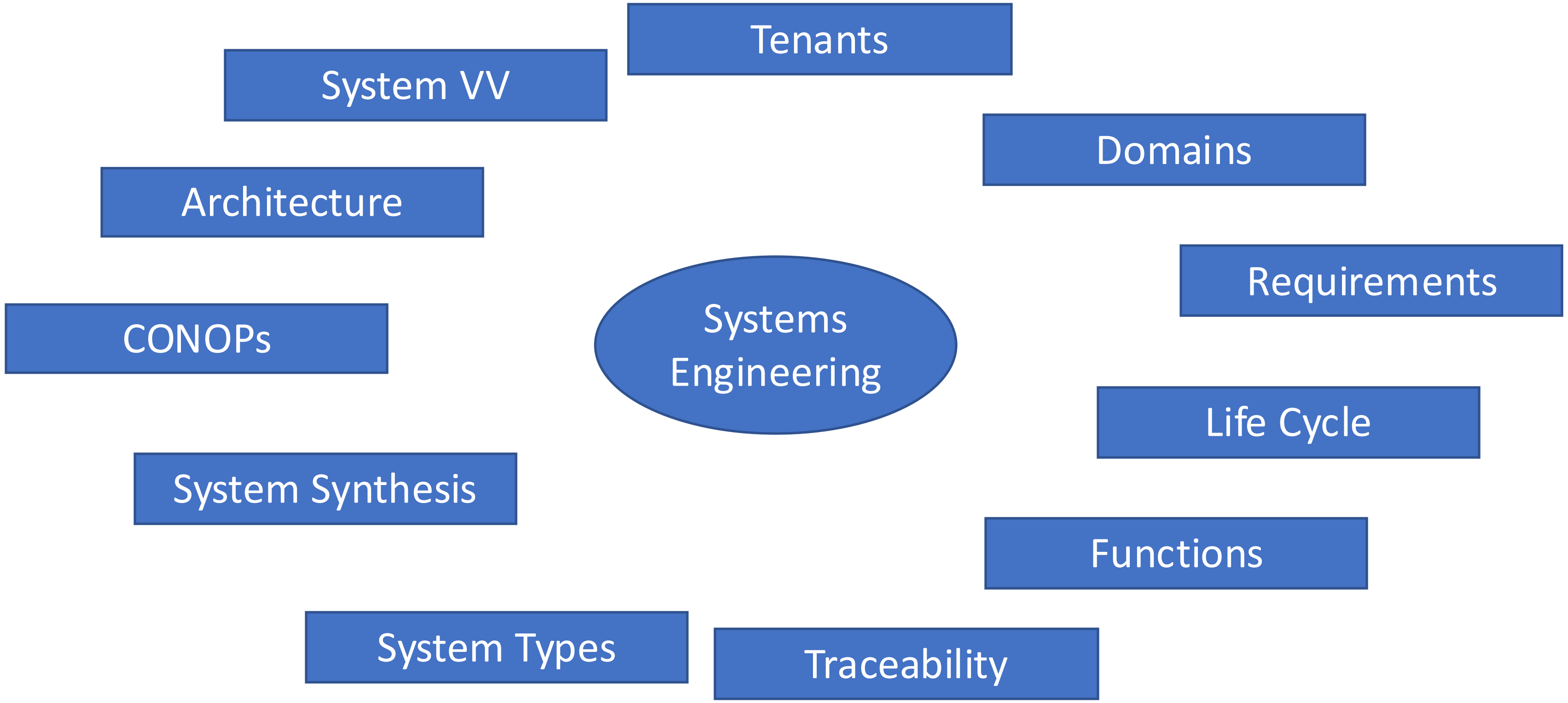
METHODOLOGIES

WEEK	CLASS ACTIVITY	REF	INDIVIDUAL	W	GROUP	W
1 28/Jul	Course Structure and Initial Definitions Systems Engineering Review	[1][2][3][4]	IA-01 - Reading and Conceptual Questions (10)	10%		0%
2 04/Aug	Classical Systems Engineering Diagrams (IDEF-0/N2/eFFBD/DFD)	[4] *papers	IA-02	0%	GA-02 - Prepare a representation of your system using classical Diagrams	50%
3 11/Aug	Transition from Legacy to MBSE MBSE Methodologies MBSE Languages	[5] [7] *papers	IA-03 - Reading and Conceptual Questions (10)	10%		0%
4 18/Aug	OPM - Basic	[6]	IA-04 - Exercises	10%		0%
5 25/Aug	OPM - Extended	[6]	IA-05 - Exercises	10%		0%
6 01/Sep	OPM - Group Presentation		IA-06	0%	G6 - Prepare a presentation of your system using OPM	50%
7 08/Sep	SysML Introduction (bdd/ibd)	[7]	IA-07 - Exercises	10%		0%
8 15/Sep	P1 - Conceptual Questions and Case	[1] [2] [3] [4] [6]	IA-08 - Questions and a mini-case	50%	GA-08 -	
				100%		100%

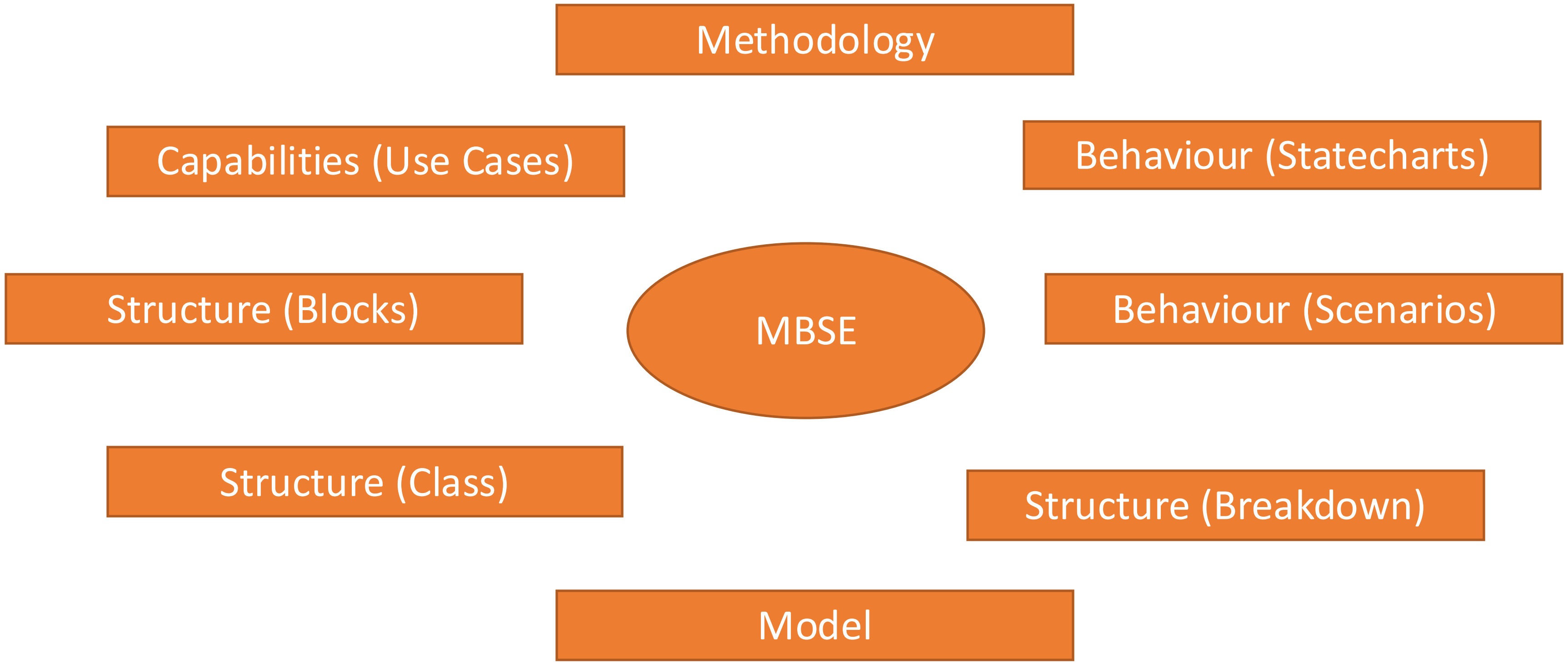
WEEK	CLASS ACTIVITY	REF	INDIVIDUAL	W	GROUP	W
9 29/Sep	SysML (act/stm)	[7]	IA-09 - Exercises	10%	GA-09 -	0%
10 06/Oct	SysML (seq/uc)	[7]	IA-10 - Exercises	10%	GA-10 -	0%
11 13/Oct	Simulation on SysML		IA-11 -	0%	GA-11 -	0%
12 20/Oct 21/Oct	SysML (pkg/req)	[7]	IA-12 - Exercises	10%	GA-12 -	0%
13 27/Oct	Arcadia process applied into the SysML	[5]	IA-13 -	0%	GA-13 -	0%
14 03/Nov	Some System Analysis on SysML SysML V2 Perspectives	[8]	IA-14 -	0%	GA-14 -	0%
15 10/Nov	SysML Group Presentation Course Ending		IA-15 -	0%	GA-15 - Prepare a presentation of your system using SysML	100%
16 17/Nov	P2 - Conceptual Questions and Case	[5] [7]	IA-16 - Questions and a mini-case	70%	GA-16 -	
				100%		**100%**
EXAM 24/Nov 08/Dec	**If necessary: Writing an article (min 6pgs / max 10pgs) reporting the case of their group in the SIGE standard.**					**100%**

Systems Engineering Artifacts

Systems Engineering Helm



MBSE HELM


Methodology
Capabilities (Use Cases)
Behaviour (Statecharts)
Structure (Blocks)
MBSE
Behaviour (Scenarios)
Structure (Class)
Structure (Breakdown)
Model

This course

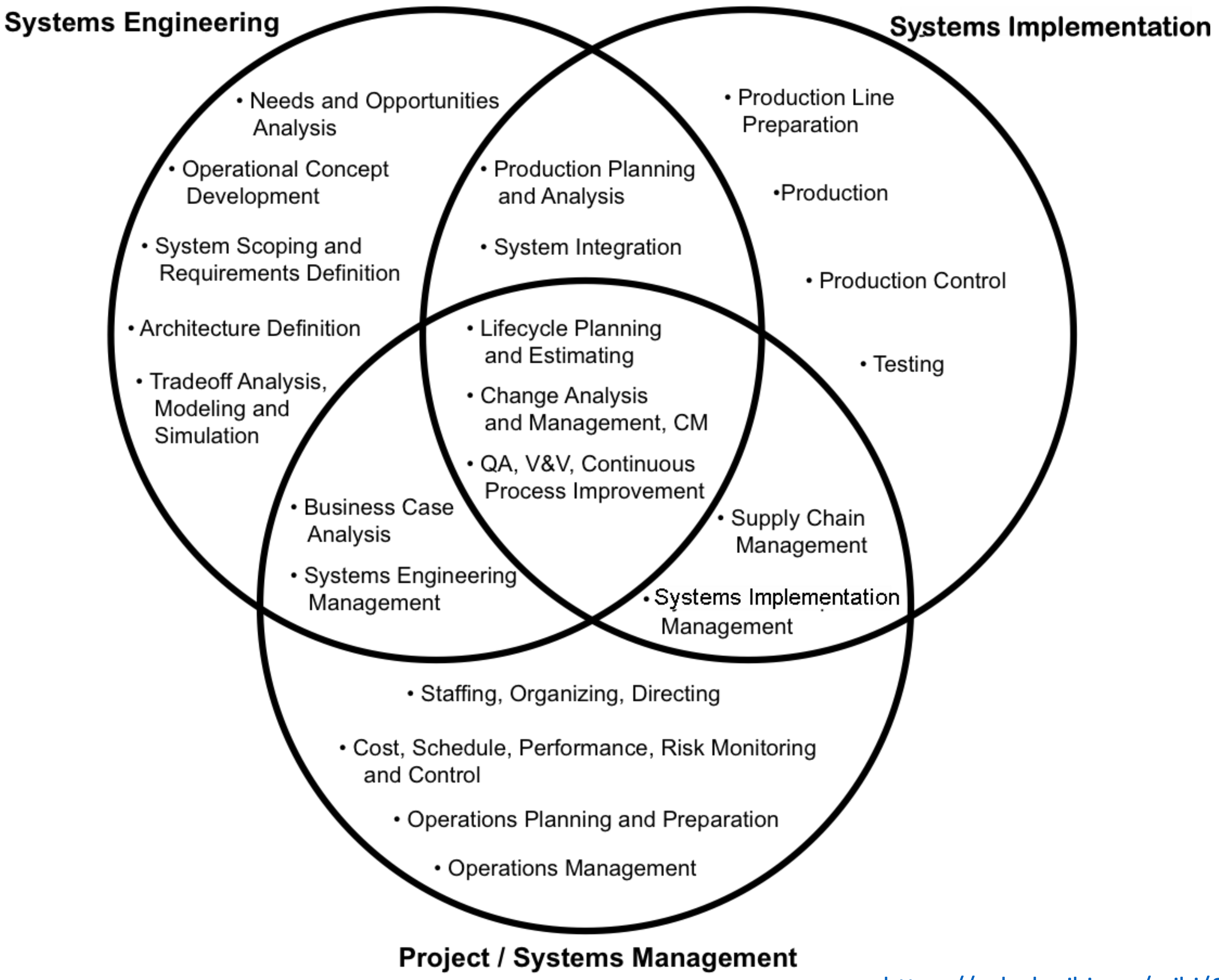
Systems Engineering

- Tenants
- Domains
- Requirements
- Life Cycle
- Functions
- System Synthesis
- Traceability
- System Types
- CONOPs
- Architecture
- System VV

MBSE

- Model
- Capabilities (Use Cases)
- Behaviour (Statemachine)
- Structure (Blocks)
- Behaviour (Scenarios)
- Structure (Breakdown)
- Structure (Class)
- Methodology

Relationship with Other Disciplines



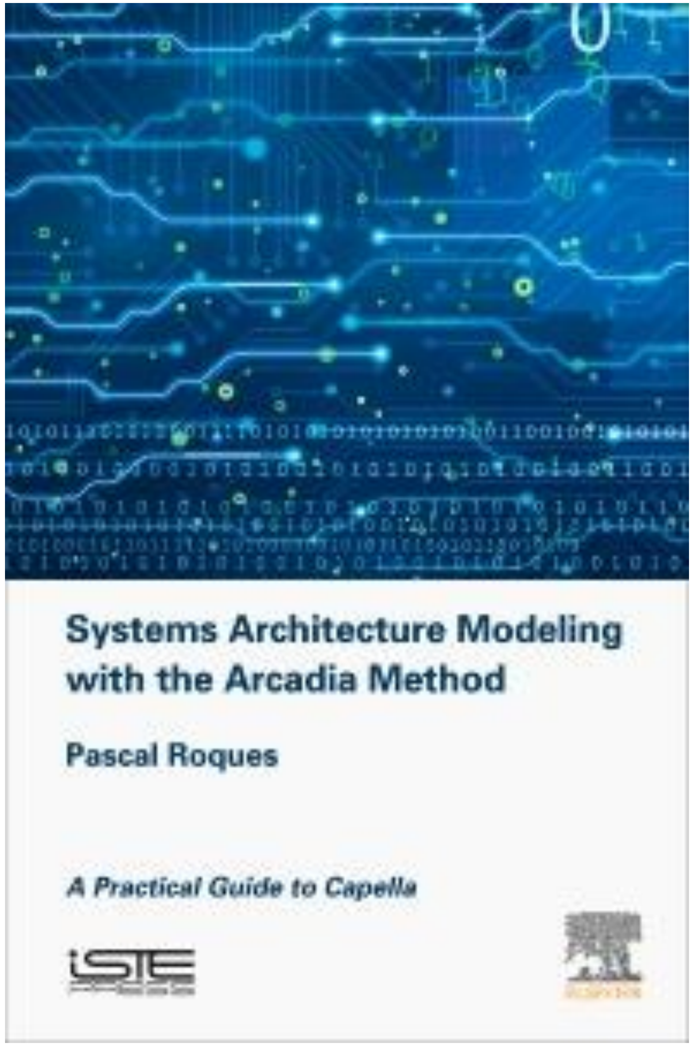
https://sebokwiki.org/wiki/Systems_Engineering_Overview

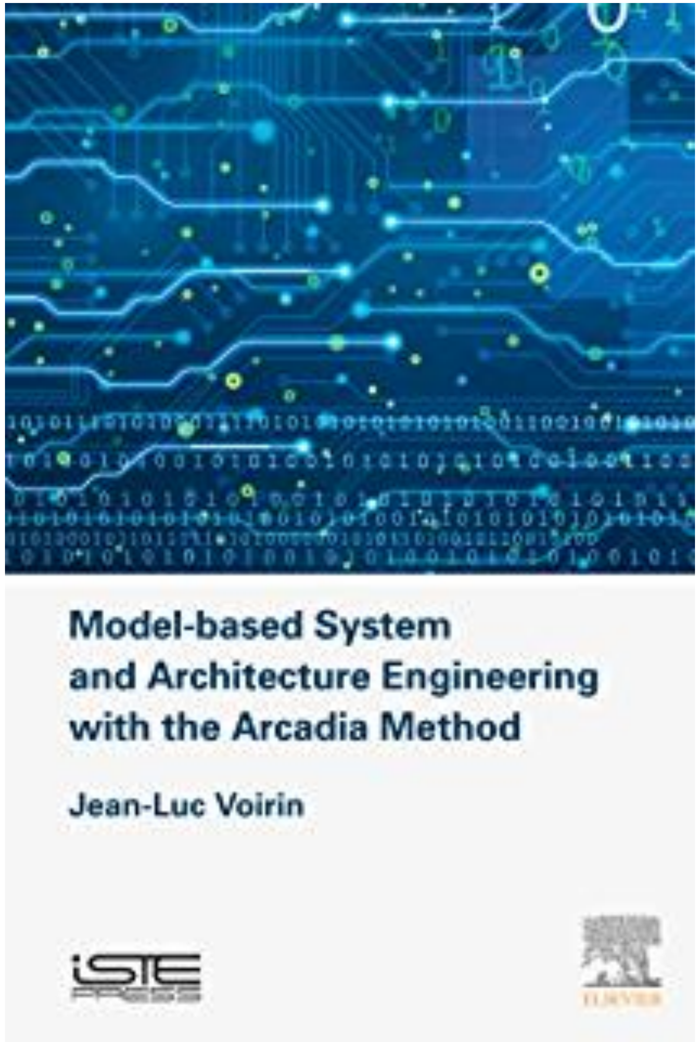
Arcadia Methodology

REF-006: VOIRIN, J.L. Model-based System and Architecture Engineering with the Arcadia Method. Elsevier, 2017. ISBN 978-0-0810-1794-4.

REF-007: ROQUES, P. Systems Architecture Modeling with the Arcadia Method – A Practical Guide to Capella. Elsevier, 2017. ISBN: 978-0-0810-1792-0

Key References





- Systems engineers have been making use of modeling techniques for a long time.
- **The technique of structured analysis and design (SADT) and structured real-time analytics (Structured Analysis for Real Time SA/RT) are some of the best known and date back to the 1980s**.
- There are many other approaches based on Petri nets or finite state machines.
- However, they are also limited by their comprehensiveness and expressiveness, as well as by the difficulty in integrating them with other formalisms and requirements.

- **Unfortunately, in practice, it has been shown that the affiliation of the SysML language to UML often leads to difficulties in terms of understanding and use for systems engineers who are not also computer scientists.**

- This is the reason that led Thales to define the ARCADIA method, structured by Jean-Luc Voirin, along with its underlying formalism, for his own needs.

https://www.linkedin.com/in/jean-luc-voirin-8087a9155/

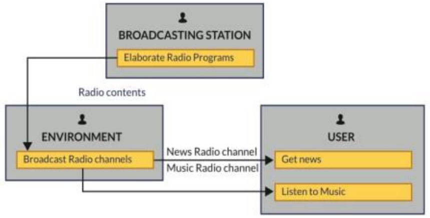
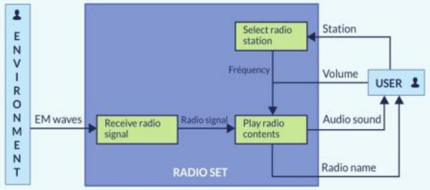
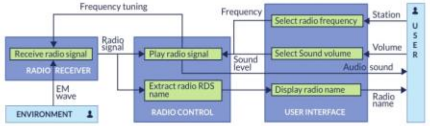
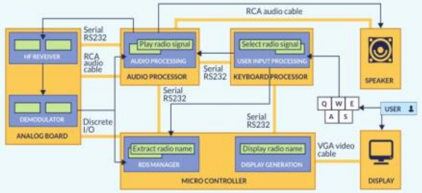
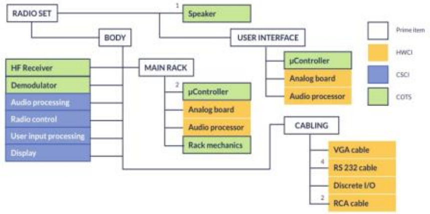
https://www.youtube.com/watch?v=NIFayQAueso

https://www.youtube.com/watch?v=2fveJ7nwiuU

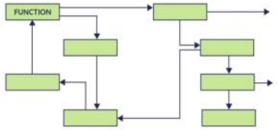

Architect
Specialty engineering: safety, perf, security, ...
Functions
Safety
Performance
Human Factors
Security
IVVQ, Product Line, Cost...
ViewPoints
Evaluation Rules
Product Line Manager, Etc.
Sub-contractors
Solution Architecture

Founding principles

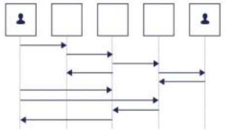
- All engineering **stakeholders share the same methodology, the same information, the same description** of the need and the product in the form of a shared model;
- Each specialized type of engineering (e.g., safety, performance, cost, and mass) is formalized as a **"point of view"** against the requirements from which the proposed architecture is then verified;
- The **rules for early verification of the architecture are established** in order to verify the architecture as quickly as possible;
- **Co-engineering** between the different levels of engineering is supported by the joint elaboration of models, with the models of the different levels and specialties being deduced/validated/linked to each other.

METHOD STEPS	TASKS	SAMPLE MODEL	CONCEPTS
NEED — **Customer Operational Need Analysis** What the users of the system need to accomplish	✓ Define operational capabilities ✓ Perform an operational need analysis		- Operational capabilities - Actors, operational entities - Actor activities - Interactions between activities & actors - Information used in activities & interactions - Operational processes chaining activities - Scenarios for dynamic behaviour
NEED — **System/ SW/HW Need Analysis** What the system has to accomplish for the Users	✓ Perform a capability trade-off analysis ✓ Perform a functional and non-functional analysis ✓ Formalise and consolidate requirements		- Actors and system, capabilities - Functions of system & actors - Dataflow exchanges between functions - Functional chains traversing dataflow - Information used in functions & exchanges, data model - Scenarios for dynamic behaviour - Modes & states
SOLUTIONS — **Logical Architecture Design** How the system will work so as to fulfil expectations	✓ Define architecture drivers and viewpoints ✓ Build candidate architectural breakdowns in components ✓ Select best compromise architecture		*SAME CONCEPTS, PLUS :* - Components - Component ports and interfaces - Exchanges between components - Function allocation to components - Component interface justification by functional exchanges allocation
SOLUTIONS — **Physical Architecture Design** How the system will be developed & built	✓ Define architectural patterns ✓ Consider reuse of existing assets design a physical ✓ Design a physical reference architecture ✓ Validate and check it		*SAME CONCEPTS, PLUS :* - Behavioural components refining logical ones, and implementing functional behaviour - Implementation components supplying resources for behavioural components - Physical links between implementation components
SOLUTIONS — **Development Contracts** What is expected from each designer/ sub-contractor	✓ Define a components IVVQ strategy ✓ Define & enforce a PBS and component integration contract		- Configuration items tree - Parts numbers, quantities - Development contract (expected behaviour, interfaces, scenarios, resource consumption, non-functional properties...)

