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INNOTRACK

Integrated Project (IP)

Thematic Priority 6: Sustainable Development, Global Change and Ecosystems

D6.3.3 Necessary developments of RAMS technologies

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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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1. Executive Summary

By the work carried out on RAMS analysis so far within INNOTRACK several facts become apparent and should be appreciated as a background for this study.

Firstly, the use of RAMS analysis in the railway infrastructure is limited and where it occurs it is in an early stage, especially in the track and civil engineering sector This is in contrast e.g. to the signalling sector where the use of RAMS is more used. The reason is the complexity of the railway system and the tradition of the track and civil engineering system. The complexity stems from several sources. One is the interaction of several railway areas (track, s&c, catenary and signalling, etc.). A second complication is the vast need of data for RAMS analysis. This data is often hard to define and scattered between different databases and organisations. In other words, there are a lot of measured data in the track sector, but these are seldom easy to obtain and often difficult to compare between railways since they are defined/measured in different manners.

In contrast to parts of the infrastructure like the signalling equipment, where the RAM-parameters are defined in relation to the operation time, the technical performance of the track has to refer at least to the load of the track. For a complete analysis other boundary conditions like distribution of speed or vehicle types are necessary. But these important conditions that may change over the years are rarely monitored and therefore not available in detail.

. Additionally the geographical distribution of assets and the various influences of the environment increase the complexity. A final, and very important factor, is the current high proportion of human intervention in track operations (e.g. in maintenance operations). This results in a large and currently largely unquantifiable scatter in RAMS input parameters.

Secondly, where RAMS is beginning to be adopted it shows promising results. By an operational RAMS assessment the problems described above become visible and can be addressed. Furthermore there is a strong link between RAMS and LCC analysis and many of the obstacles faced are similar.

Due to the reasons above it was realised that more basic development is necessary before RAMS analysis can become fully functional in the railway community.

Consequently, it was decided to focus on the identification of necessary developments in the current deliverable. The objective is to highlight, by examples, how RAMS analysis is currently adopted by the participating IMs ÖBB, ADIF, DB, BV and NR. Furthermore complications and challenges are communicated and needs for future developments are identified.

Some conclusions of the current study are:

- Railway organisations currently use RAMS technologies as a tool for the decision in specific cases. For the complete railway system it is currently not possible to combine the different requirements of the various product fields in a general RAMS analysis.
- It is necessary to find common definitions of RAMS-related terms in the railway sector. As an example we can pose some questions regarding the term “availability”, e.g.:
    - is it function of the capacity of utilisation of the line;
    - what data can we collect in order to describe this;
    - do we need a common definition for train delays?

  Definitions currently employed differ between the infrastructure managers.
- The problem of different definitions is further enhanced by the different maintenance strategies of the European railway organisations.
- New products pose a problem in that key data for RAMS analysis are normally not available.
- Areas identified as priorities for future developments are:
  1. More extensive data collection and analysis
  2. More extensive databases

3. Better definitions of failures and general RAMS terminology
4. Improvements in verification of data employed for reliability analyses
5. More data collection through load detectors and intelligent infrastructure
6. Use of reliability data in planning of predictive maintenance

Due to above reasons the work in INNOTRACK with RAMS is not fully what was planned in the DoW. The work is more an important step forward in using RAMS for track and civil engineering purposes. The work in WP6.3 is therefore probably more important than expected.

2. Necessary developments of the European railway partners

In this chapter the necessary developments from the European railway partners of WP6 from INNOTRACK are shown:

2.1 Input from ÖBB

2.1.1 Introduction

ÖBB is currently structured as shown in the diagram below.

