Systems Engineering

Engineering Standard

Rail Commissioner

AM4-DOC-001217

Government of South Australia
Rail Commissioner

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Action	**Name and Position**	**Signature**	**Date**
Prepared By:	Name: Kim Tan Title: Senior Asset Planner		2/4/20
Reviewed By:	Name: Keith Charlton Title: A/Unit Manager, Rail Asset Management	K.Charlton	2/4/20
Approved By:	Name: Peter Lawson Title: A/Manager, Rail Infrastructure Management		2/4/20
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1. Introduction

The Department of Planning, Transport and Infrastructure (DPTI) operates and maintains the Adelaide Metropolitan Passenger Rail Network (AMPRN) under the rail accreditation assigned to the Rail Commissioner (RCom). This standard describes the implementation of the Systems Engineering (SE) framework which forms part of the Rail Commissioner's Safety Management Systems and Processes against which Rail Accreditation has been awarded by the Office of the National Rail Safety Regulator (ONRSR).

The systems engineering approach described in Australian Standard *AS/NZS 15288:2015 Systems and Software Engineering – System lifecycle processes* has been tailored to produce this standard.

2. Purpose

The purpose of this standard is to provide a structured set of requirements used by the RCom to establish a systems engineering framework and activities to:

- provide guidance on the lifecycle approach for rail assets;
- provide a consistent approach for the delivery of any rail project;
- integrate rail projects with each other and with existing rail infrastructure; and
- maintain the technical integrity of rail infrastructure, rolling stock and operational systems across the AMPRN.

3. Scope

This standard applies to:

- all rail projects undertaken by RCom (including DPTI projects) to introduce new or altered rail systems;
- rail operations; and
- rail engineering & maintenance to maintain and dispose of rail systems.

4. Related Documents

DOCUMENT NAME	DOCUMENT NUMBER
Asset Management Policy (kNet #9324565)	-
Design Lifecycle Management Procedure (kNet #4297365)	PTS-MU-10-EG-PRC-00000023
System Safety Standard for New or Altered Assets / Infrastructure (kNet #11222290)	ST-RC-MC-1015
Development and Approval of Engineering Waivers (kNet #502192)	PR-AM-GE-807
Design Decision Records Procedure (kNet #4808444)	PTS-MU-10-EG-PRC-00000016
Type Approval for Railway Products (kNet #7575191)	AM4-DOC-000466
Asset Management Handover Requirements Standard (kNet #11288747)	AM4-DOC-000940

5. References

- *Rail Safety National Law (South Australia) Act 2012*
- AS 15288 Systems and Software Engineering – System Life Cycle Processes
- AS 24748 Systems and Software Engineering – Life Cycle Management – Part 2 and Part 4
- EN 50126 Railway Applications – the specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
- EN 50121 Railway Applications – Electromagnetic Compatibility
- AS 7470 Human Factors Integration in Engineering Design – General Requirements

- AS IEC 60300.3.14 Dependability management Part 3.14 Application guide- Maintenance and maintenance support
- ISO 55001 Asset management – Management systems – Requirements
- INCOSE Systems Engineering Handbook – A guide to systems lifecycle process and activities.

6. Acronyms

ACRONYM	FULL NAME
AMPRN	Adelaide Metropolitan Passenger Rail Network
BITE	Built in Test Equipment
BRS	Business Requirements Specification
CSTR	Contractual Scope and Technical Requirements
DPTI	Department of Planning, Transport and Infrastructure
EMC	Electromagnetic Compatibility
EMS	Engineering Management System
LRU	Line Replacement Unit
MCD	Maintenance Concept Definition
MoC	Management of Change
MTTR	Mean Time to Repair
OCD	Operations Concept Definition
PEMP	Project Engineering Management Plan
RAMS	Reliability, Availability, Maintainability and Safety
RCom	Rail Commissioner
RSNL	Rail Safety National Law (South Australia) Act 2012
SE	Systems Engineering
SMS	Safety Management System
SRS	System Requirements Specification
SSRS	Sub-System Requirements Specification
RAATM	Requirements Allocation Analysis and Traceability Matrix
3PMO	Portfolio, Program, Project Management Office

7. Definitions

TERM	DEFINITION
Functional Group	DPTI Rail Engineering & Maintenance Groups responsible for the design, construction, maintenance, modification or removal of AMPRN assets. The groups are: Asset Management, Track & Civil, Rolling Stock, Rail Maintenance, Signals, Communications, Electrical Engineering, Overhead, Tram Maintenance.
Life cycle model[3]	Framework of processes and activities concerned with the life cycle that may be organised into stages, which also acts as a common reference for communication and understanding
System[2]	A system is an arrangement of parts or elements that together exhibit behaviour or meaning that the individual constituents do not.
Railway Operations[1]	As defined in the Rail Safety National Law (South Australia) Act 2012 or moved on rail infrastructure.
Systems Engineering[2]	Systems Engineering is an engineering discipline whose responsibility is creating and executing an interdisciplinary process to ensure that the customer and stakeholder's needs are satisfied in a high quality, trustworthy, cost efficient and schedule compliant manner throughout a system's entire life cycle.

[2] The International Council on Systems Engineering (INCOSE)

8. Systems Engineering Overview[3]

A system is a combination of interacting elements organized to achieve one or more stated purposes. The system may be configured with one or more of the following system elements; material, product, tool, processes, data, hardware, software, humans, facilities and naturally occurring entities. For users it may be referred to as products, assets or services. In the RCom system it may be part of an individual functional group or may be multi-disciplinary.

Systems engineering is an interdisciplinary approach governing the total technical and managerial effort required to transform a set of stakeholder needs, expectations and constraints into a solution and to support that solution throughout its life.

The systems engineering approach considers life cycle outcomes measured by performance, reliability, availability, maintainability, safety and cost-effectiveness.

9. Systems Engineering Management

Systems engineering is a methodology for planning, specifying and delivering complex systems and it supports the RCom asset management framework.

The RCom has adopted the systems engineering philosophy for all rail projects. In all cases the rail project is expected to appropriately tailor the systems engineering philosophy to suit the project needs.

Systems engineering management requirements for planning and acquiring new or altered systems include defining and demonstrating management structures for the following:

- organisational structure and responsibilities for systems engineering;
- requirements management;
- system architecture;
- system interface;
- systems integration;
- reliability, availability, maintainability and safety; and
- verification and validation.

A project shall deploy a ‘whole of life’ systems engineering approach to the planning and acquisition of the new or altered system. The level of systems engineering shall be scaled and tailored according to an assessment of the complexity and risk associated with introducing the new or altered system.

[3] AS 15288: Systems and software engineering – System life cycle processes

10. System Life Cycle

The RCom's systems engineering life cycle adopts *AS ISO 55001 Asset management – Management systems – Requirements* approach and comprises four main stages:

- Plan
- Acquire
- Operate and maintain
- Dispose

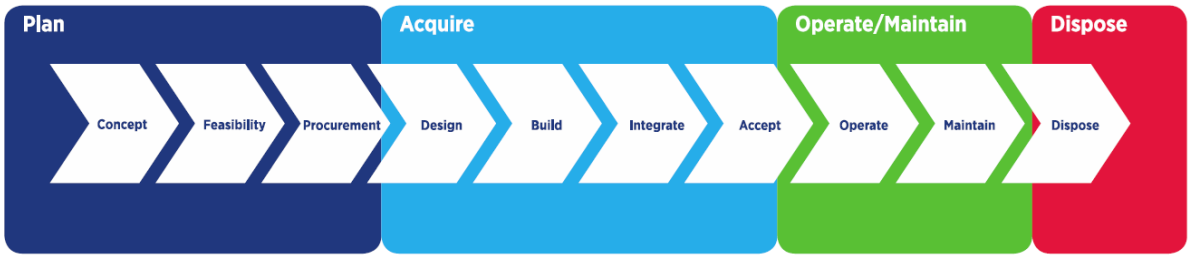

Figure 1: System Engineering Life Cycle

The systems engineering life cycle model is also consistent with the life cycle activities and responsibilities defined in *AS 15288: Systems and software engineering – System life cycle processes.* Each life cycle stage has its distinct purposes and contribution to the whole of life cycle and has to be considered when planning and executing the system life cycle.

