Project no. TIP5-CT-2006-031415O

INNOTRACK

Integrated Project (IP)

Thematic Priority 6: Sustainable Development, Global Change and Ecosystems

D 6.1.1 Incorporated Rules and Standards

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Organisation name of lead contractor for this deliverable: Banverket

Revision [Final]

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Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Glossary

FMECA	Failure Modes Effect Criticality Analysis
FOM	Figure of Merit
FTA	Fault Tree Analysis
IM	Infrastructure manager
KPI	Key Performance Indicator
LCC	Life Cycle Cost
LICB	Lasting Infrastructure Cost Benchmarking
LCS	Life Support Cost
MGT	Million Gross Tonne
RAMS	Reliability, Availability, Maintainability and Safety
RBD	Reliability Block Diagram
ROI	Return on Investment
SME	Small and Medium scale Enterprises
SP	Sub Project
WP	Work Package

1. Executive Summary

INNOTRACK addresses mainly the objective of reducing Life Cycle Costs (LCC), while improving the RAMS characteristics of a conventional line with a mixed traffic duty. In the field of railways, RAMS technology and LCC are as widely implemented as they could be and will provide a definite advantage to the Infrastructure Managers (IMs) in helping calculate costs for the implementation of innovative technologies. In the frame of INNOTRACK these methods will be defined at a European level and used to identify cost drivers and assess the track components. The sub-project SP6 deals with RAMS and LCC.

Banverket (BV) had the responsibility to conduct a survey on different rules and standards used by different IMs and related industries as a part of work of WP1 (Work Package 1) within SP6. Eleven questionnaires have been received, out of 24 sent out (answering rate 46%). However, the input from the IMs and related industries is not sufficient to enable a fully comprehensive picture of RAMS and LCC to be reported. Based on this limited information, the following conclusions can be drawn. For ease of comparison BV divided the participants into 4 categories i.e. Infrastructure Manager, Contractors, Manufacturers and SAO (SME, Academia, and Organisation).

General understanding about RAMS and LCC:

- IMs have a slightly better understanding of RAMS and LCC than the manufactures and contractors. RAMS and LCC analysis don't seem to be exhaustive as not many factors are being considered.
- Tools and models are mostly self-developed.

RAMS standards, database and tools:

- Not many RAMS standards are being used. It concludes participants don't consider RAMS issues in all phases of system life cycle.
- Most of the participants use their self-developed software for RAMS analysis.
- Only IMs define reliability target for their systems. One reason may be that there is not sufficient feed back from the IMs to the manufacturers. Reliability analysis is mostly done by expert estimation not by the tools. Most of the participants have failure databases.
- All IMs define availability targets. Very few do spare parts planning in accordance with target availability. Availability analysis is also done mostly by expert estimation.
- Maintainability targets are considered by only very few participants. Analysis is mostly done by experts.
- 50 % of IMs have safety target for their systems and 35 % of the participants do prepare hazard log for their system.

Life Cycle Cost:

- Less than 50% of the participants do have a LCC standard/ guideline.
- LCC is used evaluate investment alternatives.
- Very few participants consider penalty cost, traffic disruption cost, cost due to un-availability/ downtime in their LCC calculations.
- Participants reported service life time both as technical life time and economical life time.
- LCC calculation is considered in investment phase, operation and maintenance phase and disposal phase

Synergy:

- Synergy effects with LICB were reported and the areas were identified where it will provide useful information to INNOTRACK.

This report identified different tools and standards that are used by different participants. The following report will look more into the models that were used to develop these tools also models used by different other industries will be considered which will help in providing useful information in the field of RAMS and LCC analysis. The subsequent report will also look into how different data are collected for the LCC calculation especially for the operation and maintenance phase.

Finally, it can be concluded that the low amount of answers Is due to LCC and RAMS being in its infancy stage among most of the participants, This means that INNOTRACK can support the use of LCC thinking and RAMS technology within the railway sector.

2. Introduction

The Project INNOTRACK aims to develop a Cost-Effective high performance track infrastructure for heavy rail systems. INNOTRACK addresses mainly the objective of reducing Life Cycle Costs (LCC), while improving the RAMS characteristics of a conventional line with a mixed traffic duty.

INNOTRACK project brings infrastructure managers and railway supply industry together, to investigate and evaluate leading edge track system technologies, adopting a controlled methodology to assess life cycle cost benefits of “track-technology solutions” and of a set of emerging railway hardware solutions. It will also support the overall sustainability of the railway sector, meeting needs such as the increase of track availability and network capacity. The results of this project will build on a standardised LCC formulation developed within the project, based on best LCC practices at EU level and independently assessed.

Optimisation of track constructions or track components regarding technical and economic requirements is essential for railway companies to fit the market and to compete against other means of transport. Due to the long lifetime of the track and track components – ranging between 20 to 60 years – pre installation technical and economic assessments are necessary to optimize the track construction, and get the return on investment (ROI), in a manageable timeframe. LCC and RAMS technology are two acknowledged methods for assisting the optimisation process.

The RAMS characteristics determine essential parameters of the system such as the usability and acceptability of the system, the operation and maintenance costs, and the users’ safety and health risk when operating the system. The RAMS technology is a recognised management and engineering discipline to guarantee the specified functionality of a product over its’ complete live cycle, and to keep the operation, maintenance and disposal costs at a predefined accepted level, by establishing the relevant performance characteristics at the beginning of the procurement cycle and by monitoring and controlling their implementation throughout all project phases.

LCC is an appropriate method to identify cost drivers and to gather the costs of a system, module or component over its whole lifetime including development, investment maintenance and recycling costs. Different views and evaluations allow the comparison of different systems and delivers necessary information for technical and economic decision.

In the field of railways, RAMS technology and LCC are as widely implemented as they could be and will provide a definite advantage to the IMs in helping calculate costs for the implementation of innovative technologies.

In the frame of INNOTRACK these methods will be defined at a European level and used to identify cost drivers and assess the track components. The project is divided in 7 Sub-projects:

1. Duty.
2. Track support structure.
3. Switches and crossings.
4. Rails.
5. Logserv.
6. LCC.
7. Dissemination and Training.

This report is included in Sub-project 6 LCC and covers an estimated state-of-the-art of LCC and RAMS knowledge and use among INNOTRACK partners as well as information about existing models and tools.

3. Main section

3.1 Objective

The objective is to collect and analyse work in the field of LCC and RAMS for railway infrastructure and related industries. It also includes different standards being followed and synergies with other projects.

3.1.1 Activities

The following activities were carried out as the part of the objective:

- Analysis and assessment of LCC and RAMS for railway infrastructure and related industries
- National procedure of railway companies.
- Synergy with ongoing projects and experiences of concluded projects like the UIC LICB (Lasting Infrastructure Cost Benchmarking) activity.
- Collection and assessment of national and international rules and standards like EN 13460, EN 50126.

3.1.2 Time schedule

The time to furnish the report (D6.1.1) was 3 months from the start of the project. The status of the report will be “public”.

3.1.3 Risk

Following risks were identified which can lead not to give the clear picture of current status of RAMS and LCC:

- Insufficient data collected.
- Not adequate involvements of Infrastructure Managers as well as suppliers (Manufacturers and Contractors).
- Unawareness of different RAMS and LCC terms. Not common understanding of different terms.
- Not common definitions concerning investment, operation, maintenance and renewal.

3.2 Organisation and resources

The organisation and resources for this work package is given in Table 1. Banverket is responsible for delivery of WP 6.1 which includes D6.1.1 and D6.1.2.

Table 1. Organisation and resources.

Workpackage	6.1 - State of the art			Start date or starting event:			T0
Participant id	UIC	VAS	BV	ADIF	Alstom	NR	OBB
Person-months per participant	2	1	1	1	0.5	0.5	1
Participant id	RFF	DB					
Person-months per participant	1	1					

Other partners in the working group are

- Birmingham University.
- České dráhy, a.s.
- Corus.
- PRORAIL.

Each partner in the working group was responsible to collect data on RAMS and LCC from IM and Suppliers (within INNOTRACK participants) in its respective countries. Each partner was also responsible to translate the questionnaire into respective languages in order to get the answers with ease.

3.3 Information acquisition

Information on RAMS and LCC was obtained from following sources:

- Questionnaires sent to the participants in INNOTRACK, to get an overview of their knowledge, understanding and use of RAMS and LCC.
- Discussion and telephone conversation with infrastructure managers and suppliers.
- Previous related project, like Lasting Infrastructure Cost Benchmarking (LICB).
- Published papers
- Internet search

The primary source of data was from the questionnaire, shown in Annex1. Annex 13 shows the list of IMs/ Suppliers to which the questionnaires were sent.

The questionnaire was sent to 24 participants within INNOTRACK and 11 responses were received by April 15, 2007. Hence, the survey does not claim to be exhaustive because of not many responses from the IMs and suppliers contacted. The layout of the report reflects the format of the questionnaire.

The summery of the synergy with LICB project was prepared by BV and is included in this report.

A synopsis of the information received from each railway IM/ supplier as of 15th April, 2007, is shown in Appendix 2 to 11. Analysis of this information is presented in section 3.4.

3.4 Collated information

Eleven questionnaires have been received, out of 24 sent out. These 24 participants were divided into 4 categories i.e. Infrastructure Manager, Contractors, Manufacturers and SAO (SME, Academia, and Organisation). All the IMs, 4 contractors, 7 Manufacturers and 4 SAO were chosen to answer the questionnaire (see Annex 13). The answering rate can be seen below in Figure 1.

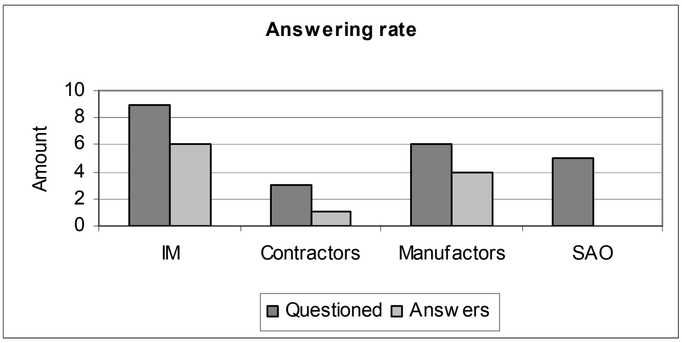

Figure 1: Answering rate of the participants

3.4.1 General understanding about RAMS and LCC

IMs have a slightly better understanding of RAMS and LCC than manufacturers and contractors (see Annex 2A). Two IMs have a history of RAMS/LCC data and they do the RAMS and LCC analysis regularly. Most of the participants do RAMS and LCC calculation for their systems as well as components.

Traffic volume, type of track, sleeper and rail as well as type of maintenance strategy are the most considered factors by the participants for RAMS and LCC analysis (see Annex 2B). Factors like speed, switches and cant deficiency are also considered by some participants. Next report will look into how these factors affect RAMS and LCC of the track.

3.4.2 Standards, database and software

Annex 3 shows that not many RAMS are used by the participants. EN 50126 is the most used standard by IMs and Manufacturers. Annex 12 categorises different RAMS standards.

Almost no participant use commercially available data base (see Annex 4). Few of them use their own maintenance and testing database. Most of the participants use self developed software for RAMS and LCC analysis (see Annex 5). Subsequent report will investigate more into these self-developed software.

3.4.3 Reliability

Reliability is defined as the probability that an item can perform a required function under given conditions for a given time interval.

Number of failures, failure rate, Mean Up Time, Mean Time To Failure etc are the parameters used by IMs as well as manufacturers for representation of reliability. But the most common reliability parameters used are Mean Time Between Failure and number of failures per month/per year (see Annex 6A). Reliability tools such as FMECA, FTA are used by many of the participants. But the most common method used by participants for reliability analysis is done by experts (see Annex 6B). Next report will depict how it is done.

Annex 6C shows that all the IMs have a reliability targets and they identify most failed components and their failure rate. Only one IM and one Manufacturer do Reliability Block Diagram (RBD) for their track system. Failure categories are not done three IMs. Few only demonstrate to achieve system reliability during validation phase. Traffic, Axle load, MGT, Speed, Rail profile etc are the different boundary conditions used by different participants for reliability analysis. It was also seen that two participant consider failures effect on environment. Most of the participants do have a failure database.

3.4.4 Availability

Availability is defined as the ability of a product 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 assuming that the required external sources are provided.

Inherent availability and technical availability are used by many as availability parameters. But most IMs consider train delay as the yardstick to measure availability (see Annex 7A). Expert estimation is the most used tool for availability analysis (see Annex 7B). Next report will look deep into this.

Annex 7C shows that all IMs have availability targets. Only one IM does spare parts planning in accordance with target reliability.