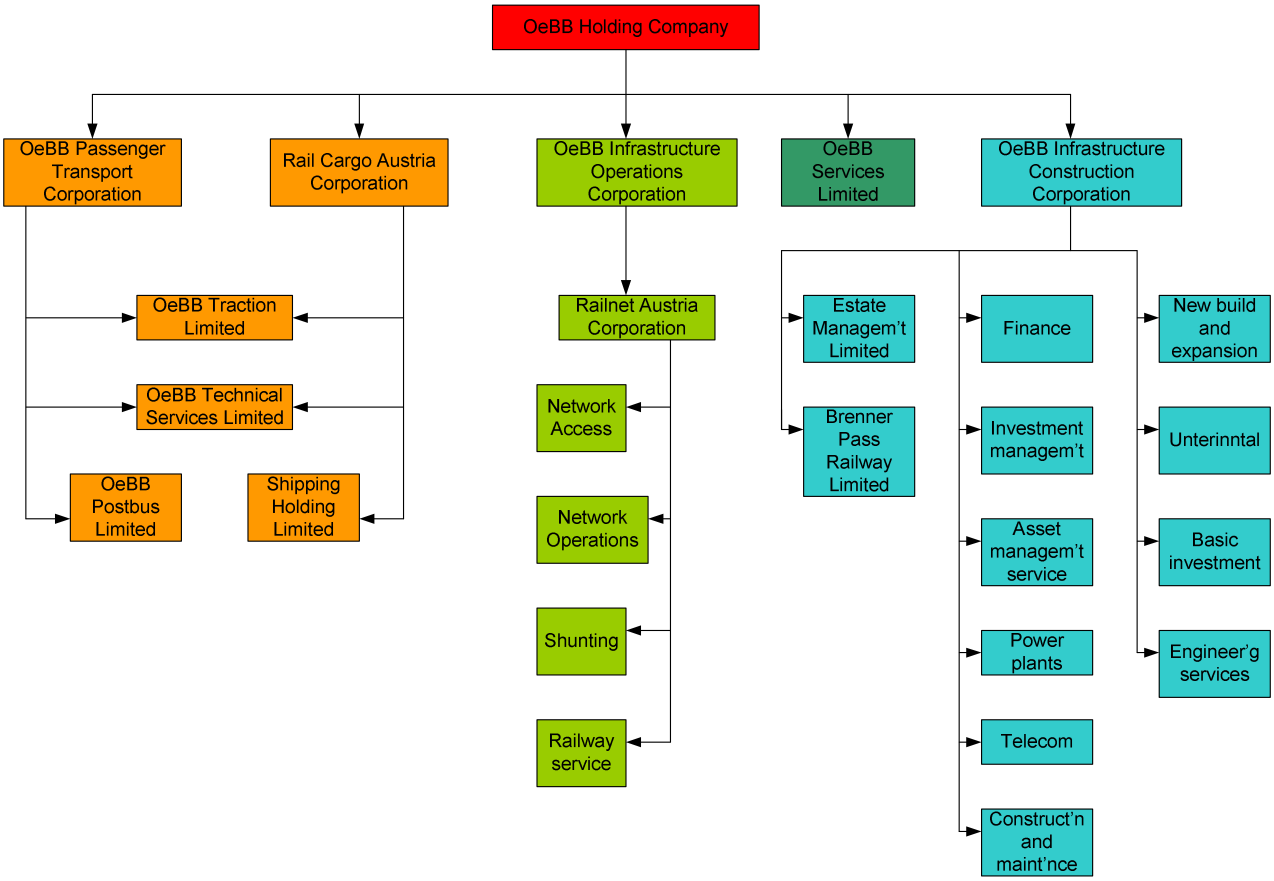

Figure 1: Company structure of ÖBB

ÖBB-Infrastruktur Bau AG (ÖBB Infrastructure Construction Corporation) is responsible for planning, construction,funding and asset management of the Austrian railway infrastructure. All essential assets of the ÖBB Group – power plants, rail infrastructure including related installations and facilities, all buildings, telecom installations and the overall real estate assets – have been brought together in this corporation.

ÖBB-Infrastruktur Betrieb AG (ÖBB Infrastructure Operations Corporation) is responsible for RailNet Austria, which was established on 17 May 2004 to create the conditions necessary for modern and efficient passenger and freight services. RailNet Austria provides customized services for rail transports and responds to the requirements of the transport market. Services include:

- Allocation of train paths

- Authorizations
- Assistance in obtaining the necessary licenses
- Assistance prior to, during and after a train movement
- Optimum support to customers in traffic planning and in obtaining information on the conditions of access to the infrastructure of other Infrastructure Managers
- Management of trains on the rail network
- Shunting of rail vehicles
- Inspection, maintenance, fault clearance, repairs on and around the railway network
- Demand-driven construction of new and conversion of existing infrastructure facilities to meet future customer requirements

ÖBB Infrastructure Operations Corporation is responsible for deciding on the maintenance work required, but contract out the bigger items of work to ÖBB Infrastructure Construction Corporation

The general issue in maintenance is to improve the present facilities and the engineering respectively and in second instance to answer the question “Which new installations can be applied and at which time?” The decision is mostly based on evaluated LCC (see D 6.2.1) with integrated algorithm for operating complication costs (discussed below) which represents RAMS.

2.1.2 Examples of Developments:

In the following the necessary developments for RAMS at ÖBB are shown. ÖBB is currently using a RAMS assessment system. The following points include information about ongoing and necessary developments of this system.

Development in assessment of breakdown

Reliability and Maintenance: The current system LEIDIS is a planning system for signalling that records all breakdowns, which are reported from workforce. The main problem is that currently the mapping to the facilities is missing.

All adjustments of breakdowns are booked on one track account. Information regarding which facility that is maintained is not stored. For example there are two different switches with the same radii (same geometrical dimensions) but with two different locking and driving systems in use. The system can not distinguish between these. There should also be the possibility to describe the necessary time of the workforce and material needed for adjustments related to maintenance. This information is at the moment only available in the books of the line inspector. It is thus only possible to make a comparison between the switches in the observation area of the line inspector and not over the whole rail network.

A necessary objective is to create/install a database based IT-system for planning and calculating e.g. SAP with mapping to the facilities.

Development in terms and definition within the company and structure

Availability: At ÖBB the availability is considered in costs of operating complications in the calculation of LCC. Train delays are calculated with an in-house simulation software; additional workforce, penalties and consequence delays can also be calculated.

To define the availability of the railway is the main complication with respect to currently known methods from mechanical and electrical engineering for calculating availability. An overview of this complex topic is the focus for the ÖBB funded survey “Strategy LCC – operational difficulty costs” as described in in chapter 3.1.3 and in reference [1].

Common mathematical functions are needed to describe characteristic numbers for R A M S for all technical areas. There is a discussion about which functions to use for describing the characteristic values for availability. The availability of a line from A to B should be a function of the utilised capacity of the line. There are different maintenance strategies for utilisation levels of 10% and 90% of the maximum capacity.

Transparency of data and access to the data for all members of the company's inter-disciplinary RAMS working group is needed. Since 2004 there is a new company structure for ÖBB (see introduction) and all processes are not fully developed within the two current companies.

Development in monitoring of load

At the moment ÖBB do not record the exact load of the rolling stock in the whole rail network. Some measurement sites (type ARGOS® - see D 6.3.2 and http://www.argos-systems.eu) are operational as prototypes. These are currently successfully tested. ÖBB will start the rollout of countrywide installation of these sites so that a mapping from loading to each facility is possible in the entire rail network.