11. System Life Cycle Model

The RCom's systems engineering life cycle is based on the 'V' model described in *AS 15288 Systems and software engineering – System life cycle processes*

The 'V' model aligns to the asset life cycle stages and its configuration management and the Portfolio, Program, Project Management Office (3PMO) gateways process.

Figure 2 shows the relationship between the asset life cycle stages and 3PMO gateways.

11.1. Plan (Gate 0, Gate 1, Gate 2 and Gate 3)

The plan stage is used to assess new opportunities, identify the requirements, stakeholders' needs, explore the feasible solutions/concepts, understand implications for the Rail Accreditation / Management of Change (MOC) process, develop preliminary system requirements and a feasible design solution.

This stage is driven by the requirements to support the delivery of the State and Departmental public transport vision, target, values and goals. Key responsible parties in RCom may include:

- Portfolio Management
- Organisation Performance and Development
- Procurement and Contracting
- Transport Project Delivery
- Rail Infrastructure Management & Maintenance
- Rail Operations,
- Rail Safety & Operations Performance
- Customer & Information Services
- Transport Planning & Program Development

Key activities and deliverables should consider transport demand and needs analysis, work force planning, business cases, transport performance modelling, draft operations concept definition, draft maintenance concept definition, risk-assessed cost estimate, concept design, 3D plans/visuals and business requirements specifications.

11.2. Acquire (Gate 4A, Gate 4B, Gate 4C,Gate 4D, Gate 4E, Gate 4F)

The acquire stages of the systems engineering life cycle are used to develop and produce a system which meets requirements and can also be commissioned, verified and tested. This stage may also be referred to as procure, acquire and implement. Key responsible parties in RCom may include:

- Portfolio Management
- Organisation Performance and Development
- Procurement & Contracting
- Infrastructure Project Delivery
- Rail Infrastructure Management & Maintenance
- Rail Operations,
- Rail Safety & Operations Performance and
- Customer & Information Services

Key activities and deliverables may include detailed transport performance modelling, final costing, final operational concept definition, final maintenance concept definition, final business case, product specifications, detailed design, System Requirements Specification (SRS), Sub-System Requirements Specification (SSRS), Requirements Allocation Analysis and Traceability Matrix (RAATM), progressive safety case (and associated hazard logs), Reliability, Availability and Maintainability (RAM) allocation and analysis, Human Factors Assessment, Electromagnetic Compatibility (EMC) assessment, bill of materials, finished product and systems, asset management technical data, site installation & integration, testing & commissioning, operational readiness, training and hand over.
Reference: Design Lifecycle Management Procedure (PTS-MU-10-EG-PRC-00000023)

11.3. Operate and Maintain (Gate 5)

The operate and maintain stage is used to operate the system to deliver services within intended operating environments for continued operational effectiveness and maintain the system for its continued intended operation and sustainable service. This stage is used by RCom to ensure that the State and Departmental public transport vision, targets, values and goals are being met. Key responsible parties in RCom may include:

- Rail Infrastructure Management & Maintenance;
- Rail Operations;
- Rail Safety & Operations Performance; and
- Customer & Information Services.

Key activities and deliverables may include scheduling, ongoing operation, preventative/corrective maintenance, condition assessment, asset management plans, technical maintenance plans, assurance and performance measurements.

11.4. Dispose (Gate 6)

The dispose stage is used to remove the system from the operation and support its disposal. Key responsible parties in RCom may include:

- Rail Infrastructure Management & Maintenance;
- Rail Operations;
- Rail Safety & Operations Performance; and

- Customer & Information Services.

Key activities and deliverables shall include a risk assessment to support any decisions to retire the system or part thereof.

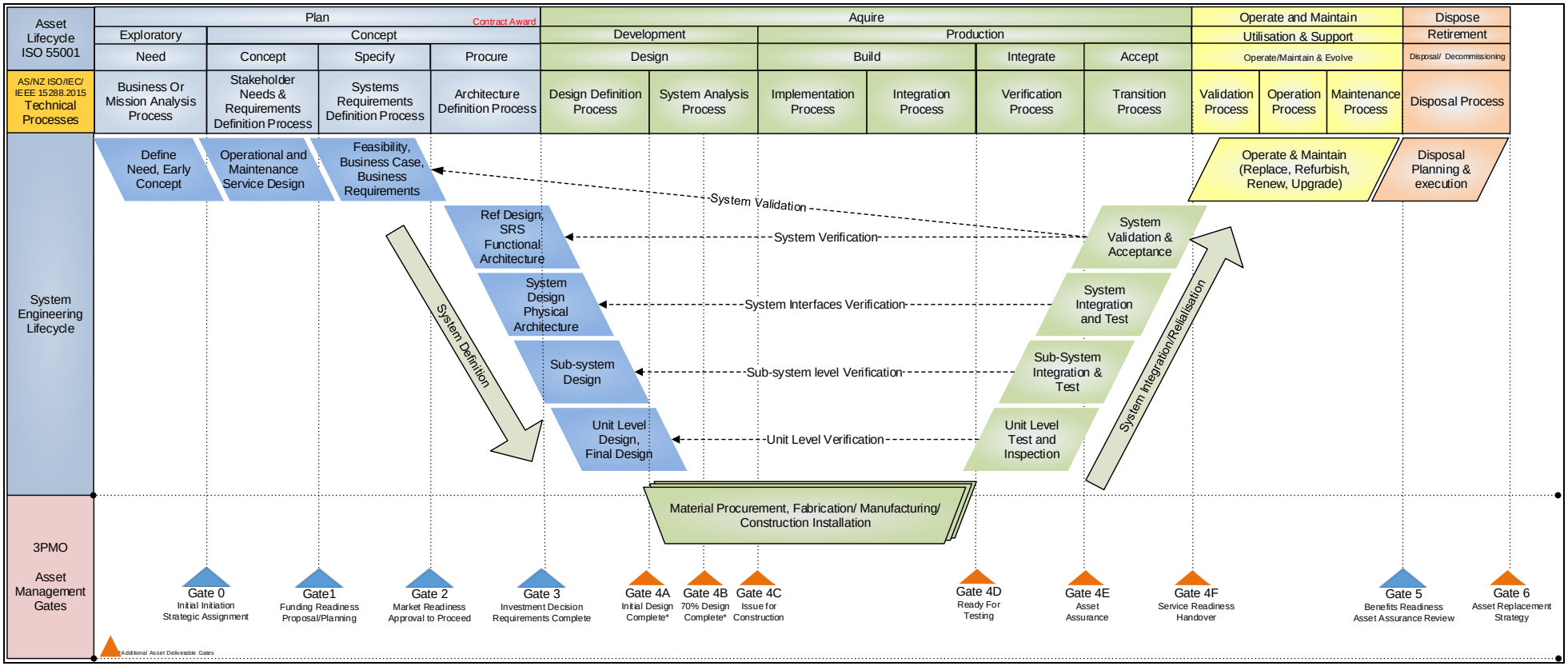

Figure 2: V lifecycle and Gateways Alignments

12. System Life Cycle Processes

The activities that can be performed during the life cycle of a system are categorized into four process groups in accordance with *AS 15288 Systems and software engineering – System life cycle processes.*