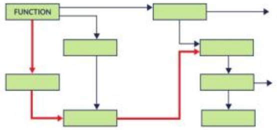
DESCRIPTION MEANS



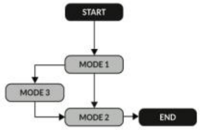
Dataflow: functions, op. activities interactions & exchanges



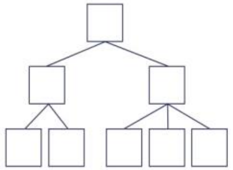
Scenarios: actors, system, components interactions & exchanges



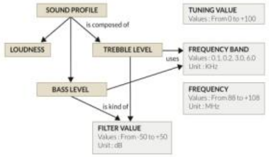
Functional chains, operational processes through functions & op. activities



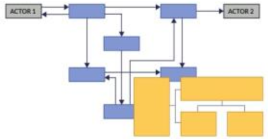
Modes & states of actors, system, components



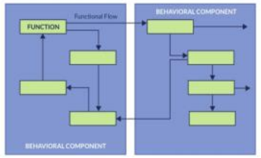
Breakdown of functions & components



Data model: dataflow & scenario contents, definition & justification of interfaces



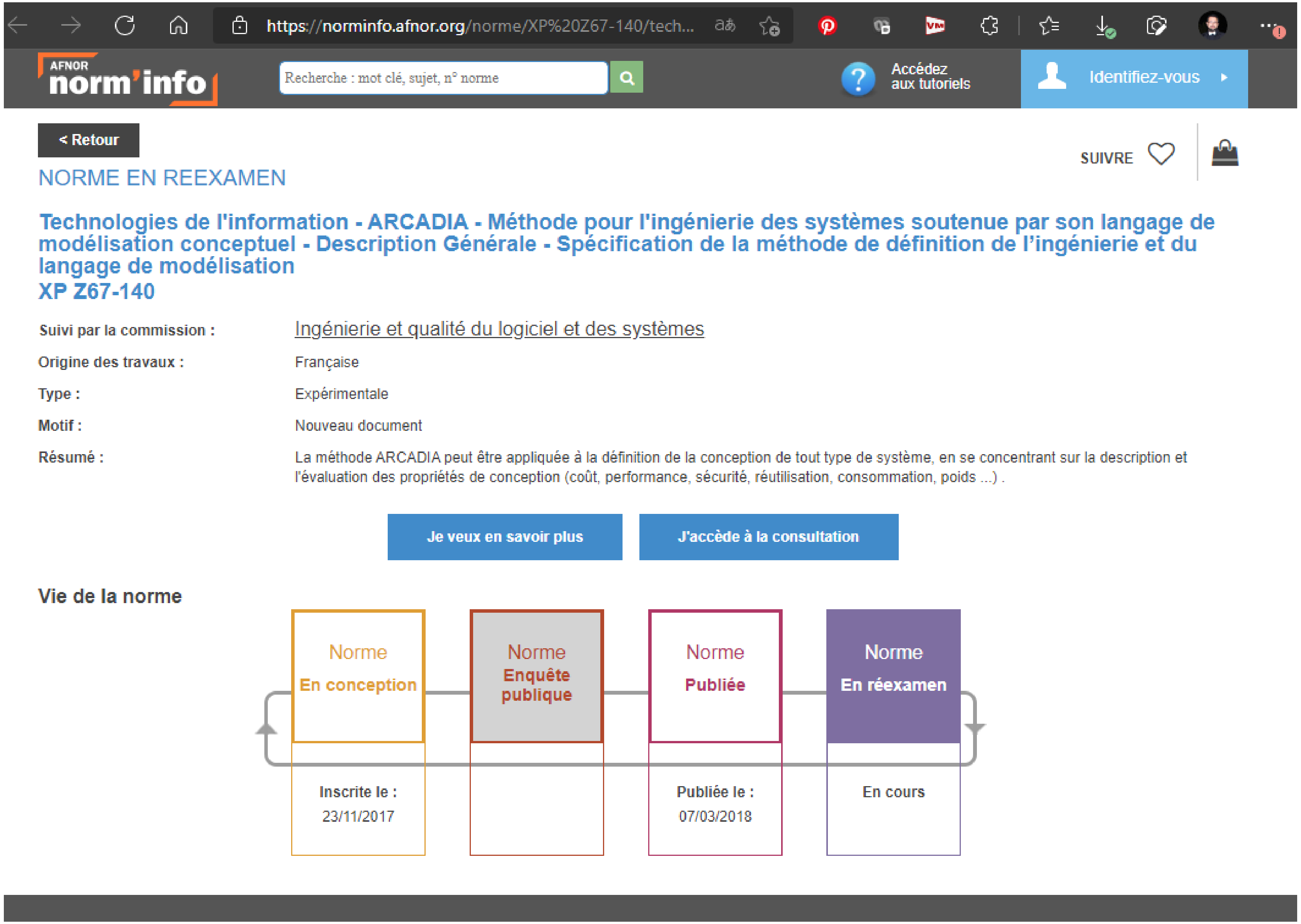
Component wiring: all kinds of components



Allocation of op.activities to actors, of functions to components, of behav.components to impl.components, of dataflows to interfaces, of elements to configuration items

XP Z67-140 - ARCADIA

[Norme XP Z67-140 (afnor.org)]


https://norminfo.afnor.org/norme/XP%20Z67-140/tech...

AFNOR norm'info

Recherche : mot clé, sujet, n° norme

Accédez aux tutoriels

Identifiez-vous

< Retour

SUIVRE

NORME EN REEXAMEN

Technologies de l'information - ARCADIA - Méthode pour l'ingénierie des systèmes soutenue par son langage de modélisation conceptuel - Description Générale - Spécification de la méthode de définition de l'ingénierie et du langage de modélisation

XP Z67-140

Suivi par la commission :	Ingénierie et qualité du logiciel et des systèmes
Origine des travaux :	Française
Type :	Expérimentale
Motif :	Nouveau document
Résumé :	La méthode ARCADIA peut être appliquée à la définition de la conception de tout type de système, en se concentrant sur la description et l'évaluation des propriétés de conception (coût, performance, sécurité, réutilisation, consommation, poids ...) .

Je veux en savoir plus

J'accède à la consultation

Vie de la norme

Norme En conception	Norme Enquête publique	Norme Publiée	Norme En réexamen
Inscrite le : 23/11/2017		Publiée le : 07/03/2018	En cours

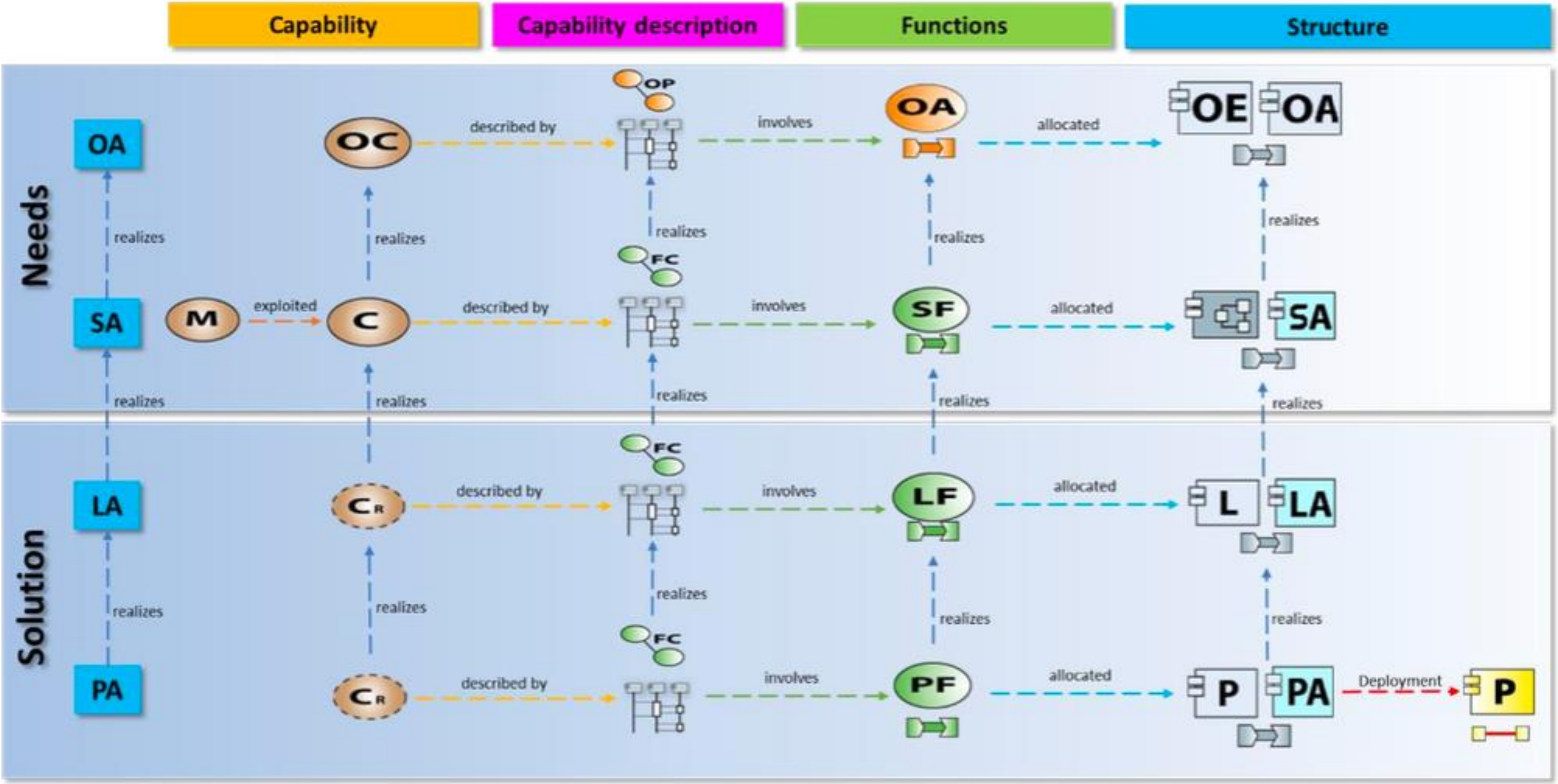


Figure 2.3: Arcadia ontology traceability

https://www.slideshare.net/HelderCastro3/mbse-with-arcadia-methodpdf-256664096

Arcadia layer	Requirements	Capability	Capability description	Functional	Structure	Modes and States	Data	Interfaces
Operational Analysis	**R-OA** Capture stakeholder requirements	**OA1** Define Operational Capabilities	**OA2** Define processes and scenarios	**OA3** Define Operational Activities and interactions	**OA4** Capture Operational Entities and Actors. Allocate Operational Activities to Operational Actors, Entities	**M&S-OA5** Define operational modes and states	**D-OA6** Define operational data model	**I-OA7** Define interfaces and describe interfaces scenarios
System Analysis	**R-SA** Derive Stakeholder requirements and capture System requirements	**SA1** Define System Missions and System Capabilities	**SA2** Define Functional Chains and Scenarios.	**SA3** Define System Functions. Define Functional Exchanges and components	**SA4** Allocate System Functions to System and Actors	**M&S-SA5** Define system modes and states	**D-SA6** Define system data model	**I-SA7** Define interfaces and describe interfaces scenarios Enrich Logical Scenarios.
Logical Architecture	**R-LA** Derive system requirements and Capture components requirements	**LA1** Transition Capabilities Realization from system layer	**LA2** Define Functional Chains and scenarios	**LA3** Derive System Functions and define Logical Functions. Define Functional Exchanges and components.	**LA4** Allocate Logical Functions to Logical Components	**M&S-LA5** Define logical components modes and states	**D-LA6** Define logical data model	**I-LA7** Delegate System Interfaces and create Logical Interfaces. Enrich Logical Scenarios.
Physical Architecture	**R-PA** Derive logical requirements and capture physical requirements	**PA1** Transition Capabilities Realization from logical layer	**PA2** Define Functional Chains, Scenarios, and Physical Path	**PA3** Derive Logical Functions and define Physical Functions. Define Functional Exchanges and components.	**PA4** Define Physical Nodes and refine Behavioural Physical Components. Allocate Behavioural Components.	**M&S-PA5** Define physical nodes modes and states	**D-PA6** Define physical data model	**I-PA7** Delegate Logical Interfaces and create Physical Interface. Enrich Physical Scenarios.

Table 3.2: Arcadia matrix activities

https://www.slideshare.net/HelderCastro3/mbse-with-arcadia-methodpdf-256664096

Arcadia layer	Requirements	Capability	Capability description	Functional	Structural	Modes and States	Data	Interfaces
Operational Analysis	**R-OA** No dedicated diagram	**OA1** [OCB] Operational Capabilities	**OA2** [OAS] Operational Activity Scenario [OPD] Operational Process Scenario [OES] Operational Entity Scenario	**OA3** [OABD] Operational Activity Breakdown Diagram [OAIB] Operational Activity Interaction Blank	**OA4** [OEBD] Operational Entities Blank Diagram [ORB] Operational Roles Blank [OAB] Operational Architecture Blank	**M&S-OA5** [MSM] Modes and States	**D-OA6** [CDB] Class Diagram	**I-OA7** [IDB] Interface Definition Blank [CEI] Component External Interfaces [IS] Interface Scenario [CDI] Component Detailed Interface
System Analysis	**R-SA** No dedicated diagram	**SA1** [MCB] Mission and Capabilities Blank [CC] Contextual Capability	**SA2** [FS] System Functional Scenario [ES] System Entity Scenario [SFCD] System Functional Chain Description	**SA3** [SFBD] System Functional Breakdown Diagram [SDFB] System Data Flow Blank	**SA4** [CSA] Contextual System Actor [SAB] System Architecture Blank	**M&S-SA5** [MSM] Modes and States	**D-SA6** [CDB] Class Diagram	**I-SA7** [IDB] Interface Definition Blank [CEI] Component External Interfaces [IS] Interface Scenario [CDI] Component Detailed Interface
Logical Architecture	**R-LA** No dedicated diagram	**LA1** [CRB] Capabilities Realization Blank [CRI] Contextual Capability Realization Involvement	**LA2** [FS] Logical Functional Scenario [ES] Logical Entity Scenario [LFCD] Logical Functional Chain Description	**LA3** [LFBD] Logical Functional Breakdown Diagram [LDFB] Logical Data Flow Blank	**LA4** [LCBD] Logical Component Breakdown Diagram [LAB] Logical Architecture Blank	**M&S-LA5** [MSM] Modes and States	**D-LA6** [CDB] Class Diagram	**I-LA7** [IDB] Interface Definition Blank [CEI] Component External Interfaces [IS] Interface Scenario [CDI] Component Detailed Interface
Physical Architecture	**R-PA** No dedicated diagram	**PA1** [CRB] Capabilities Realization Blank [CRI] Contextual Capability Realization Involvement	**PA2** [FS] Physical Functional Scenario [ES] Physical Entity Scenario [PFCD] Physical Functional Chain Description	**PA3** [PFBD] Physical Functional Breakdown Diagram [PDFB] Physical Data Flow Blank	**PA4** [PCBD] Physical Component Breakdown Diagram [PAB] Physical Architecture Blank	**M&S-PA5** [MSM] Modes and States	**D-PA6** [CDB] Class Diagram	**I-PA7** [IDB] Interface Definition Blank [CEI] Component External Interfaces [IS] Interface Scenario [CDI] Component Detailed Interface

Table 3.3: Arcadia diagrams matrix

https://www.slideshare.net/HelderCastro3/mbse-with-arcadia-methodpdf-256664096

ADOPTERS

Eclipse Capella is a MBSE solution adopted worldwide in various industrial domains.
Discover some of the many organizations using Capella.

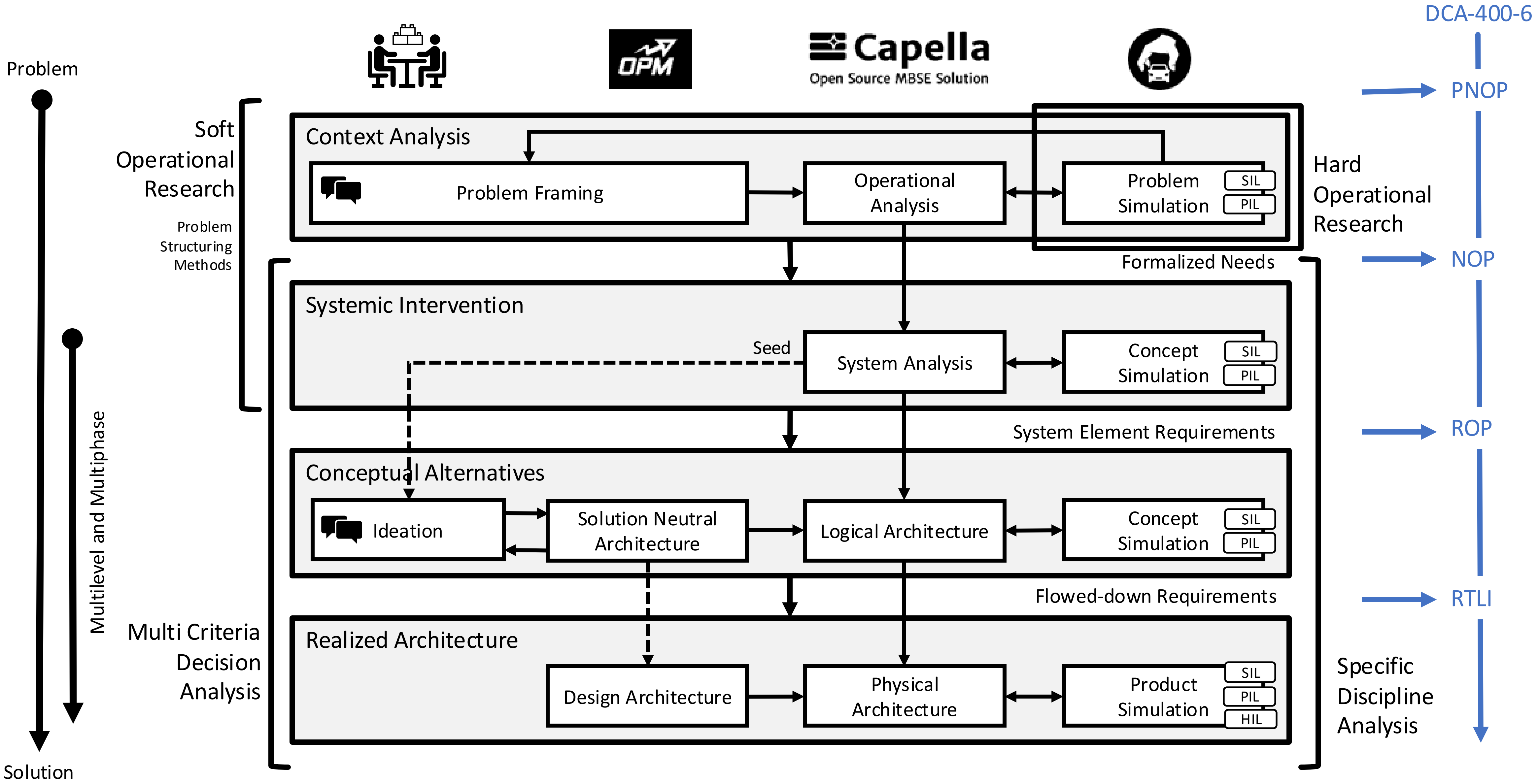
https://www.eclipse.org/capella/adopters.html

ALL4TEC
axone
CNXMOTION
CT ENGINEERING DRIVEN PEOPLE
EMBRAER
gmv
Grus
ISAE ENSMA
ITA
Maplesoft
MARQUETTE UNIVERSITY BE THE DIFFERENCE.
Mentor A Siemens Business
NEXTRAIL
OBEO
PRFC
SAMARES ENGINEERING
SIEMENS
Solutions Thinking
SUTD SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN
THALES
The Reuse Company
UNIVERSITY OF INDIANAPOLIS
Université Toulouse Jean Jaurès
Virgin Hyperloop one
VISION:EER
vitesco TECHNOLOGIES
wsp

https://youtu.be/nv8IOg_xVMs

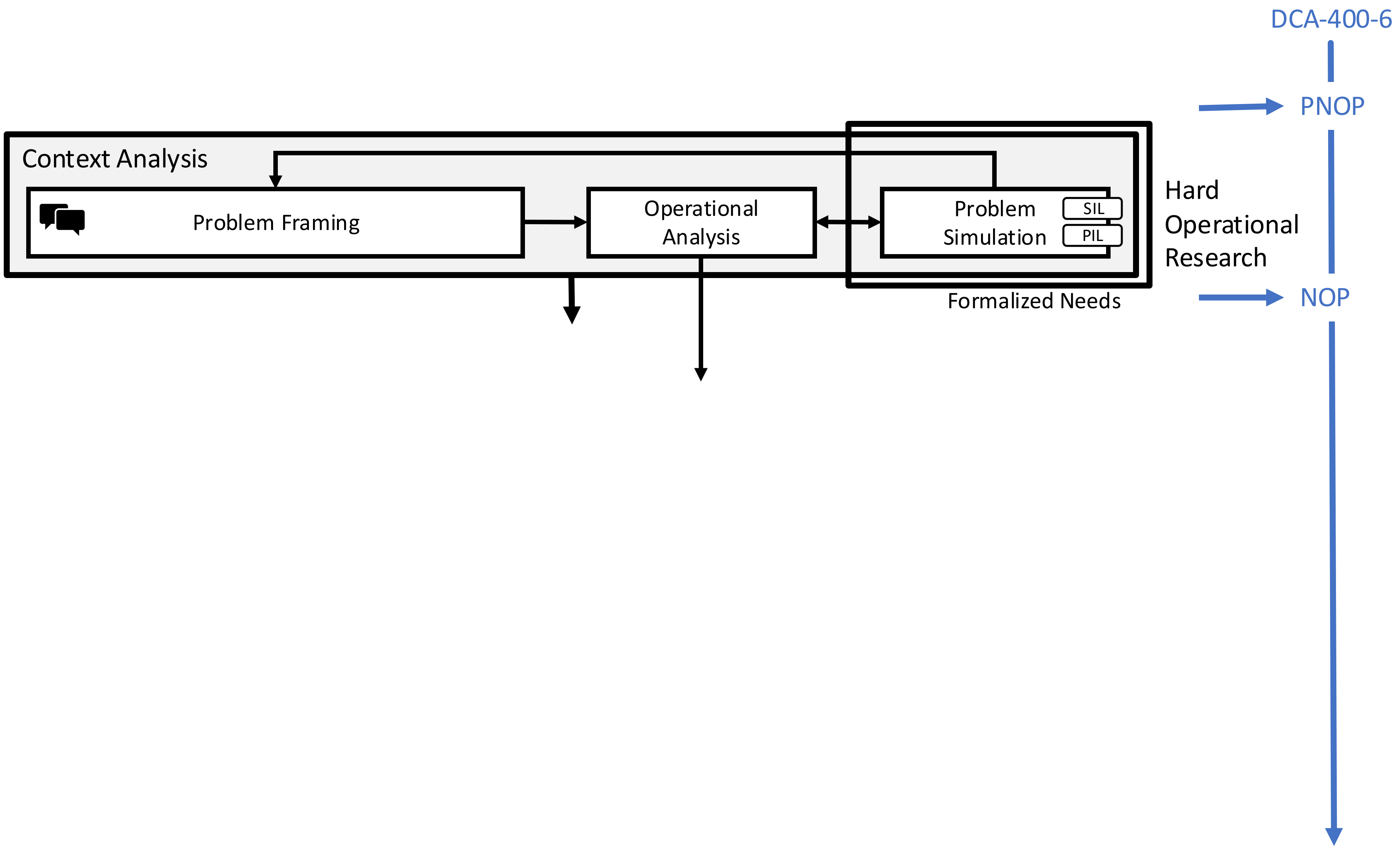
UP Example

MMMF

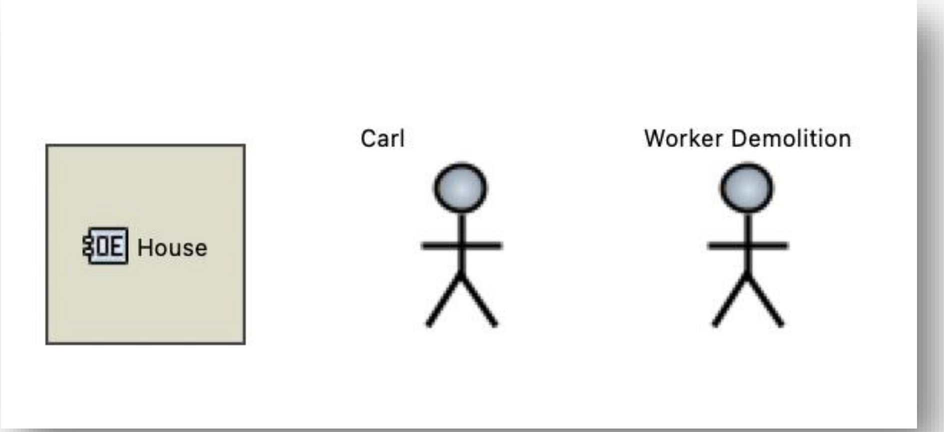


DCA-400-6
Capella
Open Source MBSE Solution
OPM
Problem
Solution
Soft
Operational
Research
Problem
Structuring
Methods
Multilevel and Multiphase
Multi Criteria
Decision
Analysis
Context Analysis
Problem Framing
Operational Analysis
Problem Simulation
SIL
PIL
Hard
Operational
Research
Formalized Needs
Systemic Intervention
Seed
System Analysis
Concept Simulation
SIL
PIL
System Element Requirements
Conceptual Alternatives
Ideation
Solution Neutral Architecture
Logical Architecture
Concept Simulation
SIL
PIL
Flowed-down Requirements
Realized Architecture
Design Architecture
Physical Architecture
Product Simulation
SIL
PIL
HIL
Specific
Discipline
Analysis
PNOP
NOP
ROP
RTLI

Context analysis


DCA-400-6
PNOP
Context Analysis
Problem Framing
Operational Analysis
Problem Simulation
SIL
PIL
Hard Operational Research
Formalized Needs
NOP

Modelling the Actors/Entities of what is happening now (as is)



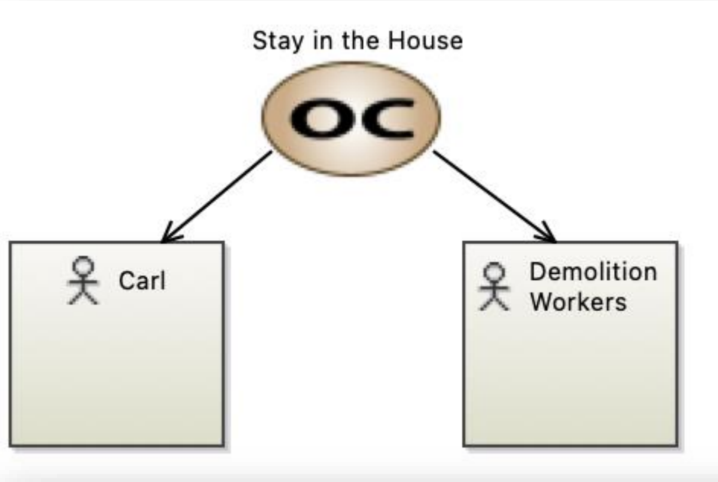
Symbols

Use context images

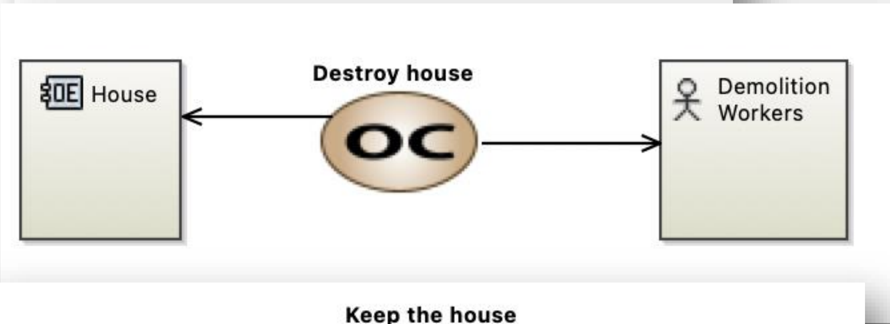
Capella>>Operational Analysis>>Operational Entity Breakdown Diagrams

Map what is happening

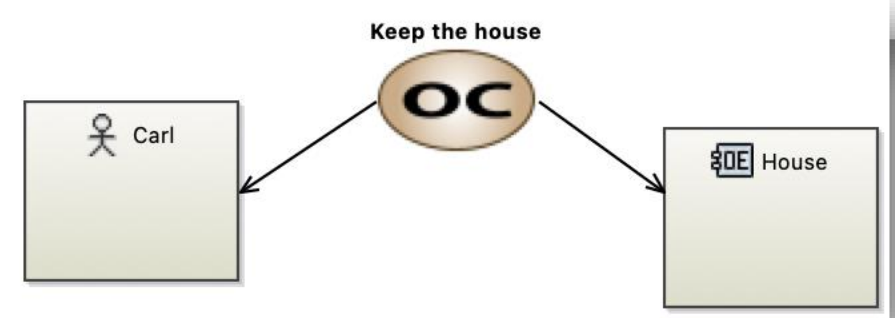
1.



