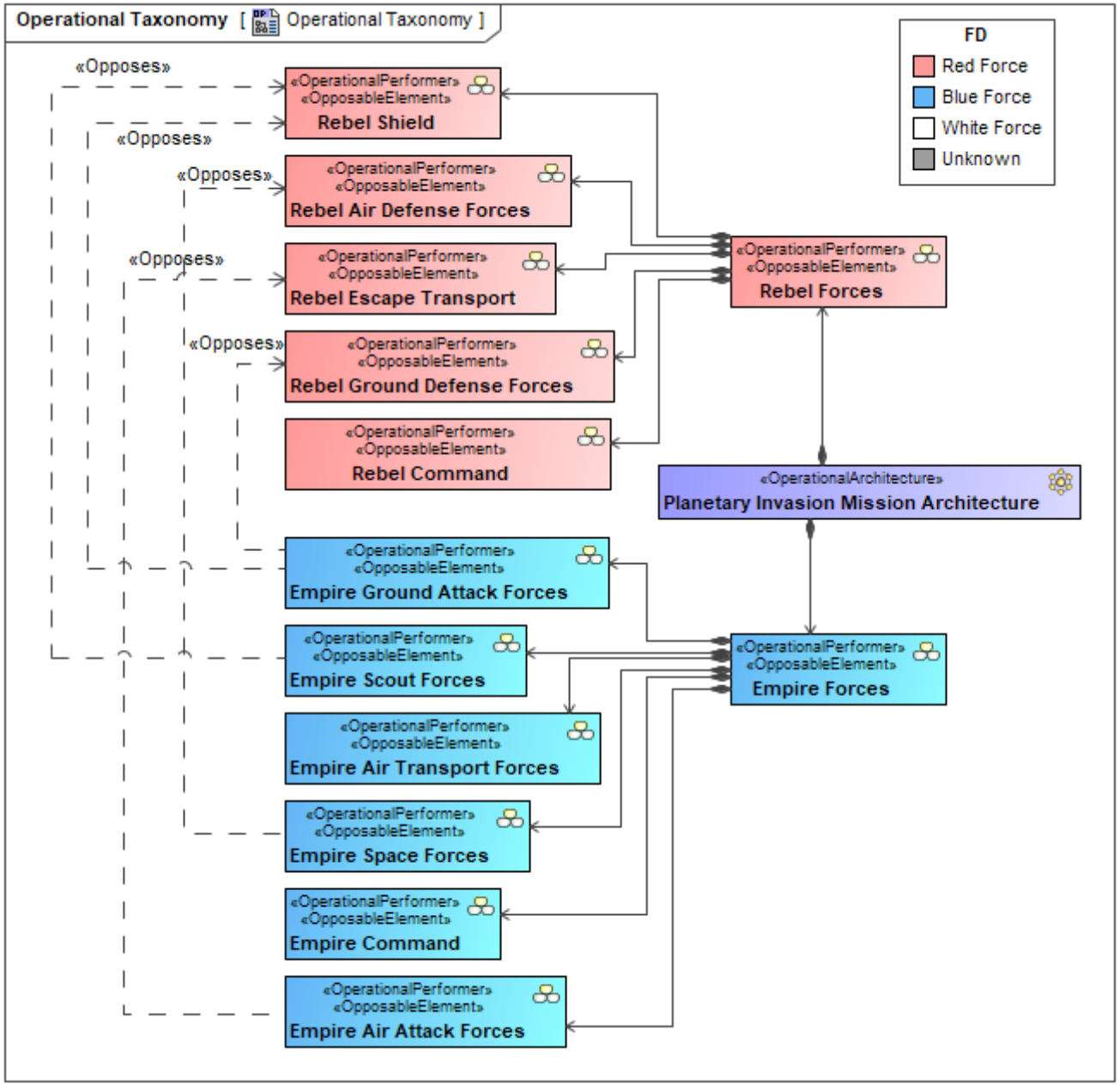
Key Strategic Relationships Relating to the Goal of Delivering Luke

- The complete set of elements for a single goal are shown here
- Darth Vader has the concern of protecting his son, tracing to the goal of delivering him alive
- Luke's vulnerability enables the goal which is motivated by the challenge to tip the balance of the force
- Jedi power threatening the Dark Side is presented by this challenge and motivated by the goal, impacted by the human intelligence capability, realized by spies and the Sith Lords



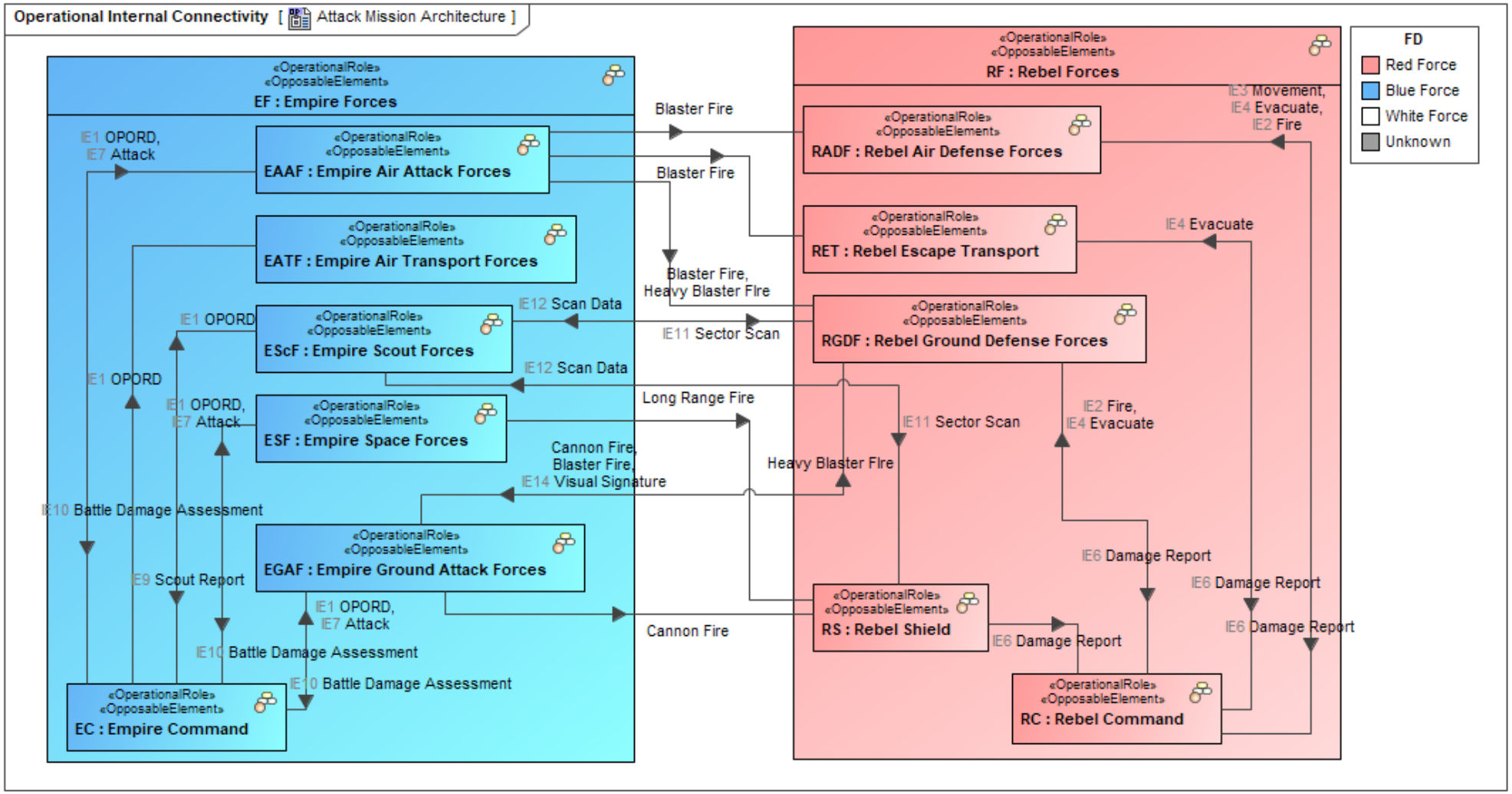
Operational Performer Types (ie, the Actors)

- Defines the Operational Architecture hierarchy of the context in which the Empire (Blue Force) and Rebel Forces (Red Forces) will engage
- The previously defined Force Designator stereotypes are shown via colors and labels
- The Empire forces are those which will be deployed as part of their attack strategy. These are the abstract elements, from which Resources will be chosen to implement them
- The Rebel Forces are less clear. They have been discovered by reconnaissance systems. Additional attributes such as provenance, confidence level, etc. can be added as shown later
- The Rebel Forces were able to escape as the Empire underestimated the strength of the ground forces cannon which destroyed one of their spaceships



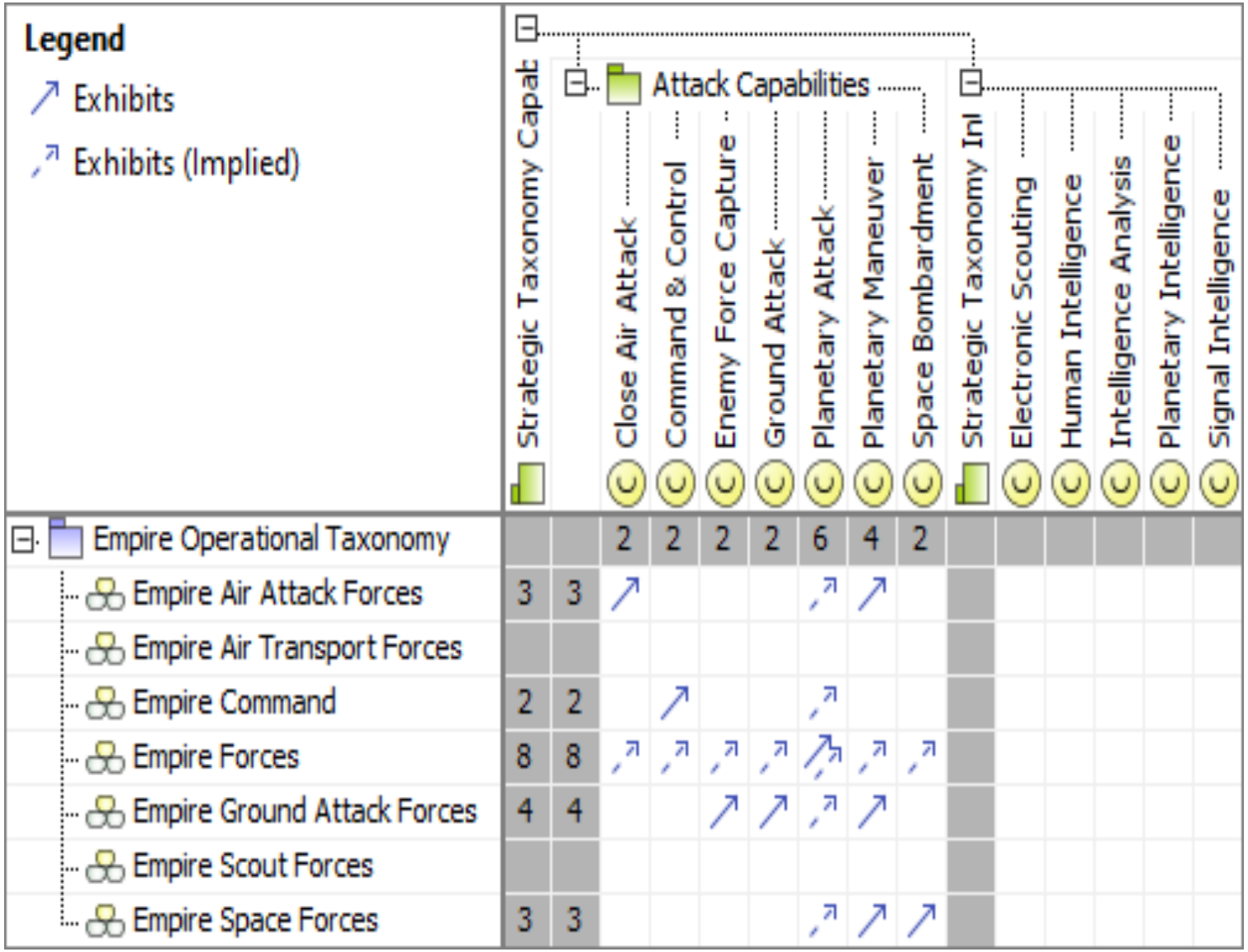
Attack Mission Architecture with Red and Blue Forces