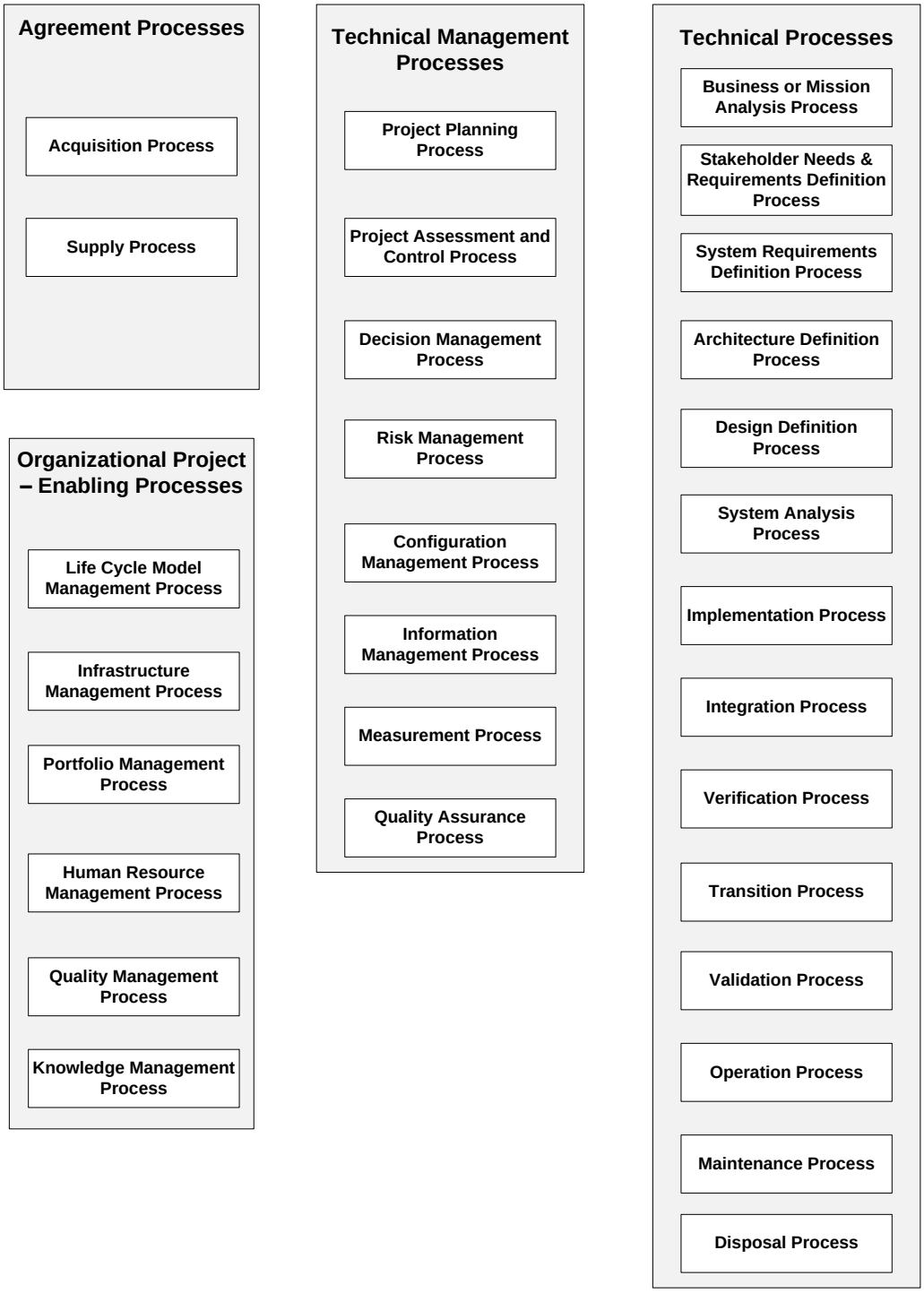

Figure 3: System Life Cycle Processes[4]

[4] AS 15288: Systems and software engineering – System life cycle processes

13. Systems Engineering – Agreement Processes (*AS 24748.2:2016 Section A.2)*

The Agreement Processes are used within DPTI to agree on the respective responsibilities of the organisation, project and technical functions. The Agreement Processes consist of the Acquisition process and the Supply process. The Acquisition and Supply Processes are managed in accordance with the South Australian State Procurement Board and DPTI's Procurement and Contracting Procedures.

The Acquisition Process is to ensure:

- The change has been approved;
- Request for supply has been prepared;
- Suppliers have been selected;
- Supplier agreements have been established;
- Agreement has been monitored;
- Defined obligations have been satisfied; and
- Product/Service has been accepted;

The Supply Process is to ensure:

- Product/Service has been identified;
- A response to request has been produced;
- Agreements have been established;
- Product/Service has been provided;
- Defined obligations have been satisfied; and
- Responsibilities of product/service have been transferred;

14. Systems Engineering – Organisational Project-Enabling Processes (*AS 24748.2:2016 Section A.3*)

The Organisational Project-Enabling Processes establish the environment in which projects are conducted, typically concerned at a strategic level to enable the project to meet the needs and expectations of the organisation's interested parties.

The organisation establishes the processes and life cycle models to be used by projects; provides resources required, including human and financial; and sets and monitors the quality measures for systems and other deliverables that are developed by projects for internal and external customers.

Organisational Project-Enabling Processes consist of the following:

a) Life Cycle Model Management Process
During this stage the DPTI policies, life cycle processes, life cycle models and procedures are defined, maintained and assure availability for use by DPTI. Various activities associated with this stage are establishment of process, assessment of the process and improvement of the process.

b) Infrastructure Management Process
The infrastructure management process is to provide infrastructure and services to projects to support objectives throughout the life cycle. Activities associated with this stage are establishment and maintenance of the infrastructure.

c) Portfolio Management Process
The Portfolio management process is to initiate and sustain necessary, sufficient and suitable projects in order to meet the strategic objective of DPTI. Activities

associated with this stage are to define and authorize projects, to evaluate the portfolio of projects and to terminate projects.

d) Human Resource Management Process
The Human Resource Management Process is to provide DPTI with the necessary human resources and to maintain their competencies to achieve DPTI's objectives. Various activities associated with this stage are to identify skills, develop skills, acquire and provide skills.

e) Quality Management Process
The Quality Management Process is to ensure that products/services and implementation of the quality management system meet DPTI's and project's objectives. Various activities associated with this stage are to plan quality management, assess quality management and perform quality management.

f) Knowledge Management Process
The Knowledge Management Process is to create the capability and assets that enable DPTI to achieve opportunities and re-apply existing knowledge. Various activities associated with this stage are to plan knowledge management, share knowledge and skills throughout the organisation, share knowledge assets throughout the organisation and manage knowledge, skills and knowledge assets.

Refer AS ISO/IEC/IEEE 24748.4:2016 Systems and software engineering - Life cycle management - Systems engineering planning, Section 8.3 Elements of the SEMP, Table 2 Example outline for a SEMP.

15. Engineering – Technical Management Processes[5] (*AS 24748.4:2016 Section 6)*

RCom has adopted *AS 24748 Systems and software engineering – life cycle management Part 4: Systems engineering planning* to implement *AS 15288 Systems and software engineering – System life cycle processes* for technical management processes throughout the rail projects.

To develop the Project's Engineering Management Plan, the project shall implement the following processes. Project Engineering Management Plan templates for projects are described in Section 20.

15.1. Project Planning

The purpose of the Project Planning process is to produce and coordinate effective and workable project plans.