References for positive use of RAMS assessment

Report of under sleeper pads and frame-sleepers (available on the KMS) – 7 years survey

Report of asymmetric rail profile for straight line (in work until the end of 2008) – 10 years survey

2.1.3 Operating complication costs ÖBB

Operational disability or breakdowns in different sites of the railway system can cause additional costs, increasing costs and causing cutbacks as compared to a fully functional system. It is a matter of real costs and cutbacks of return, respectively. However, the incurred costs , are not always caused at the place were the breakdown is and at the time when the breakdown occurred. Often the root causes of costs are to be found at other times and in another organisation.

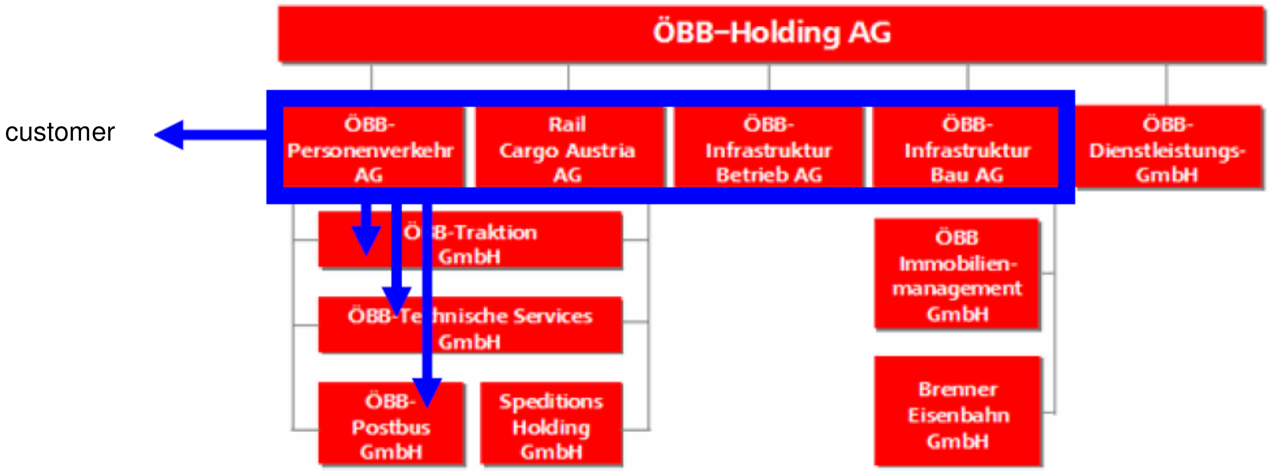

Figure 2: Organisation of ÖBB

As a simple example it can be noted that operating complications can be caused by:

- ÖBB Railnet Austria in the frame of treatment of maintenance and renewal or in administration of railway operations
- railway undertakings by means of own caused delays, own caused line interruption, etc.
- external railway operators
- …

Some simulation tools allow the collection of operational events when disturbances occur. This increases the awareness of complication costs.

2.2 Input from ADIF

2.2.1 Introduction – process of implementation of RAMS in the track subsystem in ADIF.

The main objective of Railway Infrastructure Managers is to improve the overall railway system performance reducing costs (LCC).
Railway system is composed of subsystems and components. At the same time, among the RAMS concepts, safety and availability are inter-linked, and are both depending of the other two factors (reliability and maintainability) and those of operations and maintenance (EN 50126:1999).
On the other hand, the necessary holistic approach of the railway system needs to consider RAMS with the budget optimisation; this means that RAMS and LCC should form a binomial totally interlinked. All this should be treated globally into the concept of "asset management".
According to this, ADIF is in the process of making the Asset Management Plan (AMP) to make this plan; a first step is to analyse the critical components, subsystems and system considering the following aspects of the infrastructure characteristics: performance evaluation (RA), risk assessment (S) and costs (M/LCC). So, it is necessary, among other parameters, to have those related to RAMS.

2.2.2 RAMS implementation for track

System

To guarantee the maintainability of railway lines, a deployment of wheel dynamic detectors is in progress, 6 detectors have been installed so far in the most important lines. The essential information on the dynamic and static vertical load of every wheel is monitored by the Control Centre staff, taking actions according the specific procedure if loads reach the various alarm levels considered. In this way, ADIF controls an important aspect of the quality of the rolling stock (RS), the one that most affects to the track geometry.
Once the behaviour of the RS is controlled and it can be assured that it is not making extra damage, ADIF have to assess the performance, risks and condition of the track subsystem and its components subject to standard loads.

Subsystem

The track subsystem (including, indirectly, ballast condition) is mostly inspected by the track-measuring car. A software code has been developed to optimise maintenance activities through a prioritisation process according to the level of defects and their criticality. Speed restrictions due to track condition or engineering works are controlled to reduce the effects on trains and on line availability.

Components

Rail conditions are assessed also by the measuring car (superficially: wear and running surface), and internally by an ultrasonic car. In case of rail breaks, they are registered in the data base after being analysed and known the causes of the break in order to take the proper actions if they are considered convenient.
Sleepers, fastening and drainage condition is assessed through periodic on foot runs by inspectors, and recently with the use of an image processing method and video recordings.
Special attention is dedicated to switches and crossings, because they are the part of the track more prone to failures affecting traffic, both from the mechanical and electric/electronic parts.
The above mentioned aspects were done after a simple FMECA analysis of track components.
A data base has been developed to register every failure, incident or accident (safety), controlling not only the number of them but their effects on traffic disturbance (number and types of trains affected, minutes delays, track availability, etc).

Maintainability

An indirect way to assess this parameter is through the maintenance costs, in absolute terms and in relative ones (comparing the analysed section with similar sections). The evolutions of the total costs also with its components (human factor costs, materials, etc) are split into the preventive maintenance and the corrective one for more detailed analysis.

