Superseded by T MU AM 06007 GU v3.0

T MU AM 06007 GU

Guide

Guide to Requirements Definition and Analysis

Version 2.0

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Standard governance

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Document history

Version	Summary of Changes
1.0	First issue
2.0	Addition of more guidance about system requirement specifications, including the new Appendix D

For queries regarding this document,
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Preface

The Asset Standards Authority (ASA) is an independent unit within Transport for NSW (TfNSW) and is the network design and standards authority for defined NSW transport assets.

The ASA is responsible for developing engineering governance frameworks to support industry delivery in the assurance of design, safety, integrity, construction, and commissioning of transport assets for the whole asset life cycle. In order to achieve this, the ASA effectively discharges obligations as the authority for various technical, process, and planning matters across the asset life cycle.

The ASA collaborates with industry using stakeholder engagement activities to assist in achieving its mission. These activities help align the ASA to broader government expectations of making it clearer, simpler, and more attractive to do business within the NSW transport industry, allowing the supply chain to deliver safe, efficient, and competent transport services.

The ASA develops, maintains, controls, and publishes a suite of standards and other documentation for transport assets of TfNSW. Further, the ASA ensures that these standards are performance-based to create opportunities for innovation and improve access to a broader competitive supply chain.

This *Guide to Requirements Definition and Analysis* has been developed on the technical processes of AS/NZS ISO/IEC 15288:2013 *Systems and software engineering – System life cycle processes* by the Asset Standards Authority, reviewed by a consultative group containing members from Transport for NSW (TfNSW) stakeholder groups and approved by the Asset Standards Authority Configuration Control Board.

This *Guide to Requirements Definition and Analysis* provides the supplier organisations with guidance through the steps involved in identifying and capturing stakeholder requirements and developing the systems requirements based upon the stakeholder needs.

T MU AM 06007 GU *Guide to Requirements Definition and Analysis*, Version 2.0 is the second issue.

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1. Introduction

An Authorised Engineering Organisation (AEO) engaged by Transport for NSW (TfNSW) to undertake engineering activities is required to have formalised requirements definition and analysis arrangements in place. These arrangements should be relevant to the engineering services or products that are provided by the AEO to TfNSW.

The mandatory requirements for requirements definition and analysis are defined in T MU MD 00009 ST *AEO Authorisation Requirements*.

An AEO's engineering management plan, systems engineering management plan or equivalent documents and procedures should contain the plan, management and approval of the AEO's engineering activities to facilitate formalised requirements definition and analysis.

Any organisation applying for an AEO status should ensure that the requirements management documentation of an AEO meets the minimum level required for the complexity of its projects or contracts.

2. Purpose

This *Guide to Requirements Definition and Analysis* describes the process and key responsibilities that an AEO and TfNSW divisions are expected to implement in managing this process.

It also contains the general guidance on requirements management tools, requirements change control and sources of requirements.

2.1. Scope

This guide forms part of a suite of systems engineering documents and guidance notes and further develops the guidance on requirements management as described in TS 10504 *AEO Guide to Engineering Management*.

This document does not outline the evidence that an AEO should produce in order to be authorised to perform systems engineering for TfNSW, but provides an outline of the processes that an AEO should demonstrate.

2.2. Application

The *Guide to Requirements Definition and Analysis* is primarily intended for use by all AEOs conducting systems engineering activities related to engineering services undertaken for or on behalf of TfNSW.

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The guidance provided in this document also applies to organisations that are currently applying for authorisation to carry out engineering activities for TfNSW in response to a tender or are applying to be pre-registered as an AEO to be considered for tendering for TfNSW work.

3. Reference documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

Australian standards

AS/NZS ISO/IEC 15288:2013 Systems and software engineering – System life cycle processes

International standards

ISO/IEC/IEEE 29148:2011 Systems and software engineering – Life cycle processes – Requirements engineering

Transport for NSW standards

TS 10504 AEO Guide to Engineering Management

TS 10506 AEO Guide to Verification and Validation

TS 20001 System Safety Standard for New or Altered Assets

T MU AM 04003 GU Configuration Management Guide

T MU AM 06010 GU Business Requirements Specification

T MU MD 00009 ST AEO Authorisation Requirements

Other references

INCOSE Guide for Writing Requirements

SEBoK v1.0 Guide to the Systems Engineering Body of Knowledge (SEBoK) version 1.0

4. Terms and definitions

The following terms and definitions apply in this document:

accountable the obligation of an individual or an organisation to account for its activities, accept responsibility for them, and to disclose the results in a transparent manner. The job role that is ultimately responsible for the engineering service. Accountability cannot be delegated.

AEO Authorised Engineering Organisation; it means a legal entity (which may include a Transport Agency as applicable) to whom the ASA has issued an ASA Authorisation

ASA Asset Standards Authority

assurance a positive declaration intended to give confidence. It is the evidence of an effective management.

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authorisation the conferring of authority, by means of an official instruction and supported by assessment and audit

availability the measure of the percentage of time that an item or system is available to perform its designated function

BRS business requirements specification; the document in which the business goals and stakeholder requirements are documented

client person that has a business need, and uses the project's product, service or result

> *Note: The client is responsible and accountable for realising and delivering the benefits and is usually also the beneficiary of the benefits. The client can also be the sponsor.*

compliance the state or fact of according with, or meeting, rules, standards or requirements

COTS commercial off the shelf

EMP engineering management plan

framework a basic structure underlying a system, concept, or text

governance the rules, processes, or laws by which a business is operated, regulated, and controlled. The exercise of authority and control between the accountable and responsible entities within TfNSW and the AEOs such that planned outcomes are achieved.

human systems integration (as defined in ISO 29148) an interdisciplinary technical and management process for integrating human considerations with and across all system elements

maintainability the probability that an item will be restored to operating condition, within a given period of time, using prescribed procedures and resources

MCD maintenance concept definition

OCD operations concept definition

OMG Object Management Group, Inc

performance the extent or how well a function or task is conducted

RAM reliability, availability and maintainability

RAMS reliability, availability, maintainability and safety

RATM requirements allocation and traceability matrix

reliability the probability that a specified item will perform a specified function within a defined environment, for a specified length of time

Req IF Requirements Interchange Format; the requirements interchange format defines an open, non-proprietary exchange format

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responsible a duty or obligation to satisfactorily perform or complete a task (assigned by someone, or created by one's own promise or circumstances) that one fulfils, and which has a consequent penalty for failure. This is the job role that is responsible for producing the service or product but is not ultimately accountable. Responsibility can be delegated.

