Metrolinx
RAM (Reliability, Availability, Maintainability) Plan Process

MX-SEA-STD-003

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MX-SEA-STD-003

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Preface

This is the second edition of the RAM Plan process published as part of Metrolinx RAMS (Reliability, Availability, Maintainability and Safety) Standards. While the standard number changed from RAMS-3 to MX-SEA-STD-003, the standard's content did not change. It describes RAM Plan Process throughout the system lifecycle and the main tasks and deliverables from concept phase to system integration phase.

The purpose of Metrolinx RAMS Standards is to formalize the framework to adequately manage RAMS performance of all Metrolinx assets for the entire life cycle starting from concept, through risk assessments, stage gate approvals, design and specifications, construction, systems integration, validation, acceptance, operation, maintenance, performance monitoring and decommissioning. Metrolinx RAMS standards, which are built as an adaptation of European Standard EN 50126-1:2017, provide internal Metrolinx staff and external stakeholders involved in design, construction, operation and maintenance of Metrolinx assets with a common understanding and a systematic process for RAMS management. Ultimately, they provide a systematic approach for specifying RAMS requirements and demonstrating that these requirements are achieved.

This document was developed by the Systems Engineering Assurance Office, Engineering and Asset Management Division, Operations Rapid Transit Group, Metrolinx.

Suggestions for revision or improvements can be sent to the Metrolinx Systems Engineering Assurance office, Attention: Director of Systems Engineering Assurance who shall introduce the proposed changes to the Metrolinx Systems Engineering Assurance office. The Director of the Systems Engineering Assurance office ultimately authorizes the changes. Be sure to include a description of the proposed change, background of the application and any other useful rationale or justification. Be sure to include your name, company affiliation (if applicable), e-mail address, and phone number.

March 2022

Amendment Record

Revision	Date (DD/MM/YYYY)	Description of changes
01	15/03/2022	Document numbering format updated and Preface updated to reflect current standard owner name change.

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Documents

TABLE 0-1 SUPPORTING DOCUMENTS

Document Number	Document Title	Relation
BS EN 50126-1:2017	Railway Applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) (PHASE 1: Adoption of European Standard EN 50126-1:2017)	Parent Standard
CKH-ASMT-PRC-001	Asset Data and Information Standards	Reference
CPG-QAT-FRM-106	CPG Terms Glossary	Reference
GO-DRM-STD-2017-Rev3	GO Design Requirements Manual	Reference
TBD	Roles and Responsibilities Matrix (RACI) for RAMS tasks	Reference
MX-SEA-STD-005	RAM Verification and Validation (V&V) Process	Reference

Acronyms and Abbreviations

TABLE 0-2 ACRONYMS AND ABBREVIATIONS

Acronym	Full Name
BU	Business Unit
CPG	Capital Projects Group
FMECA	Failure Modes, Effects and Criticality Analysis
FRACAS	Failure Reporting, Analysis and Corrective Action System
RACI	Responsible Accountable Consulted Informed
RAM	Reliability, Availability and Maintainability
RAMS	Reliability Availability Maintainability and Safety
SOGR	State of Good Repair

Definitions

Term	Definition	Source
Acceptance criteria	A list of specific and defined conditions that must be met before a project has been considered completed and the asset/ system will be accepted by the Asset Class Teams.	
Approved Project	A project that has passed successfully through the investment panel stage gates and has approval to proceed with budget allocation.	*CPG-QAT-FRM-106*, *CPG Terms Glossary*
Asset	Any physical or tangible item that has potential or actual value to Metrolinx (excluding intellectual property, inventory to be sold, human resources, and financial instruments), as well as IT systems and software.	CKH-ASMT-PRC-001, Asset Data and Information Standards Note: refer to CKH-ASMT-PRC-001 Asset Data and Information Standards for additional asset-related definitions.
Asset Class Teams	Metrolinx business units who have been designated as being accountable for the completeness and accuracy of information about a given class of assets.	CKH-ASMT-PRC-001
Assurance	Confidence in achieving a goal being pursued. Declaration intended to give confidence.	BS EN 50126:2017
Availability	Ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided.	BS EN 50126:2017
Design	Activity applied in order to analyse and transform specified requirements into acceptable solutions.	BS EN 50126:2017
Investment Panel (Metrolinx)	The Investment Panel ("IP") is management's ultimate accountable governance body for benefits management of business cases across the entire capital project lifecycle	Investment Panel ToR (03-1-2019)
Lifecycle	Series of identifiable stages through which an item goes, from its conception to disposal.	BS EN 50126:2017

