IRIS
International Railway Industry Standard

GUIDELINE 4 : 2016
RAMS / LCC

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Guideline 4 : 2016 RAMS / LCC

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 IRIS requirements.

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.

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

Therefore, in the RAMS / LCC paragraph, the IRIS requires RAMS / LCC process that is maintained continuously in order to ensure reliability, availability, maintainability and safety.

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 a company.

This guideline does not go into detail concerning total cost of ownership (TCO) which apart from maintenance includes costs such as infrastructure (track), assurance and energy during operations. TCO also includes cost of operational failures impact and unavailability as well as the cost of operational stall.

2 PURPOSE

In order to bring the safety and costs in line, the decision during the procurement lays not only on the price, but on the consideration of all costs incurring during the whole 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 rolling stock and all railway subsystems, assemblies and parts belonging to the rolling stock should be met constantly, and the ongoing and long-term maintenance and operational

environment should be monitored in order to achieve the objectives of safety and availability during operation. To ensure the availability, a company must know 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.

3 TERMS, DEFINITIONS, ABBREVIATIONS

3.1 RAMS = Reliability, Availability, Maintainability, Safety

Reliability is the ability of a component to perform a required function under given conditions and over a given period of time. 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. Key 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 supplier can control. Elements not in control of supplier (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. Key performance indicator for availability could be the intrinsic availability 1–MTTR/MTBF with MTBF: mean time between failures (time = operating time) and MTTR: mean time to restoration.

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 (MDT: mean down time) from the failure until the restoration of the function, i. e. including logistical delays for waiting and travelling.

Maintainability is described under defined framework conditions of maintenance and operation using the terms ease of service and ease of repair. 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.

The most important measure of maintainability is MTTR: mean time to restoration.

We distinguish 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.

RAMS is defined by IEC 62 278 (EN 50126) as a method helping to prevent failures during any phase of a project.

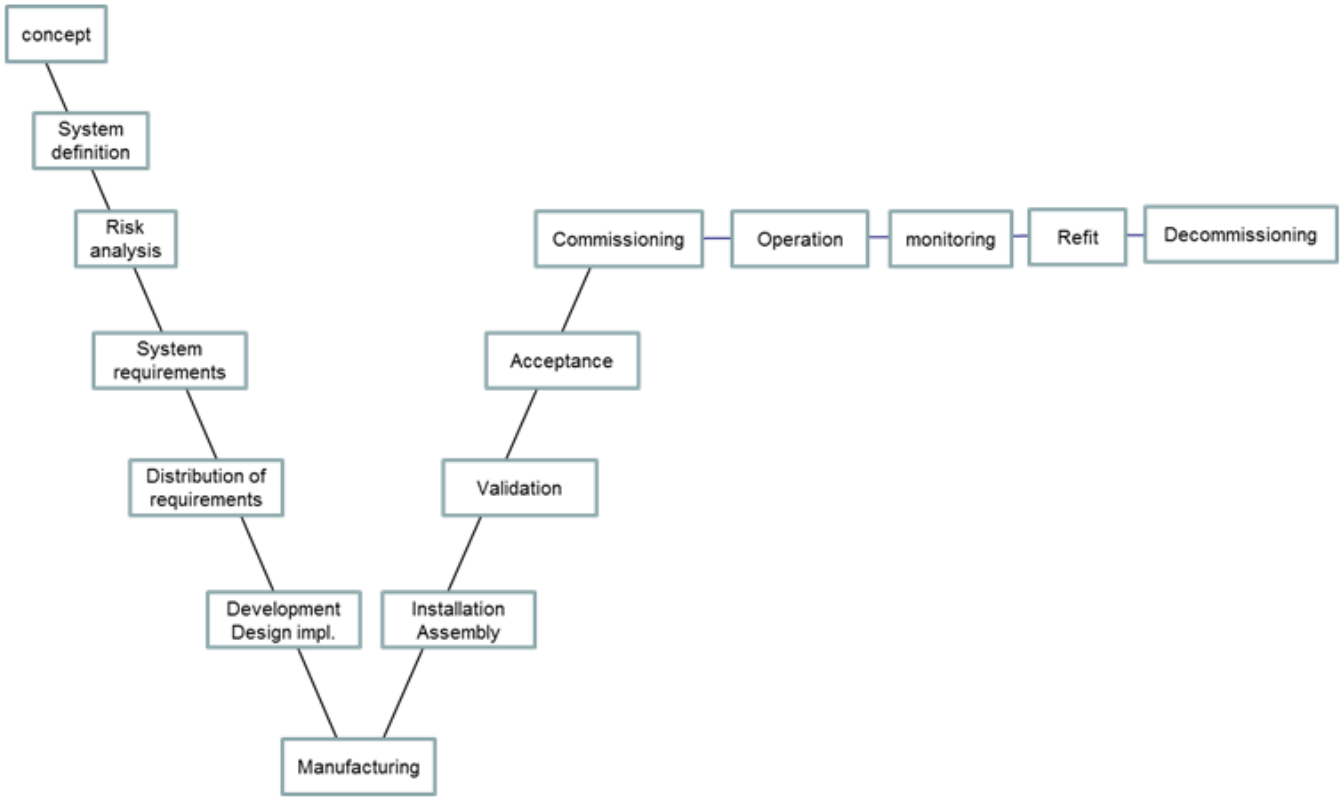
In order to ensure an optimum maintainability of the rolling stock and its components the following fundamental conditions are essential:

- proven design,
- the use of already proven technology,
- the easy accessibility 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 IEC 62278 (EN 50126).

This Guideline recommends to develop plans and procedures in accordance with IEC 62278 (EN 50126).

The V-Model according to IEC 62 278 (EN 50126) is shown below.



3.2 LCC = Life Cycle Cost

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

- Acquisition
- Ownership and
- Disposal

4 IRIS RAMS / LCC Requirements

The IRIS standard requires the following elements being in line with RAMS / LCC:

Maintainability is an integrated part of the design and development process. This means that in the very beginning of the concept, RAMS aspects are taken into account.

Standardized routines for the maintenance of software are established and recorded according to established standards such as IEC. Not only the physical parts of components but also software is regarded.

A documented procedure covers all aspects of RAMS activity, e.g. calculation, documentation, data collection and an improvement action plan.

Furthermore a process is in place to manage LCC. This process can include all costs occurring by following the V-model. A documented procedure may help to better understand the way of execution of the process.

In addition, it is important to define financial, material and human resources for every step of the V-model. The definition of roles and responsibilities in this process ensures that the staff involved is aware of their responsibilities.

A company can thus meet RAMS, by collecting all data needed for the product, e.g. data from the past operating period. Companies fulfilling the RAMS requirements take also into account the sequence according to IEC 62278 (EN 50126) and incorporate these requirements and the individual steps in the processes of their own management system.

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

5 RESPONSIBILITY

Responsibilities and activities milestones should be described in the RAMS/LCC Plan. Duties and commitments of the different individuals appointed for the corresponding activities could be stated therein. The content of a RAMS/LCC Plan is addressed in IEC 62278 (EN 50126).

6 RAMS / LCC Process

6.1 RAMS/LCC Management

To properly and punctually manage the RAMS/LCC Process, an Organization can address the following main questions, e.g.:

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, requirements for mandatory input boxes,
- hierarchical fault catalog by type,
- hierarchical catalog 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 catalogs 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 a company or an organizational unit is to define the whole overall process

Such concerns should be included by the Organizations into the documentation of their Business Management Systems.

6.2 Applicability

The RAMS / LCC process begins with the tender phase and ends with the decommissioning and disposal of vehicles and components.

Chapter 3 IRIS 7.11 RAMS/LCC requires a documented procedure with:

- calculation and documentation,
- data collection, analysis and improvement plans,
- implementation of the defined measures of the improvement plans.

These requirements can be fulfilled, when these aspects are integrated in all processes of the management system. It is therefore not necessary to formulate a separate process. Existing processes can be customized. In any case, the PDCA should be respected.

The RAMS / LCC process is part of the development process and not complete until the product has been removed from service and disposed of, so in the operational phase, the LCC-aspect is of particular importance. Therefore, field data should be collected during the entire life cycle.

6.3 KPI / Records

Records are mandatory to the RAMS / LCC-process. Therefore KPI shall be determined.

KPI that help in controlling and directing the process are:

- Vehicle availability (available vehicles in relation to the fleet size),
- Availability of signaling system or subsystems,
- MTBF of the systems,
- the number of warranty claims in relation to time (after starting),
- material consumption.