- IBD version of the Operational Architecture
- An abstract/solution independent expression of the proposed battle
- Interactions include Information Exchanges between troops and commanders, weapons fire, sustained damage, scan data, etc.
- Red/Blue designations are included, in this case for the Operational Roles



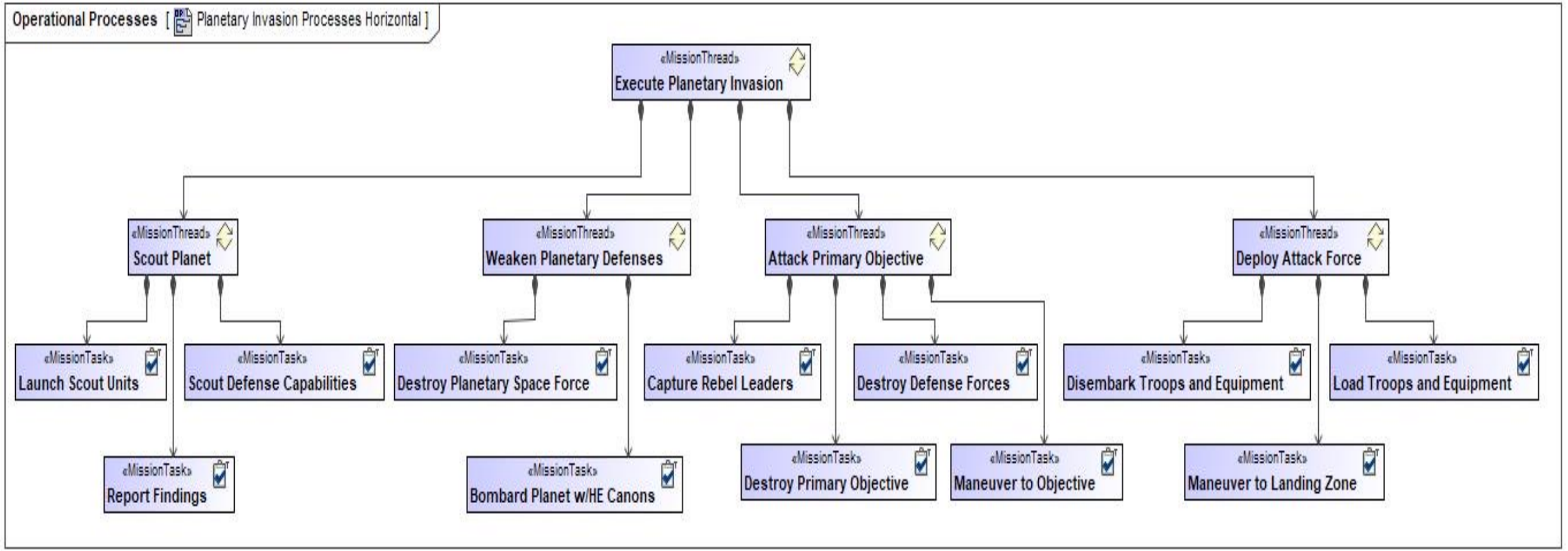
Operational Performers to Capabilities Mapping Matrix

- Automatically generated table
- Traceability between the required Capabilities and the proposed Operational Performers. The Scout Forces and Air Transport Forces are not included in the Attack context
- All required capabilities have been exhibited



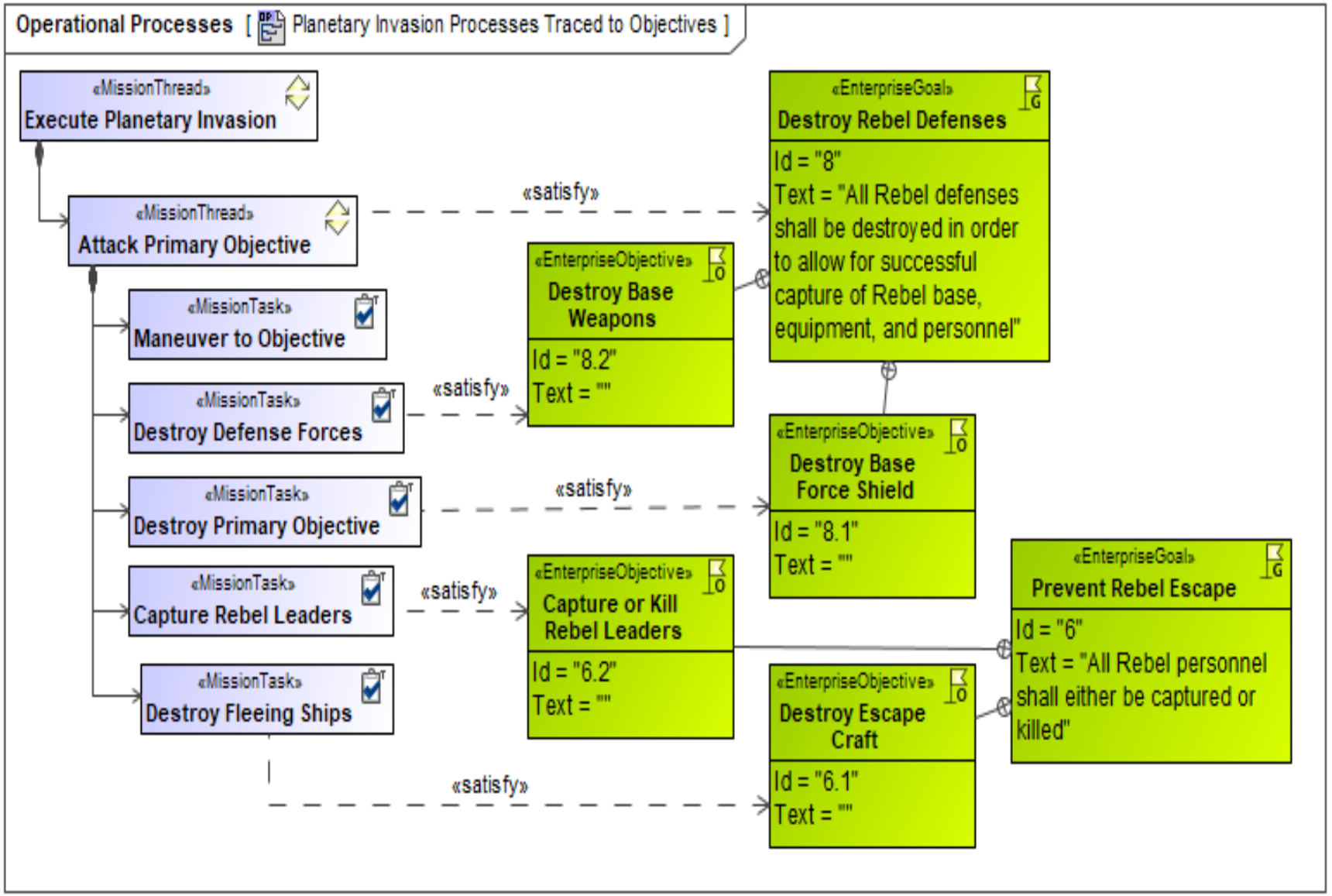
Planetary Invasion Processes – Mission Threads & Tasks Decomposition

- This is the functional hierarchy of the Execute Planetary Invasion Mission Thread
- It is broken into Mission Threads of Scout Planet, Weaken Planetary Defenses, Attack Primary Objective and Deploy Attack Force
- Each of these are further decomposed into Mission Tasks



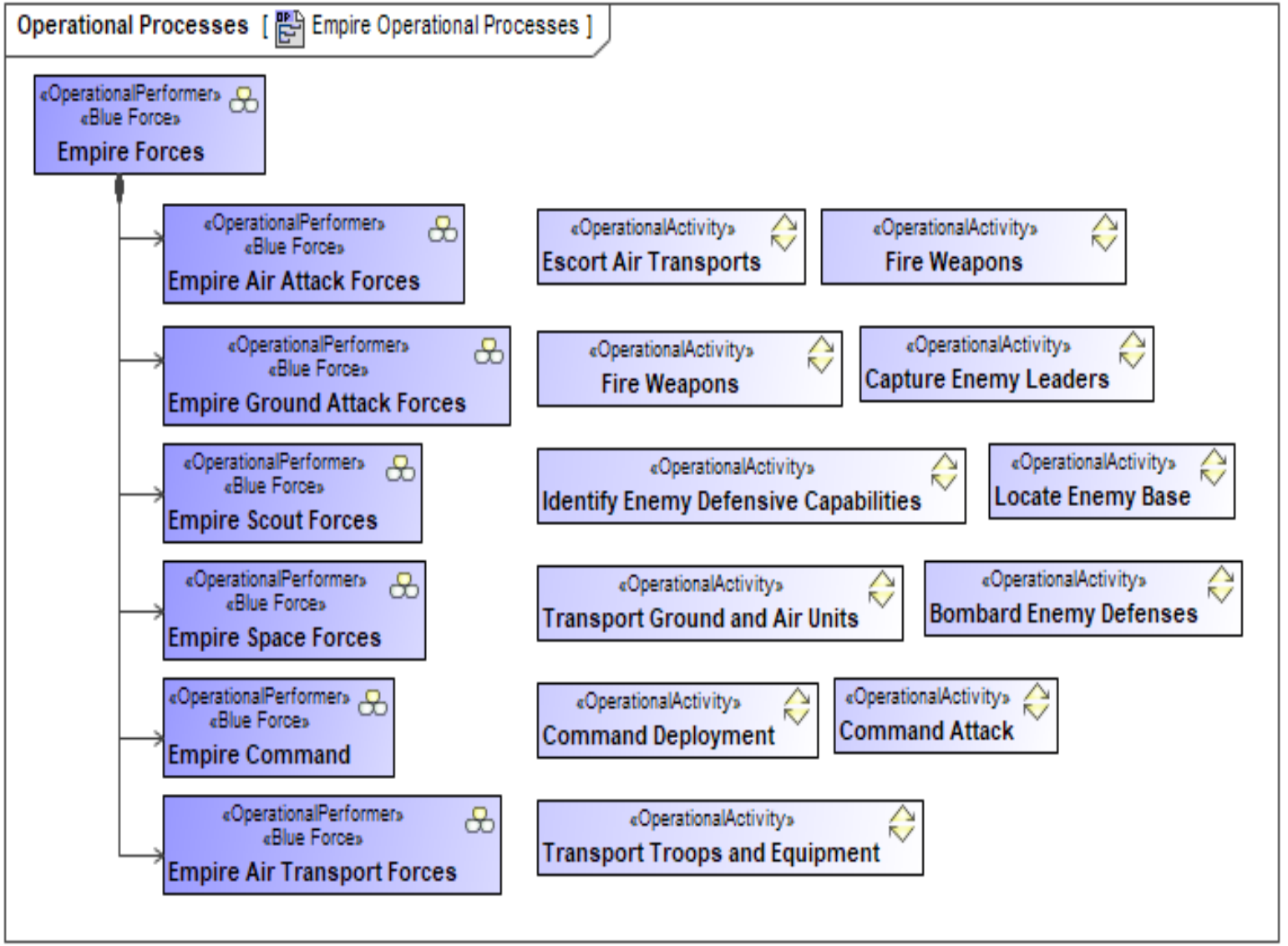
Linking Mission Tasks to Mission Objectives

