26th annual INCOSE international symposium

Edinburgh, UK

July 18 - 21, 2016

Case Study: A Model Based Systems Engineering (MBSE) Framework for Characterising Transportation Systems Over the Full Life Cycle

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Overview

- Introduction
- Transport Infrastructure Procurement Challenges
- Overview of the Approach
- Examples of the Framework
- Lessons Learnt
- Conclusion

Introduction: Objectives of Work with ASA in TfNSW

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- UOW SMART is working with the ASA Systems Engineering Process Network and Standards Section to apply Model Based Systems Engineering (MBSE) to meet the needs of TfNSW for High Level Planning Capability across the organisation. This includes:
  - Asset Stewardship,
  - Standards Realignment and Management,
  - Support for Competency Frameworks,
  - Knowledge Management for the very complex System of Systems involved- interdependencies, traceability, stakeholder Views, intermediate states during acquisition, environmental issues, …
  - Introducing MBSE into TfNSW organisations

Transport Procurement Challenges

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- Asset Management of Upgrades
  - Some upgrades only apply to some areas of the transport network
    - Network contains multiple technologies
  - Rollout can take significant time
    - Transition periods will have multiple technologies with different implementation timelines
- Safety Assurance
  - Need to protect against unsafe configurations, working conditions, response to incidents
- Diversity of locations and contexts
  - Transport lines pass through multiple regions
    - Multiple conditions to manage
    - Increases stakeholders numbers and type (such as local councils)
- Multi-ownership of Systems
  - Responsibility for some systems are shared between organisations and users
    - E.g. Rail network shared between freight and passengers
  - Different organisations owning different aspects of the system
    - Operation vs maintenance vs upgrades
- ASA also has the challenge of getting a mature organisation to adopt the use of MBSE approaches to its ongoing modernisation demands

Overview of the Approach

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- Use an Architecture Framework to:
  - Capture design drivers
    - Top-down drivers from enterprise goals and needs
    - Bottom-up drivers based on existing standards, assets and operations
  - Merge to form a generic system depiction
    - Map future and existing systems
    - Identify dependencies and interrelationships
    - Outline evolution of system over time
- UoW began by working in parallel with ASA
    - Both using TRAK
    - ASA using UML, UoW using SysML
    - UoW began looking into other AF representations
  - Found that UPDM was more suited to TfNSW needs
- Both models were then merged utilising the best approaches and representations for either model to produce the “Transport Network Architecture Framework” or TNAF
  - SysML
  - Ability to support multiple AFs as needed

Modelling with Views

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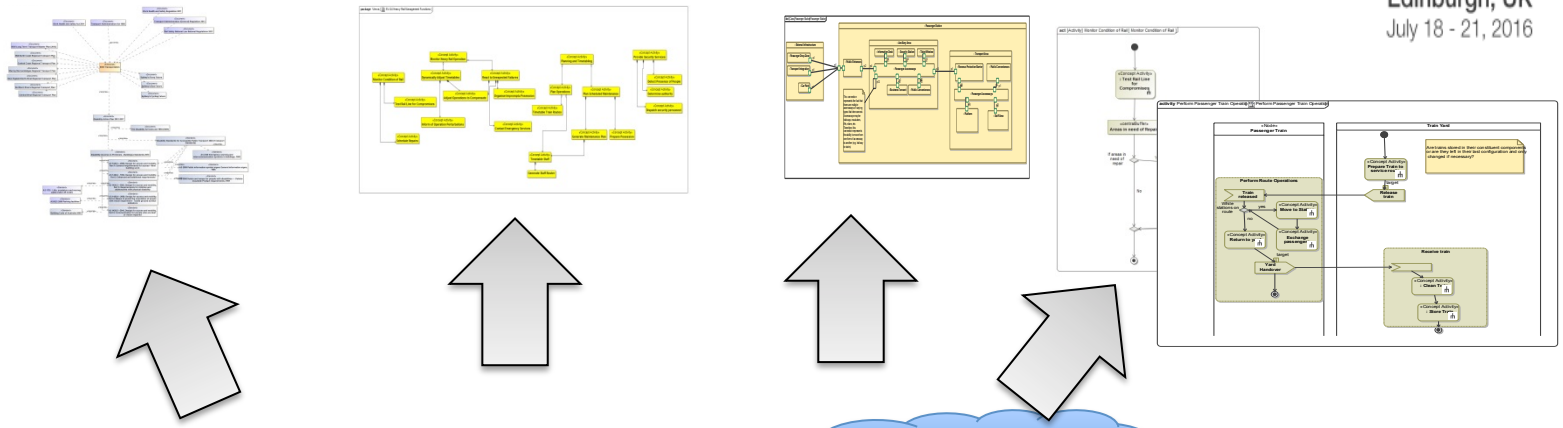

