INTERNATIONAL RAIL QUALITY BOARD

IRIS Guideline 4: RAMS/LCC

2022 / rev. 01

English

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1. Introduction

The aim of this guideline is to provide guidance to all organizations during the implementation and maintenance of an IRIS Certified Business Management System (BMS) concerning RAMS/LCC to comply with the ISO/TS 22163 or ISO 22163 requirements.

Reliability, Availability, Maintainability and Safety (RAMS) together are the basis for Life Cycle Costing (LCC). Therefore, the LCC technique is used to give a value to compare the different alternatives and to control the costs of a project.

RAMS and LCC are key success factors in the rail sector. Therefore, all parties lay on this aspect great importance during the whole project phase in the rail industry, such as vehicles and their components. Customers require reliable products that are easily maintainable during their lifetime. The cost for a product in the rail sector is not only influenced by the initial cost (price) but also by the operating and maintenance cost during its lifetime. LCC includes all costs in the life of a product from the concept to the decommissioning, e.g. investment and maintenance.

Both, the preventive and the corrective maintenance (repair) can cause operating costs. The consideration of costs occurring throughout the life cycle of vehicles and components is of crucial importance for the economic success of an organization.

RAMS/LCC is covered in ISO/TS 22163 and ISO 22163 within chapter 8.8 and in addition is a knockout requirement according to the IRIS Certification Conformity Assessment.

Regarding ISO/TS 22163 requirements *the organization shall establish, implement and maintain documented processes to manage RAM/LCC activities*. In case the organization delivers safety-related products or services, related aspects to this have to be identified and covered.

ISO 22163 reflects an evolution regarding RAMS/LCC and it requires that an *organization shall address processes for RAM and for safety* (in the above-mentioned cases). In addition, it *should establish, implement and maintain a process to manage life cycle costing activities*. In all cases it *shall retain related documented information*.

EN 50126-1 and EN 50126-2 give further support regarding a generic RAM process and a system approach to safety. An application guide for RAMS is given in CRC/TR 5016-3.

As mainly RAM is applicable to all organizations seeking for IRIS Certification® this guideline will focus more on the RAM aspects than on the ones related to safety.

2. Terms and definitions, Abbreviations

2.1. Terms and definitions

RAMS – Reliability, Availability, Maintainability, Safety

Reliability ability to perform as required, without failure, for a given time interval, under given conditions. It is also considered as to be qualitative or quantitative. Reliability can be measured in time, distance travelled or switching cycles or something similar. Time may refer to calendar time, vehicle or component operation time or journey time.

Performance indicators could be:

- MTTF: mean time to failure
- MTBF: mean time between failures (time = operating time)
- MDBF: mean distance between failures

In a contract it is important to clarify the definitions for failure, time, categories of failure (significant, major, minor) etc. between the parties involved. Failure definitions should be linked to elements the external provider can control. Elements not in control of external providers (e.g. traffic density) should not impact the failure severity or penalty.

Availability is the 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 and assuming that the required external resources are provided.

Performance indicator for availability could be:

- Availability: $A = \frac{MUT}{MUT+MDT}$ (MUT: mean up time; MDT: mean down time)

Availability and Reliability are not the same. Availability combines reliability and the maintenance time for corrective or preventive maintenance. Either the net maintenance time is considered or the full down time MDT from the failure until the restoration of the function, i.e. including logistical delays for waiting and travelling.

Maintainability is described as ability of an item under given conditions of use, to be retained in or restored to, a state in which it can perform a required function, when maintenance is performed under given conditions and using stated procedures and resources.

Its principle features are accessibility, testability and exchangeability. Maintenance is the combination of all technical and administrative actions, including supervisory actions intended to retain an item in or restore it to, a state in which it can perform a required function.

Performance indicator for maintainability could be:

- MTTR: mean time to restoration.

There is the distinction between preventive and corrective maintenance: maintenance carried out after fault recognition and intended to put an item into a state in which it can perform the required function is corrective maintenance. Preventive maintenance is carried out at a predetermined interval or according to other prescribed criteria. Predictive maintenance is a condition-driven preventive maintenance program. The addition of a comprehensive predictive maintenance program

provides factual data to the maintenance manager to make the final decision in preventive or run-to-failure, on repair or reschedule.

The intention is either to reduce the probability of failure or the degradation of the functioning of a unit in service or to extend the predetermined interval according to prescribed criteria in order to reduce Life Cycle Costs.

Safety is freedom from unacceptable risk of harm. RAM and safety tasks might sometimes seem conflicting and need to be aligned.

It can be considered as good practice of an organization to perform safety audits with team members of the quality and safety departments.

LCC – Life Cycle Costing

Life cycle costs are the cumulative costs generated by the product during its lifetime. The total costs can be grouped under the following three categories:

- Acquisition
- Ownership and
- Disposal

3. RAMS/LCC Management

In order to bring safety and costs in line, the process for externally provided products, processes and services may not only focus on the purchasing costs, but on the consideration of all costs occurring during the whole product life cycle. The right maintenance (time-and situation-dependent) ensures the safety in operation and has a significant impact on operating results. Ultimately, they also determine the reputation and image of the rail industry.

