RAMS and LCC for railway infrastructure

Part 1 - How RAMS and LCC can support your work and decision?
Part 1 – Why to use RAMS and LCC
Starting point and motivation

InnoTrack – originator for this lecture

Introduction to RAMS and LCC

How can RAMS and LCC support your decision?

Summary and question?
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InnoTrack – targets and partners

**Targets**

Delivery of new **products, processes and methodologies** in order to achieve the ERRAC objectives

Significant **LCC reductions** and **RAMS improvements** in order to strengthen the competitiveness of railway sector.
InnoTrack - approach

**PRODUCTS**
- new rail steel materials
- optimised track components (sleepers, resilient elements etc.)
- innovative switch designs
- improved driving and locking devices (DLDs)
- new cost effective track forms

**PROCESSES**
- logistics processes
- sensor technologies & signal processing
- soil improvement methods
- innovative grinding methods
- improved welding techniques
- preventive and planned maintenance
- inspection techniques

**INNOVATION**

**METHODOLOGIES**
- classification methods for track and vehicle characteristics
- defining duty conditions from vehicle track interaction
- assessment of technical and economical problems
- Europe-wide accepted LCC and RAMS evaluations
InnoTrack – project structure

SP0 InnoTrack Coordination
UIC

SP 2 Track support structure
SNCF
Track subgrade monitoring & assessment
Evaluation and tests of superstructure innovations

SP 3 Switches and Crossings
DB
Predictive models for S&C
Switch designs
Standards & LCC analysis

SP 4 Rails
VAS/CORUS
Methodology for duty conditions
Supported track form
Rail steel material
Grinding methodology

SP 5 Logserv
ALSTOM
Vehicle & track characteristics
Generic model of failure/degradation
Best logistics practices
New logistics processes
Cost effective methodologies

SP 1 Duty NR
LCC methodology
RAMS technology
LCC models

SP 7 Dissemination and Training
UIC

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InnoTrack addresses innovations

**Product**
- Unified relational database of modelling tools used across Europe

**Methodology**
- Standardised methodology for classification of European rail vehicles and tracks
- Methodology for developing and simulating ‘virtual tracks’
- Novel process of linking different modelling tools
- Validation of using different resolution models to allow modular simulations

**Process**
- New measurement tools for track subgrade investigations
- Geogrid soil reinforcement
- Non-intrusive cement mixing subgrade reinforcement

**Product**
- Bi-steel slab track system

**Methodology**
- Track assessment and classification methodology
- Identification of validation criteria and standardized methodology for the acceptance of substructure and superstructure innovations
**Product**
- New materials (in terms of steel alloys, heat treatment etc)
- New driving and locking devices with better availability
- New customer oriented monitoring systems
- Optimized switch design to minimize mechanical deterioration

**Process**
- Innovative combinations of sensor technologies and data analysis

**Methodology**
- A standard interlocking interface to drive innovative solutions

**Process**
- Use of high speed grinding combined with optimised rail metallurgy & track quality
- Tests that more closely reflect the in-service performance
- Modified gas pressure welding unit suitable for European practices

**Product**
- Application of narrow heat affected zone and improved geometry welds

**Methodology**
- “Minimum action rules” for maintenance
- Definitive guide to the selection of rail grades as a function of duty conditions
Methodology
• Integration of a supply chain approach in railway track construction
• Development of a partnership approach between infrastructure managers and contractors in new track construction and track maintenance

Process
• Development of construction methods integrating modular concept of track equipment (“plug & play”)

Methodology
• European standards for LCC and RAMS
• Internationally (European) accepted method for identification and verification of European issues and cost drivers
• Method for LCC and RAMS, economical verification and assessment of technical solutions
• Compilation of best practices to cut LCC and improve RAMS

Process
• Cost break down structure for infrastructure components on different levels

Product
• LCC and RAMS relevant databases
State of the Art in 2008 – summary of results

- **Life cycle costing** is rarely used as a basis for decisions for track
- LCC relevant **data are not available** in general
- **RAMS analyses** are only used for new installations of track
- RAMS analyses are **not used for optimization** of track
- RAMS parameter like probabilistic density functions of failures are not available
- RAMS and LCC relevant **boundary conditions are not monitored** for required periods
Implementation of InnoTrack results

Guideline for LCC and RAMS analysis created by
- Deutsche Bahn
- Network Rail
- ProRail
- Travikverket (Banverket)