Like to Like Replacement	Replacing deteriorated asset with a similar asset in terms of type, specification and design.	NA
Maintainability	Ability to be retained in, or restored to, a state to perform as required, under given conditions of use and maintenance.	BS EN 50126:2017
Planned Project	A project intended to go through the Investment Panel stage gates that is not yet approved to proceed and does not have budget approval.	*CPG-QAT-FRM-106*, *CPG Terms Glossary*
RAM Plan	Documented set of time scheduled activities, resources and events serving to implement the organisational structure, responsibilities, procedures, activities, capabilities and resources that together ensure that an item will satisfy given RAM requirements relevant to a given contract or project.	BS EN 50126:2017
Reliability	Ability to perform as required, without failure, for a given time interval, under given conditions.	BS EN 50126:2017
Subsystem	Part of a system, which is itself a system	BS EN 50126:2017
System	Set of interrelated elements considered in a defined context as a whole and separated from their environment	BS EN 50126:2017

1. Overview

1.1 Purpose

1.1.1 The purpose of the RAM Plan is to define the steps and timetable of events needed to ensure that RAM requirements are being met throughout the lifecycle of the project. This includes details of the policy to be applied, the scope of the plan and the planning of the RAM activities.

1.1.2 The intended audience for this process is:

a) Asset Class Teams

b) Project Delivery Teams

c) Design Teams

d) Sponsorship Office

1.2 Scope

1.2.1 The RAM Plan is a documented set of time scheduled activities, resources and events serving to implement the organisational structure, responsibilities, procedures, activities, capabilities and resources to ensure the RAM requirements are achieved.

1.2.2 The lifecycle tasks for the RAM Plan need to be created, reviewed and maintained throughout the project lifecycle. The RAM Plan is essentially an oversight document that contains all of the RAM tasks. Following these tasks will ensure the system's RAM requirements are met.

1.2.3 The RAM Plan should be reviewed and approved by the Asset class teams and the Project Delivery Team.

1.2.4 The RAM Plan is the framework to ensure that all stakeholders contribute to the following project milestones:

a) Milestone 1- Complete the system requirements specification and validation

b) Milestone 2- Complete the sub-systems and components design

c) Milestone 3- Complete the sub-systems and components manufacturing/build and installation

d) Milestone 4 - Complete the sub system integration

e) Milestone 5 - Complete the system validation and acceptance

f) Milestone 6 - Complete the system acceptance and handover to operation

1.2.5 The RAM Plan is considered to be a living document. Therefore, if some content is not fully available in the early lifecycle phases, this information may be added in later lifecycle phases.

1.2.6 The RAM Plan procedure applies to:

a) Metrolinx new assets (from the concept to integration phase)

b) Metrolinx Non Like for Like Asset replacements

1.2.7 This procedure does not apply to:

a) Non-operational BUs (i.e. Finance, HR, etc.)

b) Assets in the operation, maintenance and performance monitoring phase

c) SOGR Like for Like replacements

Note: This process is limited to RAM and not the safety element of RAMS, safety will be addressed separately.

1.3 Key Responsibilities

Note: For detailed responsibilities, please refer to the Roles and Responsibilities Matrix (RACI), responsibilities will vary based on the contract type.

1.3.1 The following sets out the key responsibilities for each stakeholders, however in the event of conflict the RACI shall take precedence.