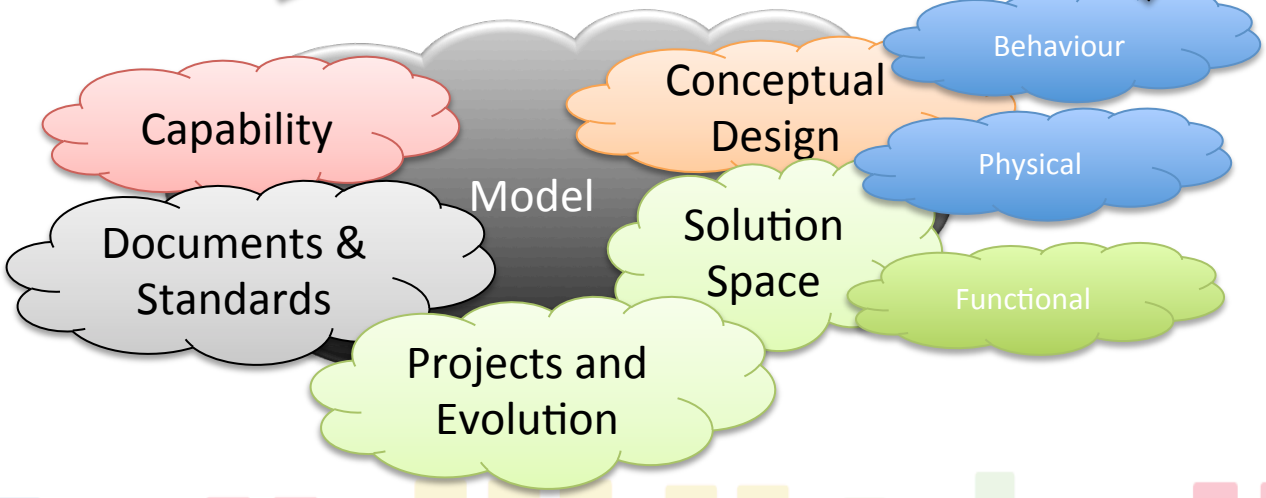

Multiple perspectives of the same data

Tailored to audience

Conversion from Existing Disparate Documents to an Integrated Model

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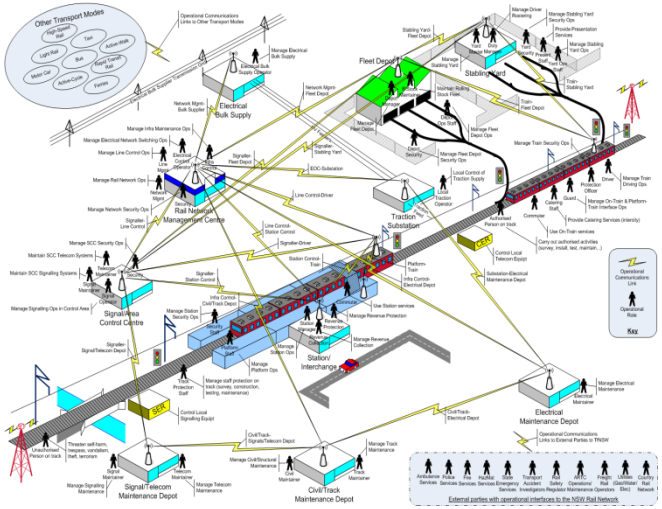
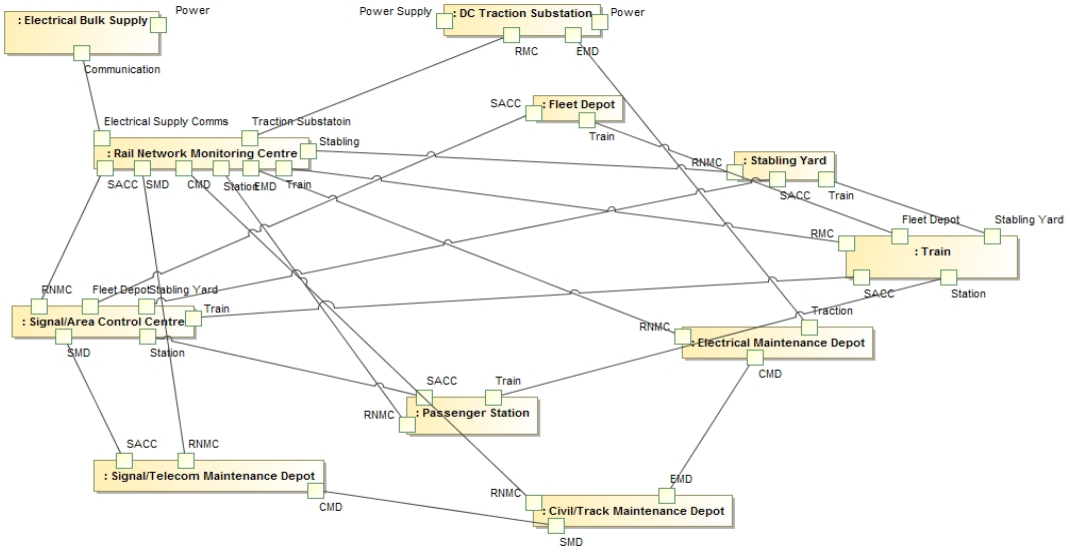
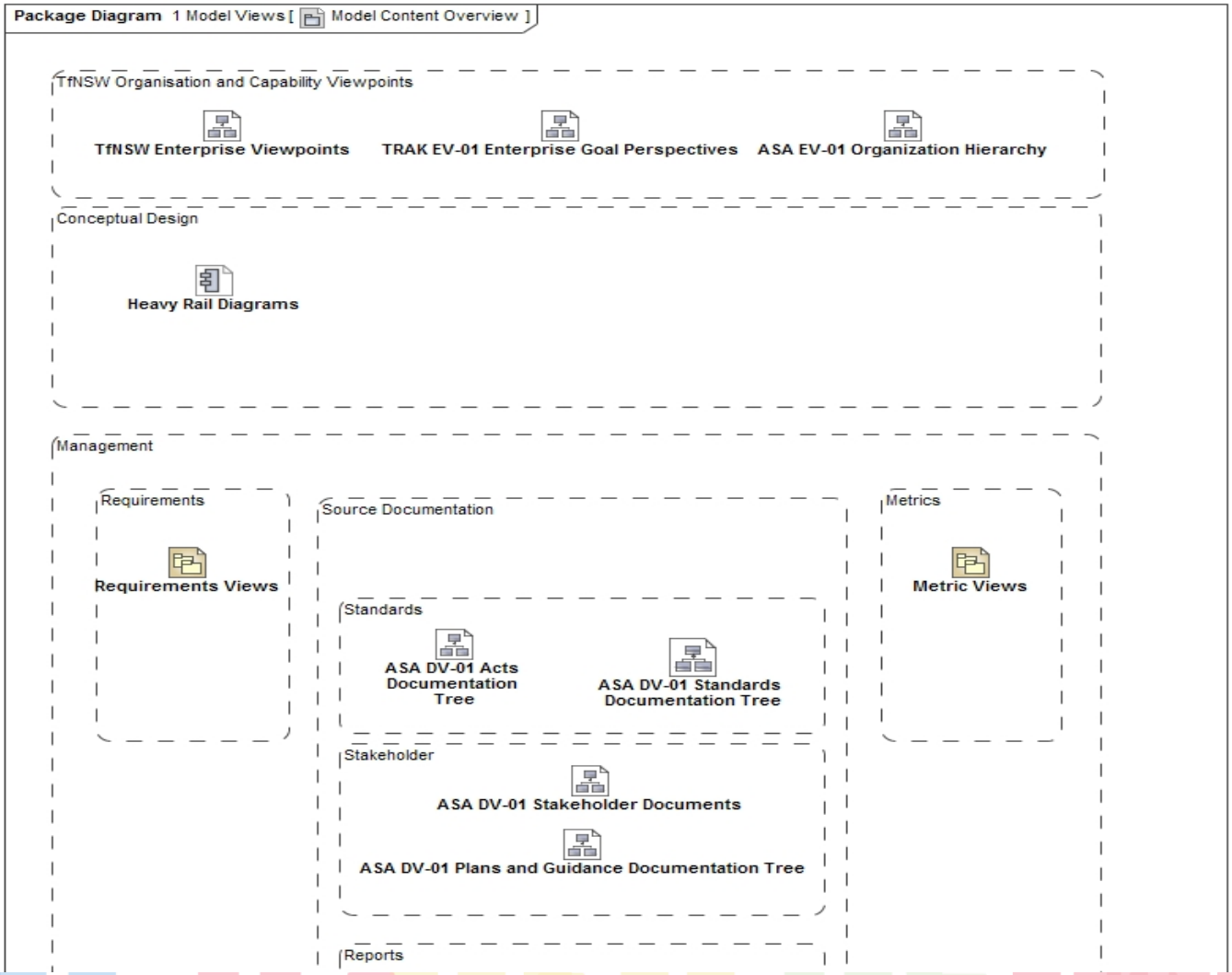
Source



