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Using UPDM for Defense Architectures

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Lockheed Martin Master Architect

UPDM – It's Not Just for Acquisition Milestones Anymore

Why Architect?

- Architecting is an Integral Part of Systems and Software Engineering
  - Starts with understanding stakeholder concerns
  - Extends through requirements analysis and derivation
  - Relevant at multiple levels of abstraction
- Architecture Definition generates and evaluates multiple candidate architectures that frame stakeholder concerns and meet system requirements, then down-selects the architectural basis for Design Definition

It is critical NOT to select an architecture just because you did it that way on the last project

Why Use UPDM?

- UPDM provides a reasonably concise language to capture stakeholder concerns and to express high level architectures that address them
  - Standardization reduces ambiguity in communicating, particularly with external stakeholders
  - Simplifies source selection all along the supply chain
- Integrates cleanly with SysML and UML to support refining the architecture and to enable design

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LM DoDAF Architecting Methodology

- Object-oriented Model-Based Systems Development evolved from OMG OOSEM using UPDM for the 'upper architecture', SysML for most systems engineering and design, augmented by UML where needed for software and services
- DoDAF is used to frame (not dictate) the set of architectural viewpoints modeled – but NOT to drive the process of architecting
  - *Viewpoints are selected or defined to address specific concerns, not checklists*
  - *Note that for US DoD programs, the JCIDS process requires specified DoDAF views for key milestone documents (ICD/CDD/CPD)*

Methodology applicable at each level in the supply chain

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Worked Example
Notional Combat System for New Conventional Attack Submarine (NAS)

Submarine Combat System Example

DISCLAIMER

Notional Missions, Capabilities and Architecturally Significant Requirements adapted from Wikipedia Collins Class and Virginia Class descriptions, and RAN Whitepaper on SEA-1000

This notional architecture was developed for training purposes only.

DISCLAIMER

http://en.wikipedia.org/wiki/Collins_class_submarine
http://en.wikipedia.org/wiki/Virginia_class_submarine

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Australian Future Submarine

- “9.3 For the reasons spelled out in Chapter 8, the Government has decided to acquire 12 new Future Submarines, to be assembled in South Australia. This will be a major design and construction program spanning three decades, and will be Australia's largest ever single defence project. The Future Submarine will have greater range, longer endurance on patrol, and expanded capabilities compared to the current Collins class submarine. It will also be equipped with very secure real-time communications and be able to carry different mission payloads such as uninhabited underwater vehicles.
- 9.4 The Future Submarine will be capable of a range of tasks such as anti-ship and anti-submarine warfare; strategic strike; mine detection and mine-laying operations; intelligence collection; supporting special forces (including infiltration and exfiltration missions); and gathering battlespace data in support of operations.
- 9.5 Long transits and potentially short-notice contingencies in our primary operational environment demand high levels of mobility and endurance in the Future Submarine. The boats need to be able to undertake prolonged covert patrols over the full distance of our strategic approaches and in operational areas. They require low signatures across all spectrums, including at higher speeds. The Government has ruled out nuclear propulsion for these submarines.“

Defending Australia in the Asia Pacific Century: FORCE 2030
Defense White Paper 2009, Australian Department of Defense, pg. 70

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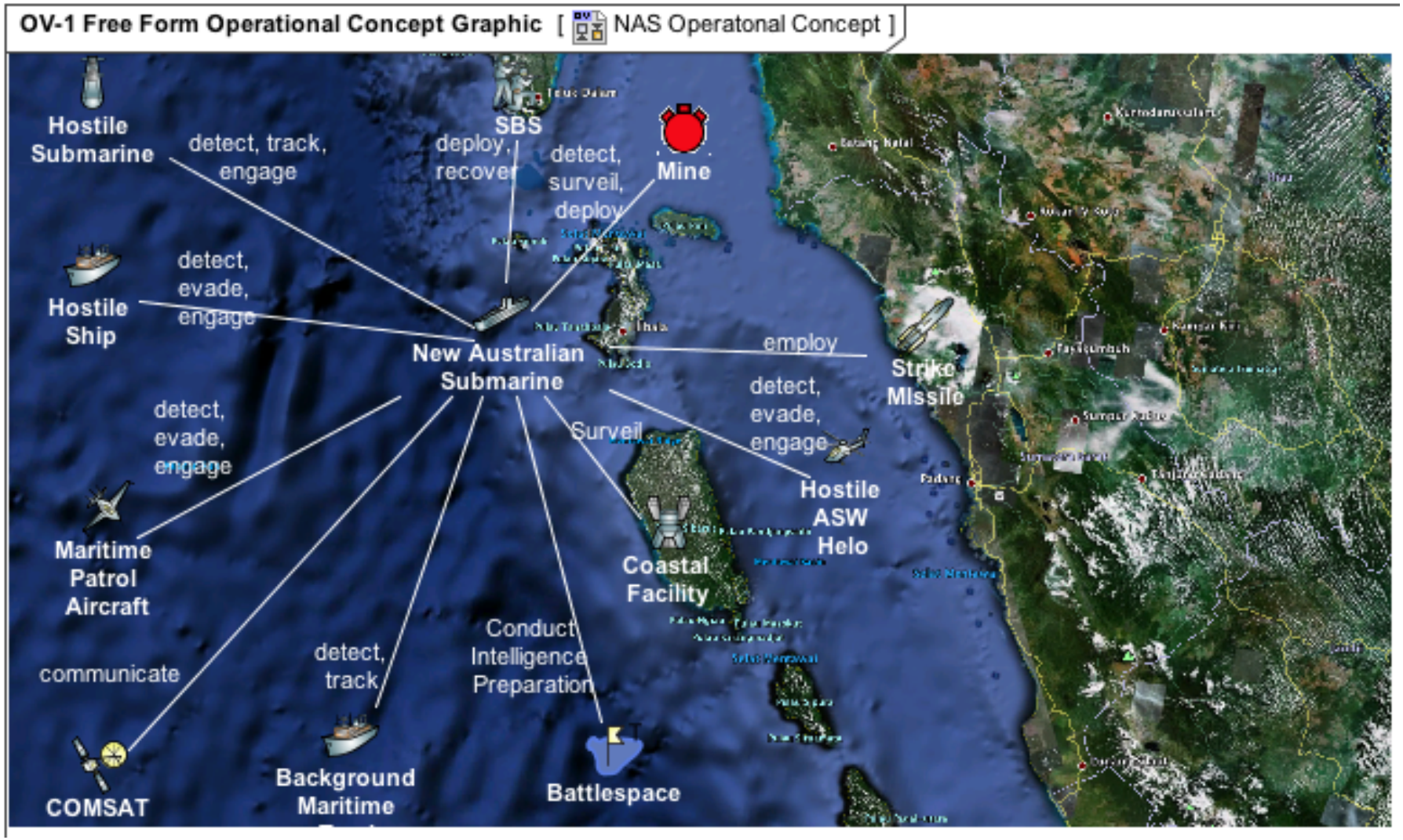
Understanding Stakeholders Concerns

OV-1 Operational Concept



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NAS Operational Use Cases

- Anti-Submarine Warfare
- Anti-Surface Warfare
- Combat Search and Rescue
- Damage Control
- Engage Hostile ASW Aircraft
- Experimentation
- Force Protection
- Indications and Warning
- Intelligence Preparation of the Battlespace
  - Clandestine Survey
  - Coastal Surveillance
  - Maritime Surveillance
- Mine Warfare
  - Lay Minefield
  - Chart Minefield
- Recharge Batteries
- Special Boat Squadron (Special Forces) Support
- Strike Warfare
  - Strike using Missile
  - Strike using SBS
- Transit
  - Harbor Transit
  - Hostile Waters Transit
  - Surface Transit
  - Submerged Transit
- Team Training

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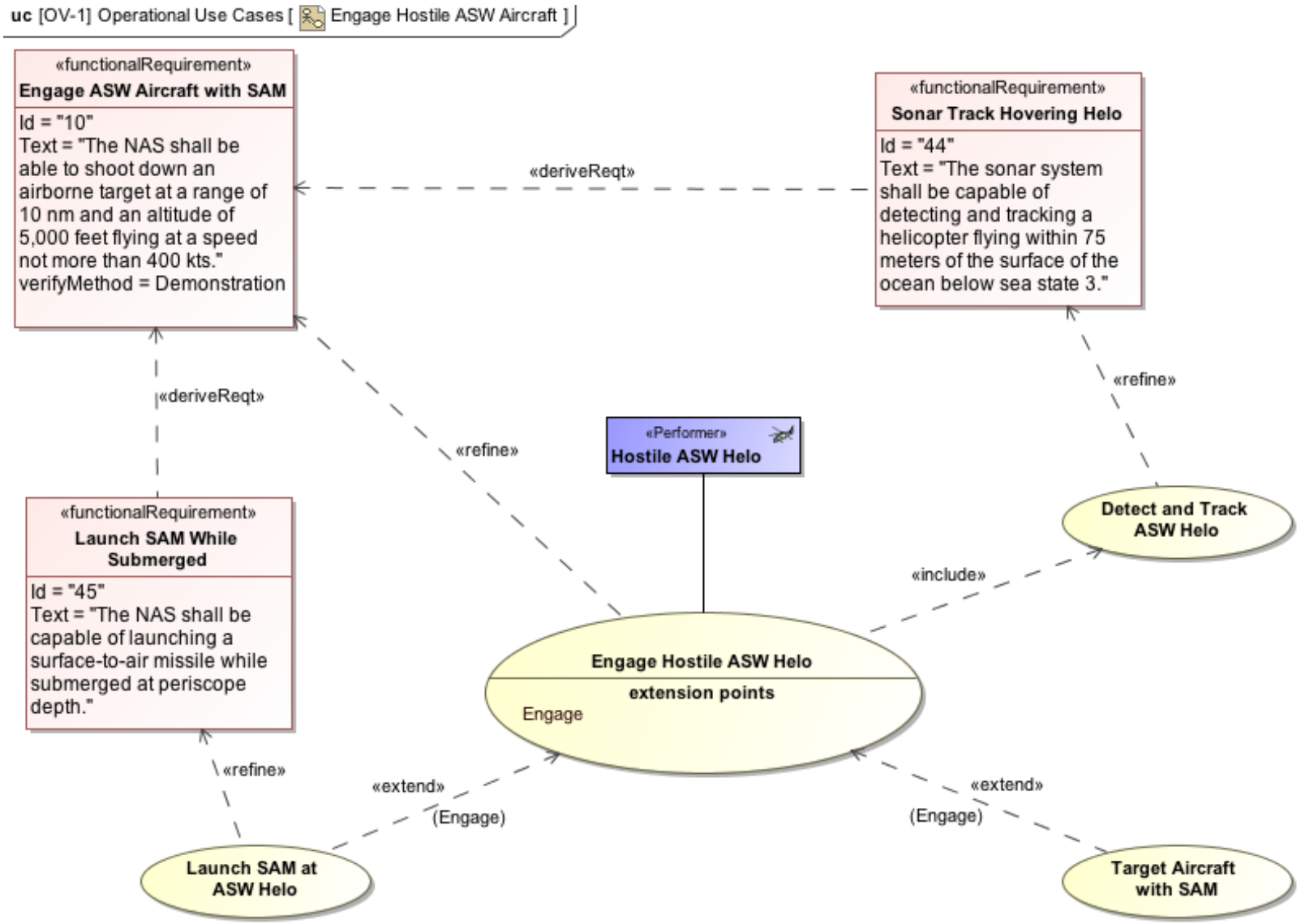
Use Cases Analyzed to Derive Requirements



