Capella in Transport and Infrastructure

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23 Sep 2025

Arcadia Overview

What is Arcadia?

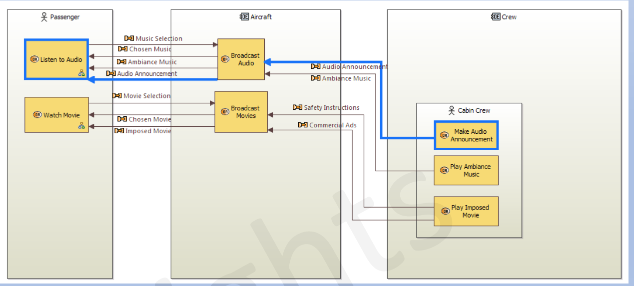
- Arcadia stands for Architecture And Design Integrated Approach
- Arcadia is a structured analysis approach to developing and decomposing a problem into a system architecture.
- It integrates with requirements analysis in an iterative fashion
  - The architectural design informs the requirements analysis and vica versa
  - Is integral to planning IVV activities
- Arcadia is designed to be flexible and scalable such that an engineer only needs to model what is important

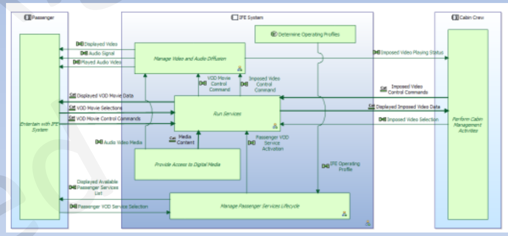
Arcadia Overview

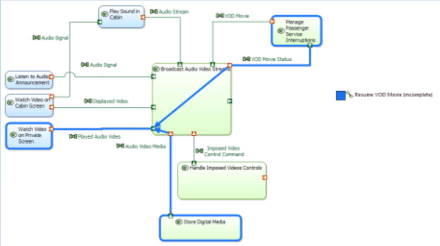
Top level concepts

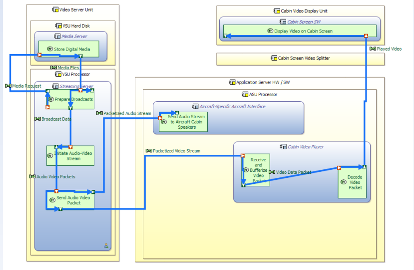
Arcadia has 4 main Architectural layers

- Operational Analysis [OA] – what the users need to do
- System Analysis [SA] – What the system needs to achieve for the users
- Logical Architecture [LA] – Conceptual Architecture
- Physical Architecture [PA] – How the system will be built









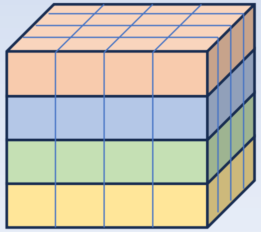
So which layers to use?

It Depends

- Sure…. but what does it depend on and how do I decide?

Questions to ask?

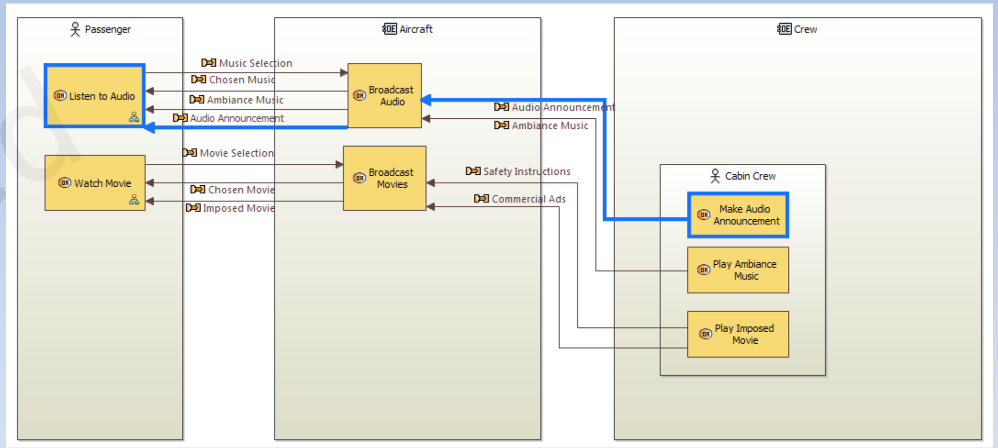
- How will the layer add value?
- How well is the solution understood already / what is already known?
- How will it help the system through the life-cycle?
- Is the system deployed to multiple site/platforms?
- Is the scope of each sub-team team well understood?
- How much is needed to help the project?



Operational Analysis [OA]

Overview

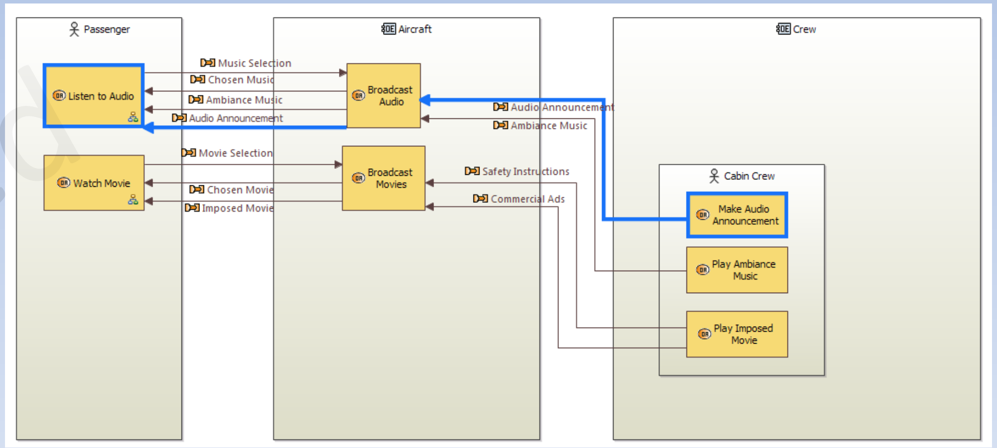
- The objective of the operational analysis is to formalise the needs, missions and activities of the end users of the system and capture them in a series of operational processes and scenarios
- The operational analysis forms the basis for a Concept Of Operations (CONOPS)
- The operational analysis ensures the system analysis is grounded in a clear understanding of the end users needs and how the system will be used



Operational Analysis [OA]

Overview

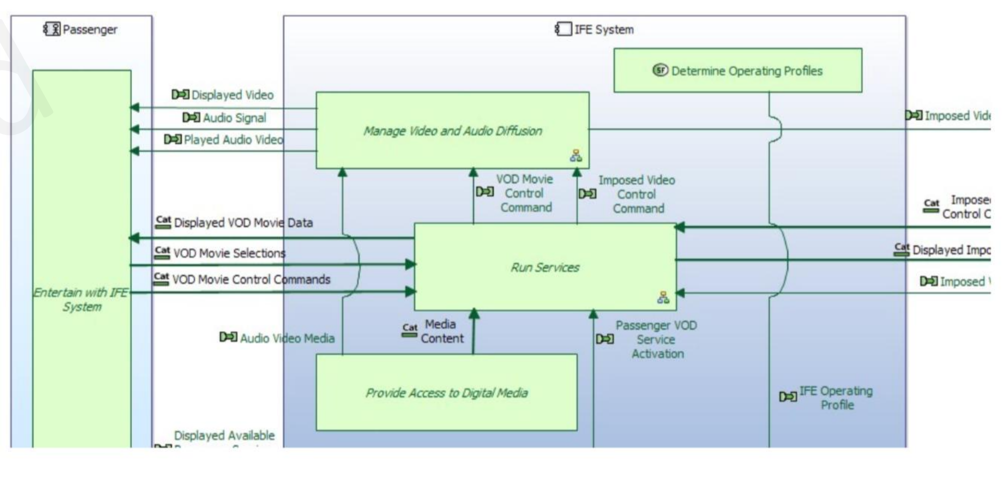
- Very conceptual for a realistic Transport or Infrastructure solution
- If the technical solution is already understood and implemented in many similar ways in many installations, limited value can be extracted
- Many projects start with organisations that already exist and are already operating similar systems, so generally limited help is needed at this level of abstraction



System Analysis [SA]

Overview

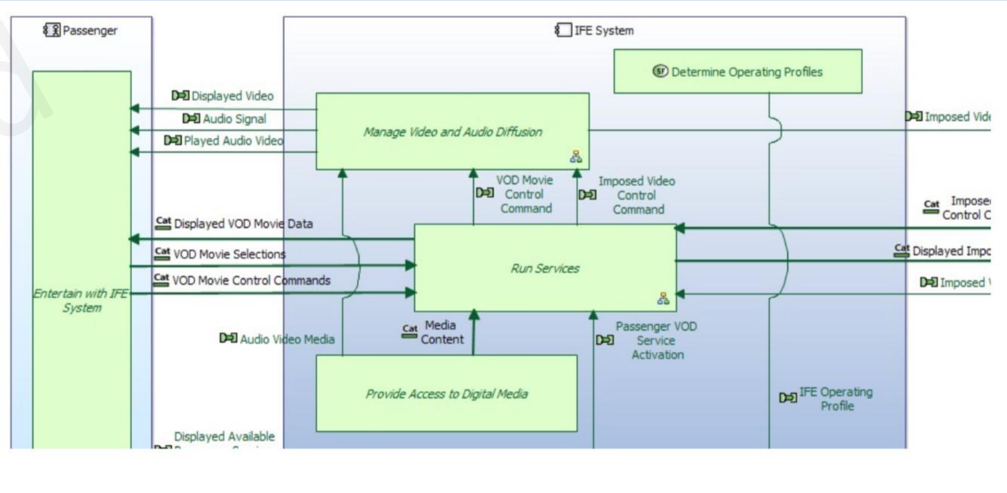
- The objective of the system analysis is to define the system role in satisfying the operational needs/CONOPS
- It is a black-box analysis that identifies:
  - The functions the system has to perform
  - The exchanges and interfaces between the system and external actors
  - Derives scenarios used to describe the use of the system from the functions, exchanges and interfaces of SA and the scenarios from OA



System Analysis [SA]

Overview

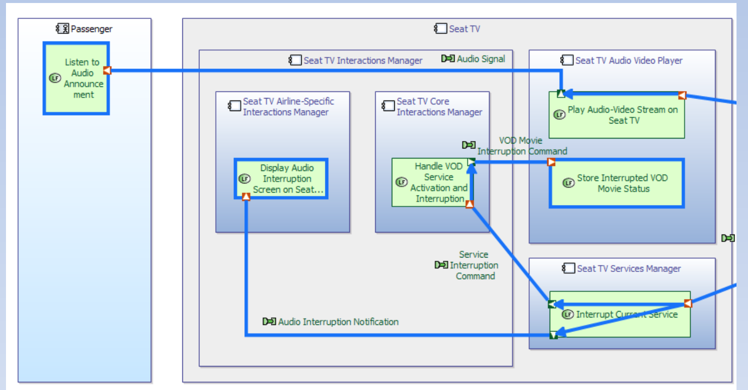
- Can be used to inform the development of customer/contract requirements and form the basis of initial cost estimates
- Identifies system boundaries and interfaces, potentially useful to identify the SoI boundaries within a large complex system
- Doesn’t provide clarity on multi-site Transport & Infrastructure deployments
- Doesn’t delve deeply beyond identification into interface physical design



Logical Architecture [LA]