3.4.5 Maintainability

Maintainability is defined as the probability that a given active maintenance action, for an item under given conditions of use can be carried out within a stated time interval when the maintenance is performed under stated conditions and using stated procedures and resources.

Mean Time To Repair is the most used parameter by the participants. Some IMs also use number of maintenance shortcomings per month/per year as parameter (see Annex 8A). It was seen that manufacturers don't use many maintainability parameters like IMs. One possible reason to overcome this may be IMs should give more feedback to manufacturers on maintainability front and indicate these criteria in the contracts. Most common method for maintainability analysis is by expert estimation (Annex 8B). One IM uses Trend monitoring systems as maintainability tool.

Annex 8C shows that two IMs have a maintainability target for their system and it do calculate repair/replacement time for each component/system. Most of the participants define preventive maintenance periodicity. It was understood that more participants define maintenance on technical point of view rather than economical point of view.

3.4.6 Safety

Safety is defined as the state of a technical system freedom from unacceptable risk of harm.

It is IMs rather than manufacturers who measure safety of their systems. Most IMs measure safety as the number of accidents/derailments (Annex 9A). Most commonly used tool for safety analysis is FMECA (Annex 9B).

Annex 9C shows that no participant has a safety target for its system. However participants use hazard log for their systems. Only two IMs demonstrate to achieve safety target during validation phase.

3.4.7 LCC

Analysis of the answers from the questionnaires show that overall there is less than 50% of the participants that use LCC standards / guideline. Most participants reported that LCC is used as a tool to evaluate investment alternatives. Only IMs feel LCC can be used for target costing analysis (see Annex 10A, B, and C).

Less than 50% participants define service life time for their LCC calculation. Participants reported service life time both as technical service life time and economical service life time (see Annex 10C and D).

Only two IMs and one manufacturer consider system warranty period for LCC calculation. Discounting rate is considered by more than 65% of the participants for LCC calculation. Only two IMs consider discounting rate to be constant over the life cycle period. Four IMs consider cost due to un-availability/ cost due to downtime and traffic disruption in the LCC model. Few participants consider penalty cost in LCC calculation where as only two IM considers security cost and environmental cost (see Annex 10E).

Most of the participants consider all kinds of maintenance i.e., corrective maintenance, preventive maintenance, condition based maintenance and renewal for their LCC calculation. Two IMs did not answer on this (see Annex 10F). IMs report maintenance cost as performance wise while manufacturers consider as asset wise (Annex 10H). In annex 10I, it shows the major maintenance actions that are considered by IMs and manufacturers in LCC calculation. Some other maintenance actions that are considered by the participants are maintenance of insulated joints, changing interlayer pads, build-up welding, deburring.

Consider LCC calculation, only two IMs considers cost during R&D phase. One IM did not answer on this. (see Annex 11A). The answers by different IMs and manufacturers are shown in Annex 11 B, C and D.

3.4.8 Synergy with other projects

The working group of INNOTRACK found out LICB as an ideal project for synergy. Banverket has also looked into the possible synergy effects from projects such as UNIFE, UNILIFE and Prom@in. LICB (Lasting Infrastructure Cost Benchmarking) is an international benchmarking project established by the Infrastructure Commission of the International Union of Railways (UIC).

Currently thirteen European Infrastructure Manager (IM) participate in the project and deliver information each year. Data has been collected and analysed since 1996 (then known as Infra Cost project) so that it is possible to identify trends over time, see Figure 2.

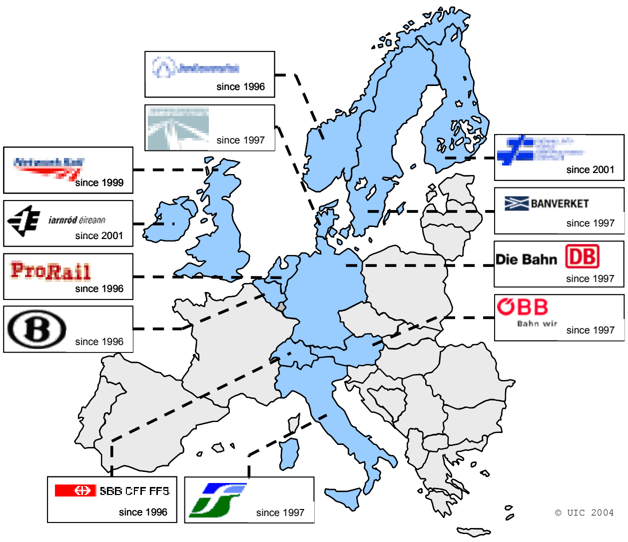

Figure 2. IM's joining the project over the years

The two different benchmarking areas of LICB are:

- Maintenance and renewal expenditures are jointly analysed as an integrated life-cycle-cost approach for the entire railway networks.
- Investment costs are compared for track renewal projects.

Following harmonisation steps were considered for benchmarking:

- Purchasing Power Parities.
- Individual labour cost levels.
- Degree of electrification.
- Single vs. multiple track.
- Switch densities.
- Track utilisation.

The harmonisations steps are shown in Figure 3.

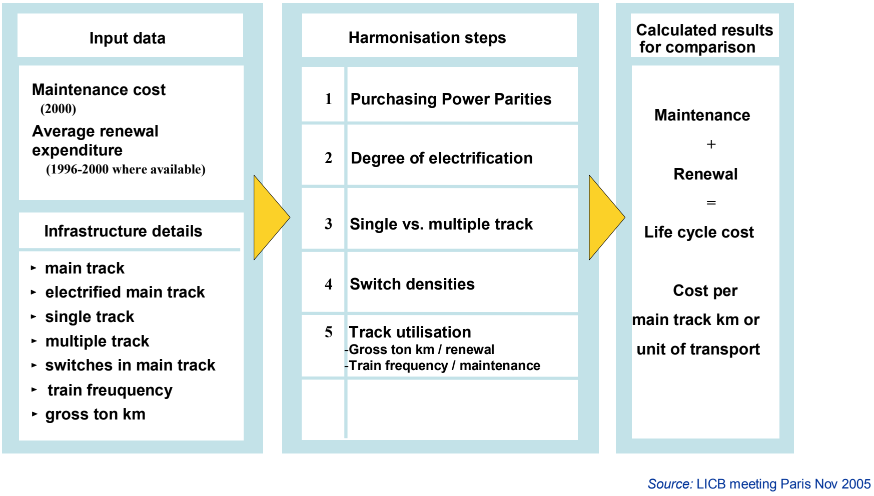

Figure 3. Harmonisation steps.

LICB considered Investment cost, maintenance and renewal cost as the Life Cycle Cost of the asset and the possible reasons for the difference in LCC between IMs identified were:

- Line type coupled with complexity and utilisation (train frequencies/tonnage) of the asset.
- Technical life time of the infrastructure components. Protecting asset life through well-conceived maintenance strategies and by expanding life times through a more advanced condition based decision making may save money.
- Re-investment planning.
- Track quality.
- RAMS requirement of the track.

Possible synergies of LICB with INNOTRACK can be found below:

- Definitions such as main track, high speed track, freight lines, branch lines, passenger track etc can be used.
- Harmonisation steps can be used for realistic comparison of costs.
- Different possible reasons for cost differences were shown by LICB. Further cost drivers such as construction in urban territory, design speed, traffic interface , labour cost can be considered.
- Average life times of infrastructure components were found out in LICB in terms of years. It can be changed to MGT for effective calculation. This will in turn help in defining service life time of the infrastructure.
- LICB showed the relationship of LCC with RAMS, Quality and Age of the infrastructure. This can be used for effective calculation of LCC.
- Amount of exchanged rails/sleepers/ballast that are exchanged per year can be used as indices for following up with the target LCC.

The second synergy can be drawn from the LCC guidelines developed by UNIFE. These guidelines can be used as check point list for LCC activities.

UNILIFE and UNIDATA are the LCC tools used for rolling stock application. UNILIFE is used for sub-system LCC data transfer where as UNIDATA is used for component LCC data transfer. UNIDATA is a subset of UNILIFE.

UNILIFE/UNIDATA handles line replaceable units and service replaceable units taking into account their corrective and preventive maintenance. Failures are split into train failure categories. The impact on LCC or Life Support Cost (LSC) can be evaluated by the introduction or removal of redundancy, improvements to equipment reliability or changes to the maintenance requirements.

These are simple calculation tools and can be downloaded from www.unife.org/docs/lcc/Unidata.xls and www.unife.org/docs/lcc/Unilife.xls (this is described in report D6.1.2).

In the above mentioned guidelines measures for reliability, availability, maintainability, safety, security and logistic support called FOM (Figure of Merit) or KPI (Key Performance Indicators) are mentioned which can be of interest in WP 6.4 (TAMS and LCC in contracts/wordings/policies).

The third Synergy effect comes from the project Prom@in where the LCC model for The Norwegian IM Jernbaneverket is discussed. This will be review in the report D6.1.2.

4. Conclusions

Eleven (46%) questionnaires have been received, out of 24 sent out. However, the input from the IMs and related industries is not sufficient to enable a fully comprehensive picture of RAMS and LCC to be reported. Based on this limited information, the following conclusions can be drawn. For ease of comparison BV divided the participants into 4 categories i.e., Infrastructure Manager, Contractors, Manufacturers and SAO (SME, Academia, and Organisation). The survey does not claim to be exhaustive because of not many responses from the IMs and suppliers contacted

- IMs have a slightly better understanding of RAMS and LCC than the manufactures and contractors. RAMS and LCC analysis don't seem to be exhaustive as not many factors are being considered.
- Not many RAMS standards are being used. It concludes participants don't consider RAMS issues in all phases of system life cycle.
- Most of the participants use their self-developed software for RAMS analysis.
- Only IMs define reliability target for their systems. One reason may be that there is not sufficient feed back from the IMs to the manufacturers. Reliability analysis is mostly done by expert estimation not by the tools. Most of the participants have a failure database.
- All IMs define availability targets. Very few do spare parts planning in accordance with target availability. Availability analysis is also done mostly by expert estimation.
- Maintainability targets are considered by only very few participants. Analysis is mostly done by experts.
- No participants have safety target for their systems but participants do prepare hazard log for their system.
- Less than 50% of the participants do have a LCC standard/ guideline.
- LCC is used to evaluate investment alternatives.
- Very few participants consider penalty cost, traffic disruption cost, cost due to un-availability/ downtime in their LCC calculations.
- Participants reported service life time both as technical life time and economical life time.
- LCC calculation is considered in investment phase, operation and maintenance phase and disposal phase.
- Synergy effects with LICB were reported and the areas were identified where it will provide useful information to INNOTRACK.

Conclusion can be drawn that in this report different tools and standards were identified that are used by different participants. The following report will look more into the models that were used to develop these tools also models used by different other industries will be considered which will help in providing useful information in the field of RAMS and LCC analysis. The subsequent report will also look into how different data are collected for the LCC calculation especially for the operation and maintenance phase.

Finally, it can be concluded that the low amount of answers Is due to LCC and RAMS being in its infancy stage among most of the participants, This means that INNOTRACK can support the use of LCC thinking and RAMS technology within the railway sector.

5. Bibliography

1. EN 50126: Railway applications – the specification and demonstration of RAMS
2. LICB Project
3. Reports form UNIFE

6. Annexes

1. Questionnaire-I
2. General understanding of RAMS and LCC
3. RAMS standards
4. RAMS database
5. RAMS software
6. Reliability
7. Availability
8. Maintainability
9. Safety
10. General questions on LCC
11. LCC calculation
12. RAMS standards classification
13. Participants to whom questionnaires were sent

6.1 ANNEX 1: QUESTIONNAIRE – I

Questionnaire – I

INNOTRACK SP6 WP1
State of the art (RAMS & LCC)

Questionnaire-I has been prepared to conduct a survey on what different Infrastructure Managers (IMs) and track component suppliers understand by RAMS and LCC. The scope of this questionnaire is to find out what are the rules and standards followed by different IMs and Suppliers in their RAMS and LCC analysis. Following the feedback from Questionnaire-I, Questionnaire-II will be prepared. Questionnaire-II will deal with how RAMS and LCC analysis (models, data, formulas, etc) are conducted by different IMs and suppliers.

This Questionnaire is divided into 3 parts. 1st part deals with the general understanding of RAMS and LCC in your organisation. 2nd and 3rd parts deal with more specific to RAMS and LCC respectively.

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PART – I *General understanding*

PART – II *RAMS*

Part A *Standards*
RAMS database
RAMS software
Part B *Reliability*
Availability
Maintainability
Safety

PART – III *LCC*

Part C *General Questions on LCC*
Part D *LCC calculation*

*** Please refer to EN 50126 and IEV 191 standards for definitions of different RAMS parameters**

Name of the organisation:

Contact Person:

Designation:

Tel. No.:

Fax No.:

E-mail:

Please provide a brief description of your organisation

Part – I

General understanding (*Please put cross mark if your answer is YES*)

☐ 1.1 Do you analyse/ calculate RAMS and LCC regularly?