review a method to provide assurance by a competent person that a defined engineering output complies with relevant standards and specific requirements, is safe, and fit for purpose

RVTM requirements verification and traceability matrix; a list of requirements, their verification attributes, and their traces; sometimes referred to as a requirements allocation and traceability matrix (RATM)

SEMP systems engineering management plan

specification a document that fully describes a design element or its interfaces in terms of requirements (functional, performance, constraints, and design characteristics) and the qualification (validation) conditions and procedures for each requirement

SRS system requirements specification

stakeholder individual or group whose interest in the project is recognised if the project is to be successful

> *Note: In particular, those who may be positively or negatively affected during the project or on successful completion of the project*

supplier a supplier of engineering services or products. Defined as an 'applicant' until such time as it has been granted AEO status, after which it is referred to as an AEO

system requirements all of the requirements at the system level that describe the functions which the system as a whole should fulfil to satisfy the stakeholder needs and requirements, and is expressed in an appropriate combination of textual statements, views and non-functional requirements; the latter expressing the levels of safety, security, reliability, etc… that will be necessary

system requirements specification a description of what the system should do, in terms of the system's functions, interactions and interfaces with its operational environment. It communicates the stakeholder requirements to the technical community who will specify and build the system. Alternatively, referred to as the system requirements document.

TfNSW Transport for NSW

validation the process of ensuring that the final product conforms to defined client requirements

verification the process performed to ensure that the output of a design stage, or stages, meets the design stage input requirements

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5. Requirements management

Technical requirements management processes are used to define the requirements for a system to achieve the following:

- transform the requirements into an effective product
- use the product to provide the required services
- sustain the provision of those services
- dispose the product when it is retired from service

T MU MD 00009 ST *AEO Authorisation Requirements* states mandatory requirements for requirements definition and analysis.

5.1. Objectives of requirements management

Requirements management is a broad heading for the definition, analysis, allocation, verification and validation of stakeholder requirements throughout a product or service life cycle. Requirements management delivers the following objectives across the full asset life cycle:

- provide a structured means for identifying and defining all requirements from all relevant stakeholders
- provide a means for analysing, allocating and recording all stakeholder requirements
- provide a complete set of unambiguous requirements
- define a structure for the storage and management of the requirements
- eliminate conflicting and duplicating requirements
- provide traceability of requirements, design output and the final product or service
- provide for the structured management of changes to requirements and approval process
- provide control and ensure data integrity in the recording, storing, and changing of requirements
- provide a foundation for system verification and validation

5.2. Requirement types and attributes

Each requirement statement is reviewed and written in such a way that they exhibit the following attributes:

- clear and concise
- specific
- necessary

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- valid
- implementation independent – the needs should be independent of the solution
- unambiguous - all readers of a statement should reach a common interpretation of the meaning of the requirement
- verifiable - the requirement is expressed in a manner that compliance with the requirement can be verified by an acceptable method
- feasible - the requirement can be achieved by one or more developed system concepts at a definable (or bounded) cost
- traceable - each requirement is traceable from stakeholder level down to the appropriate system or element level with established parent-child relationships
- consistent - no contradictions or conflicts with other requirements
- atomic - the statement contains only one requirement
- complete - all requirements of a given product or service has been specified including interfaces

A list of these attributes with description and requirement examples is provided in Appendix C.

5.3. Requirement construction

Requirements are constructed in order to express a need and the conditions and constraints associated with this need. For stakeholder requirements, the need is to achieve an objective of a stakeholder or to solve a problem of a stakeholder. Stakeholders include customers, operators, maintainers, or external parties such as local councils and utilities. In the case of a system or subsystem requirements, the needs to be achieved are those of the system or the subsystem in order to fulfil the needs of the parent stakeholder requirements.

Requirements should be written in simple English. Best practice states that the requirements written in English contain a subject of the requirement, imperative, a verb and a complement. The requirement construct is therefore defined as follows:

- subject indicates the focus, for example: 'the system' or the 'driver control console'
- imperative indicates the priority of the requirement; for example shall, should or may
- verb outlines what action is performed, for example 'brake' or 'display'
- complement provides additional information in order to make the requirement bounded, verifiable and unambiguous

  The complement syntax can be further broken down into the following:

  - conditions are attributes that can be measured, verified and validated; for example, 'normal mode' is a condition

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- objects are physical or logical entities referred to within the requirement; for example, 'the train' and 'train speed' are objects
- values provide quantitative numerical definitions for requirements; for example, '80 km/h' is a value
- constraints provide bounds for requirements; for example, 'visually to the train driver' and 'within a distance' are constraints

The requirement forms a complete and clear sentence as shown in the following examples:

The passenger waiting time [subject] shall [Imperative] be [verb] a maximum of [constraint] 10 minutes [value] at stations [object] in peak service periods [condition].

The braking system [subject] shall [imperative] brake [verb] the train [object] on application of service braking [condition] from a speed of 80 km/h [value] to a speed of 0 km/h [value] within a distance of 1500 m [constraint] when fully loaded at a gross weight of 500 tons [condition].

The driver control console [subject] shall [imperative] display [verb] the train speed [object] visually to the train driver [constraint] in units of km/h [constraint] during normal mode [condition].

Imperatives indicate that the sentence is actually a requirement. To standardise on a set of imperatives and agreed meanings for these imperatives, and be consistent, the following imperatives should be used for requirements:

- 'shall' for mandatory requirements
- 'should' for non-mandatory or desirable requirements
- 'may' for non-mandatory suggestions

The use of words such as 'must', 'are', 'is' and 'will', should be avoided as they can convey unclear and inconsistent meaning.

Negative imperatives such as 'shall not', 'should not' or 'may not' should be avoided where practicable as they can convey ambiguous meaning.

The following terms should be avoided, where possible, in requirement construction as they are unbounded and can lead to ambiguous requirements:

- undefined terms such as 'user-friendly', 'versatile', 'flexible', 'approximate', 'minimal', 'fastest', 'smallest'
- speculative terms such as 'usually', 'generally', 'often', 'normally', 'typically'
- over specification such as '100% reliability', 'safe', 'handle all failures', 'fully upgradeable', 'run on all platforms'

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- non-verifiable terms such as 'work reliably', 'clearly display'
- optional terms such as 'if available', 'as required', 'with approval'

Further details regarding requirement construction is provided in *INCOSE Guide for Writing Requirements.*

5.4. Requirements management tools

A requirements management tool that provides a structured framework for storing requirements and provides parent-child traceability between levels of requirements should be used.