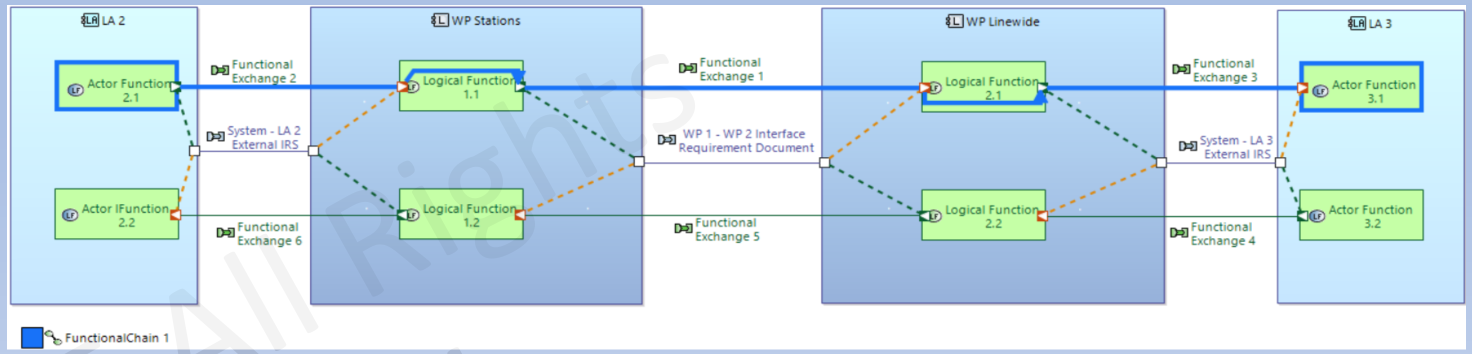
Overview

- The objective of the logical architecture is to identify how the system will work without considering specific technology or deployment issues.
- Functions are decomposed and grouped into logical components. Interfaces and functional chain are identified
- The system can be analysed from a number of non-functional perspectives including performance, IVV, safety, etc… and appropriate compromises found
- Logical architecture can be used to
  - Focus first on how the system will function rather than how it will be built
  - Define a general architecture for a product line, system that has multiple variants or multiple deployment configurations
  - Generalise an architecture such that it is resistant to technology obsolescence
  - Manage the breakdown of scope between design teams