Model



Overview of TNAF Contents



Selected Views of Model Components Developed to Date

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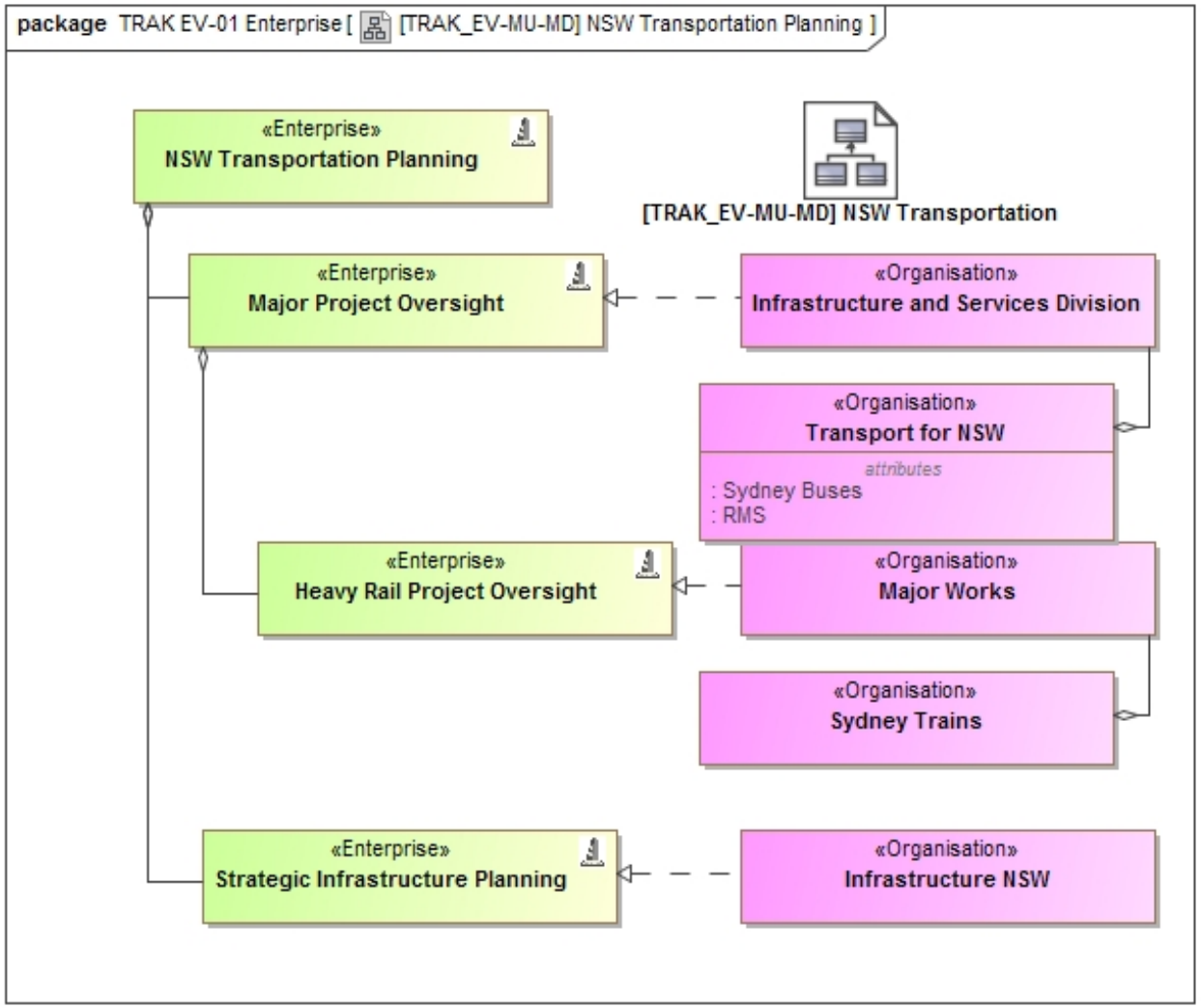
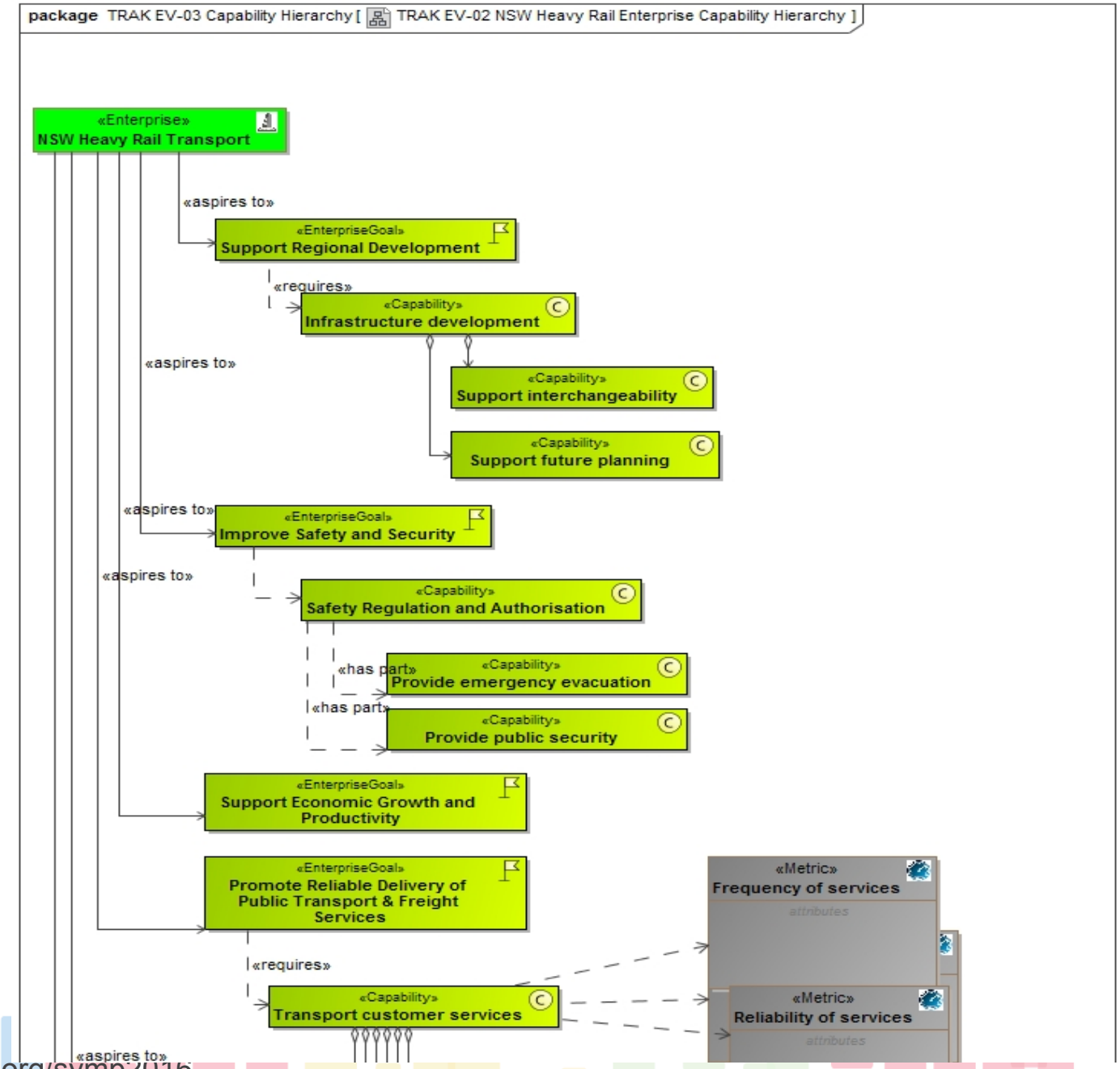
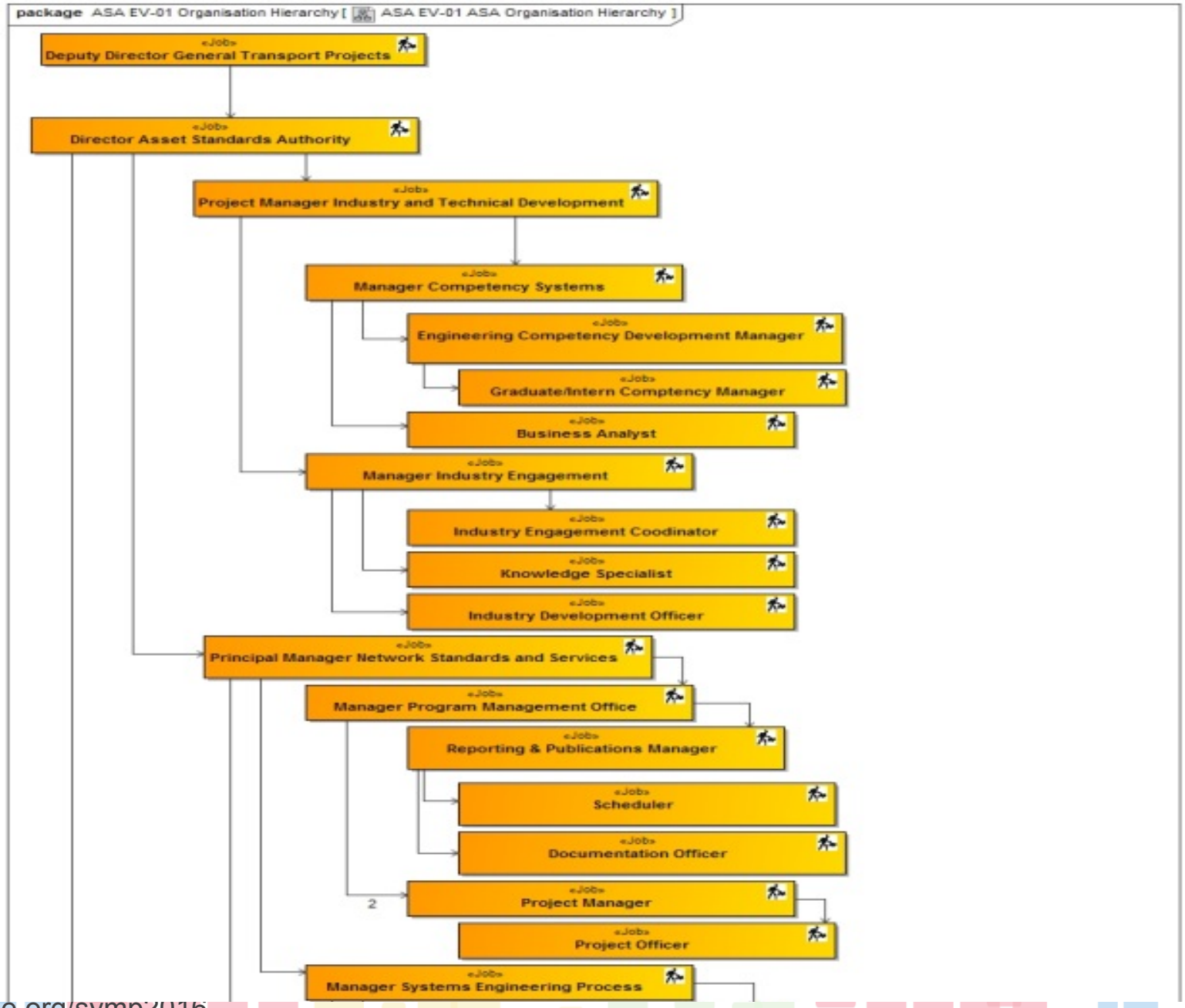
- The following slides show various components of the model that have been developed to date.
- So far the work has identified and developed:
  - 490+ Diagrams
  - 4630+ Elements
  - 9420 + relationships
- Degree of development is variable and depends on both the need to demonstrate the capabilities of the approach and developments related to stakeholders beyond ASA

