

Master Specification

Part RW-RAMS-D1

Reliability, Availability, Maintainability and Supportability

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Contents

Contents	3
RW-RAMS-D1 Reliability, Availability, Maintainability and Supportability	4
1 General	4
2 Documentation	4
3 Contractor's obligations	5
4 Design for RAMS	6
5 RAMS assurance	7
6 Hold Points	10

RW-RAMS-D1 Reliability, Availability, Maintainability and Supportability

1 General

- a) This Master Specification Part sets out the requirements for the Reliability, Availability, Maintainability and Supportability (**RAMS**) analysis for Rail Infrastructure including:
 - i) the documentation requirements, as set out in section 2;
 - ii) the Contractor's obligations, as set out in section 3;
 - iii) the design for RAMS requirements, as set out in section 4;
 - iv) the RAMS assurance requirements, as set out in section 5; and
 - v) the Hold Point requirements, as set out in section 6.
- b) The RAMS analysis for Rail Infrastructure must comply with the Reference Documents, including:
 - i) BS EN 50126-1 Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) Generic RAMS process;
 - ii) PTS MS 05 AM PRC 00000091 Asset Management Technical Data Requirements Specification; and
 - iii) T MU AM 06002 GU Transport Asset Standards Authority Guide to Reliability, Availability and Maintainability.
- c) The Contractor must ensure the management of design complies with PC-RW30 "Design" and PC-EDM1 "Design Management".
- d) For the purposes of this Master Specification Part, railway systems include OHWS, traction power, signalling and communication, communications and electronics, and track and civil railway system.
- e) The gate details in this Master Specification Part are in accordance with PC-RW10 "Railway Management Planning".

2 Documentation

2.1 RAMS management plan

- a) The Contractor must prepare a RAMS management plan for Rail Infrastructure which:
 - i) includes the RAM assurance process used to demonstrate compliance with:
 - A. the requirements set out in section 5;
 - B. the Contract Documents; and
 - C. BS EN 50126-1 Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) Generic RAMS process, including the RAM programme outline guidance provided in BS EN 50126-1 Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) Generic RAMS process - Annex A;
 - ii) includes the RAMS assurance process used across the design lifecycle demonstrating compliance with the Contract Documents, and section 4;
 - iii) includes an obsolescence management plan, as set out in section 4c)ii);

- iv) apportions RAMS performance targets to railway system levels, as set out in section 5b)ii);
 - v) proposes the model, formula, calculations and sources of all data used in RAMS analysis, as set out in section 5b)viii);
 - vi) proposes functional analysis and failure modes, effects and criticality analysis (**FMECA**) approach and FMECA worksheet template, as set out in section 5d)iv);
 - vii) includes the reliability, demonstration and verification plan, as set out in section 5h);
 - viii) includes the failure, review and corrective action (**FRACAS**) template, as set out in section 5g); and
 - ix) includes the qualification, experience and authorities for each RAMS management role.
- b) The RAMS management plan is a Project Plan and must be prepared, submitted and updated in accordance with the requirements of PC-PM1 “Project Management and Reporting”.
- c) The initial RAMS management plan must be submitted 10 Business Days prior to the Initial Design at Gate 4A.

2.2 Design Documentation

In addition to the requirements of PC-EDM1 “Design Management” and PC-RW30 “Design”, the Design Documentation must include:

- a) details of any component of the system being upgraded or becoming obsolete from general availability as required in section 4c)iv);
- b) details of pending unavailability of components or system as required in section 4c)vii)
- c) a RAMS assurance report as required in section 5a);
- d) a FMECA report as required in section 5d)viii);
- e) a maintainability analysis as required in section 5e); and
- f) a spares analysis as required in section 5f).

2.3 O&M Manual

In addition to the requirements of PC-CN2 “Asset Handover”, the O&M Manual must include:

- a) the provisions for all equipment as set out in section 4d)viii);
- b) the line replaceable units requirements as set out in section 4d)iv); and
- c) the special tools and test equipment requirements as set out in section 4d)xi).