So, it can be said that ADIF is progressing in the use of the RAMS concepts and their application to track subsystem. ADIF apply this to both maintenance and modernisation policies and processes (renewal decision or prioritisation of activities).

An example of the use of the RAMS available data for further analysis is how ADIF use them to make the track part of the Asset Management Plan. ADIF has set up a new global indicator called Track Potential Maintenance Demand (valid for maintenance policies and for the renewal decision process), to get this indicator ADIF has developed a software that takes into account: track condition and its evolution (through the track recordings during some years), number of rail breaks, present traffic, lay out of the section (tight radius, gradient etc), costs (absolute and relative), residual life etc., that is, a combination of indicators mostly related to RAMS.

The next steps are to enlarge the data base and to make a more in depth statistical analysis of the data in the four basic concepts (R, A, M and S) that can give hints to improve the overall track performance reducing costs (LCC) which is the main objective of Railway Infrastructure Managers, as it was said before.

2.3 Input from DB

2.3.1 Introduction of RAM(S) process in DB

RAM(S) is very important for comparing systems performance (especially reliability) and set up safety requirements. Based on a contract, the values and assessment method have to be defined.

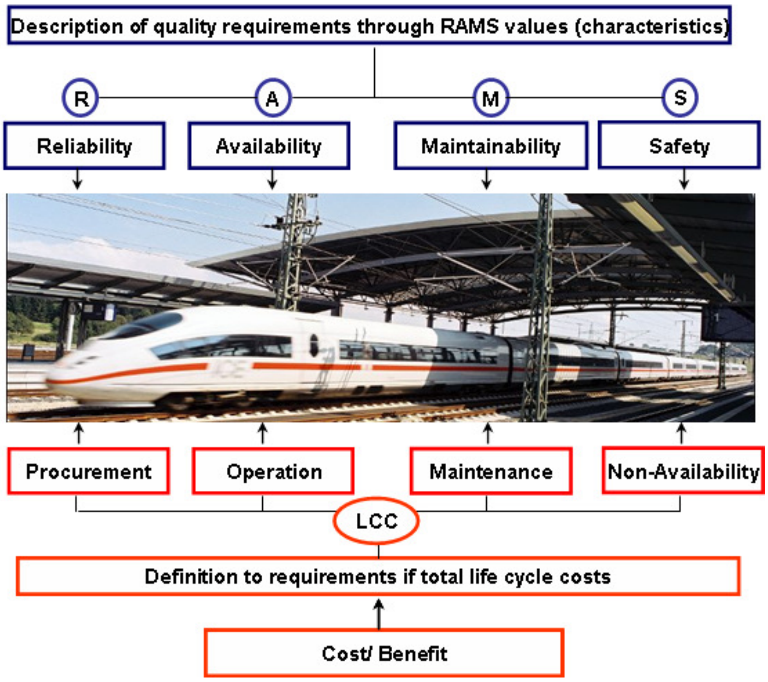

Figure 3: RAMS and LCC

Source: DB Project

RAM(S) analysis is one possibility to obtain necessary LCC input data (Fig. 3); the other is to get the data as result of expert estimation (meeting, workshop), measurements, simulation and workshops combined with the procurement volume.

Due to the age of the database, that contain the technical parameters and maintenance activities in relation to the total life span of the track, a combination is useful or in most cases the only possibility to achieve reasonable data and results.

2.3.2 Safety

Safety is a very important task for the railway industry. In this study it is separated from the other tasks, because of one reason: A new system mustn't be worse than the existing system. Also as part of a contract verification often has to be done. Figure 4 shows (example for a slab track) the process for a RAMS analysis – with the main task to proof the safety – and the results of each step. The procedure assures that all possible hazards are critically examined, and the first priority will be preventing their occurrence.