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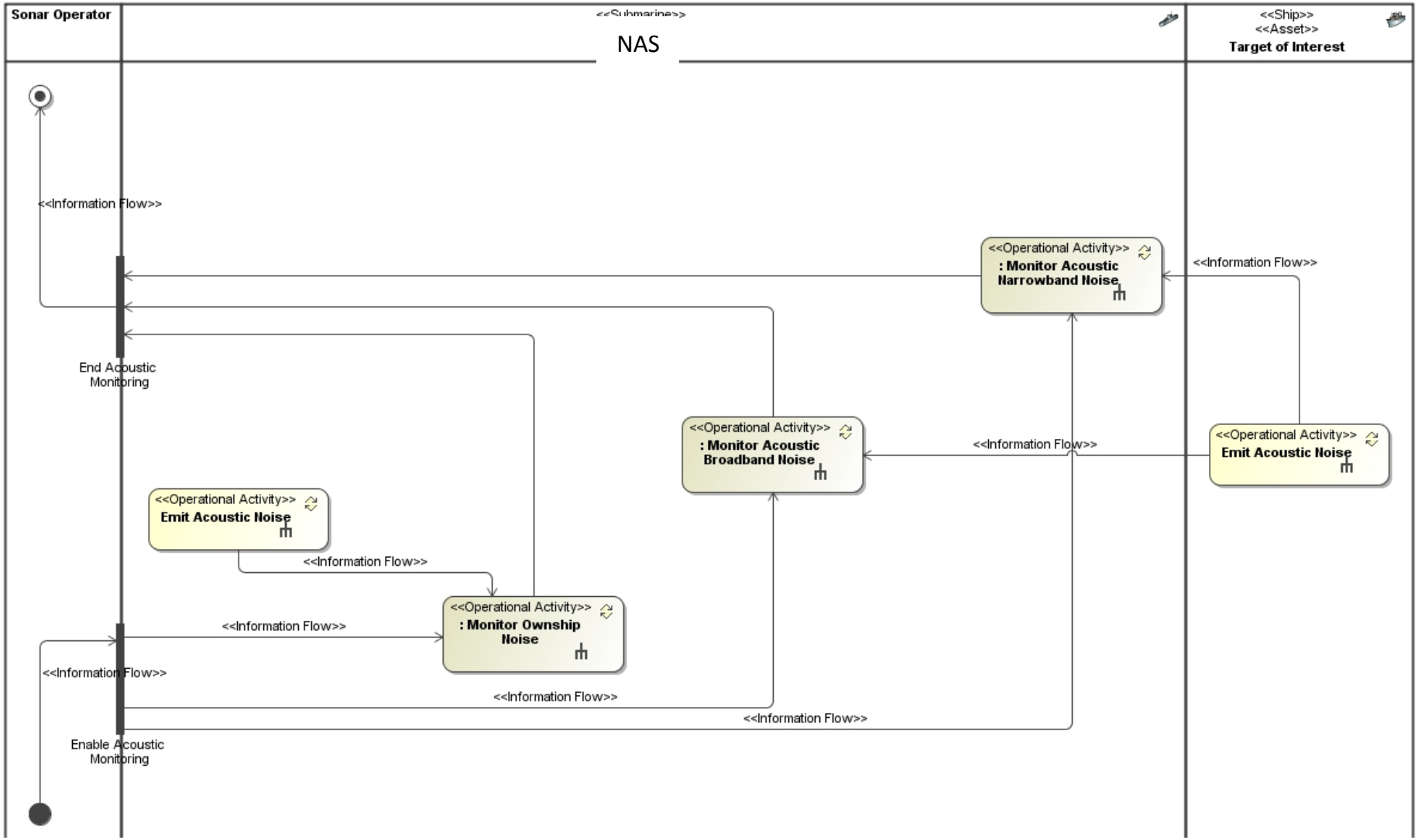
OV-5 Operational Activities



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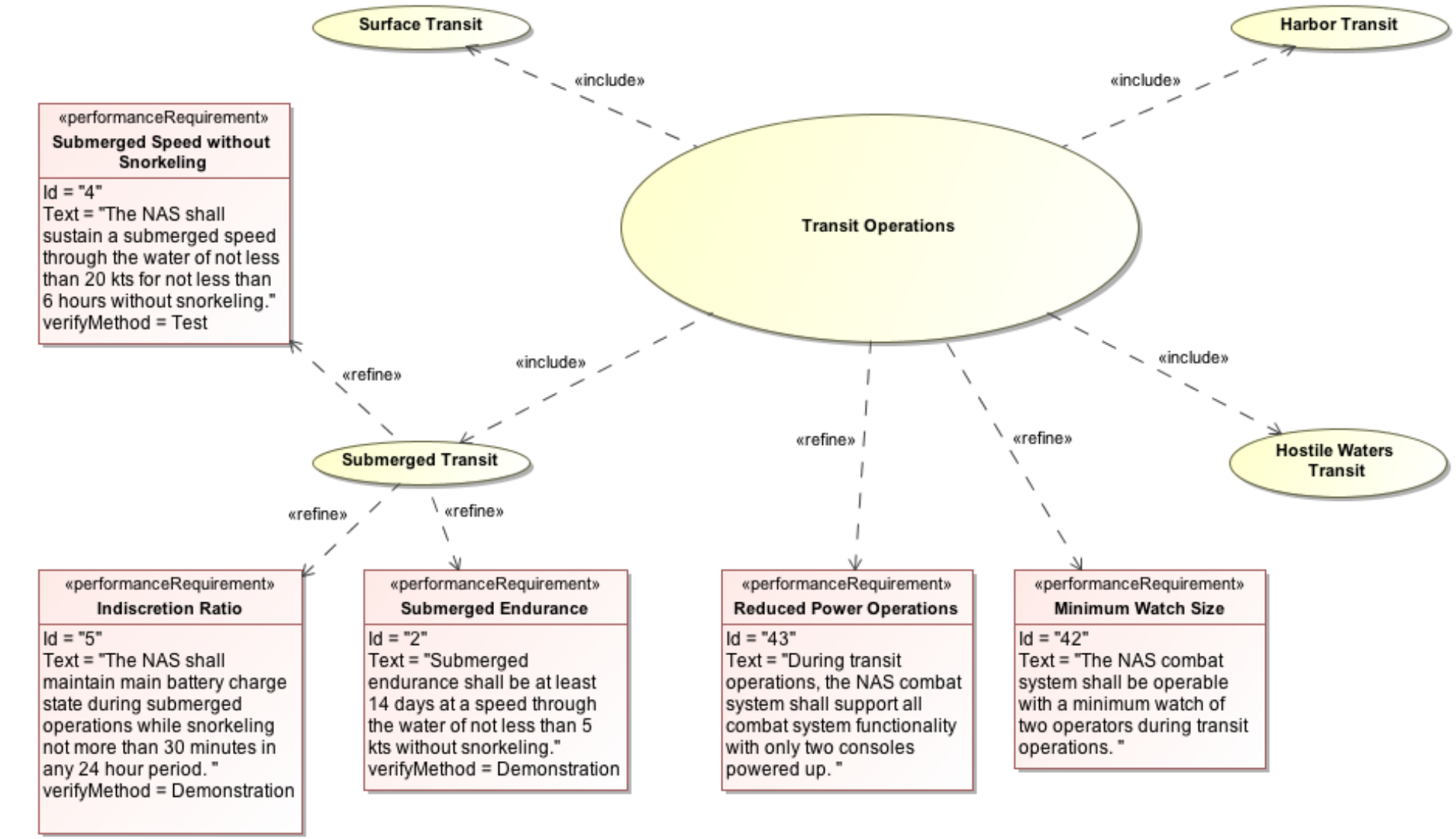
Use Cases Refine Driving Requirements



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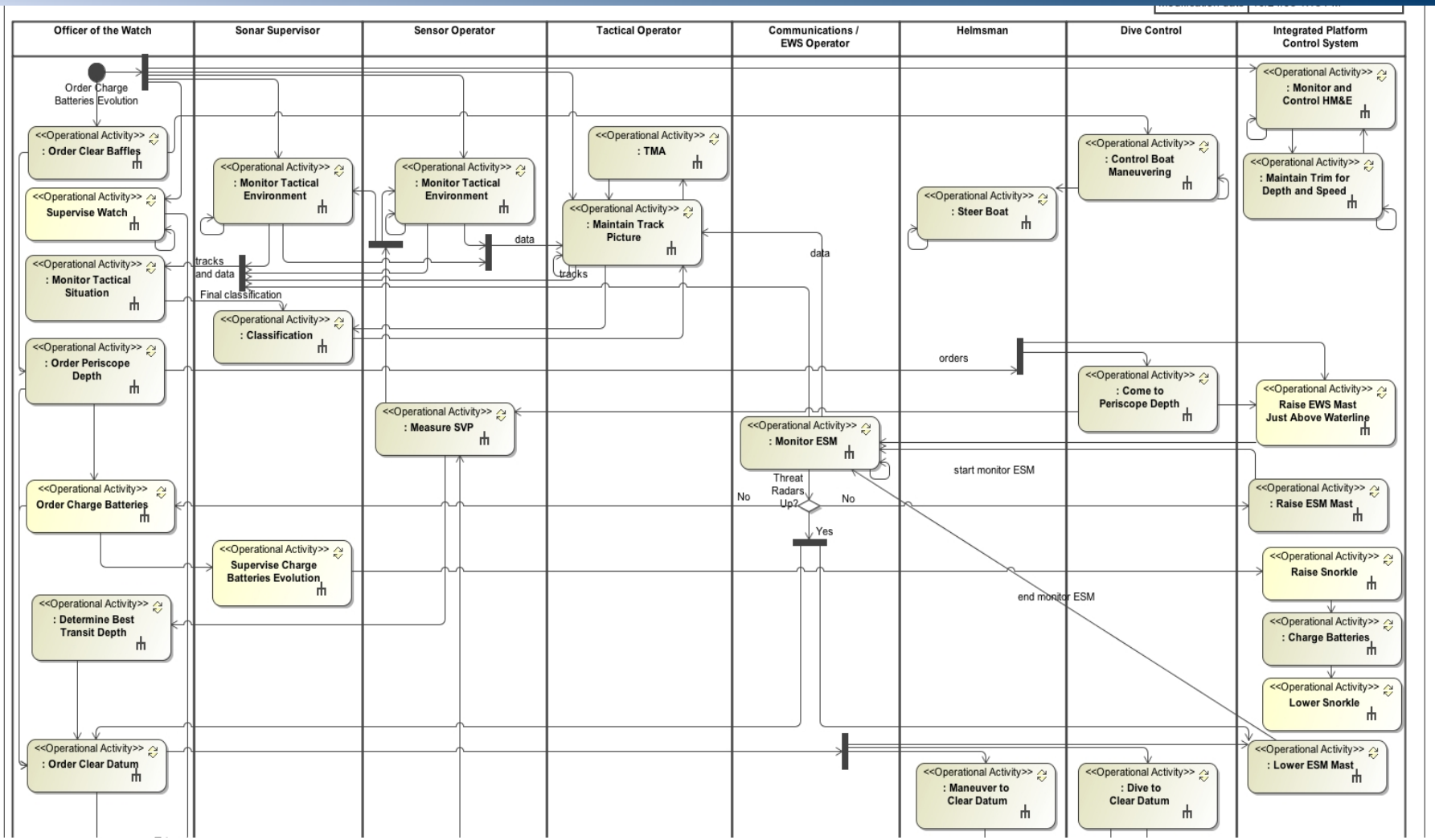
OV-5b Recharge Batteries



Operational Activities may be modeled at the UJTL level, or down to whatever level is needed to flesh out the architecture and design.