Parent-child traceability provides the following:

- improved integrity of requirements
- tracking of requirements development, decomposition and allocation
- a means of documenting and reviewing the relationships between the levels of requirements that capture certain aspects of the design
- easier maintenance and change implementation of the system in the future

When an agreed set of stakeholder needs is defined, a requirements verification and traceability matrix (RVTM) should also be developed as a part of this process. This RVTM lists all the stakeholder requirements, their verification attributes, and the traceability back to the source of a particular requirement. The RVTM also includes the status of the requirement, that is, whether the requirement is compliant, partially compliant or noncompliant.

A list of attributes, which features in a requirements verification and traceability matrix, is located in Appendix A.

5.4.1. Tools for external interface of requirements management

The preference is for the requirements to be imported and exported directly from the requirements management tool to a standard format for interchange, such as the Object Management Group, Inc. requirements interchange format (OMG Req IF).

5.4.2. Requirements management tool selection

The complexity of the project determines the suitability of a requirements management tool. For low complexity projects, a requirements verification and traceability matrix in a spreadsheet format may be appropriate. However, a dedicated requirements management tool should be employed for projects that are more complex.

Any selected tools should be capable of transferring data to the TfNSW requirements management tool using the OMG requirements interchange format (Req IF).

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5.5. Requirements change management

Requirements definition, decomposition and management continue to evolve as system development activities are applied over the life cycle. Management of requirements changes during the systems life cycle is a critical aspect of the process.

Changes are managed by ensuring proposed changes are subjected to an impact assessment, a review and a stakeholder approval process applying careful requirements tracing and version management. This stakeholder approval process includes approval by the TfNSW configuration management and asset assurance committee (CMAAC) and permission from key stakeholders.

The project configuration management plan should identify the baselines that are used for the project including associated levels of authority required for change approval.

5.6. Requirements configuration management

Requirements should be managed in accordance with the project and organisational configuration management processes. This includes baseline control of the business requirements specification (BRS), system requirements specification (SRS), design documentation, and verification and validation evidence.

Details on configuration management are covered in T MU AM 04003 GU *Configuration Management Guide*.

5.7. Establishing baselines

When all stakeholder requirements have been identified and captured, baselines should be established which enable design changes to be identified and the impact of those changes on all systems or elements to be identified and traced. Traceability to the agreed requirements should be recorded throughout the development and production stages to assure the final system-of-interest complies with the original stakeholder requirements and agreed changes. This includes the production of system level requirements sets and compliance matrices against the agreed baseline stakeholder requirements.

5.8. Types of requirements sources

When acquiring engineering products or services, TfNSW usually issues a specification that describes the intended outcomes expected from the product or the service. This specification is often referred to as a works or service brief. The requirements can be included in a separate requirements specification that is included within the tender specification, or incorporated in the tender specification itself.

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The types of requirements sources included in a requirements specification include the following:

- functional requirements
- performance requirements
- interface requirements
- process requirements
- non-functional requirements
- quality requirements
- human factors requirements
- design constraints
- safety

The requirements that are agreed between TfNSW and the AEO at the time of signing the contract become the baseline requirements for the product or service.

The requirements specification takes the form of a suite of requirements depending upon the level of requirements definition performed in TfNSW prior to AEO engagement. Stakeholder requirements are also known as a business requirements specification (BRS). System level requirements are also known as a system requirements specification (SRS).

A diagram describing the relationship between the business level requirements, system level requirements and element level requirements is provided in Appendix B.

Further baselines of requirements are performed at the successful completion of each life cycle stage. Changes to baseline requirements are implemented through an agreed change control process.

6. Requirements definition and analysis

Requirements definition and analysis are systems engineering processes designed for managing requirements. The purpose of requirements definition and analysis is to minimise the risks that arise from decisions and actions throughout the project life cycle, thus enabling the products and services to meet a project's expectations and legislated requirements.

Requirements definition and analysis forms part of the continuous requirements management process. This incorporates the following processes throughout a project life cycle:

- eliciting requirements
- defining and analysing requirements
- tracing requirements

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- agreeing requirements
- documenting requirements
- controlling and communicating changes to the requirements

An initial design brief incorporating a set of desired outcomes is expanded into a full set of manageable requirements using stakeholder requirements definition.

Requirements analysis takes the initial set of stakeholder requirements and assists in developing them into a full set of guidelines and specifications that are required to guide the work. The stages or output of a system is measured against these specifications to determine whether the system is fit for purpose as intended.

7. Stakeholder requirements definition

The requirements management for multidisciplinary transport projects is performed at the system level. This involves capturing stakeholder requirements from the user requirements, stakeholder specifications, a works brief or service brief and applicable standards.

The purpose of stakeholder requirements definition is described in the following documents:

- AS/NZS ISO/IEC 15288:2013 *Systems and software engineering – System life cycle processes*
- ISO/IEC/IEEE 29148:2011 *Systems and software engineering – Life cycle processes – Requirements engineering*

Figure 1 provides a high-level representation of stakeholder requirements definition.