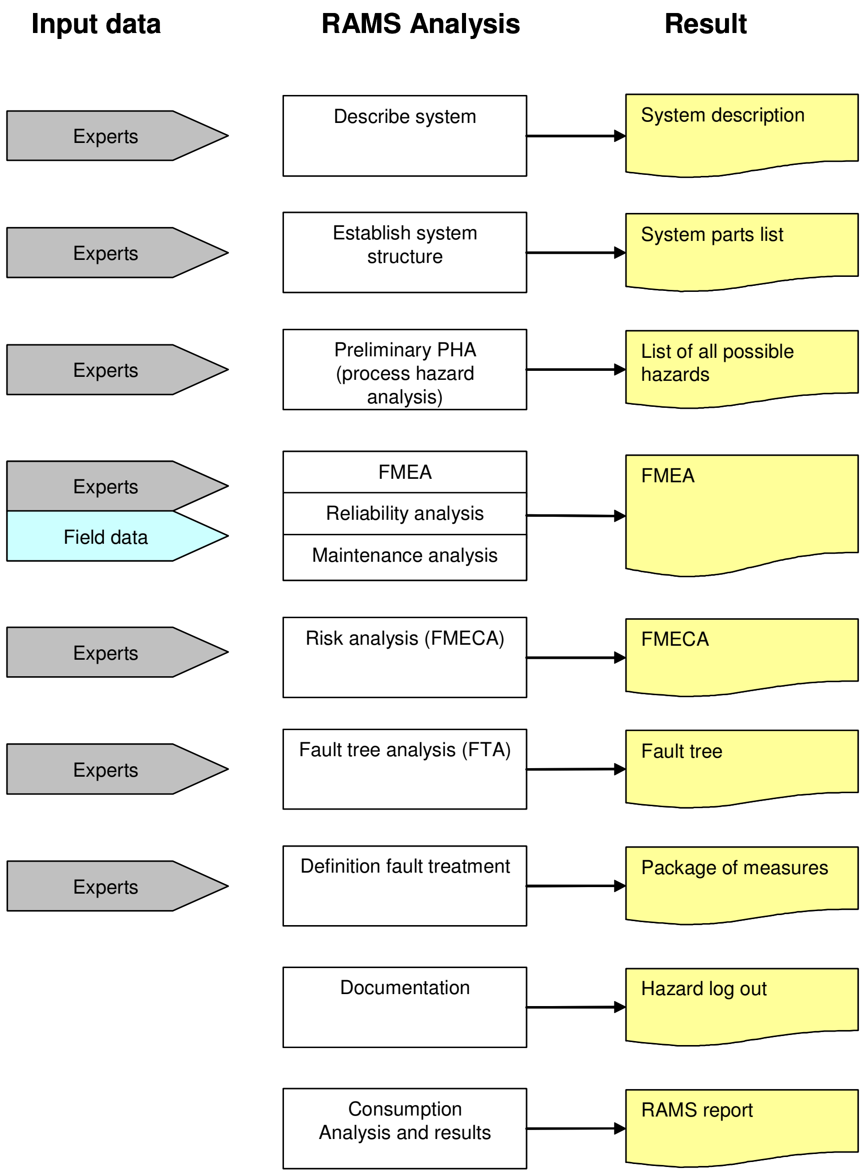

Figure 4 - RAMS Analysis – schematic diagram process system provider

Source: ZEVRail, 01/04[1]

[1] Stephan Freudenstein et al.:RAMS-Analyse der Festen Fahrbahn aus der Sicht des Systemanbieters

For demonstration and also as the result of an Innotrack decision, the following procedure is based on a specific chosen high speed line, and restricted to the track (in the current study with Switches & Crossings excluded). At DB most analyses based on the database SAP R/3 Net. The objective of this procedure is to appraise and to apply the database of the specific chosen high speed line based on DB's internal system SAP R/3 Net and furthermore to investigate whether the available SAP data of the chosen track are suitable for a RAMS analysis and eventual decision regarding selection of components, maintenance and investment of infrastructure based on LCC. The database containing the representative panels[2] for track (and S&C) serve as input parameter for the LCC analysis and the identification of cost drivers.

The procedure of the LCC/RAMS methodology using the track as an example contains:

- Validation of the data base:
  - the database contains information concerning master data (technical structure of the system as type of rail, sleeper, etc.)
  - information deposited in the database is checked and complemented with additional relevant input data for technical and economical purposes corresponding to the relevant panel (e. g. track condition, substructure, etc.).
- Evaluation of data base information:
  - determination of the quantity structure corresponding to the maintenance measures
  - identification of cost drivers and causes related to the maintenance measures
- Analysis of reliability as input for the LCC analysis
- Definition of important values and methods for monitoring (and also as part of the contract)

The present data of the analysed track is the basis for reliability analysis. The information deposited in the database has to be checked in the first step and filled with additional relevant input data, which are not part of the master records e. g. the date of the recording, length of the track in km etc.

Parameters for Reliability are:

(1) Reliability function: the probability that a component or a system will work for a given amount of time without any failure. In other words it indicates the percentage of a subject matter (component) that is still intact.

(2) Density function: frequency of failures at a certain time, i.e. it indicates the information when a component will fail. It shows the field with the most failures (density of the failures)

(3) Distribution function: it indicates that x % of the subject matter (component) are failed at a certain time, thus it is consistent with the level of the failure rate at a certain time.

(4) Failure rate: this is a degree for the probability that at X time a still intact component will fail in a following period of time. Failure rate is the frequency with which an engineered system or component fails, used with different units, for example in failures per hour. In practice, the reciprocal rate Mean Time Before Failure is more commonly expressed and used for high quality components or systems.

(5) Quantile: indicates the time at which X % of the components failed, that is to say the failure rate at a certain time.

Weibull's distribution is one of the most commonly used distributions in reliability engineering. This distribution is widely used due to its versatility and to the fact that the Weibull probability density function can assume different shapes based on the values of the parameters. Service life times particularly of mechanical components which in general are markedly subjected to deterioration/corrosion shouldn't be described by the exponential function but by Weibull's distribution.

[2] Representative panels means the selection of technical places (in the SAP R/3 structure)

In DB's experience application of LCC analysis is possible with the available SAP data. Furthermore the data of the chosen track are suitable to make RAMS analysis for each single component. Due to the fact that the available database contains relevant information from a short period of almost four years, resilient statements could be derived from the RAMS analysis in that extent that is possible with the software MathOffice©.

The current state of the database contains relevant information for a period of almost four years, which is to say from 1st of January 2004 till 31st of September 2008. Thus the analysis could be accomplished just for this period. In general all component related information needed for RAMS analysis is available, like the deterioration rates of components, the influence of maintenance on life time and failure rates etc. The more data you have the better it is for RAMS analysis and the longer the period is, the database based on, the more resilient are the statements. So, in this respect, the period of the available database for the upcoming RAMS analysis is relatively too short to provide resilient statements in terms of improvements of techniques and maintenance strategies. This is backed up by calculations of confidence levels of the parameters determined using the database. However this procedure should verify the available SAP data by application of LCC/RAMS methodology and investigate whether the data of the chosen track are suitable to make RAMS analysis.

As mentioned in the summary one difficulty is to get the history of operational conditions like (dynamic) track loading, speed distribution or distribution of vehicles. These conditions are important to derive valid RAM-parameter. For the load estimation DB uses the database IBL that contains the number of trains per week, separated by four different types and the estimated total load of the track per week. This information is available for the whole network for at least the last 10 years.