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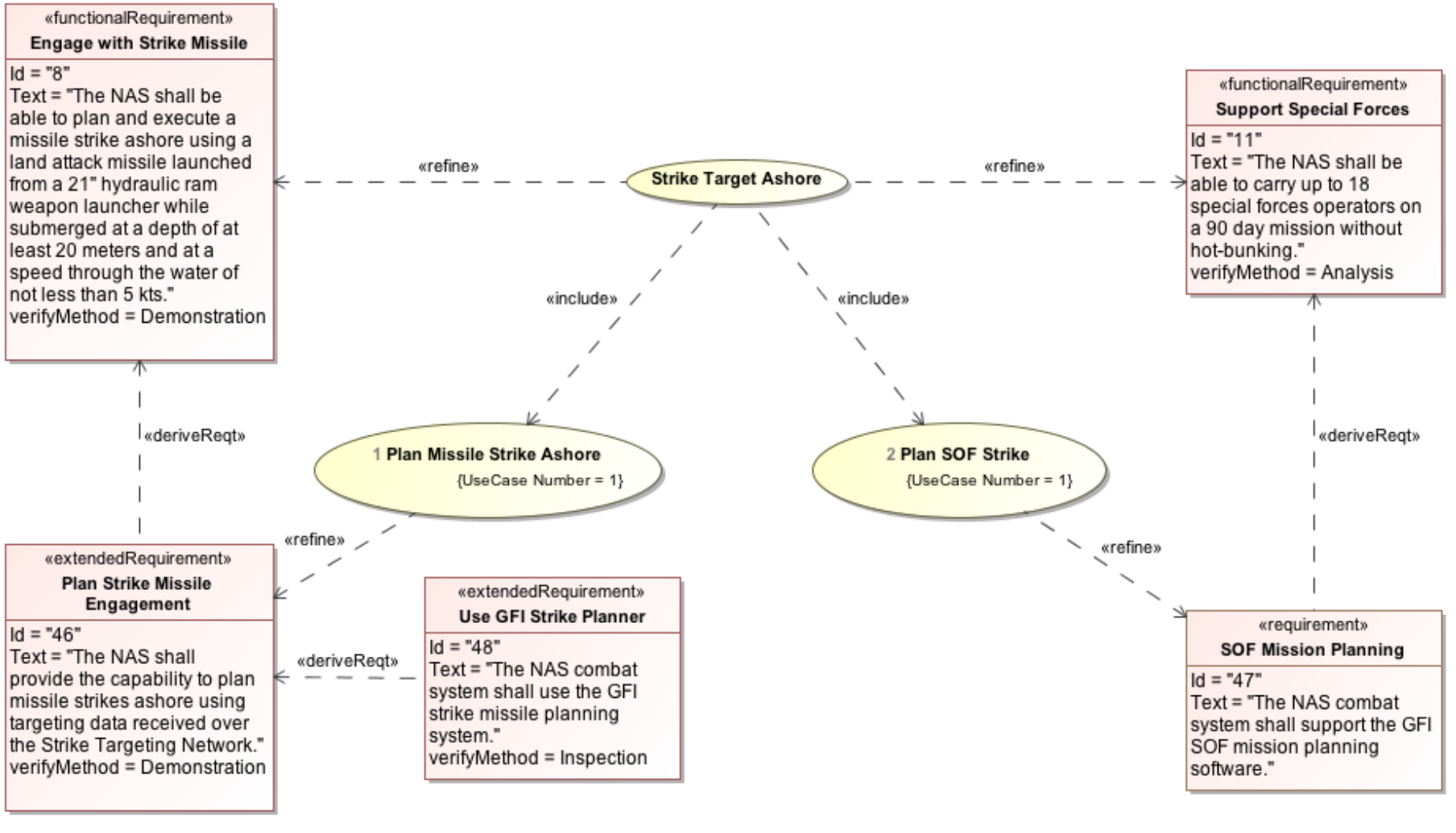
Strike Requirements Refinement



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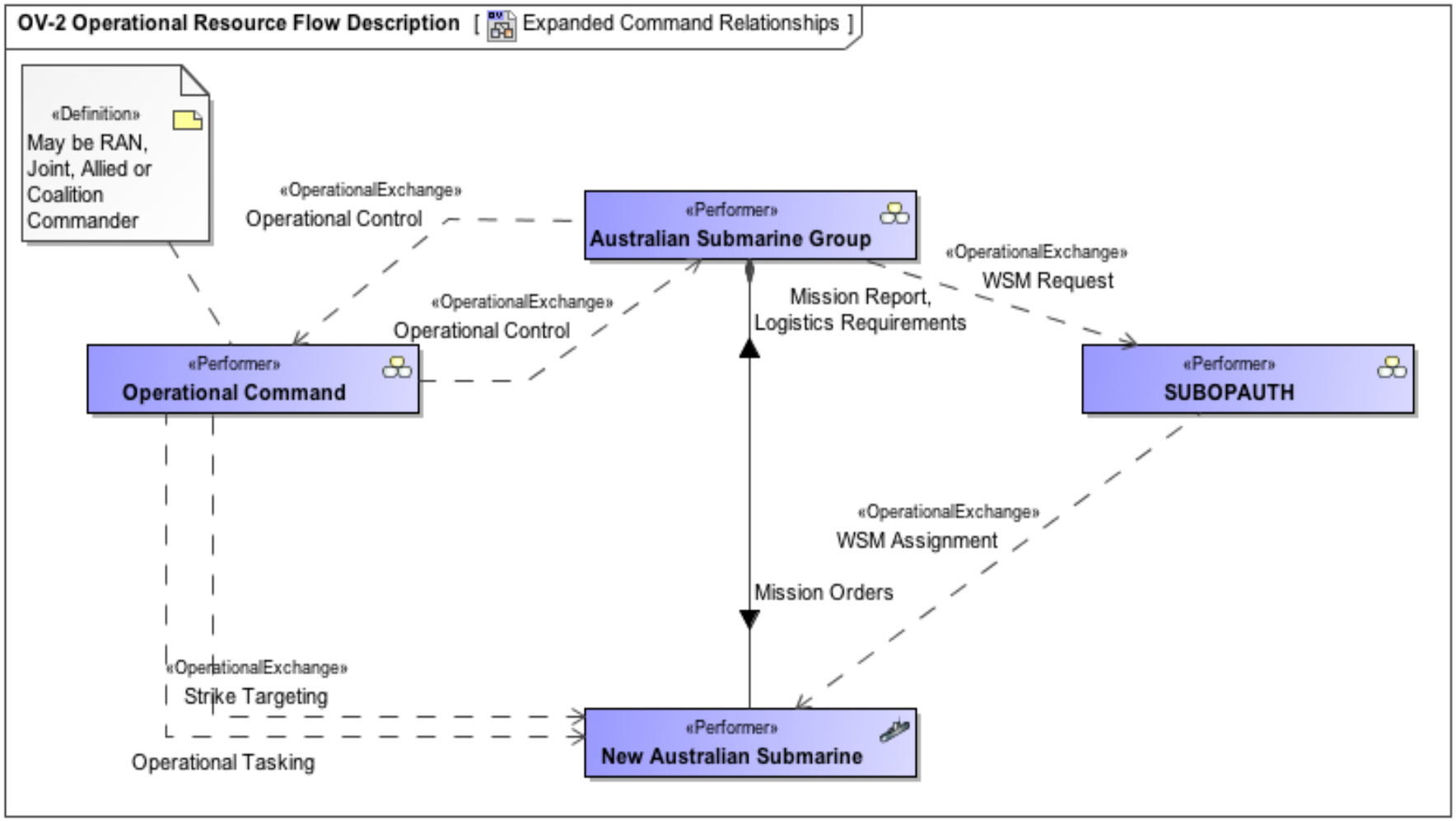
OV-4 Command Relationships



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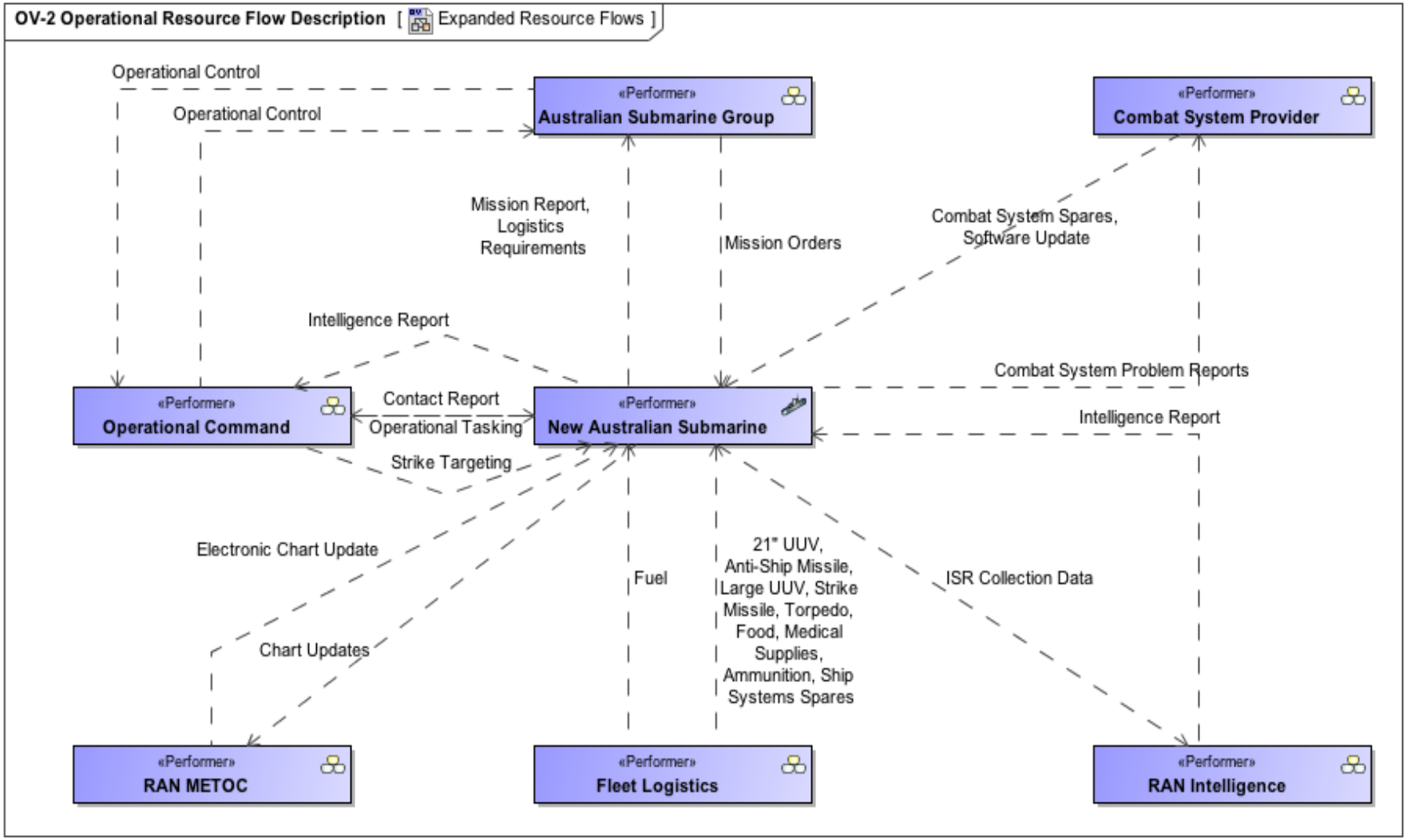
OV-2 Resource Flows