1.3.2 The **RAMS team** is responsible to ensure the completion of the following tasks:

a) Together with the Asset class teams, investigating the previous RAM requirements and performance of similar systems as well as the existing RAM policy and targets during the conceptual design phase of the project.

b) Working with the Asset class teams to define the scope of the system's RAM requirements.

c) Creating the initial RAM Plan with the Asset class teams, integrating the scheduled RAM activities into the Metrolinx IP stage gates and confirming resources to implement the organisational structure, responsibilities and procedures. This will ensure the RAM requirements are achieved.

d) Ensuring the RAM Plan is continuously revisited and updated as necessary throughout the project lifecycle.

e) Working with the Asset class teams to define the RAM requirements and specifying the acceptance criteria, procedures and compliance required (including demonstrations).

f) Updating the RAM Plan while considering the risks and acceptance criteria.

g) For approved projects, working with the Project Delivery Team to update the RAM Plan with the RAM requirements and specifications.

h) Working with the Project Delivery Team to create RAM assurance during manufacturing (build phase) to ensure that systems and subsystems are built accordingly.

i) Verifying that the RAM Plan is followed and tasks, events and timelines within the RAM plan are achieved.

1.3.3 The **Asset Class Teams** is responsible for ensuring the completion of the following tasks:

a) Investigating in conjunction with the RAMS team, the previous RAM requirements and performance of similar systems. Also investigating the existing RAM policy and targets during the conceptual design phase of the project.

b) Defining the scope of the RAM requirements for the system, in close coordination with the RAMS team.

c) Defining RAM requirements, specifying the acceptance criteria and compliance (with demonstrations), in close coordination with the RAMS team.

d) Working with the Project Delivery Team to allocate the RAM requirements to the subsystems.

e) Creating RAM assurance procedures so that the systems (and related subsystems) are built as specified.

f) To gain RAM assurance, following tasks shall be completed:

1) Ensure quality assurance measures are acceptable to meet RAM requirements.

2) Implement manufacturing or construction process improvements and assurance measures (as applicable).

3) Complete environmental stress screening (as applicable).

4) Perform inspection and testing for RAM-related failure modes.

5) Ensuring that all systems (including subsystems) are built, assembled and installed to form the complete system.

6) Creating a documented RAM management system including documented assurance records for each lifecycle stage.

7) Evaluating the System Integration Report.

1.3.4 The **Project Delivery Team** is responsible for the completion of the following tasks:

a) For approved projects, working with the RAMS team to update the RAM Plan to documenting the RAM requirements.

b) Allocating the RAM requirements to the subsystems, in close coordination with the Asset class teams.

c) Working with contractors/ designers (if applicable) to ensure that the design of the subsystems (including components) is per the RAM requirements.

d) Applying RAM assurance procedures so that systems/subsystems are built as specified.

e) To gain RAM assurance complete the following procedures:

1) Ensure quality assurance measures are acceptable to meet RAM requirements.

2) Implement manufacturing process improvements and assurance measures (as applicable).

3) Complete environmental stress screening (as applicable).

4) Perform inspection and testing for RAM-related failure modes.

f) Ensuring that all systems and subsystems are installed/assembled as per the design.

1.3.5 The **Designer/Contractor** is responsible for completing and/or delegating the following tasks:

a) Ensuring that the design of subsystems/components is according to the RAM requirements.

b) Applying RAM assurance procedures to ensure that systems and subsystems are manufactured accordingly.

c) Demonstrating that the integrated system (including subsystems and components) work together as required.

d) Creating the System Integration Report for the RAM requirements.

