TD-FT00.B00.101.0015

[Rev. 00]

225 km/h National Electrical Multiple Unit Project - RAMS Analysis Requirements for Metal-Elastic Elements

Issued Date:	06/04/2023
Revision Date:	--/--/----

	Name	Signature
Approved by		
Checked by		
Created by		

Form No: TAGF-10	Issued Date: 09/12/2021	Rev. No: 00	Form Name: TECHNICAL DOCUMENT

Revision History

Rev. No	Revision Info	Date
00	First Issue	06/04/2023

Copyright © TÜRASAŞ. All rights reserved, including industrial property rights applications.
TÜRASAŞ retains any power of disposal, such as copying and transferring.

INDEX

1 INTRODUCTION 4
1.1 SUBJECT 4
2 RELIABILITY, AVAILABILITY, MAINTENABILITY & SAFETY (RAMS) 4
2.1 INTRODUCTION TO RAMS 4
2.2 RAMS PROGRESS AND REVIEW MEETINGS 4
2.3 RAMS TARGETS 4
2.4 RELIABILITY TARGETS 5
2.5 MAINTENANCE TARGETS 7
2.6 RESPECT OF RAMS TARGETS 7
2.7 RAMS PERFORMANCE VERIFICATION PERIOD 8
2.8 RAMS DOCUMENTATION (DELIVERABLES) 8
2.9 PREVENTIVE MAINTENANCE REGIME 9
2.10 MATERIAL AND LABOUR COST 10
2.10.1 Man-Hours 10
2.10.2 LRU Policy 11
2.10.3 Spare Parts 11
2.10.4 Special Tools List 12

I. LIST OF TABLES

Table 1 – Reliability targets for elastic element for axlebox 5
Table 2 – Reliability targets for trailing rod and rocker arm elastic element 6
Table 3 – Reliability targets for shock absorber 6
Table 4 – Reliability targets for traction motor elastic joint 6
Table 5 – Maintenance targets (2 years period) 7
Table 6 – Maintenance targets (30 years period) 7
Table 7 – RAMS documentation deliverables 8
Table 8 – First level kilometre based maintenance frequency 9
Table 9 – First level based maintenance frequency 9
Table 10 – Second level preventive maintenance 10
Table 11 – Technical time 11

II. LIST OF ACRONYMS & ABBREVIATIONS

EMU	Electrical Multiple Unit
EN	European Norm
FPMK	Failures per Million Kilometres
MKBF	Mean Kilometres Between Failure
MTBF	Mean Time Between Failures
RAMS	Reliability, Availability, Maintainability and Safety
SAF	Service Affecting Failure
SI	International System
TBD	To be defined
TOR	Top of Rail

Copyright © TÜRASAŞ. All rights reserved, including industrial property rights applications.
TÜRASAŞ retains any power of disposal, such as copying and transferring.

1 INTRODUCTION

1.1 SUBJECT

This document provides the requirements to be applied to the RAMS analysis in the frame of 225 km/h National Electrical Multiple Unit Project.

2 RELIABILITY, AVAILABILITY, MAINTENABILITY & SAFETY (RAMS)

2.1 INTRODUCTION TO RAMS

The following sections detail the requirements for the implementation of Reliability, Availability, Maintainability and Safety (RAMS) activities to be undertaken by the Supplier for the scope of supply specified in this technical specification.

The specification and demonstration of RAMS shall be done from early design phase through manufacture, testing, integration and introduction into service phases and through their established life.

RAMS assurance shall be controlled through the standard

- EN50126 – Railway applications
  The specification and demonstration of Reliability, Availability, Maintainability and Safety.

This standard shall be used as guideline in the development of all the analyses following the methodological approach reported.

Following standards shall be followed when applicable i.e.:

- IEC 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems
- EN 50129 Railway applications. Communication, signalling and processing systems. Safety related electronic systems for signalling
- EN 50128 Railway applications – Software for railway control and protection system

2.2 RAMS PROGRESS AND REVIEW MEETINGS

RAMS progress and review meetings shall be held on the frame of established design reviews between the Supplier and TÜRASAŞ to ensure that scheduled milestones are respected, to provide a forum for issues generated by RAMS analysis and to formally review the content of the RAMS activities undertaken by the Supplier.

2.3 RAMS TARGETS

The Supplier shall demonstrate that the system/equipment supplied fulfils the following RAMS requirements and targets by means of analyses during the project development and verification on the final product. The mission profile described in this document has to be used as reference during the design development.

Copyright © TÜRASAŞ. All rights reserved, including industrial property rights applications.
TÜRASAŞ retains any power of disposal, such as copying and transferring.