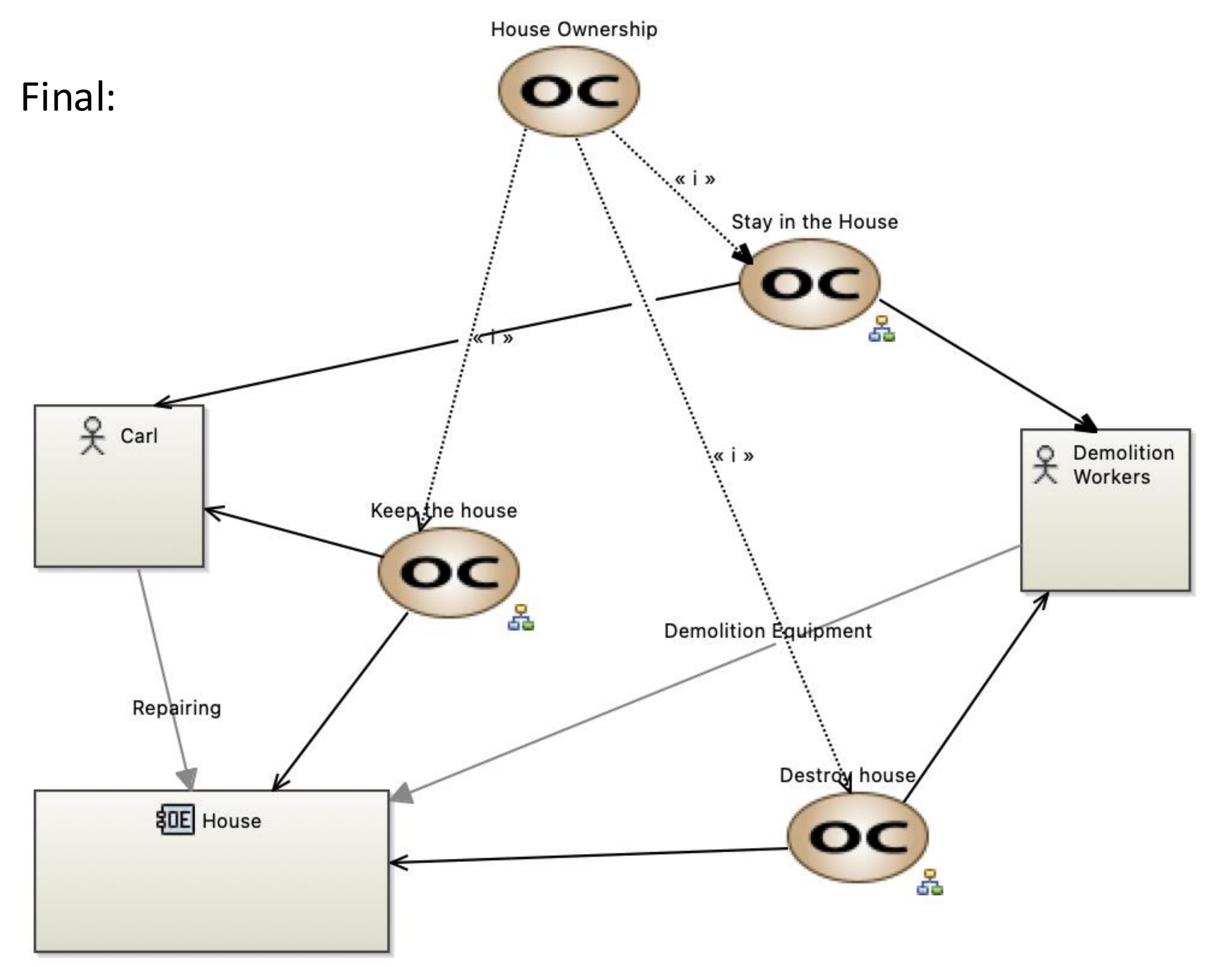
2.



3.

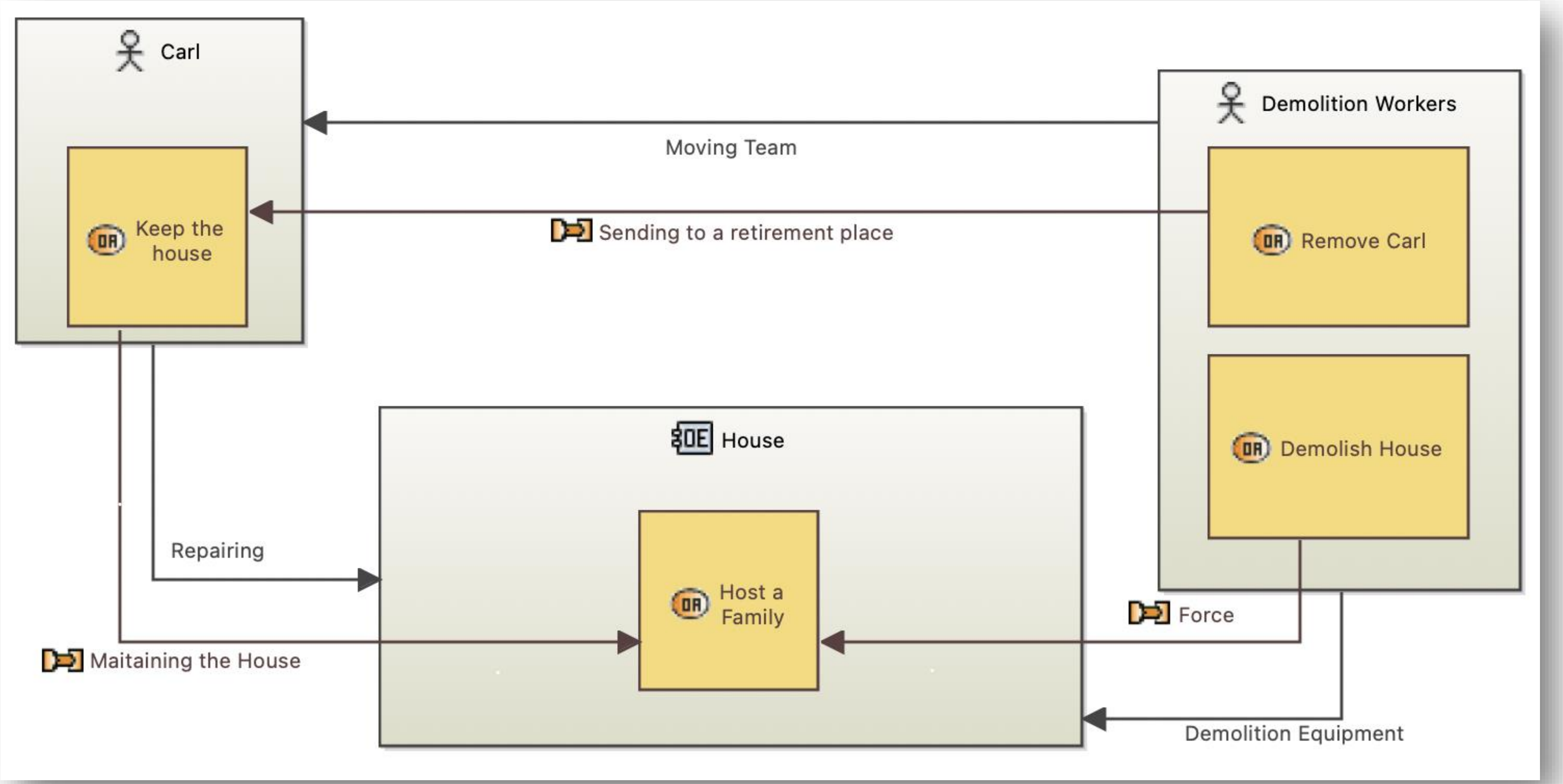


Final:



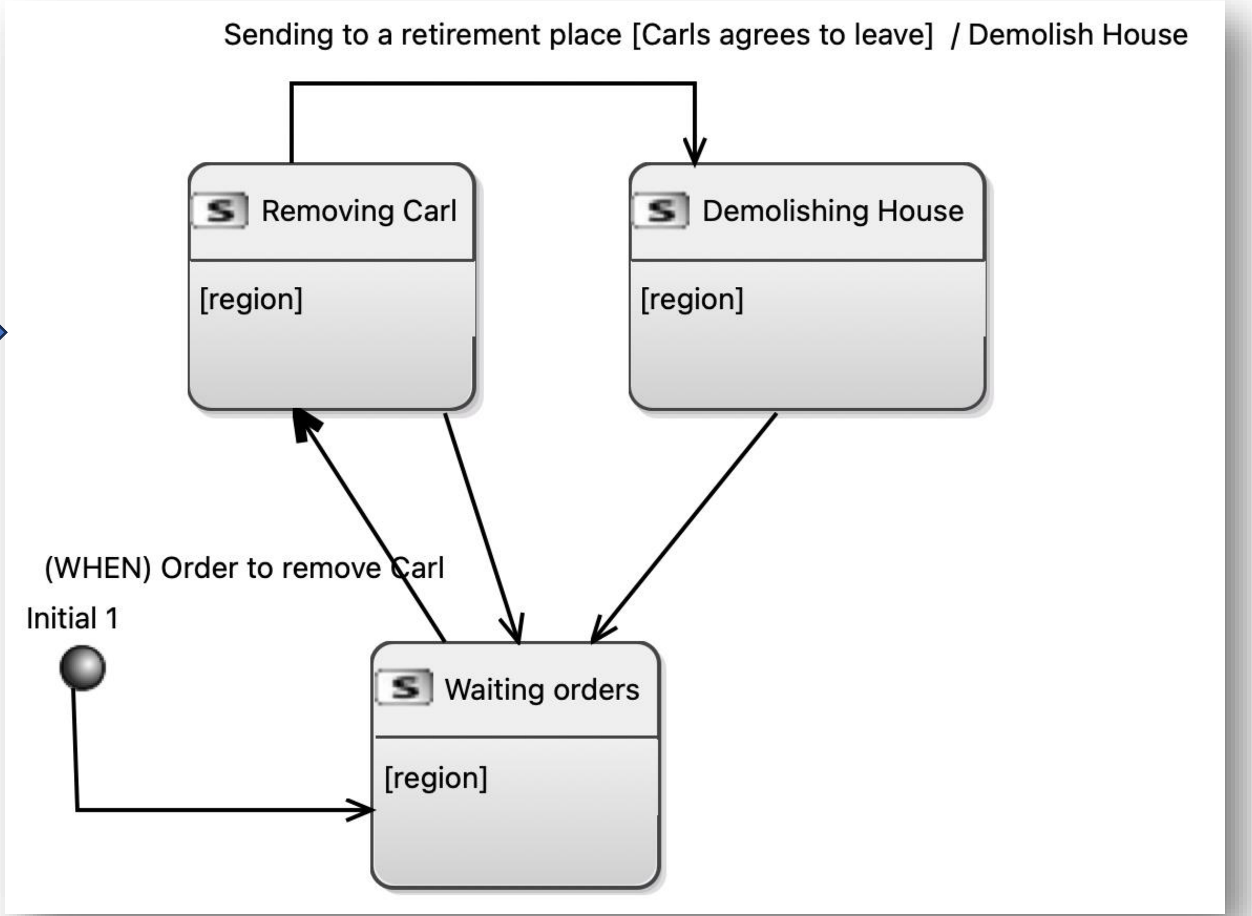
Capella>>Operational Analysis>>Operational Capabilities Diagrams

Each Stakeholder (Actor/Entity) do something (activity) and relates to each Other (interaction)



Capella>>Operational Analysis>>Operational Architecture Diagram

Describe the stakeholders' behaviors



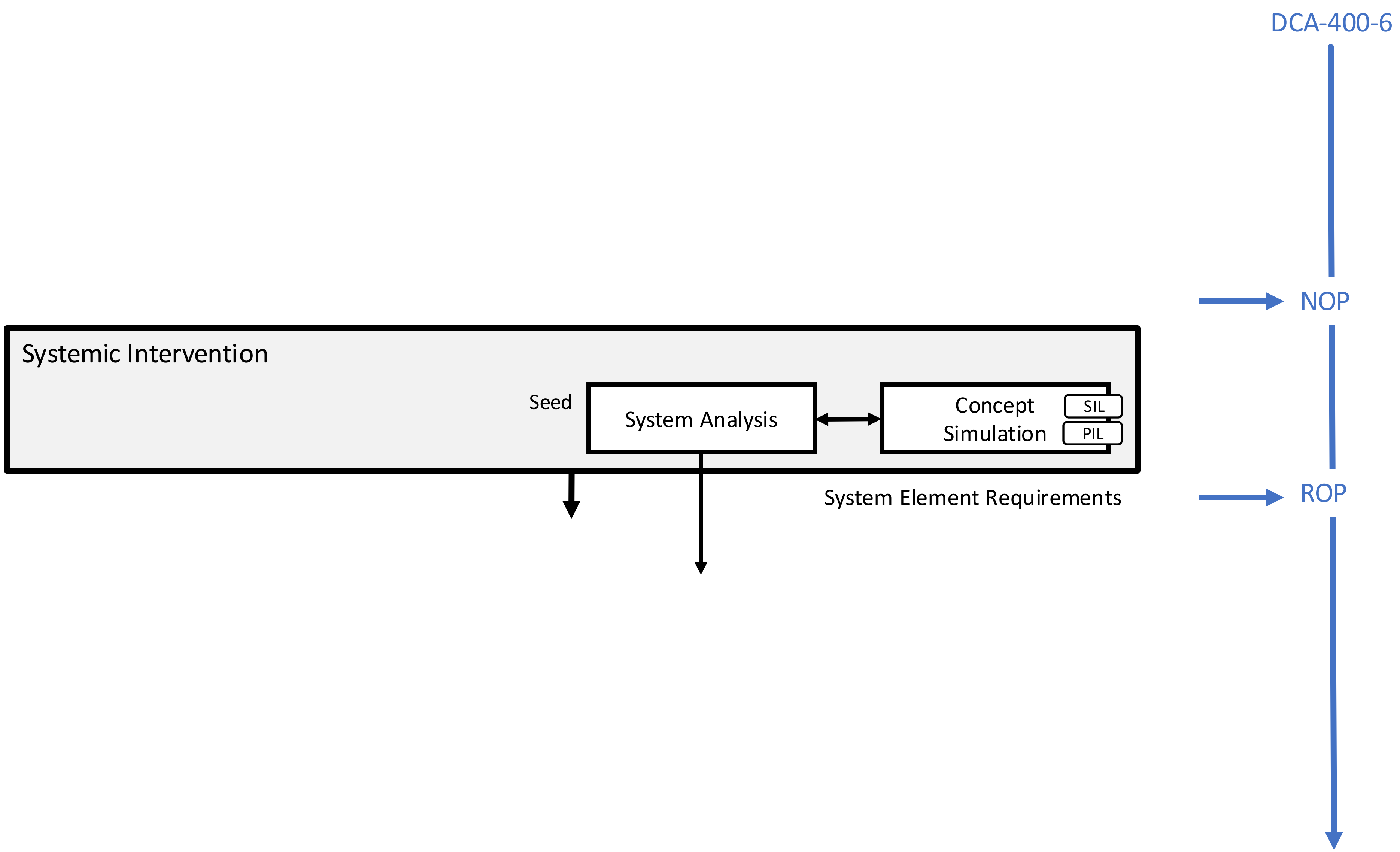
Capella>>Operational Analysis>>StateMachine Diagram

What do we need to finish with it?

- Needs mapped: What the users of the system need to accomplish
  - Mission Requirements
  - User Requirements
- Maybe not all the stakeholders opinion/needs are going to be “relevant”. It is a matter of analysis and priorization of the organization.
- One thing: this is the problem domain..... So your systems ***DOES NOT EXIST.***

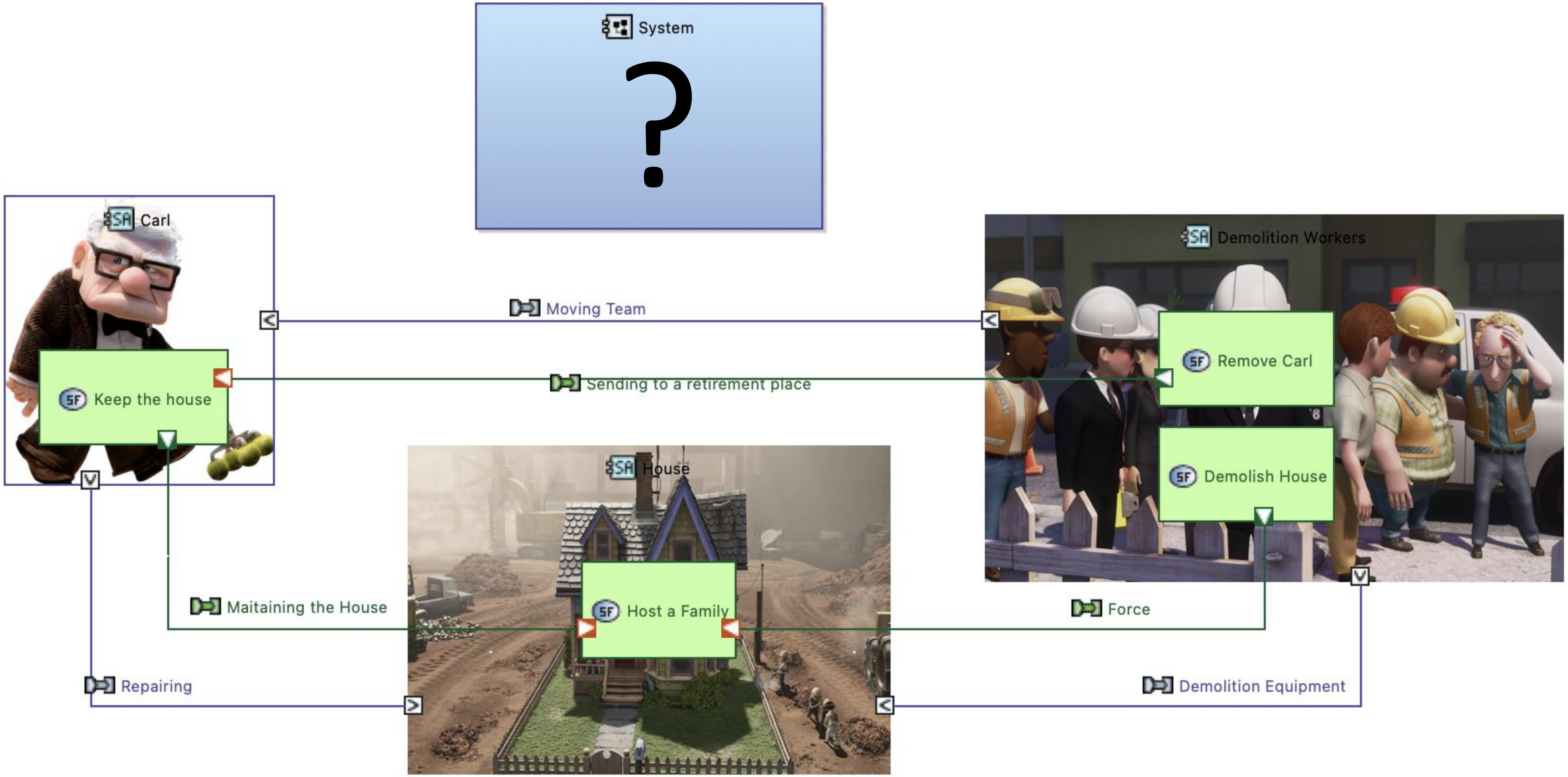
System intervention

What the system has to accomplish for the users


DCA-400-6
NOP
Systemic Intervention
Seed
System Analysis
Concept
Simulation
SIL
PIL
System Element Requirements
ROP

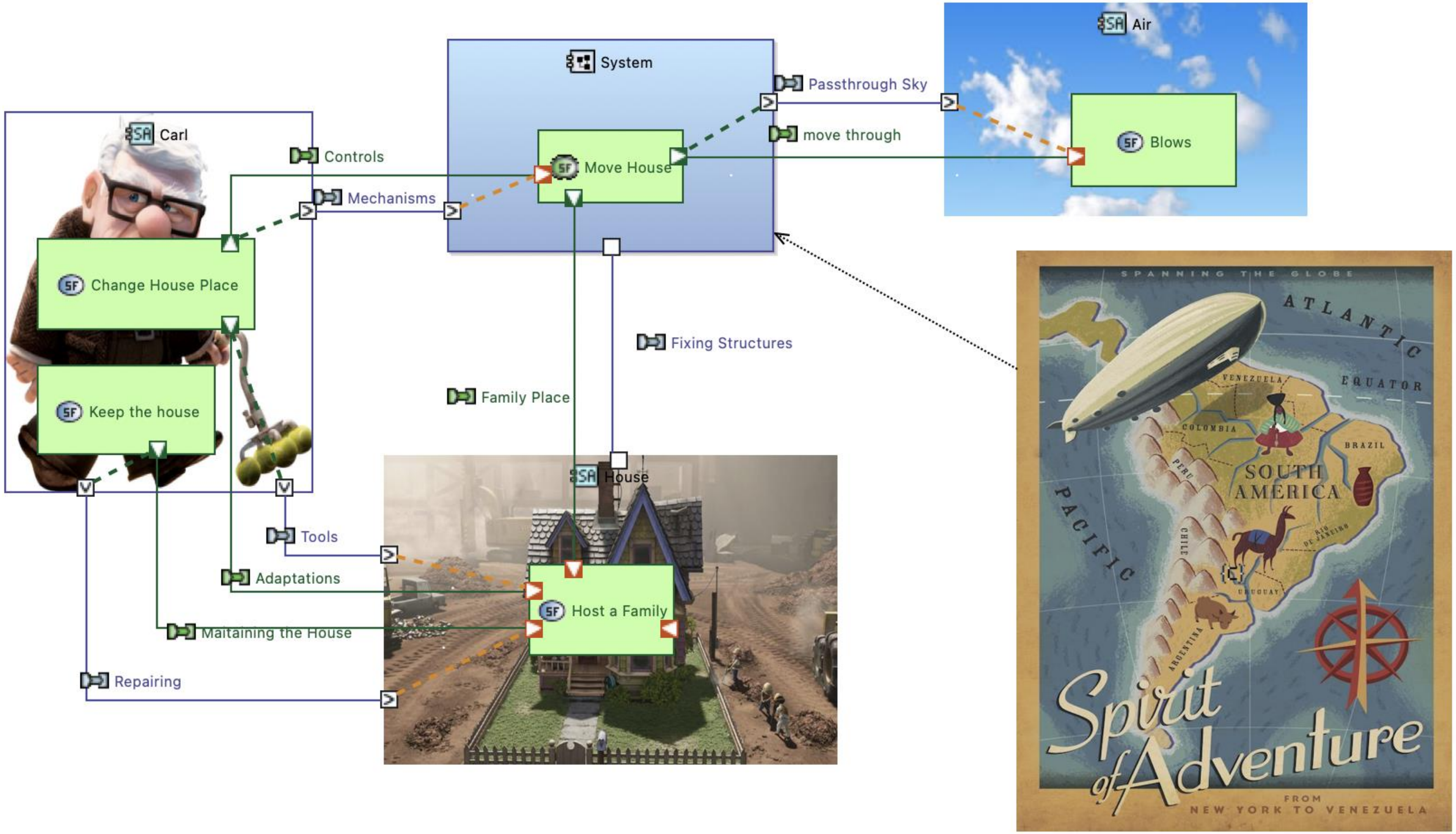

SPANNING THE GLOBE
ATLANTIC
EQUATOR
VENEZUELA
COLOMBIA
BRAZIL
PERU
SOUTH AMERICA
PACIFIC
CHILE
RIO DE JANEIRO
URUGUAY
ARGENTINA
Spirit of Adventure
FROM
NEW YORK TO VENEZUELA

Well.. What do the system must do?!