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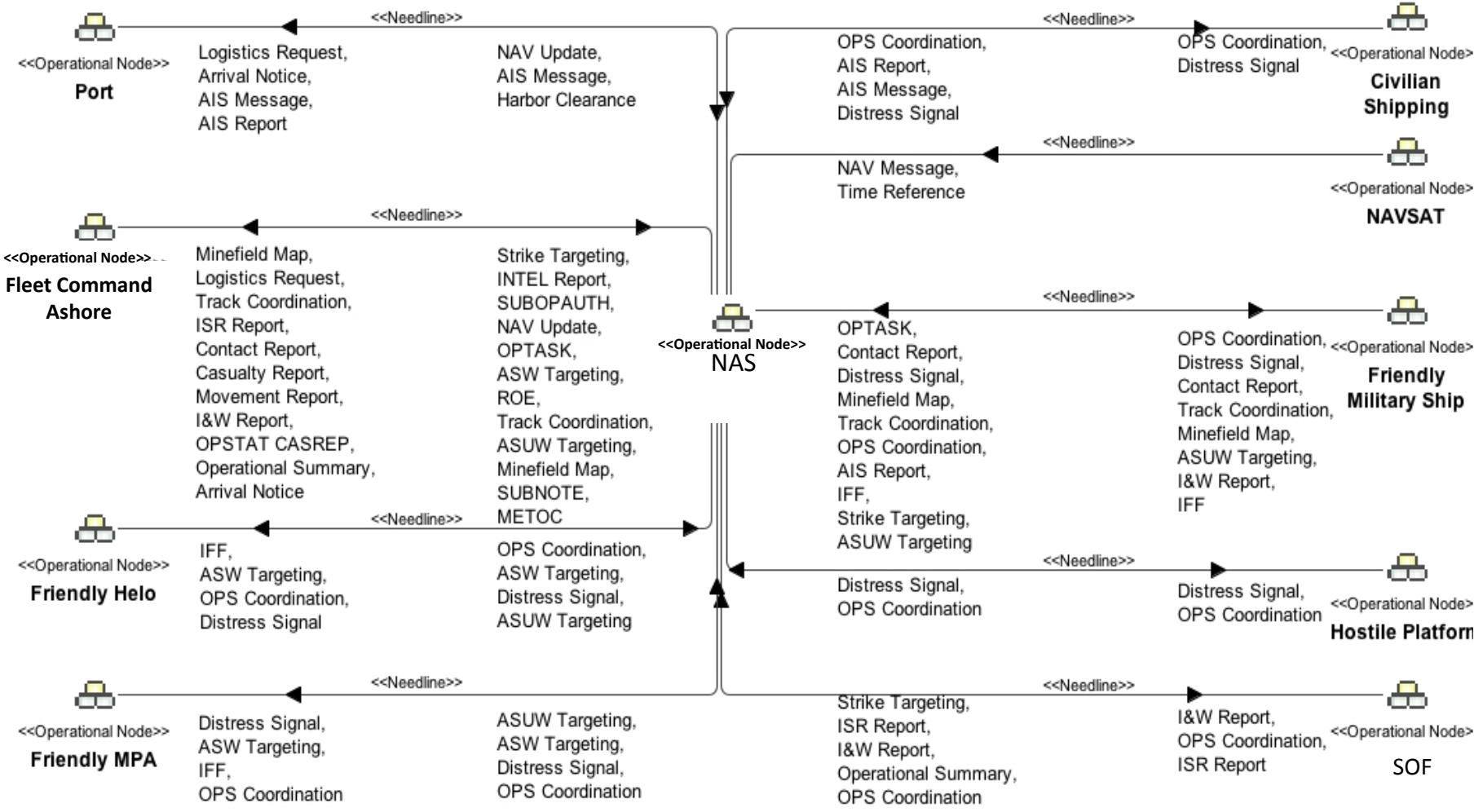
OV-2 Information Flows



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OV-3 (Selected Elements)

Exchange ID	Exchange Name	Operational Exchange Item	Sending Performer	Receiving Performer
OE9	LOG-00001	IE15 Combat System Problem Reports	New Australian Submarine	Combat System Provider
OE7	LOG-00002	Combat System Spares, Software Update	Combat System Provider	New Australian Submarine
OE5	TAC-00001	IE7 Strike Targeting	Operational Command	New Australian Submarine
OE3	TAC-00002	IE1 Mission Orders	Australian Submarine Group	New Australian Submarine
OE2	ADM-00001	IE6 Mission Report, E2 Logistics Requirements	New Australian Submarine	Australian Submarine Group
OE17	TAC-00003	IE38 ISR Collection Data	New Australian Submarine	RAN Intelligence
OE16	TAC-00004	IE16 Intelligence Report	RAN Intelligence	New Australian Submarine
OE15	NAV-00001	IE19 Electronic Chart Update	RAN METOC	New Australian Submarine
OE14	LOG-00003	21" UUV, Anti-Ship Missile, Large UUV, Strike Missile, Torpedo, Food, Medical Supplies, Ammunition, Ship Systems Spares	Fleet Logistics	New Australian Submarine
OE13	LOG-00004	Fuel	Fleet Logistic	New Australian Submarin
OE12	TAC-00005	IE17 Contact Report	New Australian Submarine	Operational Command
OE10	TAC-00006	IE16 Intelligence Report	New Australian Submarine	Operational Command
OE18	NAV-00002	IE39 WSM Assignment	SUBOPAUTH	New Australian Submarine
OE19	NAV-00003	IE40 WSM Request	Australian Submarine Group	SUBOPAUTH
OE20	HBR-00001	IE48 Port Coordination	New Australian Submarine	Harbor Control
OE23	TAC-00007	IE49 SAS Tactical Coordination	Special Forces Operators	New Australian Submarine
OE24	TAC-00008	IE49 SAS Tactical Coordination	New Australian Submarine	Special Forces Operators
OE25	OPS-00001	IE52 Operational Control	Australian Submarine Group	Operational Command
OE26	OPS-00002	IE52 Operational Control	Operational Command	Australian Submarine Group
OE27	TAC-00009	IE53 Operational Tasking	Operational Command	New Australian Submarine
OE28	NAV-00004	IE54 Chart Updates	New Australian Submarine	RAN METOC

NAS Architecturally Significant Requirements

ID	Name	Text	Type
1	Range	Unrefueled range shall be at least 12,000 nm.	P
2	Submerged Endurance	Submerged endurance shall be at least 14 days at a speed through the water of not less than 5 kts without snorkeling.	PR
3	Engage with 21" Torpedo	The NAS shall be able to engage one target with at least two wire- or fiber-optic guided 21" torpedoes simultaneously.	SAD
4	Submerged Speed without Snorkeling	The NAS shall sustain a submerged speed through the water of not less than 20 kts for not less than 6 hours without snorkeling.	PC
5	Indiscretion Ratio	The NAS shall maintain main battery charge state during submerged operations while snorkeling not more than 30 minutes in any 24 hour period.	PS
6	Large Diameter UUV Operations	The NAS shall be able to launch and recover a large diameter UUV (not less than 2 meters diameter, not less than 6 meter length) while submerged.	YPS
7	Built in Australia	To the maximum extent practical, the NAS shall be built in Australia of Australian components	KCD (A?)

Key Architecture Design Cost Platform Combat_System PaYloads CRew

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NAS Architecturally Significant Requirements 2

ID	Name	Text	Type
8	Engage with ASM	The ASM shall be able to engage and sink a surface ship with an anti-ship missile launched from a 21" hydraulic ram weapons launch tube while submerged at a depth of at least 20 meters and at a speed through the water of not less than 5 kts.	PSA
9	Engage with Strike Missile	The NAS shall be able to plan and execute a missile strike ashore using a land attack missile launched from a 21" hydraulic ram weapon launcher while submerged at a depth of at least 20 meters and at a speed through the water of not less than 5 kts.	PSA
10	Launch and Recover UAV	The NAS shall be able to launch and recover a hatchable UAV while surfaced.	S
11	Engage ASW Aircraft with SAM	The NAS shall be able to shoot down an airborne target at a range of 10 nm and an altitude of 5,000 feet flying at a speed not more than 400 kts.	PSR
12	Support Special Forces	The NAS shall be able to carry up to 18 special forces operators on a 90 day mission without hot-bunking.	P
13	Submerged Lock-Out	The NAS shall be able to lock-out 18 special forces operators in not more than 12 minutes while the top of the sail is submerged to a depth of at least 5 meters.	P

Key Architecture Design Cost Platform Combat_System PaYloads CRew

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NAS Architecturally Significant Requirements 3

ID	Name	Text	Type
14	Weapons Load-out	The NAS shall carry a weapons load-out of not less than 36 heavyweight 21" torpedo equivalents.	P
15	Large Payload Tubes	The NAS shall have at least two payload tubes capable of launching and recovering a large UUV at least 2 meters in diameter and at least 6 meters long.	PSA
16	Large Payload Tube Power Interface	Each large payload tube shall be capable of providing at least 10 amps of power at 120 VAC inductively coupled at 1 meter from the bottom of the tube.	P
17	Large Payload Tube Data Interface	Each large payload tube shall be capable of supporting an IEEE 802.11n wireless data interface sustaining at least 54 Mbps coupled through 1 cm of sea water at the bottom of the tube.	SP
18	Number of 21" Weapons Launchers	The NAS shall have at least 6 21" hydraulic ram weapon launchers capable of accommodating any of a UUV, Stonefish Mark III mine, Sub-Harpoon ASM, strike missile, or Mk.48 CBASS heavyweight wire-guided torpedo.	PSR
19	Control Six Torpedoes Simultaneously	The NAS shall be able to simultaneously control at least six 21" wire- or fiber-optic guided torpedoes.	SAD