The project planning process involves developing multiple plans in line with one master project plan. These multiple plans shall be reviewed and updated regularly to be consistent with other plans e.g. Statement of work, Project Management Plan, Project Engineering Management Plan etc. should be considered.

15.2. Project Assessment and Control

The purpose of the Project Assessment and Control process is to assess if the plans are aligned and feasible; determine the status of the project, technical and process performance; and direct execution to help ensure that the performance is according to plans and schedules, within projected budgets, to satisfy technical objectives.

[5] AS 24748.4 Systems and software engineering – Life cycle management Part 4: Systems engineering planning

This process evaluates, periodically and at major events, the progress and achievements against requirements, plans and overall business objectives. Information is provided for management action when significant variances are detected. This process also includes redirecting the project activities and tasks, as appropriate, to correct identified deviations and variations from other technical management or technical processes. Redirection may include re-planning as appropriate.

15.3. Decision Management

The purpose of the Decision Management process is to provide a structured, analytical framework for objectively identifying, characterizing and evaluating a set of alternatives for a decision at any point in the life cycle and select the most beneficial course of action.
Refer to RCom document PTS-MU-10-EG-PRC-00000016 Design Decision Record Procedure.

15.4. Risk Management

The purpose of the Risk Management process is to identify, analyze, treat and monitor the risks continually.

The risk management process is a continual process for systematically addressing risk throughout the life cycle of a system. It can be applied to risks related to the design, development, operation or maintenance of a system. The system safety and risk assessment requirements shall be in accordance with ST-RC-MC-1015 System Safety Standard for New or Altered Assets/Infrastructure.

15.5. Configuration Management

The purpose of Configuration Management is to manage and control system elements and configurations over the life cycle. Configuration Management also manages consistency between a system and its associated configuration definition.
Refer to RCom document PR-RC-MC-009 Management of Change.

15.6. Information Management

The purpose of the Information Management process is to generate, obtain, confirm, transform, retain, disseminate and dispose of information, to designated stakeholders.

Information management plans execute and control the provision of information to designated stakeholders that is unambiguous, complete, verifiable, consistent, modifiable, traceable and presentable. Information includes technical, project, organisational, agreements and user information. Information is often derived from the data records of the organisation, system, process or project.

15.7. Measurement

The purpose of the Measurement process is to collect, analyze and report objective data and information to support effective management and demonstrate the quality of the products, services and processes.

15.8. Quality Assurance

The purpose of the Quality Assurance process is to ensure the effective application of the organisation's Quality Management process to the project.

Quality Assurance focuses on providing confidence that quality requirements will be fulfilled. Proactive analysis of the project life cycle processes and outputs is performed to assure that the system being produced will be of the desired quality and that organisation and project policies and procedures are followed.

15.9. Handover

The purpose of the handover is to ensure the effective application of the organisation's requirements for the handover of rail systems from the project. The handover plan shall

commence during the planning stage of system life cycle. The Handover plan shall be established in accordance with *AM4-DOC-000940 Asset Management Handover Requirements Standard*.

16. Systems Engineering – Technical Processes (*AS 24748.2:2016 Section A.5)*

Systems Engineering – Technical Processes are required throughout the life cycle stages of a system. Technical processes are used to establish requirements for the system as the basis for the efforts to create an effective product or service; to sustain the system through its useful life; and to support retirement of the system. Technical processes are enabled to coordinate the interactions between engineering specialists, systems stakeholders, operators and maintainers.

In addition to Section 15 the project shall address, as a minimum, the following:

16.1. Business or Mission Analysis Process (*AS 15288:2015 Section 6.4.1*)

During the Business or mission analysis process problems or opportunities are defined, preliminary operational concepts and other concepts defined, alternative solution identified and analyzed, preferred solution selected, support systems or services are available and traceability of problems and opportunities to solutions established.

16.2. Organisation Structure and Responsibilities

Organisational management structures for systems engineering shall be defined.

System engineering roles and responsibilities within the project shall be defined.

Levels of responsibility and engagement of systems engineering organisational roles shall be mapped to systems engineering management processes and activities across the system life cycle and communicated to staff. This is typically achieved by establishing a responsibility, accountability, consulting, informing (RACI) matrix, with systems engineering management processes on one axis and systems engineering roles on the other axis.

16.3. Requirements Management *(AS 24748.4: 2016 Section 9.8.8.2)*

The purpose of Requirements management is to identify, negotiate, document and maintain stakeholder's requirements for the system and transform those requirements into a functional and technical view of a system description capable of meeting the stakeholder's needs.

Requirements management includes the following activities:

- Identify the key requirements in consultation with relevant authorised stakeholders.
- Define and specify the baseline business requirements in consultation with relevant authorised stakeholders. In DPTI these stakeholders are:
  - Rail Infrastructure Management;
  - Rail Infrastructure Maintenance;
  - Rail Operations;
  - Rail Safety and Operational Performance;
  - Public Transport Operations and Planning; and
  - Frontline Services.
- Define and specify the system requirements specification in consultation with relevant authorised stakeholders.
- Define and specify the sub system requirements from the system requirements specification.
- Maintain requirements traceability from the very beginning.

- Identify the requirement management tools based on complexity, scale and DPTI contractual requirements. This tool shall be able to exchange requirements information using a common interchange format with DPTI requirements databases and associated schema.
- Identify standards required to meet design considerations as identified by stakeholder's needs.
- Identify the external interfaces.
- Identify the system boundaries.
- Identify the design considerations and constraints.
- Identify the life cycle process requirements.
- Identify the construction considerations and constraints.
- Identify the operations and maintenance considerations & constraints.