- Not only is it beneficial to show how your structural elements support your Goals/Objectives (via Capabilities), but it also helps to show how your Mission Threads/Tasks support them
- Can also be done for Mission Engineering Threads and Functions



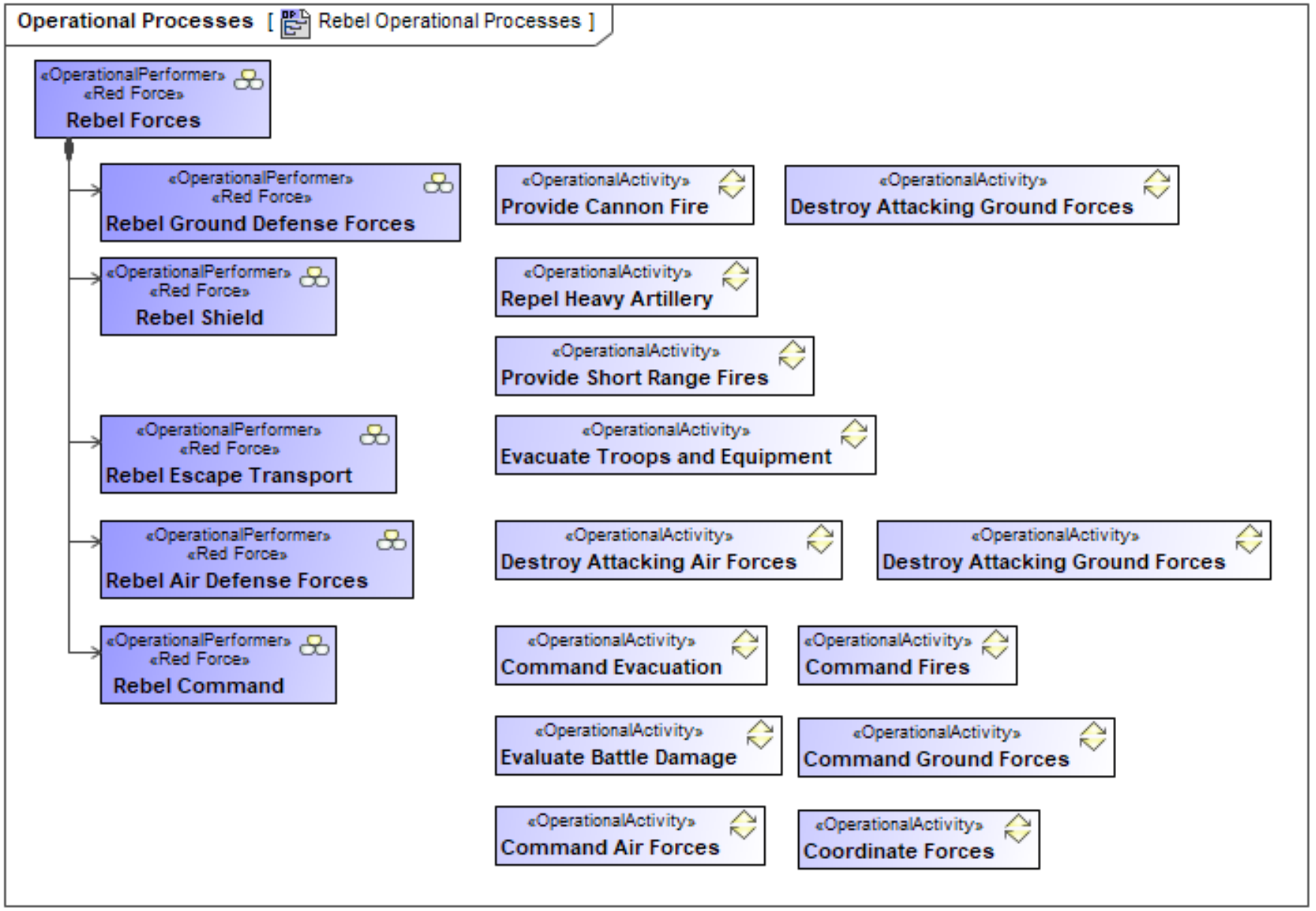
The Empire's Operational Actors and Behaviors

- The Empire forces are those which will be deployed as part of their attack strategy. These are the abstract elements, from which Resources will be chosen to implement them
- These are designated as Blue Force
- Each has a set of Operational Activities that they can perform
- If MBSE is already established in an organization, these would be part of a library and reused
- For a new installation, these would form the basis of the library to be populated as further missions are defined
- These activities are referenced by the Mission Tasks



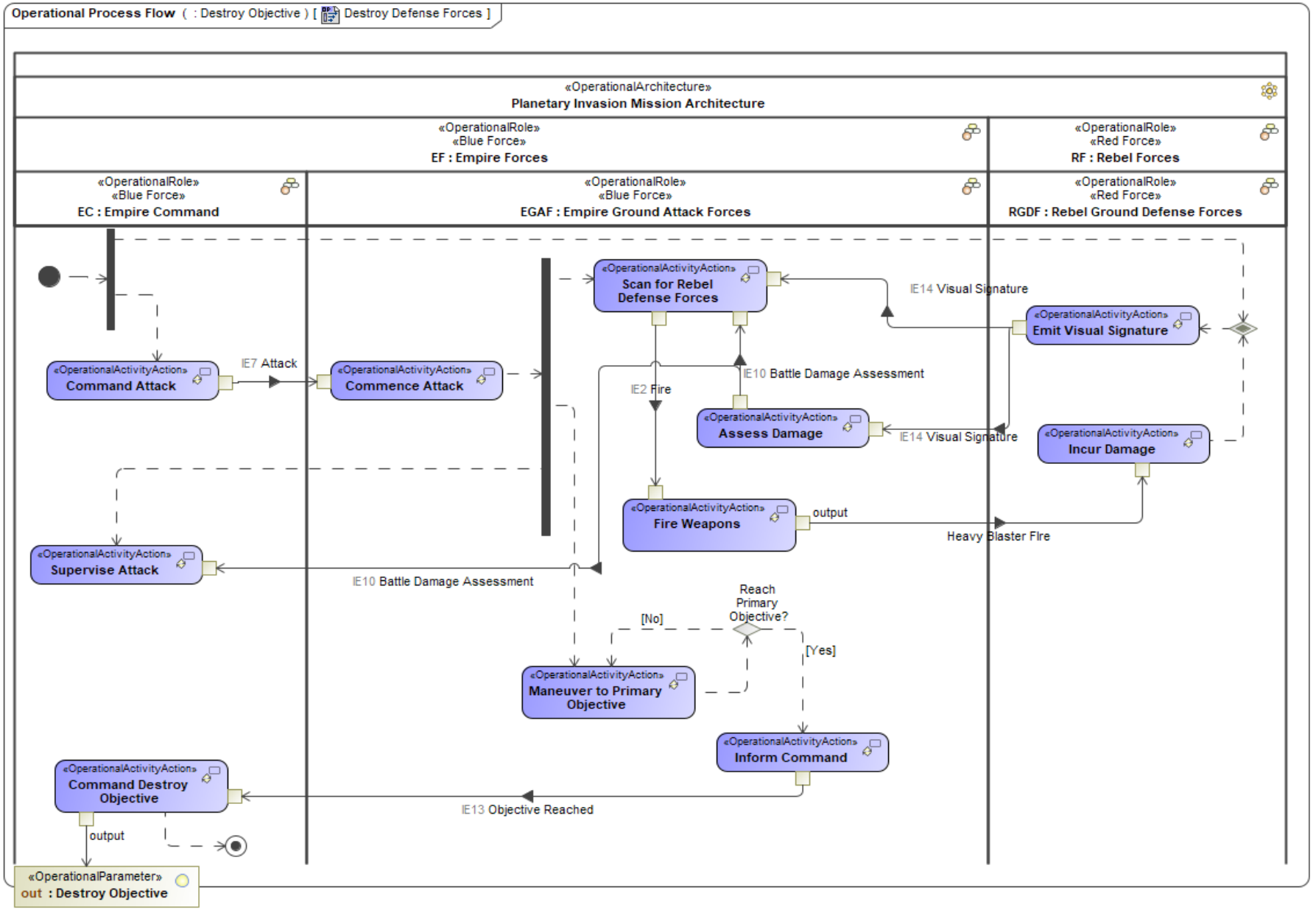
Rebel Force's Operational Actors and Behaviors

- Once again, these are the Rebel Force elements that have been discovered as well as their perceived functionality
- The Operational Performers have been designated as Red Force