2.4 Maintenance Plan

In addition to the requirements of PC-CN2 “Asset Handover”, the Maintenance Plan must include the requirements set out in section 4d)vii).

3 Contractor’s obligations

The Contractor must establish a system and framework for the overriding RAMS analysis system / framework for Rail Infrastructure and continuously provide evidence, which meets the requirements of:

- a) BS EN 50126-1:2017 Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) Generic RAMS process, excluding safety for this Master Specification Part; and
- b) RAMS assurance as set out in section 5.

4 Design for RAMS

The Contractor must, in designing the Rail Infrastructure:

- a) consider lifecycle cost by:
 - i) minimising the Principal's whole-of-life costs, taking into account equipment acquisition cost, disposal cost and operating and maintenance cost; and
 - ii) where practicable, utilising existing systems to minimise the number of spares and test equipment required over the AMPRN;
- b) consider system availability by:
 - i) minimising single-points-of-failure in systems and their operation;
 - ii) development of FMECA, including identification of failure modes, addressing identified design alteration and reviewing any additional requirements for maintenance; and
 - iii) designing the Works to meet the RAMS requirements;
- c) conduct obsolescence planning by:
 - i) considering obsolescence during the selection of equipment and components;
 - ii) implementing and delivering an obsolescence management plan which addressing processes and methodologies of dealing with equipment or spares becoming obsolete throughout Project lifecycle;
 - iii) ensuring minimum Design Life, as specified in the design requirements of various railway systems, are met;
 - iv) ensuring that the Design Documentation clearly identifies any component of the system being upgraded or becoming obsolete from general availability;
 - v) providing functionally identical replacement units of any components that become unavailable for the Design Life of that component or system;
 - vi) in addition to the warranty requirements in PC-CN3 "Construction Management", ensuring minimum required support from the original equipment manufacturer (OEM) by providing a written notice from the OEM on the availability of required components;
 - vii) ensuring that the Design Documentation clearly identifies the pending unavailability of components or system by the later of the Preliminary Design stage or within six months of the Commencement Date for the component or system, with an additional six months to allow the Principal to purchase additional stock if so desired; and
 - viii) ensuring that any components that have been upgraded or replaced are fully backward compatible with the originally installed components;
- d) plan for maintainability and supportability by:
 - i) preparing maintainability and maintenance support from the beginning of the design phase by considering trade-offs between functional needs, capability required, total life cycle cost, reliability and maintainability targets, safety and maintenance support requirements;
 - ii) where practicable, incorporating and display root cause alarms (as opposed to cascaded alarms) as part of systems design;
 - iii) minimising the requirements for special tools and test equipment for maintenance;
 - iv) clearly labelling all line replaceable units and provide instructions on repair or replacement and tools and equipment required for the maintenance in the O&M Manual;
 - v) including keying pins or similar into the design for connectors and Line Replaceable Units to prevent potential incorrect insertion or installation;