☐ 1.2 Do you have specialists in your organisation?

☐ 1.3 Do you have a guideline for RAMS/LCC?

You calculate RAMS and LCC for

☐ 1.4 Components

☐ 1.5 System

1.6 What is the history of your data for RAMS and LCC? Please mention the year.

☐ 1.7 Do you have RAMS/LCC parameters in your contract?

What factors do you consider for RAMS/LCC analysis?

☐ 2.1 Traffic volume

☐ 2.2 Type of traffic (e.g. passenger/freight; commuter/intercity ;...)

☐ 2.3 UIC traffic classification (type of line)

☐ 2.4 Axle load (average)

☐ 2.5 Axle load (maximum)

☐ 2.6 Weighted axle load (equivalent axle load of the vehicles)

☐ 2.7 Unsprung mass (maximum)

☐ 2.8 Unsprung mass (weighted/equivalent)

☐ 2.9 Type of track

☐ 2.10 Type of track: specific indicator (vertical stiffness, bearing capacity,…)

☐ 2.11 Type of sub grade

- ☐ 2.12 Type of ballast
- ☐ 2.12 Type of sleeper
- ☐ 2.13 Type of rail
- ☐ 2.14 Type of maintenance strategy/policy

If you consider any other factors than the above mentioned, please mention below

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Part – II

RAMS (Reliability, Availability, Maintainability & Safety)

Part A

Standards (*Please put cross mark on the standards that you follow for RAMS activities*)

- ☐ **3.1 EN 50126:** Railway applications – the specification and demonstration of RAMS
- ☐ **3.2 IEC 61160:** Formal design review (amendment 1)
- ☐ **3.3 IEC 60300-3-1:** Dependability management- part 3, application guide – section 1: Analysis techniques for dependability, guide on methodology
- ☐ **3.4 IEC 60706:** Guide on maintainability of equipment (part 1 – 6)
- ☐ **3.5 IEC 60812:** Analysis technique for system reliability – procedures for FMEA
- ☐ **3.6 IEC 60863:** Presentation of reliability, maintainability and availability predictions
- ☐ **3.7 IEC 61025:** Fault tree analysis
- ☐ **3.8 IEC 61078:** Analysis techniques for dependability – reliability block diagram method
- ☐ **3.9 IEC 61165:** Application of markov techniques
- ☐ **3.10 IEC 61709:** Reliability of electronic components
- ☐ **3.11 IEC 61508:** Functional safety of electrical/electronic safety related systems (parts 1-7)
- ☐ **3.12 IEC 60605:** Equipment reliability testing
- ☐ **3.13 IEC 61014:** Programmes for reliability growth
- ☐ **3.14 IEC 61070:** Compliance test procedure for steady-state availability
- ☐ **3.15 IEC 61123:** Reliability testing – compliance test plan for success ratio
- ☐ **3.16 IEC 60319:** Presentation of reliability data on electronic components
- ☐ **3.17 MIL STD 471a:** Military standard maintainability verification/ demonstration/evaluation
- ☐ **3.18 MIL STD 2173:** Reliability centred maintenance
- ☐ **3.19 IEC 60571:** Electronic equipment used on rail vehicles, components, programmable electronic equipment and electronic system reliability (part 3)

☐ **3.20 MIL STD 785B:** Reliability program for systems and equipment development and production

☐ **3.21 MIL STD 756:** Reliability modelling and prediction

☐ **3.22 MIL STD 1629:** FMECA

☐ **3.23 IEC 812:** Analysis techniques for system reliability - procedure for FMECA

If you use any other standards than the above mentioned, please mention below

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Database (*Please put cross mark on the database that you follow for RAMS activities*)

☐ **4.1 MIL HDBK 217:** Reliability prediction for electronic system

☐ **4.2 MIL HDBK 882C:** System safety programme requirements

☐ **4.3 IEEE 500:** Mechanical and electronic component database

☐ **4.4 NPRD:** Non electronic parts reliability database

☐ **4.5 MIL HDBK 472:** Maintainability data handbook

☐ **4.6 RDF 2000:** Reliability prediction for electronic components

☐ **4.7 RAC Prism:** Failure prediction for both electronic and non-electronic parts

☐ **4.8 China 299B:** Electronic equipment reliability

☐ **4.9 Telcordia SR-332:** Reliability prediction of electronic components

☐ **4.10 NSWC 98/LE1:** Failure rate prediction of mechanical components

If you use any other database other than the above mentioned, please mention below

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Software (*Please put cross mark on the software that you follow for RAMS activities*)

- ☐ **5.1 Relex**
- ☐ **5.2 Reliasoft** (Weibull ++, ALTA, BlcokSim etc)
- ☐ **5.3 Item software**
- ☐ **5.4 RAM Commander (A.L.D)**
- ☐ **5.5 MathOffice (IZP Dresden)**
- ☐ **5.6 MS Excel (Developed software)**
- ☐ **5.7 MS Access**

If you use any other software other than the above mentioned, please mention below

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Part B

Reliability

Definition: probability that an item can perform a required function under given conditions for a given time interval (EN 50126:1999)

i) Parameters (In what parameters do you represent Reliability of component/system?)

☐ 6.1 Failure rate (λ)

☐ 6.2 Mean Up Time (MUT)

☐ 6.3 Mean Time To Failure (MTTF)

☐ 6.4 Mean Time Between Failure (MTBF)

☐ 6.5 Mean Distance Between Failure (MDBF)

☐ 6.6 Mean Time Between Service Affecting Failure (MTBSF)

☐ 6.7 Number of failures in the system per month/per year

Any other parameters

____

____

ii) Tools (What tools do you use to calculate/analyse Reliability of component/system?)

☐ 7.1 FMECA (Failure Modes Effects and Criticality Analysis)

☐ 7.2 Fault Tree Analysis

☐ 7.3 Parts stress analysis

☐ 7.4 Worst case analysis

☐ 7.5 Expert estimation

☐ 7.6 Simulation

Any other tools

iii) Reliability analysis (*Please put cross mark if your answer is YES*)

☐ 8.1 Do you have a failure database?

☐ 8.2 Do you have a reliability target for the track system?

☐ 8.3 Do you do a reliability block diagram (RBD) for the track system?

☐ 8.4 Do you calculate failure rate for each component/sub-system in the system?

☐ 8.5 Do you identify the most failed component in the system and have their failure rates?

☐ 8.6 Do you categorise the failures in the system in terms of their effect on the operation of the system? (e.g., Significant, Major, Minor, Negligible)

☐ 8.7 If you answer 'yes' to the above question, do you have failure rate for each kind of failure category?

☐ 8.8 Do you have a reliability analysis database for different boundary conditions? (*Example of boundary condition: axle load (25 ton), MGT (30), Temperature (-10 C to 25 C), Humidity (50 – 60%), Speed, Rail type (UIC 60), Curve radius, Track elevation etc*)

Please mention below the different boundary conditions

☐ 8.09 Do you do reliability testing during design phase?

☐ 8.10 Do you carry out reliability growth analysis?

☐ 8.11 Do you demonstrate to achieve system reliability target during system validation phase?

☐ 8.12 Do you consider the different failures effect on environment?

Any other questions you like to mention

Availability

Definition: ability of a product 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 assuming that the required external sources are provided (EN 50126:1999)

i) Parameters (In what parameters do you represent Availability of system?)

☐ 9.1 Inherent availability (when you consider corrective maintenance only)

☐ 9.2 Technical availability (when you consider corrective maintenance as well as preventive maintenance)

☐ 9.3 Operational availability (when you consider logistic time also along with both kind of maintenance mentioned above)

☐ 9.4 Train delay (hours)

- ☐ 9.5 Total train delay
- ☐ 9.6 Train delay caused by infrastructure
- ☐ 9.7 Train delay caused by specified infrastructure asset

Any other parameters

ii) Tools (What tools do you use to calculate/analyse Availability of component/system?)

☐ 10.1 Markov analysis

☐ 10.2 Spares optimisation

☐ 10.3 Expert estimation

☐ 10.4 Simulation (e.g., RailSys)

Any other tools

____

____

iii) Availability analysis (*Please put cross mark if your answer is YES*)

- ☐ 11.1 Do you have an availability target for the track system?
- ☐ 11.2 Do you do spare parts planning in accordance with the target availability of the track system?
- ☐ 11.3 Do you have an availability analysis database for different boundary conditions?

Please mention below the different boundary conditions

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- ☐ 11.4 Do you demonstrate to achieve system availability target during system validation phase?
- ☐ 11.5 Do you simulate the train delay caused by track construction, maintenance etc?
- ☐ 11.6 Do you have service availability criteria to achieve?

Any other questions you like to mention

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Maintainability

Definition: probability that a given active maintenance action, for an item under given conditions of use can be carried out within a stated time interval when the maintenance is performed under stated conditions and using stated procedures and resources (EN 50126:1999)

i) Parameters (In what parameters do you represent Maintainability of system?)

- ☐ 12.1 Mean Time Between Maintenance (MTBM)
- ☐ 12.2 Mean Distance Between Maintenance (MDBM)
- ☐ 12.3 Mean Time To Maintain (MTTM)
- ☐ 12.4 Mean Down Time (MDT)
- ☐ 12.5 Mean Time To Repair (MTTR)
- ☐ 12.6 Mean Logistic Time (MLT)
- ☐ 12.7 Mean Time To Recover (MTTRec) (Time to recover a service after system disruption)
- ☐ 12.8 Number of maintenance shortcoming per month/per year (In terms of failing to execute the maintenance action in stipulated time)

Any other parameters

____

____

ii) Tools (What tools do you use to calculate/analyse Maintainability of component/system?)

- ☐ 13.1 Failure Reporting And Corrective Action System (FRACAS)
- ☐ 13.2 Markov analysis
- ☐ 13.3 Reliability Centred Maintenance (RCM)
- ☐ 13.4 Expert estimation

Any other tools

____

iii) Maintainability analysis (*Please put cross mark if your answer is YES*)

☐ 14.1 Do you have maintainability target for the track system?

☐ 14.2 Do you calculate the repair/replacement time (troubleshooting+removal+refit+testing+logistic) for each component/sub-system in the system?

☐ 14.3 Do you define the periodicity of each and every kind of preventive maintenance/overhaul that you do on the track?

☐ 14.4 Do you calculate the material and maintenance personnel required for each kind of maintenance that you perform on the track?

☐ 14.5 Do you have a maintainability analysis database for different boundary conditions?

Please mention below the different boundary conditions

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____

____

☐ 14.6 Do you demonstrate to achieve system maintainability target during system validation phase?

☐ 14.7 Do you consider logistic time in the parameters?

Do you define your maintenance on?

☐ 14.8 Technical point of view

☐ 14.9 Economical point of view

Any other questions you like to mention

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Safety

Definition: state of a technical system freedom from unacceptable risk of harm (EN 50126:1999)

i) Parameters (In what parameters do you represent Safety of system?)

- ☐ 15.1 Mean Time Between Hazardous Failure (MTBHF)
- ☐ 15.2 Mean Time Between Safety System Failure (MTBSF)
- ☐ 15.3 Hazard rate (H(t))
- ☐ 15.4 Number of accidents
  - ☐ 15.4 Number of derailments
  - ☐ 15.5 Number of accidents due to external sources
  - ☐ 15.6 Number of accidents due to internal sources

Any other parameters

____

____

ii) Tools (What tools do you use to calculate/analyse Safety of component/system?)

- ☐ 16.1 HAZOP
- ☐ 16.2 Preliminary Hazard Analysis (PHA)
- ☐ 16.3 Event Tree
- ☐ 16.4 Risk analysis
- ☐ 16.5 RCA (Root Cause Analysis)
- ☐ 16.6 FMECA

Any other tools

____

____

iii) Safety analysis (*Please put cross mark if your answer is YES*)

☐ 17.1 Do you have safety target for the track system?

☐ 17.2 Do you prepare a hazard log?

☐ 17.3 Do you identify hazards and their probabilities for the system?

☐ 17.4 Do you define hazard severity levels with consequence to person and environment? (e.g., Catastrophic, Critical, Marginal, Insignificant)

☐ 17.5 Do you have a safety analysis database for different boundary conditions?

Please mention below the different boundary conditions

☐ 17.6 Do you demonstrate to achieve system safety target during system validation phase?

Any other questions you like to mention

Part – III

LCC (Life Cycle Cost)

Description

LCC is a decision support tool which calculates the cost during the system life cycle.