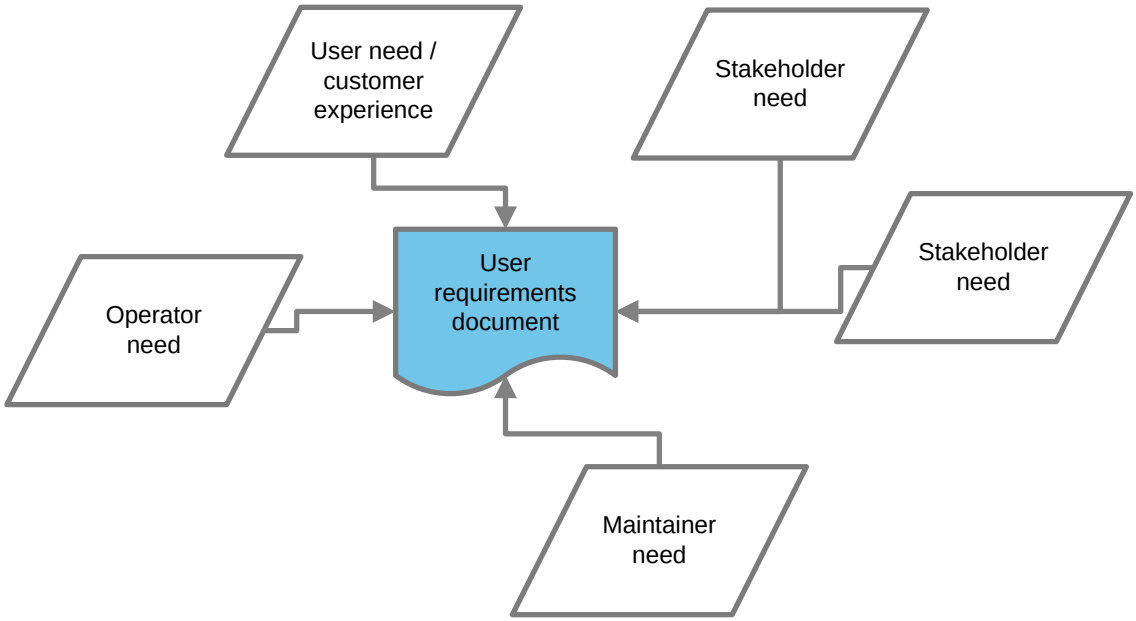

Figure 1 - Stakeholder requirements definition

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7.1. Stakeholder requirements definition output

The output of the stakeholder requirements definition process is an initial set of stakeholder requirements for the required product or service, which should define the required capability and any constraints including supporting information.

For each stakeholder requirement, traceability to the source of the stakeholder requirement is identified and recorded.

The stakeholder requirements form the baseline documents that are used as the basis of design and should be subject to configuration control.

The process flow charts for generic requirements definition are available in the *Systems Engineering Body of Knowledge* (SEBoK).

Further details regarding verification and validation, including the allocation of verification methods is provided in TS 10506 *AEO Guide to Verification and Validation*.

7.2. Business requirements specification

The document that contains the business goals and stakeholder requirements is referred to as the business requirements specification (BRS) within TfNSW.

The BRS contains the following information:

- stakeholder and business requirements in the context of why the system is being developed or changed which is also referred to as the business case
- the stakeholders, users, operators, maintainers and interfaces to the system
- the manner in which the system interacts with the intended users
- the manner in which the system is operated and maintained
- new or improved capabilities including any interfaces and constraints
- policies and rules under which the system is used
- high level strategic requirements
- key benefits and values

A completed BRS typically outlines the stakeholder requirements relating to the following strategic areas:

- enterprise or business
- maintenance - often also documented in a maintenance concept definition
- operations - often also documented in an operations concept definition
- user needs or expected customer experience

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In certain situations, a BRS might exist but contain insufficient information to address all of the stakeholder requirements including the business requirements, user requirements, maintenance requirements and operational requirements. Where this situation arises, further work is required to elicit and define the complete set of necessary stakeholder requirements before any attempt is made to develop the system level requirements.

Business requirements specifications are usually prepared by the transport planning entity. However, in some situations the transport planning entity may contract an AEO to assist with the preparation of this document.

Further details regarding business requirements specifications is provided in T MU AM 06010 GU *Business Requirements Specification*.

7.3. Defining stakeholder requirements

Defining stakeholder requirements comprises the following elements:

- eliciting requirements from stakeholders
- defining the requirements
- analysing stakeholder requirements
- on-going maintenance of stakeholder requirements

Figure 2 provides a high-level representation of the stakeholder requirements definition processes.

Figure 2 - Stakeholder requirements definition process

7.3.1. Elicit stakeholder requirements

Eliciting stakeholder requirements is undertaken to ensure that the system or product that is being acquired or developed meets the needs of all stakeholders.

Eliciting stakeholder requirements requires the AEO to identify all the individuals, groups or organisations that have a legitimate interest in the system and then identify their requirements.

7.3.2. Define the stakeholder requirements

Identifying the needs of stakeholders is crucial for defining the objectives of the desired product or service and the way it should be designed. Accurate and clear documentation of these requirements reduces inefficiency in the design, and review process and ensures that the final

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product or service adequately fulfils the stakeholder's expectations. The following high-level steps can assist in compiling a comprehensive requirements document:

- define the constraints on the system
- identify the required products or services
- identify the operational needs and environment
- identify the interactions between users, operators and maintainers and the system
- define any reliability, availability, maintainability, safety, security, environmental or other stakeholder requirements that are needed

Development of a system to meet all of the stakeholder's needs is often subject to many constraints. These constraints can include the following:

- requirements to use commercial off the shelf (COTS) or proprietary systems
- requirements to use existing facilities
- operations interfaces with other systems or organisations
- standards
- safety features
- operational environment
- regulatory and architectural constraints

Each requirement should originate from an authorised source, signed by all of the relevant stakeholders and be attributed a finalised status. The elicited requirements should include input from all identified stakeholders.

7.3.3. Review and maintain stakeholder requirements

Stakeholder's needs and expectations are unique. The captured stakeholder requirements should be recorded, reviewed and maintained. The following activities are undertaken to assist in managing stakeholder requirements:

- record the stakeholder requirements in a form suitable for management throughout the life cycle
- establish a requirements database and store all requirements with information that can be traced back to their source documents
- review the complete set of elicited requirements
- identify each requirement uniquely by implementing a logical coding system

  This unique identifier should remain with the requirement.

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- identify and categorise requirements according to types to meet the project and design constraints
- review the captured requirements with stakeholders to ensure needs have been captured and expressed correctly
- identify the verification and validation method and acceptance criteria for the stakeholder requirement

8. Requirements analysis

Requirements analysis is explained in Section 8.1 through to Section 8.3.

8.1. Purpose of requirements analysis

Requirements analysis develops the initial set of requirements into a fully scoped set of specifications. It takes the user requirements and develops them into system requirements.

The purpose of requirements analysis is more comprehensively described in AS/NZS ISO/IEC 15288:2013.

Figure 3 provides a high-level representation of requirements analysis.

