

1st edition:
Version:

October 2021
Original

**Railway applications - Reliability, availability,
maintainability and safety -**

**Guidelines for the implementation of RAMS analysis to
mechanical components of railway vehicles**



© International Union of Railways, 2021. All rights reserved.

This document may not be reproduced – even in part – without the written authorisation of UIC.

IRS to be classified in volumes of UIC:

Chapter VIII – Technical specifications

Subsection 88 – Guidelines

Complete reference in case of citation:

IRS 80881:2021, Ed1: Railway applications - Reliability, availability, maintainability and safety - Guidelines for the implementation of RAMS analysis to mechanical components of railway vehicles

Approbation date:

22 October 2020

With effect from:

1 October 2021

Application recommended to:

Railway Undertakings and Entities in charge for the vehicles' maintenance

Keywords:

Availability; criticality; detectability; failure mode; frequency; maintainability; maintenance in service; mechanical components; off vehicle maintenance; operating time; preventive maintenance; railway vehicles; reliability; risk acceptance; risk management; root causes; safety; severity; user; vehicle.

Warning

No part of this publication may be copied, reproduced or distributed by any means whatsoever, including electronic, except for private and individual use, without the express permission of the International Union of Railways (UIC). The same applies for translation, adaptation or transformation, arrangement or reproduction by any method or procedure whatsoever. The sole exceptions - noting the author's name and the source - are "analyses and brief quotations justified by the critical, argumentative, educational, scientific or informative nature of the publication into which they are incorporated".
(Articles L 122-4 and L122-5 of the French Intellectual Property Code).

© International Union of Railways (UIC) - Paris, 2021

Published by the International Union of Railways (UIC)

16 rue Jean Rey, 75015 Paris - France, October 2021

Dépôt Légal October 2021

ISBN 978-2-7461-3115-6



Record of updates:

1st edition, October 2021

Creation of the document.

CONTENTS

Foreword	1
Executive summary	3
Field of application	5
Reference documents	6
Abbreviations and Symbols	7
Concepts, terms and definitions	9

General Application

1 – Introduction	11
2 – Risk Management process	12
2.1 – Characterisation of the system / Functional analysis	13
2.2 – Risk Analysis	15
3 – RAM - calculation	21
3.1 – General information about the calculation tool	21
3.2 – Procedure for calculating RAM values	21
3.3 – Operation_Data sheet	22
3.4 – R_Reliability sheet	23
3.5 – A_Availability sheet	24
3.6 – M_Maintainability sheet	24
Appendix A: External and Internal Functional Analysis tool	26
Appendix B: Failure Mode, Effects and Criticability Analysis tool	27
Appendix C: RAM calculation tool	28
Regulatory listing	29
Bibliography	30

Foreword

An International Railway Solution (IRS) is a document drawn up by consensus and applied on a voluntary basis which aims to facilitate and harmonise railway operation.

IRSs are gradually replacing UIC leaflets.

Members of the International Union of Railways (UIC) participate in the creation of IRSs, of which they benefit in full. Furthermore, marketing to railway stakeholders contributes to the sharing and harmonisation of good practices, in accordance with UIC's primary goal.

While IRSs do not have the force of law, they are created and published in a professional manner and with technical approval on the basis of UIC procedures, and have full technical legitimacy in the railway sector.

The "General application" section constitutes the heart of the IRS and contains the working group's expertise applicable in the broadest manner. The addition of a "Specific application" aims to cover factors specific to a region, a type of service, etc.

Some provisions shall be implemented in all cases to ensure correct application and maintain the system's cohesiveness. Certain operational circumstances require that specific provisions be systematically applied by all users of the document.

For the purposes of understanding, the user acknowledges that the expression of:

- obligation indicates requirements to be respected in order to comply with the expertise expressed in the document (usually "shall");
- recommendation indicates options that are favourable but not essential (usually "should");
- permission indicates options that are recognised but without consequence (usually "may");
- capacity indicates possibilities from a technical standpoint and not permissions or probabilities (usually "can").

Obligation, recommendation and capacity can be expressed in the negative to indicate prohibiting, non-recommendation and incapacity.

If applicable, notably for the purposes of compliance with a UIC approval, passages that are recommended or mandatory for the cohesiveness of the system will be accompanied by the letters "R" and "MCS" respectively.

This IRS reflects the following UIC working group expertise:

Rail System Forum - Rolling Stock Sector - SET_06: "Running gears"

It integrates in full or in part the following UIC leaflets:

- none

It complements the following standards:

- (see Reference documents - page 6)

The following IRSs constitute a complementary series:

- IRS 80882 (see Reference documents)

Executive summary

The International Union of Railways (UIC) develops and distributes International Railway Solutions (IRSs) in order to help railway stakeholders, achieve further harmonisation and collaboration.

The design, product and maintenance requirements of mechanical components of railway vehicles are defined in the relevant standards or technical specifications (e.g. ISO and EN Standards, IRSs, UIC Leaflets, Technical specifications provided by operators, manufacturers or any actor of the railway sector).