Capella>>System Analysis>>System Architecture Diagram

Well... Carl wants to move the house



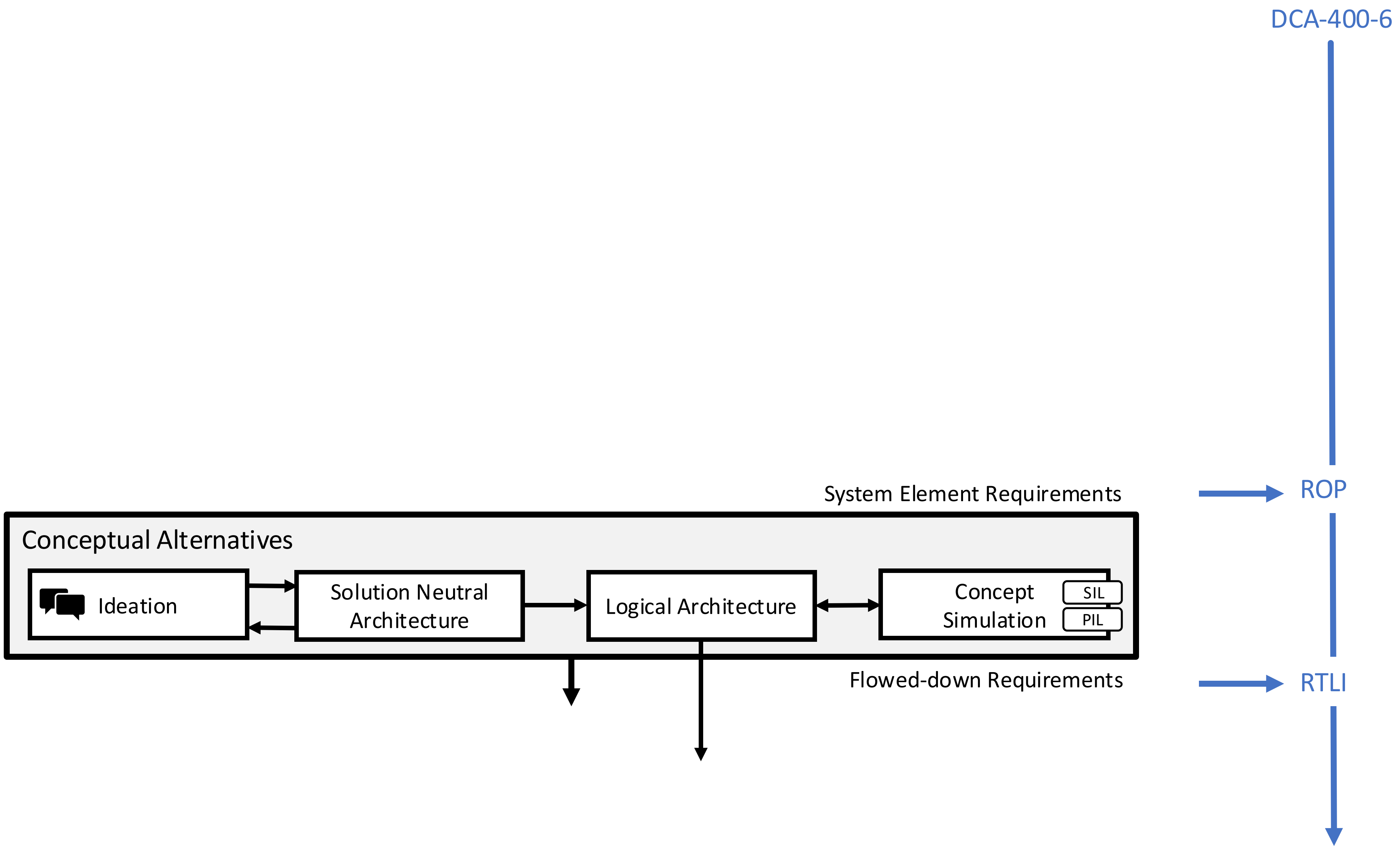
Capella>>System Analysis>>System Architecture Diagram

What do we need to finish with it?

- Requirements mapped: What the system has to accomplish for the users
  - System Requirements
- Remember that requirements are on the problem domain → does not carry solution on it.
  - The system must receive 24V /// and not /// The Li-Po Battery must provide 24V to the System.
- One thing: The System is a black box... We can not see inside only the frontier functions (interface/external functions) – such functions are what emerges!!! (emergent properties)

Conceptual Architecture

How the system will work to fulfill the expectations


DCA-400-6
System Element Requirements
ROP
Conceptual Alternatives
Ideation
Solution Neutral Architecture
Logical Architecture
Concept Simulation
SIL
PIL
Flowed-down Requirements
RTLI


ZEPPELIN


ZEPPELIN

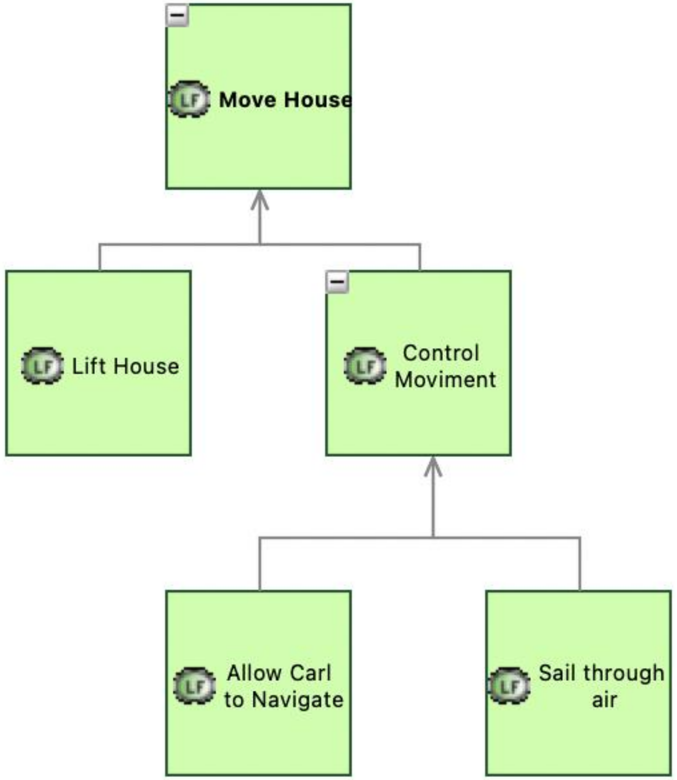
LED-ZEPPELIN

hummm

- Even though the joke with Led Zeppelin is a good one... And I could not avoid to make it... ☺

- It is more a balloon than a zeppelin.

Well.. The main function was: Move House

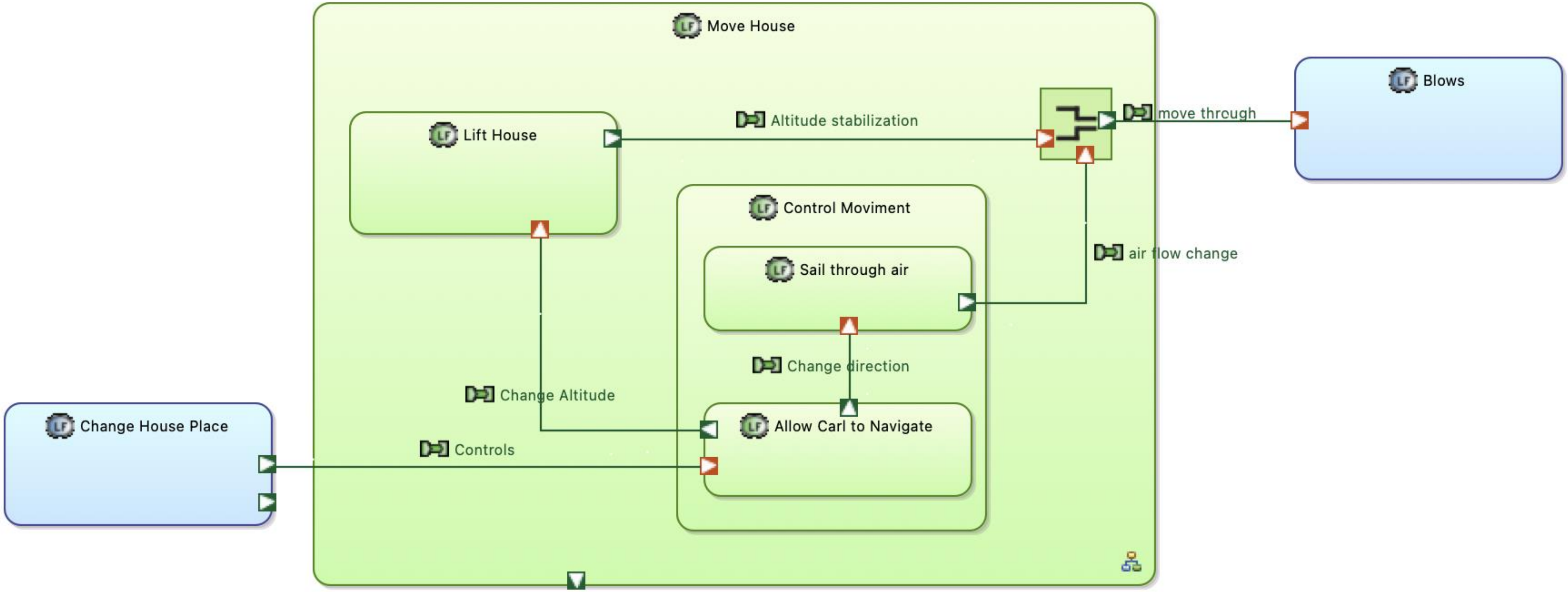


We can decompose the functions in subfunctions.

Only leaf functions must be used.

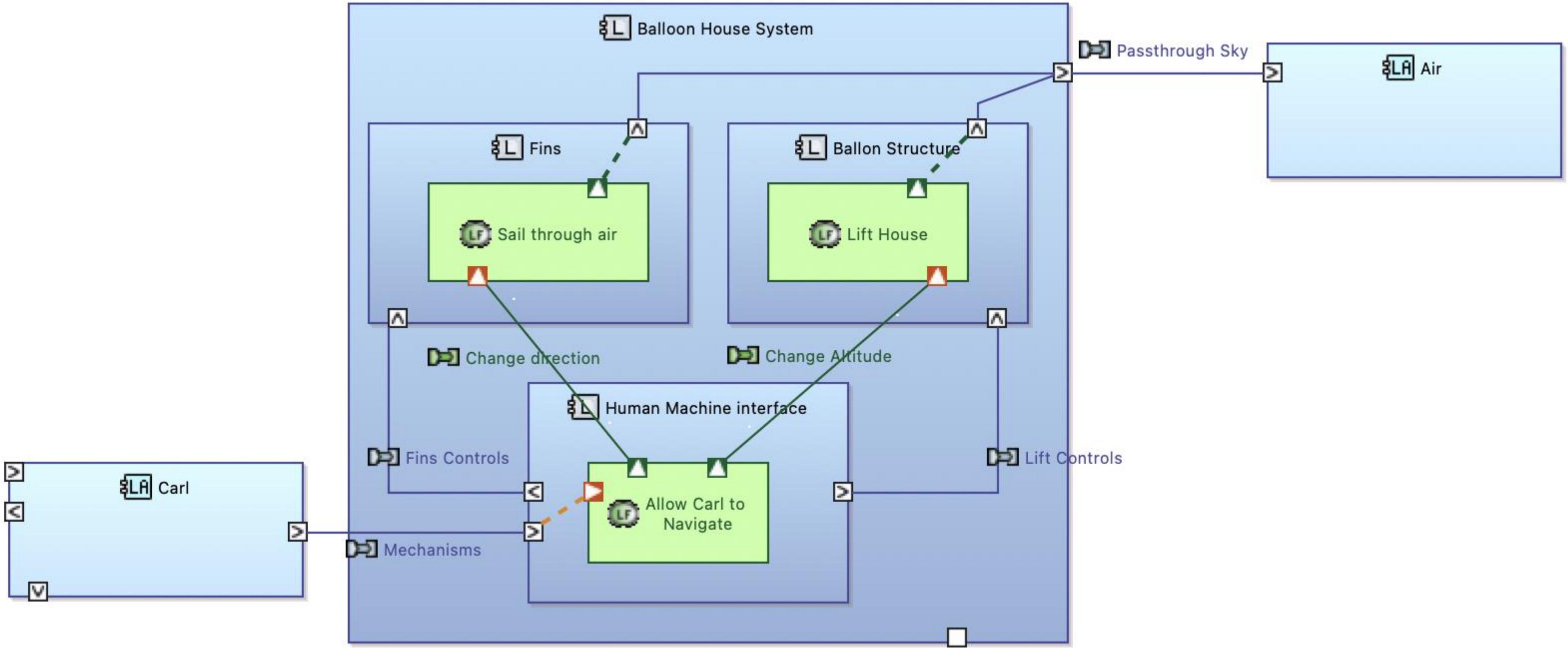
Capella>>Logical Architecture>>Logical Function Breakdown Diagram

The functions might have its own architecture: Functional Architecture



Capella>>Logical Architecture>>Logical Function Data Flow Diagram

We can conceptually split functions into a reference architecture of the aiming solution



Capella>>Logical Architecture>>Logical Architecture Diagram

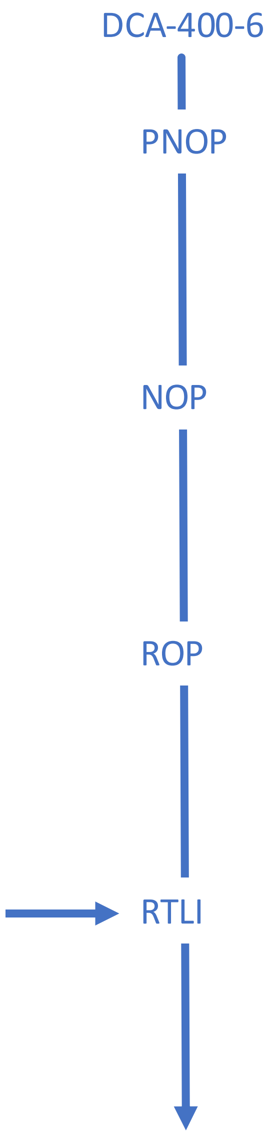
We could have decided a CONOPs to this solution concept

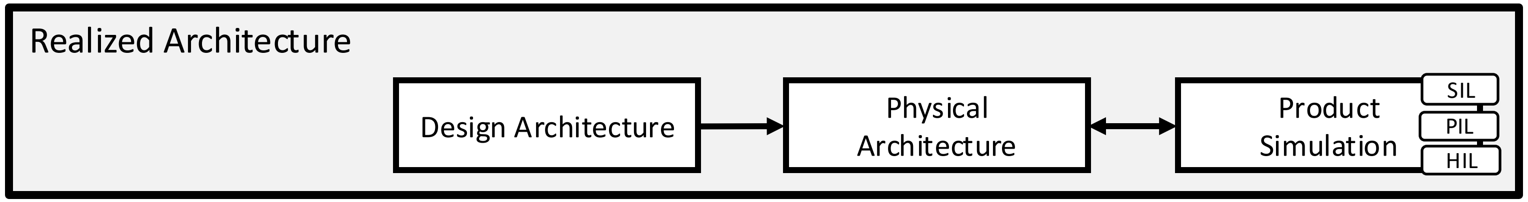
What do we need to finish with it?

- Requirements mapped: How the system will work to fulfill the expectations
  - Subsystem Requirements (or any decomposition part of it)
- We have a functional architecture spread through a desired architecture.
  - We can plan verifications, transitions, integrations, operations, and everything.
  - Here is the place to ask for functions that will have a technological solution on the next step.
- One thing: The System is now a white box... We can see inside and design the desired (at least requested) architecture.

Concrete Architecture

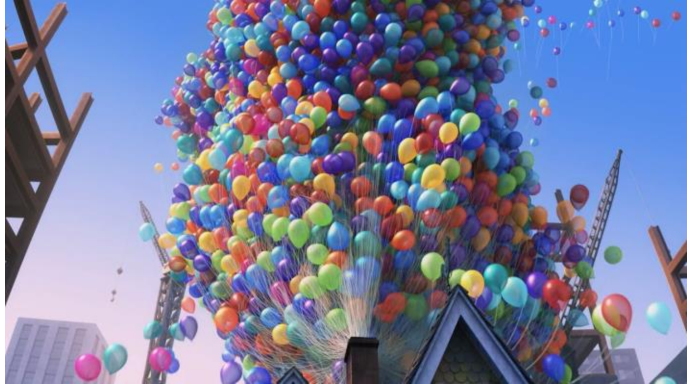
How the system will be built


DCA-400-6
PNOP
NOP
ROP
RTLI


Realized Architecture
Design Architecture
Physical Architecture
Product Simulation
SIL
PIL
HIL

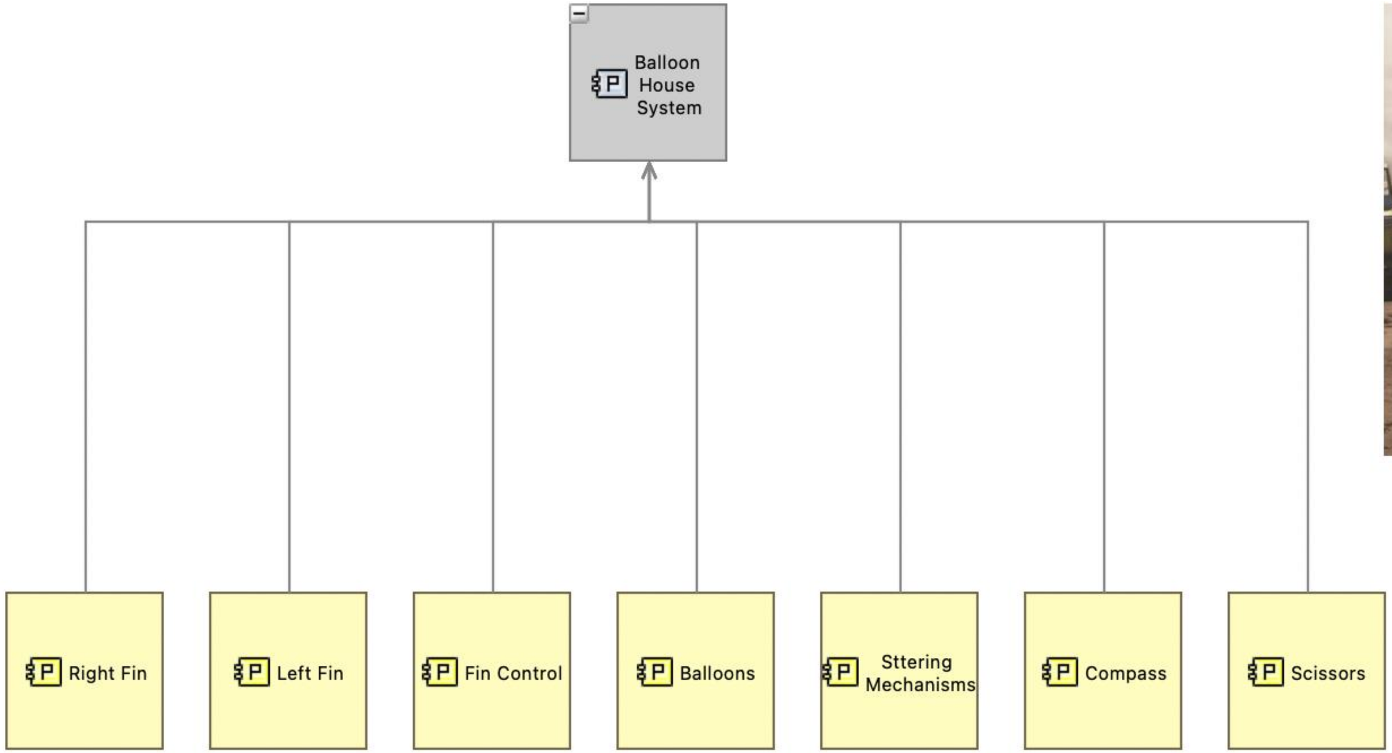
So ok... Final step is specify what is going to be built

- He had the “things” that were feasible, pre-existing in the house and easily acquirable.
  - To lift: balloons
  - To steer: some house tools
  - To sail: towels, blankets
  - To navigate: compass
  - To adjust altitude: cut the balloon strings