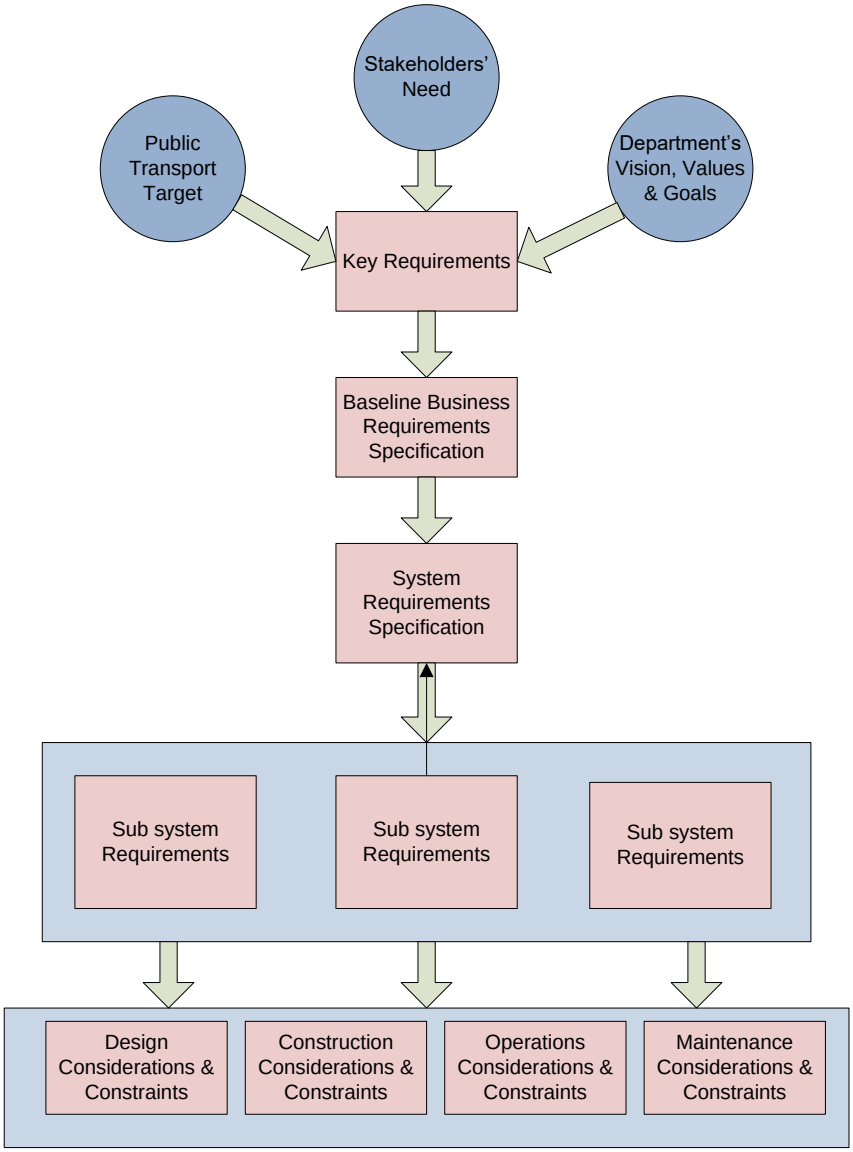

Figure 4: Requirements Management

16.3.1. Operation Concept

A project shall ensure that a preliminary operational concept definition (OCD) for the new or altered system is prepared early in the system life cycle, to inform, and be part of, the final business case and business requirements specification.

The OCD shall be reviewed and refined as the system definition progresses beyond the business requirements specifications and should be finalised when the system solution has been sufficiently defined.

The OCD shall describe how the system will be used and operated over its operational lifetime.

The OCD shall support the business case and associated whole of life funding, which includes how much it will cost to operate over its operational lifetime.

A project should take into consideration, during the concept and plan stage, the following:

- plan for obsolescence before selection of equipment and components which include:

  (i) Ensure minimum design life, as specified in individual design requirements of various railway systems, are met;
  (ii) Notify in writing prior to any component of the system being upgraded or becoming obsolete from general availability;
  (iii) Provide functionally identical replacement units of any components that become unavailable for the design life of that component or system.

- DPTI current operational skills level/competency;
- Intention of use; and
- Environment of the intended usage.

16.3.2. Maintenance Concept

A project shall ensure that a maintenance concept definition (MCD) for the new or altered system is prepared early in the system life cycle, to inform, and be part of, the final business case and business requirements specification.

The MCD shall describe how the system will be maintained over its lifetime. A Project shall consider maintenance and maintenance support at the earliest stage of the life cycle in accordance with AS IEC 60300.3.14 Dependability management Part 3.14 Application guide- Maintenance and maintenance support.

The MCD shall support the business case and associated funding, which includes how much it will cost to maintain and support over its operational lifetime.

Maintenance concepts defined in the MCD shall align with, and support, operational concepts defined in the operational concept definition.

A project should take into consideration, during the concept and plan stage, the following:

- Minimum lifecycle cost;
- Type and amount of maintenance required for various assets;
- DPTI current maintainer’s skills level/competency;

- Provide sufficient envelope for operational and maintenance access and minimise the need for network access and track possession when operating or maintaining the assets;
- Mean time to Repair (MTTR);
- Line Replacement Unit (LRU) concept;
- Built-in test Equipment (BITE) for critical and least-accessible asset; and
- Provision for failure reporting and to be integrated with DPTI Asset Management System.

16.4. Design Definition Process *(AS 15288:2015 Section 6.4.5)*

During this process design characteristics of each system element are defined, system requirements are allocated to system elements, design definition selected, interfaces between system elements defined, design artifacts developed, enabling systems or services are available and traceability of design characteristics to system architecture established.

16.5. System Analysis Process *(AS 15288:2015 Section 6.4.6)*

During this process System analyses are identified, system analysis assumptions and results validated, system analysis results provided for decisions, enabling systems or services are available and traceability of system analysis results established.

16.6. Implementation Process *(AS 15288:2015 Section 6.4.7)*

During this process integration constraints are identified, approach and checkpoints identified, enabling systems available, interface elements and system are checked, interfaces with system and external environment are checked, integration results and anomalies identified and traceability of integrated system elements established.

16.7. Engineering Management

Engineering management includes, but is not limited, to the following:

16.7.1. Engineering Authority and Competency

Engineering Authority defines an individual's capability to assess and approve designs or otherwise certify the engineering delivery process. The Engineering Authority shall only be granted to persons with appropriate competence. The Engineering Authority shall be assigned to an individual based on their position, their qualifications, experience, and their level of demonstrated competence.

Engineering competency is the combination of qualifications, judgement and experience of individuals performing technical functions within the engineering team. The appointment process for technical roles is to follow DPTI policies for human resource management and is to include an auditable trail including:

- Development of specific and appropriate job descriptions;
- Diligent verification of individual qualifications and experience;
- Observation and mentoring especially during early work;
- Regular review of performance; and
- Further training and proactive corrective action.

Refer to RCom PR-AM-GE-1170 Assessment of Engineering Competence for Rail Safety Workers Procedure

16.7.2. Lifecycle Management

The Lifecycle Management Procedure is based on enforcing the application of the systems engineering process at key points during the project lifecycle. At early points the requirements will be broad and will expand as the systems

analysis proceeds. The key points in the lifecycle occur upon completion of a planned amount of work, that is, the "design stage", and are referred to as "design stage reviews". The design stage reviews align with comparable project management reviews.

In order to conduct a design stage review, the appropriate document set must be created to inform the participants, which is known as striking a "baseline". At the conclusion of the review the outcome must be agreed by all stakeholders. This agreement, preferably unconditional, is recorded in the design stage review minutes or similar document, and forms the basis for the next stage of design. It is possible, even normal, for stakeholders to record actions in the minutes that are addressed in the next design stage rather than being a pre-requisite for entering that stage. Independent engineers may be engaged to verify design elements and provide independent peer review of design work.

Projects differ across the rail program so projects can tailor the Lifecycle Management Procedure to suit. As a minimum, the following development stages are to be formally recognised, reviewed and recorded.

- Engineering Requirements Design Stage Review
- Reference Design Stage Review
- Preliminary Design Stage Review – Shall be provided prior to Gate 4A
- Detailed Design Stage Review – Shall be provided prior to Gate 4B
- Final Design Stage Review – Shall be provided prior to Gate 4C
- Any Progress Review
- Testing and Commissioning Review – Shall be provided prior to gate 4D
- Engineering Completion Review – Shall be provided prior to Gate 4E
- Engineering Closedown Review

16.7.3. Authorised Engineering Standard

The Engineering Standards authorised for use are listed in the DPTI Rail Engineering and Maintenance web portal as shown below:

http://cms.dpti.sa.gov.au/public_transport_resources/engineering_and_maintenance/rail_engineering_standards_and_instructions_new

16.8. System Interface Management

A Project shall make sure that all technical interfaces are properly managed during the project lifecycle. Where deemed appropriate the Project shall establish a technical interface working group and also appoint a Technical Interface Manager depending on the requirements, complexity and multiplicity of the projects in progress.

16.9. Reliability, Availability, Maintainability and Safety (RAMS)

A Project shall implement management arrangements that define the reliability, availability and maintainability process, responsibilities, structures, tools and deliverables in accordance with EN 50126 Railway Applications – the specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS).

A project shall consider RAMS performance and how it relates to operational performance for the systems early in the system life cycle, starting with development of the operational concept definition and maintenance concept definition.

A project shall use RAMS modelling to ensure that the system will meet the stated operational capability and provide value for money over the designed system lifetime.

Under no circumstances shall the RAMS performance be less than that applying to existing systems

A project shall consider sustainable operation and maintenance of the system over the full system life cycle.