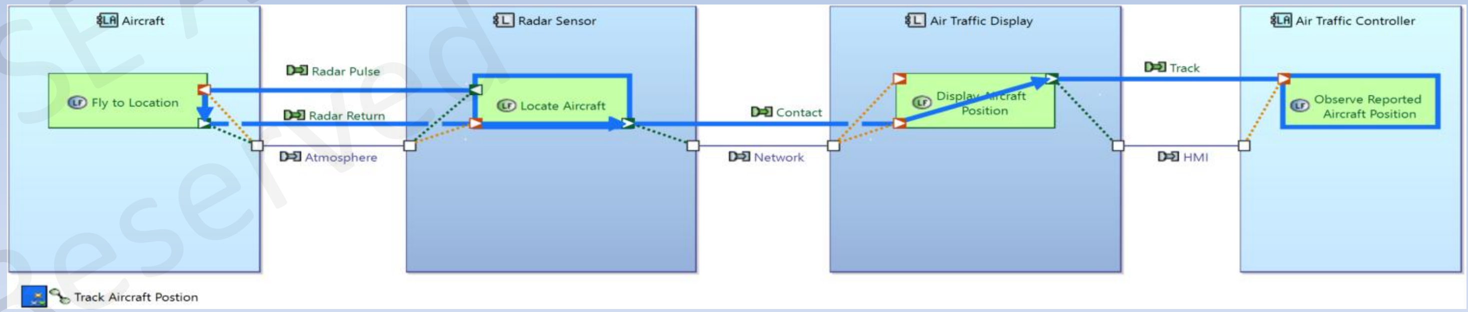


Types of Logical Architecture

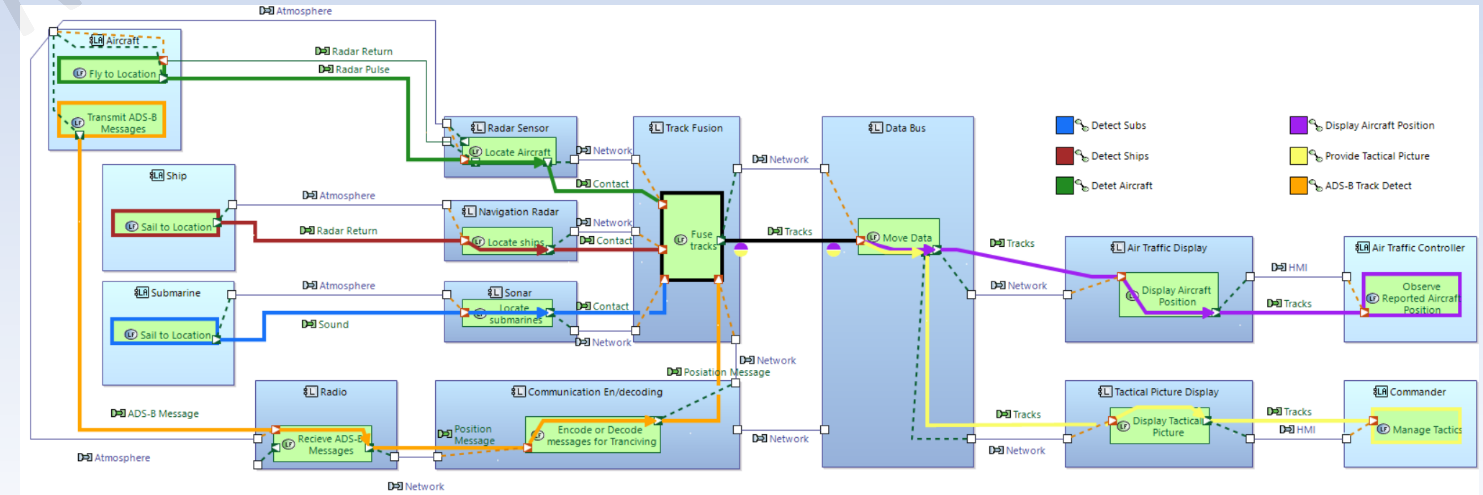
- Scope breakdown



- Solution class / options

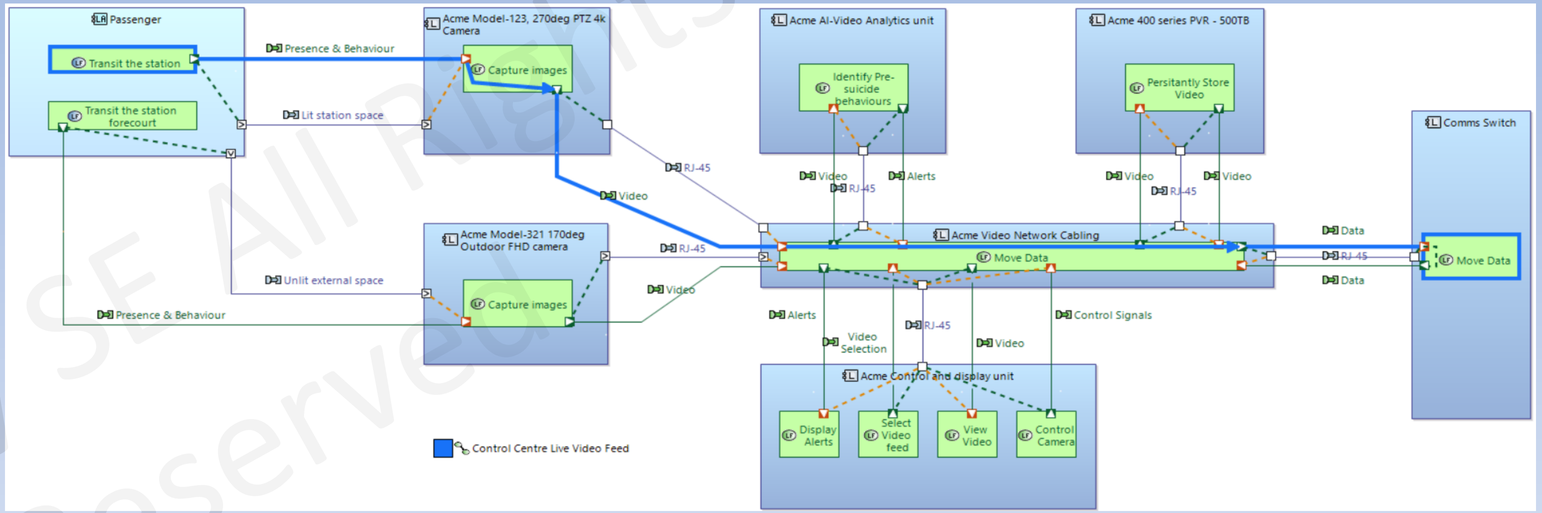


- Detailed technology agnostic solution

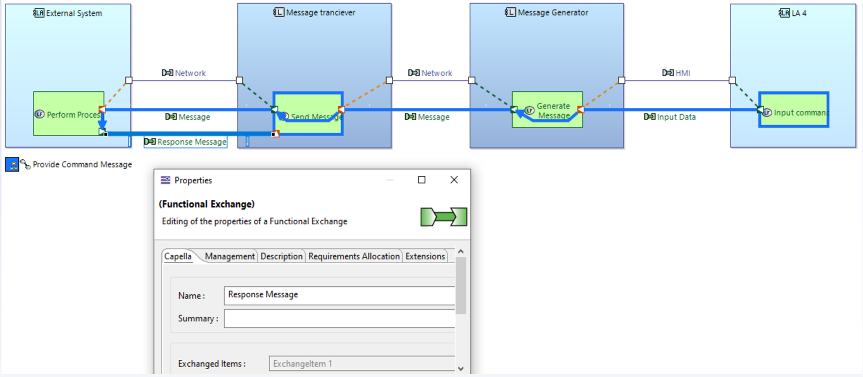


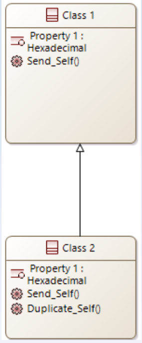
Types of Logical Architecture

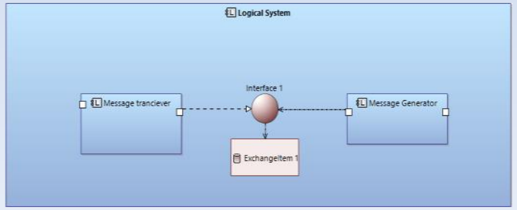
- Deployment agnostic solution



- Specific solution

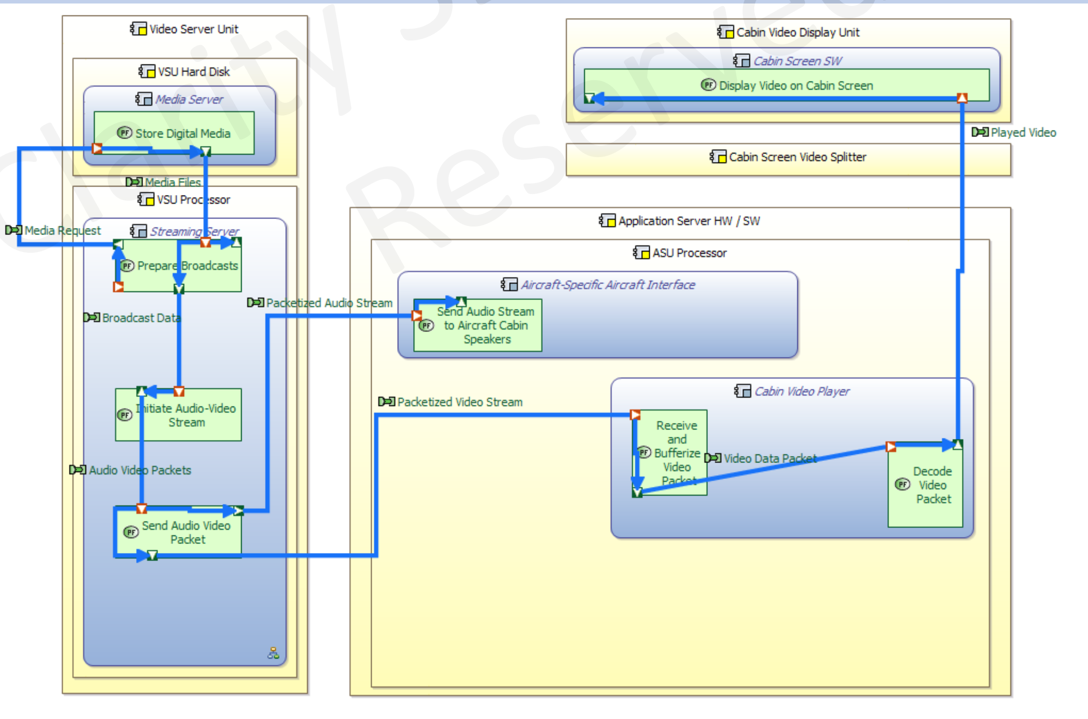






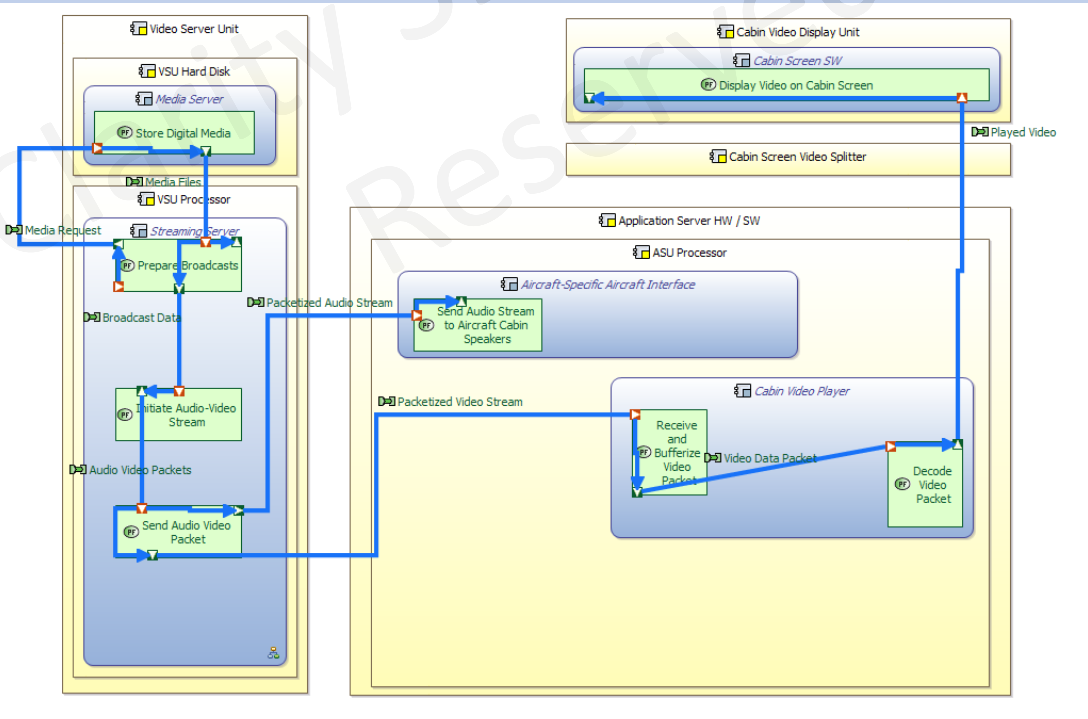
Physical Architecture [PA]

- The objective of the physical architecture is to identify all the system components their behaviours, interfaces and account for technological, deployment and system variant decisions
- The physical architecture forms the basis for a system design synthesis



Physical Architecture [PA]

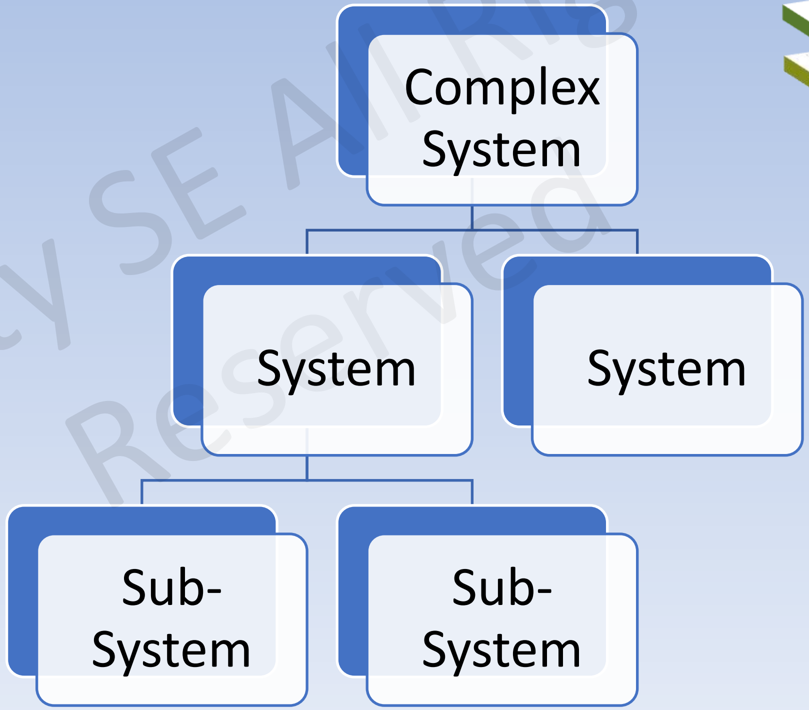
- Aligns with well understood solutions like transport and infrastructure, as the technical solutions can be completely described
- Separates the concepts of physical and logical interfaces
- Allows for deployment relationships rather than just part of/contains relationships
- When including the EPBS allows for clear scope delineation between delivery teams
- Shows the mapping of functional chains/thread required by customers to the technical solutions

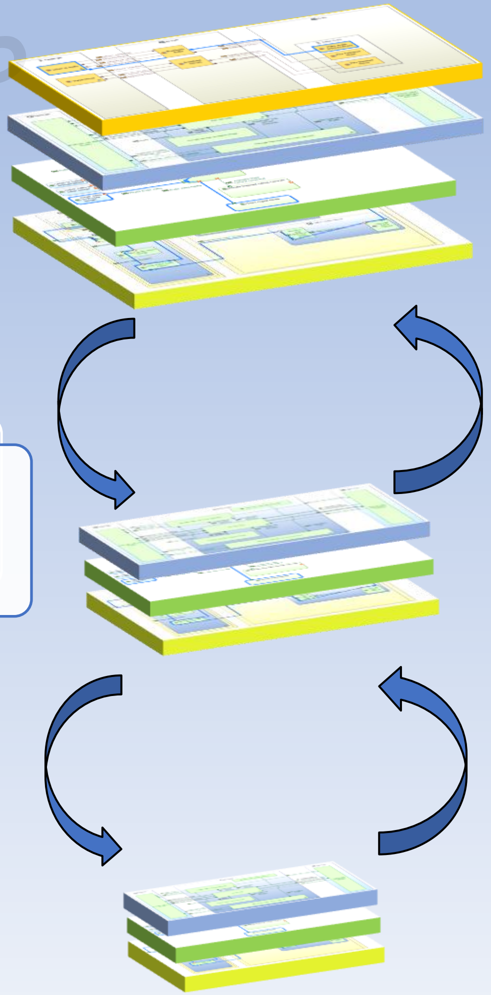


Arcadia Recursively Masters Complex Systems

Main Concepts

- Arcadia builds recursive system to sub-system models
- Traceability and automated transitions between models allows smaller focused models to work together in the larger context of a complex system



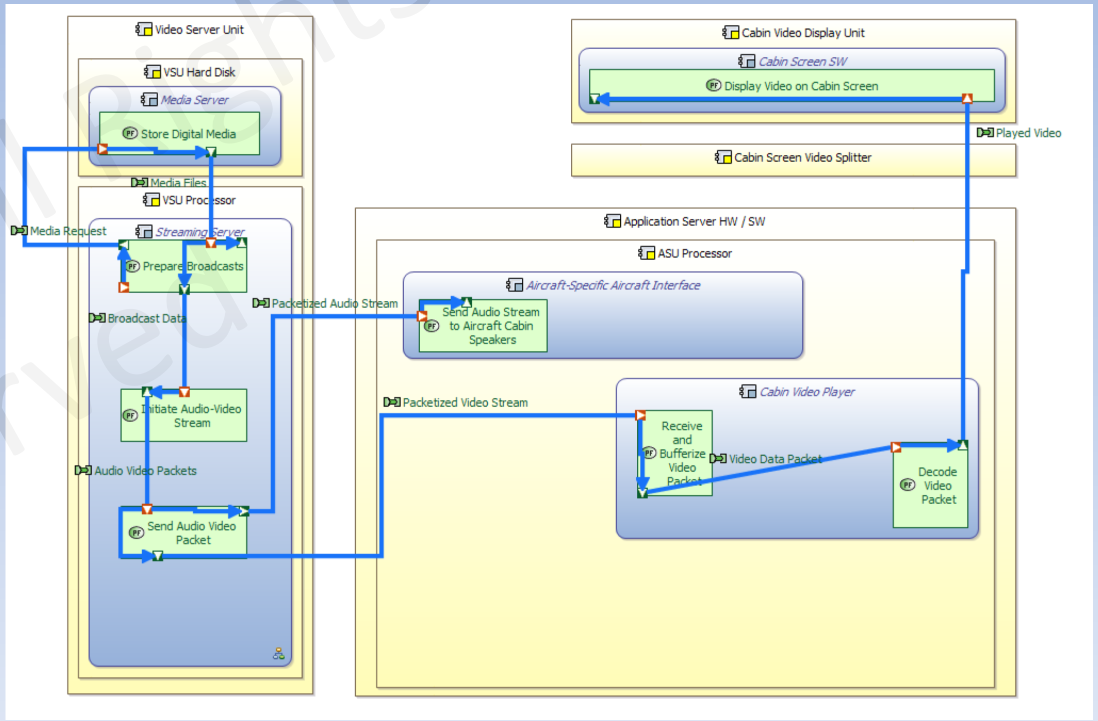


PA in Transport and Infrastructure

Main Concepts

Capella brings significant advantages to transport and infrastructure projects through its use of the ARCADIA framework.

- This includes structured use of Physical Architecture Nodes, Behavioural Components, and Functional Chains, enabling clear modelling of system behaviour and interfaces.
- The REC/RPL paradigm supports rapid scaling of models with repeated elements, common in infrastructure and transport systems, while functional and component exchanges naturally reflect logical and physical interface patterns
- These features provide a solid foundation for interface documentation, further enhanced by Capella’s document generation capability, which enables efficient, repeatable production of artefacts at scale where many documents need to be produced.



A starting point for Layers in Transport and Infrastructure

- Operational Analysis – Only if the client is building a new organisation. CONOPS?
- System Analysis – Useful to define the context, external interfaces, what is in scope and what is not, help build the contract spec. CONOPS?
- Logical – **It depends**, may not be needed
- Physical – where most of the work should take place

Warning: Getting this right is about balancing the simplest way to get a job done, and avoiding rework, reworkshoping, taking too long.