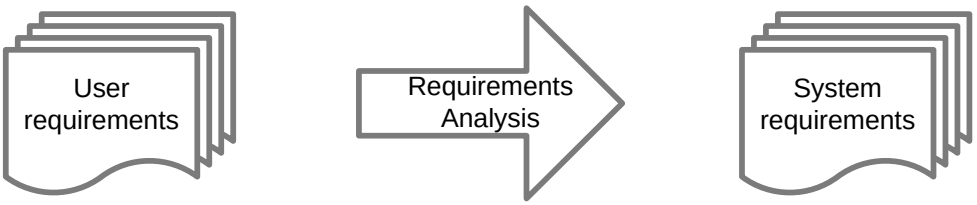

Figure 3 - Requirements analysis

8.2. Requirements analysis output

The output of the requirements analysis process is the establishment of an initial set of system requirements for the required product or service, which fully responds to the stakeholder requirements. This initial set of system requirements should define the following requirements and attributes of the proposed product or service:

- required characteristics and attributes
- functional requirements
- performance requirements

For each system requirement, traceability should be identified and recorded against the stakeholder requirement.

The verification method for each system requirement should also be defined.

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When these system requirements are approved, they form the baseline specifications for design purposes, and are subject to configuration control.

When an agreed set of system requirements is established, the requirements verification and traceability matrix (RVTM) should be established or updated.

8.2.1. System requirements document

The purpose of the system requirements specification (SRS) is to provide a description of the functional intent of the system including any expected interactions and interfaces with its operational environment. The SRS communicates the stakeholder requirements to the technical community who specify and build the system.

A system requirements document performs the following functions:

- defines the high-level system requirements
- defines the functional, performance and non-functional requirements (including reliability, availability, maintainability and safety requirements)
- identifies any constraints or assumptions
- identifies the technical specifications for the selected system-of-interest
- identifies usability for human-system interaction and interfaces
- provides background information about the overall objectives for the system and its operating environment
- can include conceptual models designed to illustrate the system context, usage scenarios, the internal and external interfaces with the operational environment, data, information and workflows

SRSs are usually prepared by the transport projects entity; however, in most situations the transport projects entity contracts an AEO to undertake the development of a SRS.

Examples of SRSs are provided in Appendix D.

8.3. Requirements analysis activities

An AEO, on engagement by TfNSW, should carry out a detailed analysis of the requirements in order to produce a technical view of a product or service that can deliver the expected outcome.

Requirements analysis comprises defining the system requirements and then analysing and maintaining the system requirements.

Figure 4 provides a high-level representation of requirements analysis activities.

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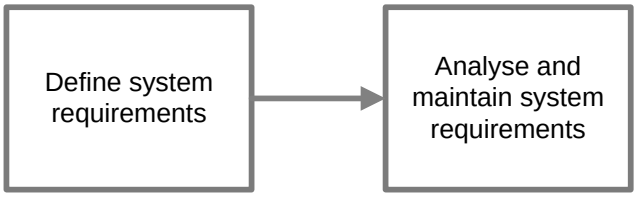

Figure 4 - Requirements analysis activities

When the requirements analysis process is complete, the system requirements are submitted to all authorised stakeholders for review and validation.

8.3.1. Define system requirements

The following activities are undertaken to develop a technical view of the required product or service from the stakeholder needs:

- define the system boundaries

  Review the stakeholder requirements, including both users' and maintainer's requirements and the operation environment to understand the boundaries of the required product or service.

- define the system functions

  Undertake functional analysis and derive new functional requirements that are required to achieve the project mission or service outcome. This can include safety controls identified to mitigate risks as identified through hazard analysis workshops.

- define any implementation constraints

  These can include constraints defined by the stakeholders, limitations of the solution or compliance with standards.

- define interfaces

  This should include technical and enterprise interfaces both internal and external to the system-of-interest. Interfaces should be defined and should be categorised as one or more of the following:

  - functional system interface
  - physical system interface
  - information interface

- define speciality process factors; for example, health and safety, security, human factors, reliability, availability and maintainability

  These can include factors defined by the stakeholders, compliance with standards or outputs from hazard and risk analysis activities.

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Further details regarding system safety, including hazard analysis is provided in TS 20001 *System Safety Standard for New or Altered Assets*.

8.3.2. Analyse and maintain system requirements

The following activities are undertaken in order to analyse the technical system view of the required product or service:

- review the integrity of the system requirements

  Each system requirement statement should be checked to ensure that it is unique, complete, unambiguous, consistent with other requirements, verifiable, and able to be implemented.

- define the verification criteria for each system requirement

  Identify the evidence required to demonstrate where and how the requirements will be verified. This occurs through executing verification and validation plans. Verification and validation plans are also referred to as inspection and test plans.

- allocate the requirements to the relevant system or element

  This includes the identification of internal and external interfaces, which requires management to ensure that the implications of design development in one system or element are fully incorporated in other systems or elements.

- allocate the responsibilities associated with each of the system requirements

  Requirements can have more than one aspect of responsibility.

- establish and maintain system level traceability

System requirements should have parent-child traceability to the source document or direct to the stakeholder need. This should include all derived requirements with information that traces back to parent requirements or source documents. The established traceability includes all identified interfaces.

Establishing and maintaining traceability is fundamental to ensure that all stakeholder requirements are satisfied, and that each system requirement is justified. Requirements traceability ensures that stakeholder requirements have been realised in the proposed solution and that an impact analysis can be undertaken when requirements change.

Parent-child traceable relationships exist between stakeholder requirements through system elements at multiple levels of derived requirements all the way down to the lowest configuration items.

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A parent-child traceable relationship exists between stakeholder requirements or requirements that have been derived from hazard analysis and failure mode analysis such as safety, reliability, availability or maintainability requirements to any one or more of the following sets:

- architectural design
- system elements that implement a requirement
- verification entities that satisfy a requirement, along with any supporting models and analysis
- all interfaces

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Appendix A Requirements verification and traceability matrix template

Table 1 through to Table 8 provides a list of attributes under different headings and these should feature in a typical requirements verification and traceability matrix (RVTM).

Table 1– Attributes for 'Description' in a RVTM

Attribute	Suggested type	Description
Requirement ID	String	Unique identifier for the requirement.
Requirement clause	String	Description of the requirement.
Requirement type	String	• capability – requirements from the stakeholders on the functionality of a design discipline or disciplines or the system, that is, requirements on what the system does or provides • constraint – requirements defining the boundaries for the possible solution, that is, qualities demanded by the user • assumptions – a statement that is ambiguous or requires further clarification prior to it being accepted as a requirement • supporting – information that supports a requirement or group of requirements; supporting objects do not need to be verified and validated
Rationale	String	A description of why this requirement is required or why this requirement is important to the stakeholders.

Table 2 – Attributes for 'Assign' in a RVTM

Attribute	Suggested type	Description
Allocation	String	Teams or elements that are partially or fully responsible for ensuring this requirement is met.
Accountable	String	Person who will be accountable for ensuring this requirement is met.
Due date	Date	Date by when the requirement should be implemented.