Key Architecture Design Cost Platform Combat_System PaYloads CRew

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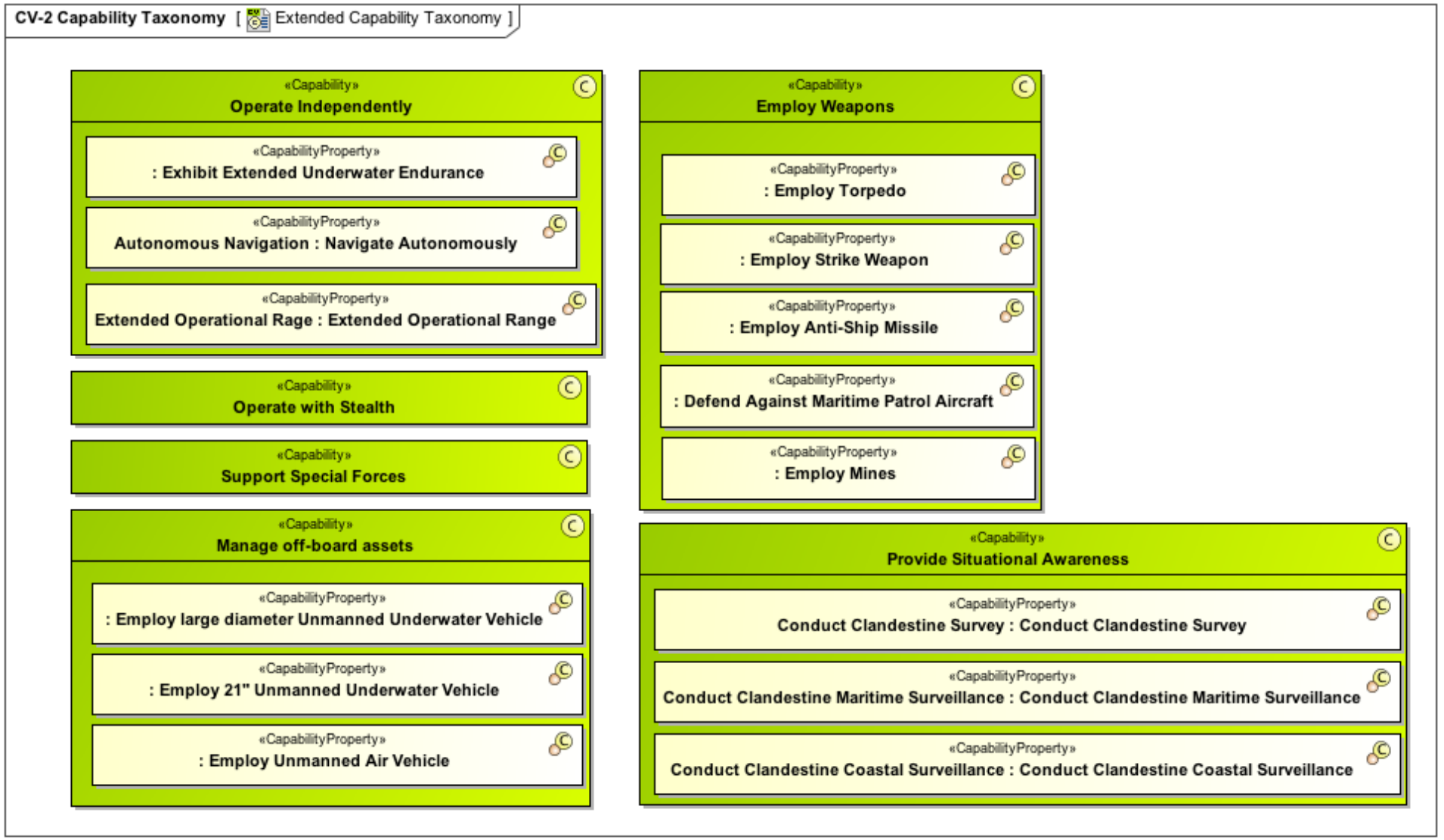
Identifying Needed Capabilities

CV-2 Capabilities Taxonomy



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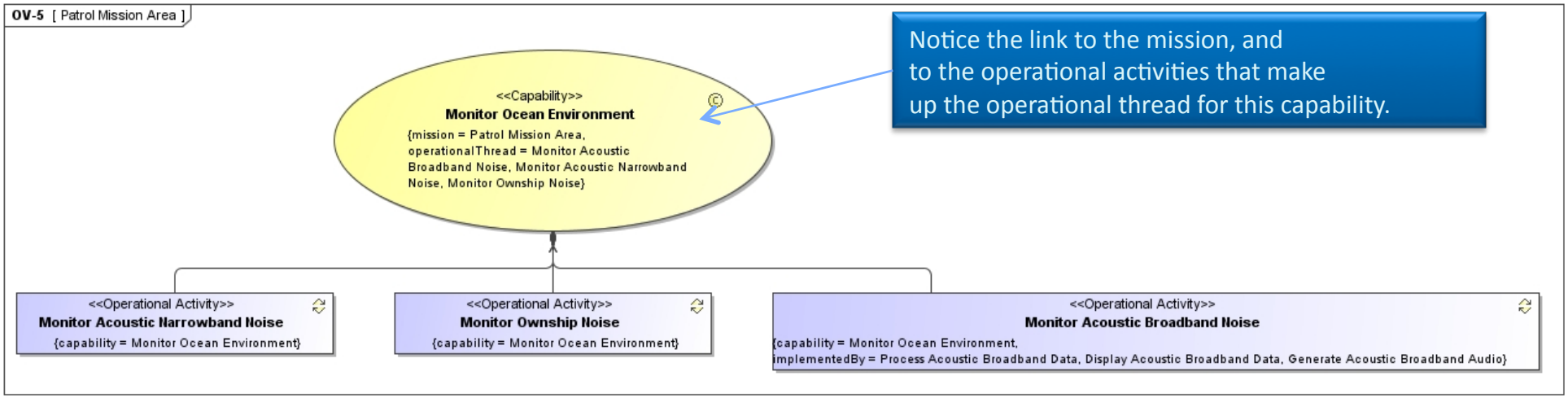
CV-6 Linking Activities to Capabilities

The Objective of “Monitoring the Ocean Environment” has been used as the basis for the capability “Monitor Ocean Environment”



A sample of the type of Operational Activities that support the capability is shown. These will be further elaborated through System Services and Functions later.

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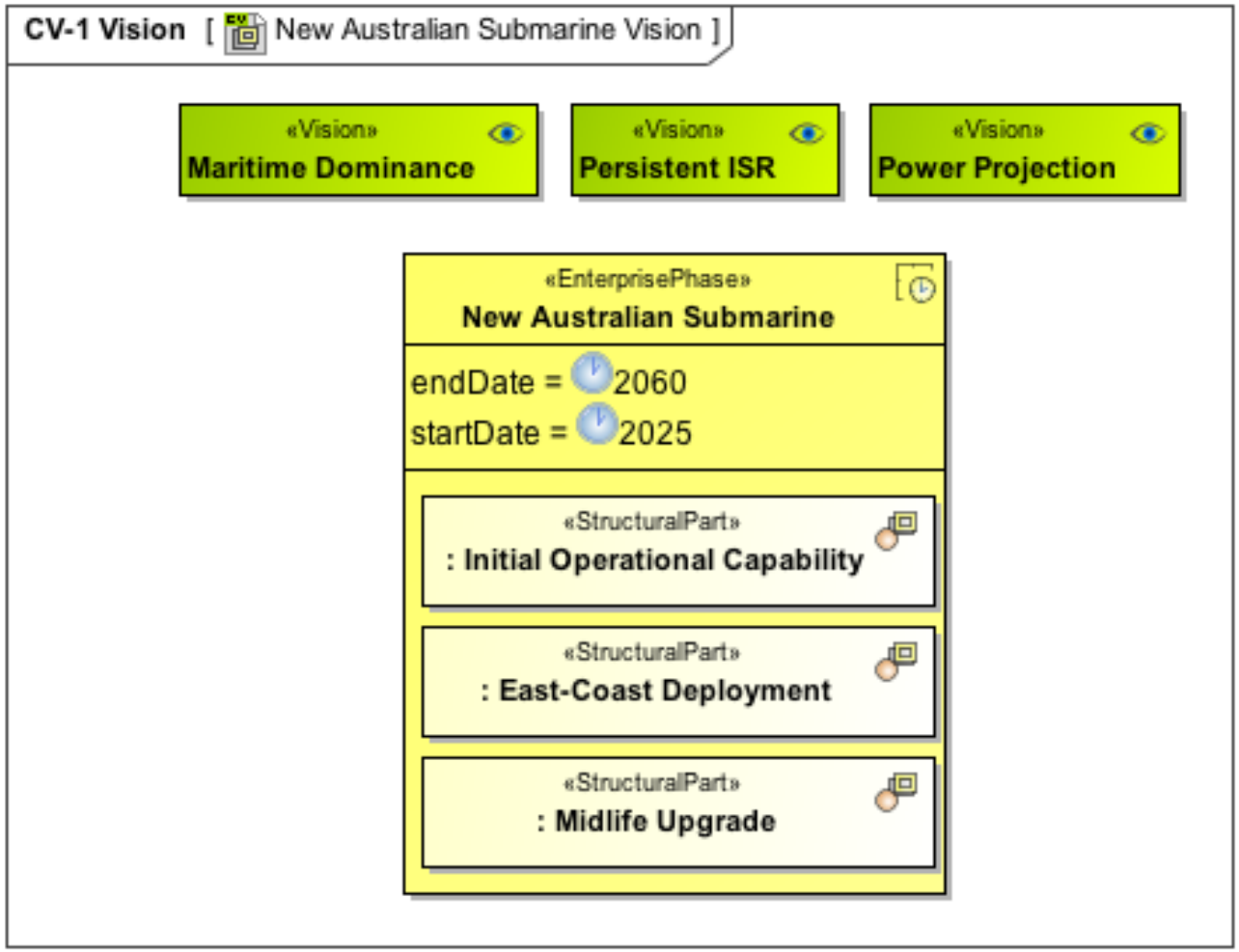
CV-1 NAS Vision – Phased Implementation



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Defining the Solution Architecture

Solution Architecture Considerations

- Foregoing analysis has defined the problem we need to solve
- Multiple paths forward lead to good, compliant solutions
  - Analysis methods like structured decomposition and object oriented analysis
  - Design techniques like functional integration and SOA
- The best solution almost always requires tradeoffs and compromises

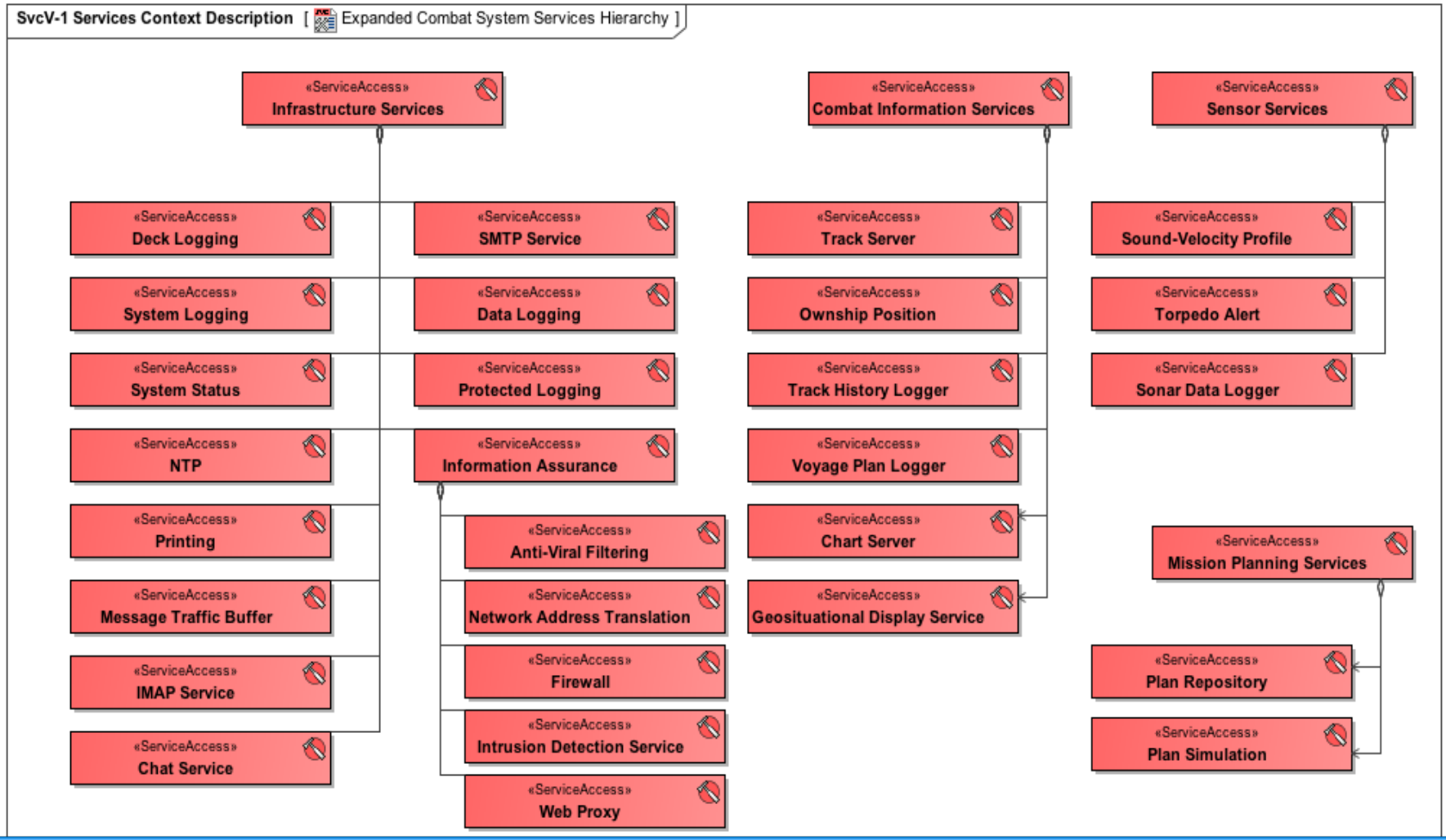
Consider alternatives and avoid the temptation to dive down to a point solution