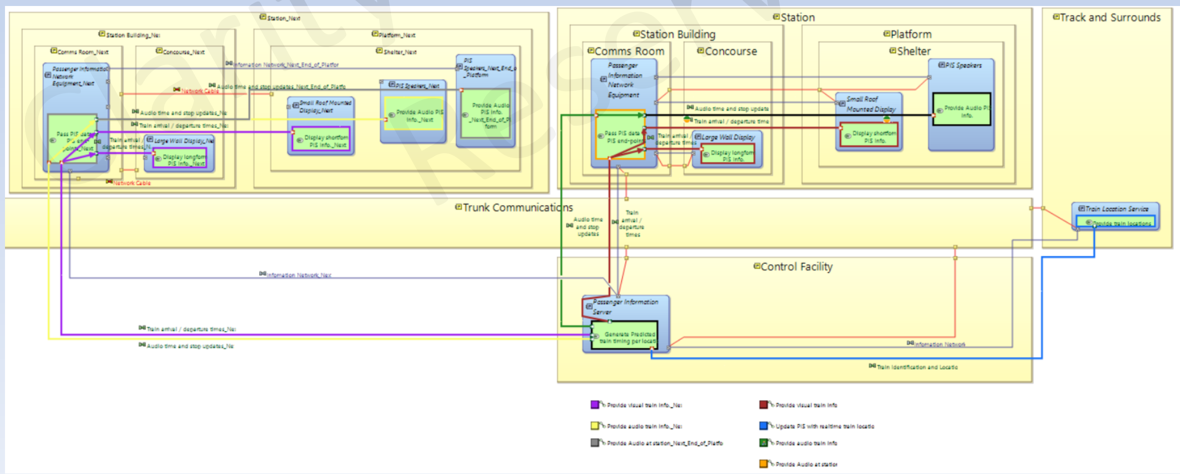
A relevant Transport and Infrastructure Example

Architecture: The fundamental concepts or properties of an entity in its environment and governing principles for the realisation and evolution of this entity and its related life cycle processes (ISO/IEC/IEEE 42020, 2019)

A passenger information system

or Electrical Distribution System, or HVAC System, Fire Protection System, etc…

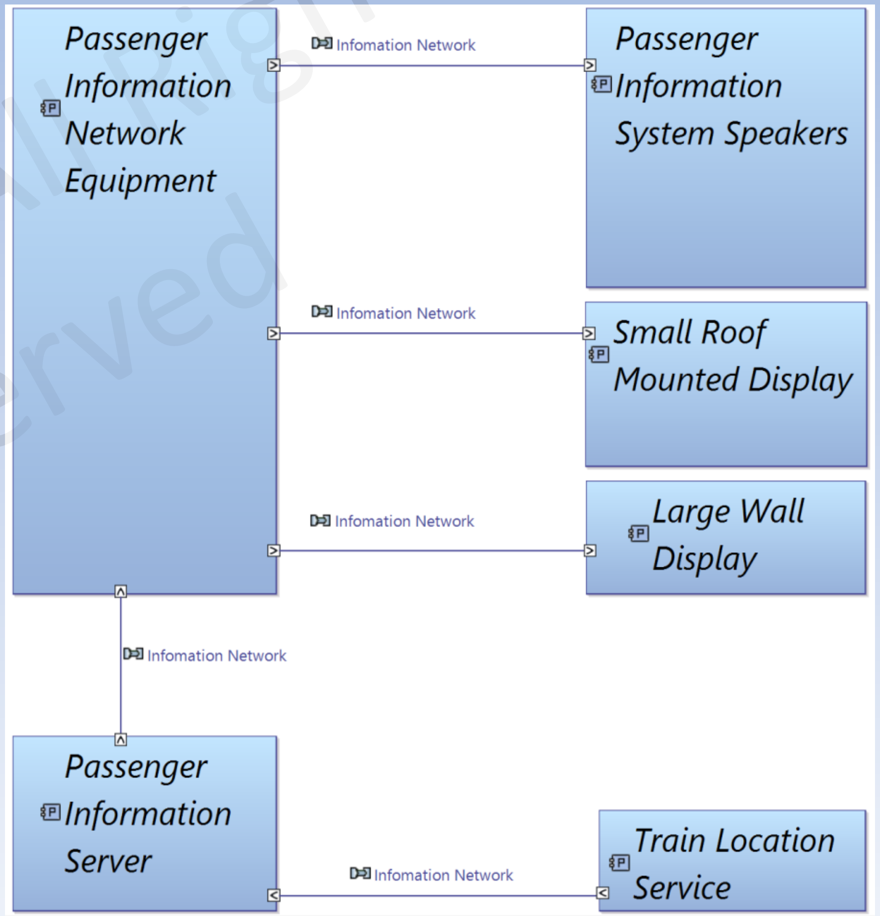
- An example typical of the sorts of systems we see in Transport and Infrastructure



A passenger information system

or Electrical Distribution System, or HVAC System, Fire Protection System, etc…

- We start by defining the general pattern for the system
- The Passenger Information System (PIS) has a head-end system at a different location from the endpoints
- Data traverses a comms system between them
- The endpoints are deployed to a structure



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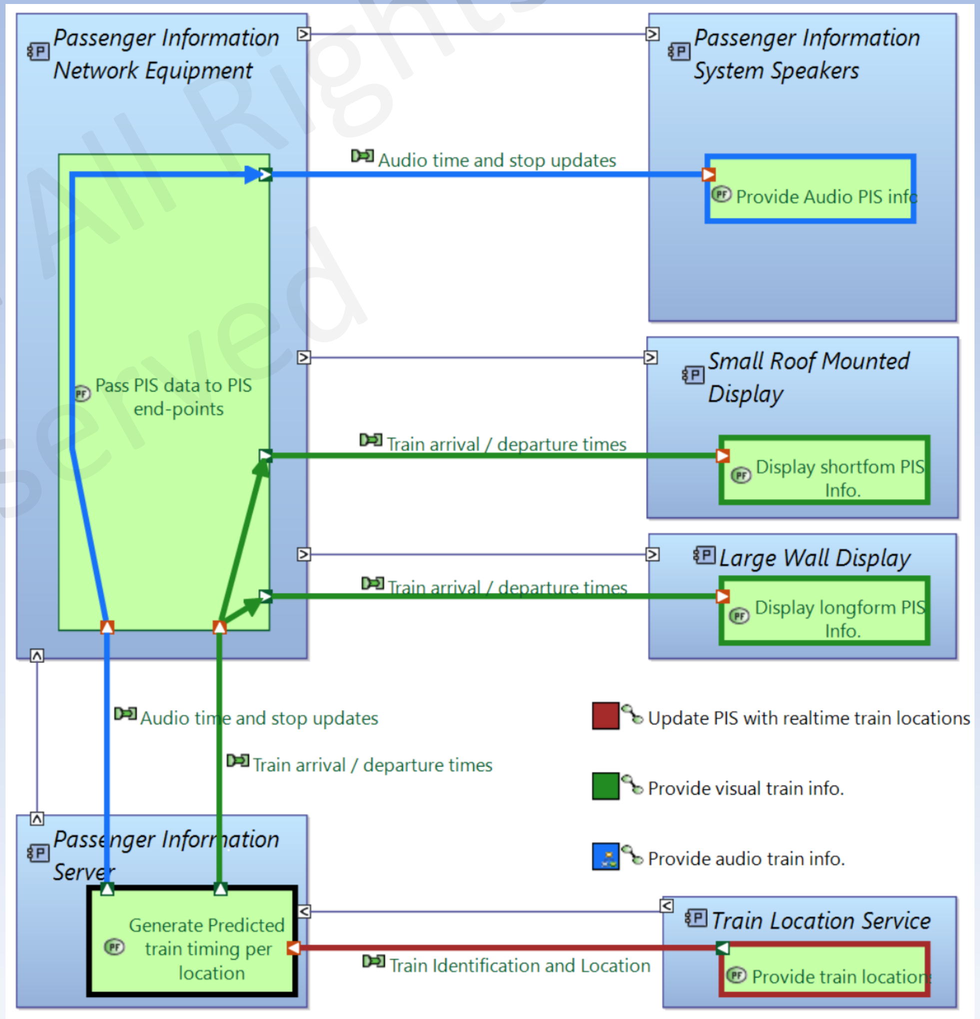
- The functional threads through the system show how the system addresses its high level requirements
- The functions show each subassembly / asset’s role in achieving the requirements



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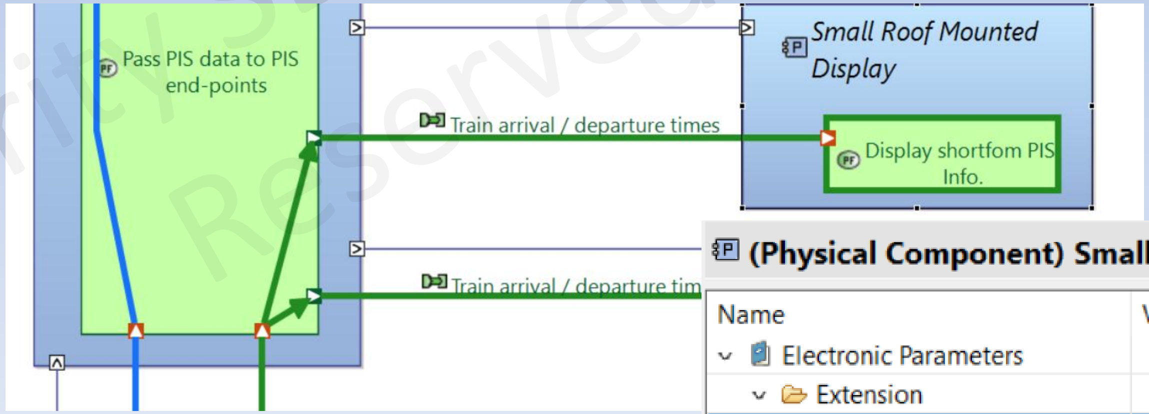
- Properties and/or viewpoints can be used to capture other key design parameters
- The general case shows us how the system works, but we need to see the system deployed at the locations… This is where Capella really excels

Name	Type	Default Value
Electronic Parameters		
EnumerationDefinition		
Extension		
Scope	[PHYSICAL]	
EClass Rule	PhysicalComponent	
Model No.	stringProperty	ACME_HW-123
Max Weight	floatProperty	5.0 kg
Bandwidth	floatProperty	100.0 Mb/s



(Physical Component) Small Roof Mounted Display [REC]

Name	Value
Electronic Parameters	
Extension	
Model No.	SRMD-1000
Max Weight	5.0 kg
Bandwidth	100.0 Mb/s