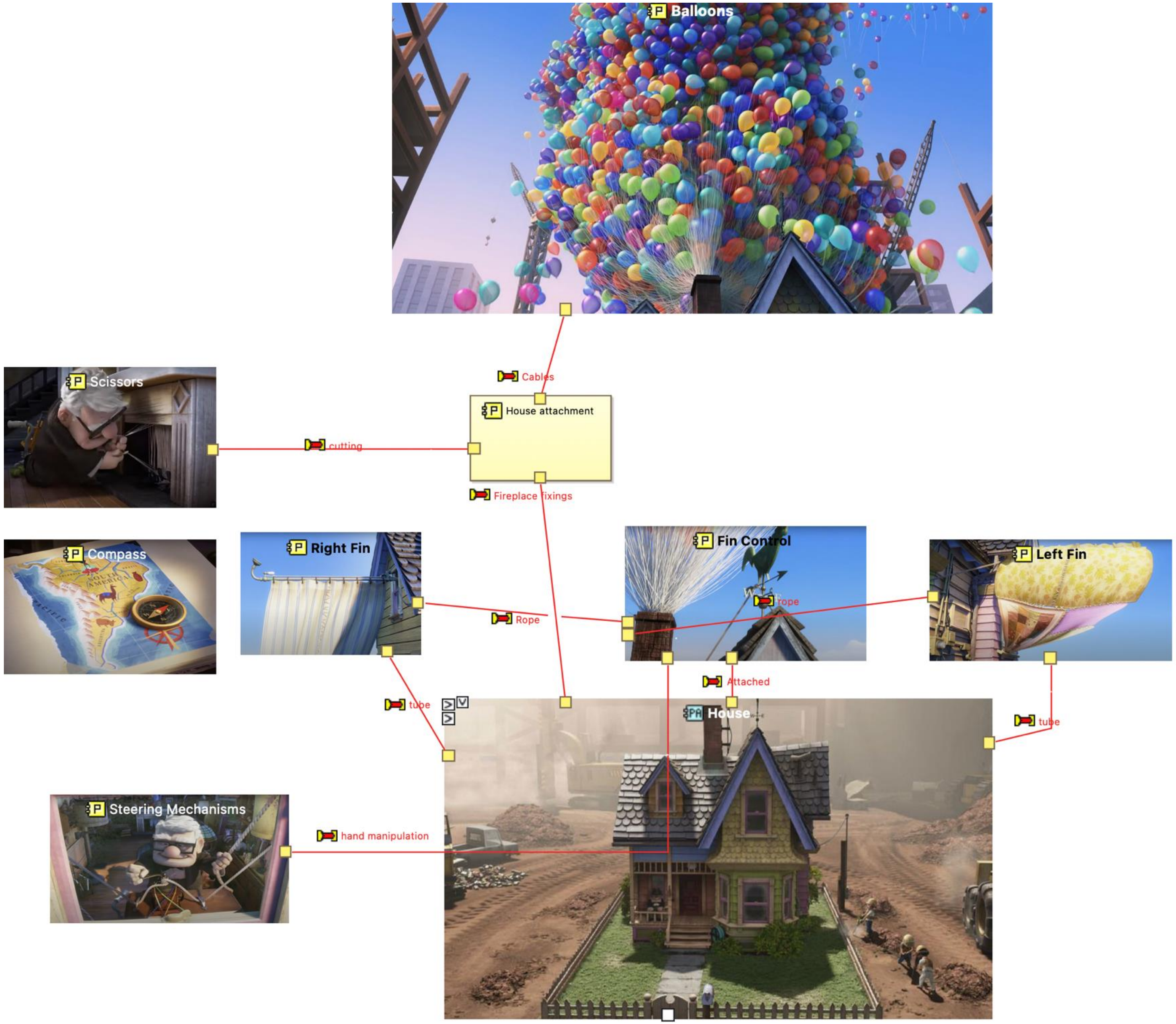



SOUTH AMERICA
PACIFIC

Point out the technological choices to built the Balloon House System



Capella>>Physical Architecture>>Physical Component Breakdown Diagram



To be built model

Capella>>Physical Architecture>>Physical Architecture Diagram

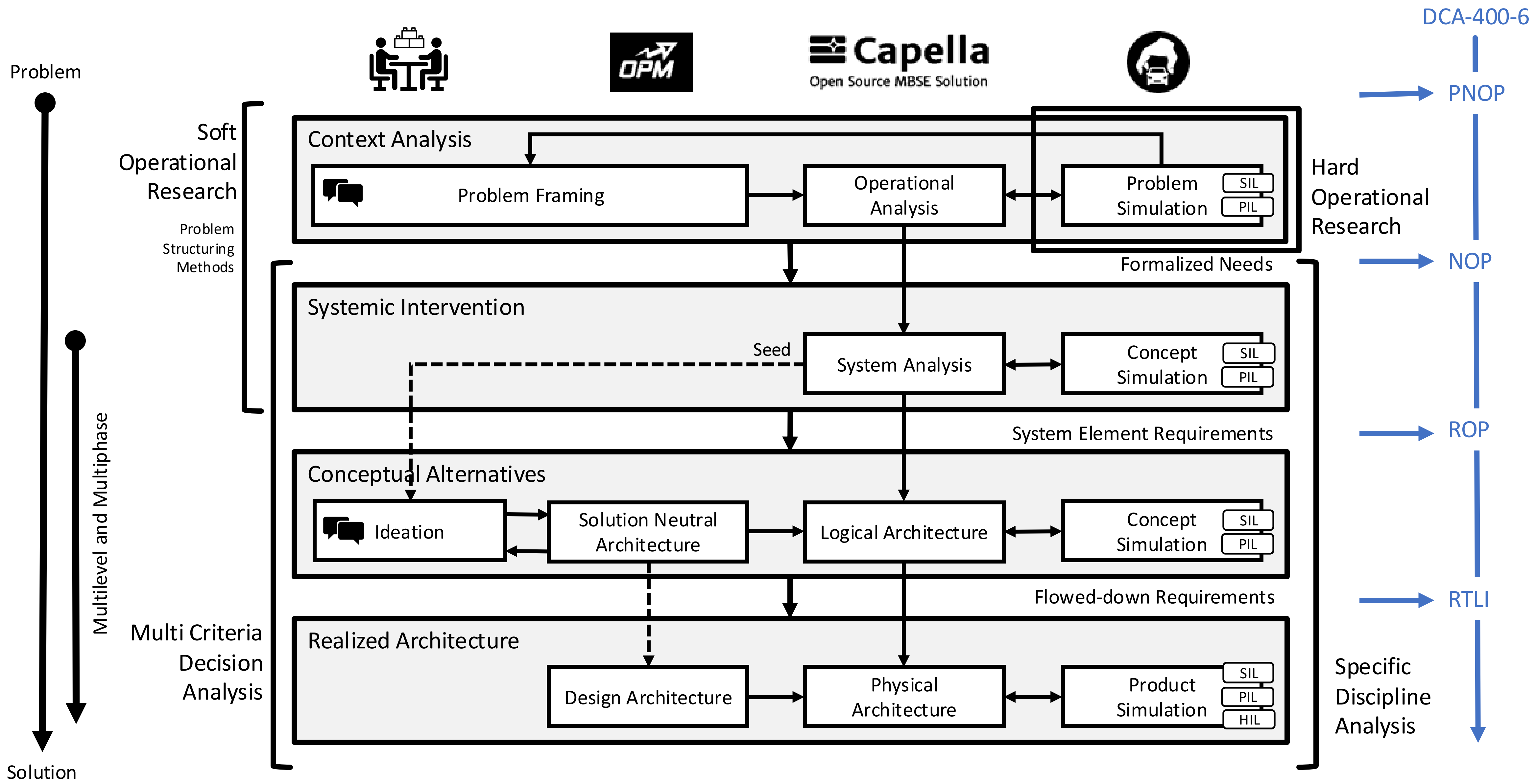
What do we need to finish with it?

- Specifications to the development/acquisition/building process
  - Would go to every details necessary to build the system.
- We have a concrete architecture (do not be confused by the word physical – does not need to be “physical”… can be a process, software, information, so on)
- Usually in the Phase 0 / Pre-A of the Space System Lifecycle it is designed a feasibility architecture with co-engineering (in Concurrent Engineering Labs). This Architecture would be born in this phase and iterated/adapted through the next life cycle phases.

System Delivered:

FireSAT Example

MMMF



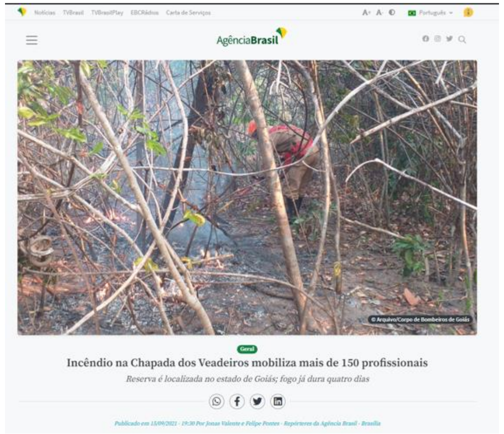
Problem
Solution
Multilevel and Multiphase
Soft Operational Research
Problem Structuring Methods
Multi Criteria Decision Analysis
Capella
Open Source MBSE Solution
OPM
Context Analysis
Problem Framing
Operational Analysis
Problem Simulation
SIL
PIL
Formalized Needs
Systemic Intervention
Seed
System Analysis
Concept Simulation
SIL
PIL
System Element Requirements
Conceptual Alternatives
Ideation
Solution Neutral Architecture
Logical Architecture
Concept Simulation
SIL
PIL
Flowed-down Requirements
Realized Architecture
Design Architecture
Physical Architecture
Product Simulation
SIL
PIL
HIL
Hard Operational Research
Specific Discipline Analysis
DCA-400-6
PNOP
NOP
ROP
RTLI

Context Analysis

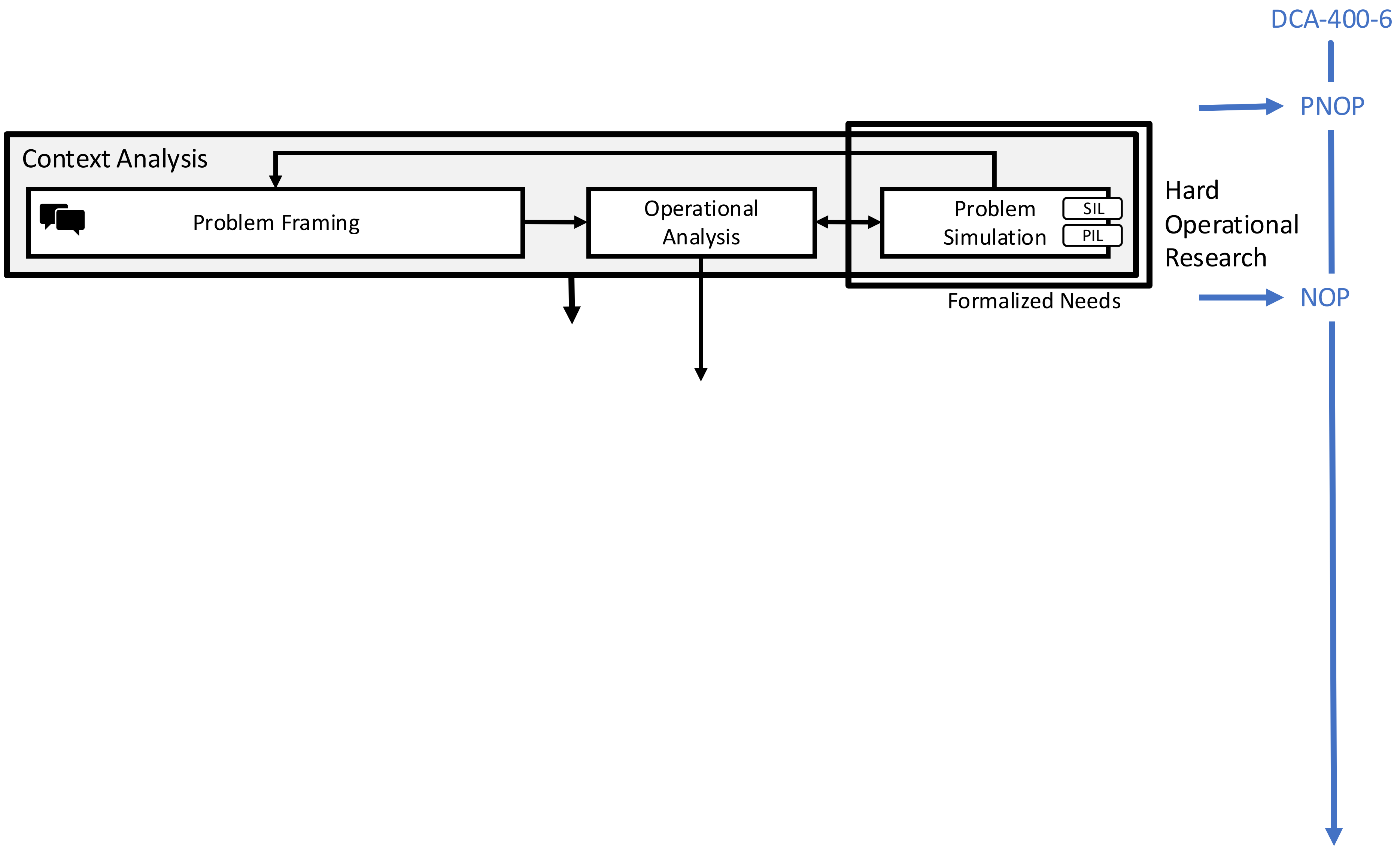
Research before engineer

- Initial understanding: free explorations of the problem.
- Learning the domain to improve knowledge

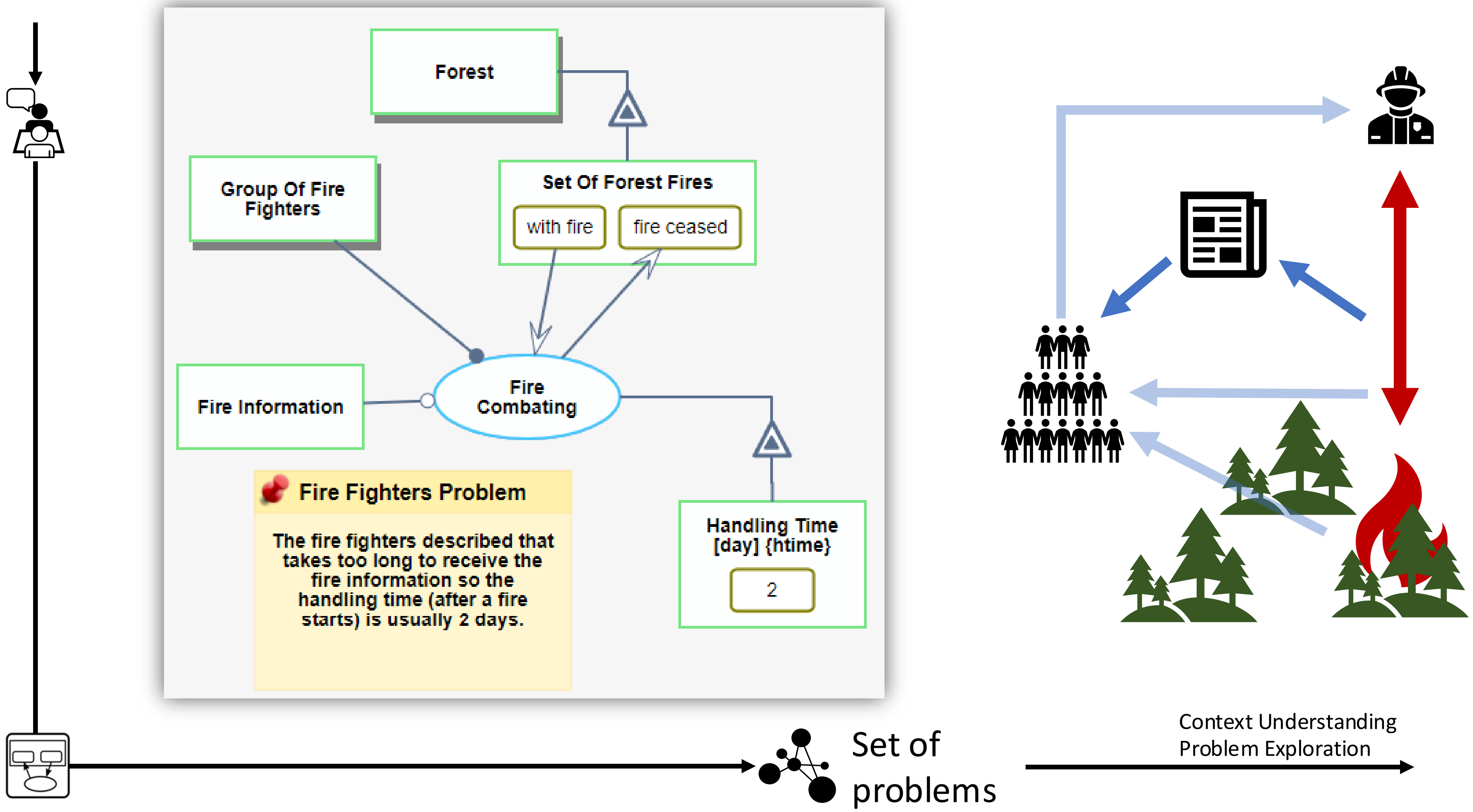
Find stakeholders!



Framework Activities



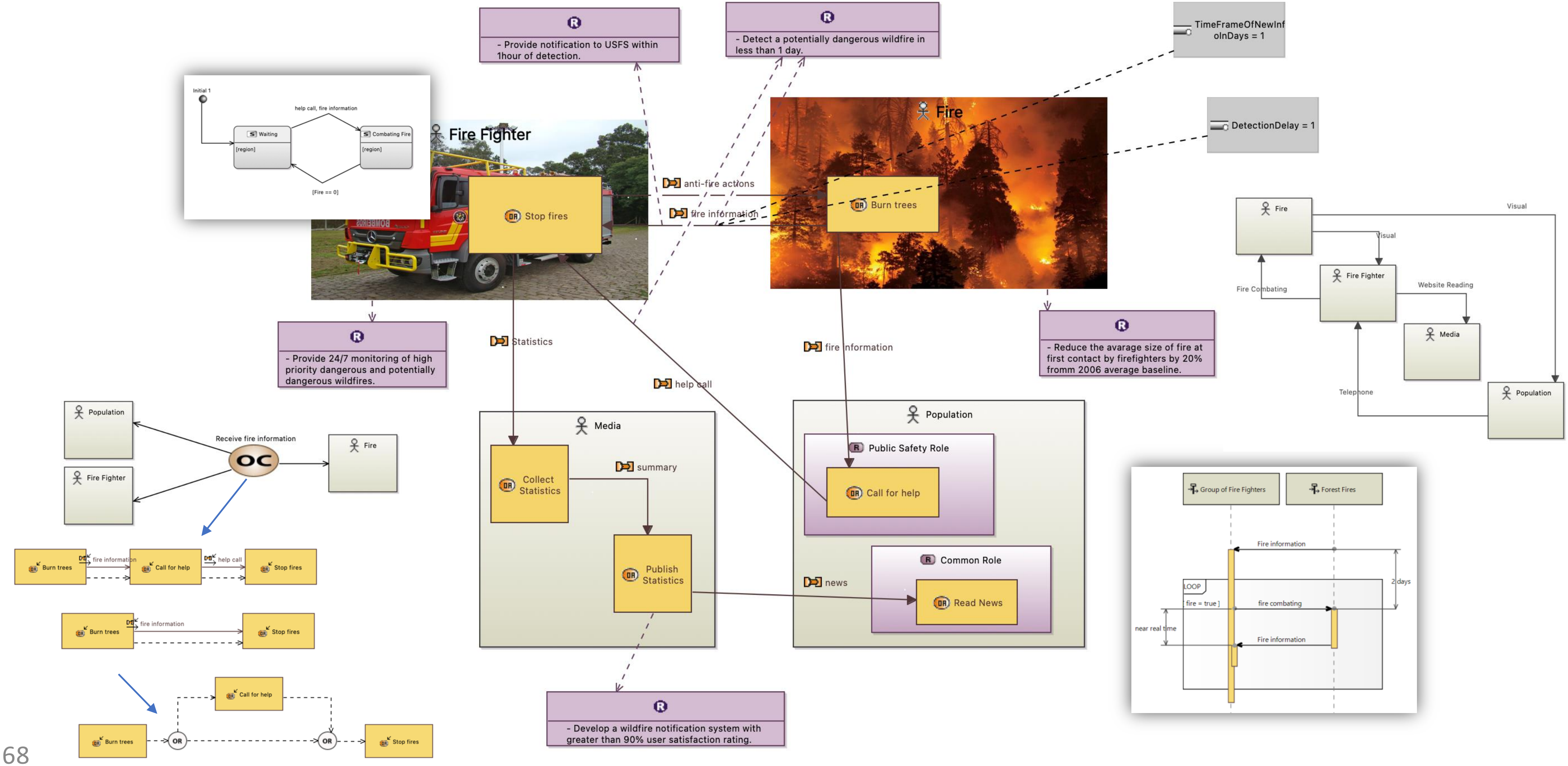
Structuring the problem (infinite ways of doing)



Identification of stakeholders

- Raising who they are
- What they want
- What changes are desired in the current situation
- Capture Success Metrics (MoEs)
- Lift

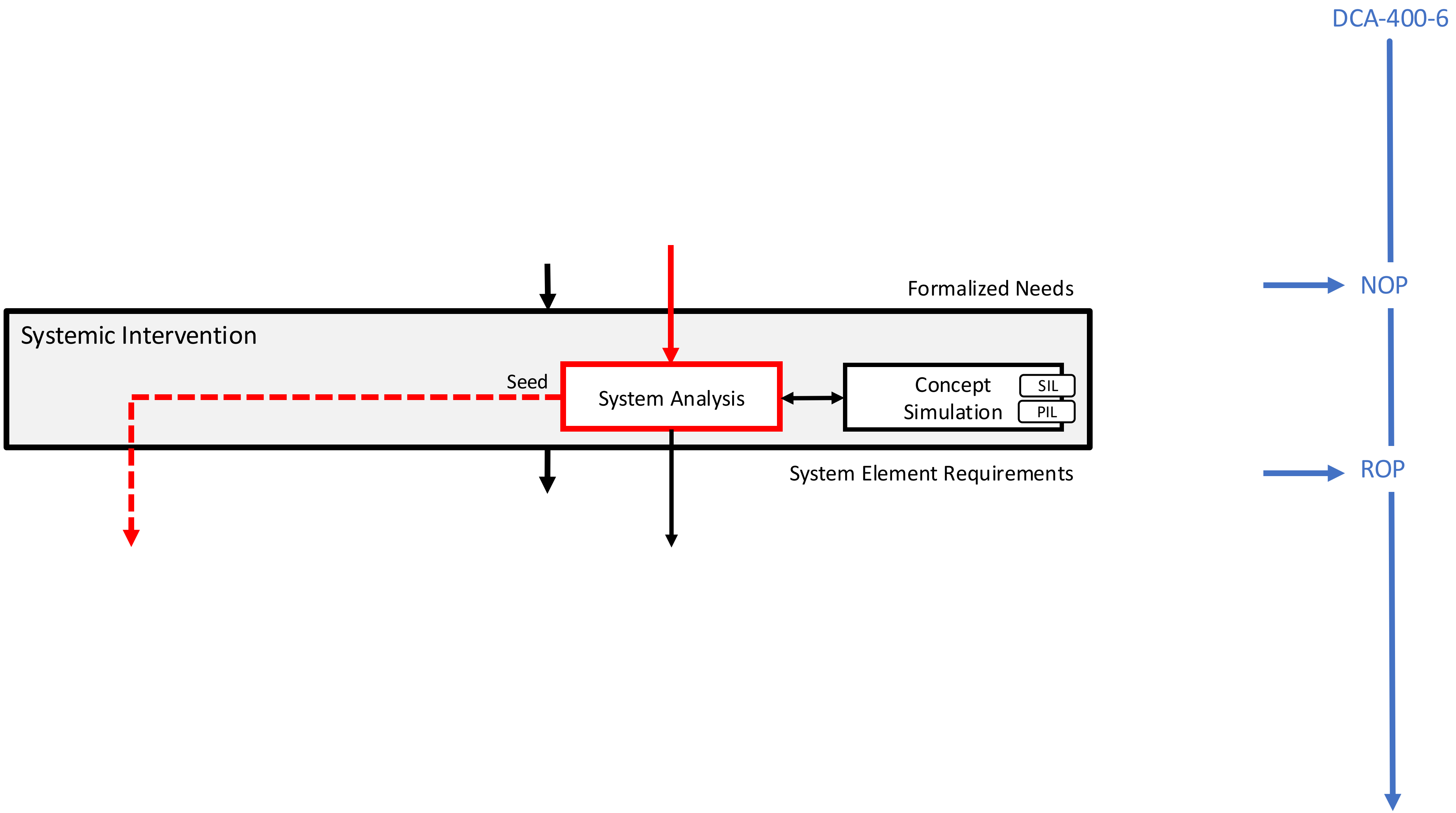
Operational analysis



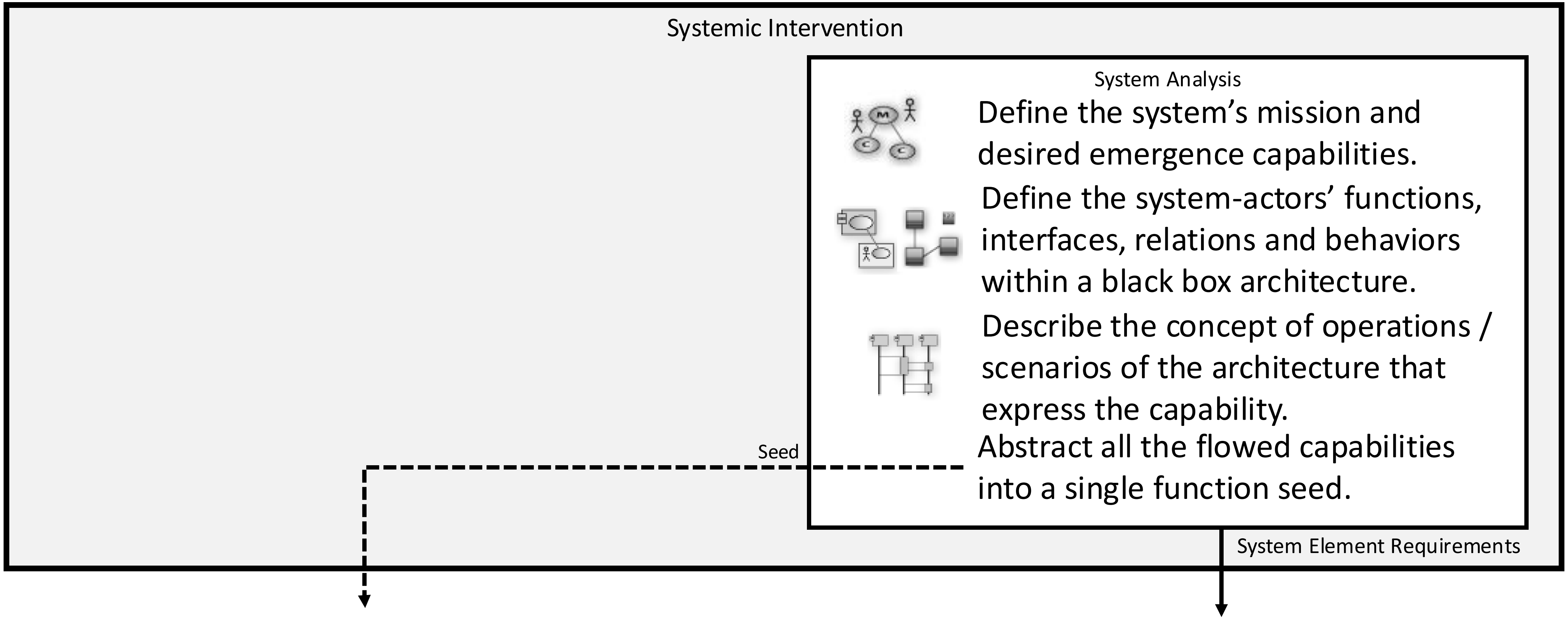
FAB: Publicação do NOP

- Descrever os stakeholders (OMs)
- Descrever o conjunto de documentos originadores
- Estruturar as propostas de necessidades
- Descreve a situação atual com a mudança que precisa existir.
- Rastrear o desejo de mudança com a arquitetura da situação atual
- Justificar conjunto de necessidades.
  - Isento de solução

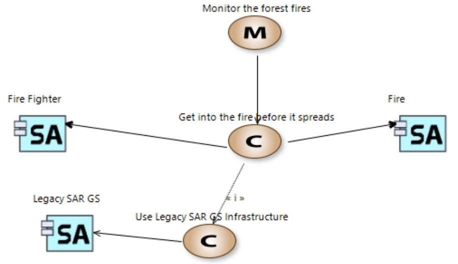
Systemic intervention

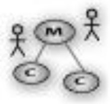

DCA-400-6
Formalized Needs
NOP
Systemic Intervention
Seed
System Analysis
Concept
Simulation
SIL
PIL
System Element Requirements
ROP

Systemic intervention

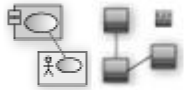


Systemic Intervention Analysis

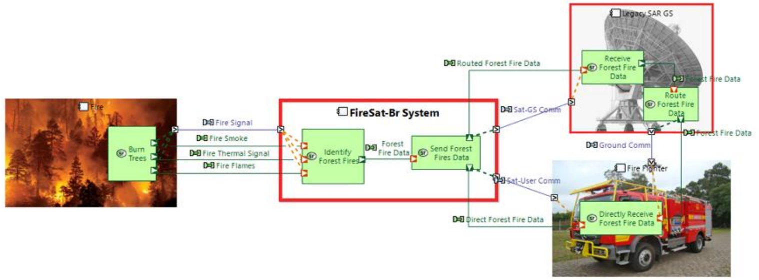


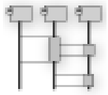


Define the system's mission and desired emergence capabilities.