Table 3 – Attributes for 'Backward traceability' in a RVTM

Attribute	Suggested type	Description
Source	String	Original source of the requirement.
Stakeholders	String	People who use this requirement. Should be consulted on changes.

Table 4 – Attributes for 'Forward traceability' in a RVTM

Attribute	Suggested type	Description
Dependencies	String	Child requirements that have traceability linked to this requirement.

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Attribute	Suggested type	Description
Use case	NA	Link to relevant use cases that verify the requirement is necessary.
Design elements	NA	Link to relevant design elements.
Test cases	NA	Link to test cases that verify the requirement will be met.

Table 5 – Attributes for 'Verification and validation' in a RVTM

Attribute	Suggested type	Description
Verification and validation method	String	Examples include inspection, analysis, demonstration, test, and certification.
Verification and validation document	String	Identify the documents that demonstrate where and how the requirements will be verified or validated or both.
Verification and validation evidence	String	Identify where the verification or validation evidence can be located.

Table 6 – Attributes for 'Requirement status' in a RVTM

Attribute	Suggested type	Description
Requirement status	String	• proposed – new or changed requirements are set at this classification • approved – requirements that have been approved and baseline established by the stakeholders are set at this classification • completed – requirements that have been satisfied by testing, or other means are set to this classification • nonconformance – requirements which cannot be delivered by the project • removed/on hold – statements that were previously requirements, but have been removed from scope or suspended are set to this classification • N/A – items that are not requirements are set to this classification
Date	Date	Date the requirement was last reviewed.
Author	String	The most recent editor of the requirement.
Version	Integer	Current version of the requirement.

Table 7 – Attributes for 'Requirement prioritisation' in a RVTM

Attribute	Suggested type	Description
Priority, importance	Integer	How important the delivery of this requirement is for the project success.
Risk	Integer	Level of risk that this requirement places on the project and company.

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Table 8 – Attributes for 'Miscellaneous' in a RVTM

Attribute	Suggested type	Description
Comments	String	NA

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Appendix B Requirements repository structure

Figure 5 shows the relationships between the business level requirements, system level requirements and element level requirements.

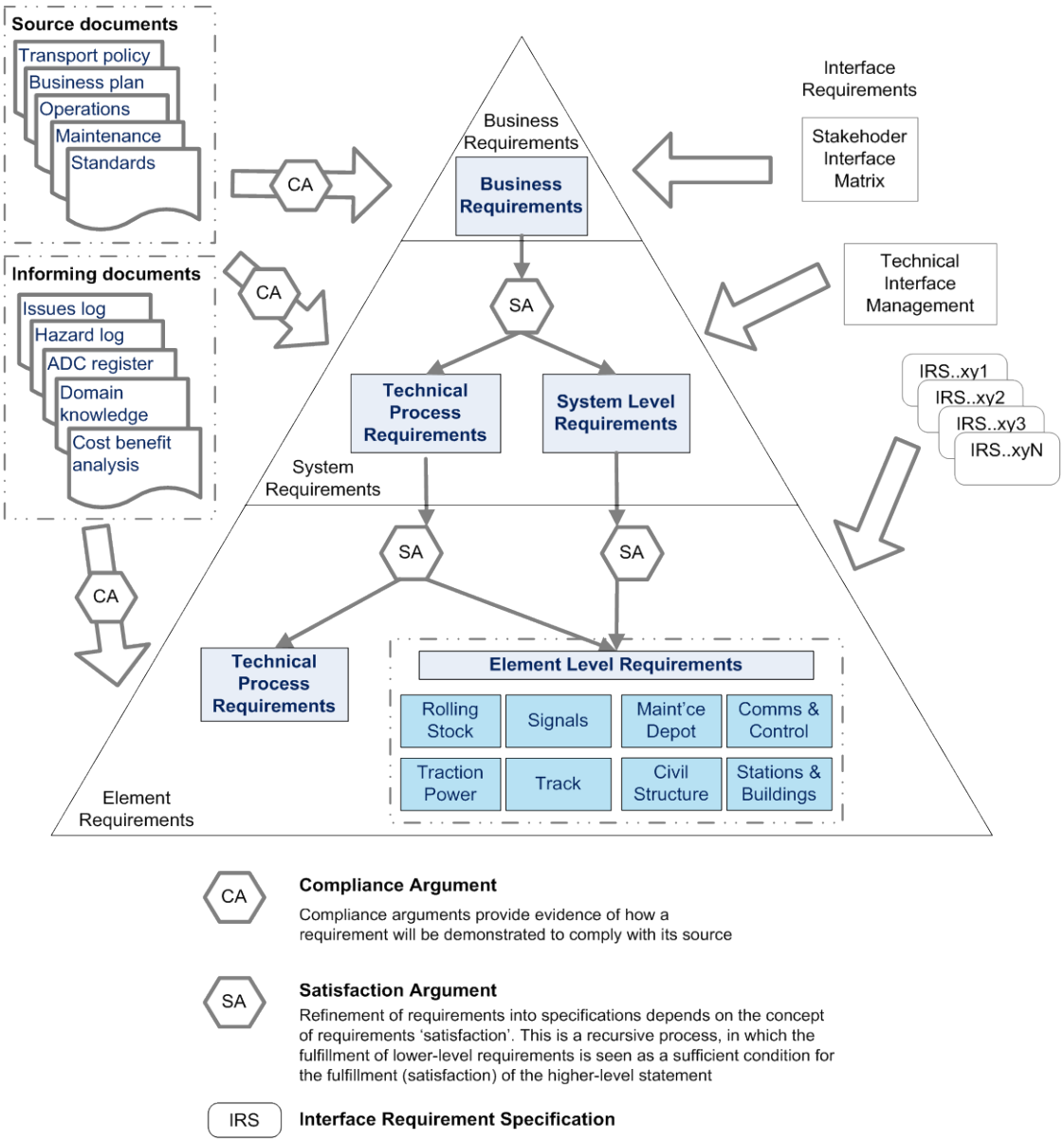

Figure 5 - Requirements repository structure diagram

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Appendix C Requirement examples

Table 9 provides the list of attributes that are exhibited in the requirement statements.