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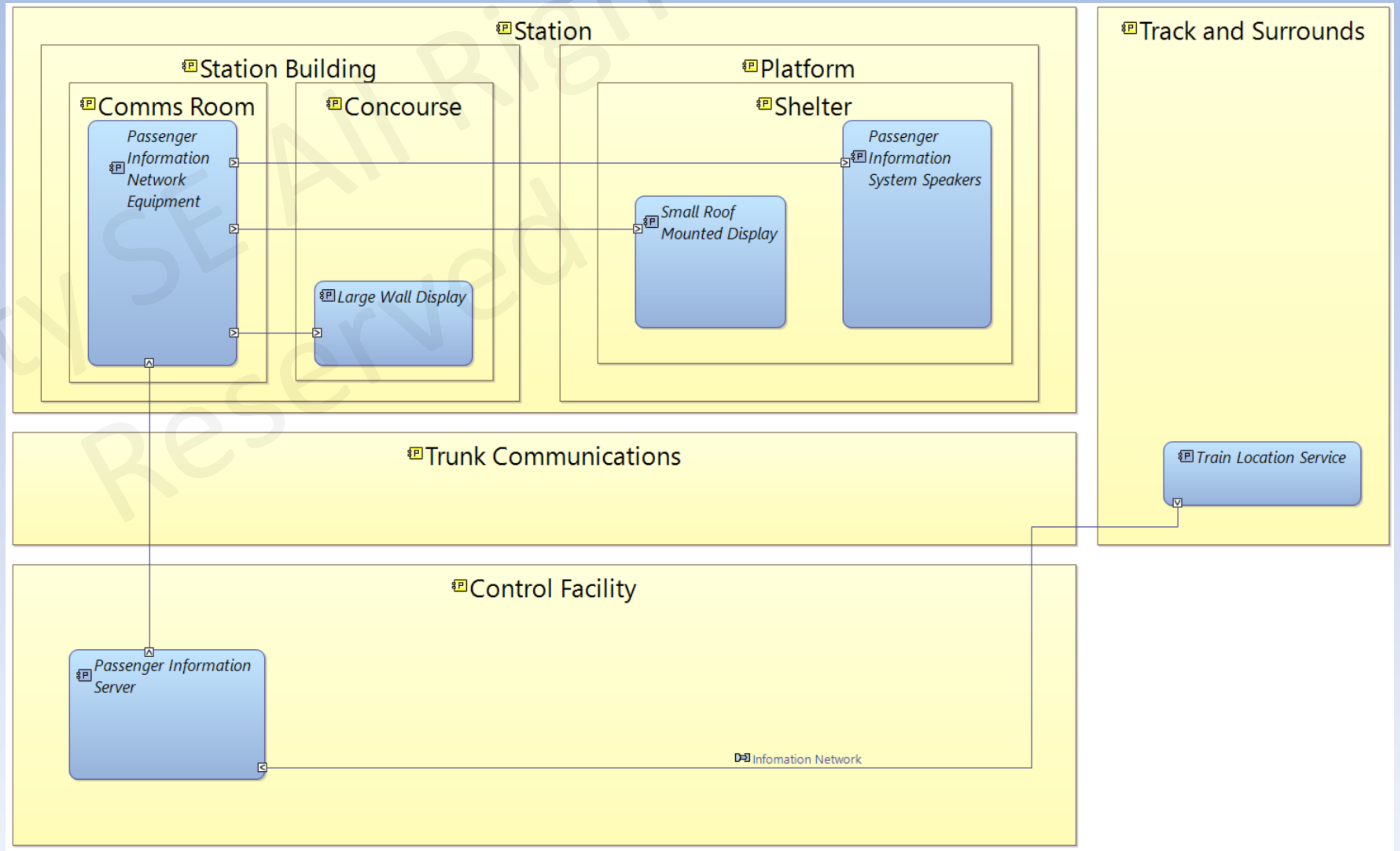
- First, let's examine a simple case
  - We can see that we have the structure of the station / building modelled
  - We can see that we have deployed the subsystem to the station
  - We can see it is logically connected to the head-end via a simplified comms system



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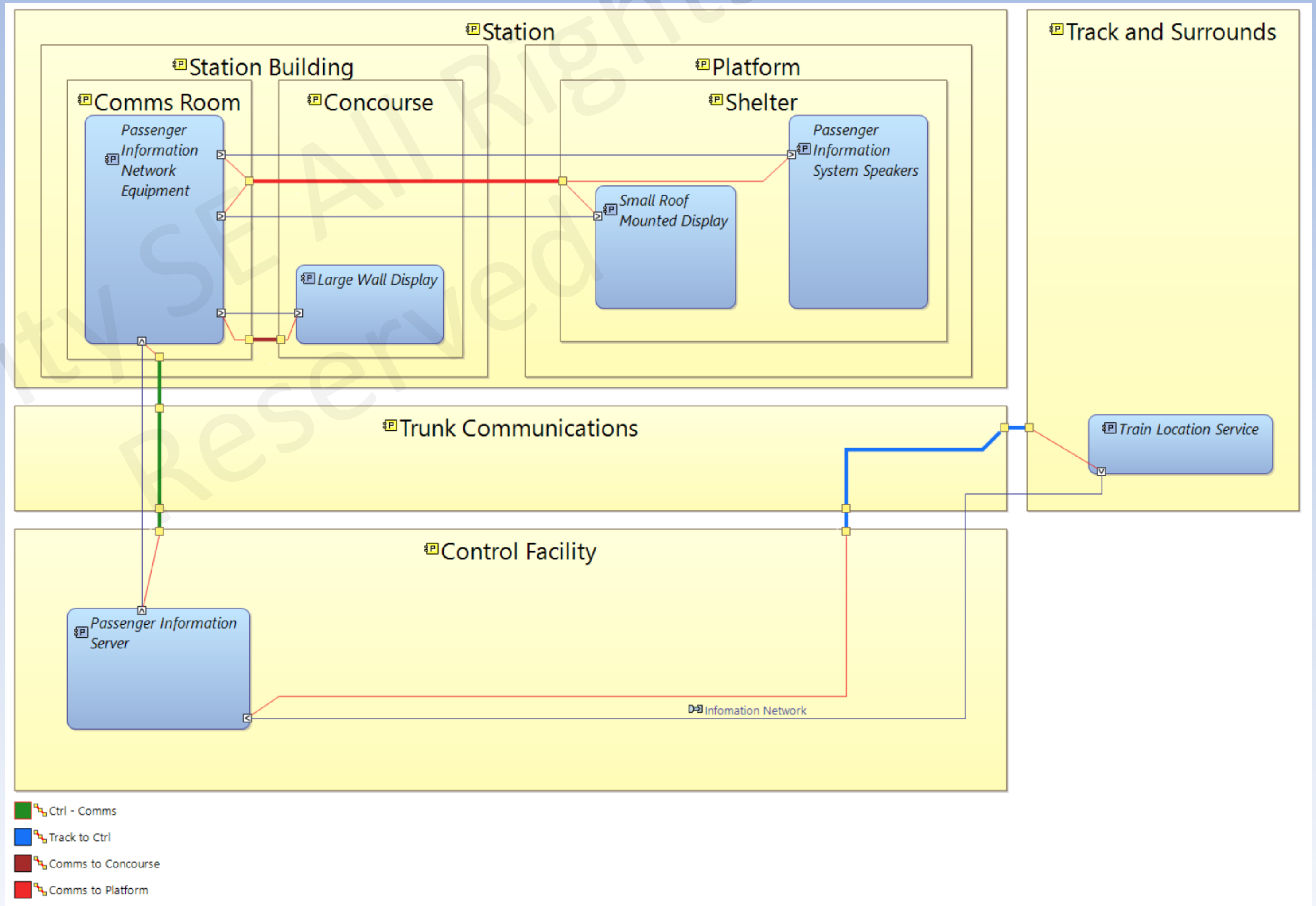
- Now we can add the real physical links rather than conceptual links and start mapping the logical links to the physical links



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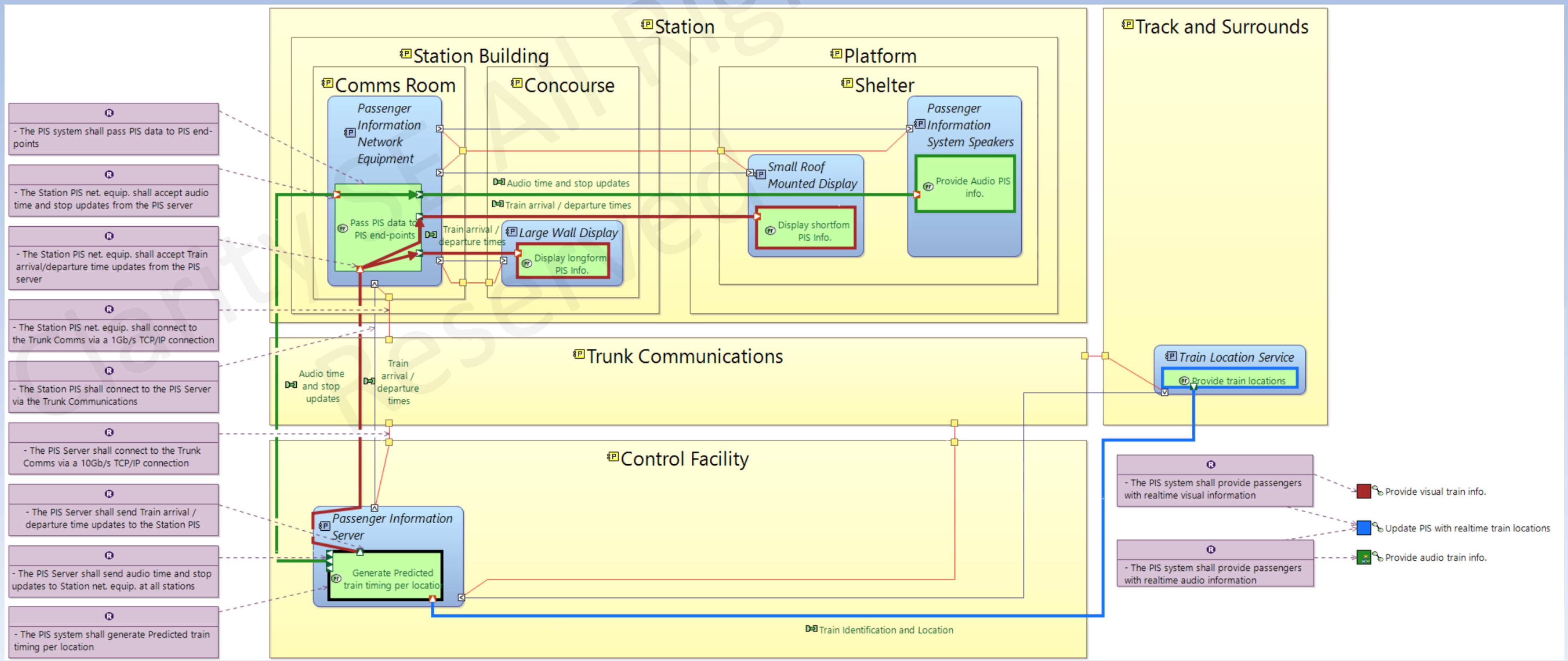
- We can expose where the functions are deployed
- And we can map the requirements to each element of the solution, ensuring nothing is missed



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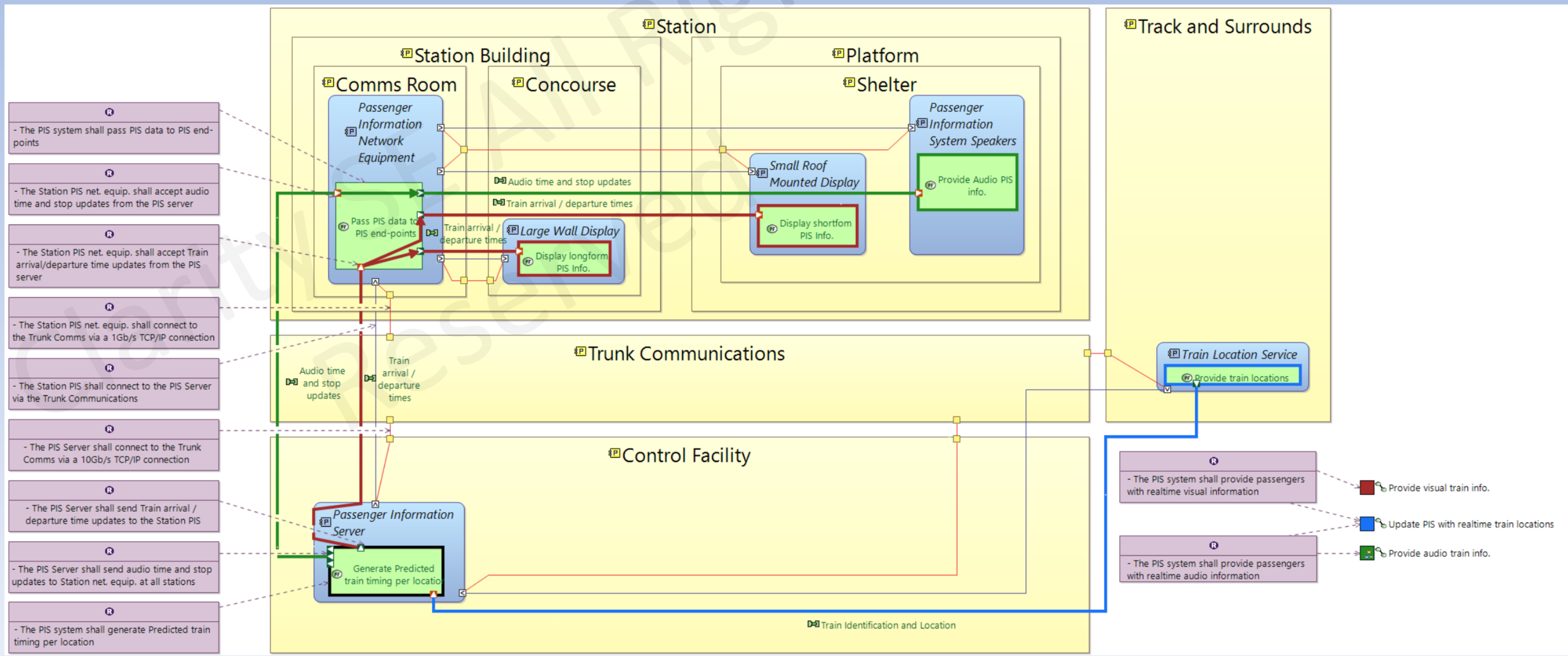
- But, that's not how real systems are built
  - There will be some endpoints repeated multiple times, some not there at all
  - There will be multiple deployments and multiple locations