- vi) taking into consideration for ease of maintenance during design especially the following:
 - A. modularity;
 - B. accessibility;
 - C. ease of diagnosis; and
 - D. standardised support tools and equipment for repairs and replacement;
- vii) providing clear and detailed information in the Maintenance Plan with, at minimum, the following:
 - A. types and amount of maintenance to be carried out by each line of maintenance. The Contractor must inform and obtain approval from the Principal for potential third line of maintenance or any requirements for new maintenance facilities; and
 - B. maintainer skills levels required for all maintenance tasks;
- viii) providing O&M Manuals for all equipment. The O&M Manuals must consist of clear and detailed information in accordance with PTS-MS-05-AM-PRC-00000091 - Asset Management Technical Data Requirements Specification;
- ix) considering the following:
 - A. tools, equipment, spare part and consumables required for the maintenance;
 - B. maintenance procedures;
 - C. maintenance tasks sequences;
 - D. competencies required for the maintenance;
 - E. maintenance check lists;
 - F. safety instructions to be observed during maintenance;
 - G. disposal instructions;
 - H. maintenance frequencies;
 - I. tasks required to return the system to operation after maintenance;
 - J. impact on operations during the period the line replaceable units has failed and being repaired; and
 - K. troubleshooting and system restoration guide and method of determining that a Line Replaceable Units has failed or is faulty;
- x) delivering clear and detailed information for all support tools and equipment in accordance with PTS-MS-05-AM-PRC-00000091 - Asset Management Technical Data Requirements Specification; and
- xi) in addition to the special tools and test equipment requirements listed in PTS-MS-05-AMPRC-000000091 - Asset Management Technical Data Requirements Specification (AMTD), the following information must be provided for every support tool / equipment:
 - A. O&M Manual;
 - B. calibration frequency;
 - C. calibration type / method; and
 - D. certification requirement.

5 RAMS assurance

- a) The Contractor must provide RAMS assurance reports as part of the Design Documentation accompanied with a softcopy of RAMS analysis for all systems, equipment and components

that contribute to Rail Commissioner's ability to meet the service requirements in Excel spreadsheet with all underlying formulas and references and must include:

- i) verification of compliance with all RAMS requirements addressed in:
 - A. this Master Specification Part;
 - B. BS EN 50126-1: Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) Generic RAMS process; and
 - C. BS EN 50126-1: Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) Generic RAMS process - Annex A;
 - ii) a summary of all high-risk failure modes and actions plans as required in section 5d)iii); and
 - iii) verification of compliance from reliability demonstration and verification as required in section 5h).
- b) As part of the overarching RAMS delivery, the Contractor must include the following outputs as part of RAMS assurance report:
- i) demonstrate compliance with RAMS requirements stated in:
 - A. this Master Specification Part;
 - B. the Contract Documents; and
 - C. BS EN 50126-1 Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) Generic RAMS process, including the RAMS programme outline guidance provided in BS EN 50126-1 Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) Generic RAMS process - Annex A;
 - ii) apportion RAMS performance targets to railway system level and document in the RAMS management plan;
 - iii) where RAMS targets provided in the Contract Documents are insufficient to form a complete RAMS model, the Contractor must convert the Rail Commissioner's operational requirements into RAMS performance targets;
 - iv) implement and document the processes and methodology of achieving RAMS targets for all railway systems;
 - v) account for all potential factors, as part of RAMS analysis, that might affect services, including those which may be beyond the control of the Rail Commissioner;
 - vi) develop and document a RAMS assurance process encompassing the entire Project lifecycle that is aligned with the design, engineering and testing plan(s) and is integrated with the requirements management processes;
 - vii) deliver a reliability block diagram including a list of identified reliability critical items and single-points-of-failure; and
 - viii) deliver and document the model, formula, calculations and sources of all data used in RAMS analysis.
- c) The Contractor must submit an interim RAMS assurance report and RAMS analysis in accordance with section 5a) and 5b) 10 Business Days prior to the 70% Design Complete at gate 4B which will constitute a **Hold Point**. Further development of the RAMS assurance report and RAMS analysis must not commence until the Hold Point is released.
- d) The Contractor must conduct and deliver functional analysis and FMECA in accordance with T MU AM 06002 GU Transport Asset Standards Authority Guide to Reliability, Availability and

Maintainability as part of RAMS assurance. The following must be addressed as part of the FMECA delivery:

- i) analyse to the lowest subsystem level and if required to Line Replaceable Units level with the aim to identify critical items and failure modes that could result in loss of function;
 - ii) document all interface failure modes within FMECA worksheet and present in the form of an interface block diagram or matrix;
 - iii) ensure that the identified prevention controls that are used to drive design or process improvements through the FMECA addresses all high-risk failure modes with effective and executable action plans. A summary of all high-risk failure modes and actions plans must be appended in the RAMS assurance report;
 - iv) within the RAMS management plan provide the proposed FMECA approach and FMECA worksheet template, including:
 - A. descriptors for all columns of the worksheet including failure likelihood parameters, consequence parameters, risk matrix and risk acceptability; and
 - B. include all functions, systems, subsystems and components that will be analysed;
 - v) continually update the FMECA worksheet with failure modes of functions, systems, subsystems, component and the resultant criticality and improvement required in the design or process, up to and including the testing and commissioning phases;
 - vi) ensure that a comprehensive FMECA is initiated from the beginning of the design and completed before finalising the Design Documentation, in consultation with the relevant designers, in order to incorporate relevant design or process improvements;
 - vii) for the output of the FMECA process, provide a list of:
 - A. reliability critical item (**RCIs**) which have at least one failure mode classified as critical according to its criticality analysis;
 - B. single point of failure (**SPoF**); and
 - C. prevention controls and updates reliability / design verification plan with identified failure modes;
 - viii) provide a FMECA report as part of the Design Documentation to accompany proposed design alterations or additions to built-in test equipment as required of CAT I and CAT II failure modes and single point of failure; and
 - ix) provide details in the FMECA report on local effect, next higher effect, that is, system effect and end effect, that is, operational effect and not just the maintenance responses for each level of effect.
- e) The Contractor must deliver a maintainability analysis as part of the Design Documentation, using manufacturer's data or actual field data.
- f) The Contractor must deliver spares analysis as part of the Design Documentation to meet the stipulated requirements in the Contract Documents, including, but not limited to the following information:
- i) the recommended number of spares to hold per equipment type;
 - ii) criticality and rational of criticality of the recommended spares;
 - iii) price of spares;
 - iv) required storage condition;
 - v) prediction lead time;
 - vi) OEM and distributor details; and
 - vii) OEM part number and / or part number of purchase.

- g) The Contractor must implement and manage a FRACAS during testing and commissioning phases and continuing into the delivery and operations phases. The FRACAS must:
- i) be integrated into the Rail Commissioner's Asset Management Information System (AMIS);
 - ii) include a best practice root cause analysis process;
 - iii) record all failures and problems related to a product or process;
 - iv) include technical data of the system;
 - v) include failure analysis;
 - vi) include corrective actions;
 - vii) include the man-hours required for maintenance action;
 - viii) include the number and skill level of personnel;
 - ix) include a list of spare parts, consumables, tools and equipment required;
 - x) identify the cost of spare parts and consumables;
 - xi) propose and append a FRACAS template to the RAMS Management Plan;
 - xii) contain failures recorded, using the agreed FRACAS template, from testing phase until the end of warranty in the FRACAS report; and
 - xiii) be submitted to the Principal, along with the FRACAS template and FRACAS report 10 Business Days prior to service readiness/Handover at gate 4F which will constitute a **Hold Point**. The Contractor cannot progress to service readiness/Handover until the Hold Point is released.
- h) The Contractor must provide a reliability demonstration and verification plan as part of the RAMS management plan to demonstrate the system meets all requirements in the Contract Documents. The reliability demonstration and verification must be scheduled together with Project system test and validation phase. The verification of compliance from reliability demonstration and verification must be provided in the RAMS assurance report.

6 Hold Points

Table RW-RAMS-D1 6-1 details the review period or notification period, and type (documentation or construction quality) for each Hold Point referred to in this Master Specification Part.

Table RW-RAMS-D1 6-1 Hold Points

Section reference	Hold Point	Documentation or construction quality	Review period or notification period
5c)	Submission of an interim RAMS assurance report and RAMS analysis	Documentation	10 Business Days
5g)xiii)	Provision of FRACAS, FRACAS template and FRACAS report	Documentation	10 Business Days