Examples of the Framework


package TRAK EV-01 Enterprise [[TRAK_EV-MU-MD] NSW Transportation Planning]
«Enterprise»
NSW Transportation Planning
[TRAK_EV-MU-MD] NSW Transportation
«Enterprise»
Major Project Oversight
«Organisation»
Infrastructure and Services Division
«Organisation»
Transport for NSW
attributes
: Sydney Buses
: RMS
«Enterprise»
Heavy Rail Project Oversight
«Organisation»
Major Works
«Organisation»
Sydney Trains
«Enterprise»
Strategic Infrastructure Planning
«Organisation»
Infrastructure NSW


package TRAK EV-03 Capability Hierarchy [TRAK EV-02 NSW Heavy Rail Enterprise Capability Hierarchy]
«Enterprise»
NSW Heavy Rail Transport
«aspires to»
«EnterpriseGoal»
Support Regional Development
«requires»
«Capability»
Infrastructure development
«aspires to»
«Capability»
Support interchangeability
«Capability»
Support future planning
«aspires to»
«EnterpriseGoal»
Improve Safety and Security
«aspires to»
«Capability»
Safety Regulation and Authorisation
«has part»
«Capability»
Provide emergency evacuation
«has part»
«Capability»
Provide public security
«EnterpriseGoal»
Support Economic Growth and Productivity
«EnterpriseGoal»
Promote Reliable Delivery of Public Transport & Freight Services
«requires»
«Capability»
Transport customer services
«aspires to»
«Metric»
Frequency of services
attributes
«Metric»
Reliability of services
attributes


package ASA EV-01 Organisation Hierarchy [ASA EV-01 ASA Organisation Hierarchy]
«Job»
Deputy Director General Transport Projects
«Job»
Director Asset Standards Authority
«Job»
Project Manager Industry and Technical Development
«Job»
Manager Competency Systems
«Job»
Engineering Competency Development Manager
«Job»
Graduate/Intern Comptency Manager
«Job»
Business Analyst
«Job»
Manager Industry Engagement
«Job»
Industry Engagement Coodinator
«Job»
Knowledge Specialist
«Job»
Industry Development Officer
«Job»
Principal Manager Network Standards and Services
«Job»
Manager Program Management Office
«Job»
Reporting & Publications Manager
«Job»
Scheduler
«Job»
Documentation Officer
2
«Job»
Project Manager
«Job»
Project Officer
«Job»
Manager Systems Engineering Process