2.4 RELIABILITY TARGETS

In order to keep under control the performance of the system/equipment supplied, targets has been established in the next table covering Inherent Reliability and SAF (Service Affecting Failure).

The classification of failure rate reported hereafter helps to identify the type of failure.

Level A failure rate
It is intended as “Level A failures” all failures which interrupts the "Completion of a Scheduled Train Course" and require the hauling of the train with passenger transfer.

Level B failure rate
It is intended as “Level B failures” all failures which cause an "Immediate or at the Next Station Passenger Transfer" and train comes back to the depot in degraded mode condition (light running).

Level C failure rate
It is intended as “Level C failures” all failures which cause a "Delay of the Train" for a duration exceeding 5 minutes during the service.

Level D failure rate
It is intended as “Level D failures” all failures which cause an interruption of "Completion of a Scheduled Train Course" and require an "End of Course" return of train to the depot.

Level E failure rate
It is intended as “Level E failures” all failures which do not affect the time-keeping of scheduled train course, but which requires corrective maintenance either by earliest possible withdrawal of a train from service or by deferral to a more convenient time (unscheduled maintenance intervention)

The inherent reliability failure rates are the basis for the evaluation of corrective maintenance, while the Service Affecting Failures (SAF) alias critical failures, alias mission failures, give indication how systems/equipment/components can affect the revenue service.

Failures belonging to categories A, B, C, D are the SAFs, while the category E includes the inherent failures rate.

DESCRIPTION	TARGET [At single item level]		REMARKS
Inherent Reliability	**0,5** **FR** [10^{-6} hours]	**2.000.000** MTBF [hours]	Overall failures requiring an unscheduled maintenance intervention (Class E)
SAF (Critical) Reliability	**N/A** **SFR** [10^{-6} hours]	**N/A** MTBF [hours]	Service Affecting Failure all together (Class A, B, C, D)

Table 1 – Reliability targets for elastic element for axlebox

Copyright © TÜRASAŞ. All rights reserved, including industrial property rights applications.
TÜRASAŞ retains any power of disposal, such as copying and transferring.

DESCRIPTION	TARGET [At single item level]		REMARKS
Inherent Reliability	**0,25** **FR** [10^{-6} hours]	**4.000.000** MTBF [hours]	Overall failures requiring an unscheduled maintenance intervention (Class E)
SAF (Critical) Reliability	**0,001** **SFR** [10^{-6} hours]	**10^{9}** MTBF [hours]	Service Affecting Failure all together (Class A, B, C, D)

Table 2 – Reliability targets for trailing rod and rocker arm elastic element

DESCRIPTION	TARGET [At single item level]		REMARKS
Inherent Reliability	**1,5**	**667.000**	Overall failures requiring an unscheduled maintenance intervention (Class E)
	FR [10^{-6} hours]	MTBF [hours]	
SAF (Critical) Reliability	**N/A**	**N/A**	Service Affecting Failure all together (Class A, B, C, D)
	SFR [10^{-6} hours]	MTBF [hours]	

Table 3 – Reliability targets for shock absorber

DESCRIPTION	TARGET [At single item level]		REMARKS
Inherent Reliability	**0,2**	**5.000.000**	Overall failures requiring an unscheduled maintenance intervention (Class E)
	FR [10^{-6}/ hours]	MTBF [hours]	
SAF (Critical) Reliability	**N/A**	**N/A**	Service Affecting Failure all together (Class A, B, C, D)
	SFR [10^{-6}/ hours]	MTBF [hours]	

Table 4 – Reliability targets for traction motor elastic joint

NOTE:
The reliability figures generally at system/equipment level are expressed in terms of:

- "Failure per Million Hours" [10^{-6} /hours] or by its inverse "Mean Time Between Failures (MTBF)" [hours].

The reliability figures generally at complete train level are expressed in terms of:

- "Failures per Million Kilometres" FPMK or by its inverse the "Mean Kilometres Between Failure" (MKBF)

To convert FPMH in FPMK or MTBF in MKBF the conversion speeds from mission profile are to be used.

FPMH = FPMK x (V_{con})
MTBF = MKBF / (V_{con})

Copyright © TÜRASAŞ. All rights reserved, including industrial property rights applications.
TÜRASAŞ retains any power of disposal, such as copying and transferring.

2.5 MAINTENANCE TARGETS

In order to be competitive about the fleet maintenance cost the supplier shall declare his best figures calculated for a short period of 2 years and on 30 years to give indication for a long period cost analysis.

