Workshop on
Life Cycle Management
27-29 October Rotterdam

The actual use of LCC in maintenance decision making on network level

R. Treiture[1,*], *J. Bakker*[1], M. Bakx-Leenheer[1], H. van Meerveld[2]

[1]Rijkswaterstaat, Ministry of Infrastructure and Water Management, The Netherlands
[2]TNO, Delft, The Netherlands
*Corresponding author: rob.treiture@rws.nl

ABSTRACT:

Every four years the Dutch government and the executive agency Rijkswaterstaat (RWS) negotiate a Service Level Agreement (SLA) for the performance of the main roads, main waterways and main water systems. In this SLA, the required performance of the infrastructure, the risks and the maintenance budget for the upcoming four years is agreed upon. The common opinion is, that the relatively short term and lagging character of the performance indicators in the SLA, may lead to sub-optimal decisions in the long run which may lead to a waste of public money. Recent SLA periods also learned that basing the required SLA budget on these performance indicators because of the same short term and lagging character leads to underestimating of the required SLA budget. After all, not all necessary maintenance is in the picture of the decision makers.

In order to improve transparency and increase the understanding of the long term consequences of short term SLA decisions, a new method of visualising the backlog of maintenance is introduced by Rijkswaterstaat in the present SLA negoriations. In this way the effects of different maintenance scenarios can easily be shown on different levels. From network level down to object level. This paper shows this method and how it is incorporated in the negotiations.

References:

1. J. Wessels, R. Schoenmaker, H. van Meerveld, J. Bakker, J. Schavemaker, 2014. Introducing LCC in maintenance decision making on network level.
2. InfraQuest, 2019. LCC in the SLA 2018.

The use of some simple LCC rules when prioritizing maintenance measures for complete infrastructure networks

Rob Treiture[1] and *Jaap Bakker*[1,*]

[1]Rijkswaterstaat, Ministry of Infrastructure and Water Management, The Netherlands
*Corresponding author: rob.treiture@rws.nl

ABSTRACT:

In most countries management and maintenance of infrastructure networks is subject to limited resources. Overdue maintenance is therefore lurking. In The Netherlands Rijkswaterstaat is assigned to keep all traffic on main roads and main waterways running smoothly and when a large part of the country lies below sea level to protect the land against flooding with dikes, dams, dunes and 6 storm surge barriers. In a four-yearly Service Level Agreement (SLA) with the Dutch Ministry of Infrastructure Rijkswaterstaat receives a certain amount of money to do all the maintenance for these three networks: main roads, main waterways and main water systems. How to spent this money in the most sensible way is an important focal point of Rijkswaterstaat. A chain of maintenance has been developed starting with several types of inspections to determine the necessary measures, then to prioritize these and then to realise maintenance. Because of the many of thousands of kilometres of roads and waterways and the many of thousands of individual objects this is causing to many of hundred thousands of individual maintenance measures yearly. Prioritizing these maintenance measures is done by focussing on RAMSSHEEP aspects. Due to these large amounts of individual measures in practice it appears that the focus is on the first four: Reliability and Availability due to the SLA, Maintainability due to a sensible market approach, Safety due to legal restrictions. All other aspects are mostly weighted on an ad hoc basis. For instance Environment only when required by legislation. At the moment €conomics is only weighted in general, not on individual measures. During the past years this maintenance policy has let to a rapidly growing backlog of "not urgent" maintenance waiting to be done. However this waiting brings further deterioration by aging accompanied by uncertain risks when this backlog is not well managed.

This study develops guidelines for managing the backlog of maintenance by means of some simple LCC rules helping to prioritize all these hundred of thousands measures on the aspect of €conomics in an automated way.

References:

3. Stratelligence, 2013. Cost-benefit analysis at Management and Maintenance for the SLA. A set of instruments to support policy choices in programming.
4. R. Treiture, L. van der Meer, J. Bakker, M. van den Boomen, R. Schoenmaker, R. Wolfert, 2018. Assessing approximation errors caused by truncation of cash flows in public infrastructure net present value calculations.