The problem is that the load of the track will be estimated from the planned trains. This means if a train is unloaded or not running as planned the estimation of the load may fail. Additionally the dynamic part of the load, which may have a big influence on deterioration of components, is not known.

AT DB nearly 30 track based measurement devices are distributed over the net. At the moment these devices are used to monitor the state of the vehicles and to identify necessary vehicle maintenance. In future it will be possible to use the results for gathering loading collectives, which contain also dynamic load.

The improvements of the IT systems at DB are addressing the consolidation of technical parameter, loading, maintenance activities, track degradation and track failures. Together with new or sophisticated analysis methods like clustering, fuzzy logic or neuronal networks this approach will provide valid RAM-parameter.

2.4 Input to RAMS/LCC analysis from BV

The use of LCC and RAMS within Banverket is in the starting phase. There is a need to enhance the knowledge about RAMS and LCC and how it can be used in order to decrease the life cycle cost and in the same time increase the performance for the railway infrastructure.

2.4.1 RAMS

RAMS is introduced within Banverket, by EN 50126. The use of RAMS needs to be improved and developed.

Availability

Definition in use: 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)

A definition of railway availability that has been discussed is; Obtained capacity / Planned capacity, calculated for a point in time or over a time interval.

This definition treats availability as a function of the obtained capacity and a constant planned capacity. The planned capacity might be set to the theoretical capacity, the practical capacity, or lower. One advantage of defining planned capacity as the theoretical capacity is that availability then takes on values between 0 and 1, not higher. (Nyström, 2008)

The availability depends on the combined aspects of reliability, maintainability and maintenance supportability.

Availability is measured in train delay (hours), total train delay, train delay caused by, infrastructure, train delay caused by a specified infrastructure asset and punctuality of passenger and freight train. There is also a code for what caused the train delay.

Data on train delays rests mainly on data collected by a nationally uniform automatic system, based on a division of railway lines in fixed blocks. The hereby generated train traffic data gets into the TFÖR database and hence is possible to investigate by use of the MAPS tool. (Nyström, 2008).

Definition of train delay; if the train is more than 5 minutes late. A primary delay to a train is a delay that directly affects the train. A secondary delay is a delay caused by a primary delayed train, the terms knock-on delay and cascading delay are used synonymously.

Development

To separate short delay time from longer interruptions, this normally accounts for 30-40 % of the delay hours. A definition of what is short and longer delay times is needed, today Banverket proposes 180 minutes per failure to be used.

Banverket can by using the analysis tool ProClarity analyse down to subunit level but the recording discipline is not good enough, so realistic level is subsystem levels.

Future development is to develop and conceptualize an Overall Railway Infrastructure Effectiveness (ORIE) as a Key Performance Indicator (KPI) for the railway sector. The ORIE calculation is similar to the OEE (overall equipment effectiveness) calculations used for the manufacturing and process industry. The ORIE calculation is performed by multiplication of the infrastructure availability rate (A), the infrastructure performance rate (P), and the infrastructure quality rate (Q) as: ORIE=A x P x Q (Åhrén, 2008).

Reliability

Reliability is defined as the probability that an item can perform a required function under given conditions for a given time interval (EN 50126:1999).

Parameters in use are failure rate (λ), Mean Time Between Failure (MTBF), Number of failures in the system per month/per year and Number of train influencing failures

Development

The parameters are often used in an aggregated level; per track, line etc. A development area should be to specify the parameters per asset/component.

Failure rate cannot easily be accessed by the systems. It is possible by combining data from the failure report, inspection report system together with the asset register. This work is tedious and difficult.

Discussion on how preventive maintenance is affecting the failure rate should be held. It is possible to present MTBF for an asset, but is that the true value? If inspections have led to preventive replacement was done the MTBF-value is too high and a reliability package is needed to calculate this (most probably the data is not good enough for this type of analysis).

The entry of infrastructure failures into the Ofelia infrastructure failure database or the Bessy infrastructure inspection remarks database is not entirely consistent. The Ofelia database focuses on detailed item description, but the events leading to failure and delay are not well described in it. Repair difficulties affect remedial time, sometimes very much, which is seen from Ofelia data. However, the reasons for the difficulties are not described. Ofelia does not allow coding of multiple causes. Data fields to be input, by the use of scroll down-menus, are 'Real fault', 'Cause' and 'Remedial action'. A large proportion of the delays do not have a cause reported, which might overturn the ranking of causes of delays. Uncertain causal relationships are unavoidable (Nyström, 2008).

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)

Parameters in use are: Mean Time To Maintain (MTTM), Mean Time To Repair (MTTR), Total repair time and Total logistic delay time before repair.

Maintenance supportability is "the ability of a maintenance organization of having the right maintenance support at the necessary place to perform the required maintenance activity at a given instant of time or during a given time interval" (SS-EN 13306).

Development

The parameters are often used in an aggregated level; per track, line etc. A development area should then be to specify then parameters per asset/component. Since the maintenance is outsourced, the intervals and time used for condition based maintenance is not reported back to the IM (client). Information of how long maintenance actions takes; is possible to record for corrective maintenance; through Ofelia, and predetermine maintenance (time or volume based maintenance).

The repair time consists of records where the repair is started and then not completed at the same day because of shortage of spares of traffic is prioritised before a full repair. A method to exclude these types of records is necessary.

Safety

Safety is defined as the state of a technical system freedom from unacceptable risk of harm (EN 50126:1999)

Parameters in use Number of accidents, Number of derailments, Number of accidents due to external sources, Number of accidents due to internal sources and incidents that could have led to accidents/damage

Development

Safety related failures on assets

2.4.2 Boundary conditions

LCC and RAMS-commitments will be affected by changes in traffic; e.g. – a new vehicle type is introduced. Its steering performance is rather poor which will increase the degradation in track or the maintenance on a vehicle is very poor which increase the lateral track forces and also increase the degradation speed on rail.