2 years

Description	Target [at train level]	Remarks
Preventive total cost per 1000 km [€/1000 km]	TBD	Labour cost = TBD €/h
Corrective total cost per 1000 km [€/1000 km]	TBD	Labour cost = TBD €/h
Total maintenance cost per 1000 km [€/1000 km]	TBD	

Table 5 – Maintenance targets (2 years period)

30 years

Description	Target [at train level]	Remarks
Preventive total cost per 1000 km [€/1000 km]	TBD	Labour cost = TBD €/h
Corrective total cost per 1000 km [€/1000 km]	TBD	Labour cost = TBD €/h
Total maintenance cost per 1000 km [€/1000 km]	TBD	

Table 6 – Maintenance targets (30 years period)

2.6 RESPECT OF RAMS TARGETS

The fulfillment of the above specified RAMS targets will be verified in service during a dedicated verification period (see following paragraph).

Declared RAMS targets shall be demonstrated and evaluated, during the development of the project, supplying a RAMS analyses according to the table reported in this document.

In particular the Supplier shall demonstrate that all maintainability requirements and levels of repair have been considered and satisfactorily introduced into design.

Maintainability analysis and maintenance target shall be monitored, reviewed and controlled by formal processes to be advised by TÜRASAŞ.

The End Client will verify the declared maintenance times by means of specific demonstrations.

Copyright © TÜRASAŞ. All rights reserved, including industrial property rights applications.
TÜRASAŞ retains any power of disposal, such as copying and transferring.

The maintenance plan derived from preventive analysis and the relevant tasks shall be consistent with maintenance manuals (see dedicated paragraphs).

In case of missed fulfilment the Supplier has:

- to perform all necessary modifications at no costs for TÜRASAŞ, in order to fulfil all RAMS targets.
- to pay for penalties, in the event that the End Client will charge penalties to TÜRASAŞ due to not compliant supplier system, as described in the supply contract.

2.7 RAMS PERFORMANCE VERIFICATION PERIOD

The RAMS targets verification, by recording field data for every system/sub-system/component, will be done in a "Verification Period" during the system/sub-system/component service.

RAMS performance verification period is assumed to be 2 years long for the time being.

Note: The final definition of verification period will be derived from the End Client requirements and it will be confirmed accordingly when these information become available.

2.8 RAMS DOCUMENTATION (DELIVERABLES)

Documentation		**Within TBD months from the order** (or according to scheduled design reviews)
Reliability breakdown		C
System and maintenance hazard analysis		C
Maintenance documentation:		
Preventive and corrective analysis		C
Float spares list		C
Detergent/cleaning agents safety sheets		C
Grease data sheets		C
Spare parts list		C
Special tool list		C
Capital spares list		C

Table 7 – RAMS documentation deliverables

Where:

- C = complete documentation; all the provided documentation shall be updated during design development, taking into account design revisions.

Copyright © TÜRASAŞ. All rights reserved, including industrial property rights applications.
TÜRASAŞ retains any power of disposal, such as copying and transferring.

Further remarks:

- The required documentation shall be produced using the template supplied by TÜRASAŞ or using its own formats pending upon a specific agreement (same contents and requested data shall be reported).
- The use of TÜRASAŞ template is highly recommended because simplify a lot the approval process of relevant documentations, in particular for what concern the preventive and corrective maintenance analyses.
- The failure rate adopted for corrective maintenance calculation shall be of "inherent type" (overall failure rate) and the same of those used for the reliability analysis.
- Overhauls/replacements that take place at the end of train life have not to be taken into account in the cost evaluation.

Note: Maintenance manual is object of a dedicated chapter of this technical specification.

2.9 PREVENTIVE MAINTENANCE REGIME

The Supplier shall use the preventive maintenance frequency listed in the tables below. The Supplier shall agree with TÜRASAŞ upon possible different frequency keeping into account particular needs of its scope of supply.

The maintenance frequencies are divided into 3 types.

1) First level kilometre based maintenance frequency or interval (performed at the depot)

Identification Code	Periodicity km
K-INT-1	7500
K-INT-2	30.000
K-INT-3	60.000
K-INT-6 or 2(K-INT-3)	120.000
K-INT-12 or 4(K-INT-3)	180.000
K-INT-24 or 8(K-INT-3)	360.000

Table 8 – First level kilometre based maintenance frequency

2) First level time based maintenance frequency or interval (performed at the depot)

Identification Code	Periodicity (month)
(T-INT-0)	(1 week)
T-INT-1	1
T-INT-3	3
T-INT-6	6
T-INT-12	12
T-INT-24	24

Table 9 – First level based maintenance frequency

Copyright © TÜRASAŞ. All rights reserved, including industrial property rights applications.
TÜRASAŞ retains any power of disposal, such as copying and transferring.