Table 9 – Attributes exhibited in requirement statements

Attribute	Description	Requirement example
Clear and concise	Requirements contain clear and concise language, avoiding unclear phrases such as "the required level of operation capability".	The system [subject] shall provide [verb] the level of operational capability [condition] of 24 trains per hour [value].
Specific	Requirements contain specific information, avoiding non-specific phrases such as "from electricity".	The system [subject] shall operate [verb] from an N-1 redundant electrical supply [constraint] of 240 V ac [value], 50 Hz [value].
Necessary	Requirements are essential, avoiding un-necessary requirements such as “The card reader shall operate 24/7” and “The card reader shall operate Monday through to Sunday".	The card reader [subject] shall operate [verb] continuously [constraint] over its operating life [condition] of 25 years [value].
Valid	Requirements are logically valid avoiding invalid phrases such as "operate in all modes all the time".	The system [subject] shall operate [verb] in one mode at a time [constraint].
Implementation independent	Requirements are implementation independent avoiding implementation dependent phrases such as "use Acme 123 circuit breakers".	The system [subject] shall break [verb] the load circuit [object] when the load current exceeds [constraint] 10 A ac [value], 50 Hz [value] for greater [constraint] than 200ms [value].
Unambiguous	Requirements contain unambiguous language avoiding ambiguous phrases such as "operate solely by mouse or keyboard".	The user interface [subject] shall operate [Verb] by keyboard [Object]. The user interface [Subject] shall operate [Verb] by mouse [Object].
Verifiable	Requirements are able to be verified avoiding unverifiable phrases such as: "The system shall be as light as possible".	The 8-car train [subject] shall weigh [verb] a maximum [constraint] of 500 tonnes [value] fully loaded [constraint].
Feasible	Requirements are implementation feasible avoiding not feasible phrases such as "operate from dark energy".	The base station [subject] shall operate [verb] from solar energy [constraint].
Traceable	Requirements are traceable to a source requirement, standard or document avoiding not traceable phrases such as "be repairable in two hours".	The train [subject] shall be repairable [verb] according to service level agreement XYZ [constraint].
Consistent	Requirements contain consistent information avoiding inconsistent phrases such as "non-magnetic mild steel".	The train car body [subject] shall be constructed [verb] from non-magnetic materials [constraint].

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Attribute	Description	Requirement example
Atomic	Requirements are atomic containing one requirement, avoiding non atomic phrases such as: "accelerate from 0 km/h to 60 km/h in 10 seconds and brake to 0 km/h in 5 seconds".	The train [subject] shall accelerate [verb] from [constraint] 0 km/h [value] to [constraint] 60 km/h [value] within [constraint].10 seconds [value]. The train [subject] shall brake [verb] from [constraint] 60 km/h [value] to [constraint] 0 km/h [value] within [constraint] 5 seconds [value].

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Appendix D SRS examples

Section D.1 and Section D.2 provides examples of structuring system requirement specifications based on ISO/IEC/IEEE 29148:2011.

D.1. Example 1- Replacement of a road level crossing

The following is an example of a system requirement specification for replacement of a road level crossing.

Note that this example includes the system requirement headings only and does not include the actual system requirements.

System purpose

To improve safety and traffic flow the existing road level crossing is to be replaced by a grade separation.

System scope

The system is the level crossing replacement. The business requirements for this project are defined in the level crossing replacement business requirements specification. The level crossing currently causes traffic congestion on the road, safety and security incidents.

The system will remove the existing level crossing and provide a grade separated thoroughfare for road vehicles, cyclists and pedestrians. The system will not divert the road and the railway lines.

System overview

System context

The system consists of the following major elements:

- railway lines
- trains operating on the railway lines
- thoroughfare
- vehicles driving through the thoroughfare
- pedestrians walking through the thoroughfare
- cyclists riding through the thoroughfare

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System functions

The major system capabilities, conditions and constraints are as follows:

- railway line for passenger, freight and maintenance rail vehicles
- vehicle thoroughfare for light and heavy road vehicles
- cycle thoroughfare for bicycle riders
- pedestrian thoroughfare for pedestrians

User characteristics

Users of the system have the functions and locations as provided in Table 10.

Table 10 – user functions and locations

User	Function	Location
Train crew	Operating suburban, country and freight trains	Trains
Railway maintenance personnel	Sustaining civil, track, signals, overhead wiring, electrical and communications assets	Rail corridor
Vehicle drivers	Controlling cars, motorbikes, buses, trucks and articulated vehicles	Thoroughfare
Pedestrians	Walking, jogging and running	Thoroughfare
Cyclists	Riding bicycles	Thoroughfare
Road maintenance personnel	Sustaining road, footpaths, lighting and signage	Thoroughfare

System requirement headings

Functional requirements

- decommissioning of existing
- grade separation
- railway lines
- railway signage
- railway lighting
- railway signalling
- control systems
- railway fencing
- traction power
- signalling power

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- overhead wiring
- railway safety
- roadway safety
- cycleway safety
- pathway safety
- telecommunications
- stormwater management
- water supply
- electrical supply
- fresh air supply
- fire and life safety
- exhaust fumes
- roadway
- pathway
- cycleway
- roadway signage
- thoroughfare lighting
- security monitoring
- railway fencing

Usability requirements

- train drivers
- vehicle drivers
- pedestrians
- cyclists
- maintainers

Performance requirements

- number of railway lines
- train types

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- number of vehicle lanes
- vehicle types
- number of footpaths
- number of bike lanes
- operational life
- fence heights
- train frequency
- train speeds
- roadway speeds
- cycleway speeds
- railway lighting levels
- thoroughfare lighting levels
- monitoring coverage
- monitoring resolution
- monitoring retention
- availability of thoroughfare
- availability of railway lines
- visual appearance

System interfaces

External interfaces

- railway lines
- signalling systems
- telecommunication systems
- buildings (includes railway, residential and commercial buildings)
- stabling yards
- train stations
- roadway
- footpath
- cycleway

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- overhead wiring
- water supply
- gas supply
- stormwater system
- electrical supply
- earthing and bonding

Internal interfaces

- trains on tracks
- trains to overhead wiring
- trains to signalling system
- vehicles on thoroughfare
- pedestrians on thoroughfare
- bikes on thoroughfare
- railway tracks to thoroughfare

System operations

Human system integration

- footpath operation
- bike path operation
- maintainer operation

Maintainability

- railway lines mean time to repair
- railway lines maximum time to repair
- thoroughfare mean time to repair
- thoroughfare maximum time to repair
- rail possession frequency
- rail possession duration
- thoroughfare inspection