Workshop on
Life Cycle Management
27-29 October Rotterdam

Challenges of life cycle management in the smart grid: Case Smart Otaniemi

Helena Kortelainen[1*], *Jyri* Hanski[1]

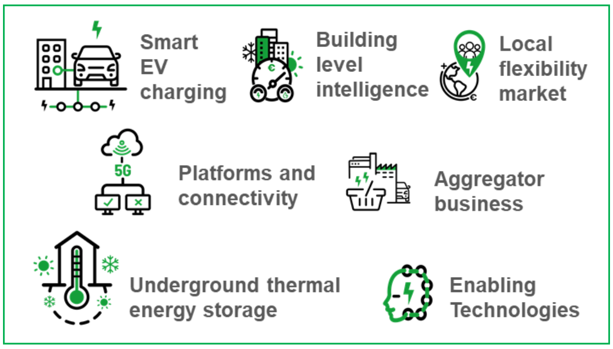
[1]VTT Technical Research Centre of Finland Ltd
*Corresponding author: Helena.kortelainen@vtt.fi

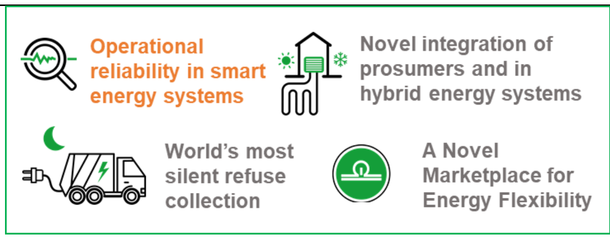
ABSTRACT:

Interconnected society is setting new requirements to the life cycle management of electricity systems. Smart Grid applies advanced information and communication technology to facilitate reliability, efficiency, and robustness of electric systems while integrating large and small renewable energy sources, electrical vehicles, and a range of devices in homes and businesses [1]. Key drivers of Smart Grid include need for more energy, increased usage of renewable energy resources, sustainability, competitive energy prices, security of supply and ageing infrastructure and workforce [2].

Implementation of smart grid elements introduces challenges to the electricity system [3]. As novel technological solutions enter the market, their impact on the life cycle management and reliability of the electricity system and the cost efficiency must be evaluated before wide-scale implementation. This goal can only be reached together with technology and service providers and in collaboration with all the ecosystem stakeholders.

SmartOtaniemi ecosystem in Finland is a test bed for future energy solutions.





The smart grid consists of (1) a physical layer connecting energy producers and consumers, (2) a monitoring and control layer, (3) an information layer that aggregates information from the monitoring and control layer, and (4) an application layer. SmartOtaniemi makes use of 5G network and IoT platform that enable flexibility to empower the customers to become prosumers.

Fig. 1. *Framework provided by SmartOtaniemi ecosystem to the research in the area of life cycle management of smart grid*

Smart Otaniemi is an innovation ecosystem consisting of 70 companies and research institutes focusing on smart grid aspects such as local flexibility, smart mobility, building level intelligence and platforms, connectivity and enabling technologies [4]. One of the main tasks of the ecosystem is to ensure reliable operation by enhancing lifecycle management and reliability with novel technologies (Fig. 1). As a result, an asset life cycle management framework and methods to assess affordability of solutions improving operational reliability are developed. In addition, technologies and solutions such as IoT and AR/VR solutions for smart field service operations for improving operational reliability are identified.

References:

1. W. Ketter, et al. 2018. Information Systems for a Smart Electricity Grid, ACM Transactions on Management Information Systems, 9(3):1–22. doi: 10.1145/3230712.
2. IEC 2010. IEC Smart Grid Standardization Roadmap. Available: https://www.iec.ch/smartgrid/downloads/sg3_roadmap.pdf. (accessed 4.9.2019).
3. C. Jung, P. Ray, S.R. Salkuti, 2019. Asset management and maintenance : a smart grid perspective, 9(5):3391–3398. doi: 10.11591/ijece.v9i5.pp3391-3398.
4. Smart Otaniemi (2019) Homepages of Smart Otaniemi innovation ecosystem. Available: https://smartotaniemi.fi/. (accessed 5.9.2019)

Life Cycle Engineering in a System of Systems
Lessons to be learnt from and for the Railways