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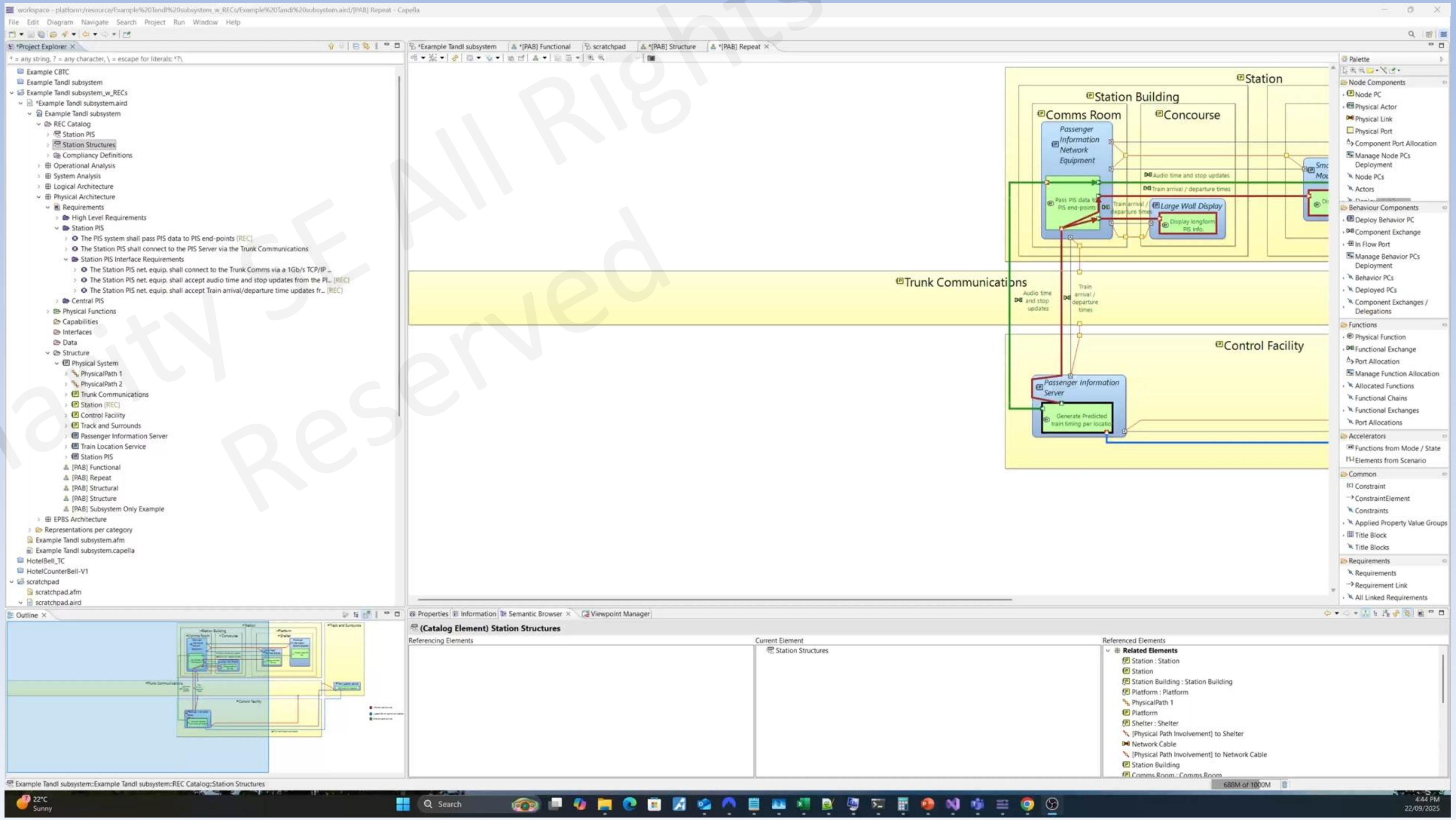
- Taking RECs (Recordings) of elements and deploying them as Replications (RPLs) allows multiple deployments that Transport and Infrastructure projects need



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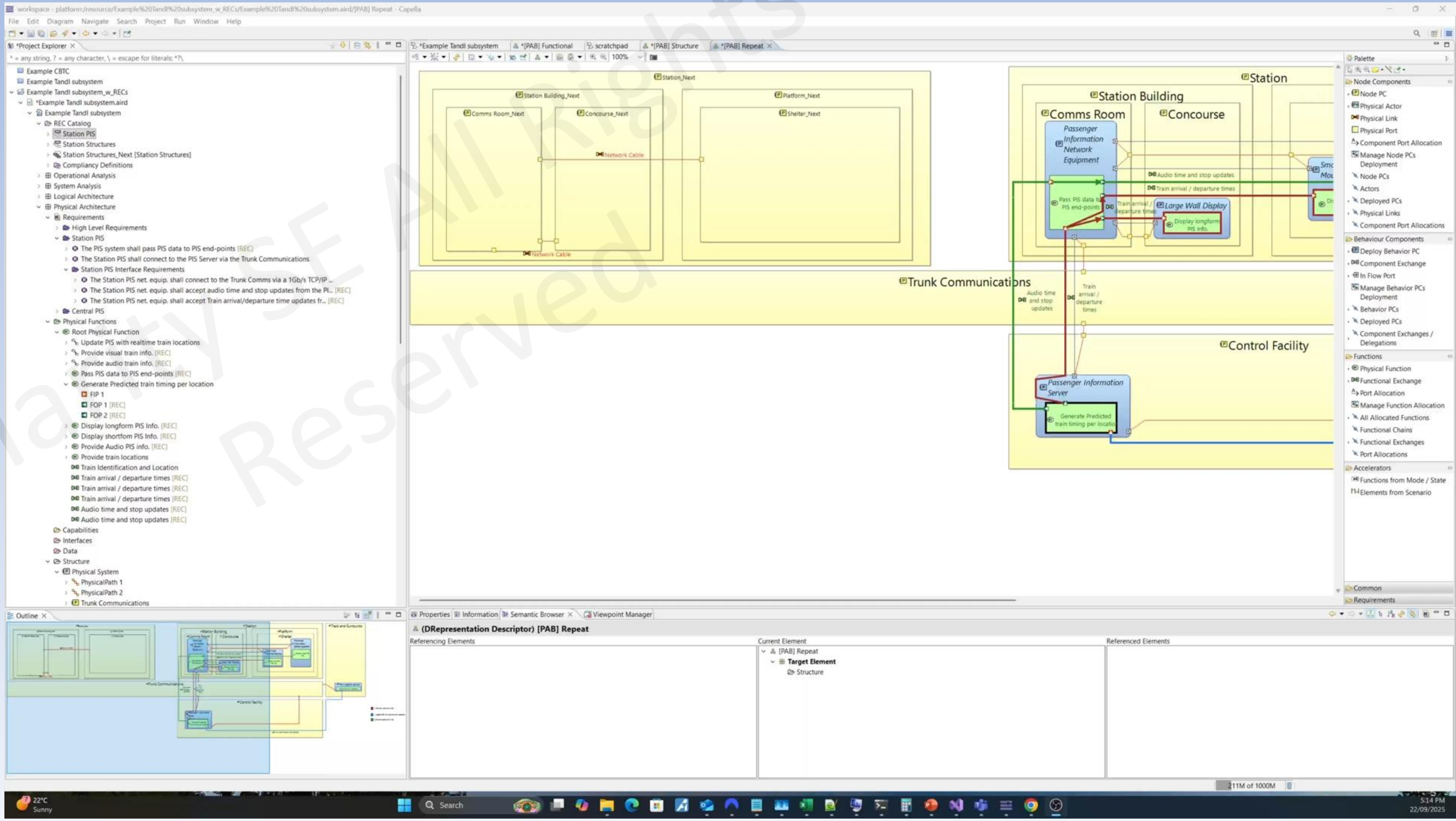

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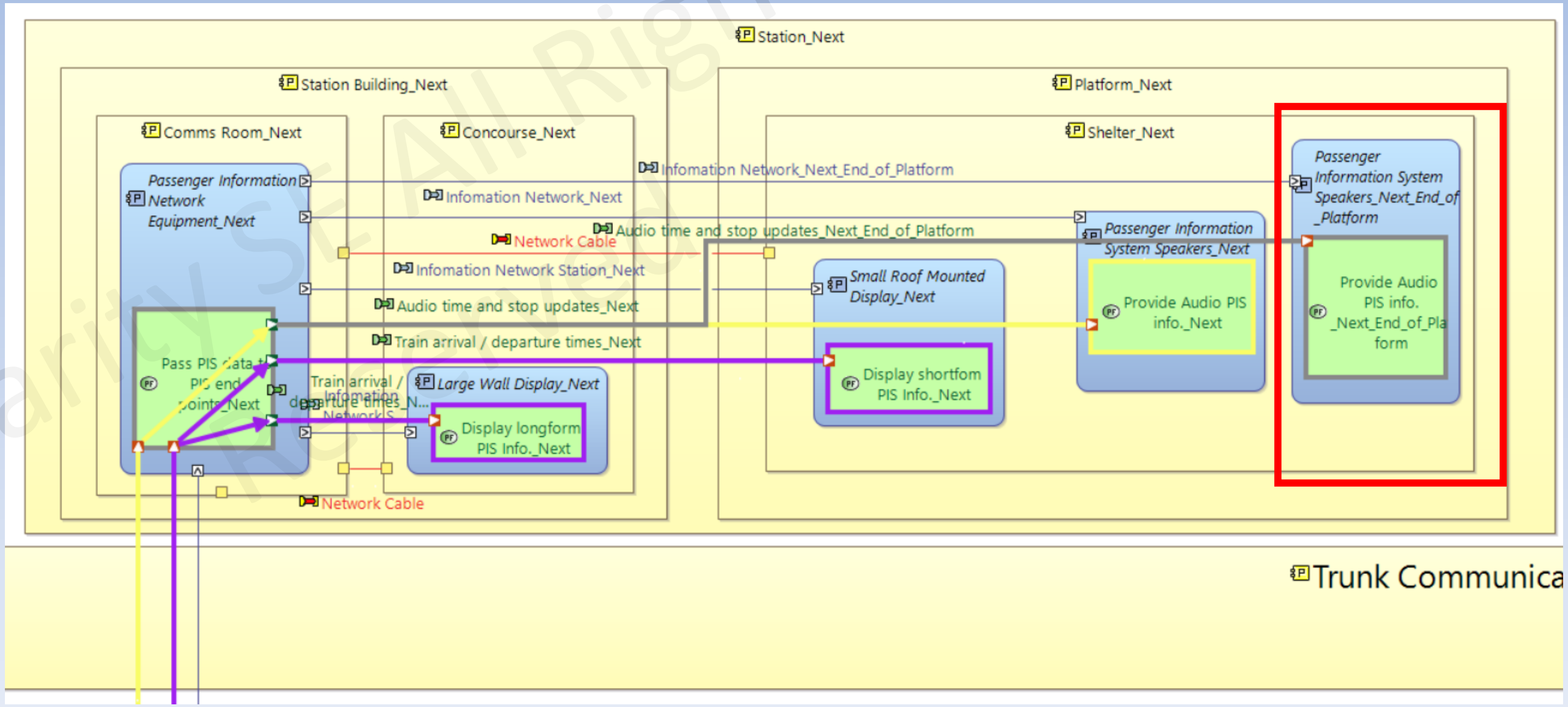
- We can take RECs of RECs as well and this allows us to deploy additional elements of the subsystem, In this case the extra platform speakers