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- graffiti prevention
- Graffiti removal

Reliability

- railway lines reliability normal operating mode
- thoroughfare reliability normal operating mode

System modes and states

- normal operating mode
- maintenance mode
- fault mode
- emergency mode

Physical characteristics

Physical

- railway line location
- thoroughfare location

Adaptability

- additional rail lines
- additional roadway lanes
- dedicated cycle lanes

Environmental conditions

- temperature range
- humidity range
- dirt and dust
- salt spray
- flooding
- railway noise
- railway vibration
- electromagnetic emissions
- ventilation

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System Security

Physical security

- access to railway lines

Network security

- access to surveillance video

Information management

- information displays
- video archiving
- video playback

Policies and regulations

- ISO standards
- Australian standards
- ASA standards
- Rail Safety Act
- Disability Discrimination Act
- WHS Act
- Sustainability Design Guidelines
- Electromagnetic compatibility standards
- RISSB standards

System life cycle sustainment

- operational support facilities
- maintenance support facilities
- training
- competency
- spare parts
- durability of components
- obsolescence of components
- documentation

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- operation manuals
- maintenance manuals
- inspection manuals

Packaging, handling, shipping and transportation

- road deliveries
- rail deliveries

Verification

The system verification plan defines the verification approaches and methods to verify each of the system requirements.

Assumptions and dependencies

- dependency between the thoroughfare and the geotechnical conditions
- assumption that the roadway alignment is retained
- assumption that railway line alignment is retained

D.2. Example 2 – Rolling stock replacement program

The following is another example of a system requirement specification for a rolling stock replacement program based on ISO/IEC/IEEE 29148:2011.

> *Note that this example includes the system requirement headings only and does not include the actual system requirements.*

System purpose

To improve the safety, reliability and overall customer experience on the existing electric rail network by replacing the electric rolling stock fleet.

System scope

The system is the rolling stock fleet replacement. The business requirements for this project are defined in the rolling stock replacement business requirements specification. The system will replace the existing electric rolling stock fleet with comfortable, safe and reliable rolling stock.

The system will operate with the existing fixed infrastructure and depots.

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System overview

System context

The system consists of the following major elements:

- trains
- trains on railway lines
- passengers on trains
- train crew on trains

System functions

The major system capabilities are as follows:

- move passengers
- carry passengers
- train crew control

User characteristics

Users of the system have the functions and locations as specified in Table 11.

Table 11 – User functions and locations

User	Function	Location
Passengers	Travelling on trains	Trains, stations
Train crew	Operating trains	Trains, stations, depots
Operational staff	Monitoring and controlling trains	Stations, control centres, depots
Revenue protection officers	Inspecting tickets or cards and issuing fines	Trains, stations
Police	Monitoring and controlling passengers	Trains, stations
Maintenance staff	Sustaining trains	Trains, stations, depots
Trainers	Educating train crew, operational and maintenance staff	Trains, stations, training facilities
Cleaners	Removing of internal rubbish and dirt and external washing of trains	Trains, stations, depots

System requirement headings

Functional requirements

- propulsion
- guide on track

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- contain passengers and train crew
- contain load
- passenger seating
- passenger standing
- customer experience
- passenger safety
- train crew safety
- heating, ventilation and air conditioning
- platform ingress and egress
- emergency ingress and egress
- fire and life safety
- external lighting
- internal lighting
- headlights
- taillights
- windows
- passenger displays
- announcements
- Wi-Fi
- passenger telephones
- electrical power
- security monitoring
- crew accommodation
- crew controls
- train monitoring
- crew displays
- crew communications

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- signage
- train visibility
- data logging

Usability requirements

- suburban metropolitan and regional rail network
- train crew
- people walking
- people with disabilities
- cyclists
- maintainers

Performance requirements

- seating capacity
- standing capacity
- crashworthiness
- temperature range
- humidity range
- ventilation capacity
- ingress and egress capacity
- station compatibility
- window coverage
- passenger display coverage
- passenger display illumination
- passenger display capacity
- announcement coverage
- announcement levels
- natural light levels
- artificial lighting levels
- ride levels
- noise levels

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- vibration levels
- security monitoring coverage
- security monitoring resolution
- security monitoring retention
- data parameters
- data retention
- crew accommodation capacity
- crew control levels
- train monitoring parameters
- crew communication types
- operating life
- operating speeds
- acceleration
- speed sustainment
- deceleration
- stopping
- supply voltage
- supply frequency
- headlight illumination
- taillight illumination
- exterior light illumination
- power consumption
- availability
- branding
- colour schemes

System interfaces

External interfaces

- railway lines
- overhead wiring

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- signalling systems
- control systems
- telecommunication systems
- earthing and bonding
- platforms

Internal interfaces

- passengers
- train crew
- operational staff
- maintenance staff

System operations

Human system integration

- door operation
- seat operation
- emergency response operation
- emergency door release operation
- train crew controls operation
- maintainer operation

Maintainability

- mean time to repair
- maximum time to repair
- periodic maintenance
- inspection access
- graffiti prevention
- graffiti removal
- internal cleaning
- external cleaning

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Reliability

- reliability normal operating mode

System modes and states

- normal operating mode
- maintenance mode
- fault mode
- emergency mode

Physical characteristics

Physical

- weight
- volume
- dimensions

Adaptability

- additional signalling systems
- additional communication systems

Environmental conditions

- temperature range
- humidity range
- wind
- rain
- snow
- dirt and dust
- noise
- vibration
- electromagnetic emissions

System Security

- access to crew accommodation
- access to surveillance video

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- access to train data

Information management

- video archiving
- data retention
- video playback

Policies and regulations

- Australian standards
- ISO standards
- ASA standards
- Rail Safety Act
- Disability Discrimination Act
- WHS Act
- Sustainability Design Guidelines
- Electromagnetic compatibility standards
- RISSB standards

System life cycle sustainment

- operational support facilities
- maintenance support facilities
- wash facilities
- training
- competency
- Spare parts
- durability of components
- obsolescence of components
- documentation
- operation manuals
- maintenance manuals
- inspection manuals

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Packaging, handling, shipping and transportation

- delivery to site

Verification

The system verification plan defines the verification approaches and methods to verify each of the system requirements.

Assumptions and dependencies

- dependency between train acceleration and the traction power supply
- assumptions that system will operate with the existing train operating conditions
- assumption that the system will operate with the existing infrastructure

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