Workshops to support
- the implementation of RAMS and LCC in railway

Top Down Approach
- Raising the awareness that implementation of RAMS and LCC is a management task

Bottom Up Approach
- the training of users doing RAMS and LCC analysis
Aim of this training course

At the end of these training course you should

- know more about the **main features** of RAMS and LCC
- be able to better estimate the **benefit and effort** in using RAMS and LCC
- know about your **responsibility** for implementation and application of RAMS and LCC in your division
- know **colleagues from other railways** working in similar areas with the possibility to establish information networks and cooperation
Part 1 – Why to use RAMS and LCC
Starting point and motivation

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Definition of RAMS and LCC
What does RAMS mean?

Specifications regarding operation and maintenance quality

Description of quality specifications through RAMS values

R
Reliability

A
 Availability

M
 Maintainability

S
 Safety

Technical specifications
Definition of RAMS
What does RAMS mean?

The technical performance and safety is described by RAMS

RAMS - defined in the CENELEC-standard EN 50126 - is the abbreviation of the terms

Reliability ⇒ MTBF – mean time between failure
Availability ⇒ availability depends on MTBF and MTTR
Maintainability ⇒ MTTR – mean time to restore / repair
Safety ⇒ normative requirement

RAMS is according to the definition in EN 50126 a process or method, which assists the avoidance of failures already in the planning phase of projects.

RAMS analyses identify the technical performance and safety on system, module or component level
Definition of RAMS and LCC
What does LCC mean?

Specifications regarding total life cycle costs

Cost / Benefit

Economical specifications

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Definition of LCC
What does LCC mean?

The economical performance is described by LCC

LCC is the abbreviation for Life Cycle Costing

Life cycle costing (LCC) is an assessment of all costs associated with the life cycle of a product that are directly covered by any one or more of the actors in the product life cycle ... (Rebitzer 2003)

Input for LCC analyses is the technical performance of the system, derived by RAMS analysis

Life cycle costing allows to

- **Compare life cycle costs** of selected alternatives
- Identify the **cost drivers**
- Assess and **benchmark improvements** of a product or innovations
- **Optimize a product** changes or process taking into account the whole life cycle
- Identify **break even points** and **trade-offs**

Life cycle costing provides important economical information and supports decision
Interlink between RAMS and LCC
Technical and economical performance are strongly connected

Specifications regarding operation and maintenance quality

Description of quality specifications through RAMS values

Reliability | Availability | Maintainability | Safety

Cost / Benefit

Specifications regarding total life cycle costs

Technical specifications

Operation & Maintenance

Economical specifications

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Why to use RAMS and LCC?
Tasks in railway infrastructure are very challenging

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Why to use RAMS and LCC?
RAMS and LCC supports your decision?

For the estimation of maintenance and non-availability costs the technical performance of the system is required as input.

Long-lasting assets ... Improvements and innovation over time?

Decision about public or private investment?
Which alternative is the best one?
How to decide about the project?
How to control the success of the project?
Cost benefit analysis to identify the cost to benefit ratio of the projects and different approaches

Analysis of investment and follow up costs like maintenance, non-availability or disposal costs

How to compare and assess the cost and environmental behavior over time for different solutions?
Big investments in infrastructure all over the world
RAMS and LCC supports efficient use of resources

[Source: Mc Kinsey 2013]
Big investments in infrastructure all over the world
RAMS and LCC supports efficient use of resources

<table>
<thead>
<tr>
<th>Type of Infrastructure</th>
<th>% World GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>1,3</td>
</tr>
<tr>
<td>Telecom</td>
<td>0,5</td>
</tr>
<tr>
<td>Transport</td>
<td>0,8</td>
</tr>
<tr>
<td>Road</td>
<td>0,3</td>
</tr>
<tr>
<td>Rail</td>
<td>0,3</td>
</tr>
<tr>
<td>Airports</td>
<td>0,2</td>
</tr>
<tr>
<td>Ports</td>
<td>0,1</td>
</tr>
<tr>
<td>Electricity transmission &amp; distribution</td>
<td>0,2</td>
</tr>
<tr>
<td>Electricity generation</td>
<td>0,7</td>
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<tr>
<td>Other energy</td>
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</tr>
<tr>
<td>Oil &amp; gas transmission &amp; distribution</td>
<td>0,2</td>
</tr>
<tr>
<td>Total</td>
<td>4,1</td>
</tr>
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</table>