Define the system-actors' functions, interfaces, relations and behaviors within a black box architecture.



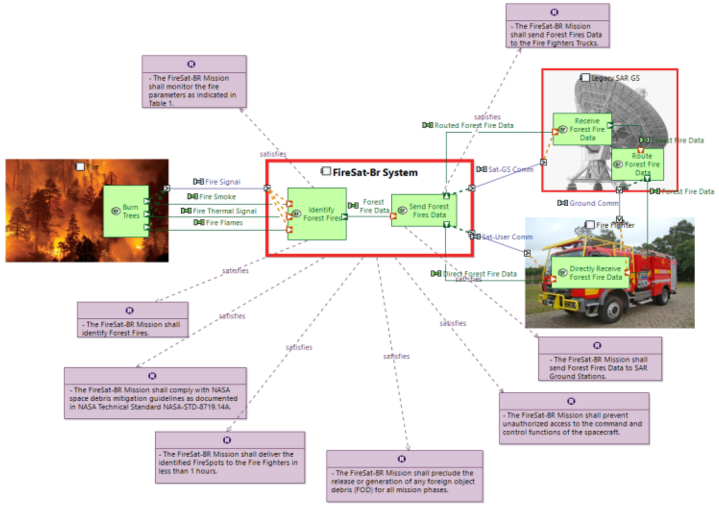


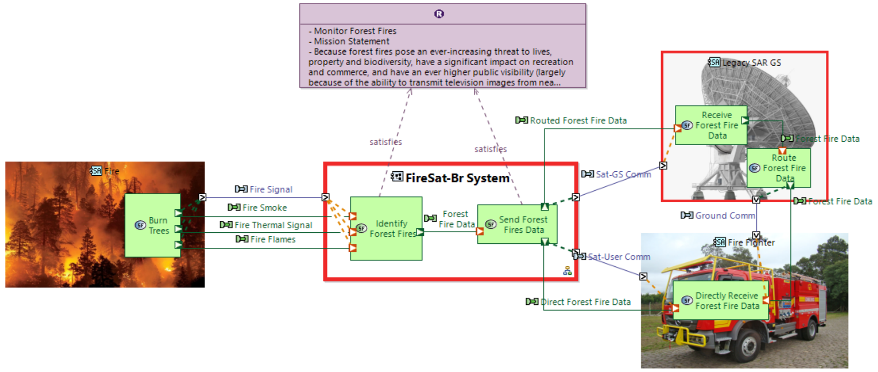
Describe the concept of operations / scenarios of the architecture that express the capability.

Seed

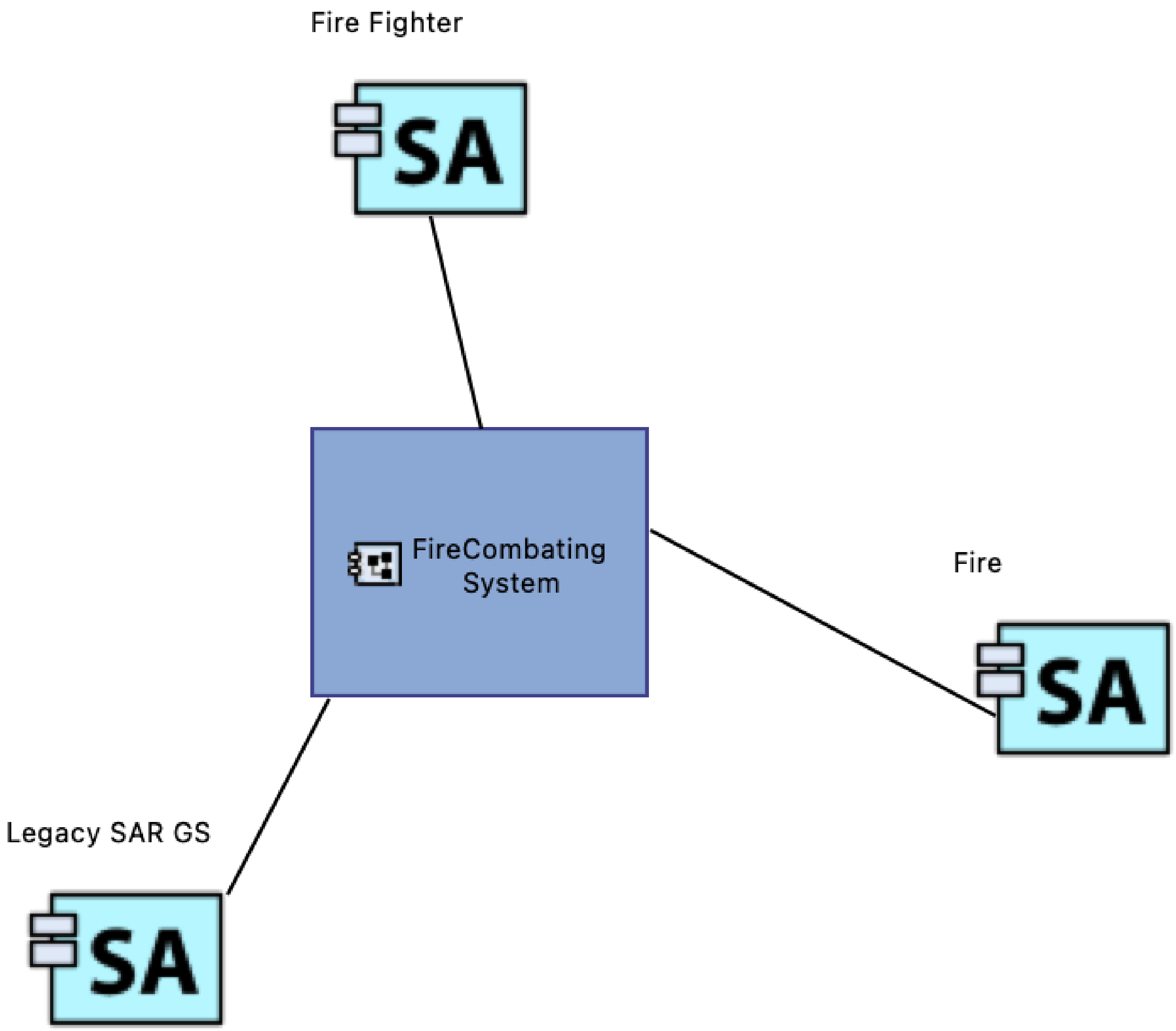
Abstract all the flowed capabilities into a single function seed.

System Element Requirements





Context



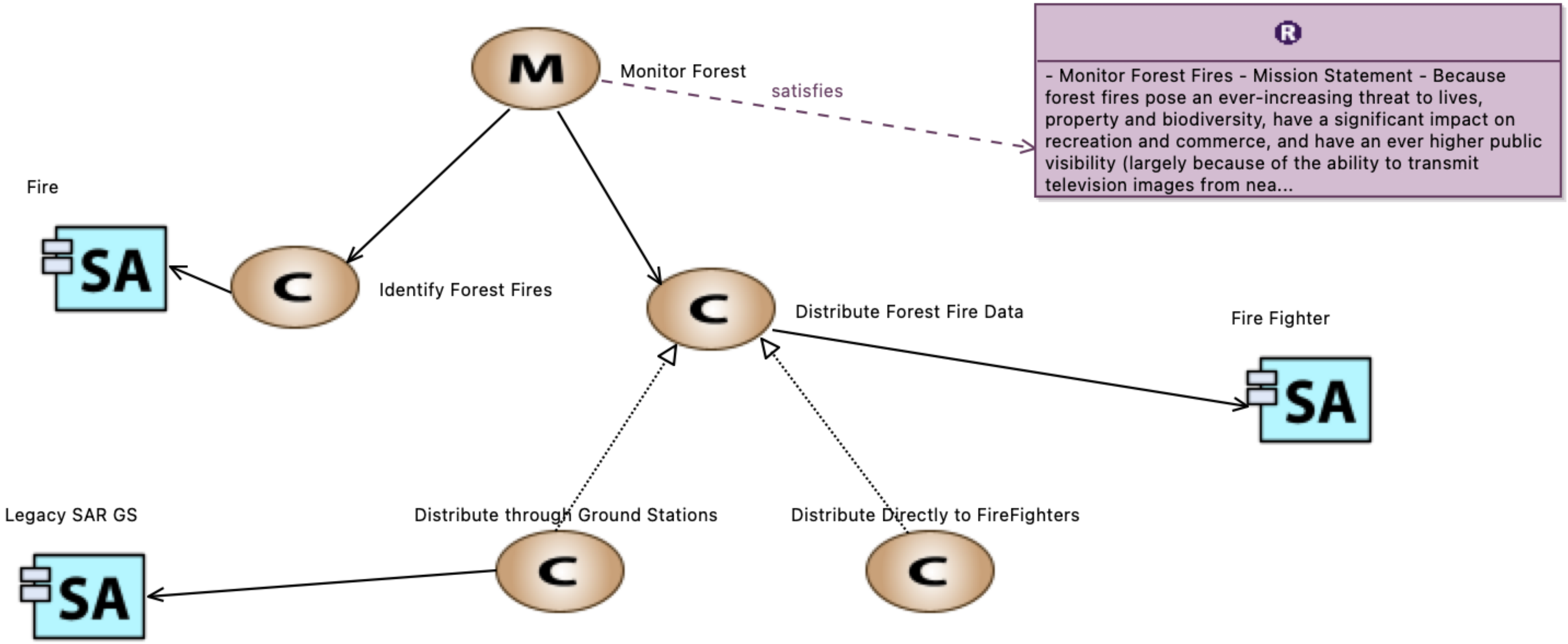
Fire Fighter
SA
FireCombating System
Fire
SA
Legacy SAR GS
SA

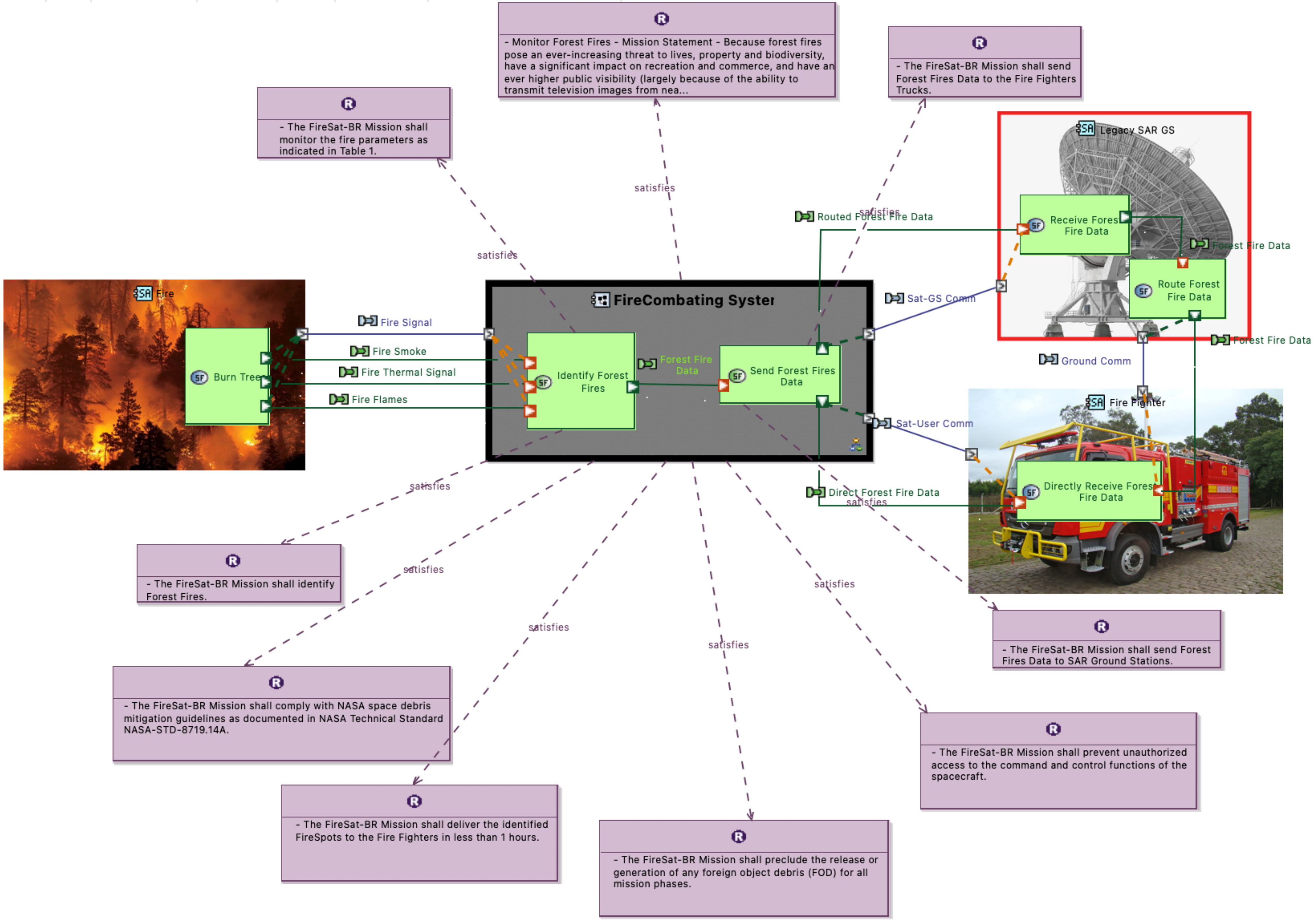
MISSION STATEMENT

Because forest fires pose an ever-increasing threat to lives, property and biodiversity, have a significant impact on recreation and commerce, and have an ever higher public visibility (largely because of the ability to transmit television images from nearly anywhere in real time), the USFS needs a more effective system to identify and monitor them. In addition, it would be desired (but not required) to monitor forest fires for other nations; collect statistical data on fire outbreaks, spread, speed and duration, and provide other forest management data. This must be done at low cost to make the system affordable to the Forest Service and not give the perception of wasting money that could be better spent on fire-fighting equipment or personnel.

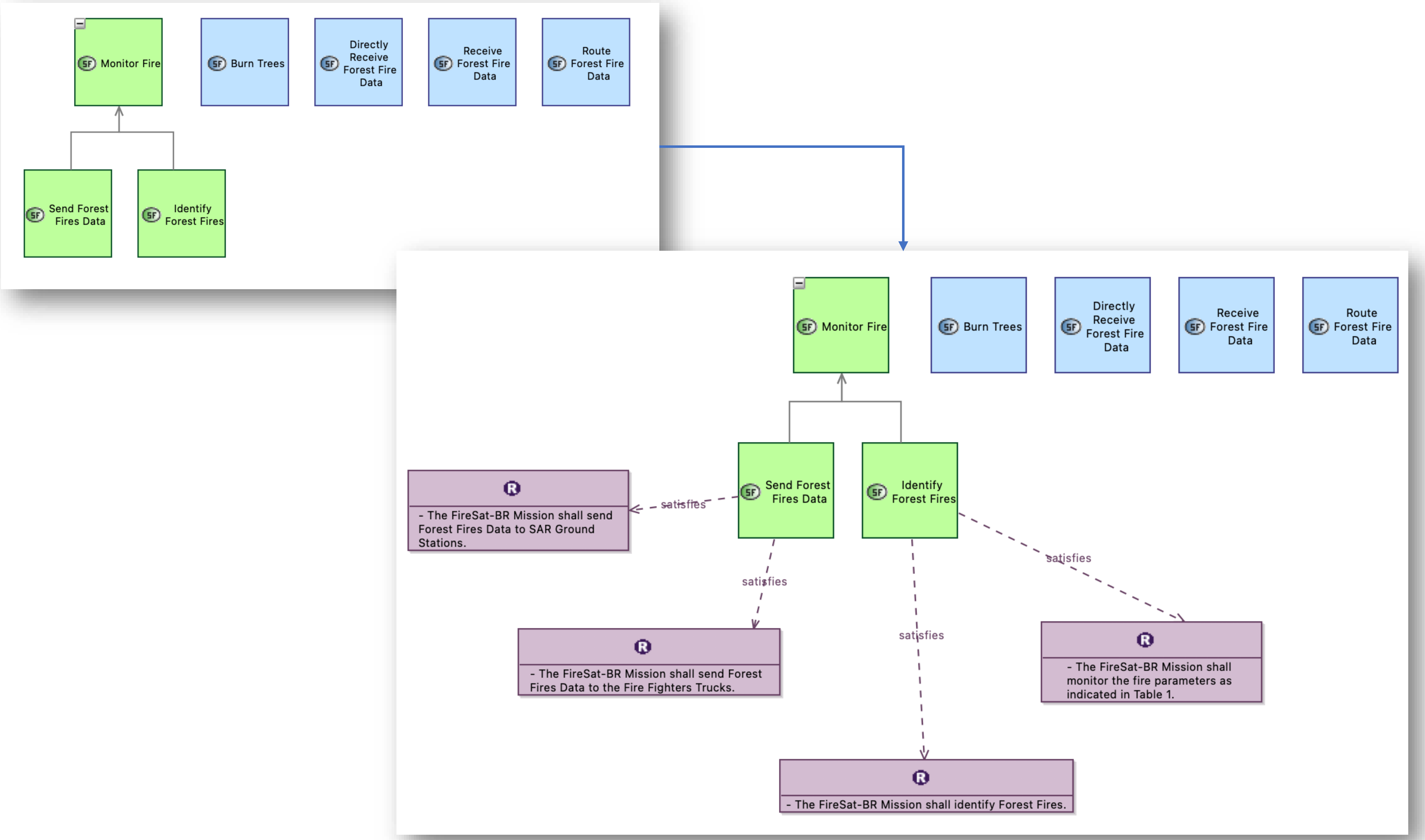
Ultimately, the Forest Service's fire monitoring office, fire management officers in the field, and individual firefighters and rangers fighting the fire will use the data. Data flow and formats must meet the needs of all the groups without specialized training and must allow them to respond promptly and efficiently to changing conditions.

(adapted from "Space Mission Engineering: the new SMAD, 2011")

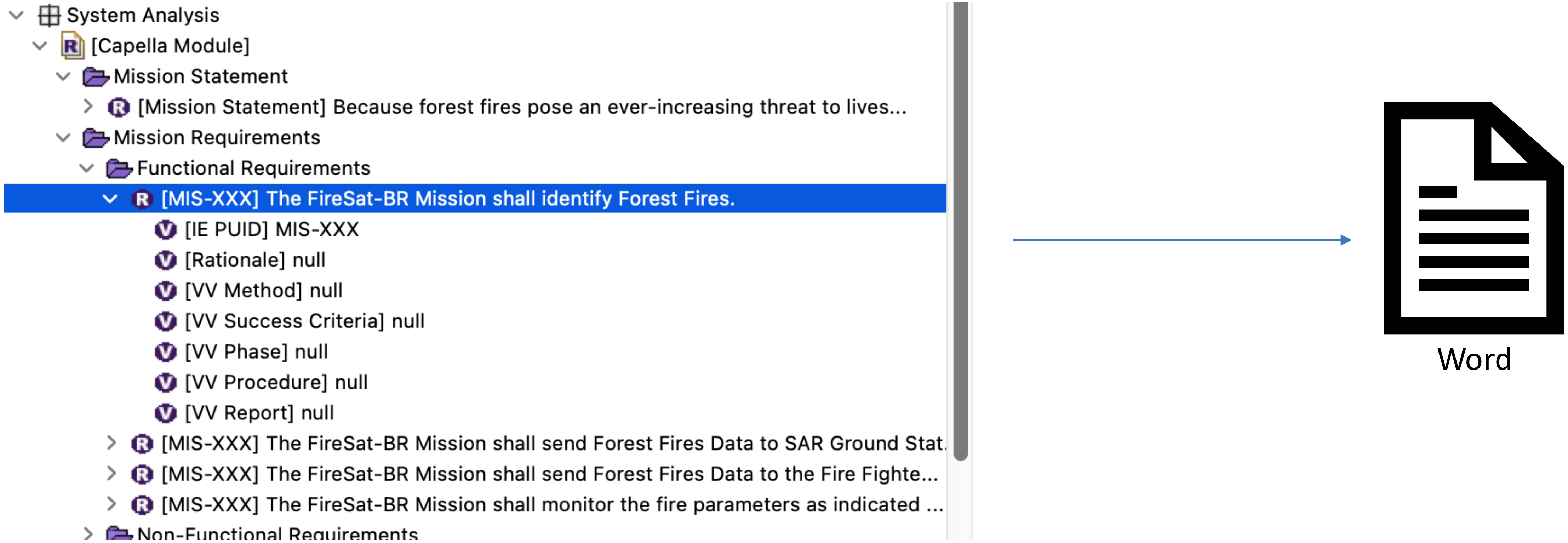

M
Monitor Forest
satisfies
R
- Monitor Forest Fires - Mission Statement - Because forest fires pose an ever-increasing threat to lives, property and biodiversity, have a significant impact on recreation and commerce, and have an ever higher public visibility (largely because of the ability to transmit television images from nea...
Fire
SA
C
Identify Forest Fires
C
Distribute Forest Fire Data
Fire Fighter
SA
Legacy SAR GS
SA
Distribute through Ground Stations
C
Distribute Directly to FireFighters
C



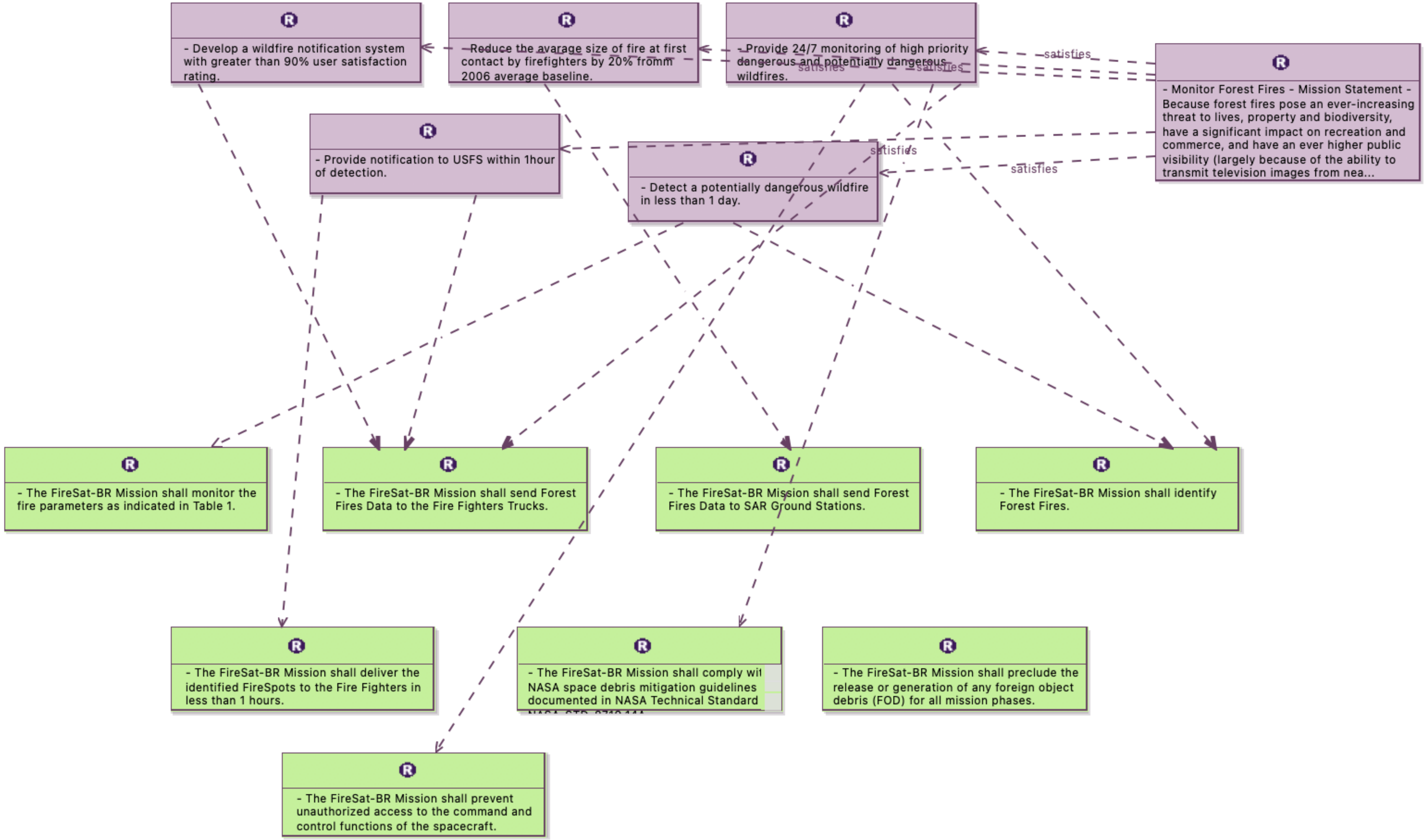
- Monitor Forest Fires - Mission Statement - Because forest fires pose an ever-increasing threat to lives, property and biodiversity, have a significant impact on recreation and commerce, and have an ever higher public visibility (largely because of the ability to transmit television images from nea...
- The FireSat-BR Mission shall send Forest Fires Data to the Fire Fighters Trucks.
- The FireSat-BR Mission shall monitor the fire parameters as indicated in Table 1.
satisfies
Legacy SAR GS
Receive Forest Fire Data
Route Forest Fire Data
Routed Forest Fire Data
Forest Fire Data
Fire
Burn Tree
Fire Signal
Fire Smoke
Fire Thermal Signal
Fire Flames
FireCombating System
Identify Forest Fires
Forest Fire Data
Send Forest Fires Data
Sat-GS Comm
Ground Comm
Sat-User Comm
Fire Fighter
Directly Receive Forest Fire Data
Direct Forest Fire Data
- The FireSat-BR Mission shall identify Forest Fires.
- The FireSat-BR Mission shall send Forest Fires Data to SAR Ground Stations.
- The FireSat-BR Mission shall comply with NASA space debris mitigation guidelines as documented in NASA Technical Standard NASA-STD-8719.14A.
- The FireSat-BR Mission shall prevent unauthorized access to the command and control functions of the spacecraft.
- The FireSat-BR Mission shall deliver the identified FireSpots to the Fire Fighters in less than 1 hours.
- The FireSat-BR Mission shall preclude the release or generation of any foreign object debris (FOD) for all mission phases.