The *EN 50126* approach is useful to identify and assess the effects of changes (e.g. use of new materials) on reliability, availability, maintainability and safety (RAMS) of the component.

The contents of this IRS are the result of the UIC project RELIABILITY AND SAFETY OF AXLES, WHEELS AND AXLE BEARINGS "Reliability, availability, maintainability, safety – Implementation of *EN 50126* – for Mechanical Components in Railways" that was launched with the aim of calculating characteristic RAMS (reliability, availability, maintainability, safety) values as per *EN 50126*. The project considered various factors influencing RAMS, such as system, operating and maintenance conditions.

Findings from the UIC project "Stresses on Running Gear" (SOR), from the work did by the Joint Sector Group for the ERA Task Force on wagon/axle maintenance and from the EU project EURAXLES were also considered. The Projects were focused on the entire wheelset (i.e. axle, wheels, axle bearing and bearing housing as well as wheel/axle-mounted brake discs).

The applications of the RAMS and risk analysis methodologies on the wheelset and bogie are described in the *UIC report B 169/RP 29* ([see Reference documents - page 6](#)).

This IRS proposes a methodology, guidelines and tools to carry out risk analysis and RAMS calculations consistent with *EN 50126* in order to monitor the reliability, availability, maintainability and safety of mechanical components of railway vehicles. In this sense this IRS allows the user to perform the RAMS analysis for mechanical components by himself.

The results of the comparison between different risk analysis methodologies on the wheelset and bogie and the reasons for choosing FMECA and RPN as the parameter to characterise the criticality level of failures/events are set out in the *UIC report B 169/RP 29*.

In order to consider also economic requirements, in addition to the RAMS analysis, an LCC methodology was defined in the framework of the UIC project "Determining the reliability / safety of the running gear of railway rolling stock".

The LCC guidelines and the LCC tools are integrated in the *IRS 80880-2 "Guidelines for the application of the Life Cycle Cost analysis to railway vehicles"*.

It integrates in full or in part the following UIC leaflets:

- none

It aims to complement the following standards:

- (see Reference documents - page 6)

Field of application

This IRS describes a methodology to carry out risk analysis and RAMS calculations, derived from the *EC - Regulation 402/2013* (see [Bibliography - page 30](#)) criteria and the *EN 50126* approach referring specifically to mechanical components of railway vehicles (axle, wheels, axle bearing and bearing housing as well as wheel/axle-mounted brake discs, bogie frames, buffers, couplings, mechanical brake system components, etc.).

This IRS is applicable only to EN standard users and its application is not mandatory but voluntary.

Considering various factors influencing RAMS, such as system, operating and maintenance conditions, as well as previous experiences on this issue this IRS provides risk analysis and RAM calculation guidelines, approaching this issue with the FMECA methodology and the corresponding tools that shall be used to make analysis.

Reference documents

The following documents are cited in this IRS or strongly support its requirements and recommendations:

1. International Railway Solution (IRS)

International Union of Railways (UIC)

- [1] *IRS 80882: Guidelines for the application of the Life Cycle Cost analysis to railway vehicles*

2. Technical reports

International Union of Railways (UIC)

- [2] *UIC B 169/RP 29: Reliability, availability, maintainability, safety - Implementation of EN 50126 - for Mechanical Components in Railways*
- [3] *UIC B 169/RP 43: RAMS - Guideline: Reliability, availability, maintainability, safety - Implementation of EN 50126 for Mechanical Components in Railway*

Note: These documents can be found free of charges on the UIC website

3. International Standards

International Electrotechnical Commission (IEC)

- [4] *IEC/FDIS 31010: Risk management - Risk assessment techniques*
- [5] *IEC 60812: Analysis techniques for system reliability - Procedure for failure mode and effect analysis (FMEA)*

4. European Standards

European Committee for Electrotechnical Standardization (CENELEC)

- [6] *EN 50126-1: Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS) - Part 1: Generic RAMS process*

Abbreviations and Symbols

CSM	Common Safety Method
Dist	Average distance between source and destination according to the track network
EFA	External Functional Analysis
FMEA	Failure Mode and Effects Analysis
FMECA	Failure Mode, Effects and Criticality Analysis
FTA	Fault Tree Analysis
IFA	Internal Functional Analysis
IRS	International Railway Solution
LCC	Life Cycle Cost
LAMIS	Time needed for logistic and administrative (LA) issues for maintenance in service (MIS)
LAMOV	Time needed for logistic and administrative (LA) issues for maintenance off the vehicles (MOV)
MIS-DC	Time expenditure for the maintenance in service (MIS) incl. delivering and collecting the vehicle
MIS	Maintenance in service - Time needed for maintenance in service
MOV	Maintenance off vehicle - Time needed for maintenance off the vehicles
MTBF	Mean Time Between Failures
OHJ	Operation hours Journey
OHL	Operation hours loading / unloading
OHML	Operation hours needed for Maintenance
OHPR	Operation hours needed for Provision and Replenish
PBS	Product Breakdown Structure
RAM	Reliability, Availability, Maintainability
RAMS	Reliability, Availability, Maintainability and Safety