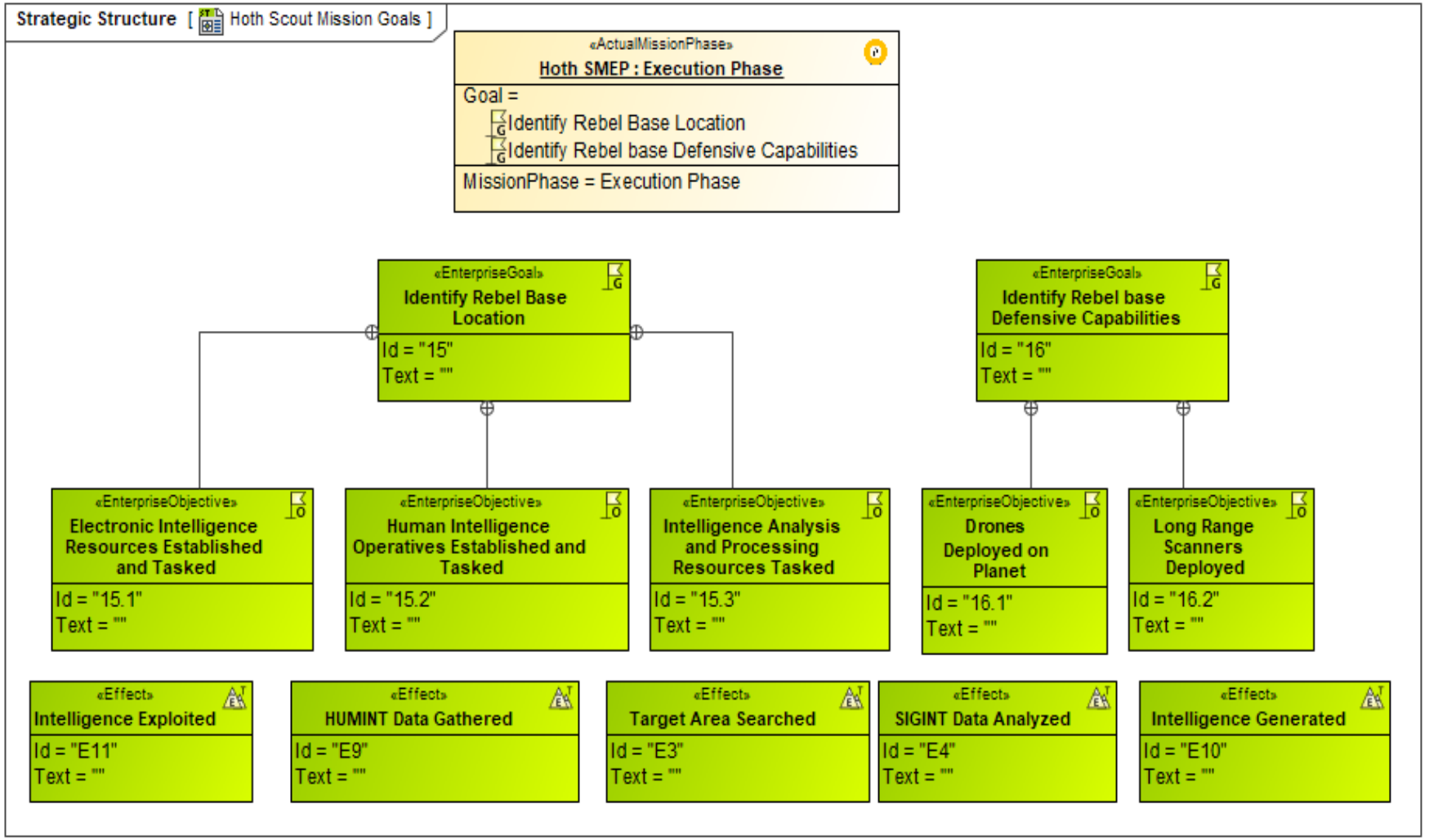
“Destroy Defense Forces” Mission Thread

- This is an abbreviated view of the Mission Thread. Details have been excluded to ensure that the diagram is legible
- Note the interactions between the rebel and Empire Forces
- The Ground Attack Forces Fire Weapons and the Rebel Forces Incur Damage and Emit a Visual Signature. The Signature is detected and analyzed by the Assess Damage and Scan for Rebel Defense Forces activities
- Counter attacks as well as other Rebel offensive activities should also be defined



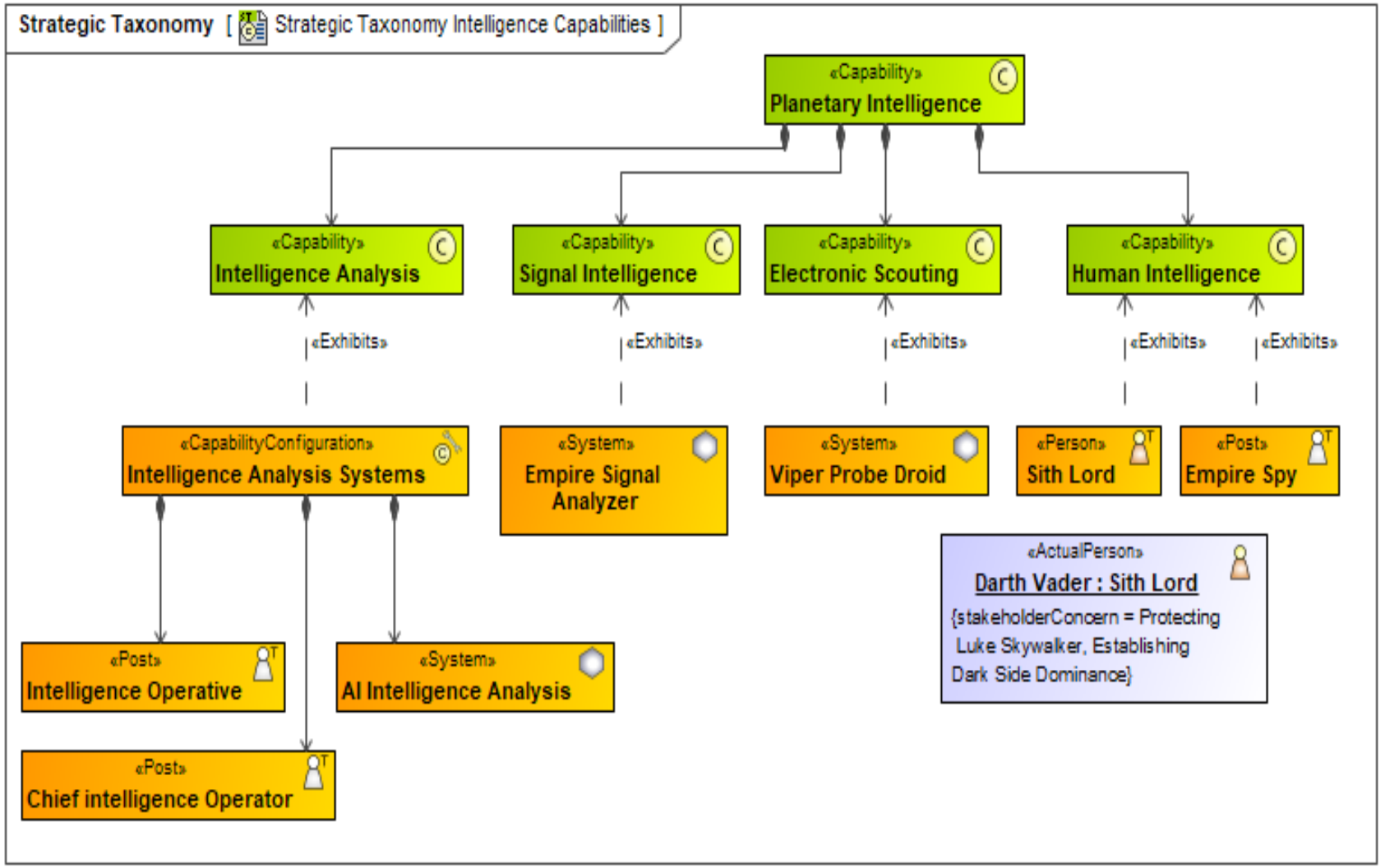
Hoth Scout Mission Goals

- The Scout Mission involves finding the Rebel base and determining its defensive capabilities
- Like the Attack Mission, the Scout Mission also has its own Goals, and Objectives that support the Goals
- Effect definitions are also shown



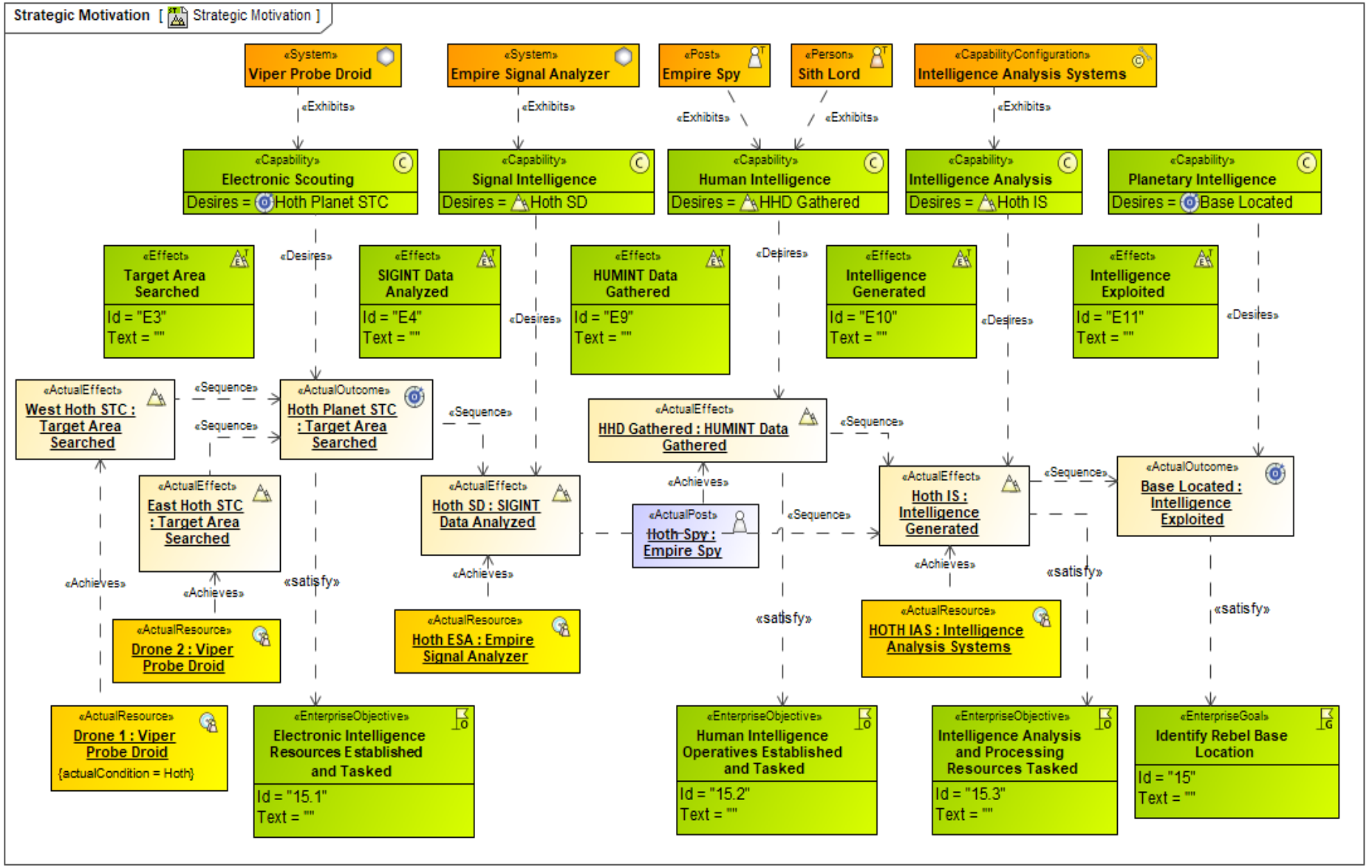
Planetary Intelligence Capabilities

- It is important to understand how your Architecture (Operational and Resource) provides the needed Capabilities for the mission
- In the example shown here, the elements of the Resource Architecture for the Scout Mission are traced to the Capabilities they provide
- Any Capability the Mission requires that is not Exhibited by at least one Resource element would suggest a high risk of Mission failure