Station Physical Hierarchy

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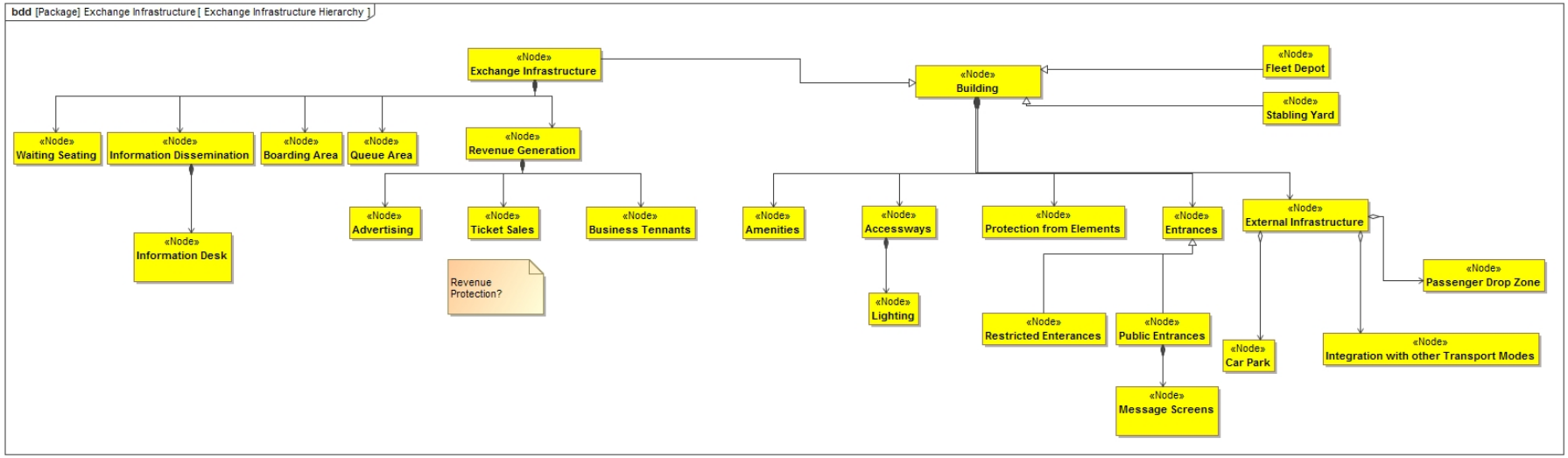
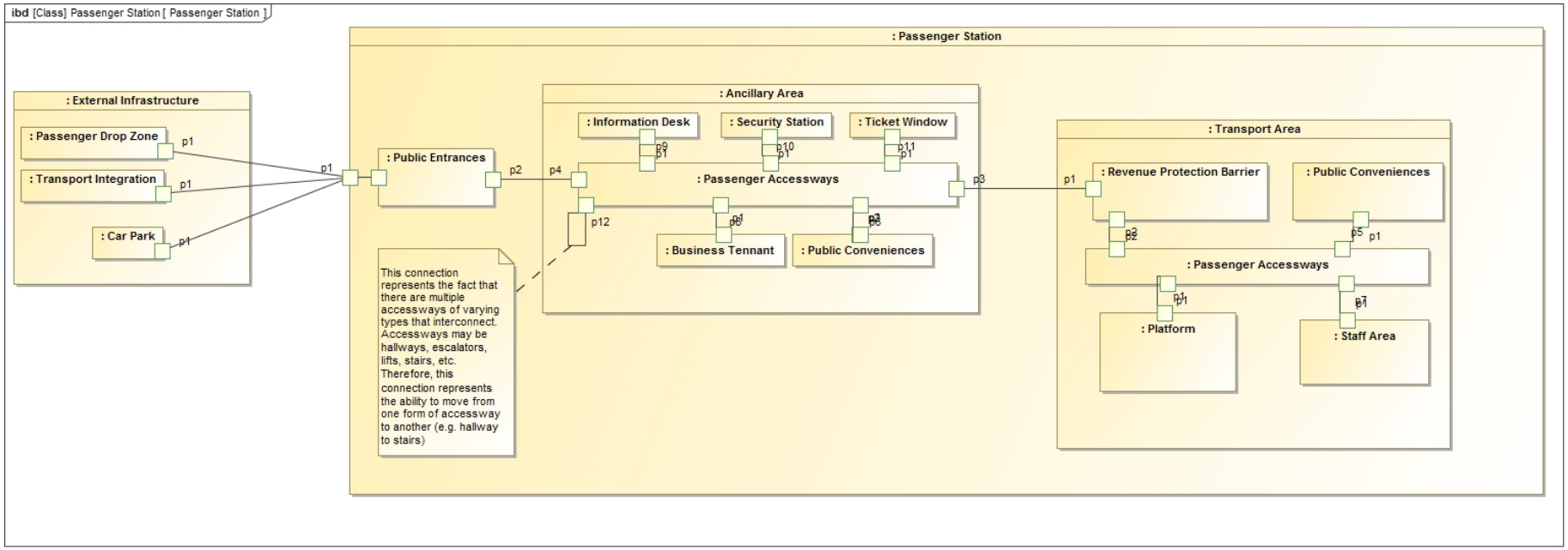
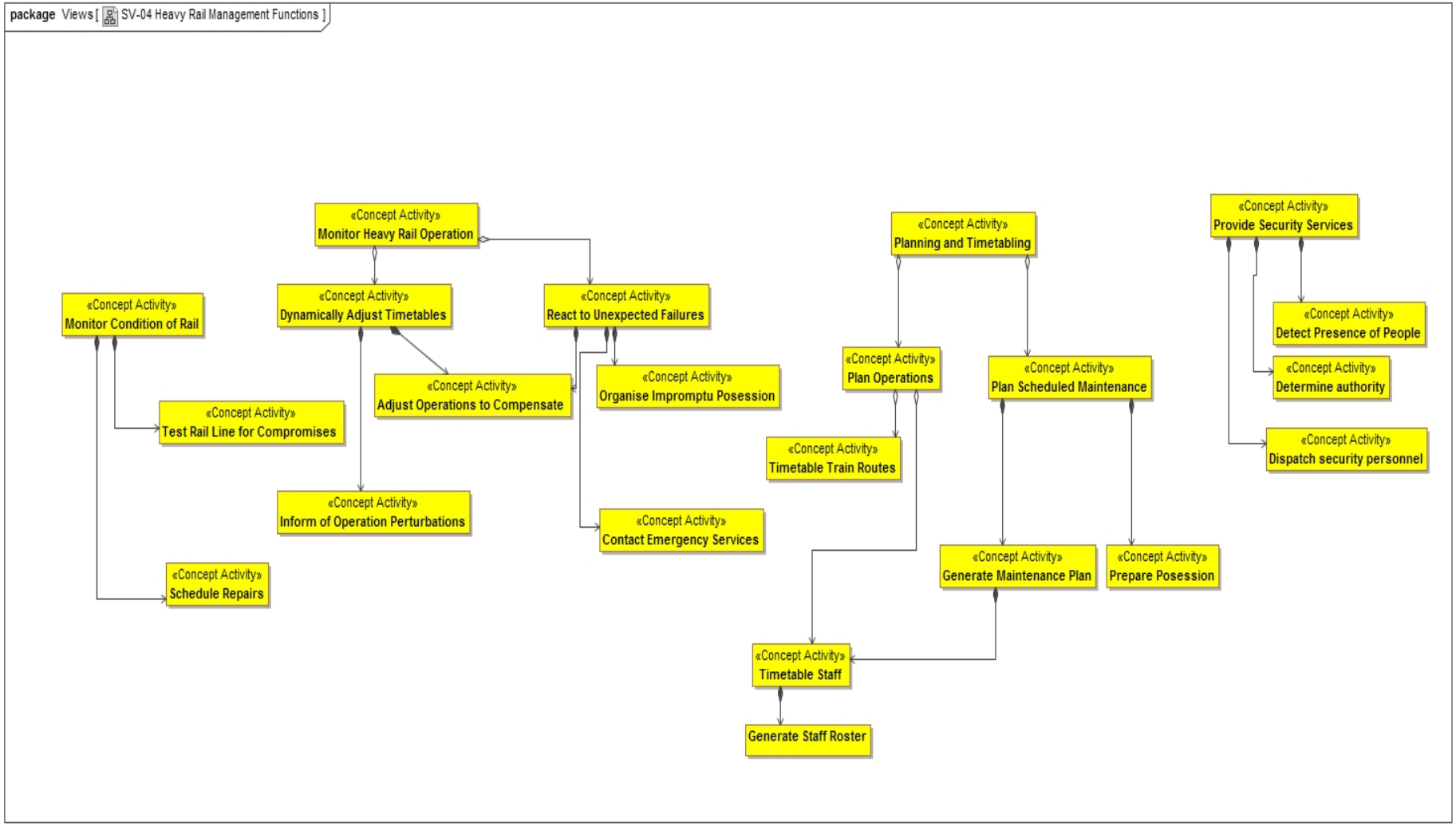