Use of Life Cycle Cost model to optimise the cost during an asset lifetime can be viewed as a process including 6 steps

1. Definition of System Requirements
    - LCC analysis needs to be based on
        - a definition of system operational requirements, maintenance concept, and
        - a program plan and profile illustration major life-cycle activities and the projected operational horizon for the system
    - Requirements should be addressed in terms of function to be performed, quantities required and geographical distribution, reliability factors, maintenance and support concept

2. Cost Breakdown Structure (Cost Categories)
    - Product break down structure
    - A cost break down structure , showing all the phases during the assets lifetime:
        - Research and development
        - Investment (manufacturing, construction and initial logistic support)
        - Operation and maintenance
        - Disposal, system phase - out
    - Cost categories must be well defined, all must have the same understanding of what is included, cost doubling must be eliminated
    - The cost structure and categories should be coded in such manner as to allow analysis of certain specific areas of interest (e.g. system operation, energy consumption, equipment design, spares, and maintenance personnel and support)
    - The cost structure should be compatible with the program work break down and with the management accounting records
    - Where subcontracting is prevalent, it is often desirable and necessary to separate supplier cost (bid-cost etc) from the product cost

3. Cost Estimating
    - Known factors or rates, estimating relationships, expert opinion
    - Discounting, relates to the time value of money, and all the future cost most be adjusted to the net present value (NPV)
    - Inflation
4. Build a cost model that is adopted to the situation
5. Cost profile, presenting the results in a graphical manner
6. Evaluation of Alternatives

Part C

General questions on LCC (*Please put cross mark if your answer is YES*)

☐ 18.1 Does a standard/guideline of LCC exist in your organisation?

☐ You use LCC analysis

- ☐ 18.2.1 To define/obtain management indicators
- ☐ 18.2.2 To have feedback for technical improvement
- ☐ 18.2.3 To evaluate maintenance strategies
- ☐ 18.2.4 To evaluate investment alternatives

☐ 18.3 Do you use LCC for target costing analysis?

☐ 18.4 Do you (or Traffic Operator) define service life time before conducting LCC calculations?

The define service life time is

- ☐ 18.5.1 Economic service life time
- ☐ 18.5.2 Technical service life time

☐ 18.6 Do you consider system warranty period in the LCC calculation?

☐ 18.7 Do you consider discounting rate?

- ☐ 18.8 Is it constant over the life cycle period?

☐ 18.9 Do you consider inflation rate?

- ☐ 18.10 Is it constant over the life cycle period?

☐ 18.11 Do you consider same rates for equity/ committed assets?

☐ 18.12 Do you consider cost of downtime/cost due to un-availability of track in the LCC model?

☐ 18.13 Do you consider traffic disruption cost in the LCC model?

- ☐ 18.14 If yes, do you distinguish planned/unplanned interruptions?

☐ 18.15 Do you consider derailment cost?

☐ 18.16 Do you consider penalty cost (failing to meet schedule, specification etc) imposed by traffic operator?

☐ 18.17 Do you consider the costumer reduction cost due to train delay?

☐ 18.18 Do you consider risk analysis while modelling LCC? (trade-off between LCC and cost due to risk)

☐ 18.19 Do you consider federal funds?

☐ 18.20 Do you consider benefits?

☐ 18.21 Do you consider environmental costs (noise, etc.)

☐ 18.22 Do you consider security costs?

☐ 18.23 Do you consider overhead costs?

☐ 18.24 Do you allocate overhead costs to different activities?

Do you consider the following maintenance categories in LCC calculation and calculate cost for each separately?

☐ 18.25.1 Corrective maintenance

☐ 18.25.2 Preventive maintenance

☐ 18.25.3 Condition based maintenance

☐ 18.25.4 Renewal

Any other category

___

Do you consider the following maintenance types in LCC calculation and calculate cost for each separately?

☐ 18.26.1 In house maintenance

☐ 18.26.2 Out sourced maintenance

☐ 18.26.3 Combined of above two types

How is the maintenance cost reported?

- ☐ 18.27.1 Asset wise
- ☐ 18.27.2 Performance wise

The major maintenance actions done on track that you consider in the LCC model are

- ☐ 18.28.1 Inspection for safety
- ☐ 18.28.3 Inspection for maintenances
- ☐ 18.28.3 Track adjustment
- ☐ 18.28.4 Rail lubrication
- ☐ 18.28.5 Snow removal
- ☐ 18.28.6 Rail grinding
- ☐ 18.28.7 Track tamping
- ☐ 18.28.8 Ballast cleaning
- ☐ 18.28.9 Ballast compacting
- ☐ 18.28.10 Weld straightening
- ☐ 18.28.11Vegetation removal
- ☐ 18.28.12 Neutralisation
- ☐ 18.28.13 Draining, ditching
- ☐ 18.28.14 Failure replacement (of rail, sleeper, fastening etc)
- ☐ 18.28.15 Rail renewal
- ☐ 18.28.16 Ballast renewal
- ☐ 18.28.17 Subsoil rehabilitation
- ☐ 18.28.18 Sleeper renewal
- ☐ 18.28.19 Turnout renewal

☐ 18.28.20 Fastening renewal

☐ 18.28.21 Track renewal

Any other maintenance actions you consider, please mention below

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____

Are you using any specific models/software for LCC calculation, please mention them

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Part D

LCC calculation (*Please put cross mark if your answer is YES*)

What phases of life cycle do you consider for LCC calculation?

☐ 19.1.1 Research and development phase

☐ 19.1.2 Investment phase

☐ 19.1.3 Operation and maintenance phase

☐ 19.1.4 Disposal phase

Any other phase you consider, please mention below

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____

i) Research and development phase (What kinds of cost are considered?)

☐ 20.1 Program management cost

☐ 20.2 Advanced R&D cost

☐ 20.3 Engineering design cost

  ☐ 20.4 Reclamation cost

☐ 20.5 Equipment development/test cost

  ☐ 20.6 Prototype fabrication and assembly labour cost

  ☐ 20.7 Prototype material cost

  ☐ 20.8 Prototype test and evaluation cost

☐ 20.9 Engineering data cost

☐ 20.10 Pre study for railway system investment cost

  ☐ 20.11 Market inquiry cost (Collection customers and stakeholders opinion)

  ☐ 20.12 Specifying alternative solution cost (considering context, working condition and environmental aspects)

☐ 20.13 Demand specification cost

☐ 20.14 Environmental consequences analysis cost

☐ 20.15 Maintenance consequences analysis cost

Any other cost you consider in this phase/sub-phase, please mention below

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ii) Investment phase (What kinds of cost are considered?)

☐ 21.1 System/equipment manufacturing cost

☐ 21.1.1 First article qualification test cost

☐ 21.1.2 Recurring manufacturing cost

☐ 21.1.3 Inspection and test cost

☐ 21.1.4 Tools and equipment cost

☐ 21.1.5 Manufacturing labour cost

☐ 21.1.6 Manufacturing material and inventory cost

☐ 21.1.7 Quality assurance cost

☐ 21.2 System construction cost

☐ 21.2.1 Land purchase cost

☐ 21.1.2 Construction fabrication labour cost

☐ 21.2.3 Construction material cost

☐ 21.2.4 Capital equipment cost

☐ 21.2.5 Construction management costs

☐ 21.3 Initial logistic support cost

☐ 21.3.1 Packing and initial transportation cost

☐ 21.3.2 Provisioning cost (data covering spares, test and support etc)

☐ 21.3.3 Initial inventory management cost

☐ 21.3.4 Training and training equipment cost

Any other cost you consider in this phase/sub-phase, please mention below

____

____

____

iii) Operation and maintenance phase (What kinds of cost are considered?)

☐ 22.1 Operation cost

☐ 22.1.1 Operating personnel cost

☐ 22.1.2 Operator training cost

☐ 22.1.3 Operational facilities cost

☐ 22.1.4 Support and handling equipment cost

☐ 22.1.5 Power supply to infrastructure cost

☐ 22.2 Maintenance cost (for all kind such as preventive, renewal, condition based etc)

☐ 22.2.1 Maintenance personnel cost

☐ 22.2.2 Maintenance training cost

☐ 22.2.3 Spare/repair parts cost

☐ 22.2.4 Test and support equipment maintenance cost

☐ 22.2.5 Transportation and handling cost

☐ 22.2.6 Maintenance facilities cost

☐ 22.2.7 Consumables cost

☐ 22.2.8 Maintenance machine cost (Grinding machine, Tamping machine etc)

☐ 22.2.9 Modification cost (due to change of requirement)

☐ 22.2.10 Environmental cost (oil, steel etc)

Any other cost you consider in this phase/sub-phase, please mention below

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iv) Disposal phase (What kinds of cost are considered?)

☐ 23.1 System disposal cost

☐ 23.2 Cleaning cost

☐ 23.3 System residual value

☐ 23.4 Regeneration/ recycling cost

Any other cost you consider in this phase/sub-phase, please mention below

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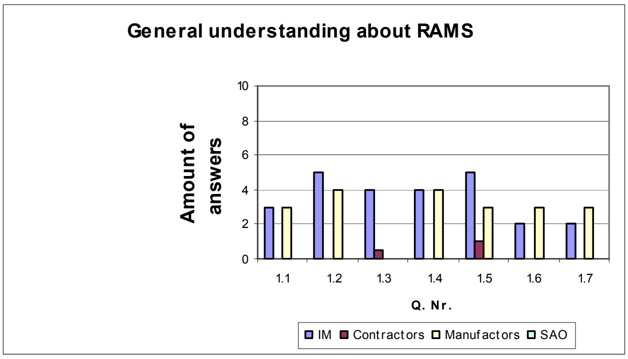
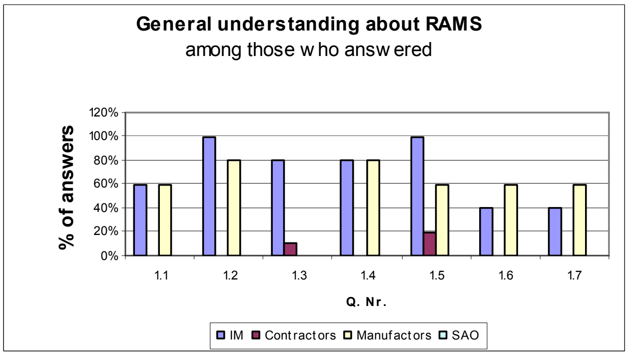
(Any other points on LCC that you like to mention which has not been discussed above)

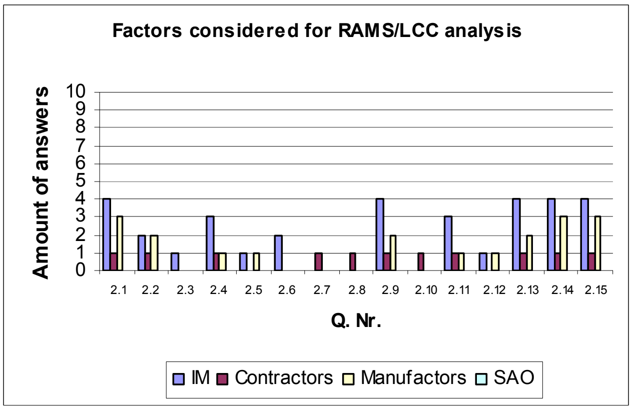
6.2 ANNEX 2: GENERAL UNDERSTANDING OF RAMS AND LCC