Maintenance tasks based on time shall be performed only for equipment whose physical characteristics are time dependant or are prescribed by regulation (for example anti-fire system, etc.).

IMPORTANT NOTE:
The maintenance intervention based on run km shall be preferred in respect of time-based intervals.

3) Second level preventive maintenance or heavy preventive maintenance or overhaul (mainly at the workshop)

Identification Code	Periodicity km
H-INT-1	1.200.000
H-INT-2	2.400.000
H-INT-3	4.800.000

Table 10 – Second level preventive maintenance

IMPORTANT NOTE:
The shorter intervals listed below shall be used for only inspections in general, unless of particular maintenance needs. Relevant justifications shall be agreed with TÜRASAŞ:

- K-INT-1
- K-INT-2
- T-INT-0
- T-INT-1
- T-INT-3

The Supplier shall declare all the cases where an important component/item requiring heavy maintenance has a defined fixed life (expressed in km or hours) that cannot match with above intervals for substitution.

The maintenance tasks (both first level and second level) shall have a tolerance interval of -0% +10%, without degradation of performances or increasing in failure (this is valid for delayed maintenance).

2.10 MATERIAL AND LABOUR COST

The material prices to be inserted for preventive and corrective maintenance calculation shall be aftermarket ex works price and the same of the spare parts list.

The “aftermarket ex works price is the price of spares parts without transport cost when purchased by TÜRASAŞ or by the End Client for preventive or corrective maintenance during the whole life of the system/sub-system/component (after production phase).

The labour cost is established for reference at TBD €/hour and it is applicable to all maintenance intervention independently from the type of task and skill level of maintainers.

2.10.1 Man-Hours

The maintenance task times to be counted shall be the so called “technical times” as specified in the following Table 8.

Copyright © TÜRASAŞ. All rights reserved, including industrial property rights applications.
TÜRASAŞ retains any power of disposal, such as copying and transferring.

Technical times **include:**	Technical times **do not** include:
Set-up time – technical cleaning	
Diagnosis and troubleshooting time	Logistic and organisation time
Accessibility time to components of the supplied equipment	Accessibility time to supplied equipment (when some other equipment not part of scope of supply are necessary to be dismounted)
Change or repair time	Unproductive time
Functional check time	Event recording time

Table 11 – Technical time

Above times are valid for both preventive and corrective maintenance.

2.10.2 LRU Policy

If it is reasonably applicable to the scope of supply, is highly recommended to perform LRUs (Line Replaceable Unit) revision (preventive maintenance) or the main repair operations (corrective maintenance) off-train. Consequently LRUs involved in the task, will be replaced with its ready spares from the depot. All that to save time and cost as already written.

To follow this approach a list of these ready to use LRU spares (also called float spares) has to be supplied in the frame of maintenance documentations.

Similarly the supplier shall provide a list of the so called “capitol spares” i.e. spares that are of paramount importance for the functionality of the scope of supply, usually large, expensive, with long lead time or having particular criticality (see also following paragraph).

2.10.3 Spare Parts

The Supplier shall supply a spares parts list consistent with the list of spares used for preventive and corrective maintenance analysis, with additional information for stock calculation purposes:

- Break down structure
- Spare description
- Quantity per “upper” equipment (sub-system quantity per each “father” system and not quantity at system/sub-system/component level)
- Serial price (1)
- After market ex works price
- Delivery time on site
- Economical buy quantity
- Life time
- Minimum buy quantity
- Obsolescence time

(1) Serial price (capital spare): new build price applied to spares in order to build the maintenance stock "capital spares" at the beginning of commercial service. TÜRASAŞ will choose within this list the equipment and quantity to be purchased.

Copyright © TÜRASAŞ. All rights reserved, including industrial property rights applications.
TÜRASAŞ retains any power of disposal, such as copying and transferring.

All the reference used by the Supplier to identify the spare parts shall be the same used in all the documentation provided (design documentation, first and second level maintenance manuals, spare parts catalogue, various instructions for personnel, etc.)

2.10.4 Special Tools List

The usage of special tools shall be avoided to perform preventive and corrective maintenance.

As special tool is intended either a tool (hardware and/or software) that is exclusively produced by the Supplier and is essential for system/equipment maintenance, either a tool available on market but expensive, sophisticated, with long lead time and so on.

If this is not possible, then the Bidder shall give a list of special tools together with their price in the tender.

The special tool list shall be consistent with the special tools mentioned into the preventive and corrective maintenance analysis.

PREPARED BY: *RAMS BLUE TEAM*

END of DOCUMENT

Copyright © TÜRASAŞ. All rights reserved, including industrial property rights applications.
TÜRASAŞ retains any power of disposal, such as copying and transferring.