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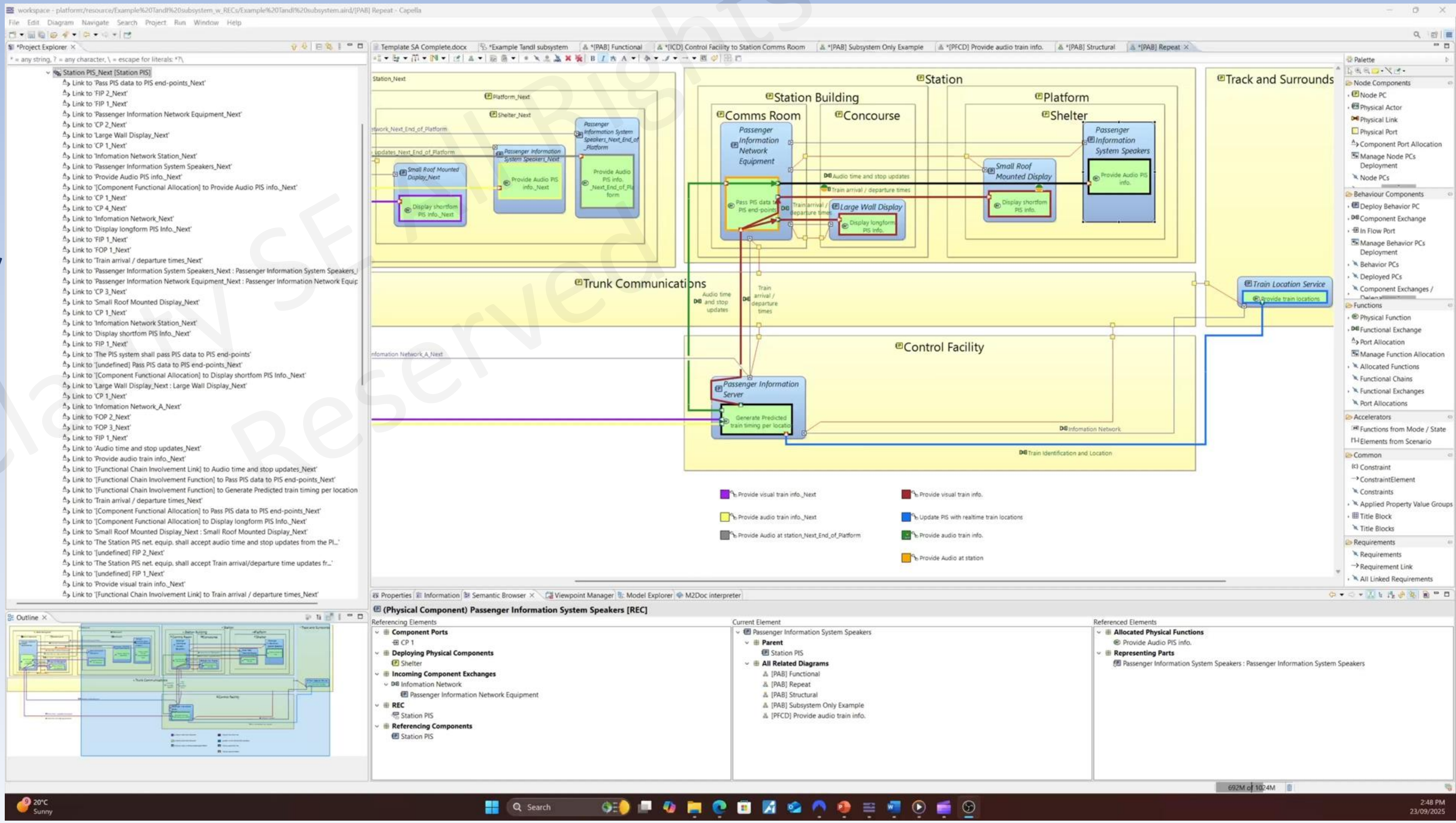
- If the main design (REC) is updated, this can flow through to some / all of the RPLs



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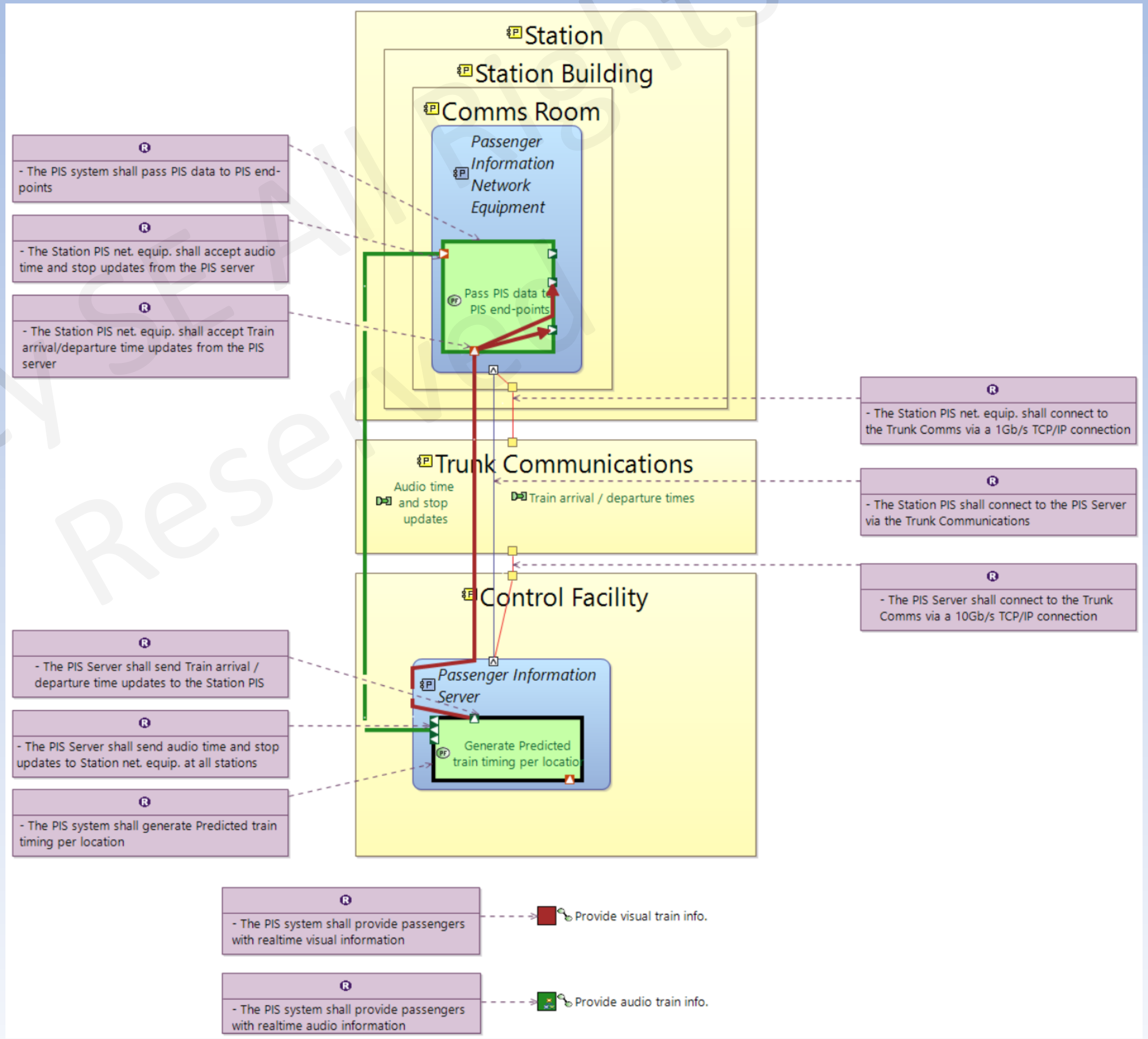
- Interfaces documentation between subsystems can be generated using M2Docs interrogation of well-structured models
- The functional exchanges translate to ‘logical interfaces’
- The Physical Links translate to ‘Physical Interfaces’



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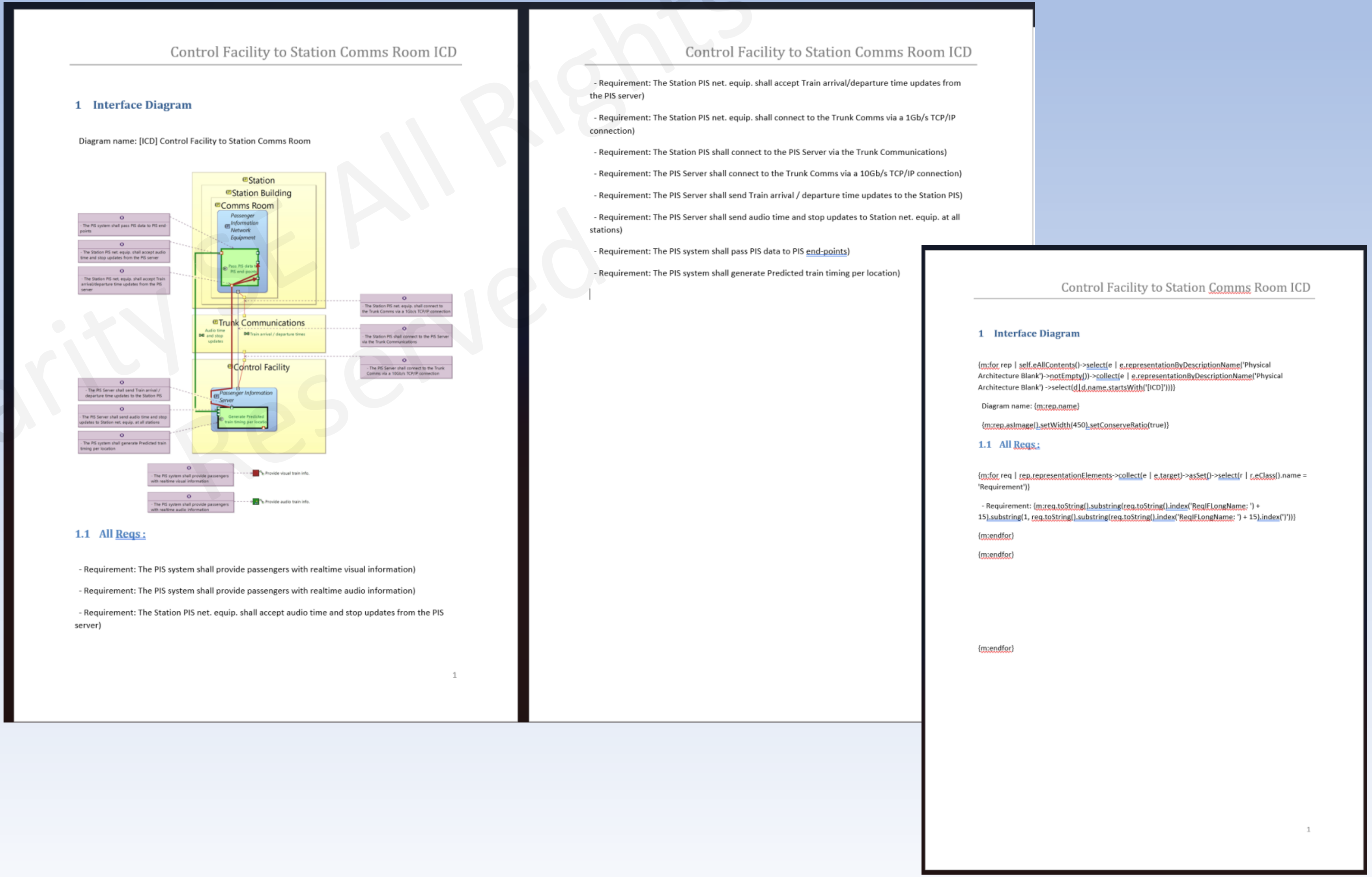
Control Facility to Station Comms Room ICD