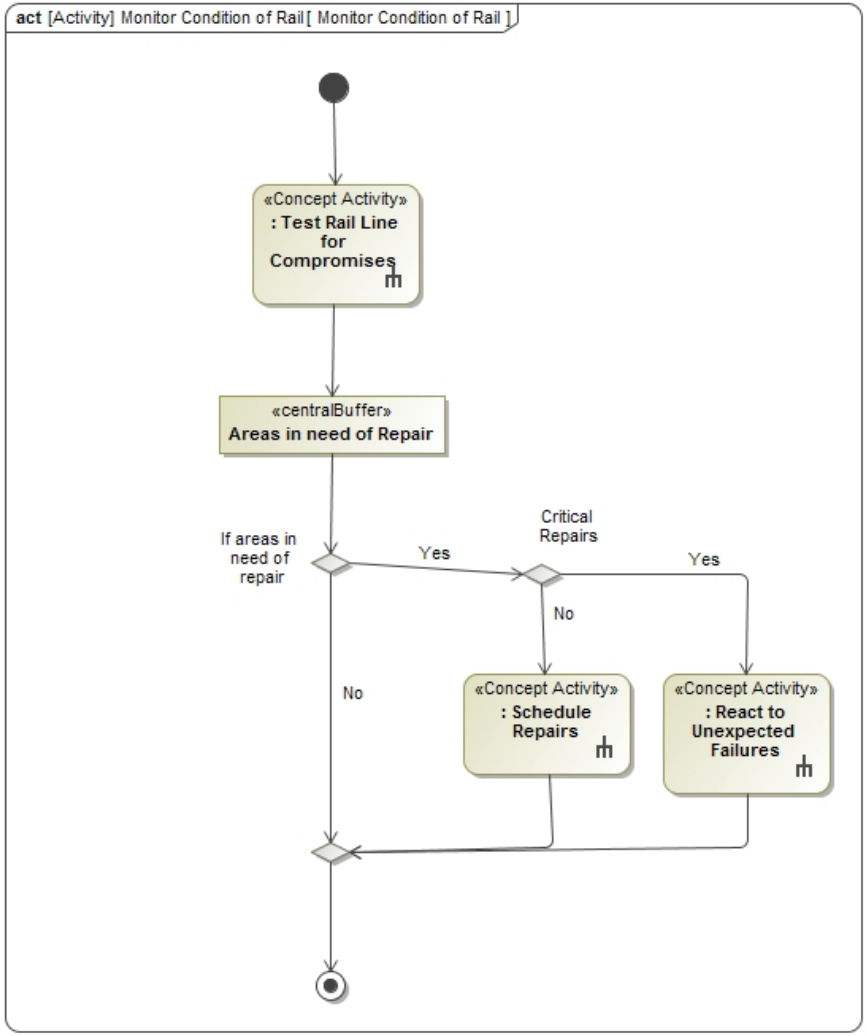
Station Internal Architecture



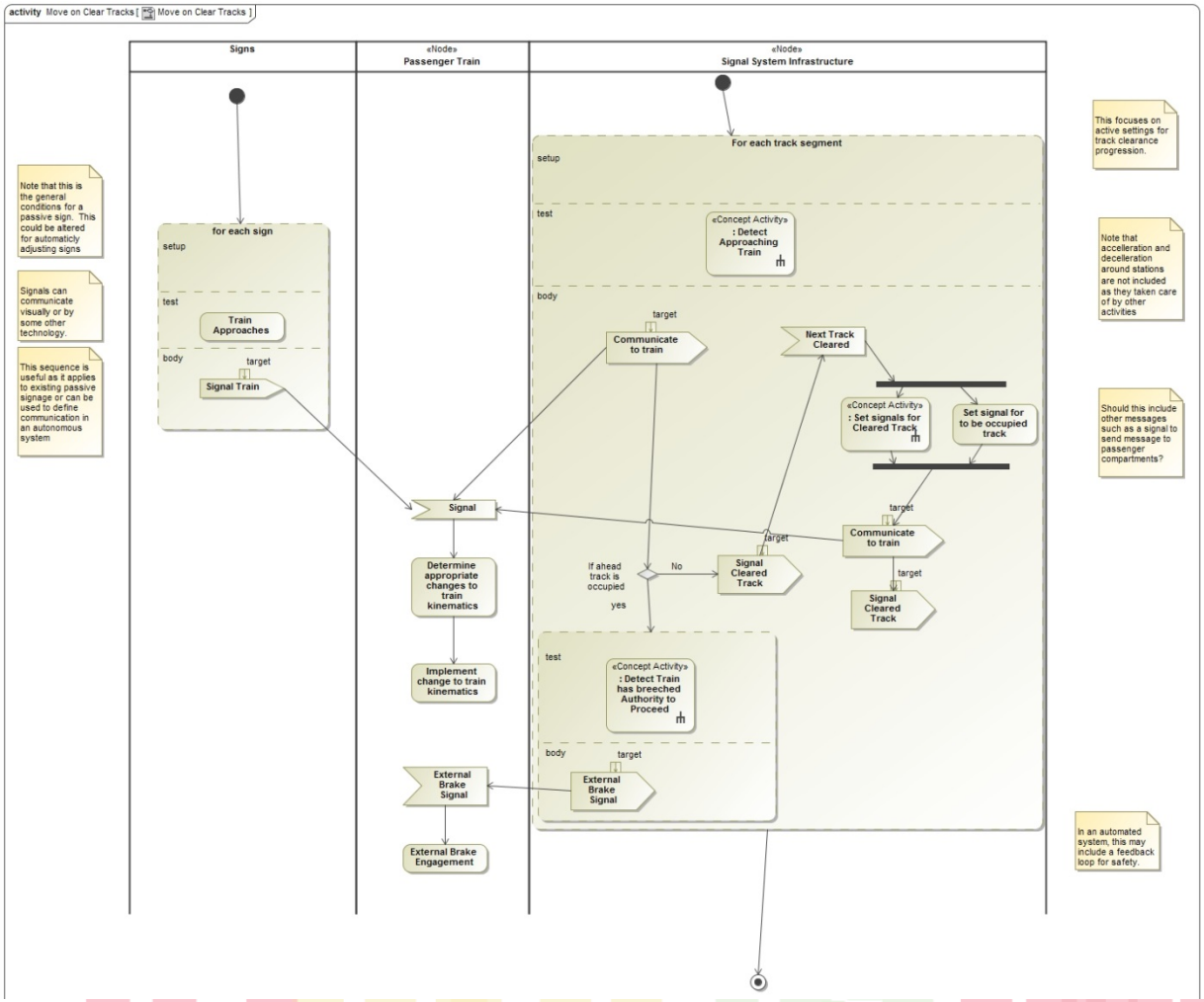
Heavy Rail Management Functions

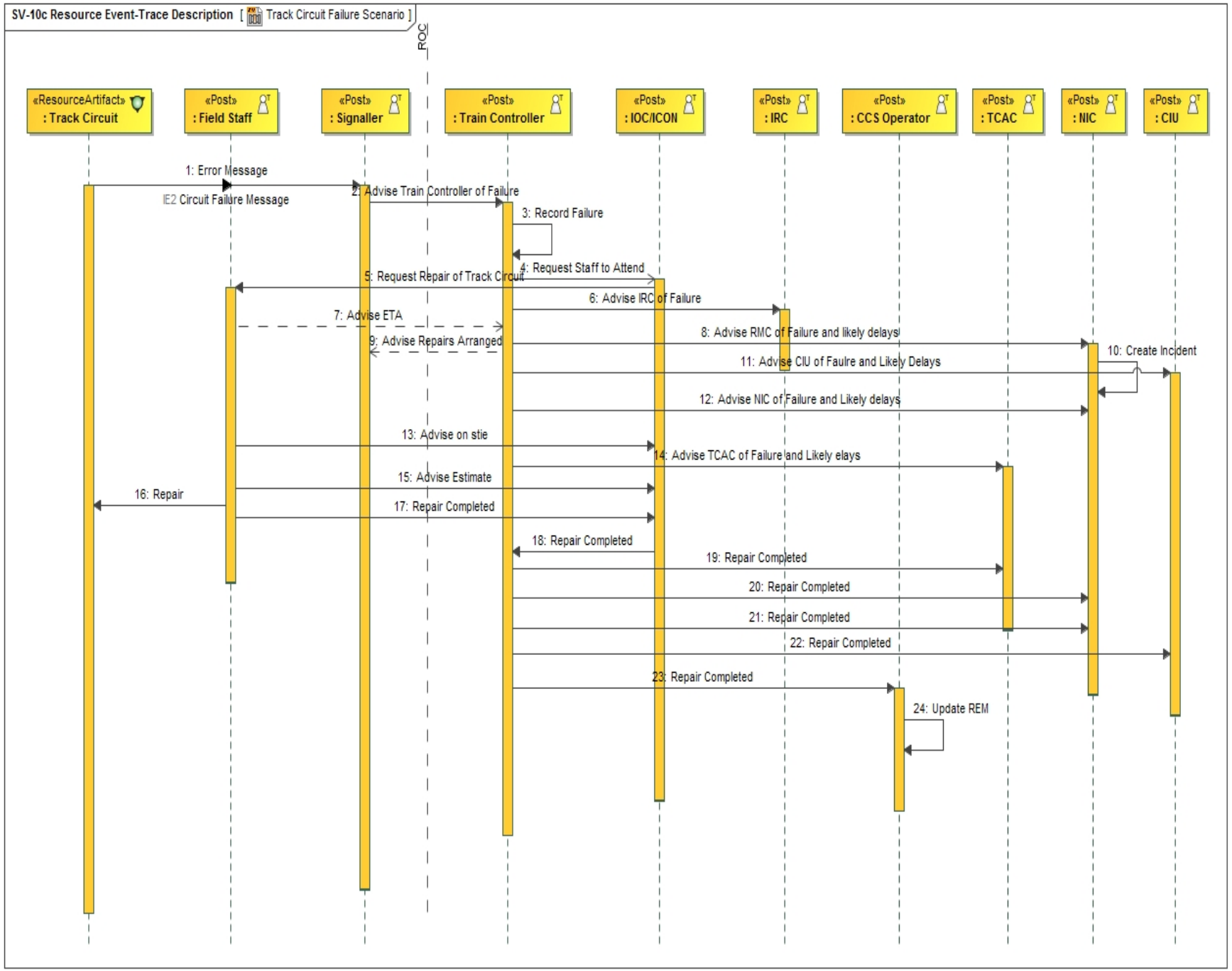


Activity Diagram
Monitor Condition of Rails

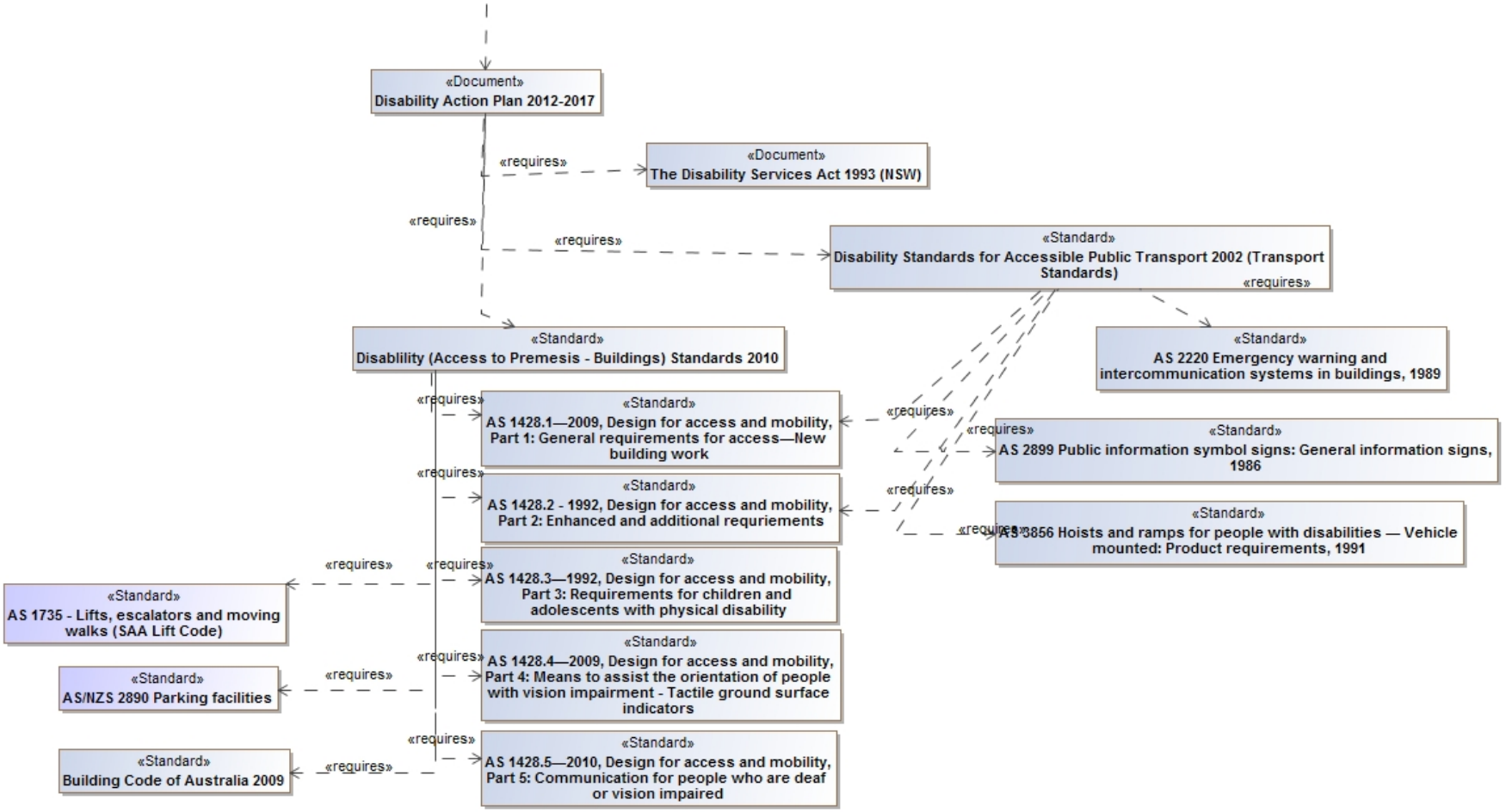


Behaviour Modelling: Move on Clear Tracks



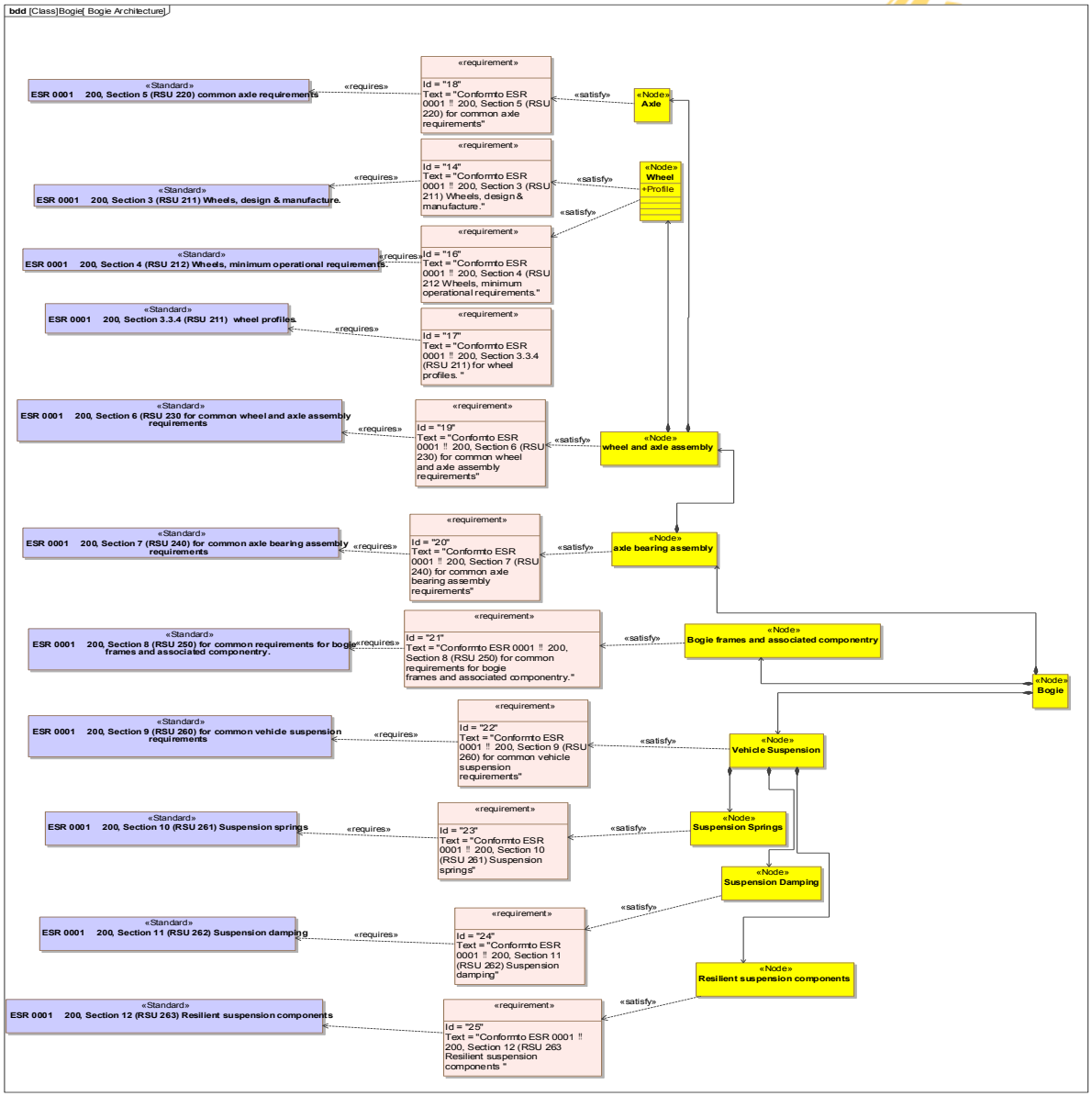

SV-10c Resource Event-Trace Description [Track Circuit Failure Scenario]
ROC
«ResourceArtifact» : Track Circuit
«Post» : Field Staff
«Post» : Signaller
«Post» : Train Controller
«Post» : IOC/ICON
«Post» : IRC
«Post» : CCS Operator
«Post» : TCAC
«Post» : NIC
«Post» : CIU
1: Error Message
IE2 Circuit Failure Message
2: Advise Train Controller of Failure
3: Record Failure
4: Request Staff to Attend
5: Request Repair of Track Circuit
6: Advise IRC of Failure
7: Advise ETA
8: Advise RMC of Failure and likely delays
9: Advise Repairs Arranged
10: Create Incident
11: Advise CIU of Faulre and Likely Delays
12: Advise NIC of Failure and Likely delays
13: Advise on stie
14: Advise TCAC of Failure and Likely elays
15: Advise Estimate
16: Repair
17: Repair Completed
18: Repair Completed
19: Repair Completed
20: Repair Completed
21: Repair Completed
22: Repair Completed
23: Repair Completed
24: Update REM

Document library

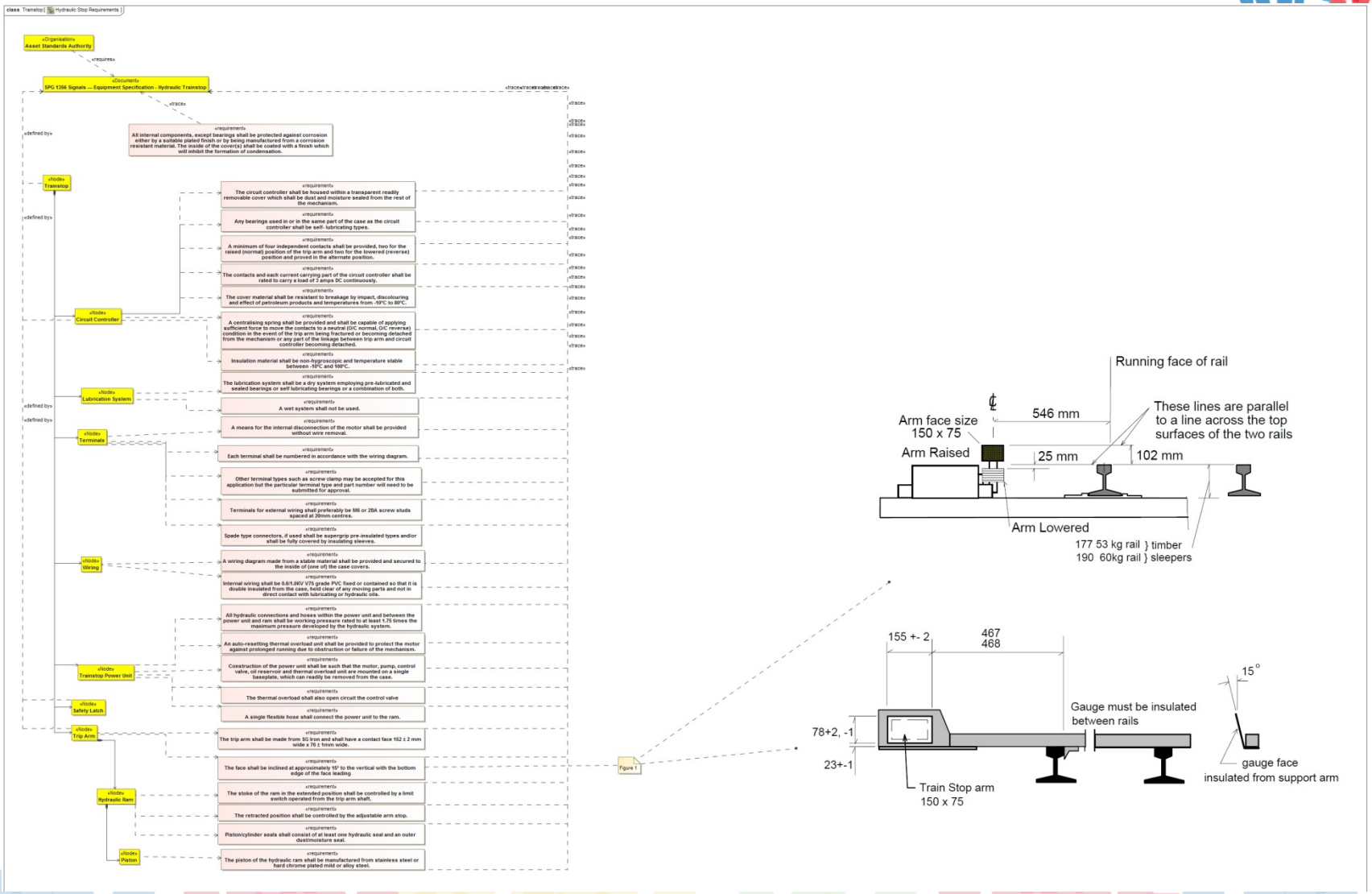


Standard Compliance for System Element