16.10. Verification

The verification process can be used to establish correspondence between the performance and characteristics of the system with respect to technical requirements and other agreement requirements. Verification will ensure that the system has been implemented or integrated correctly from the perspective of fulfilling its technical requirements. Example methods of verification include inspection, analysis, simulation, demonstration, testing etc.

16.11. Transition Process (Operational Readiness)

The transition process can be used to plan the transfer of the system from the project to the users that will subsequently operate and maintain the system. The transition process includes execution of a transition strategy for operational readiness including operator's training, logistics support, operation & maintenance support, appropriate user's skills & knowledge to perform operation and maintenance activities. As a part of this process, the user accepts that the system provides the specified capabilities in the intended operational environment prior to transition. The validation process can be performed before the transition process depending on the user's requirements.

16.12. Validation

The validation process can be used to establish correspondence between the performance and characteristics of the system with respect to stakeholder requirements and other agreement requirements. Validation will ensure that the 'right' system has been implemented or integrated to fulfill stakeholder requirements or expectations. Example methods of validation include inspection, analysis, demonstration, certification, acceptance test etc.

A project shall implement management arrangements based on a well-defined verification and validation (V&V) process, responsibilities, structure, tools and deliverables.

A project shall plan V&V activities early in the system life cycle, starting with tracing goals and operational capabilities to the development of the business requirements specification, then to a system requirements specification and finally a sub-system requirements specification.

A project shall establish and maintain a method of recording all V&V activities and results, and trace these to originating requirements.

A project shall establish and maintain a method of providing traceability between Contractual scope and technical requirements (CSTR), Business Requirements Specification (BRS) documents and System Requirements using RAATM.

16.13. Specialty Systems Engineering Processes

16.13.1. Electromagnetic Compatibility Management

A project shall implement management arrangements for assuring electromagnetic compatibility during the specification, design, integration or testing of electrical and electronic systems involving electromagnetic interference threats or victims in accordance with EN 50121 Railway Applications – Electromagnetic Compatibility.

16.13.2. Modeling, Simulation and Prototyping

Where required, the project shall implement modeling, simulation and prototyping to reduce the risk of failure in the finished system. Modeling and simulation can be used to ensure system performance requirements are met.

16.13.3. Human Factor Integration

A project shall implement management arrangements for assuring human factors integration during the specification, design, integration or testing of the new or altered system in accordance with AS 7470 Human Factors Integration in Engineering Design – General Requirements.

17. Systems Engineering – Operation (AS 15288:2015 Section 6.4.12)

The operation process sustains system services by assigning personnel to operate the system, monitoring operator-system performance and monitoring the system performance. The operation process identifies and analyses operational performance in the context of agreements, stakeholder requirements and organisational constraints.

Activities of the operation process include:

- Define an operation strategy;
- Provide operator's training;
- Perform operation;
- Track system performance and account for operational availability;
- Manage results of operation and perform operational analysis;
- Report malfunctions and recommendations for improvement; and
- Support the customer.`

18. Systems Engineering – Maintenance *(AS 15288:2015 Section 6.4.13)*

The purpose of the maintenance process is to sustain the capability of the system to provide a service throughout its useful life. The maintenance process identifies and analyses maintenance and support activities in the context of agreements, stakeholder requirements and organisational constraints.

Activities of the maintenance process include:

- Define the maintenance strategy – preventive & corrective;
- Define the maintenance constraints on system requirements;
- Obsolescence planning;
- Prepare for maintenance;
- Perform maintenance;
- Implement problem reporting and resolution procedures;
- Perform logistics support;
- Manage results of maintenance;
- Maintain history of failures, actions taken and other trends to inform operation and maintenance; and
- Monitor customer satisfaction with system and maintenance support.

19. Systems Engineering – Disposal *(AS 15288:2015 Section 6.4.14)*

The purpose of the disposal process is to remove a system or system element from the operational environment with the intent of permanently terminating its use; and to deal with any critical disposal needs in accordance with applicable guidance, policy, regulations and security aspects.

Activities of the disposal process include:

- Define the disposal strategy;
- Prepare for disposal;
- Deactivating and disassembling the system;
- Removing the system or system element;
- Facilitate such system for its reuse, recycle, reconditioning, overhaul, archiving or destruction;
- Remove any waste material with appropriate disposal method;
- Withdraw impacted operating staff;
- Confirm the disposal and document the disposal for future use;
- Confirm that no detrimental health, safety, security and environmental factors exist following disposal; and
- Return the environment to its original state or to a state that is specified by agreement

19.1. Design for Disposal

Projects should include in specifications the requirement for designs to consider the end of life of the product. Measures that may be taken include:

- Use of sustainable materials;
- Recyclability or reusability;
- Avoiding materials that are hazardous or emit hazardous materials during disposal;
- Elimination of unnecessary packaging; and
- Life cycle assessment of energy and carbon dioxide emissions.

Refer to State Disposal Guideline:
https://spb.sa.gov.au/sites/default/files/Disposal%20Guideline%20v%203.3%20December%202017_0.pdf

19.2. Decommissioning Planning

Projects shall plan for decommissioning including consideration of:

- Timing of the availability of replacement assets including overlapping operations as transition or schedule contingency;
- Reduction in preventive maintenance where safe to do so in the final period of life of the old asset (adjusted in the asset management system);
- Identification of hazardous materials (e.g. asbestos, radionucleids, carcinogens, ozone depleting gases, residual pesticides or herbicides) or environmental contaminants;
- Identification and archiving of technical data, especially information that will no longer be required and should be isolated to avoid unsafe use;
- Identification of parts or materials in inventory that will be rendered obsolete to be written off or transferred to other uses;
- Identification of special tools that will be rendered obsolete to be written off or transferred to other uses; and
- Closing off period contracts or maintenance agreements, including software agreements.

The decommissioning plan shall identify packages of work, responsibilities and schedule, including interdependencies between activities. Depending on the scope of the project the engineering management of disposal may be defined within the decommissioning plan, or a separate PEMP is to be created.

20. Project Engineering Management Plan Templates – Project

Every rail project shall have a Project Engineering Management Plan (PEMP) in line with Systems Engineering concepts as defined in this standard. The PEMP shall ensure that all system engineering management objectives are achieved. The PEMP shall be prepared during the concept/plan phase and be updated throughout the project lifecycle. A project shall provide a justification if any of the systems engineering elements are not covered or addressed in its PEMP.

The Section 20.1 provides guidance on the development of the PEMP.

20.1. PEMP Template – Rail Project

The following elements shall be considered for the development of a PEMP for a rail project.

Example Clause	Example Title	Guidance
1	Introduction	
2	Purpose	
3	Scope	
4	Related Documents	
5	Reference	
6	Acronyms and Definitions	
7	System Description and Project Summary	Section 8
8	Project Schedule	
9	System Life Cycle and Stage Gates Description	Section 11
10	Project Planning • Estimation • Staffing • Resource allocation • Training • Work activity • Schedule allocation • Resource allocation • Budget • Procurement	Section 15.1
11	Systems Engineering Organisation Structure and Responsibilities	Section 16.2
12	Requirements Management	Section 16.3
13	Operations Concept	Section 16.3.1
14	Maintenance Concept	Section 16.3.2
13	Engineering Management	Section 16.7
14	System Interface Management	Section 16.8
15	Reliability, Availability and Maintainability	Section 16.9
16	Design for Disposal and Decommissioning Planning	Section 19
17	Verification and Validation	Section 16.10, 16.12
18	Transition	Section 16.11
19	Specialty System Engineering Process	Section 16.13
20	Project Assessment & Control • Communications • Performance Assessment & control • Measurement • Reviews and Audits • Subcontractor Management • Project Management Control • Technical Project Close out	Section 15.2
21	Risk Management	Section 15.4
22	Configuration Management	Section 15.5
23	Information Management • Documentation & Data Management	Section 15.6
24	Quality Assurance	Section 15.8
25	Handover • System Handover • System Information Handover • System Documentation and Technical Data Handover	Section 15.9

Appendix 1 – Overview of AS/NZS ISO/IEC/IEEE 15288:2015

AS/NZS ISO/IEC/IEEE 15288: 2015 – System and Software Engineering - System Life Cycle Processes - Overview

Project & System Engineering Planning

SA/SNZ TR ISO/IEC 24748.4:2014
Annex A Project Planning
Annex B System Engineering Planning

Organisational, Project Enabling Processes

Processes to ensure capability to supply or to be supplied with product or services to meet satisfactory objectives and established agreements.