Generating Candidate Architectures

- There are almost always multiple valid approaches to designing a combat system. Differentiating factors include:
  - Services decompositions
  - Computational architectures
  - Re-use strategies
  - Decompositions induced by the core competencies of alternative partners
- Each approach has its own strengths and weaknesses, and may be appropriate in some application

It is critical NOT to select an architectural approach just because you did it that way on your last project, or even on the last combat system.

SvcV-1 Services Decomposition



Multiple architectures SHALL be constructed and traded!!!

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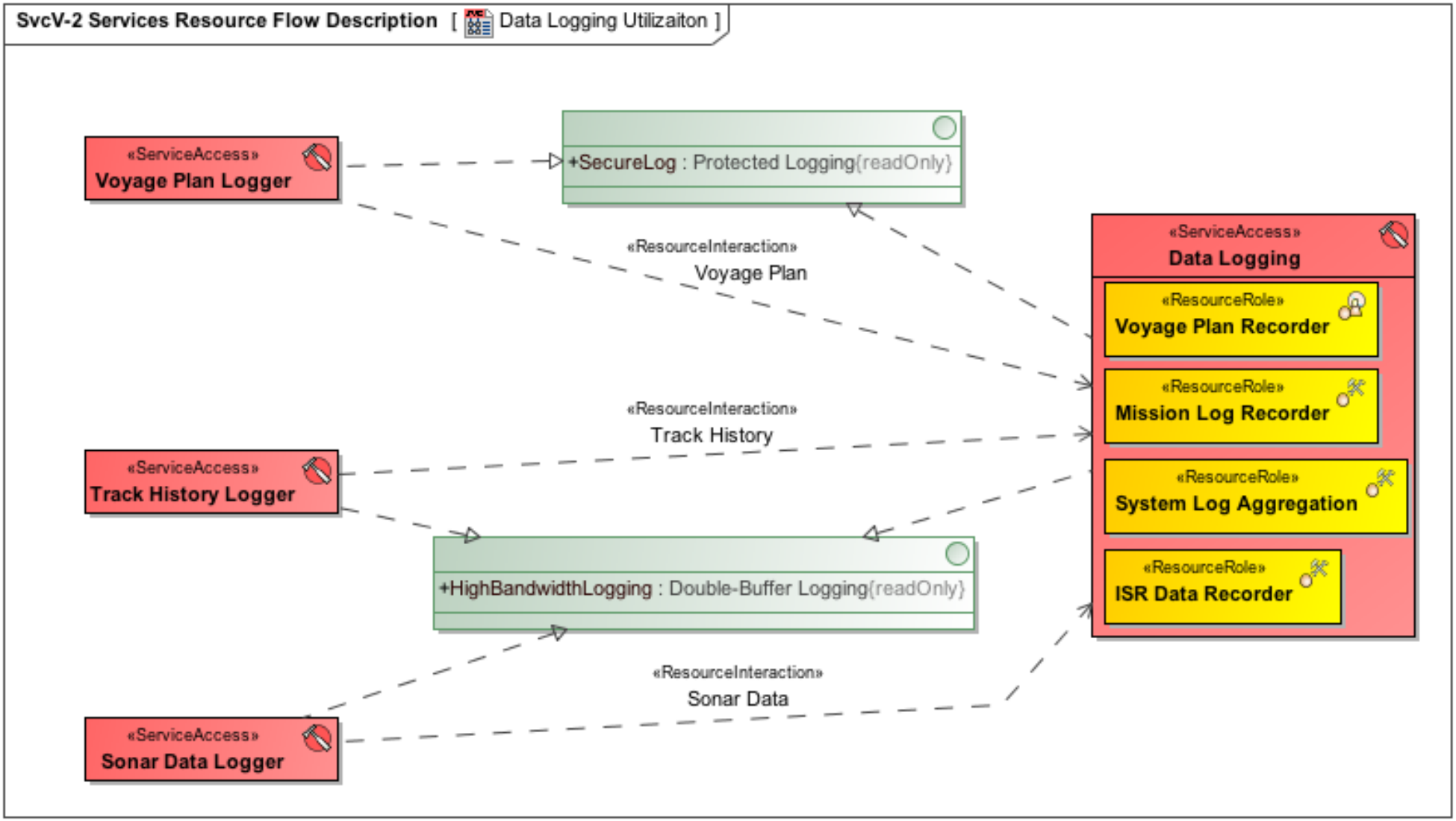
SvcV-2 Service Resource Flows



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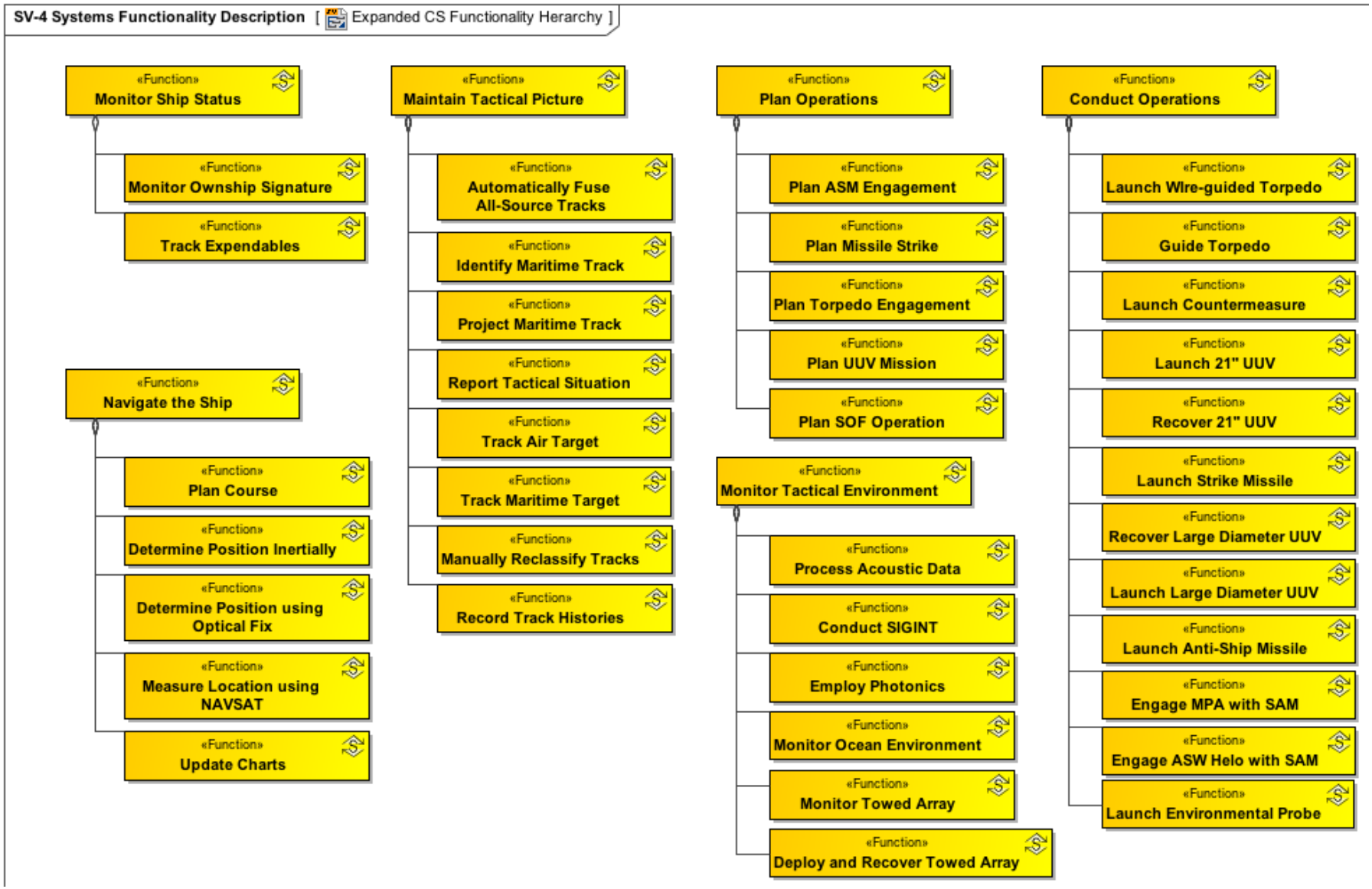
Identifying the Combat System Functions

- System functions are the foundation for services
- Based on all of the analysis up to this point, we identify the system functions needed to support the identified activities and services
- *Come up with at least two different functional decompositions – don't lock in the first one suggested*
- Requirements, new data elements, and additional services will be exposed by this process – update the model to capture all of them as you go along!
- Iterate, Iterate, Iterate, …