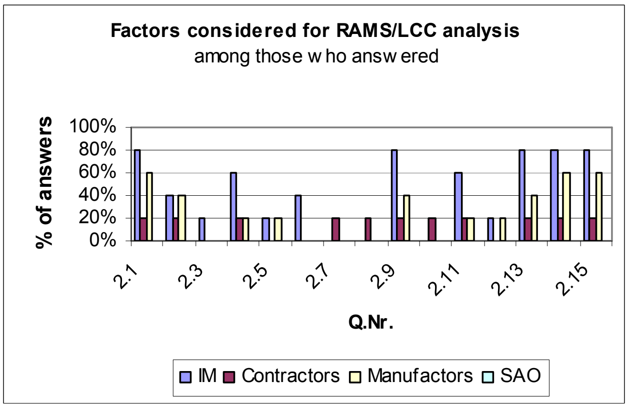
ANNEX 2A



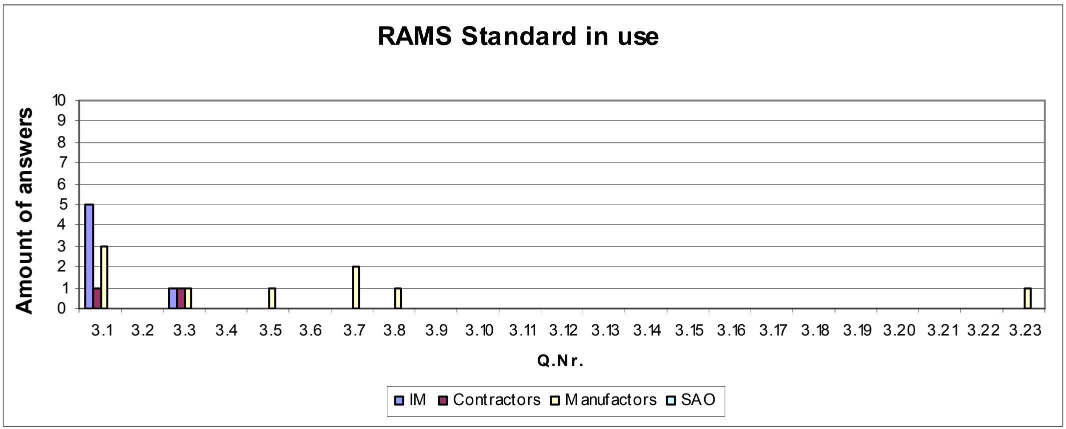


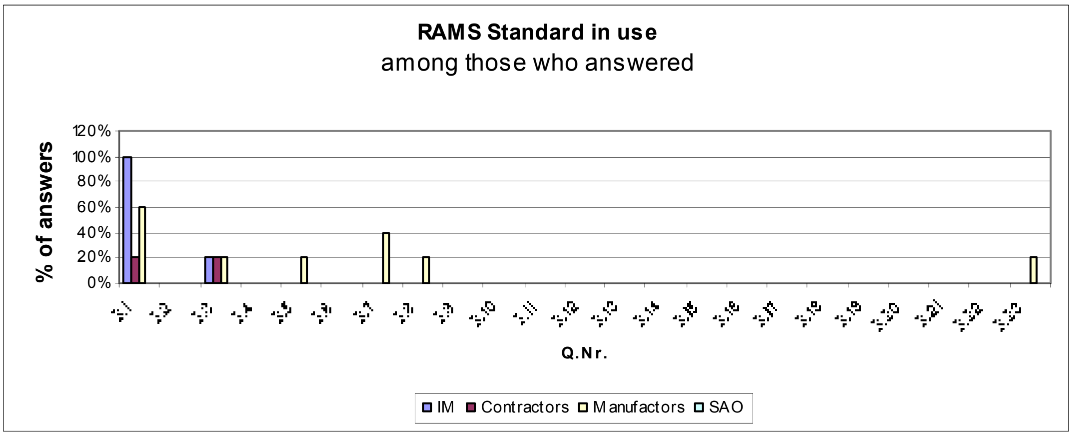
ANNEX 2B



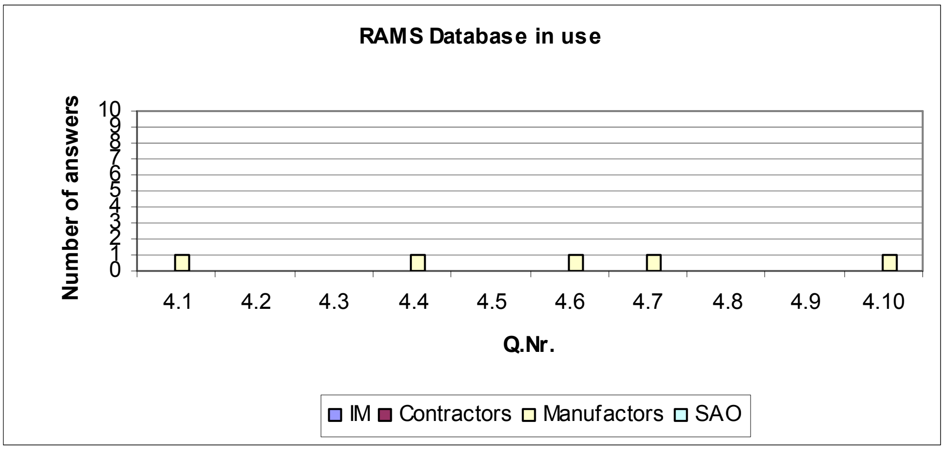


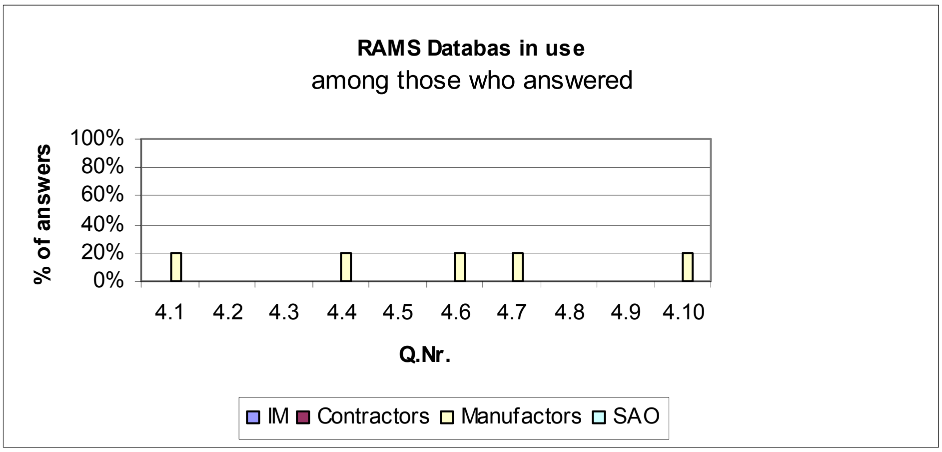
6.3 ANNEX 3: RAMS STANDARD



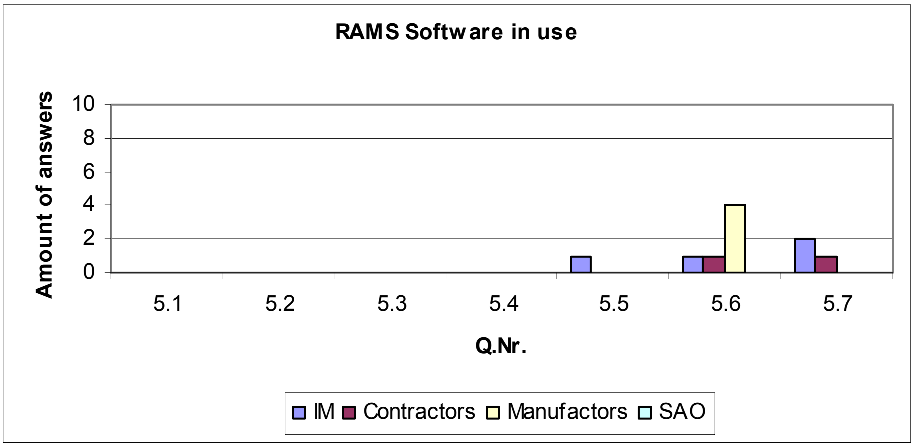


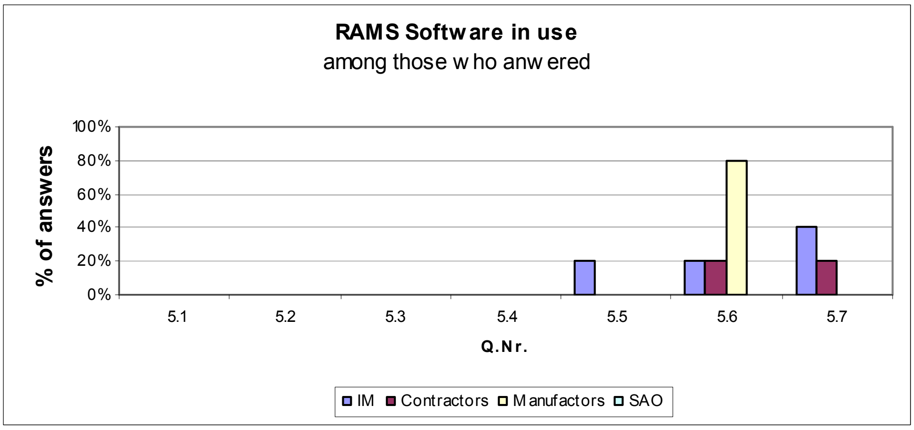
6.4 ANNEX 4: RAMS DATABASE





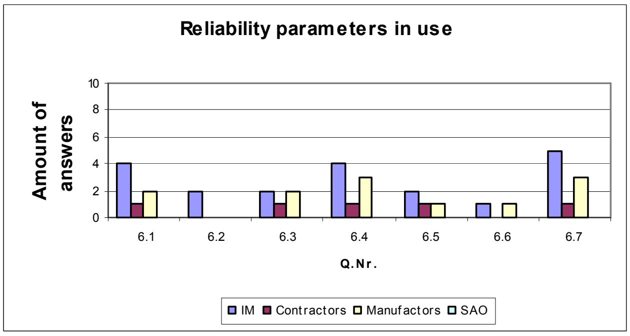
6.5 ANNEX 5: RAMS SOFTWARE

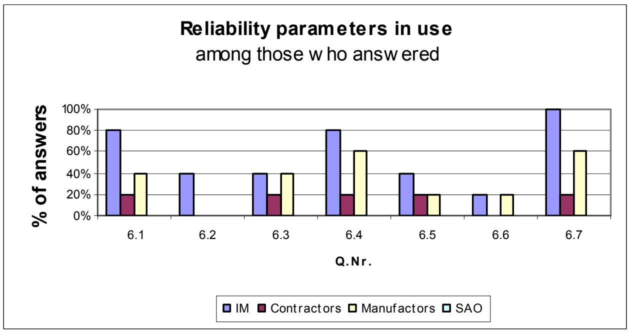




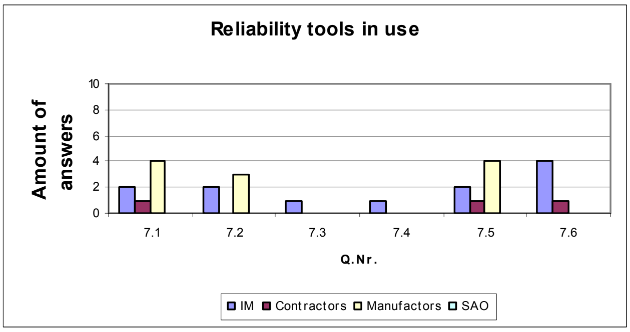
6.6 ANNEX 6: RELIABILITY

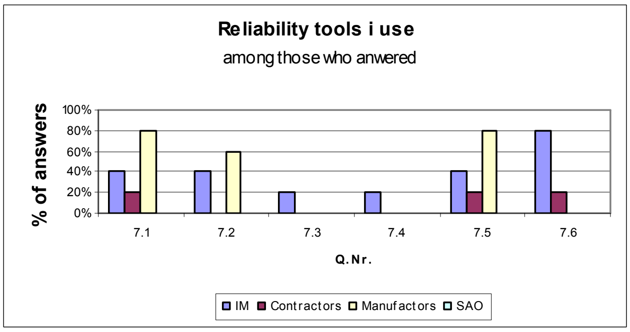
ANNEX 6A



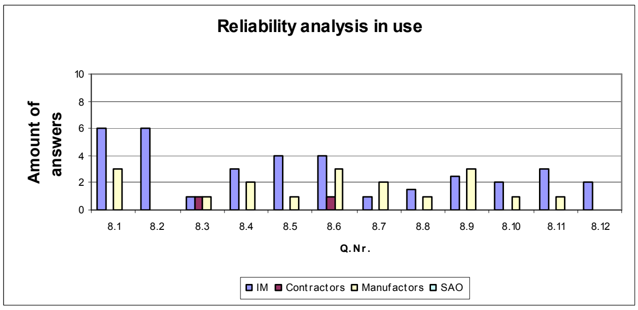


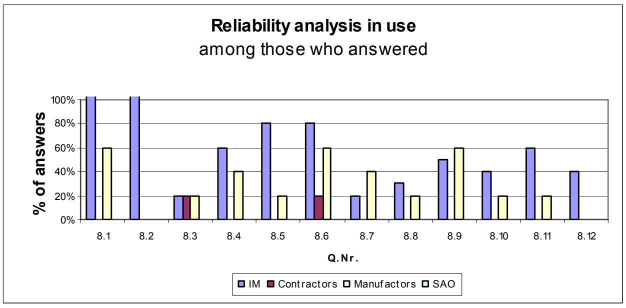
ANNEX 6B





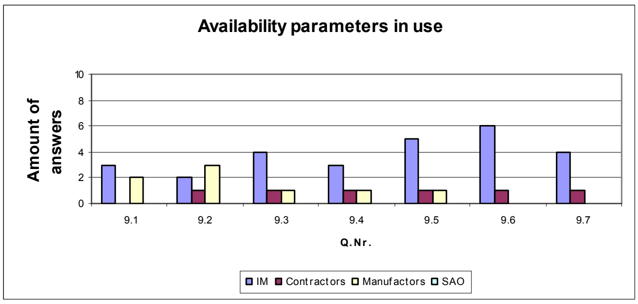
ANNEX 6C

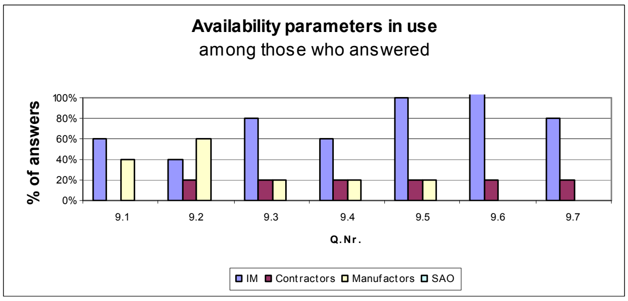