Monitor Fire
Burn Trees
Directly Receive Forest Fire Data
Receive Forest Fire Data
Route Forest Fire Data
Send Forest Fires Data
Identify Forest Fires
Monitor Fire
Burn Trees
Directly Receive Forest Fire Data
Receive Forest Fire Data
Route Forest Fire Data
Send Forest Fires Data
Identify Forest Fires
satisfies
- The FireSat-BR Mission shall send Forest Fires Data to SAR Ground Stations.
satisfies
- The FireSat-BR Mission shall send Forest Fires Data to the Fire Fighters Trucks.
satisfies
- The FireSat-BR Mission shall identify Forest Fires.
satisfies
- The FireSat-BR Mission shall monitor the fire parameters as indicated in Table 1.

Requirements...



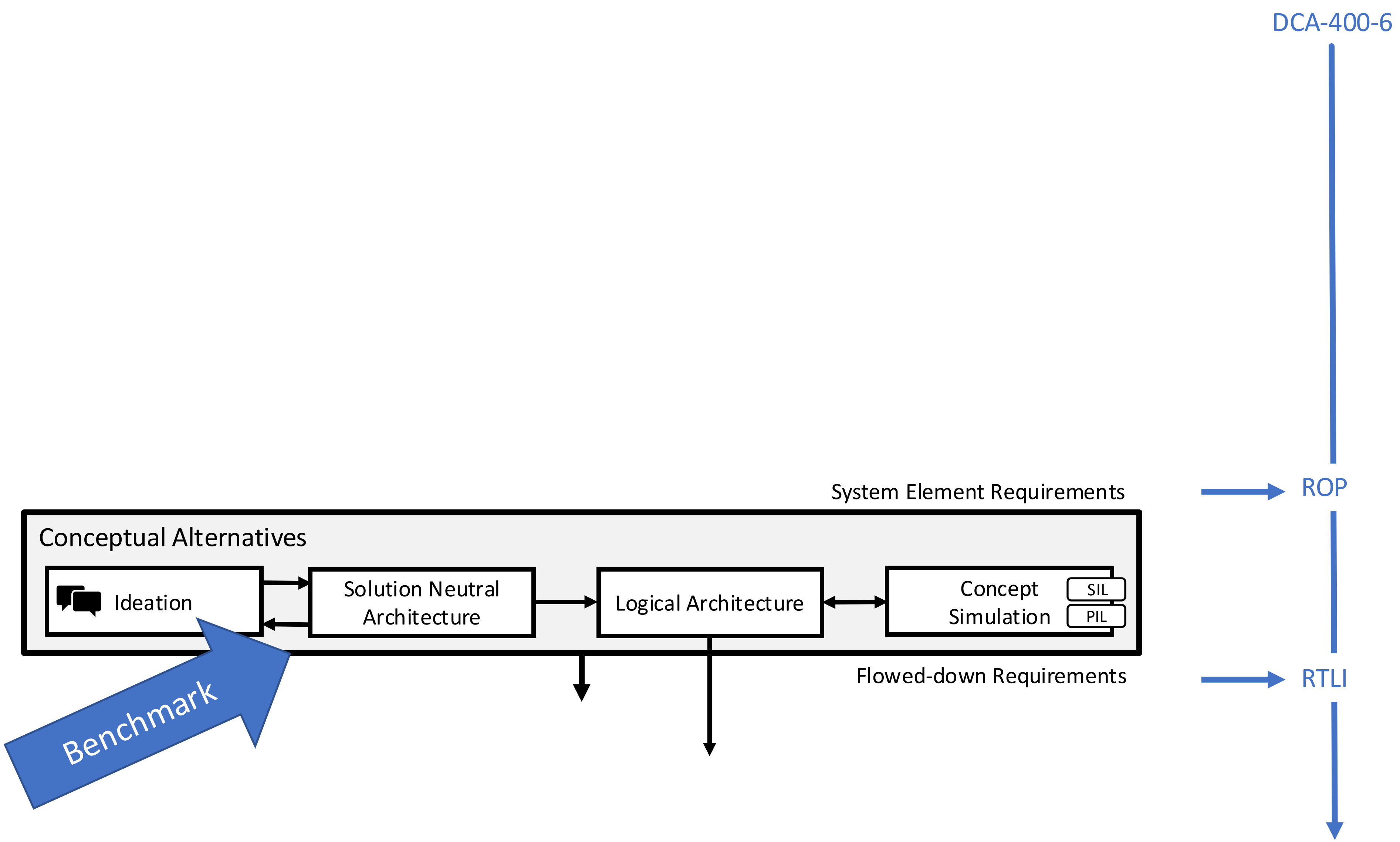
Traceability req_user – req_sys (nop-rop)



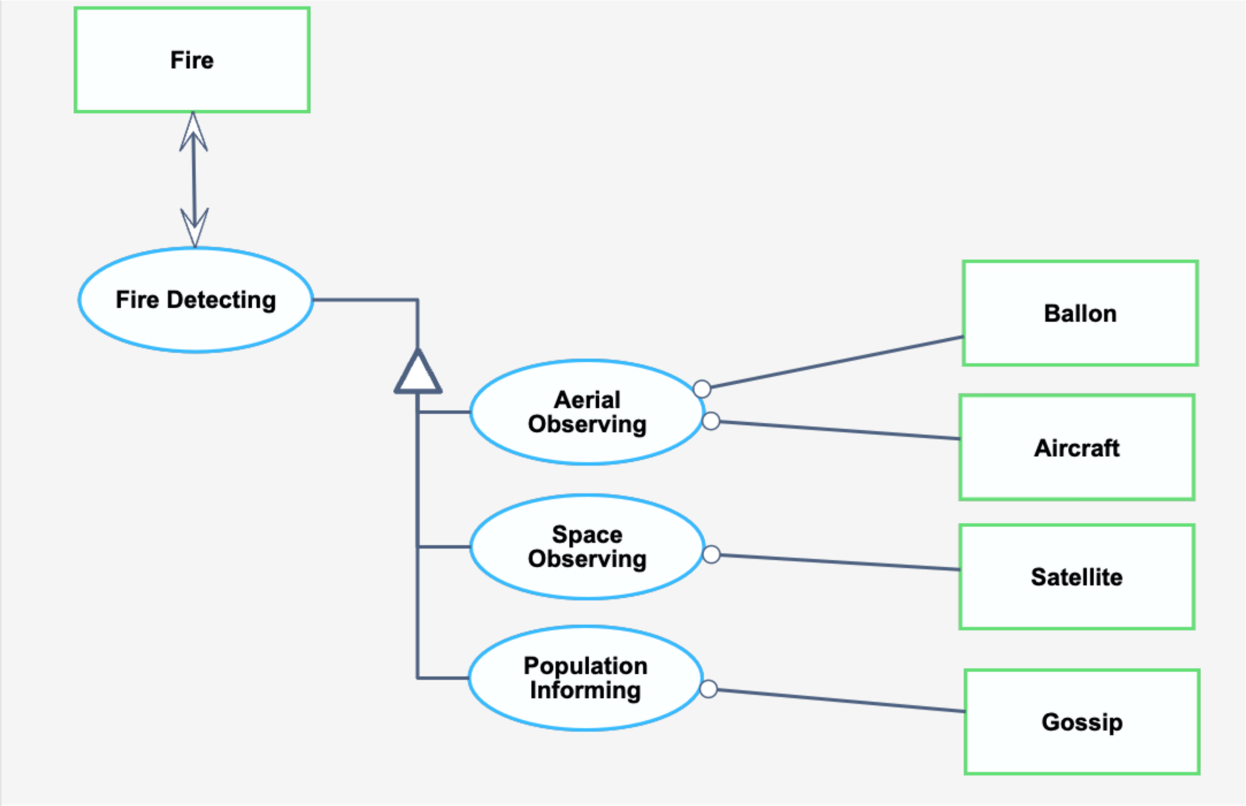
FAB: publicação do ROP

- Descrever o que o sistema tem que fazer para os stakeholders (OMs)
- Descrever o conceito de operação geral desse sistema com os stakeholders.
- Rastrear as necessidades aos requisitos.
- Justificar as interfaces e funções.
- Formaliza o que o sistema tem que prover sem explicar como e dar margem para os fornecedores.

Conceptual Alternatives


DCA-400-6
System Element Requirements
ROP
Conceptual Alternatives
Ideation
Solution Neutral Architecture
Logical Architecture
Concept Simulation
SIL
PIL
Flowed-down Requirements
RTLI
Benchmark

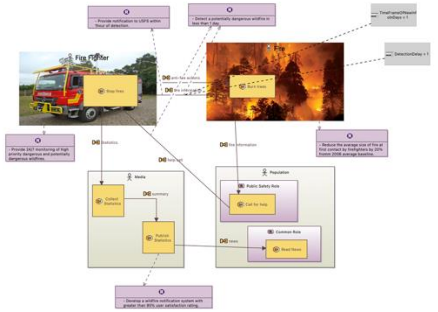
Intention exploration



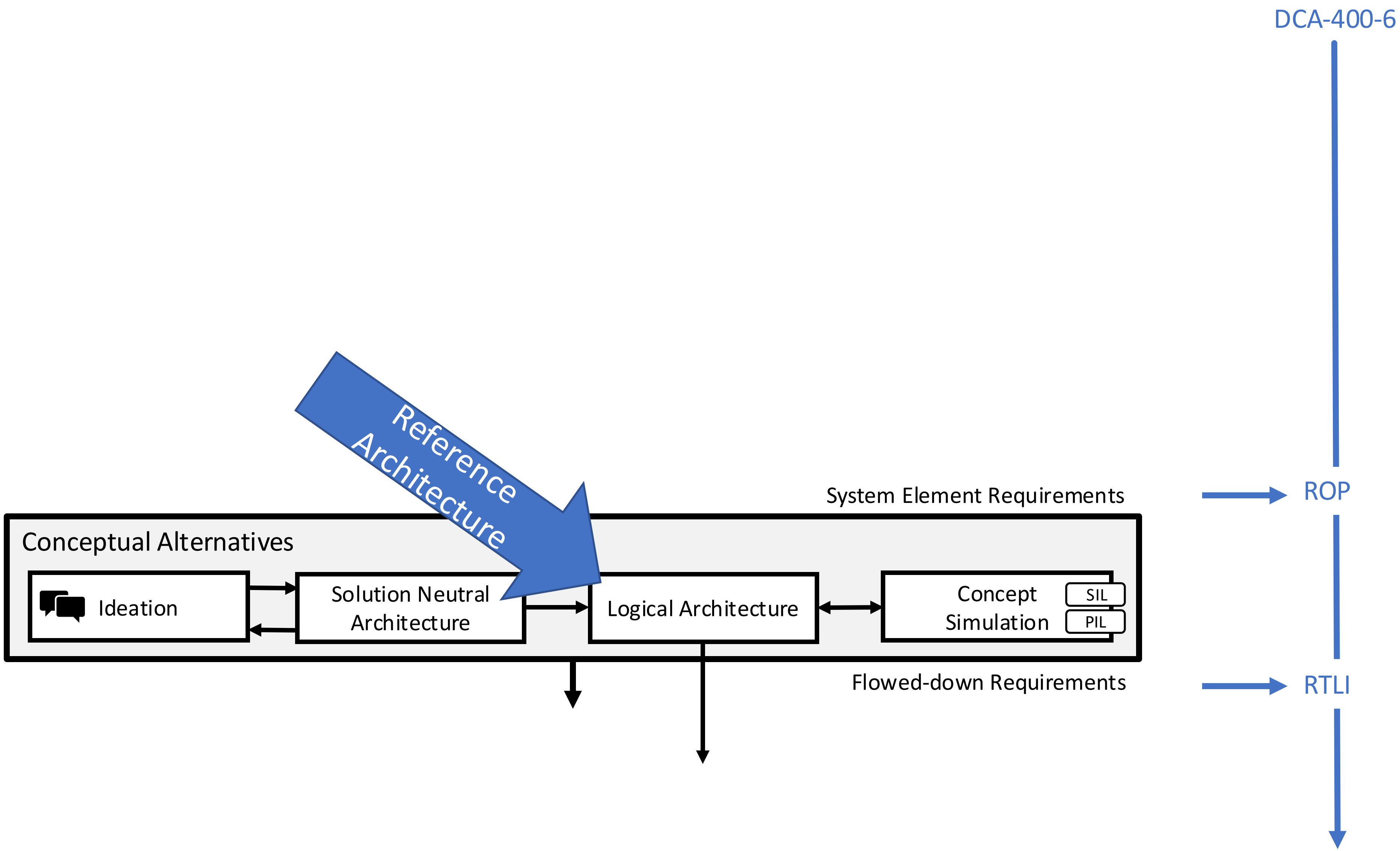
OPL

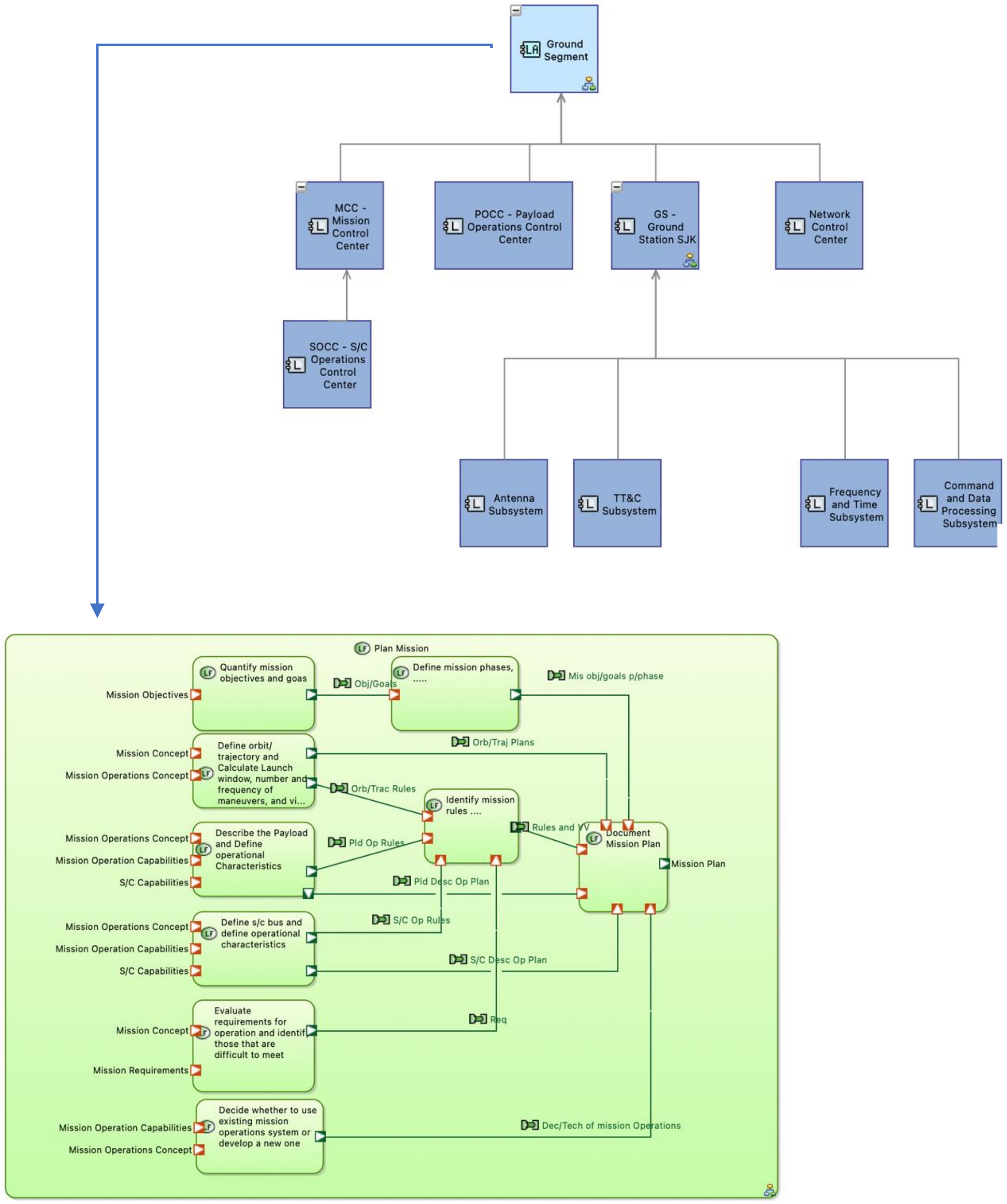
1. Aerial Observing, Population Informing and Space Observing are Fire Detecting.
2. Fire Detecting affects Fire.
3. Aerial Observing requires Aircraft and Ballon.
4. Space Observing requires Satellite.
5. Population Informing requires Gossip.