- There are often a multitude of standards that a system element needs to comply with either directly or in some of its sub-elements
- Figure shows system composition in yellow
- Requirements that relate to elements are shown in pink
- Standards that are referenced by the requirements are shown in purple



Requirements Extraction



Lessons Learnt

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- Drafting of structure and Iteration is Important
- The architecture tool can be used to bind other tools to form a consolidated SE Tool Environment
- Separation of the underlying structure from the views:
  - Encourages reuse, Makes explicit separation of views from data
  - Improves understanding
- SME/Stakeholder engagement crucial
- Transforming Interest into Engagement
  - While many consider the tool as beneficial, it is difficult to get commitment/resources from stakeholders
  - Largely due to internal pressures and lack of their own time & resources
- Development of multiple views of the same interactions
  - Sydney Trains – train control
  - Customer Experience Division - the Commuter's experience from door to destination
    - Both of these are alternative views of the same situation where changes to one will effect the other

Enhancement of Tool for Better Support

- The tools provide substantial functionality “out of the box”
- We found that many of the mundane activities could be accomplished through automation
  - Saves time which can then be spent on greater development
- Bringing together the variety of information into a single location gives rise to great opportunity to validate the collective set
- More on these enhancements in the presentation: Case Study: Customised Enhancement of an MBSE Environment for Transport Infrastructure Projects
-

Future Work

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- Continue top level model development
- Effect of new technologies on track worker safety
- Effect of new technologies on all human roles in rail operations
- Asset management for rolling stock
- MBSE for new digital systems
- Competency modelling for ICM system

Conclusion

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- We have begun development of a framework designed to better understand the transport network in NSW
  - Development will continuously evolve across a number of projects into the foreseeable future
- This framework provides a better understanding of the heavy rail system
  - Future projects can be mapped onto the framework to better understand what is needed
- This heavy rail model has also been genericised so that it can:
  - Apply to other modes of transport
  - Support commuters undertaking multi-modal transport
- The framework also acts as a conduit between stakeholders
  - Better collective understanding of:
    - Existing situations
    - The impact of changes to the system

Questions