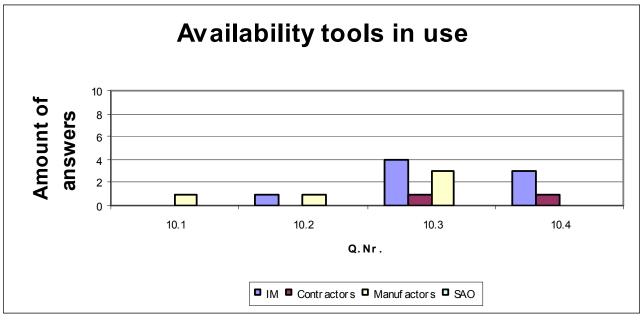
6.7 ANNEX 7: AVAILABILITY

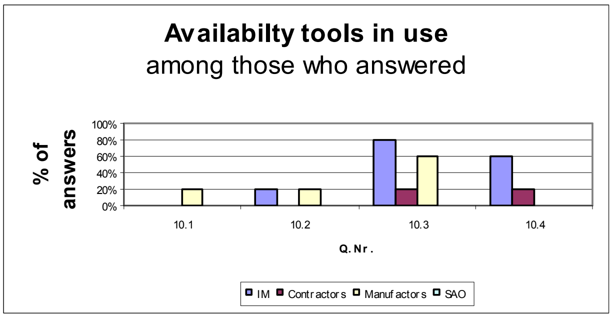
ANNEX 7A



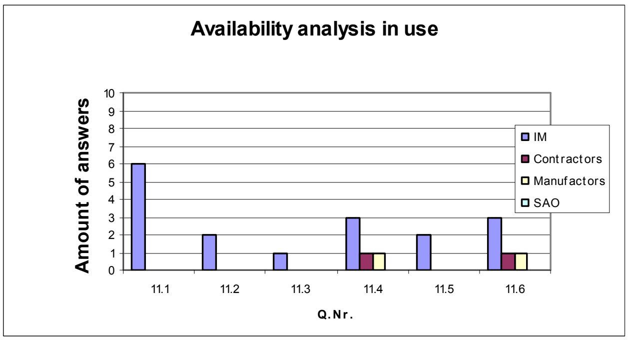


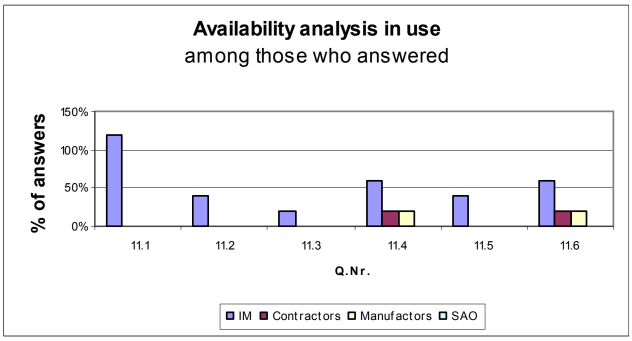
ANNEX 7B





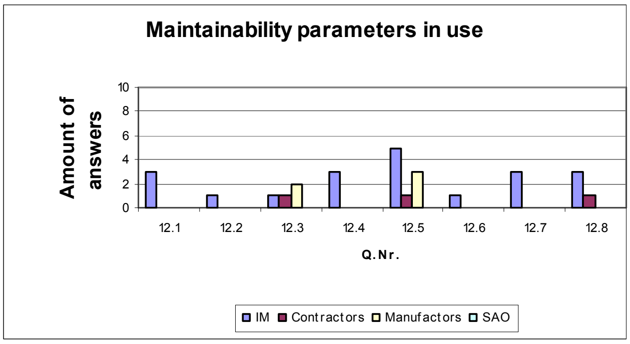
ANNEX 7C

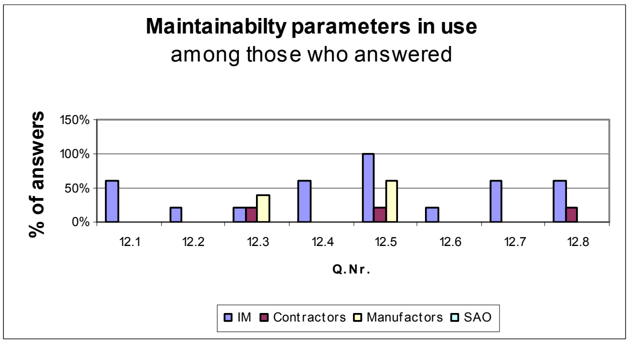




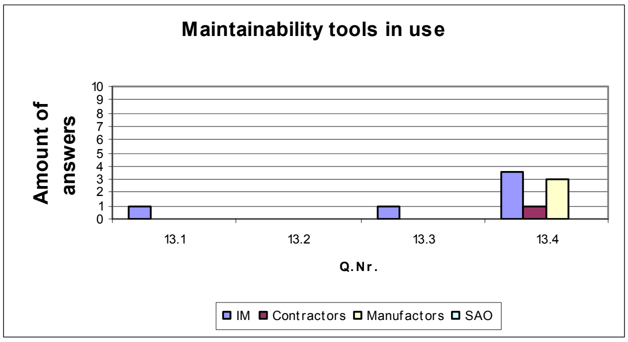
6.8 ANNEX 8: MAINTAINABILITY

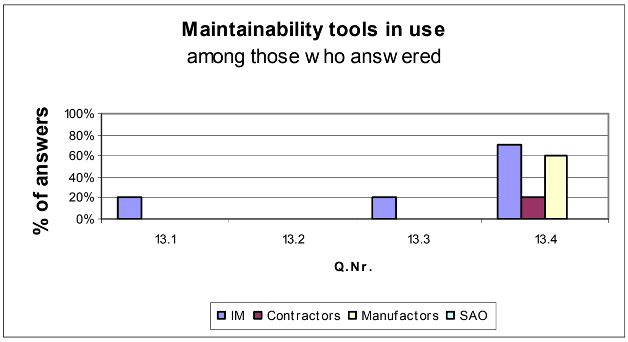
ANNEX 8A



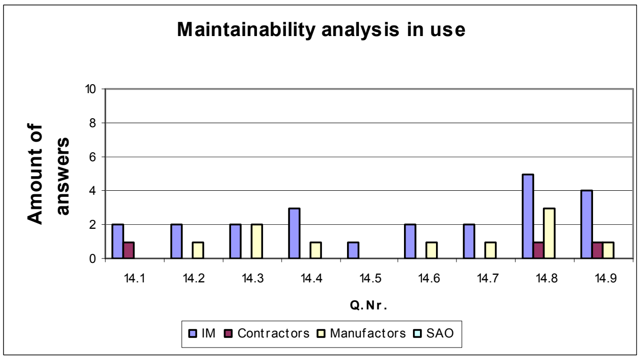


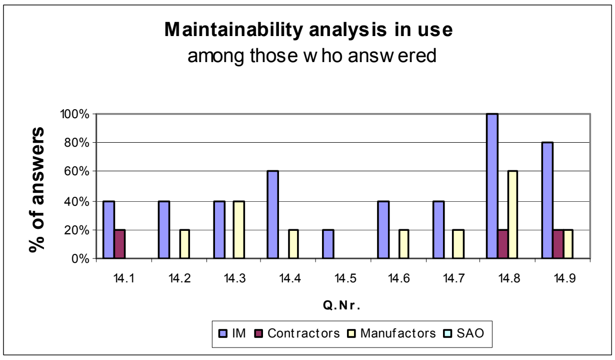
ANNEX 8B





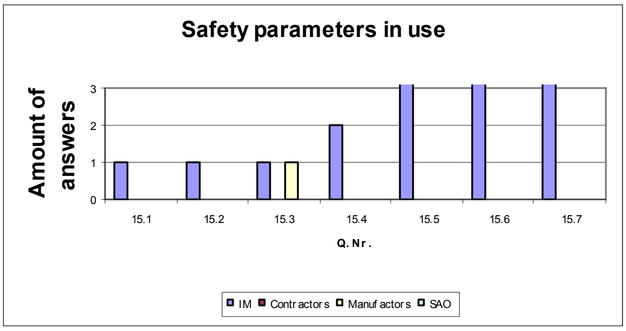
ANNEX 8C

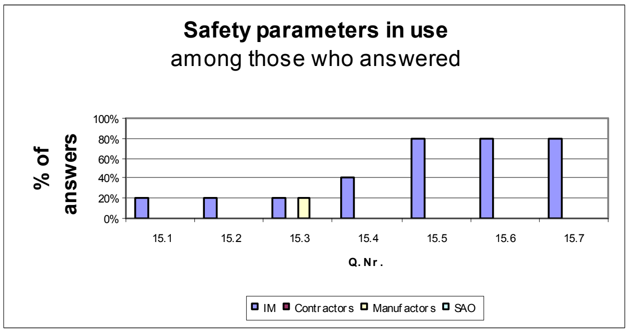




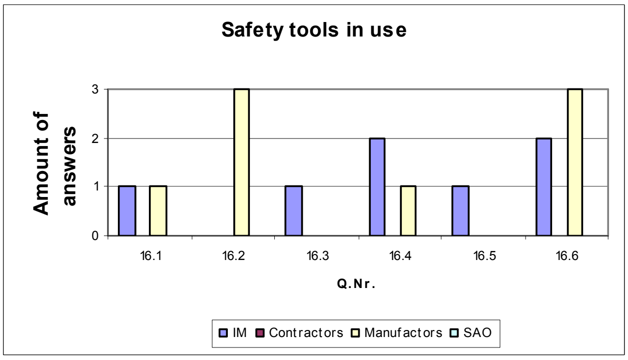
6.9 ANNEX 9: SAFETY

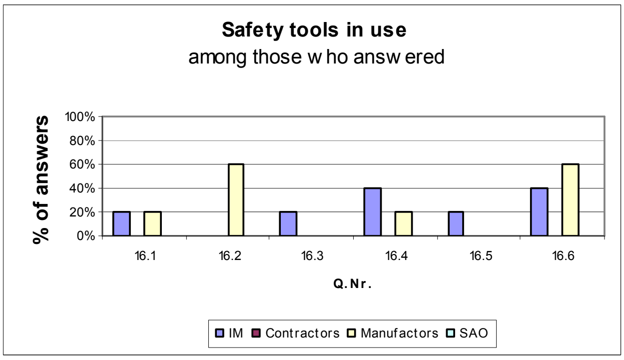
ANNEX 9A



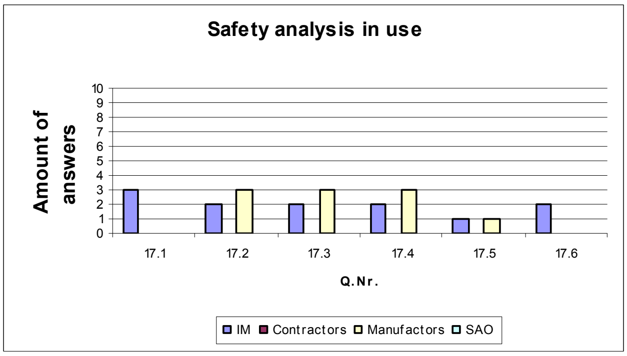


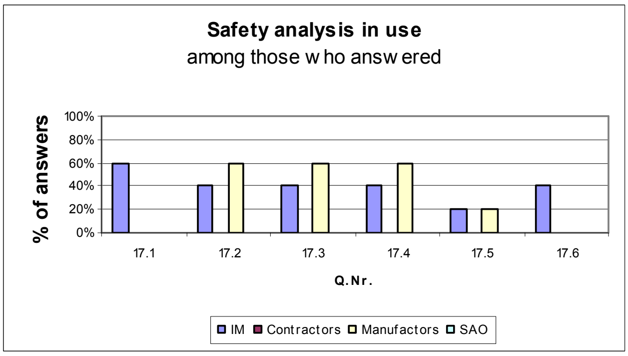