Therefore, the requirements of reliability and maintainability of infrastructure, rolling stock, subsystems, assemblies and parts belonging to the infrastructure or rolling stock need to be met constantly. In addition the ongoing and long-term maintenance and operational environment is monitored in order to achieve the objectives of availability and safety during operation. To ensure the availability, an organization is aware of the reliability of its systems and equipment.

Analysis and risk assessment need to be a valuable aid to:

- system failure rates (RAM) analysis
- analysis of possible hazards (Hazard and Operability Study),
- probability of occurrence of a fault (Fault Tree Analysis),
- effects of failure on the functionality of a system (FMEA or FMECA)
- knowledge of maintainability
- knowledge of the time needed for repair

To properly and punctually manage the RAMS/LCC process, an organization can address the following main questions:

When: During all phases, e.g. during tender, design and the development phase.

What: Several steps are necessary:

- detecting malfunctions
- quality through intensive training of staff
- easy input options in an appropriate tool
- hierarchical fault catalogue by type
- hierarchical catalogue of each part list's items with part numbers, determining the level of detail

How: By organizational embedding:

- determining the number of RAMS-engineers who evaluate malfunction regularly and customize catalogues of faults and components
- regular meetings of system specialists, who assess status and effect of the measures or other measures are set

Who: The management of organization is to define the overall process

3.1. Applicability

The RAMS/LCC process begins with the tender phase and ends with the decommissioning and disposal of vehicles and components. It might be part of the development process and not complete until the product has been removed from service and is disposed of. Therefore, in the operational phase, the LCC-aspect is of particular importance and field data must be collected during the entire product life cycle.

3.2. V-Model for RAMS

In order to ensure an optimum maintainability of the infrastructure or rolling stock and its components the following fundamental conditions are essential:

- proven design,
- the use of already proven technology,
- the easy access to repair components
- inspections and overhaul pushed at their maximum
- easy installation and easy replacement during the repair process in order to reduce downtime
- innovation must be considered, either to increase or maintain quality or to reduce costs

In addition to these principles, it is advisable to introduce a procedure along the V-model in accordance with EN 50126-1 that is shown in Figure 1.

All steps of the V-model are to be coordinated between the contractor and the client. The continuous communication between the parties includes a validation for each step by the customer.

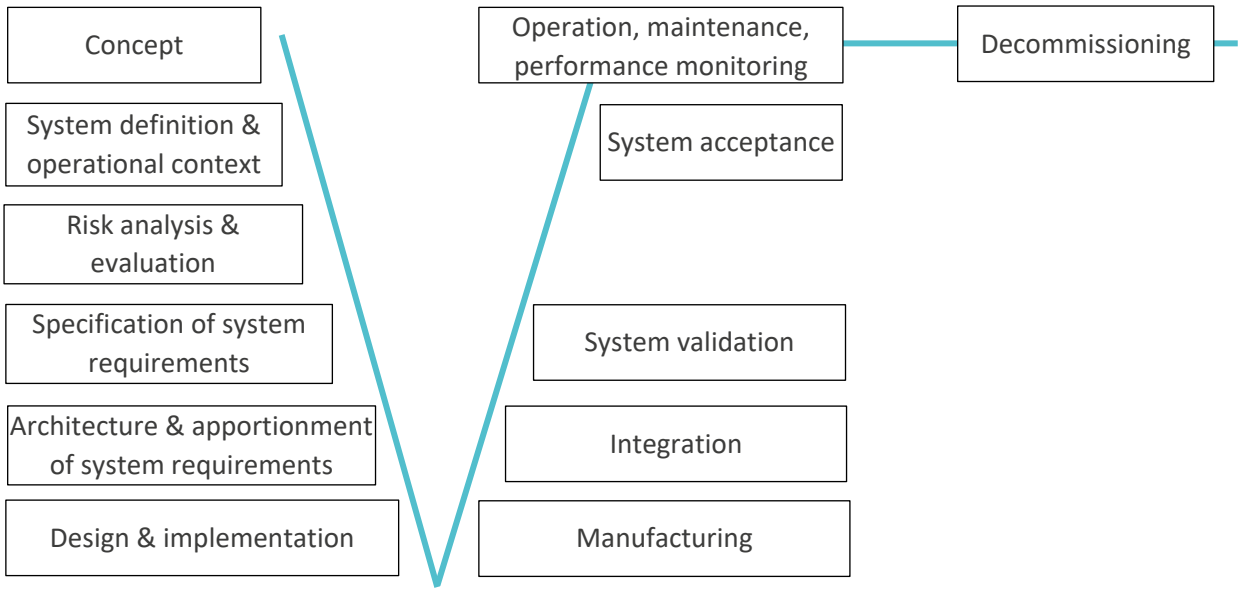

Figure 1: V-cycle in accordance to EN 50126

3.2.1. Tender phase

During the tender phase, the customer asks the potential main external providers for RAM data and analyses in order to compare between the different offers. The relevant tasks for an external provider are the feasibility analysis, the commercial risk analysis, the response to the tender and negotiation with the customer.