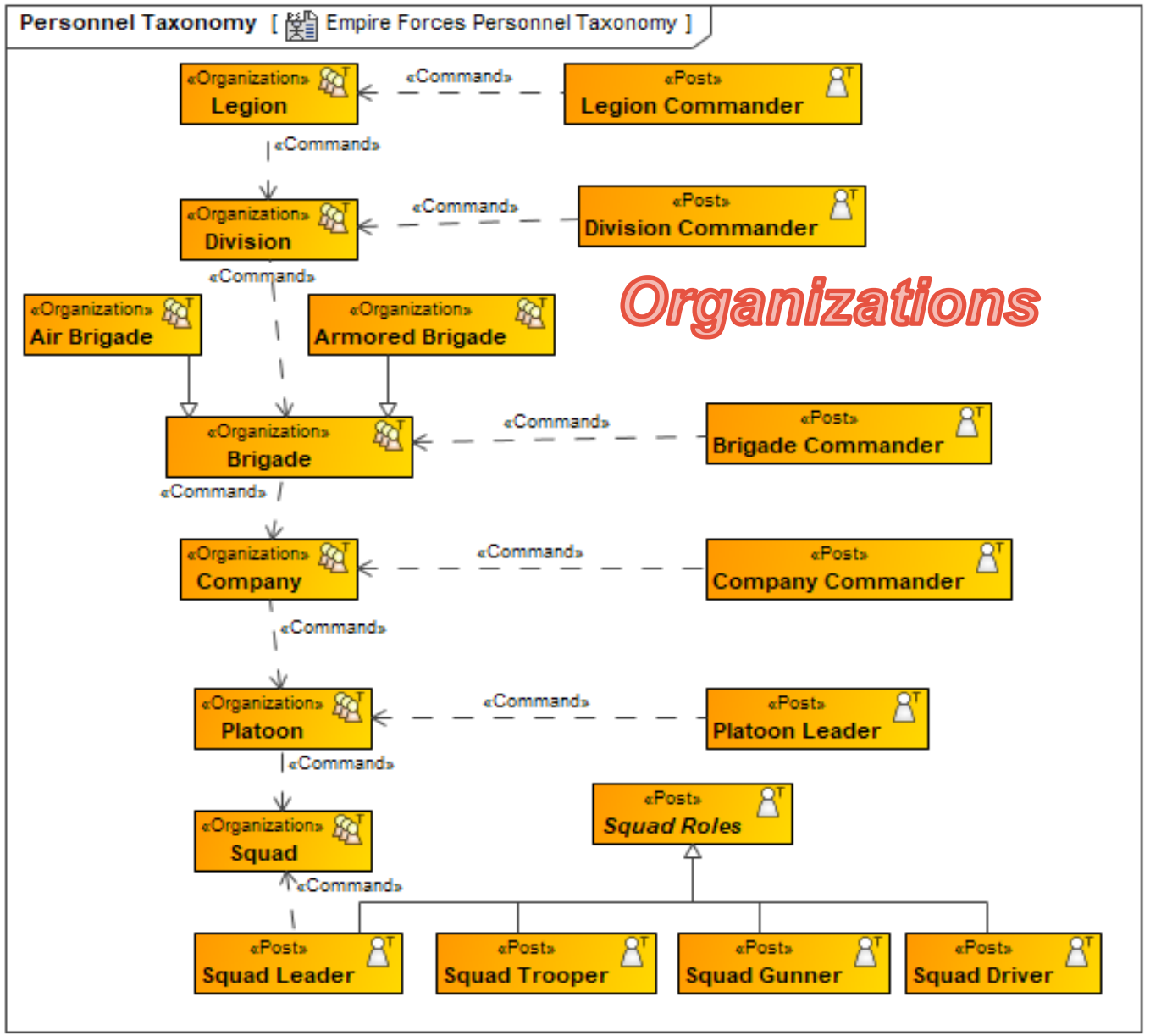
Effects, Goals and Outcomes for Hoth Scout Mission

- Shows how the Goals, Objectives, Effects and Outcomes are all linked
- Capabilities desire Actual Effects and Outcomes, and Actual Resources achieve them
- These Actual Effects and Outcomes satisfy the Goals and Objectives and are shown in a sequence
- The final Goal of Identify Rebel Base Location is finally satisfied



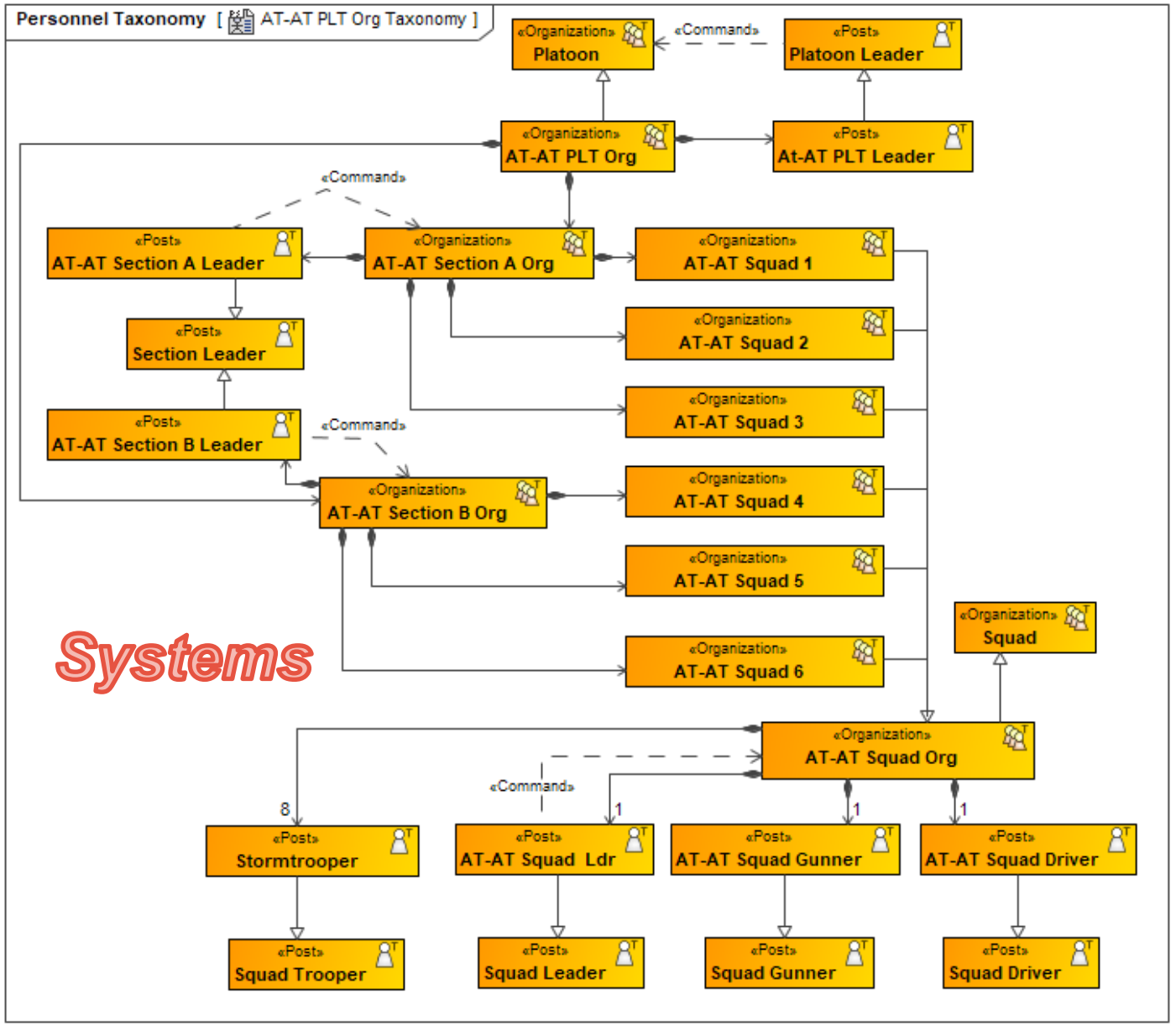
Personnel Taxonomy & Structure

- Details the command hierarchy of the generic/standard organizations and posts
- These posts and organizations are reused in subsequent diagrams/slides showing different configurations
- Instead of showing composition, a Commands relationship is shown. This keeps its elements loosely coupled
- These can then be inherited from and reused in other structures without overly constraining them
- Competencies, equipment, and executed functions can also be shown



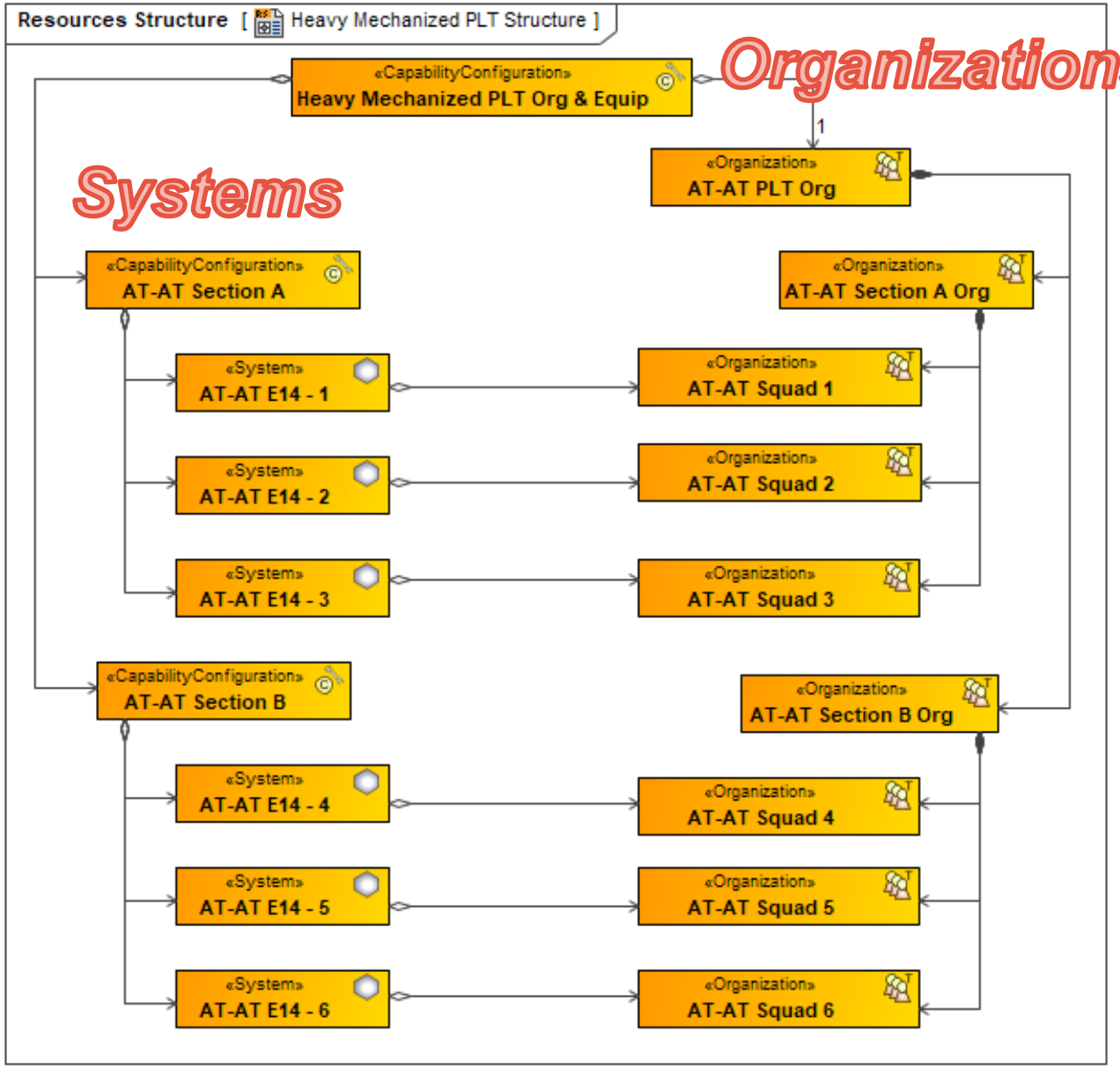
AT-AT PLT Org Taxonomy

- Similar structure to the previous slide for the AT-AT platoon reusing the previously defined structure
- Specific Posts and Organizations are inherited from the standard/generic ones defined earlier
- Elements are inherited to take advantage of equipment and competencies, etc. and ensure uniformity to Empire structures
- These will be combined with equipment to form capability configurations