Railway infrastructure in Turkey
• 2,622 km of high-speed track by 2013
• A further 6,792 km of high-speed track by 2023
• 4,707 km of new conventional track by 2023
• An additional 2,960 km of high-speed track and 956 km of conventional track in the period from 2023 to 2035
Source: C4R - Intader

Global infrastructure investment
Annual infrastructure spending would need to rise from the current US$ 2.6tn to
• US$ 3.0-3.5tn in 2020 and to
• US$ 4.1-4.8tn in 2030.
[Source: Mc Kinsey]
The roadmap till 2050 with respect to an affordable railway system

<table>
<thead>
<tr>
<th>Timeframe</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access charges</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No increase in real terms</td>
</tr>
<tr>
<td>Operating costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50% decrease</td>
</tr>
<tr>
<td>Infrastructure maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50% decrease</td>
</tr>
<tr>
<td>Environmental</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Specific mean CO₂ emissions</td>
<td></td>
<td></td>
<td>30% reduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total CO₂ emissions</td>
<td></td>
<td></td>
<td>50% reduction from 1990 - in terms of passenger km and freight tkm</td>
<td></td>
<td></td>
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<tr>
<td>Specific energy consumption</td>
<td></td>
<td></td>
<td>50% reduction from 1990</td>
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<td></td>
</tr>
<tr>
<td>Total energy consumption</td>
<td></td>
<td></td>
<td>50% reduction from 1990 - in terms of passenger km and freight tkm</td>
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<td></td>
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<tr>
<td>Exhaust emissions (NOₓ and PM₁₀)</td>
<td></td>
<td>40% reduction from 1990</td>
<td></td>
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</tr>
<tr>
<td>Safety</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Equivalent fatalities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>50% decrease</td>
</tr>
</tbody>
</table>

Key: Target given in White Paper: Target given Rail Route 2050: Based on relevant outputs

[Source: C4R – project]
Decision are often triggered by today investments. LCC takes into account the life cycle.

**Target**

**Cost effective systems**

Decision, focused on investment, do not take into account follow-up costs.

**Life cycle costing** covers the costs for investment, costs for operation, maintenance and the costs for disposal and delivers the best basis for today decisions.
RAMS analyses are necessary for valid LCC

To identify the **follow-up cost** technical assessment like RAMS analyses are necessary.

A better technical performance, often connected to higher investment costs, reduces the operational costs.

The trade-off can be estimated by RAMS and LCC analyses.
RAMS are essential for 24 hour operations

Requirements regarding reliability, availability, and maintainability of infrastructure strongly depend on train free period.

**Case 1:** All maintenance is possible in train free periods

**Case 2:** Maintenance partly possible in train free period

Reliability and maintainability \( \uparrow \)

**Case 3:** Maintenance during train operation reduces availability

Reliability and maintainability \( \uparrow \)

\( \Rightarrow \) RAMS and LCC ensure economical decisions for future demands
Why to use RAMS and LCC in optimization process?

**Status Quo**
- **Technical performance**
  - Reliability
  - Availability
  - Maintainability
  - …
- **Environmental perform.**
  - Noise
  - Ground born vibration
  - …
- **Costs (drivers)**
  - Investment
  - Operation
  - Maintenance
  - Non availability

**Innovation/Optimisation**
- **Technical performance**
  - Reliability
  - Availability
  - Maintainability
  - Tolerance against conditions
  - …
- **Environmental perform.**
  - Noise
  - Ground born vibration
  - …
- **Change in Costs**
  - …

**Economical effects**
- Change in initial investment (t=0)
- Migration costs
- Costs for new regulations
- Decreasing costs for environmental sustainability
- Decrease maintenance cost
- Decrease costs for non availability
- …
- Additional income?

**Traffic prognosis**

**Social economical effects**

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## Part 1 – Why to use RAMS and LCC
### Starting point and motivation

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InnoTrack points out a **lack of knowledge** in the field of **RAMS** and **LCC** for railway infrastructure.

**RAMS** describes the **technical performance** of system, sub-system or component and is important for today’s and future demands.

**LCC** is an economical method, that takes into account a discount rate.

**RAMS** and **LCC** are **essential** for economical system improvements.

**RAMS** and **LCC** can be used to share risks between suppliers and operators.
Questions and answers

Q:
A:
Q:
A:
End of part 1 …

We hope you are well

Let’s have a short break!

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