Life Cycle Model Process 6.2.1
Process is defined, maintained and assure availability of policies, life cycle processes/models and procedure for the organisation.
- Policy and Procedures Established
- Responsibility, Accountability and authority defined
- Processes assessed
- Process improvement implemented

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.3

Infrastructure Management Process 6.2.2
Provide infrastructure and services to projects to support objectives throughout the life-cycle
- Requirements for project infrastructure defined
- Elements identified and specified
- Elements developed or acquired
- Infrastructure maintained & available

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.4

Portfolio Management Process 6.2.3
Initiate, sustain suitable projects to meet strategic objectives.
- Opportunities/investments qualified & prioritized
- Projects identified
- Resources & budgets allocated
- Project Management responsibilities, accountabilities and authorities defined
- Agreements & Stakeholder requirements met
- Requirements redirected or terminated if agreement is not met
- Projects closed after successful completion to requirements

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.5

Human Resource Management Process 6.2.4
Provide, maintain skilled, experienced, qualified and competent personnel to achieve objectives.
- Skills required for projects identified & provided
- Skills developed and maintained or enhanced
- Conflicts in resource demands resolved

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.6

Quality Management Process 6.2.5
Ensure products/services implemented meet organisation and project objectives.
- Policies, objectives & procedures defined and implemented
- Evaluation criteria & methods established
- Resources & information provided to support operation and monitoring QA activities
- Evaluation results collected and analysed
- Process Improvement implemented

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.7

Knowledge Management Process 6.2.6
Creation of capability and knowledge assets to achieve opportunities and re-apply existing knowledge.
- Knowledge has: nomenclature/ classification
- Is developed or acquired
- Is available
- Data is gathered and anlysed

Technical Management Processes

Used to establish and evolve, execute plans which are used to asses actual achievement and process.

Project Planning Process 6.3.1
Produce and coordinate effective and workable plans.
- Objectives planned and defined
- Roles, responsibilities, accountabilities and authorities defined
- Resources and services are requested and committed
- Plans are activated

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.8 AS ISO/IEC/IEEE 24748.4:2016, 6.2

Project Assessment & Control Process 6.3.2
Assess plans to define status of processes, performance, schedule, budgets to meet planned objectives.
- Performance results are available
- Roles, responsibilities, accountabilities and authorities and resources adequate
- Processes reviewed
- Deviations in performance investigated & analysed
- Stakeholders informed of status
- Correct actions undertaken
- Replanning considered as necessary
- Progress monitored
- Objectives achieved

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.9 AS ISO/IEC/IEEE 24748.4:2016, 6.3

Decision Management Process 6.3.3
A structured, analytical framework for the identification, describing and evaluating decisions to select the beneficial course of action.
- Decisions for analysis are identified
- Alternate action identified and evaluated.
- Course of action selected
- Resolution, decision rationale and assumptions identified

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.10 AS ISO/IEC/IEEE 24748.4:2016, 6.4

Risk Management Process 6.3.4
Risks are identified, analysed, treated and monitored continuously.
Risks are:
- Identified
- Analysed
- Options identified, prioritised and selected
- Treatment implemented
- Evaluated for changes in status and progress

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.11 AS ISO/IEC/IEEE 24748.4:2016, 6.5

Configuration Management Process 6.3.5
Manage and control system elements for consistency between product and their configuration definition.
- Items are identified and managed
- Baselines established
- Changes controlled
- Status information available
- Configuration audits conducted
- Deliveries controlled and approved

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.12 AS ISO/IEC/IEEE 24748.4:2016, 6.6

Information Management Process 6.3.6
Process lifecycle which generates, obtains, transforms, retain, retrieves, disseminates and disposes of information.
Information through its lifecycle is:
- Identified
- Defined
- Status is identified
- Available to stakeholders

AS/NZS ISO/IEC 15289:2007

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.13 AS ISO/IEC/IEEE 24748.4:2016, 6.7

Measurement Process 6.3.7
The capture, analyse and report objective data and information to support quality products/services/processes.
- Needed information identified
- Measures identified or developed
- Data collected, verified & stored
- Analysed and results interpreted
- Information provided to support decisions

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.14 AS ISO/IEC/IEEE 24748.4:2016, 6.8

Quality Assurance Process 6.3.8
Providing confidence that quality requirements met with product outputs which meet desired quality.
Procedures are defined and implemented.
- Criteria, methods and evaluation defined
- Products, services, processes are evaluated against policies, procedures and requirements.
- Evaluation results available to stakeholders
- Incidents resolve
- Problems treated in accordance to priority

AS ISO/IEC/IEEE 24748.4:2016, 6.9

Portfolio Management Phases and Gateways

Gate 0 Strategic Assignment Complete
Gate1 Planning Readiness Complete
Gate 2 Approval to proceed with Change
Gate 3 Ready for Market
Tender Process
Gate 4A Contract Award
Gate 4B 70% Design Complete
Gate 4C Design Complete
Gate 4D Ready for Testing
Gate 4E Testing Complete
Gate 4F Asset Acceptance & Handover
Gate 5 Asset Assurance Review/ Project Closeout
Gate 6 Asset End of Life

Initialisation Phase	Proving Phase	Pre-Delivery Phase	Procurement Phase	Delivery Phase		Realisation Phase
Investment Planning (Investment Governance)				Project Management Framework (Delivery Governance Cat 1 Program)		

RIM Lifecycle

Plan				Implement				Operate and Maintain		Dispose
Exploratory	Concept			Development	Production			Utilisation and Support		Retirement
Need	Concept	Specify	Procure	Design	Build	Integrate	Accept	Operate/ Maintain	Evolve	Disposal/ Decommissioning

Rail Project Delivery

Phase 0 Undertake Pre-Feasibility	Phase 1 Develop Options & Recommendations	Phase 2 Develop Project Scope, Program and Costs	Phase 3A & 3B Define Project Scope and Program Procurement	Phase 4A Scope Technical Requirements, Development	Phase 4B Detailed Design	Phase 4C Manufacture and Installation	Phase 4D System Test/Validation	Phase 4E Commissioning and Safety Acceptance	Phase 5 Project Closeout

Agreement Processes

Processes to define activities between organisations for the supply of product or services

Acquisition Process 6.1.1
Product/Service meets requirements
- Change Approved
- Request for supply prepared
- Suppliers selected
- Supplier agreements established
- Agreement monitored
- Defined Obligations satisfied

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.1

Supply Process 6.1.2
Product/Service provided in accordance to requirements
- Product/service identified
- A response to request produced
- Agreements established
- Product/Service provided
- Obligations defined are satisfied.
- Responsibility of product/service Transferred