Heavy Mechanized Platoon Structure

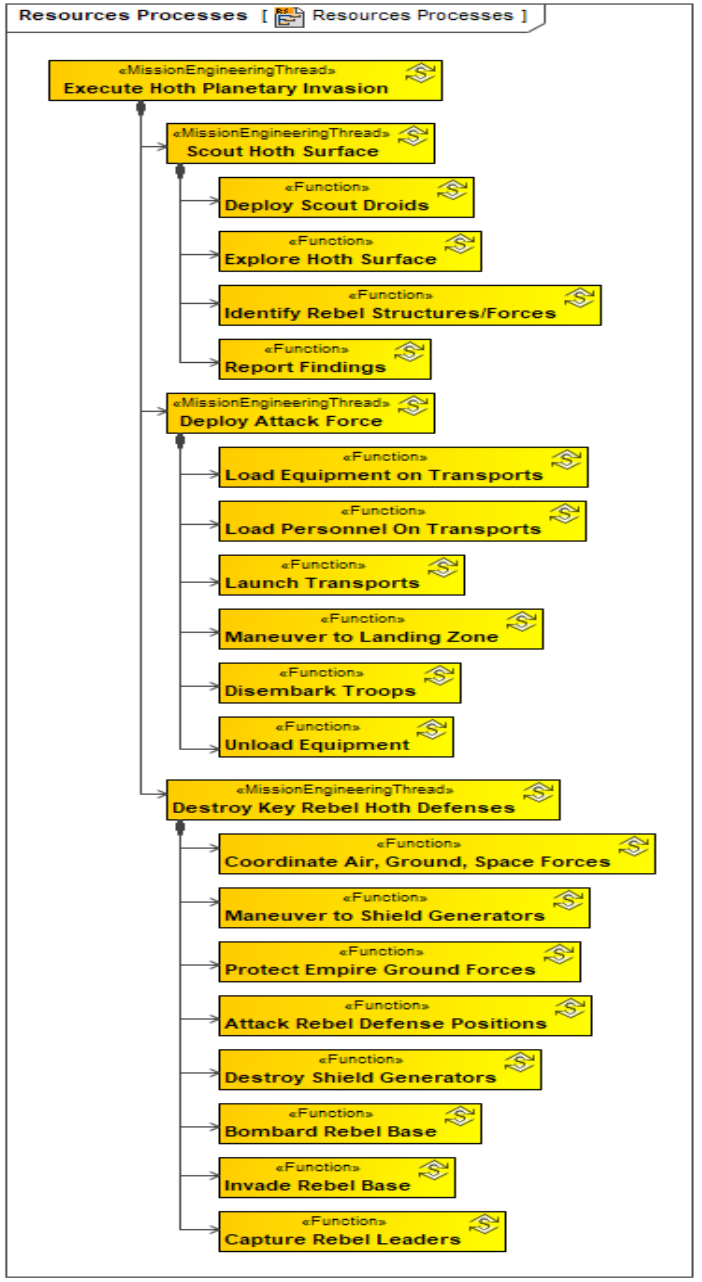
- Heavy Mechanized Platoon Structure combines the systems on the left with the organizations on the right, which were defined earlier
- These can be deployed into battle and the functionality of the capability configurations as well as the organizations can be combined and documented



Mission Engineering Thread (System Functions)

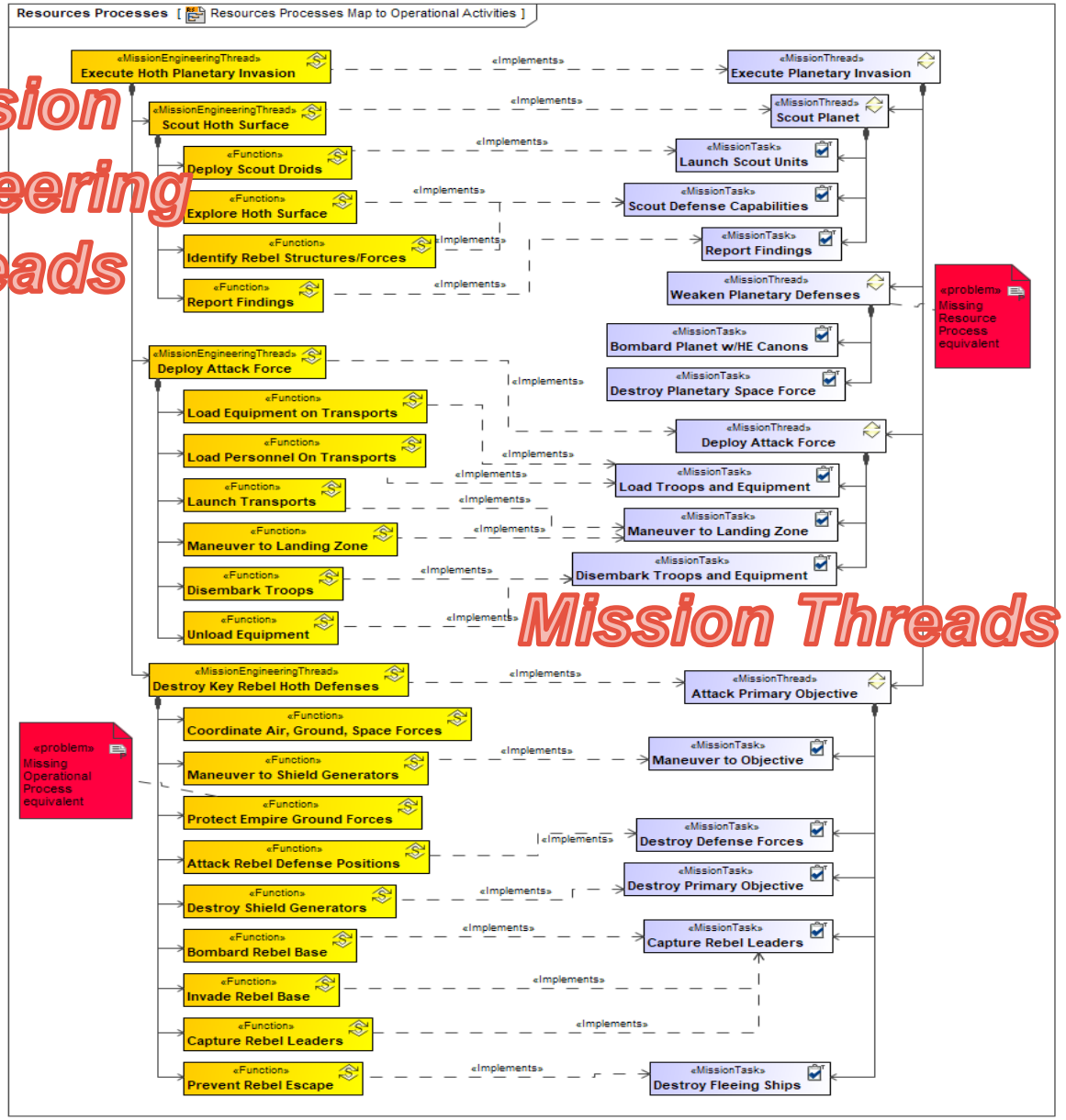
- The Mission Engineering Thread detailing the various steps of Execute Hoth Planetary Invasion

- The functions could either be part of the Mission Engineering Thread, or be Functions performed by the Resources, now that we have identified some of these Resources



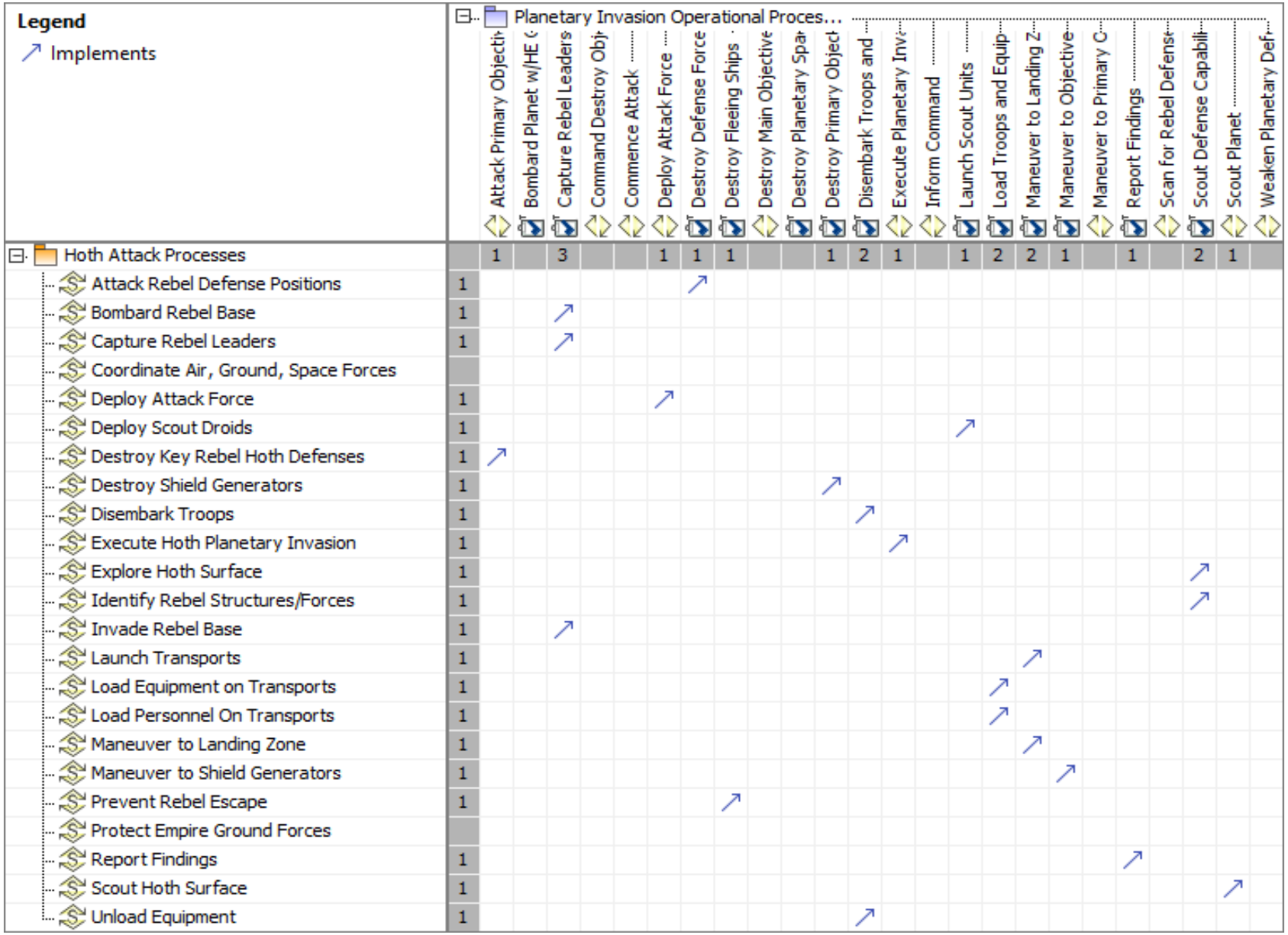
Mapping the Mission Thread to the Missions Engineering Thread

- Diagrammatic mapping between the Operational and Resource behaviors of all types
- These include the Mission Threads, Mission Tasks and Operational Activities as well as the Mission Engineering Threads and Functions
- Weaken Planetary Defenses does NOT have an implementation, which is why the rebels were able to shoot the Spacecraft out of the sky
- This mapping is essential to ensure a fully implemented battle plan
- Other relationships could also be helpful within each domain. For example:
  - Offensive Actions and Defensive responses from both sides
  - Offensive and defensive systems
  - Etc.