ANNEX 9B





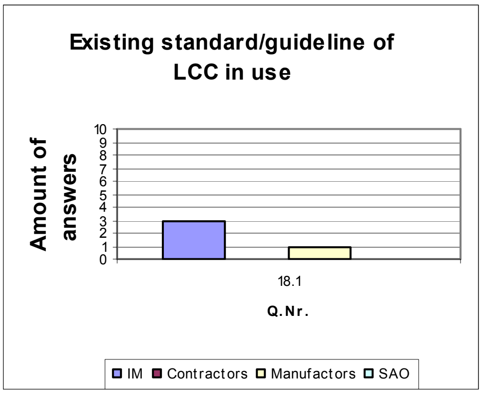
ANNEX 9C

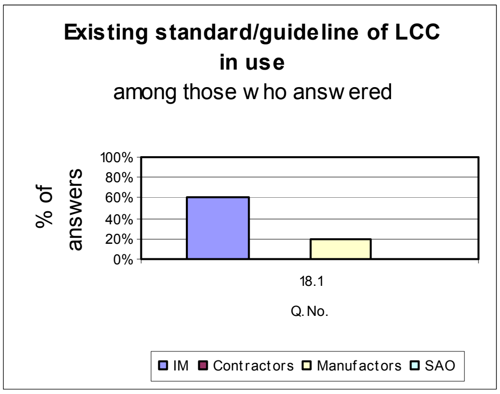




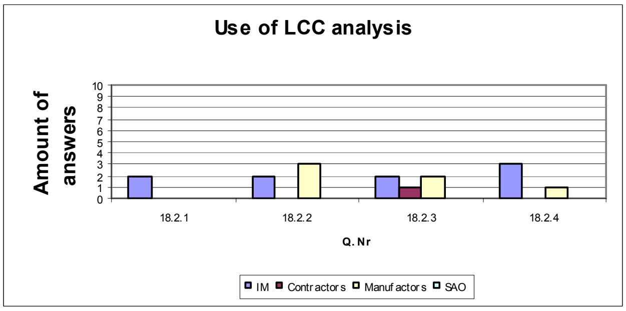
6.10 ANNEX 10: GENERAL QUESTIONS ON LCC

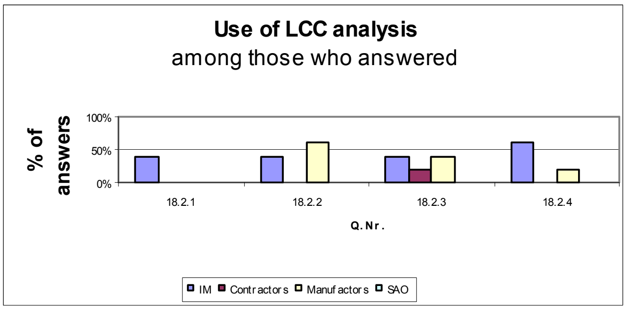
ANNEX 10A



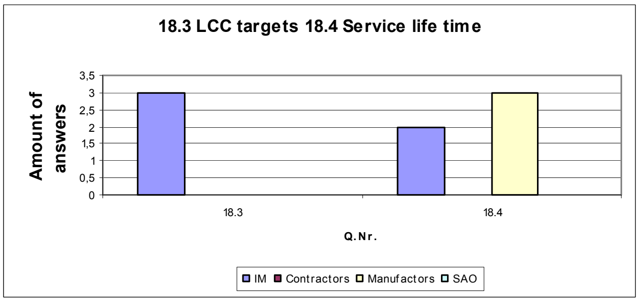


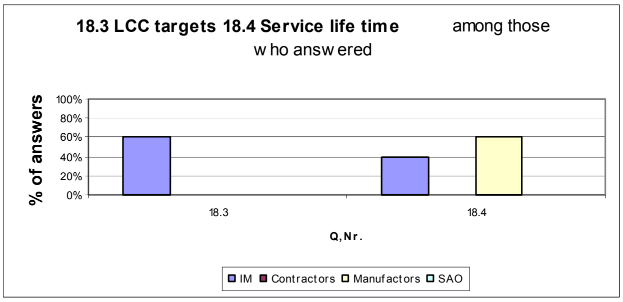
ANNEX 10B



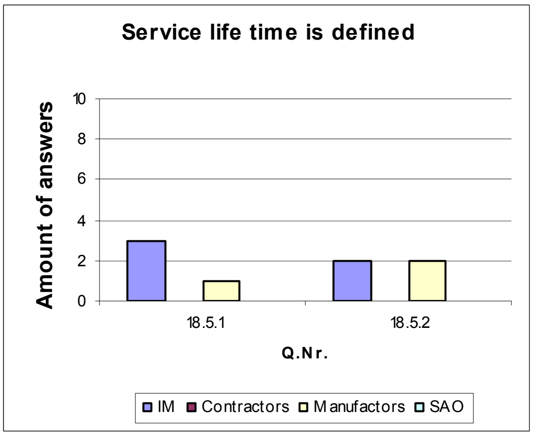


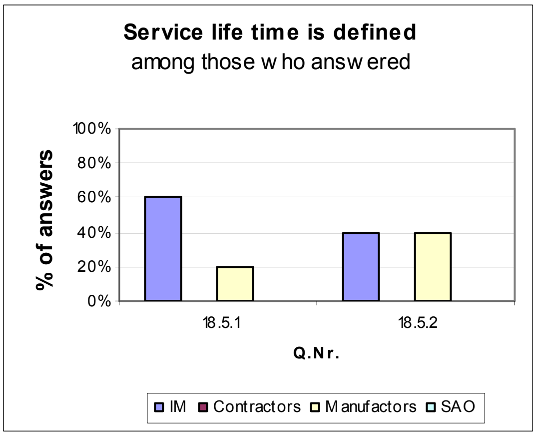
ANNEX 10C





ANNEX 10D





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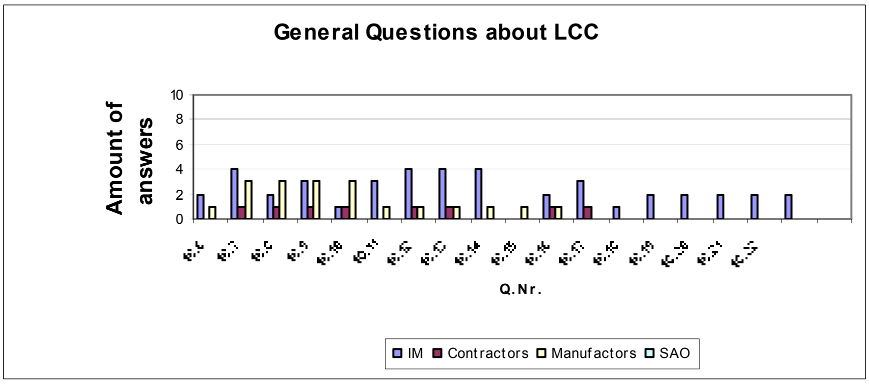

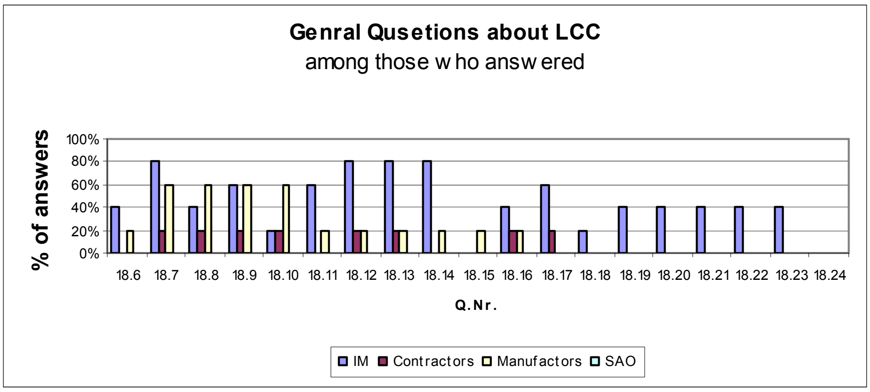

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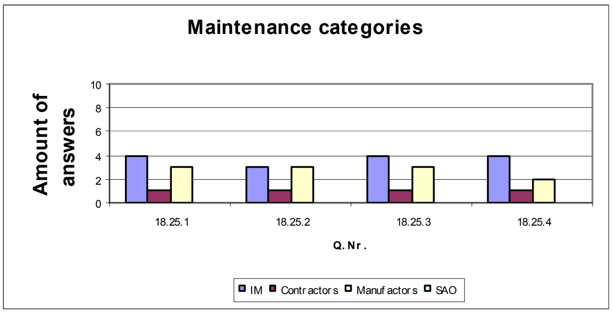
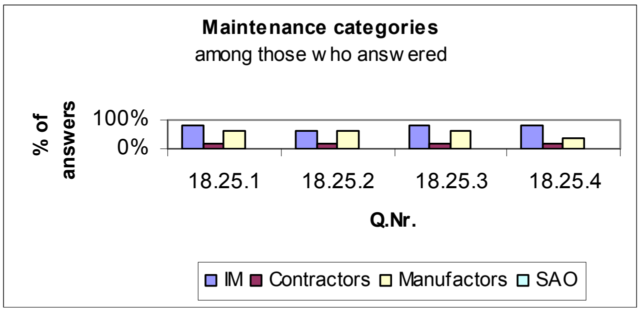
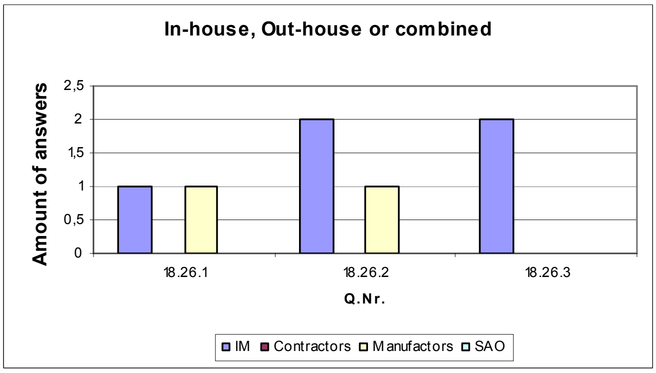
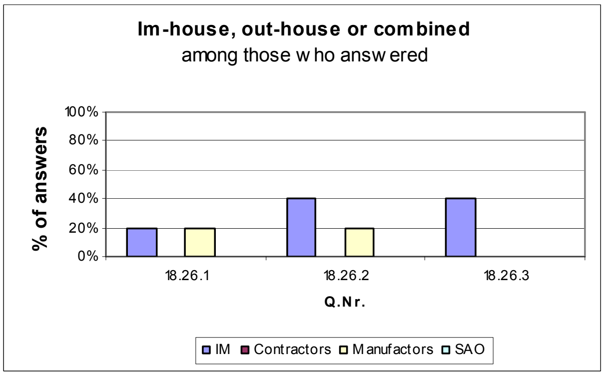