SV-4 Combat System Functional Decomposition



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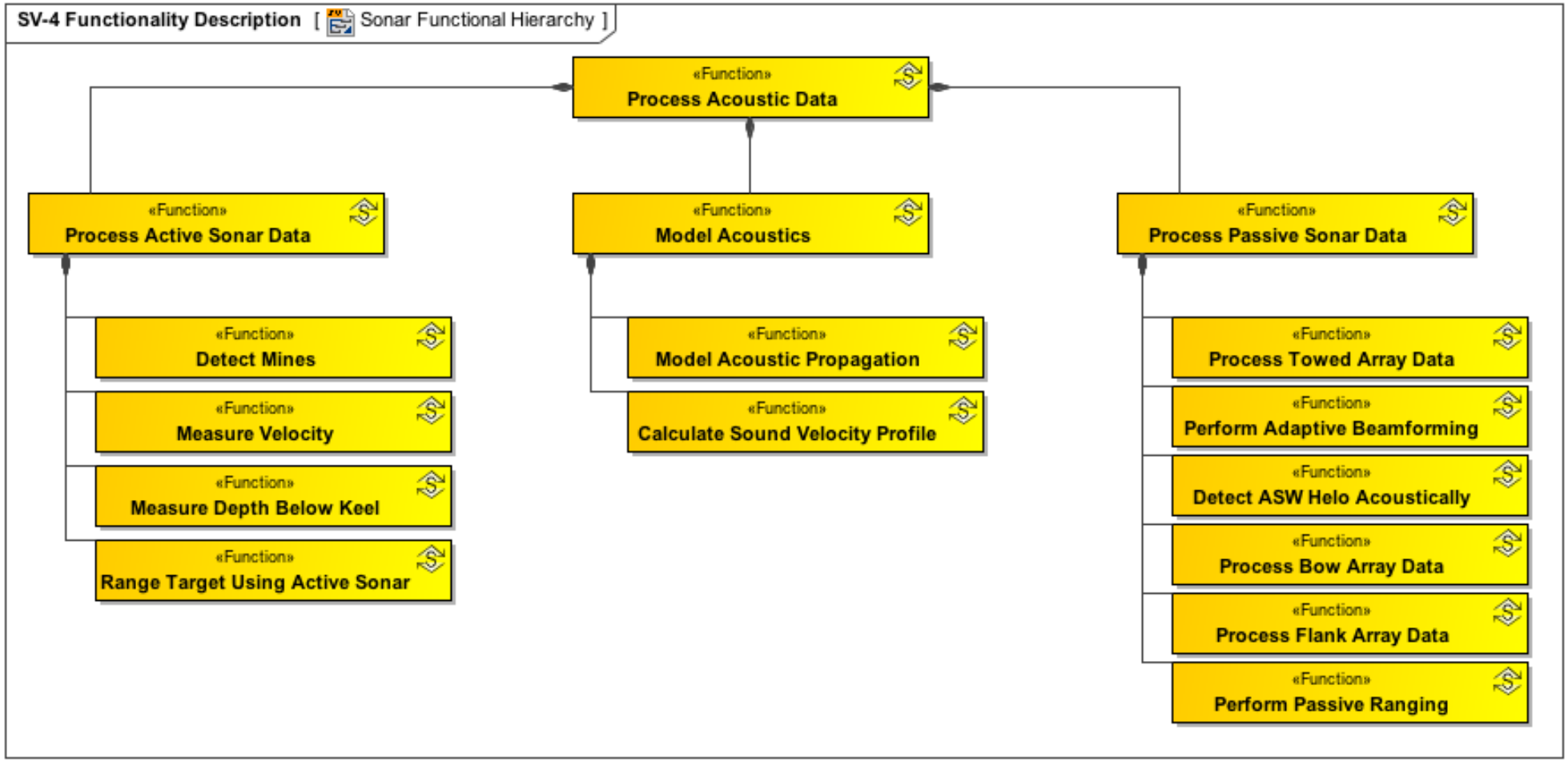
SV-4 Sonar Functional Decomposition



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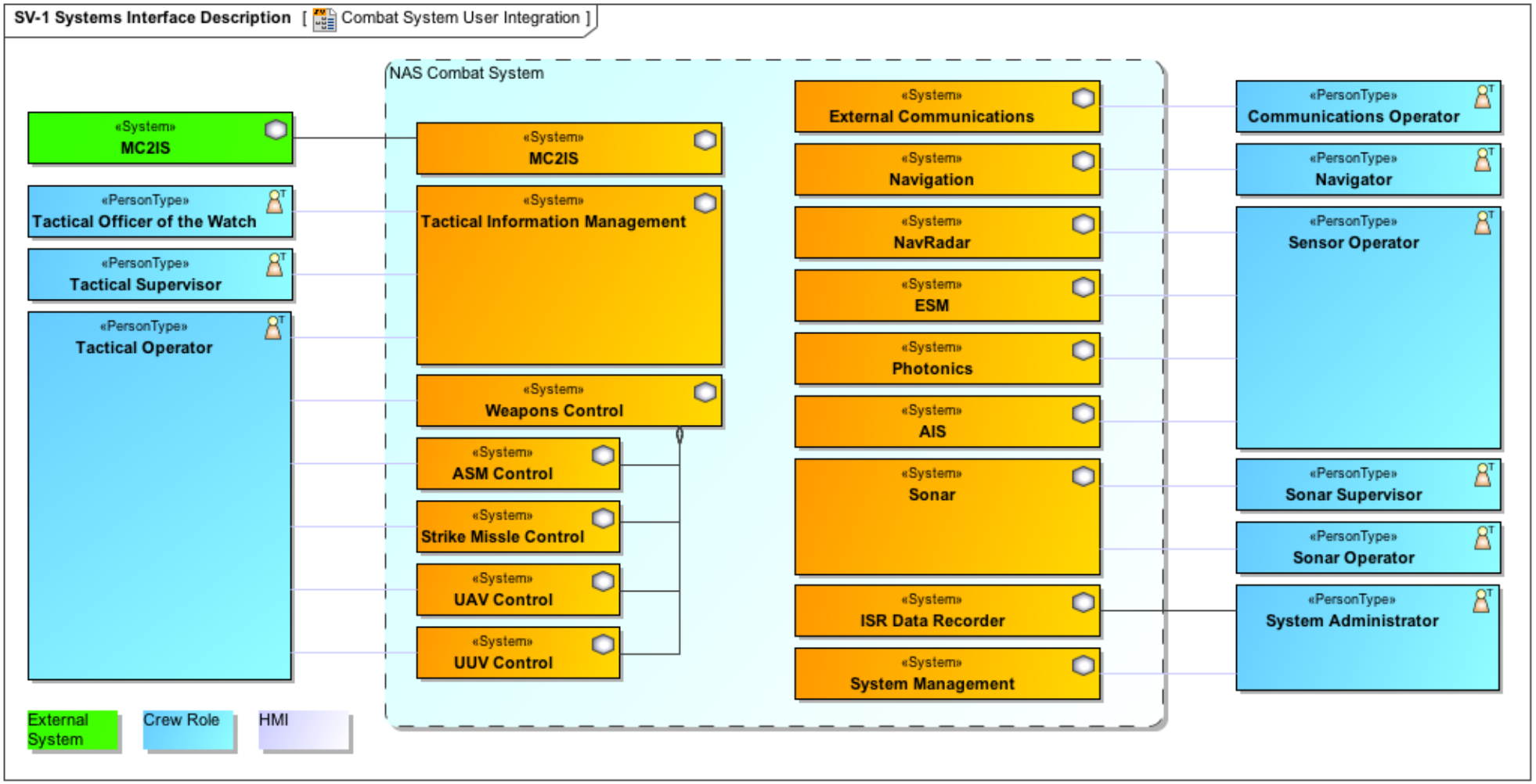
SV-1 Combat System Interfaces On-Platform



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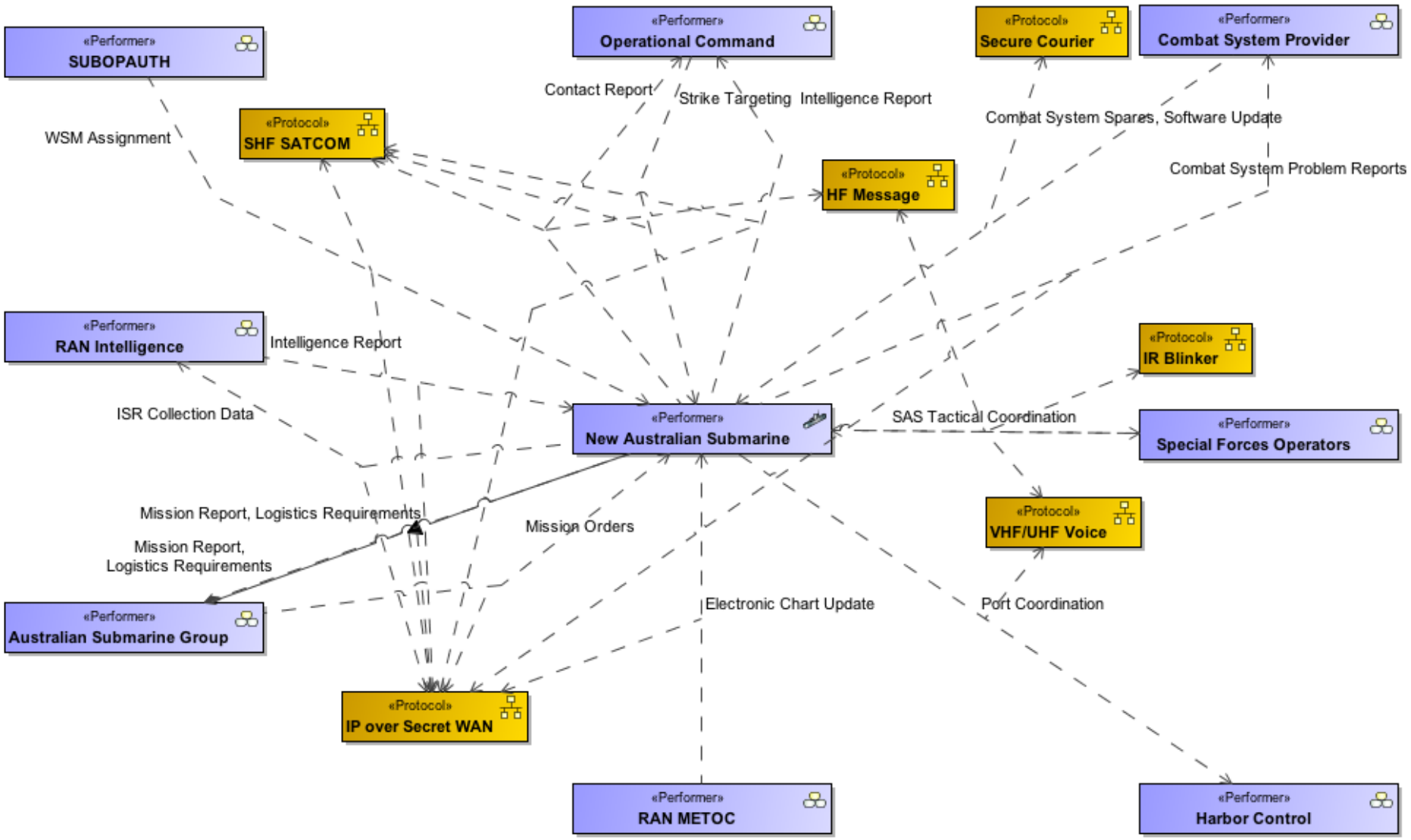
SV-2 External Communications