Resources Traceability

- Traceability table generated to map the Operational behaviors to the Resource behaviors
- Structural tables can also be generated
- This matrix could be used to spot holes in the defensive or offensive capabilities



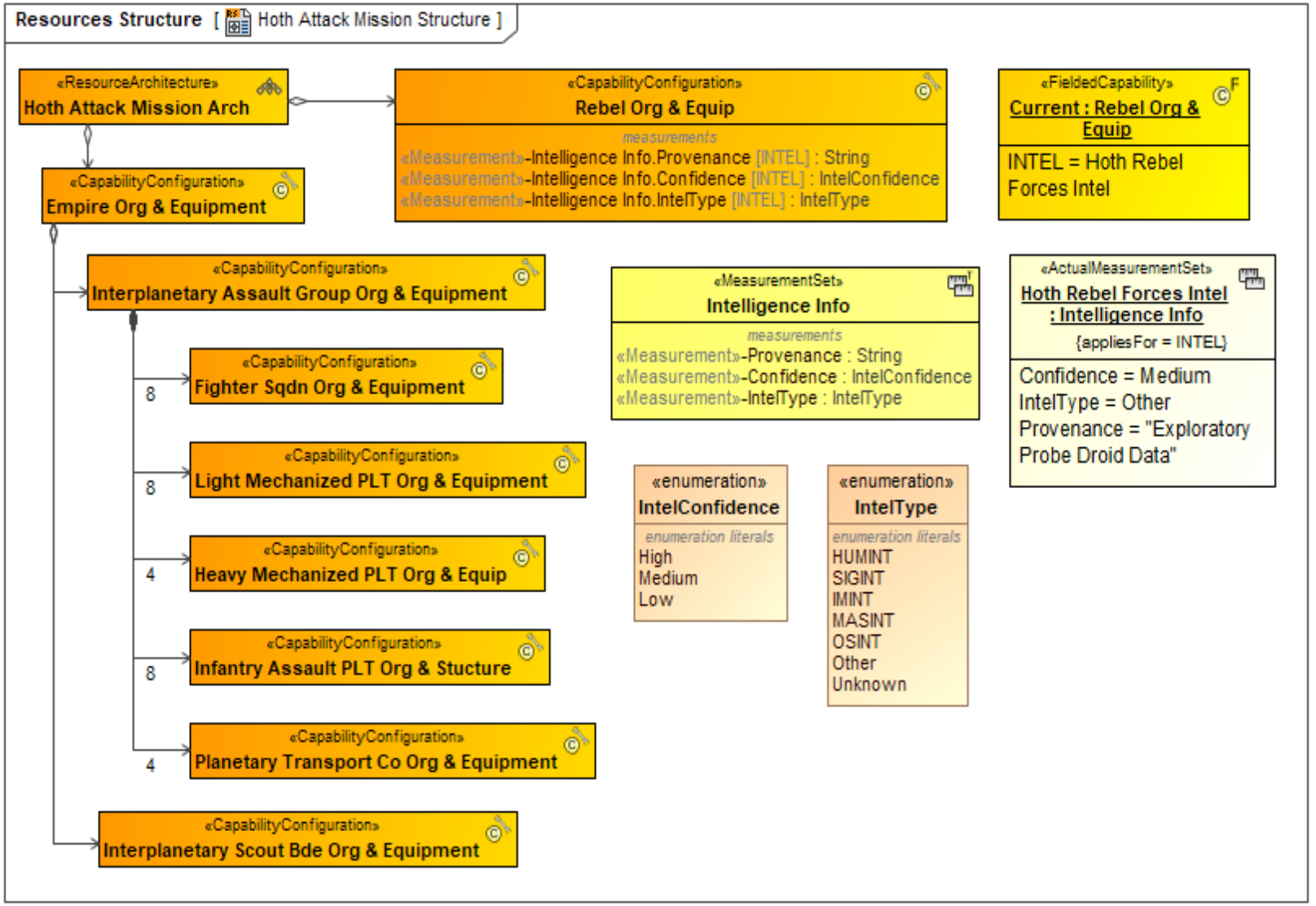
Resource Function Table

- Traceability from Resource Functions to Operational Activities, Capabilities, Goals, and other elements

#	Name	Implements	All Specifying Elements
1	Deploy Attack Force	Deploy Attack Force	Hoth LMEP : Strategy::Strategic Taxonomy::Strategic Taxono Deploy Attack Force
2	Deploy Scout Droids	Launch Scout Units	Launch Scout Units
3	Destroy Key Rebel Hoth Defenses	Attack Primary Objective	Ensure Decisive Victory O1 Base Vulnerability Planetary Attack EG5 Deliver Luke Skywalker O2 Win Over Rebel Sympathizers EG6 Prevent Rebel Escape Attack Primary Objective Controlling the Galaxy Hoth AMEP : Strategy::Strategic Taxonomy::Strategic Taxono Attack Mission Prevent Rebel Resurgence EG7 Destroy Rebel Defenses Establishing Dark Side Dominance Protecting Luke Skywalker
4	Execute Hoth Planetary Invasion	Execute Planetary Invasion	Hoth EP : Strategy::Strategic Taxonomy::Strategic Taxonomy Execute Planetary Invasion
5	Explore Hoth Surface	Scout Defense Capabilities	Scout Defense Capabilities
6	Identify Rebel Structures/Forces	Scout Defense Capabilities	Scout Defense Capabilities
7	Report Findings	Report Findings	Report Findings
8	Scout Hoth Surface	Scout Planet	Ensure Decisive Victory Loss of Position/Life Scout Planet EG9 Identify Rebel Base Location EG10 Identify Rebel base Defensive Capabilities Hoth SMEP : Strategy::Strategic Taxonomy::Strategic Taxono Planetary Intelligence
9	Load Equipment on Transports	Load Troops and Equipment	Load Troops and Equipment
10	Load Personnel On Transports	Load Troops and Equipment	Load Troops and Equipment
11	Launch Transports	Maneuver to Landing Zone	Maneuver to Landing Zone
12	Maneuver to Landing Zone	Maneuver to Landing Zone	Maneuver to Landing Zone
13	Disembark Troops	Disembark Troops and Equipment	Disembark Troops and Equipment
14	Unload Equipment	Disembark Troops and Equipment	Disembark Troops and Equipment
15	Coordinate Air, Ground, Space Forces		
16	Maneuver to Shield Generators	Maneuver to Objective	Planetary Maneuver Maneuver to Objective
17	Protect Empire Ground Forces		
18	Attack Rebel Defense Positions	Destroy Defense Forces	Destroy Defense Forces Ground Attack Close Air Attack EO4 Destroy Base Weapons
19	Destroy Shield Generators	Destroy Primary Objective	EO3 Destroy Base Force Shield Ground Attack Destroy Primary Objective Close Air Attack
20	Bombard Rebel Base	Capture Rebel Leaders	Capture Rebel Leaders Enemy Force Capture EO6 Capture or Kill Rebel Leaders
21	Invade Rebel Base	Capture Rebel Leaders	Capture Rebel Leaders Enemy Force Capture EO6 Capture or Kill Rebel Leaders
22	Capture Rebel Leaders	Capture Rebel Leaders	Capture Rebel Leaders Enemy Force Capture EO6 Capture or Kill Rebel Leaders
23	Prevent Rebel Escape	Destroy Fleeing Ships	Destroy Fleeing Ships EO5 Destroy Escape Craft

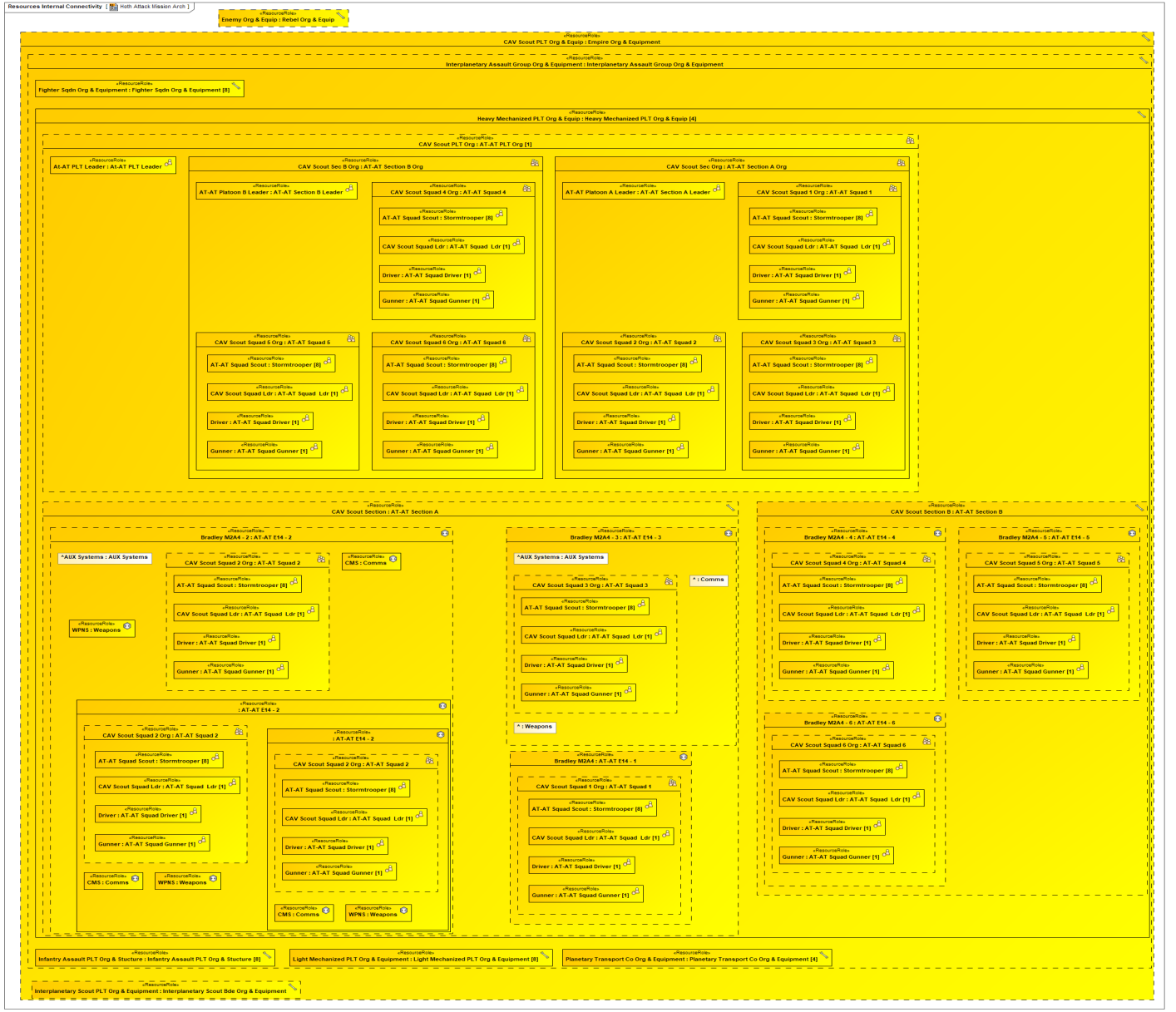
Hoth Attack Mission Structure

- Finally, the Structure of the Resource Architecture using the previously defined Organizations and Capability Configurations is created
- The Intelligence Info shows information regarding the Rebel Forces
- Given the multiplicity of the resources (8 Fighter Squadrons, 8 Light Mechanized Platoons, etc.) as well as all the posts and equipment in each one, this represents a massive scale
- This is shown on the following slide