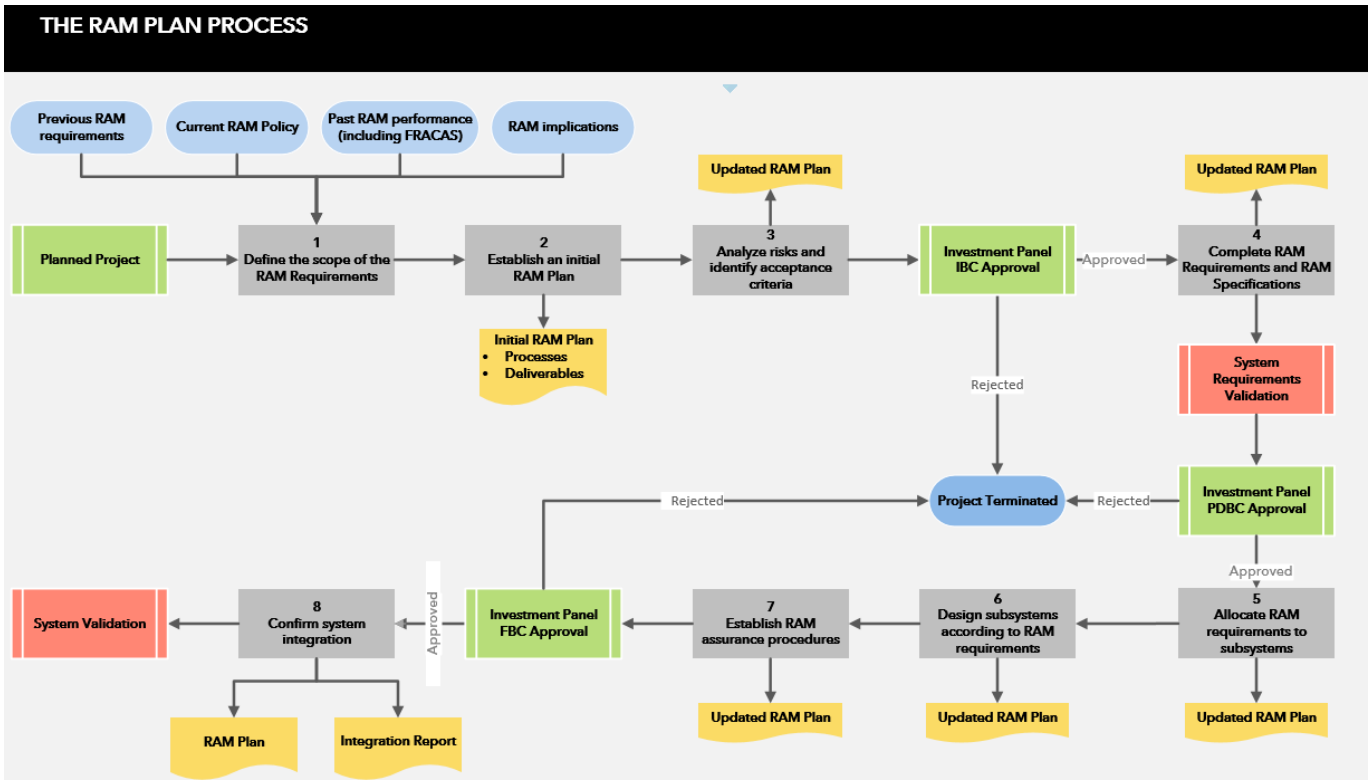
e) Generating the information required to update the RAM Plan throughout the project lifecycle.

2. The RAM Plan Process

2.1 The RAM Plan Flow Chart

2.1.1 Figure 2-1 illustrates the RAM PLAN Process (Draft for review).

FIGURE 2-1 RAM PLAN PROCESS



2.2 The RAM Plan Process Narrative

2.2.1 The following steps describe the RAM Plan Process throughout the project lifecycle:

Note: Please refer to Appendix B-The Mapping of lifecycle phases to IP Stages.

1) Phase 1: Conceptual Design: After investigating the following:
   a) General RAM implications of the system
   b) Previous RAM requirements
   c) Past RAM performance of similar systems
   d) Current RAM policies/targets:

Note: The RAMS team and the Asset class teams must define the scope of the RAM requirements for the lifecycle RAM tasks.