IM needs to know how the track is used, what kind of vehicles and their behaviour, how much (tonnage, axle per year), their maintenance condition.

Traffic data

It is up to the traffic companies to report their traffic statistics into a system called OPERA. (What wagons, wagon number, amount of freight, passenger, axle load). This data is confidential and difficult access, meaning that IMs do not have current information. Some wayside detectors can measure the amount of axles and the axle load, but there are only 5 detectors operating at the moment.

Improvement area would be to be able to monitor the traffic on line, i.e. be able to register what kind of train, type of wagons, identify them by RFID (tags) – to be able to send back condition data to the traffic company, so that they can order maintenance when needed, instead of – when it is to late.

2.4.3 Systems for collecting data

System for collecting data:

- Asset information, curvature, slopes etc. is stored in BIS – the asset information system. It also contains some maintenance history.
- Failure system, Ofelia.
- Inspection remark system, BESSY.
- Traffic statistics from OPERA
- Economics, Agreeso Accounting system

Data is collected by:

- Train Control Centres (CTTC); punctuality, failure reports, wayside monitoring systems (detectors) for axle loads and condition, used for safety reason, monitoring power supply.
- Contractors/Result units; failure reports, inspection reports, from measuring vehicles (track quality, catenary position, ultrasonic (cracks), NDT from hand held equipment.
- Economic data: from contractor’s invoices and expert estimation, calculation systems.

Train traffic control (dispatching) is carried out by Banverket, and each TOC (Train Operation Company) has a control centre of its own to monitor its traffic. Eight centralised train traffic control centres (CTTC) run by Banverket, perform train traffic control in their respective areas; that is, they execute the train plan (timetable), operationally coordinating trains and track works, including maintenance. In connection to train traffic control, delay attribution is performed. That is, causes of delays are recorded. (Nyström, 2008)

Development

- Historical data; e.g. asset age. Today input date is noted, but when the asset is exchanged – the previous date for the old asset is lost.
- A database for maintenance activities (maintenance history) is needed.

2.5 Network rail current use and development of RAMS

2.5.1 Use of RAMS data in condition reporting

"The aim of the work group is that facility managers can give a characteristic number for Reliability, Availability, Maintainability and Safety for their facility", Network Rail currently tracks measurements of the Engineering Infrastructure condition; reporting, as it is obliged to do so to the ORR (Office of Rail Regulation), key parameters including failure of points and track circuits, signal failures, rail defects and breaks, electrification power failures, track geometry indices and earthwork and structure conditions.

This Engineering Infrastructure data is also broken down into regional statistics for the purpose of assessing RAMS performance against key targets and to demonstrate improvement against historic trends. This condition reporting also clearly demonstrates trends as a new technology or maintenance regime is introduced, and the impact on reliability, availability and safety on the railway.

2.5.2 Current data collections, Railway Reliability Data Handbook and developments

Network Rail's recent RAMS development includes the collation of a Railway Reliability Data Handbook. This is to be a handbook, which contains MTBF (Mean Time Between Failure) and MTBSAF (Mean Time Between Service Affecting Failure) for key items of equipment. Currently this handbook covers switches and crossings, signalling and track circuit data. This will be expanded in the future to cover failure of overhead cables, structures and rail failures. The purpose of this handbook will be to provide MTBF and MTBSAF that can be used in assessing the reliability of new products, or for studying the potential reliability of major new schemes.

To generate this type of reliability handbook, data must be collated from numerous sources in order to categorise each type of data. At Network Rail the collection of failure data is initially collected for the individual assets across the country and fed into their regional FMS (Failure Management System) database. This data is then collated in a central FMS repository. Data for the reliability handbook is then screened by location to obtain a homogeneous population of assets and plotted to establish whether the reliability is constant or exhibiting a trend. This analysis of trends is carried out using the Duane growth model (a two parameter statistical model). Screening also allows the data to be categorised in terms of operational differences, traffic type, traffic density, location and number of tracks (e.g. single track with two way traffic or two track route). Where appropriate a mean frequency of cycles has also been calculated, for example on switching gear. The failure data can then be incorporated with other sources of data including the NR Ellipse database (equipment register and records of all the scheduled maintenance task for each asset), to obtain the identification and equipment history; TRUST (Train Running System on TOPS), used by Network Rail to monitor service performance by monitoring train movements at strategic locations to record delays greater than 3 minutes and cancellations to services and other relevant data is used where appropriate, such as meteorological data where this may have impacted the failure. The TRUST database will associate each fault as either resulting in a service interruption and contribute to the calculation of MTBSAF as well as MTBF, or no service interruption, when this failure will only contribute to the MTBF calculation. The other data sources also provide information as to the cause of the failure. Failure modes are defined for each item of equipment and categorised as either operational failure modes or technical failure modes. Technical failures are hardware failures of the components, for example due to wear, loosing tolerance and component failure. Operational incidents are due to external factors, for example water, vibration and damage/vandalism.

The calculated MTBF and MTBSAF and growth models for technical and operational failures can then be used in project evaluation.

2.5.3 Use of RAMS data in projects / Verification of RAMS data

RAMS is now considered as part of any new infrastructure investment project and design for reliability is considered to be critical. Depending upon the type of project, the use of reliability data and analysis will vary. For example in assessing the impact of a single item or system, a technology level analysis will be carried out including techniques such as FMECA (Failure Mode, Effects and Criticality Analysis); reliability benchmarking, comparing to current systems and process streamlining to reduce product complexity.