For further guidance on KPI, please refer to the IRIS Guideline 1: KPIs.

6.4 The different phases of the V-Model

6.4.1.1 Tender phase

During the tender phase, after the call for tender, the customer will ask the potential main suppliers for RAM data and analyses in order to compare between the different offers. The relevant tasks for a supplier 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. During development, the engineering is responsible for creating the concept.

ii. System Definitions and Application Conditions

The customer requirements are the basis for the development department to create the specification. The best reasonable performances are determined in the feasibility analysis.

iii. Risk Analysis.

The future operating conditions are considered. Potential hazards / risks should be identified at this stage. This must be recorded and evaluated in detail. To create a risk analysis, the evidence from the IRIS requirements, Chapter 3, Section 7.7.8 Management of risks and opportunities are seized. Special attention must be drawn to the aspect on how the product will be used in the future in a larger overall system.

iv. 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. Apportionment of System Requirements

The work packages should be 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.

6.4.1.2 Design phase

According to IEC 62-278 the main tasks of the design phase are: the RAMS specification, preliminary analyses, the preliminary design review, detailed analyses, the final design review, RAM growth monitoring and follow up of critical items.

i. Design and Implementation

The development process must take into account the respective RAMS / LCC phases. The development process essentially comprises the phases system requirements allocation and development.

The company ensures the records of the proofs of evidence that the maintainability of the product is possible. For every product there is a maintenance concept.

With regard to the maintainability of software, the requirements of IEC 62278 (EN 50126), IEC 62279 (EN 50128), IEC 62425 (EN 50129) or other provisions are used.

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. Installation / Assembly

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. The procedure of validating the development according to IRIS can be recommended.

v. System Acceptance

The first article inspection (FAI), is recommended, see also IRIS requirements in Chapter 3, 7.9 FAI and the associated IRIS Guideline 2:2012.

6.4.1.3 Operation phase

i. Operation and Maintenance

For further development of products it is crucial for the manufacturer to ensure the systematic reporting about failures in the operation, as far as possible every month. This report should 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, such data should also be taken into account for determining the business objectives and necessary actions. That could be for example:

- Adjustments to the preventive maintenance (changing the intervals, replacement and testing activities),
- Structural adaptations,
- Purchase modified repair material,
- Operating and maintenance personnel training.

Already when tendering the supplier should give relevant and reliable information on LCC elements (planned / unplanned maintenance, cleaning, energy). Its application shall be regularly reviewed using the procurement process and subsequent operation shall be assessed and controlled internally in order to improve efficiency and externally against the supplier's penalties for deviations from the contract.

For the determination of the Life Cycle Cost, 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,
- Availability of railway systems and subsystem,
- 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.

ii. Performance Monitoring

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 supplier can be a valuable prerequisite.

iii. Modification and Retrofit

The duration of the use of 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.

iv. Decommissioning and Disposal

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

6.5 LCC Life Cycle Cost

For the procurement of rolling stock and components, life-cycle cost (LCC) is a central component. LCC 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. A key observation point are the operating and maintenance costs (recurring costs), which account in addition to procurement costs (non-recurring costs) for the largest part of the 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,
- Distribution 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 supplier, 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 supplier's RAMS calculations. Both elements should be 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 corresponding LCC inspection routines by auditing the corresponding processes and methods used in the supplier's organization, if not already done otherwise. Individual milestones for pre-verifications are set in the procurement phase.

Later, vehicle operation should be monitored regularly (see 4.3). Therefore, the relevant data is recorded and analyzed. The results of the analysis serve as an input into the development process.

The corresponding tool is EN 60300-3-3, see also Requirements in Chapter 3 IRIS 7.11 RAMS/LCC.

At each stage, a full-time management (see Chapter 3 IRIS 7.7.3) and cost management (see Chapter 3, IRIS 7.7.4 included) applies.

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

6.6 CONCLUSION

The aim of this approach is the transparency with respect to failures and the components involved. Through systematic monitoring, problems can be quickly identified and kept at low relevance. Improvement measures can be timely. From an operational point of view, it is a shift from reactive behavior to proactive identification and elimination.

7 ANNEXES

7.1 Forms & Templates

Refer to IEC 62-278 p. 28 to 39

7.2 Normative references

IEC 62278 (EN 50126:2008)
prEN 50126-1:2015

A UNIFE initiative supported by

The rail industry

The rail operators

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