2) Phase 2: System definition and operations: The RAMS team must create the initial RAM Plan by the end of this phase of the project.

a) The main components of the RAM Plan are Management, Reliability, Availability and Maintainability. The table below outlines the details of each component:

TABLE 2-1: RAM PLAN MAIN COMPONENTS

RAM Plan Main Components	
Management	• The system lifecycle and RAM tasks and processes to be undertaken within each lifecycle Phase
	• a Failure Reporting Analysis and Corrective Action System (FRACAS) is to be applied to the system under consideration (from the asset lifecycle phase 7) with records including:
	o technical data on system
	o maintenance action
	o Reporting and corrective action.
	• All RAM related deliverables from the lifecycle
	• RAM acceptance tasks
	• Constraints and assumptions made in the RAM plan
	• Subcontractor management arrangements
Reliability	• Reliability analysis and prediction
	• Reliability planning
	• Reliability testing
	• Reliability data acquisition and assessment
Availability	• Availability analysis
	• Sensitivity analysis
	• Availability data acquisition and assessment
Maintainability	• Maintainability analysis and prediction
	• Maintainability planning
	• Logistic support evaluation

Note: FRACAS Process MX-SEA-STD-001 covers assets in operation and maintenance phase, the FRACAS referred to in the above table is to be performed in the build stage of the project and it is not in the scope of the current FRACAS process.

3) Phase 3: Risk analysis and evaluation: The RAMS team must update the RAM Plan to reflect the risks and relevant acceptance criteria.

4) Phase 4: Specification of System Requirements: The RAMS team and the Project Delivery Team must update the RAM Plan with the RAM requirements and specify the acceptance criteria and required compliance, RAM requirement specifications must be validated prior to proceeding to Phase 5: Architecture of system requirements.

Note: For RAM System Requirements Specification Validation details, please refer to RAMS Verification and Validation Process MX-SEA-STD-005.

5) Phase 5: Architecture of system requirements: The Project Delivery Team must apply the RAM requirements to the subsystems. The RAMS team must update the RAM Plan accordingly.

6) Phase 6: Design and Implementation: The Designer must design subsystems and components according to the RAM requirements. The RAMS team must update the RAM Plan accordingly.

   RAM analysis must be completed by the end of the design phase.

Note: For RAM analysis details, please refer to RAMS Verification and Validation Process MX-SEA-STD-005.

7) Phase 7: Manufacture: The Asset class teams must gain RAM assurance by creating RAM assurance procedures that ensures that systems (including subsystems) are

manufactured and are built around RAM requirements. The RAMS team must update the RAM Plan accordingly.

a) To gain RAM assurance complete the following procedures:

i. Ensure quality assurance measures are acceptable to meet RAM requirements.

ii. Implement manufacturing process improvements and assurance measures (as applicable).

iii. Complete environmental stress screening (as applicable).

iv. Perform inspection and testing for RAM-related failure modes.

8) Phase 8: System Integration: The Designer/Contractor must ensure that all systems (including subsystems) are assembled (and installed) to form the complete system. They also create the integration report, which is later evaluated by the Asset class teams.

After the integration phases is completed the system must be validated.

Note: For System Validation details, please refer to RAM Verification and Validation Process MX-SEA-STD-005.

END: The process ends here.