Hoth Attack Mission Architecture

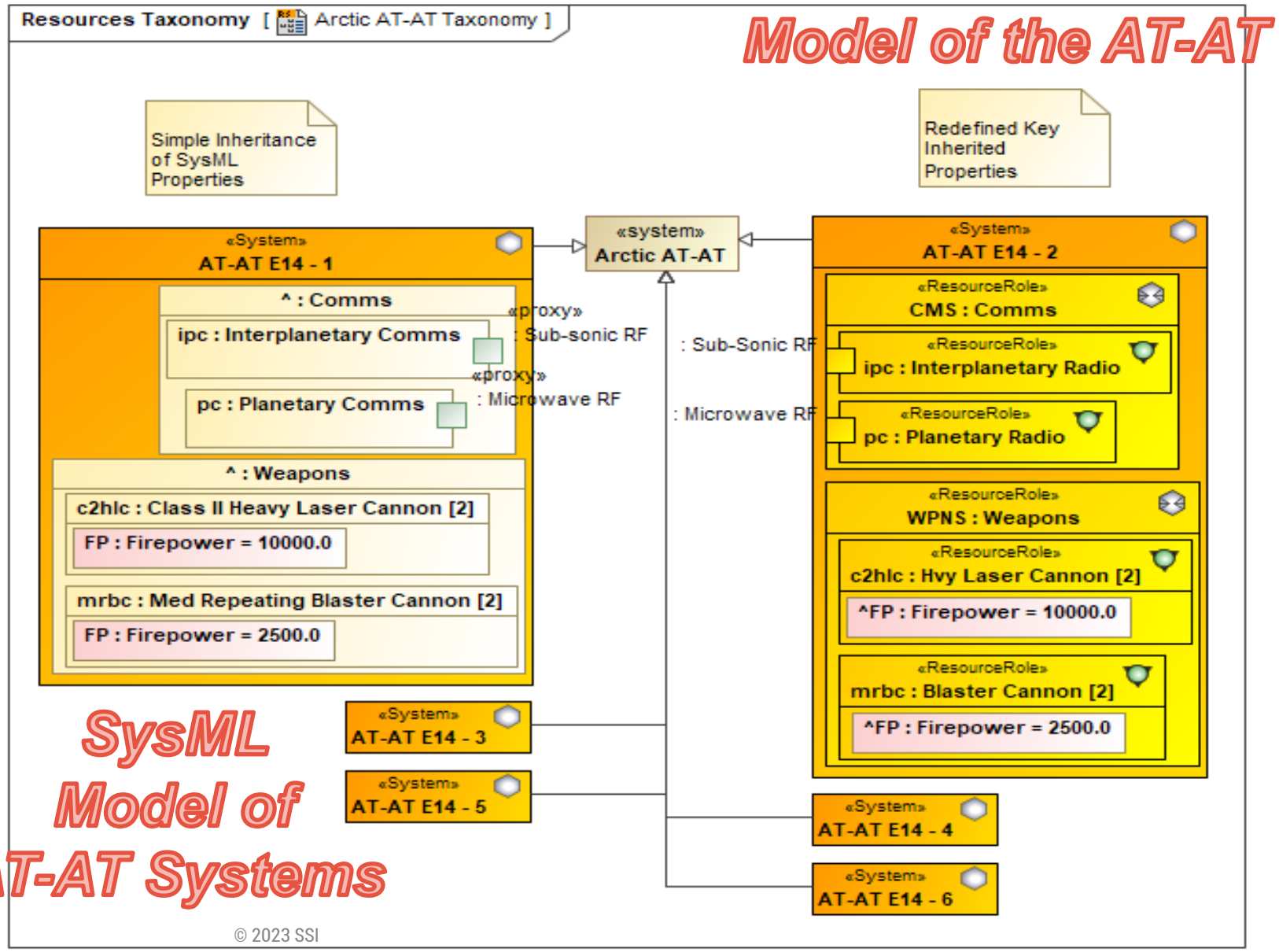
- This diagram illustrates the complexity of the structures defined so far
- Showing the detailed interactions would quickly lead to quite complex diagrams
- It would also be difficult to show interactions between lower-level elements as they are within deep structures
- Strategies will need to be devised on the best way to model this
- This may involve defining the lower levels together to form the Mission Engineering Threads




STAR WARS

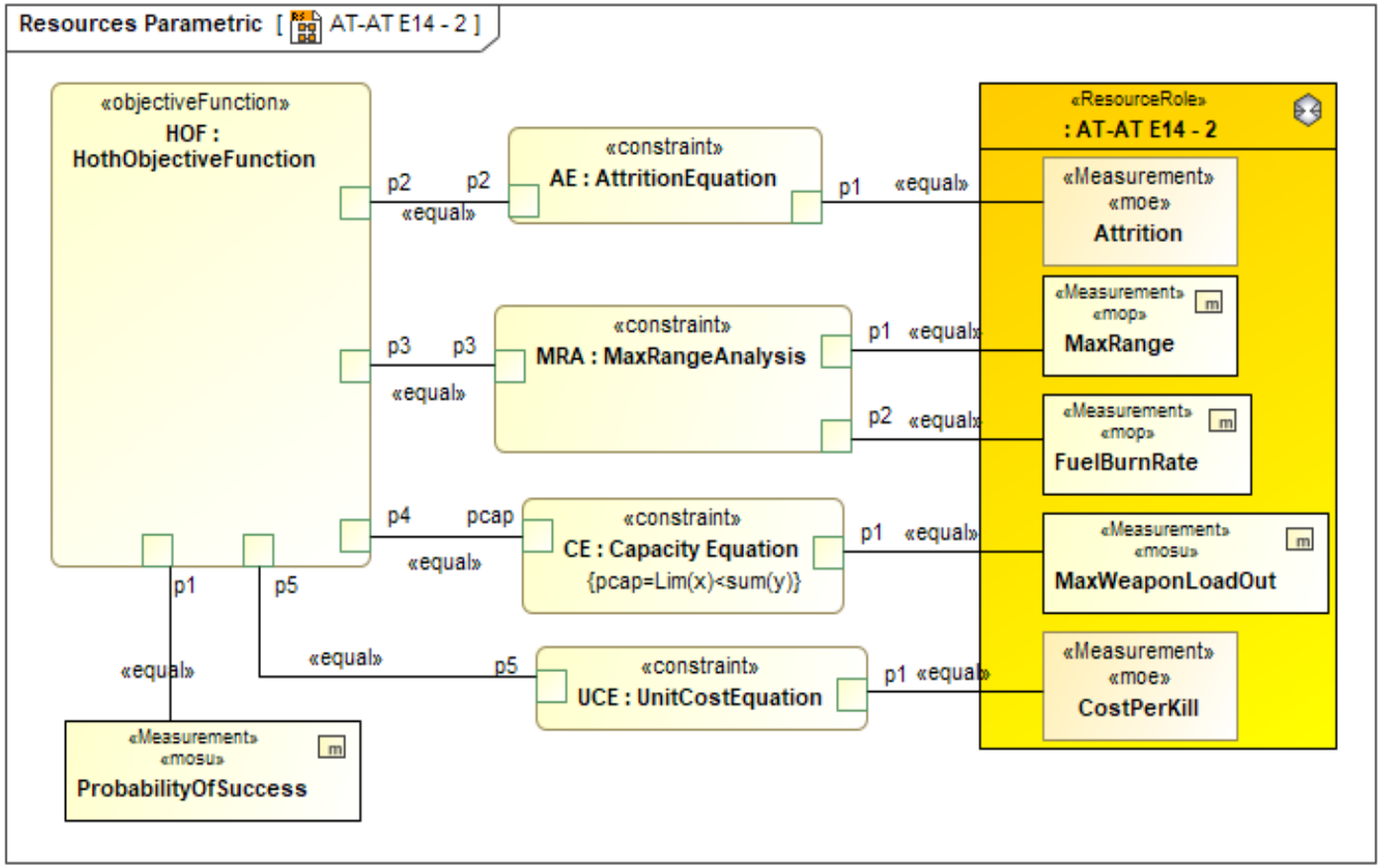
AT-AT Systems and Measures

- The figure shows two variations of the reused model: the left where the SysML parts are maintained, and the right where they are redefined to UAF elements
- Note that for readability not all elements are shown
- Because UAF limits interactions and connection to UAF-UAF elements, ports need to be redefined
- SysML can show both UAF and SysML connections



Measuring Mission Success Using UAF Parametrics

- The example parametric diagram makes use of both UAF and SysML measurements/ value properties
- These include:
  - Measures of Performance (MOP)
  - Measures of Success (MOS)
  - Measures of Suitability (MOSu)
  - Measure of Effectiveness (MOE)
- The measurements are:
  - Max Range = MOP
  - Fuel Burn Rate = MOP
  - Max Weapon Load Out = MOSu
  - Cost Per Kill = MOE
  - CostE -> Probability of Success = MOS
  - Attrition = MOE
  - The objective function calculates probability of success
- Note that the diagram simply illustrates the concept and is not a detailed example



Conclusions and Future Work (1)

- This model was built as a proof of concept for UAF support for Mission Engineering
- The current UAF metamodel and future extensions (UAF 1.3/2.0) will address most Mission Engineering concepts
- Standardization of MBSE concepts in a profile is beneficial
  - Reduces learning curve, miscommunication, confusion, etc.
- Examples of model-based standardizations
  - UML was created to standardize SW engineering
  - SysML to extend UML for systems engineering
  - UPDM/UAF to extend SysML/UML for DoDAF/MODAF/NAF
  - RAAML for safety and security in SysML model evaluation
- SysML provides many Mission Engineering concepts but needs extensions
- The approach taken in this presentation provides these extensions

Conclusions and Future Work (2)

- We will continue to build the model and examine the issues of resource architecture complexity, scale, and detail
- We need to build behavioral models at both the detailed and high levels.
  - Reuse will be an essential part of this effort – libraries, patterns, GRAs, etc.
- Add state machines and sequence diagrams
- We are socializing the model so that people can build on this to ensure that the UAF Mission Engineering extensions are fit for purpose
- We will release these profile extensions to bridge the gap until the next UAF release
  - Next expected version will be UAF 1.3 specifically to support Mission Engineering
  - This version will also include a ***NEW*** ME Guide for UAF
- Finally, we encourage any and all comments to help us achieve our goals

Questions?

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