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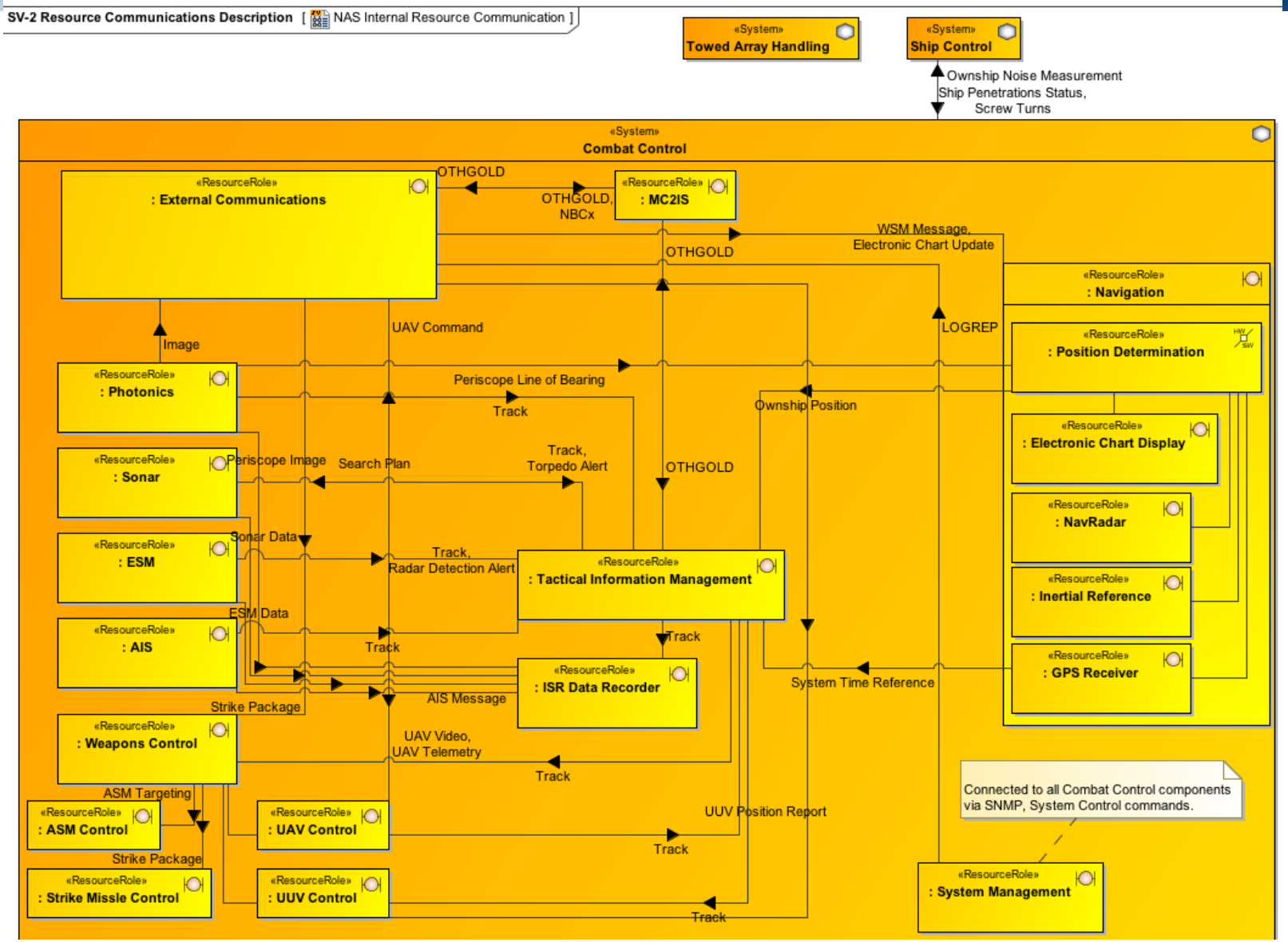
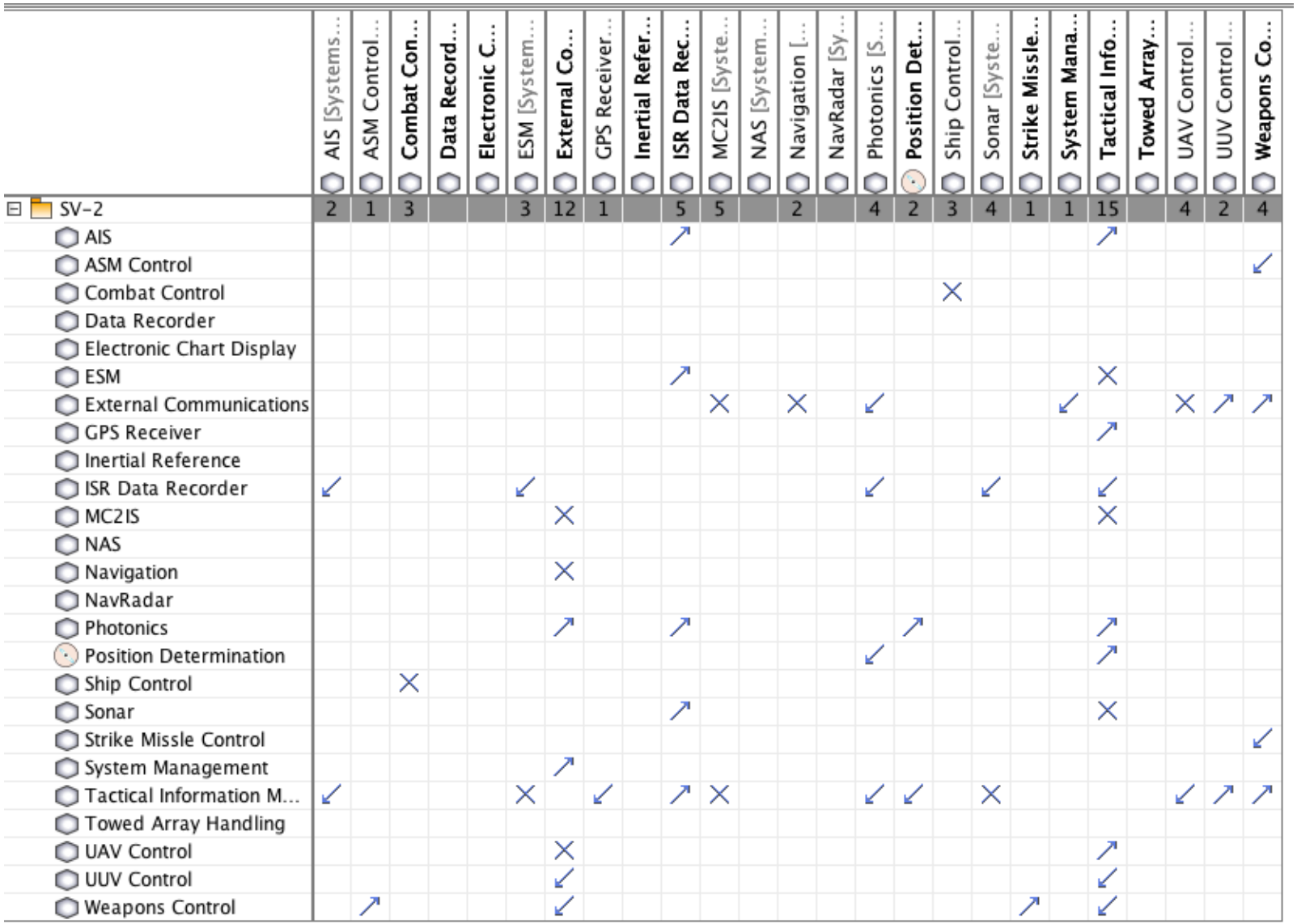
SV-2 Internal Communications



SV-3 System to System Mapping



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SV-2	2	1	3			3	12	1		5	5		2		4	2	3	4	1	1	15		4	2	4
AIS										↗											↗				
ASM Control																									↙
Combat Control																	✕								
Data Recorder																									
Electronic Chart Display																									
ESM										↗											✕				
External Communications											✕		✕		↙					↙			✕	↗	↗
GPS Receiver																					↗				
Inertial Reference																									
ISR Data Recorder	↙					↙									↙			↙			↙				
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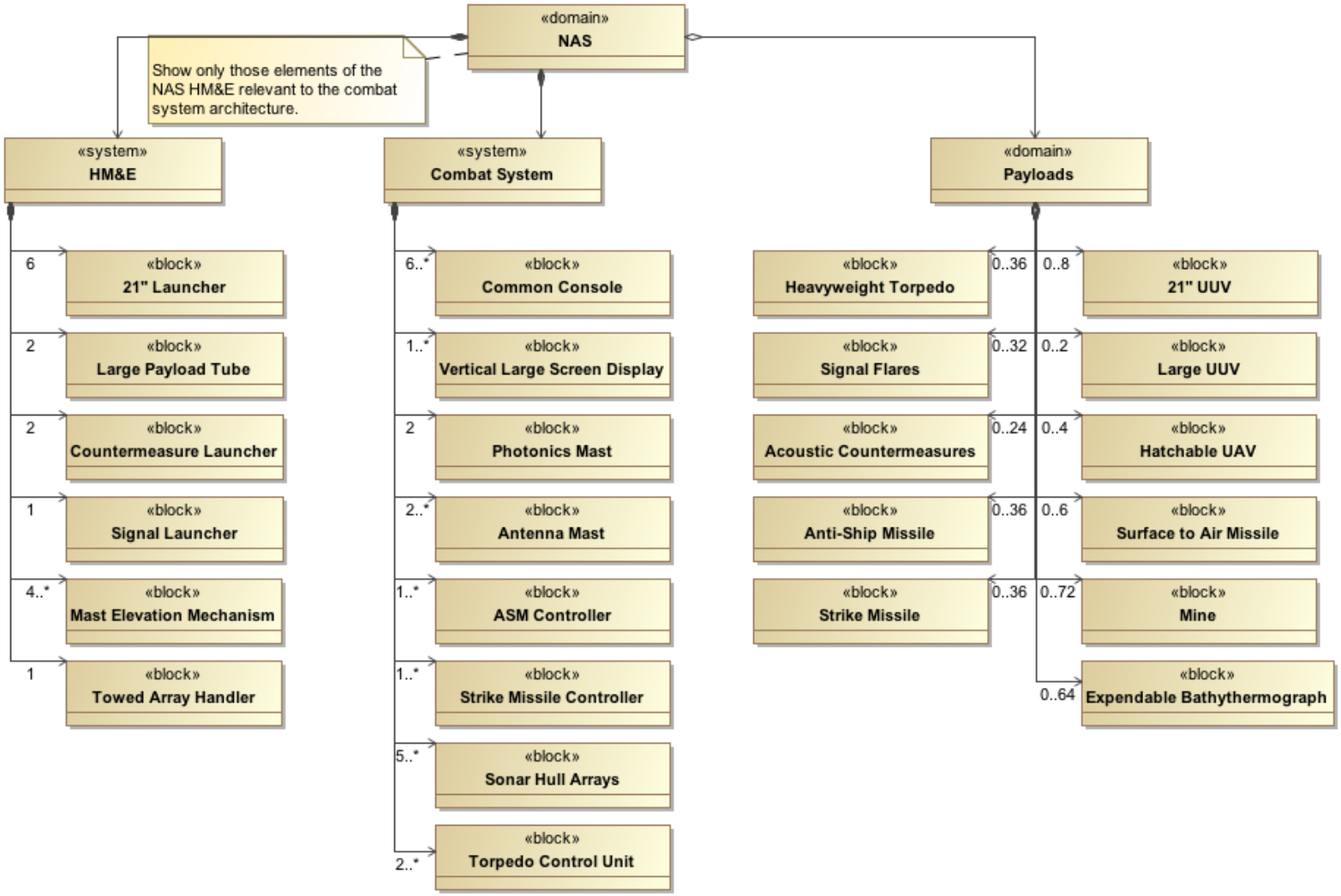
SV-4 Physical Architecture



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Summary

- UPDM is a useful language for developing and communicating solution and product family architectures
  - LM architecting methodology has been applied on multiple successful programs
  - Downside of UPDM + SysML + UML + DoDAF + powerful OO and analytic modeling tools is steep learning and knowledge/skill maintenance curve
- UPDM does help bridge the gap between enterprise architecture and solution design

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