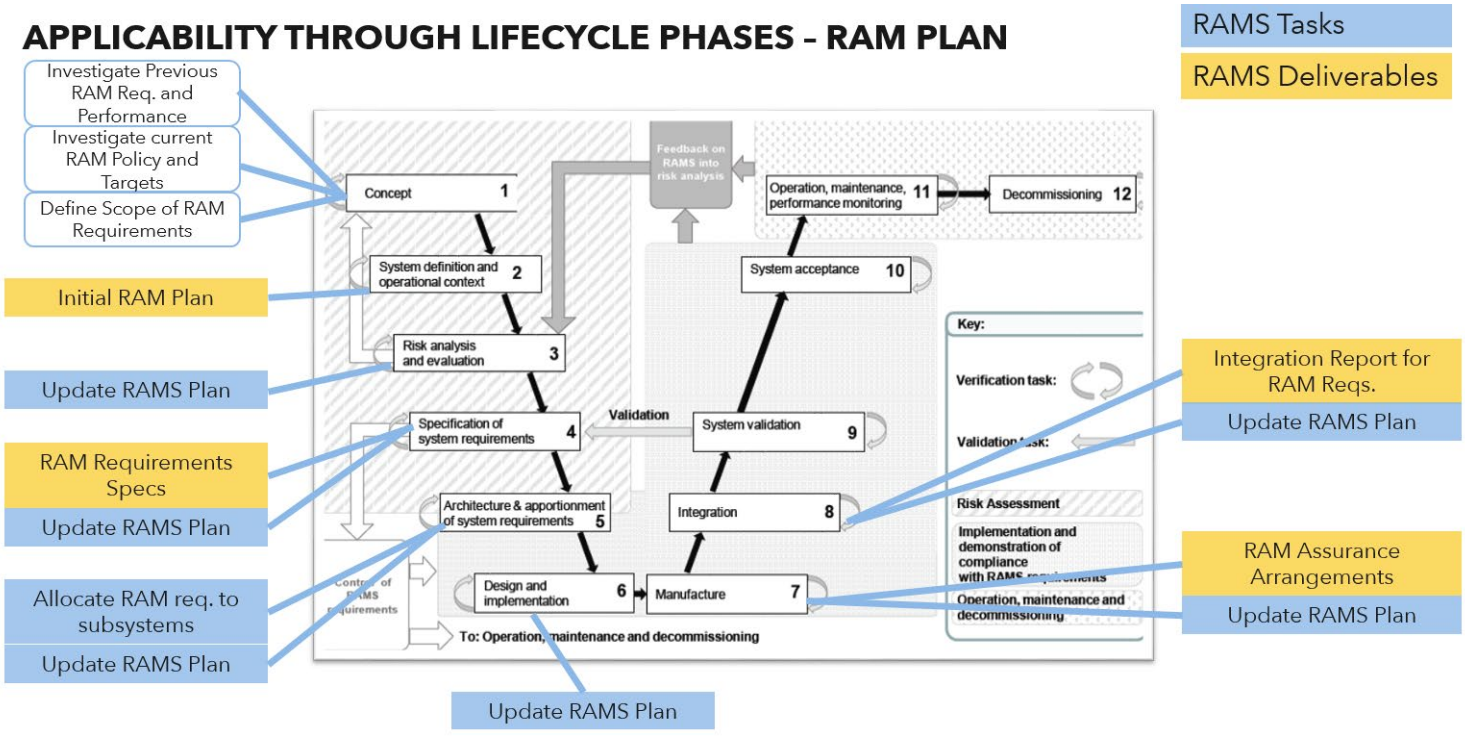
Appendix A- APPLICATION THROUGH THE SYSTEM LIFECYCLE PHASES

A.1 The RAM Plan Application through the system lifecycle phases

A.1.1 The RAM Plan application through the system lifecycle phases.

A.1.2 The figure below illustrates the main RAM Plan tasks and activities throughout the system lifecycle.

Figure A- 1 The RAM Plan Process Application Through System Lifecycle Phases



Appendix B- Mapping of lifecycle phases to IP Stages

B.1 Mapping of lifecycle phases to IP Stages

B.1.1 Mapping of lifecycle phases to IP Stages.

B.1.2 The System lifecycle phases are linked to IP stages to ensure alignment and facilitate assigning accountability as a project moves through the system lifecycle.

B.1.3 For more details on the IP stages and gate descriptions, please refer to Investment Panel ToR (03-1-2019).

FIGURE B- 1 THE MAPPING OF LIFECYCLE PHASES TO IP STAGES