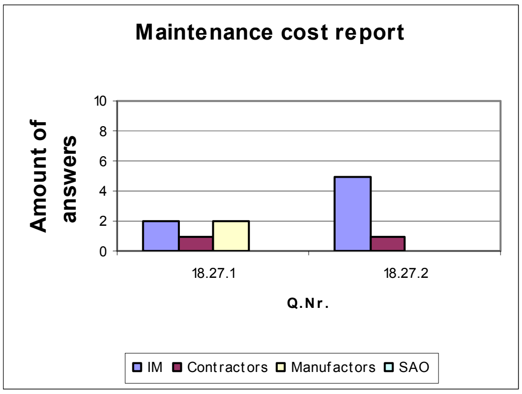


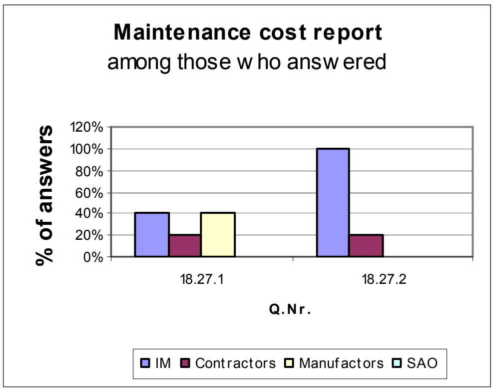
ANNEX 10G



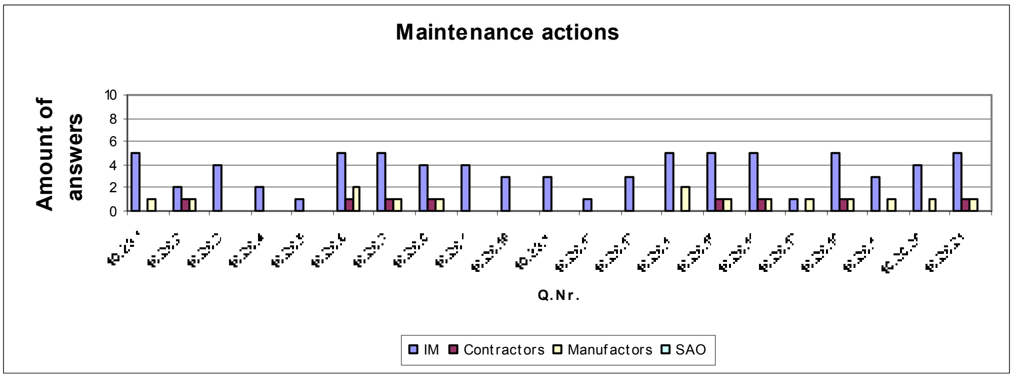


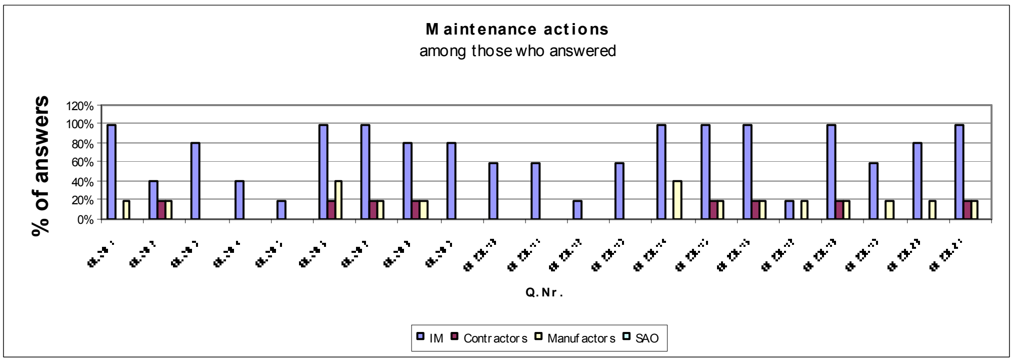
ANNEX 10H





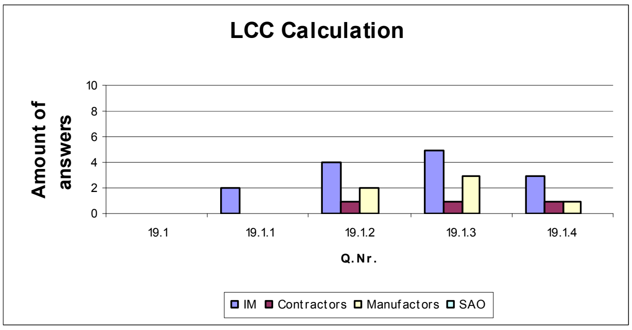
ANNEX 10I

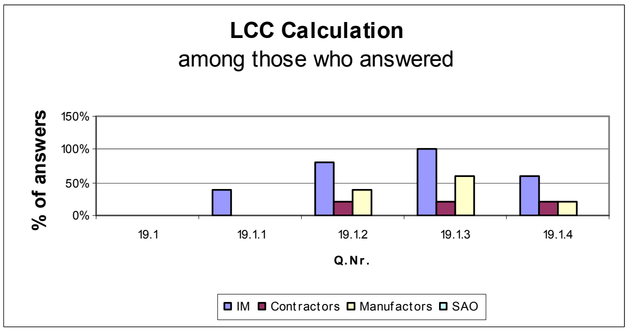

Maintenance actions
Amount of answers
10
8
6
4
2
0
Q.Nr.
IM
Contractors
Manufactors
SAO


Maintenance actions
among those who answered
% of answers
120%
100%
80%
60%
40%
20%
0%
Q.Nr.
IM
Contractors
Manufactors
SAO

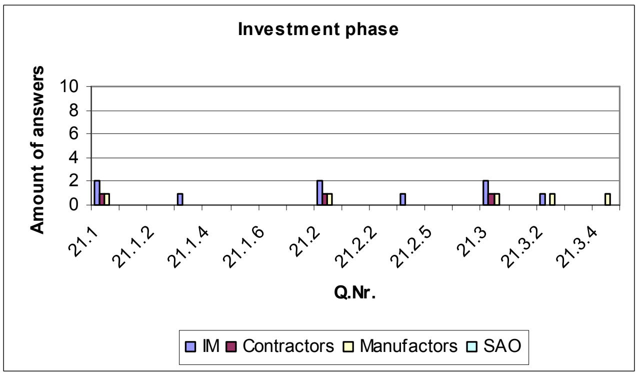
6.11 ANNEX 11: LCC CALCULATION

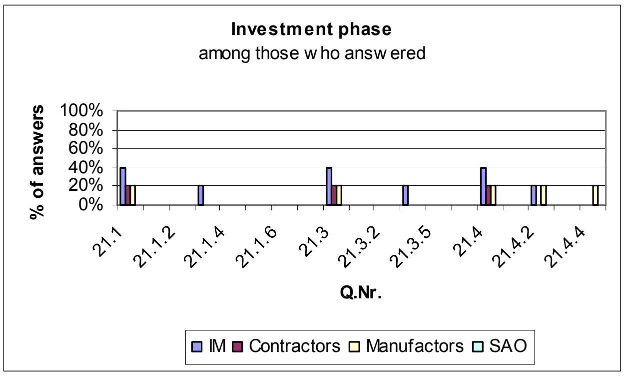
ANNEX 11A



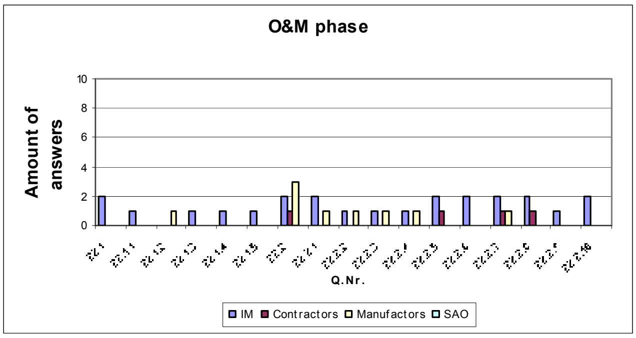


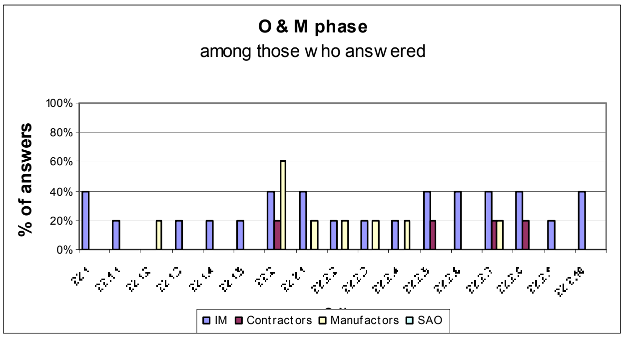
ANNEX 11B



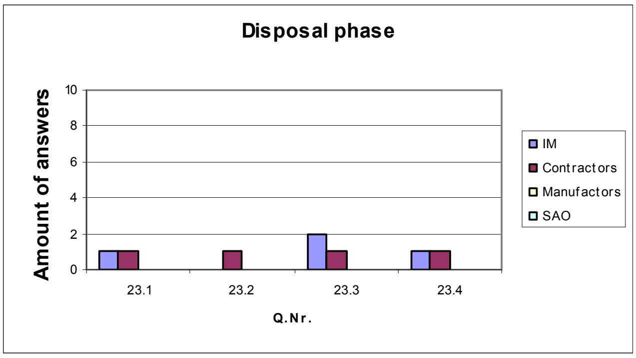


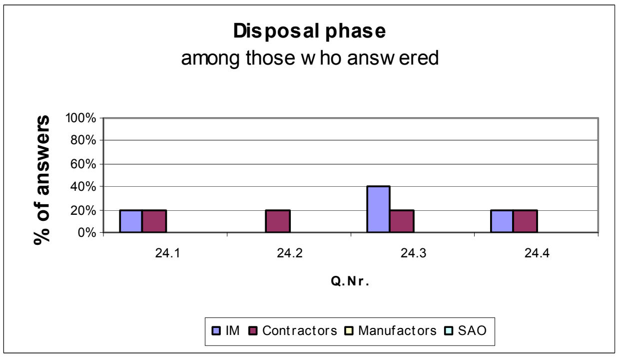
ANNEX 11C





ANNEX 11D





6.12 ANNEX 12: RAMS STANDARDS CLASSIFICATION

Reliability	**Availability**	**Maintainability**	**Safety**
EN 50126 IEC 61160 IEC 60300-3-1 IEC 60812 IEC 60863 IEC 61025 IEC 61078 IEC 61709 IEC 60605 IEC 61014 IEC 61123 IEC 60319 IEC 60571 MIL STD 785B MIL STD 756 MIL STD 1629 IEC 812	EN 50126 IEC 61160 IEC 60300-3-1 IEC 60863 IEC 61165 IEC 61070	EN 50126 IEC 61160 IEC 60300-3-1 IEC 60706 IEC 60863 MIL STD 471A MIL STD 2173	EN 50126 IEC 61160 IEC 60300-3-1 IEC 61025 IEC 61508 MIL STD 1629 IEC 812

6.13 ANNEX 13: PARTICIPANTS TO WHOM QUESTIONNAIRES WERE SENT

Infrastructure Managers

Organisation	Activity
ADIF	Constructing and Managing Infrastructure
BV	Infrastructure manager in Sweden
Ceske drahy, a.s.	Transport service – freight and passenger , railway infrastructure operation and maintenance for SZDC (Railway Infrastructure Administration)
DB Netz AG	The Track Infrastructure Business Unit (DB Netz AG) is responsible for operating and marketing the track infrastructure. Acting under its own responsibility, the Business Unit provides non-discriminatory access to the rail infrastructure. It also prepares and coordinates the timetables in consultation with its customers.
Network Rail	Operator of Britain's rail infrastructure with a mission to maintain, improve and upgrade the railway infrastructure
OBB Infrastruktur Bau AG	Constructing and Managing Infrastructure in Austria
PRORAIL	Prorail has been licensed by the Dutch government to: provide sufficient, reliable and safe railway infrastructure in the Netherlands, including the building, renewal and maintenance of railway track and stations; Supply the train operating companies with train paths, transfer capacity and (travel) information services; Ensure a fair and optimum distribution of available track capacity.
RFF	Operator and manager of the French rail infrastructure
SNCF	Transport service – freight and passenger, railway. Delegate infrastructure operation and maintenance for RFF (Réseau Ferré de France)

Contractors

Organisation	Activity
BBRP	Design, project management and construction of complex railway projects
Carillion	European contractor for railway projects and maintenance, with a broad range of capabilities.
EFRTC	Group of Interest of the Track Work Contractors
Speno International SA	Development, construction and exploitation of rail grinding equipment (including measuring systems)

Manufacturers

Organisation	Activity
ALSTOM Transport SA	Train manufacturer; Design, manufacturing, testing and commissioning, and maintenance of transport systems
Corus	A major international steel company and a leading supplier of rails, steel sleepers, design and technical consultancy, and innovative solutions
Goldschmidt Thermit GmbH	Development, Production and Sales of Consumables for the Aluminothermic Welding Technology as well as the execution of Aluminothermit Welds, enclosed arc welds, flash butt welds and grinding operations in all kinds of rail tracks worldwide
UNIFE	Group of Interest of the Railway Industry, where track infrastructure supply and track works
VAE	Railway industry (supplier of switch systems and devices)
VAS	A global leader in the development, production and supply of rails, including advanced technologies, logistics, system solutions and innovative track related services
VCSA	World leaders in the switch gear field for all types of networks, railways, metros, tramways, both in Europe and throughout the world

SAO (SME, Academia and Organisations)

Organisation	Activity
Laboratoire Central des Ponts et Chaussees (LCPC)	Research and development in the field of geotechnics, environment, civil and urban engineering, road safety
ConTraffic	Technology benchmarking for switch point systems. Benchmarking for rail signalling components of European manufactures
Damill AB	Damill perform field measurements of track forces with our prototype to a wayside monitoring system. The measurements are performed mainly in the Swedish rail network and the purpose is to identify and group different vehicles according to their track behaviour. Gathered data is then to be analysed where we want to develop some automated techniques to separate the different force directions. We also want to identify and define the key parameters for a reliable and objective vehicle classification including effects related to the vehicles maintenance condition
G - Impuls	It is a private company established in 1994. It provides all geophysical services in the fields of magnetic survey, geo-electric methods.

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