Larger scale products such as the introduction of new routes or upgrade projects will take MTBF and MTBSAF data and use this in the TRAIL model, to simulate traffic volume and type, calculate expected delay and the cost of penalties and consequence penalties, identify critical/high risk assets and maintenance regimes. In addition to the MTBF and MTBSAF data that is used, new rolling stock and route upgrades are also modelled with TrackEx for that specific vehicle and route, so predictions of rail wear and rolling contact fatigue can be made.

Once a project has been implemented the FRACAS (Failure Reporting and Corrective Action System) and DRACAS (Data Recording and Corrective Action System) are used to collate data that then feeds back into the reliability models for validation and use in future projects.

Data recording by line side measurement and Network Rail track recording vehicles are under continuous development to provide more data feeding into DRACAS. Network Rail is also working on developing intelligent infrastructure, which will provide self diagnosis and alerts in the case of incipient failure or component wear.

2.5.4 Development of RAMS data for maintenance

Currently reliability data is provided to the maintenance teams and highlights the current performance of the railway and gaps for improvement. The reliability data calculated has also provided data on high risk elements of the railway. However, as demands on the UK rail network increase there will be a greater need for projects such as Intelligent Infrastructure and the use of MTBF and MTBSAF data to predict component life to a certain level of confidence. This can lead to predictive maintenance, where components are replaced during planned maintenance before they fail, increasing safety, route availability and reliability.

2.5.5 Examples of positive use of RAMS for project work

The Enhancement Engineering Reliability Engineers within Network Rail are currently involved in the assessment of major new projects from a RAMS perspective. Two examples of where this has been evident has been ERTMS, which was a Technology Level use of RAMS and the West Coast Mainline upgrade, which demonstrates the large scale integrated strategy use of RAMS.

For ERTMS, FMECA and process streamlining where used to study the reliability and safety of critical components and the complexity of potential technologies. In the cases where similar devices are currently in use by other nations benchmarking can be carried out.

The West Coast Mainline upgrade required the input of reliability data combined with TRAIL model to allow Network Rail to establish predicted delays to the route and establish the upgrades necessary and provide confidence that the route would match commitments of availability, maintainability and performance and the assessment of impact from new technology. Since implementation RAMS data is being collected via FRACAS and DRACAS to validate the models used, for use in current and future projects and maintenance strategy.

3. Conclusions

The different examples of the five railways show the current possible use of RAMS technologies and the necessary developments from the point of view of the railway companies. It is shown that there are different possibilities for the use of the technologies.

At the moment the railway organisations only use the RAMS technology commonly as a tool for the decision in specific cases. In these specific cases, e.g. procurement or simple project management requirements in special product areas like signalling, electric devices or other series products, RAMS technologies are a good tool for quality control. This does not mean that RAMS technologies are not useful as general tools. However, for the complete railway system it is currently not possible to combine the different requirements of the various product fields in a general RAMS analysis. Consequently the railways currently are required to find other solutions or limit the use of the RAMS technologies to special items.

As a common result of the work in this project, it has been found necessary to give definitions of the specific terms with respect to their use in the railway sector. As an example we can pose some questions regarding the term “availability”, e.g.:

- is it function of the capacity of utilisation of the line;
- what data can we collect in order to describe this;
- do we need a common definition for train delays?

Some railway organisations have adopted definitions for this like Banverket or ÖBB, but these differ between the organisation.

A similar problem is the different maintenance strategies of the European railway organisations. As shown in the examples there are two types of maintenance, the condition based maintenance and the predetermined maintenance. For the pre-determined maintenance RAMS analysis is more important than for a condition based maintenance.

Another problem is the general problem of new products or the unknown behaviour of a product. Where can the railways get the relevant data to calculate the key value?

The aim was to use the RAMS technologies as a general tool for the railway infrastructure. After the different investigations and evaluation of the existing systems it must be accepted that there is no possibility at the moment to fulfil this aim. The railway system combines different product fields. Some of them are very industrial without much human intervention and therefore possible to analyse. Others are more manual with a lot of human intervention and therefore more scatter in resulting RAMS parameters. For these product fields the RAMS technologies cannot currently be used due to the difficulties in assessing the scatter in input factors.

Looking at the extracted areas of developments from the relevant sections, can conclude that priorities are:

1. More extensive data collection and analysis
2. More extensive databases
3. Better definitions of failures and general RAMS terminology
4. Improvements in verification of data employed for reliability analyses
5. More data collection through load detectors and intelligent infrastructure
6. Use of reliability data in planning of predictive maintenance
7. Looking at the extracted areas of developments from the relevant sections, can conclude that priorities are:

For the participating IMs, the identified areas of necessary development of RAMS technologies are:

ÖBB:

- Database system for planning and evaluating maintenance
- Definitions of availability, capacity and other terms
- Better transparency of data across ÖBB companies
- More wheel check/rolling stock measurement sites

ADIF:

- Expansion of database of failures
- Use of wheel/rolling stock measurement sites

DB:

- More data to build up reliable databases and determine if the chosen track for data categorisation is appropriate – validate model

BV:

- Separation of short delays and long delays – definition
- Development of Overall Railway Infrastructure Effectiveness as a KPI
- Definition of failure rates etc per asset/component etc
- Improvement of accessing failure rate data
- Does preventative maintenance skew true MTBF values?
- Requirement for more data – recording of corrective maintenance, repair time etc
- Database of maintenance activities
- Improvement to traffic data – Use of RFID tags to identify wagons

NR:

- Expansion of database of reliability data to more components and further verification of data
- Use of Intelligent Infrastructure for self diagnosis
- Predictive maintenance – replace before failure

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