I. Concept

During the tender or research phase, when customer satisfaction and the realization of the product are planned, the organization collects customer requirements and analytical results from existing, functioning systems.

II. System Definition and operational context

The customer requirements are the basis for the design & development department to create the specification. The best reasonable performances are determined in the feasibility analysis. A RAM plan is established during this phase and regularly updated during all upcoming steps until the system validation

III. Risk analysis and evaluation

In this step the future operating conditions are considered. Potential hazards / risks are identified at this stage and it needs to be decided if these risks are tolerable. Special attention must be drawn to the aspect on how the product will be used in the future in an overall system.

IV. Specification of system requirements

The next steps are the results of the risk analysis and the basis for the specification of system requirements. They are part of the negotiation with the customer.

V. Architecture and apportionment of system requirements

The work packages are prepared in detail. After having chosen the best offer, the customer will propose a contract or give notice to proceed. This event marks the end of the tender phase.

3.2.2. Design phase

I. Design & Implementation

The development process considers the respective RAMS/LCC phases. It comprises the phases for system requirements allocation and development. The organization ensures the records of the proofs of evidence that the maintainability of the product is possible. For every product there is a maintenance concept.

II. Manufacturing

All manufacturing and inspection operations planned are carried out. To ensure an efficient roll-out of this step, a close cooperation between all stakeholders is necessary.

III. Integration

During this phase the activities from the design and implementation phase are validated.

IV. System validation

During this phase the apportionment of system requirements is validated and documented in a validation report.

V. System Acceptance

System acceptance can be performed by a first article inspection (FAI) as it is also required in chapter 8.9 in ISO/TS 22163 and ISO 22163. The FAI report then also covers the system acceptance report.

3.2.3. Operational phase

I. Operation maintenance, performance monitoring

For further development of products, it is crucial for the manufacturer to ensure the systematic reporting about failures in operation. This report may contain all the relevant conditions. Perturbations have an impact on the timeliness, while a fleet is operating. In addition, the vehicle components are associated with dysfunction.

It is important that the analysis evaluates the frequency of occurrence of the failure. For certain components, it might become necessary to determine the business objectives and necessary actions. These could for example be:

- adjustments to the preventive maintenance (changing the intervals, replacement and testing activities)
- structural adaptations
- purchase modified repair material
- operating and maintenance personnel training

For the determination of the LCC, data is needed from the operation. Sources for this field data can be:

- maintenance technicians
- software data from the sites of the maintenance
- performance of the vehicle fleet
- data from the diagnostic system of the vehicle
- check of the contractually required values
- warranty cases reported by the customer
- further information from customers or authorities

During the operational phase it is important to keep records of the regular measurement of performance. The analysis of the data is necessary for further or new development. A well-structured partnership management between customer and external provider can be a valuable prerequisite.

The duration of the use of infrastructure or vehicles and components can span several decades. Adaptation and modernization requests appear during that period. For all modernization and changes, the above described procedure can be applied.

VI. Decommissioning

In order to avoid difficulties related to the disposal, it is useful to have the handling and use of environmentally friendly materials already considered in the design phase. A well-implemented environmental management system will provide a valuable service.

3.3. LCC – Life Cycle Costing

For the procurement of rolling stock and components, LCC is a central component. It is a cost management approach related to the development of a product from concept to decommissioning (product life cycle), i.e. the from "cradle to grave" view. Key observation points are the operating and maintenance costs (reoccurring costs), which account in addition to procurement costs (non-recurring costs) for the largest part of the product life cycle.

Other reasons for the application of LCC in the rail sector include:

- sustainable business success through the forward-looking development or procurement of equipment / systems,
- allocation of risk by the integration of all concerned parties

- from the lowest price to best value
- optimization of operation and maintenance
- enhancing transparency in cost planning

In order to manage life cycle costs, relevant and reliable information provide the basis for sustainable cooperation already in the tender phase. The appropriate conditions or LCC elements will mostly be contracted and may also reflect the RAMS procedure.

With the award of a procurement contract to the external provider, cooperation is intensified and is based on one hand on the customer's specifications (i.e. vehicle or system operators), on the other hand, on the external provider's RAMS calculations. Both elements are combined in order to recognize cost drivers in time, to optimize the approach and to monitor and evaluate them.

It is of advantage to verify the LCC inspection routines by auditing the corresponding processes and methods used in the external providers organization, if not already done otherwise. Individual milestones for pre-verifications are set in the procurement phase.

During operation, accrued expenses and costs included in the manufacturer's database, may serve for further product development in a new concept phase.

4. Bibliography

EN 50126-1: Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part1: Generic RAMS Process

EN 50126-2: Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 2: Systems Approach to Safety

EN 50126-3: Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS) – Part 3: Guide to the application of EN 50126-1 for rolling stock RAM

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