SA/SNZ TR ISO/IEC 24748.2:2014 Table A.2

Technical Processes

Technical Process Summary and Outputs

6.4.1 Business Or Mission Analysis Process	6.4.2 Stakeholder Needs & Requirements Definition Process	6.4.3 Systems Requirements Definition Process	6.4.4 Architecture Definition Process	6.4.5 Design Definition Process	6.4.6 System Analysis Process	6.4.7 Implementation Process	6.4.8 Integration Process	6.4.9 Verification Process	6.4.10 Transition Process	6.4.11 Validation Process	6.4.12 Operation Process	6.4.13 Maintenance Process	6.4.14 Disposal Process
Define business/problem or opportunities. • Problem or opportunity defined • Prelim operational concepts defined • Alternate solutions identified and analysed • Preferred option selected • Supporting systems available • Traceability of problem/opportunity to solution established	Define process for stakeholder needs and requirements throughout the lifecycle. • Stakeholders identified • Operations concepts defined • Constraints identified • Stakeholder needs defined, prioritised and transformed into clear requirements agreed • Critical performance measures defined • Requirements traceable to needs	Process to transform stakeholder capabilities to a technical solution to meet operational needs of user. Requirements include defining characteristics, attributes, functional and performance requirements. • System description, interfaces, functions and boundaries defined. • System requirements and design restraints defined and analysed • Critical performance measures defined • Enabling systems or services available • Traceability of system requirements to stakeholder requirements developed	Identify, generate and select system architecture alternatives to meet system requirements to resolve a problem with a satisfactory solution. • Stakeholder concerns addressed by architecture • Architecture viewpoints developed • Context, boundaries and external interfaces identified • Architecture views and models developed • Significant issues to architecture decisions allocated • System Elements and interfaces identified • Alignment between requirements & design • Enabling systems and services available • Traceability of architecture elements to stakeholder and system requirements	Provision of detail data and information on the system and elements to enable implementation. • Design characteristics for system elements defined • System requirements allocated to system elements • Design definition selected or defined • Interfaced defined and refined • Design artefacts developed • Enabling systems or services available • Traceability of design characteristics to system architecture is established	Provision basis data and information for technical understanding and decision making across the life-cycle. • System analyses needs are identified • Assumptions and results are validated • Result are provided for decisions • Enabling system are available • Traceability of system analysis results is established	The realisation of a specified system element which transforms the requirements, architecture/ interfaces into a system. • Implementation restraints that influence requirements, architecture, design are identified • System elements realised, packaged or stored, • Enabling systems or system available for implementation • Traceability established	Combine system elements into a product or service which meets system requirements, architecture and design. • Integration constraints identified • Approach and checkpoints defined • Enabling systems available • System elements integrated into the system • Interfaces elements and system checked • Interfaces with system and external environment checked • Integration results and anomalies identified • Traceability of integrated system elements established	Provide objective evidence that the system or system element fulfils its specified requirements and characteristics eg inspection, testing. • Constraints influencing requirements, architecture or design identified. • Enabling systems available. • The system or system element verified. • Data providing information for Corrective Action reported. • Objective evidence that the system fulfils requirements, architecture and design is provided. • Verification results and anomalies are identified. • Traceability of verified system elements established.	Establish the capability for a system to provide services specified by stakeholder requirements in an operational environment. • Transition constraints identified • Enabling systems available • Site prepared • System installed in location and capable of delivering functions • Operators, users and stakeholders are trained • Transition results and anomalies identified • Installed System activated and ready for operation • Traceability of transitioned elements established.	Objective evidence that the system when in use fulfils its business objectives and stakeholder requirements achieving its use and operational environment as intended. • Validation criteria for stakeholder requirements defined. • Confirmed availability of services. • Constraints of validation indentified. • System /system elements validated. • Enabling systems available. • Validation results and anomalies identified. • Objective evidence stakeholder needs have been provided. • Traceability of validated system elements established.	To use the system to deliver services. • Operation constraints identified • Enabling systems are available • Trained, qualified operators are available • System services meet stakeholder requirements delivered • System performance monitored • Support to customer provided	Sustain the capability of the system to provide a service. • Maintenance restraints identified • Enabling systems available • Replacement, repair or revised elements made available • corrective, maintenance reported • Failure and lifetime data and costs determined.	To end the system or system element from specific use as per agreed, policy, environmental, legal, safety and security aspects. • Disposal constraints provided • Enabling systems available • System elements or waste products are destroyed, stored, reclaimed or recycled in accordance to requirements • Environment returned to its original or agreed state • Records of disposal actions and analysis are available.

Supporting Standards and Guides

SA/SNZ TR ISO/IEC 24748.1:2014	AS/NZS ISO/IEC/IEE 4210:2014 - 5.3 Identification of stakeholders and concerns		AS/NZS ISO/IEC/IEE 4210:2014 System and Software Engineering – Architecture description										
	SA/SNZ TR ISO/IEC 24748.1:2014 4.2 Concept Stage 5.1.1.1 Concept Stage			SA/SNZ TR ISO/IEC 24748.1:2014 4.3 Developmental Stage 5.1.1.2 Developmental Stage		SA/SNZ TR ISO/IEC 24748.1:2014 4.4 Production Stage 5.1.1.3 Production Stage				SA/SNZ TR ISO/IEC 24748.1:2014 4.5 Utilisation Stage 5.1.1.4 Utilisation Stage	SA/SNZ TR ISO/IEC 24748.1:2014 4.6 Support Stage 5.1.1.5 Support Stage		SA/SNZ TR ISO/IEC 24748.1:2014 4.7 Retirement Stage 5.1.1.6 Retirement Stage
	SA/SNZ TR ISO/IEC 24748.2:2014 Table A.15 SA/SNZ TR ISO/IEC 24748.4:2014 B.2 Concept Stage	SA/SNZ TR ISO/IEC 24748.2:2014 Table A.16 SA/SNZ TR ISO/IEC 24748.2:2014 Table A.17		SA/SNZ TR ISO/IEC 24748.4:2014 B.3 Development Stage		SA/SNZ TR ISO/IEC 24748.2:2014 5.4.3.3.2 Implementation Process SA/SNZ TR ISO/IEC 24748.2:2014 Table A.18 SA/SNZ TR ISO/IEC 24748.4:2014 B.4 Production Stage	SA/SNZ TR ISO/IEC 24748.2:2014 5.4.3.3.3 Integration Process SA/SNZ TR ISO/IEC 24748.2:2014 Table A.19	SA/SNZ TR ISO/IEC 24748.2:2014 5.4.3.3.4 Verification Process SA/SNZ TR ISO/IEC 24748.2:2014 Table A.20	SA/SNZ TR ISO/IEC 24748.2:2014 5.4.3.3.5 Transition Process SA/SNZ TR ISO/IEC 24748.2:2014 Table A.21	SA/SNZ TR ISO/IEC 24748.2:2014 5.4.3.3.6 Validation Process SA/SNZ TR ISO/IEC 24748.2:2014 Table A.22 SA/SNZ TR ISO/IEC 24748.4:2014 B.5 Utilisation Stage	SA/SNZ TR ISO/IEC 24748.2:2014 5.4.3.4.2 Operation Process SA/SNZ TR ISO/IEC 24748.2:2014 Table A.23 SA/SNZ TR ISO/IEC 24748.4:2014 B.6 Support Stage	SA/SNZ TR ISO/IEC 24748.2:2014 5.4.3.4.3 Maintenance Process SA/SNZ TR ISO/IEC 24748.2:2014 Table A.24	SA/SNZ TR ISO/IEC 24748.2:2014 5.4.3.4.4 Disposal Process SA/SNZ TR ISO/IEC 24748.2:2014 Table A.25 SA/SNZ TR ISO/IEC 24748.4:2014 B.7 Retirement Stage