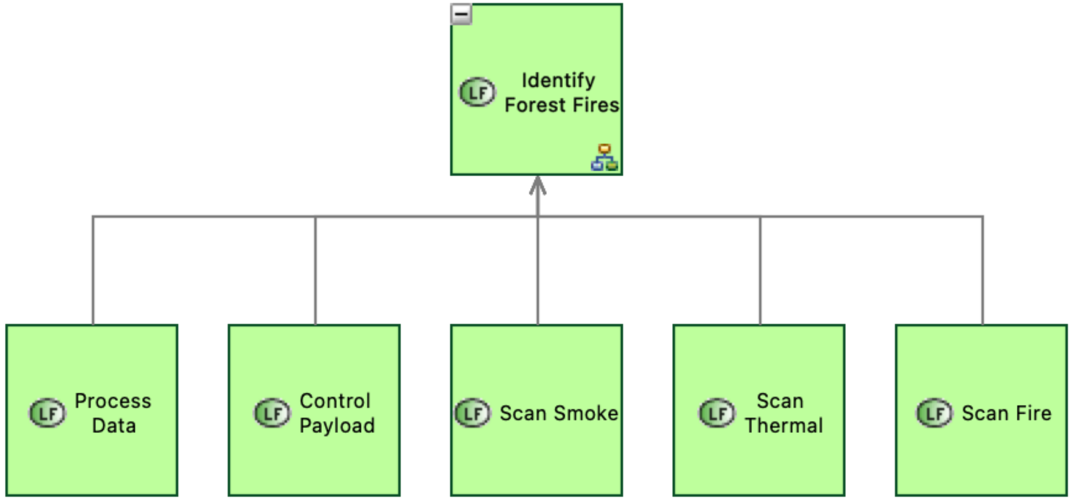
Trading

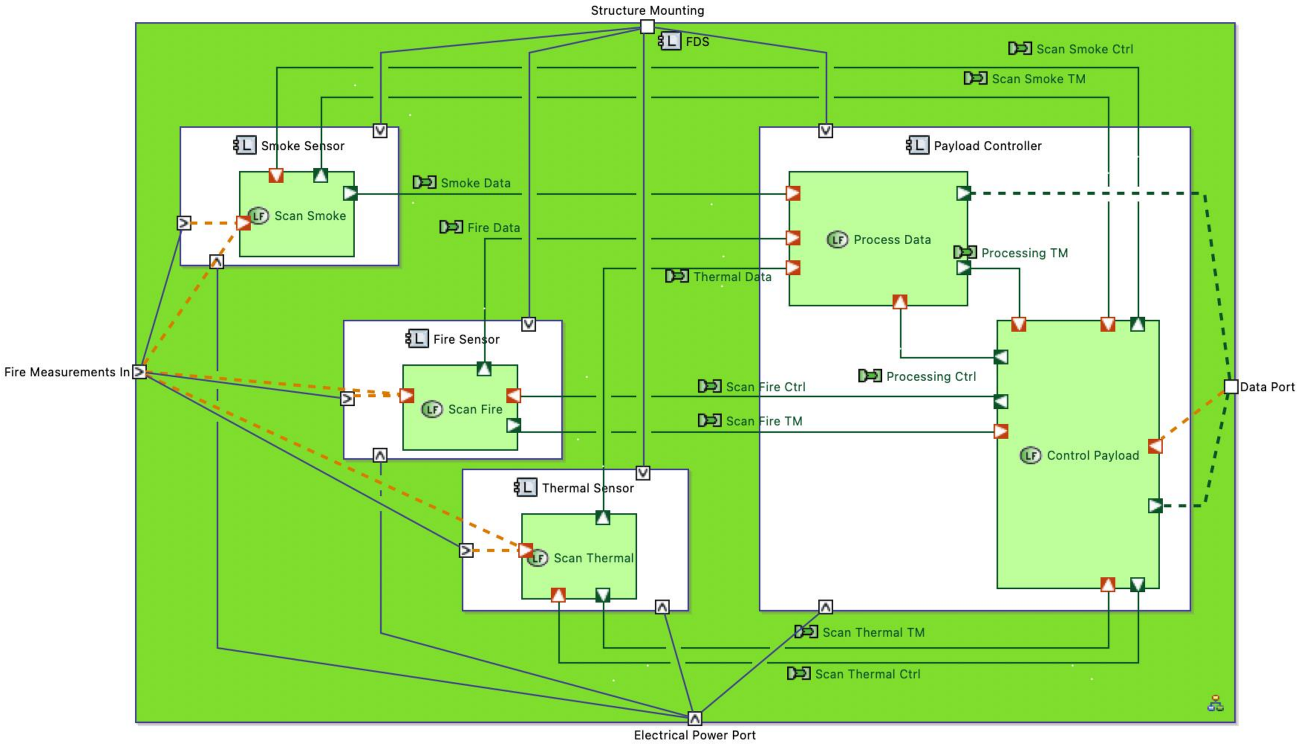


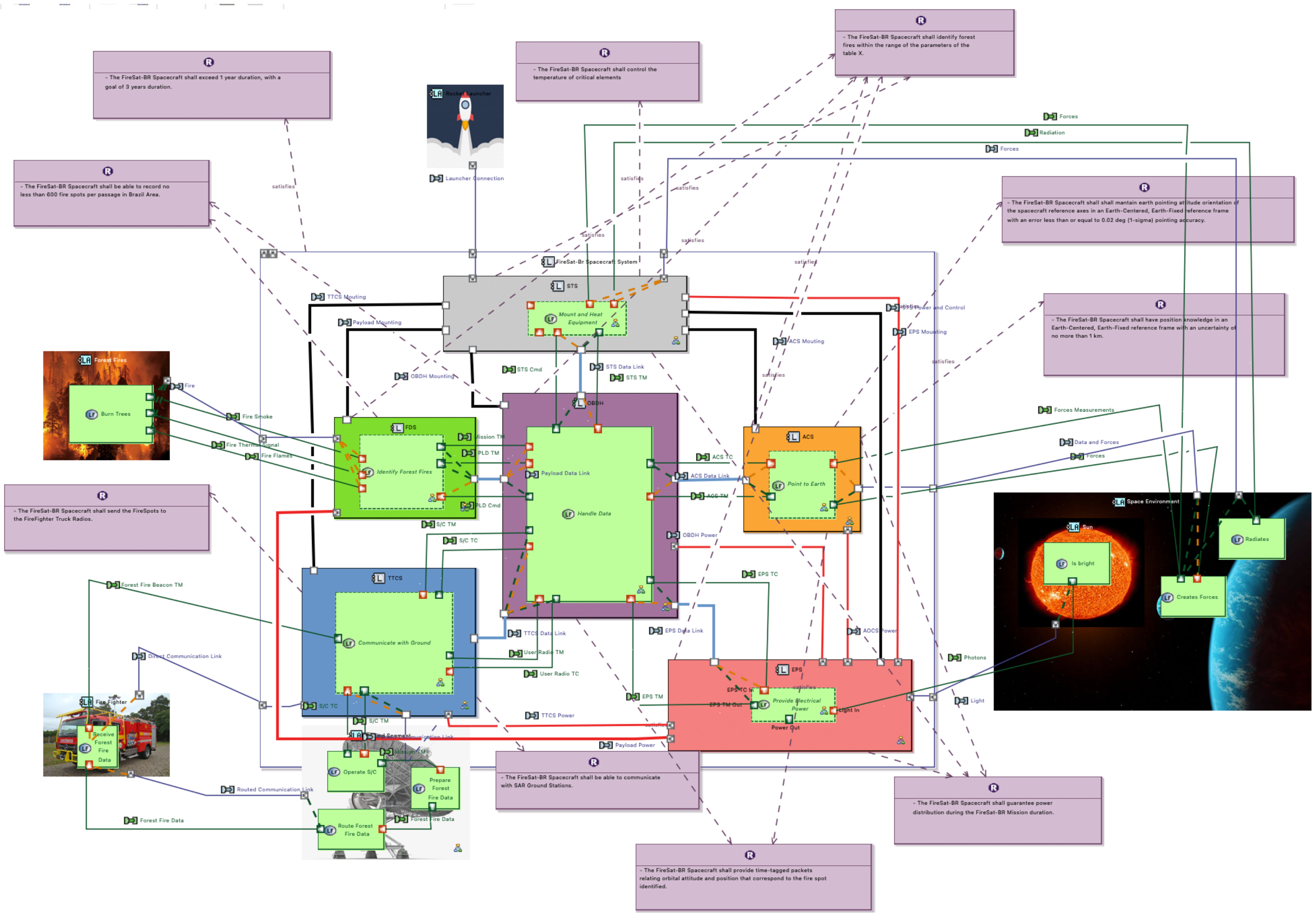
		Ballon	Aircraft	Satellite	Gossip
TimeFrameOfNewInformation	.4	-	+	+	0
DetectionDelay	.6	+	-	+	0
	Total	0	0	2	
	Weighted	.6	.4	1	

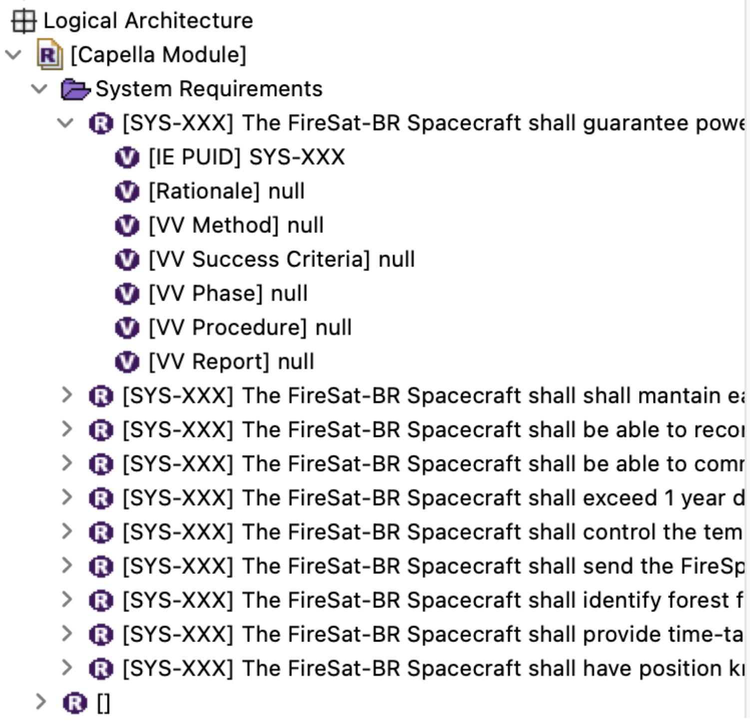

DCA-400-6
Reference Architecture
System Element Requirements
ROP
Conceptual Alternatives
Ideation
Solution Neutral Architecture
Logical Architecture
Concept Simulation
SIL
PIL
Flowed-down Requirements
RTLI


Ground Segment
MCC - Mission Control Center
POCC - Payload Operations Control Center
GS - Ground Station SJK
Network Control Center
SOCC - S/C Operations Control Center
Antenna Subsystem
TT&C Subsystem
Frequency and Time Subsystem
Command and Data Processing Subsystem
Plan Mission
Quantify mission objectives and goas
Define mission phases, ...
Mission Objectives
Obj/Goals
Mis obj/goals p/phase
Orb/Traj Plans
Mission Concept
Mission Operations Concept
Define orbit/ trajectory and Calculate Launch window, number and frequency of maneuvers, and vi...
Orb/Trac Rules
Identify mission rules ....
Rules and VV
Document Mission Plan
Mission Plan
Describe the Payload and Define operational Characteristics
Mission Operation Capabilities
S/C Capabilities
Pld Op Rules
Pld Desc Op Plan
Define s/c bus and define operational characteristics
S/C Op Rules
S/C Desc Op Plan
Evaluate requirements for operation and identify those that are difficult to meet
Req
Mission Requirements
Decide whether to use existing mission operations system or develop a new one
Dec/Tech of mission Operations


Identify Forest Fires
Process Data
Control Payload
Scan Smoke
Scan Thermal
Scan Fire

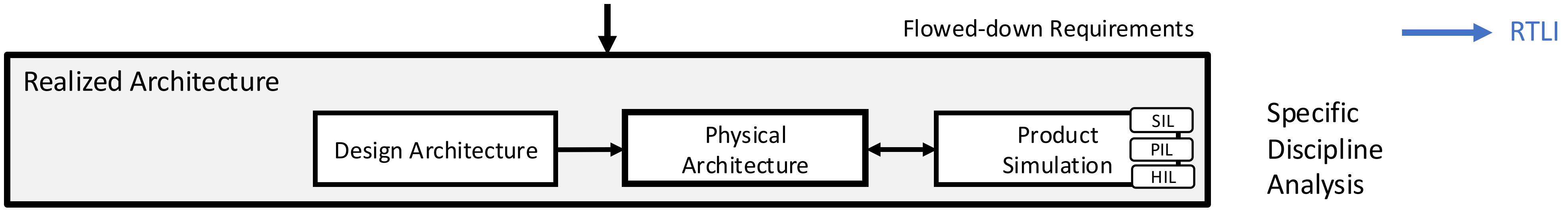

Structure Mounting
FDS
Scan Smoke Ctrl
Scan Smoke TM
Smoke Sensor
Scan Smoke
Payload Controller
Smoke Data
Fire Data
Process Data
Processing TM
Thermal Data
Fire Sensor
Scan Fire
Fire Measurements In
Scan Fire Ctrl
Scan Fire TM
Processing Ctrl
Data Port
Control Payload
Thermal Sensor
Scan Thermal
Scan Thermal TM
Scan Thermal Ctrl
Electrical Power Port



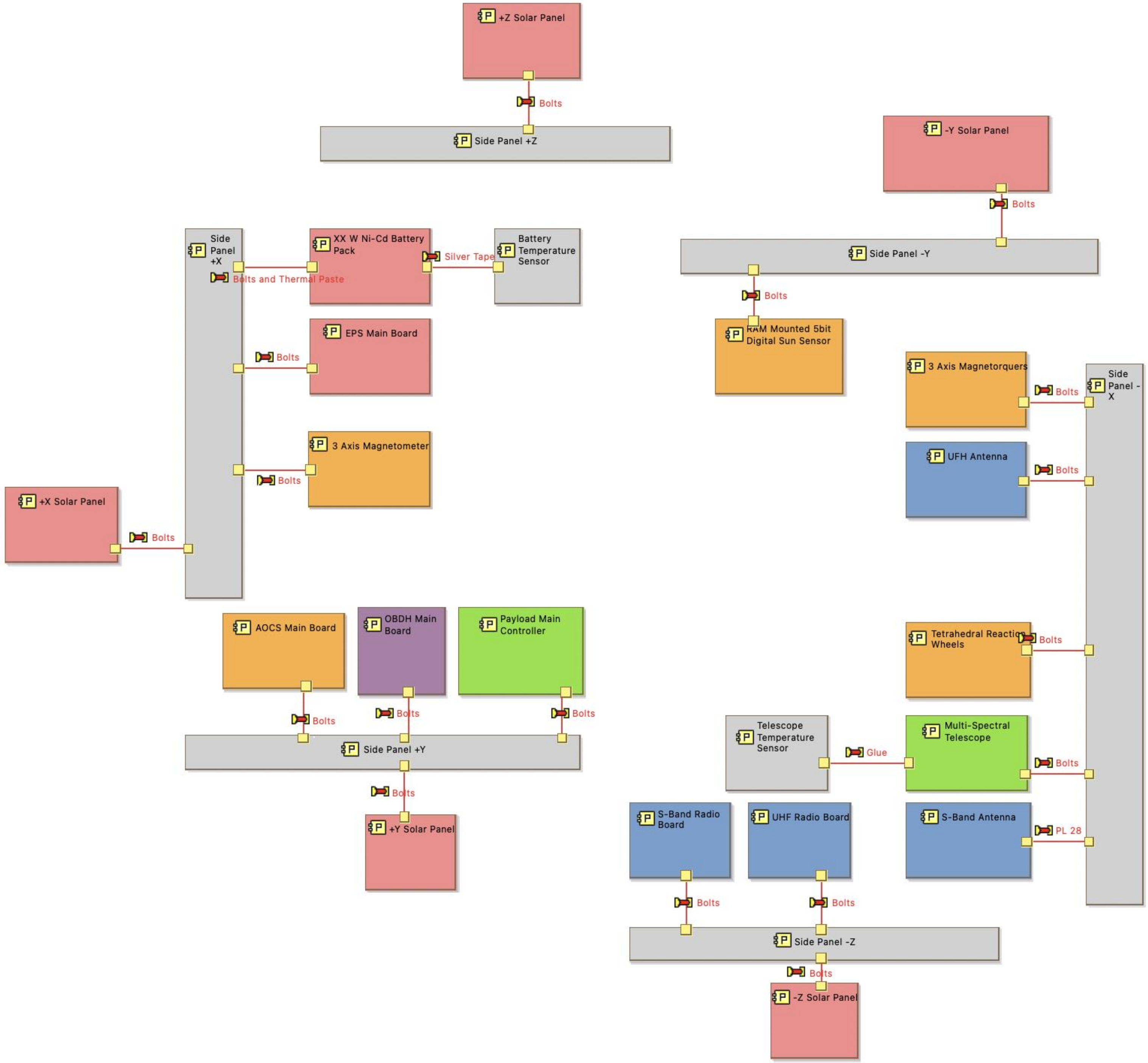


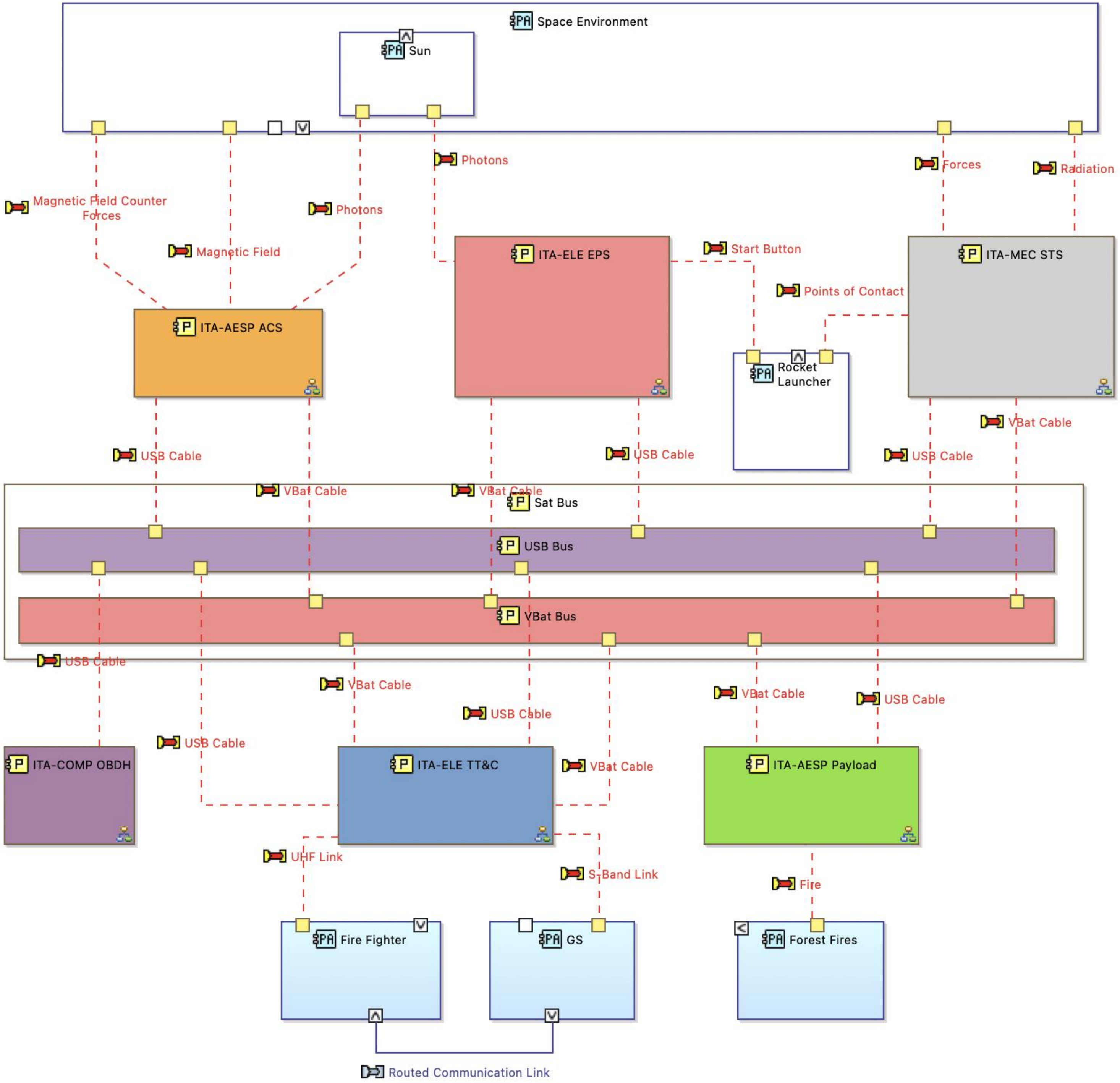
Logical Architecture
[Capella Module]
System Requirements
[SYS-XXX] The FireSat-BR Spacecraft shall guarantee powe
[IE PUID] SYS-XXX
[Rationale] null
[VV Method] null
[VV Success Criteria] null
[VV Phase] null
[VV Procedure] null
[VV Report] null
[SYS-XXX] The FireSat-BR Spacecraft shall shall mantain ea
[SYS-XXX] The FireSat-BR Spacecraft shall be able to recor
[SYS-XXX] The FireSat-BR Spacecraft shall be able to comr
[SYS-XXX] The FireSat-BR Spacecraft shall exceed 1 year d
[SYS-XXX] The FireSat-BR Spacecraft shall control the tem
[SYS-XXX] The FireSat-BR Spacecraft shall send the FireSp
[SYS-XXX] The FireSat-BR Spacecraft shall identify forest f
[SYS-XXX] The FireSat-BR Spacecraft shall provide time-ta
[SYS-XXX] The FireSat-BR Spacecraft shall have position ki
[]

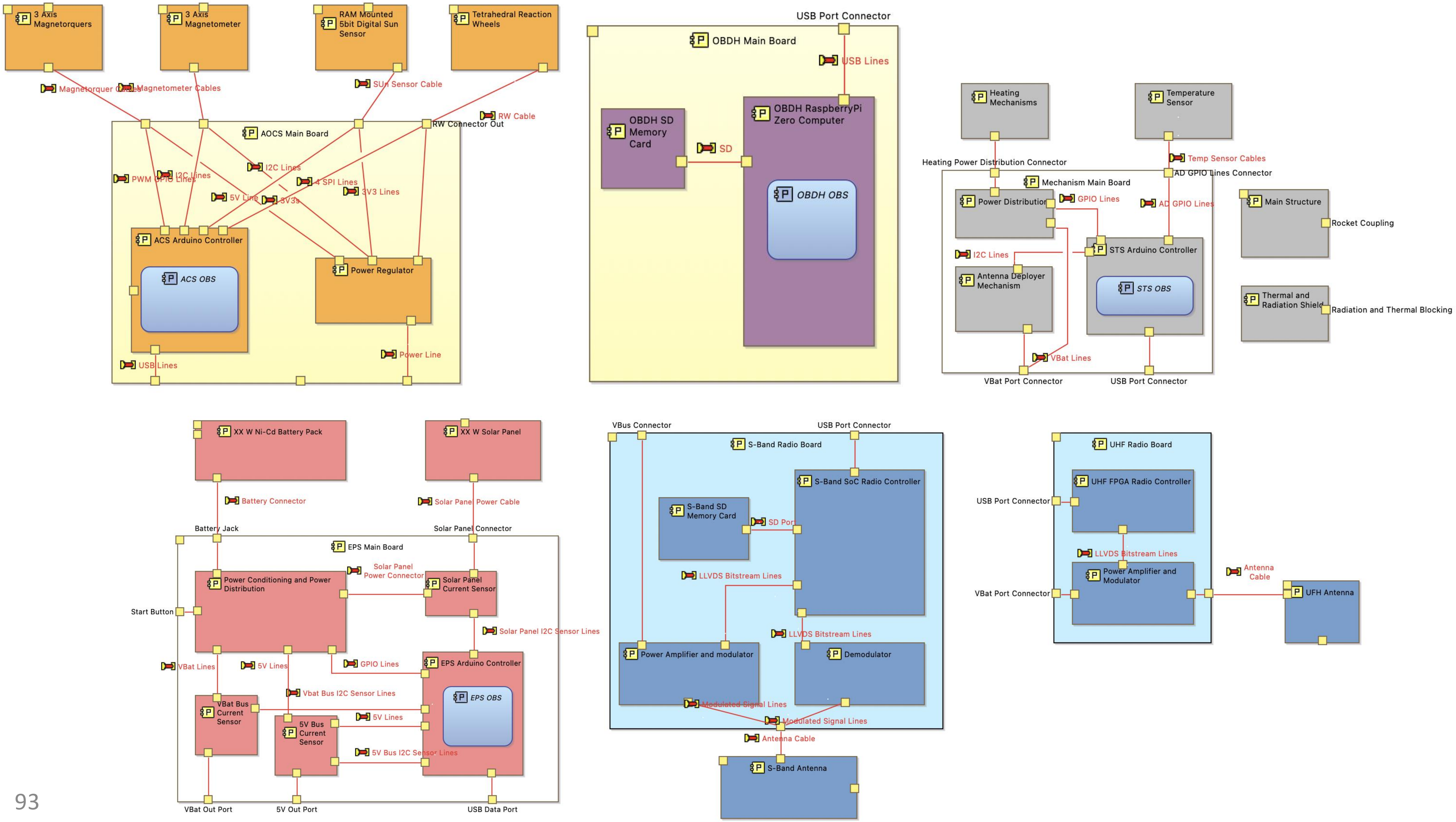
Realized Architecture



Flowed-down Requirements
Realized Architecture
Design Architecture
Physical Architecture
Product Simulation
SIL
PIL
HIL
Specific Discipline Analysis
RTLI


+Z Solar Panel
Bolts
Side Panel +Z
-Y Solar Panel
Bolts
Side Panel -Y
Bolts
RAM Mounted 5bit Digital Sun Sensor
Side Panel +X
XX W Ni-Cd Battery Pack
Silver Tape
Battery Temperature Sensor
Bolts and Thermal Paste
EPS Main Board
Bolts
3 Axis Magnetometer
Bolts
+X Solar Panel
Bolts
3 Axis Magnetorquers
Bolts
Side Panel -X
UFH Antenna
Bolts
Tetrahedral Reaction Wheels
Bolts
AOCS Main Board
OBDH Main Board
Payload Main Controller
Bolts
Bolts
Bolts
Side Panel +Y
Bolts
+Y Solar Panel
Telescope Temperature Sensor
Glue
Multi-Spectral Telescope
Bolts
S-Band Radio Board
UHF Radio Board
S-Band Antenna
PL 28
Bolts
Bolts
Side Panel -Z
Bolts
-Z Solar Panel


Space Environment
Sun
Photons
Forces
Radiation
Magnetic Field Counter Forces
Photons
Magnetic Field
ITA-ELE EPS
Start Button
ITA-MEC STS
Points of Contact
ITA-AESP ACS
Rocket Launcher
VBat Cable
USB Cable
USB Cable
USB Cable
VBat Cable
VBat Cable
Sat Bus
USB Bus
VBat Bus
USB Cable
VBat Cable
USB Cable
VBat Cable
USB Cable
USB Cable
VBat Cable
ITA-COMP OBDH
ITA-ELE TT&C
ITA-AESP Payload
UHF Link
S-Band Link
Fire
Fire Fighter
GS
Forest Fires
Routed Communication Link


3 Axis Magnetorquers
3 Axis Magnetometer
RAM Mounted 5bit Digital Sun Sensor
Tetrahedral Reaction Wheels
Magnetorquer Cables
Magnetometer Cables
SUn Sensor Cable
RW Cable
RW Connector Out
AOCS Main Board
I2C Lines
PWM GPIO Lines
I2C Lines
4 SPI Lines
5V Line
3V3s
3V3 Lines
ACS Arduino Controller
ACS OBS
Power Regulator
Power Line
USB Lines
USB Port Connector
OBDH Main Board
USB Lines
OBDH SD Memory Card
SD
OBDH RaspberryPi Zero Computer
OBDH OBS
Heating Mechanisms
Temperature Sensor
Temp Sensor Cables
Heating Power Distribution Connector
AD GPIO Lines Connector
Mechanism Main Board
Power Distribution
GPIO Lines
AD GPIO Lines
I2C Lines
STS Arduino Controller
Antenna Deployer Mechanism
STS OBS
VBat Lines
VBat Port Connector
USB Port Connector
Main Structure
Rocket Coupling
Thermal and Radiation Shield
Radiation and Thermal Blocking
XX W Ni-Cd Battery Pack
XX W Solar Panel
Battery Connector
Solar Panel Power Cable
Battery Jack
Solar Panel Connector
EPS Main Board
Solar Panel Power Connector
Power Conditioning and Power Distribution
Solar Panel Current Sensor
Start Button
Solar Panel I2C Sensor Lines
VBat Lines
5V Lines
GPIO Lines
EPS Arduino Controller
Vbat Bus I2C Sensor Lines
EPS OBS
VBat Bus Current Sensor
5V Lines
5V Bus Current Sensor
5V Bus I2C Sensor Lines
VBat Out Port
5V Out Port
USB Data Port
VBus Connector
USB Port Connector
S-Band Radio Board
S-Band SoC Radio Controller
S-Band SD Memory Card
SD Port
LLVDS Bitstream Lines
LLVDS Bitstream Lines
Power Amplifier and modulator
Demodulator
Modulated Signal Lines
Modulated Signal Lines
Antenna Cable
S-Band Antenna
UHF Radio Board
UHF FPGA Radio Controller
USB Port Connector
LLVDS Bitstream Lines
Power Amplifier and Modulator
VBat Port Connector
Antenna Cable
UFH Antenna