1 Interface Diagram

Diagram name: [ICD] Control Facility to Station Comms Room

1.1 All Reqs :

- Requirement: The PIS system shall provide passengers with realtime visual information)
- Requirement: The PIS system shall provide passengers with realtime audio information)
- Requirement: The Station PIS net. equip. shall accept audio time and stop updates from the PIS server)

1

Control Facility to Station Comms Room ICD

- Requirement: The Station PIS net. equip. shall accept Train arrival/departure time updates from the PIS server)
- Requirement: The Station PIS net. equip. shall connect to the Trunk Comms via a 1Gb/s TCP/IP connection)
- Requirement: The Station PIS shall connect to the PIS Server via the Trunk Communications)
- Requirement: The PIS Server shall connect to the Trunk Comms via a 10Gb/s TCP/IP connection)
- Requirement: The PIS Server shall send Train arrival / departure time updates to the Station PIS)
- Requirement: The PIS Server shall send audio time and stop updates to Station net. equip. at all stations)
- Requirement: The PIS system shall pass PIS data to PIS end-points)
- Requirement: The PIS system shall generate Predicted train timing per location)

Control Facility to Station Comms Room ICD

1 Interface Diagram

```
{m:for rep | self.eAllContents()->select(e | e.representationByDescriptionName('Physical Architecture Blank')->notEmpty())->collect(e | e.representationByDescriptionName('Physical Architecture Blank') ->select(d|d.name.startsWith('[ICD]'))))}

Diagram name: {m:rep.name}

{m:rep.asImage().setWidth(450).setConserveRatio(true)}
```

1.1 All Reqs :

```
{m:for req | rep.representationElements->collect(e | e.target)->asSet()->select(r | r.eClass().name = 'Requirement')}

- Requirement: {m:req.toString().substring(req.toString().index('ReqIFLongName: ') + 15).substring(1, req.toString().substring(req.toString().index('ReqIFLongName: ') + 15).index(')'))}

{m:endfor}

{m:endfor}

{m:endfor}
```

1

A passenger information system

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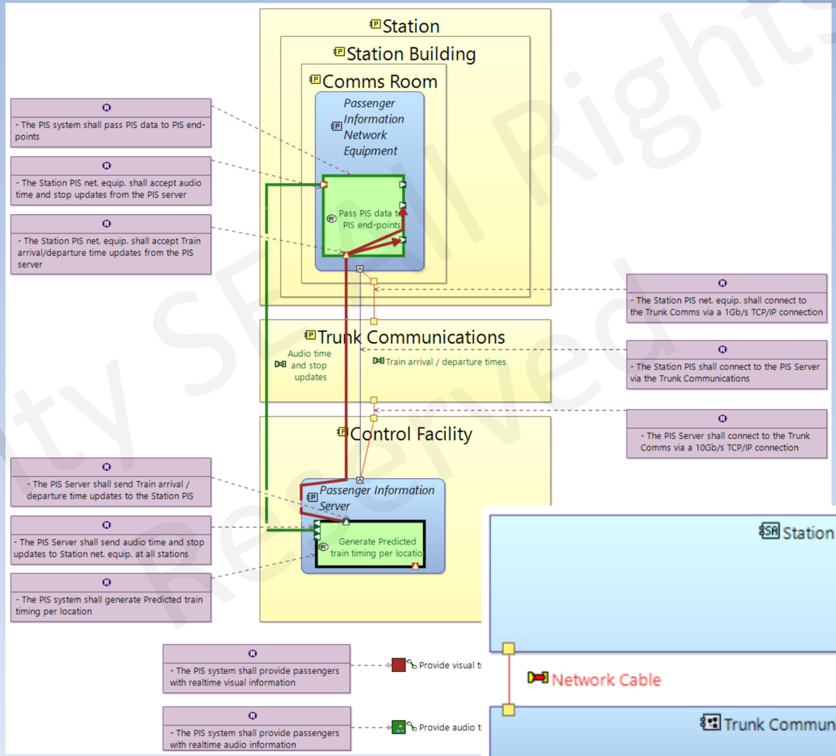
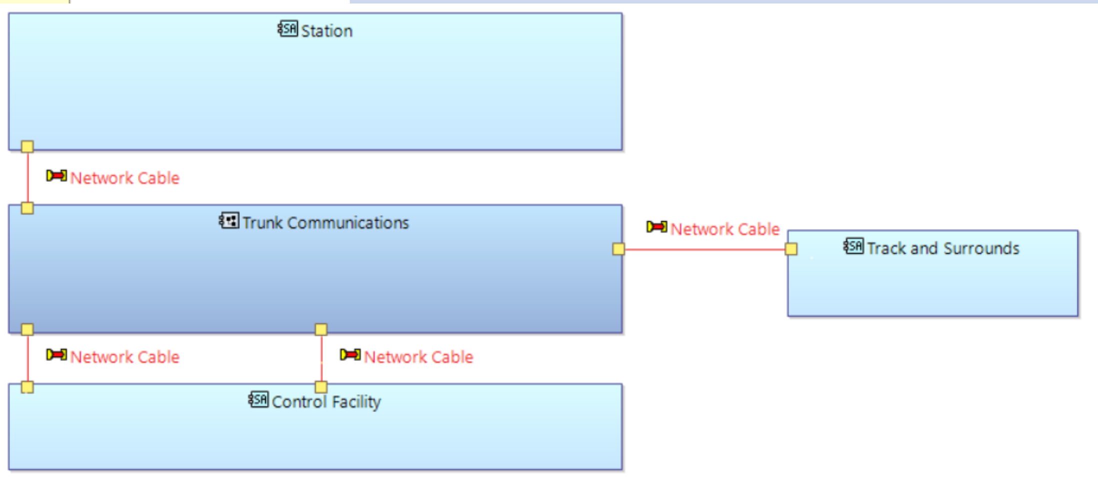
- Now, about that simplified Comms system…
  - Although we have simplified the comms system for the sake of modelling other interfacing subsystems, the comms system still needs to be modelled
  - The System to Subsystem transition allows us to explore the comms system in the appropriate detail and keep it connected to the context of the wider system





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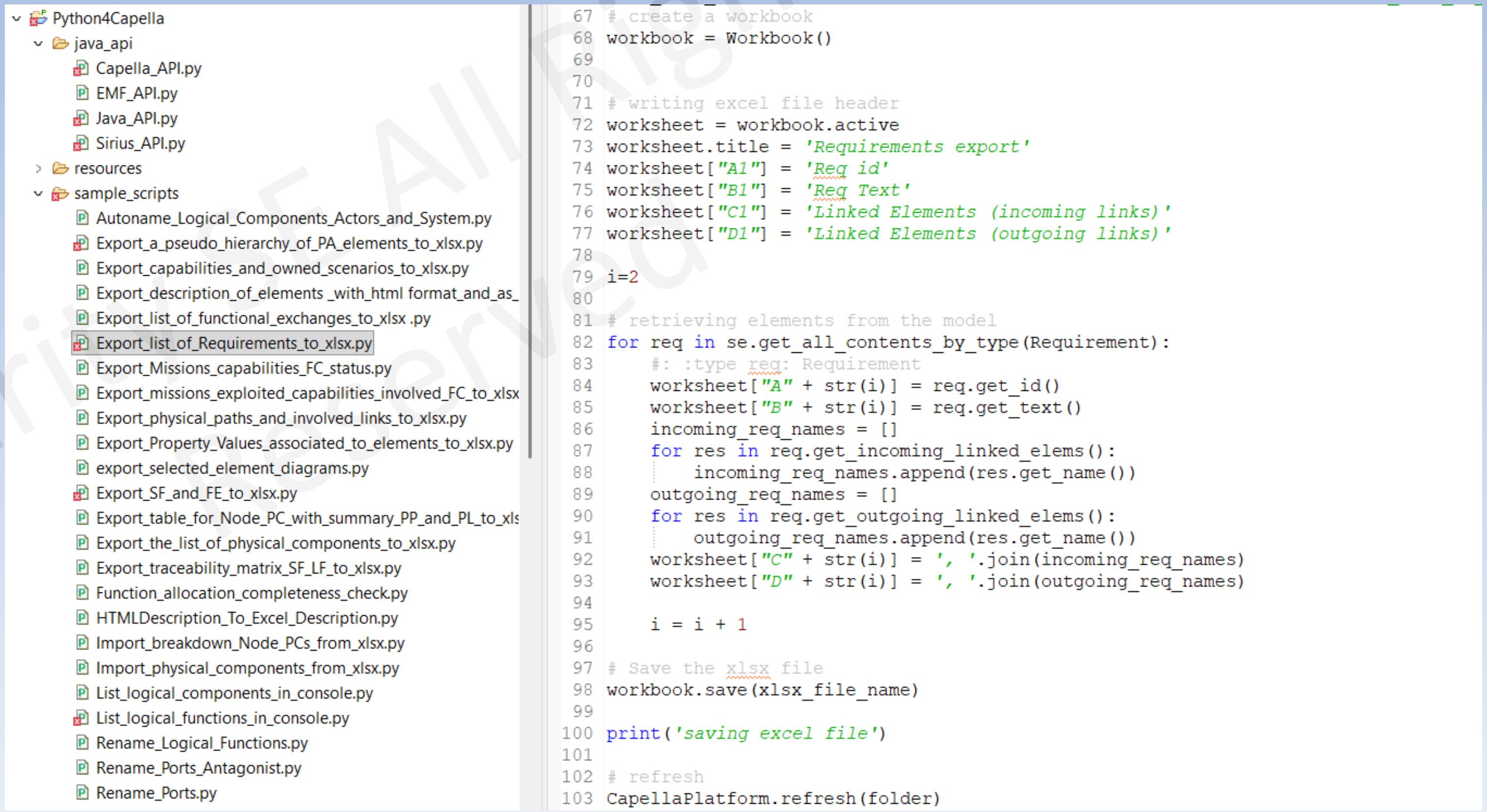
- Ad-hoc report for exchange of data between teams can be generated



Final Thought…

Remember,

“All models are wrong, some are useful”

“Know what the problem is you’re trying to solve,
Know how the model contributes,
Know when to stop!”

Thank You.

And please talk to your Systems Engineering professionals!