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## National Electrical Multiple Unit Project RAMS Analysis Requirements for Bistro Equipment

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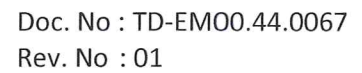
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Approved by	M.Şakir ÇELEBİOĞLU	

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### II. LIST OF ACRONYMS & ABBREVIATIONS

EMU	Electric 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

## **1 INTRODUCTION**

### **1.1 SUBJECT**

This document provides the requirements to be applied to the RAMS analysis in the frame of 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.

### **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 TÜVASAŞ 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.

### **2.4 RELIABILITY TARGETS**

No reliability targets are specified for this scope of supply, nevertheless the Supplier shall be responsible for the quality and reliability of the product.

In particular about the Bistro equipment, if the different devices and components supplied show malfunctions/defects considered chargeable to the Supplier by means of a joint assessment (between the Supplier and TÜVASAŞ), corrective actions and/or design changes shall be performed by the Supplier at own cost.

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
	N/A FR [ $10^{-6}$ /hours]	N/A MTBF [hours]	
Inherent Reliability			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**

#### 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.

$$\text{FPMH} = \text{FPMK} \times (V_{\text{con}})$$

$$\text{MTBF} = \text{MKBF} / (V_{\text{con}})$$

## 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 2 – 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 3 – 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 TÜVASAŞ.

The Final User will verify the declared maintenance times by means of specific demonstrations.

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 TÜVASAŞ, in order to fulfil all RAMS targets.
- To pay for penalties, in the event that the Final User will charge penalties to TÜVASAŞ 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 Final User 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)
System and Maintenance Hazard Analysis	C
<b>Maintenance documentation</b>	
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 4 – RAMS documentation deliverables**

Where:

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

Further remarks:

- The required documentation shall be produced using the template supplied by TÜVASAŞ or using its own formats pending upon a specific agreement (same contents and requested data shall be reported).



- The use of TÜVASAŞ 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 The TÜVASAŞ upon possible different frequency keeping into account particular needs of its scope of supply.

The maintenance frequencies is divided into 3 types.

- 1) First Level Kilometre based maintenance frequency or interval (performed at the depot)

Identification Code	Periodicity km
K-INT-1	5.250
K-INT-2	21.000
K-INT-3	62.500
K-INT-6 or 2(K-INT-3)	125.000
K-INT-12 or 4(K-INT-3)	250.000
K-INT-24 or 8(K-INT-3)	500.000

**Table 5 – 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 6 – First level based maintenance frequency**

Maintenance tasks based on time shall be performed only for equipments 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	1.000.000
H-INT-2	2.000.000
H-INT-3	4.000.000

**Table 7 – 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 TÜVASAŞ:

- 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 -10% +0%, (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 after market ex works price and the same of the Spare Parts List.

The "after market ex works price is the price of spares parts without transport cost when purchased by the TÜVASAŞ or by the Final User 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

Technical times <b>include:</b>	Technical times <b>do not</b> include:
Set-up time – Technical cleaning	
Diagnosis and trouble shooting 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 dismantled)
Change or repair time	Unproductive time
Functional check time	Event recording time

**Table 8 – 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 "capital 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. TUVASAŞ will choose within this list the equipments and quantity to be purchased.*

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 the usage of special tools is required, the Bidder shall give a list of special tools together with their price in the tender and Supplier shall supply 1 complete sets of special tools free of charge.

The Special Tool list shall be consistent with the Special Tools mentioned into the preventive and corrective maintenance analysis.



**PREPARED BY: G. Crivello**

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