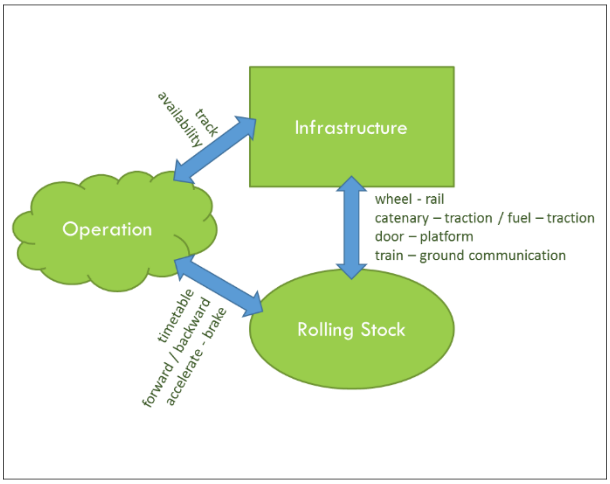
Robert Liskounig[1,*], *Judit* Sándor[1], *Giorgio* Travaini[1]

[1]Shift2Rail Joint Undertaking
*Corresponding author: robert.liskounig@s2r.europa.eu

ABSTRACT:

Shift2Rail (S2R) is the first European rail initiative to seek a coordinated and focused research and innovation (R&I) and market-driven solutions by accelerating the integration of new and advanced technologies into innovative rail product solutions. R&I carried out under this Horizon 2020 initiative develops the necessary technologies to maintain the competitiveness of the railway sector in Europe and complete the Single European Railway Area. Specifically, the programme aims to double the capacity of the European rail system and increase its reliability and service quality by 50 %, **all while halving life-cycle costs.**[see 1]

Most of the challenges for other water- and land based transport infrastructures like demographical changes, urbanisation and connectivity, adaptation to new societal demands and requirements, system optimization, network management, aging infrastructure or climate change [2] apply also to the railways. On top of that, for the railways the interaction between vehicle (stiffness, weight, power) and infrastructure (network layout, track radius, type of track) influences the life cycles of both. Also, operation of the railway networks determines the flow of goods and passengers impacting the load cycles of the infrastructure and generates additional forces by the amount of braking and accelerating of a train. Interdependencies between network operation, infrastructure and rolling stock are depicted in figure 1 and are described as a system of systems:



The "Infrastructure" subsystem of the railways follows roughly the life-cycle of public or private demand – investment decision – design – procurement – construction – operation – maintenance – demolition – recycling / re-use of materials. The life cycle of railway infrastructure lasts from a couple of decades to more than a century. "Rolling Stock" is already designed for a specific public or private demand – procurement – manufacturing – operation – maintenance / refurbishment – dismantling including recycling / re-use. Life cycle of passenger trains, locomotives and freight waggons lasts for 30 years or more (including one-time refurbishment). Assets for "Operation" follow a similar life-cycle as rolling stock, driven by assets and services both from Railway Operators and IM, the latter usually acting as traffic management managers. Life cycle of this subsystem is nowadays the shortest, following the rules of the ICT sector and lasts up to several years. Older, still operational electro-mechanical assets used in operations have / had longer life-cycles.

All subsystems are heavily regulated on European and national level with a strong focus on safety and operational rules.

All subsystems consist of sub-subsystems (stations, passenger seats, ICT networks, etc.) with specific life-cycle properties and durations.

Fig. 1. *Railways as System of Systems*

The interdependencies shown above can negatively influence LCC driven decisions if it's done at one sub-system level only. For instance, an energy efficient rolling stock could be disrupted by a network layout that does not allow crossing or overtaking of trains which leads to additional energy consumption due unnecessary braking and acceleration. LC-based maintenance of the infrastructure can be hindered by operational reasons (fully booked timetables or transport demand) and the layout of the network (no possibility of rerouting).

Shift2Rail tackles the challenges caused by the holistic system of systems of the railways by making use of the interdependencies. For example, S2R works on Integrated Mobility Management (I2M), where asset status (of rolling stock and infrastructure) and operational needs are combined to increase capacity through seamless data exchange and intelligent traffic management [see 3].

The authors want to make use of the lessons learned in the railway sector to strengthen multimodal transport chains in Europe based on life-cycle engineering. On the other hand the railways need to learn from less interdependent transport modes to become more flexible and capable to adapt to future challenges and needs in European transport.

References:
1. https://shift2rail.org/
2. https://ialcce-lcmworkshop2019.com/themes/
3. https://shift2rail.org/research-development/cca/

LCM 2019 WORKSHOP — ialcce —

Workshop on
Life Cycle Management
27-29 October Rotterdam

InfraQuest
COMPETENCE CENTRE FOR ROADS & STRUCTURES

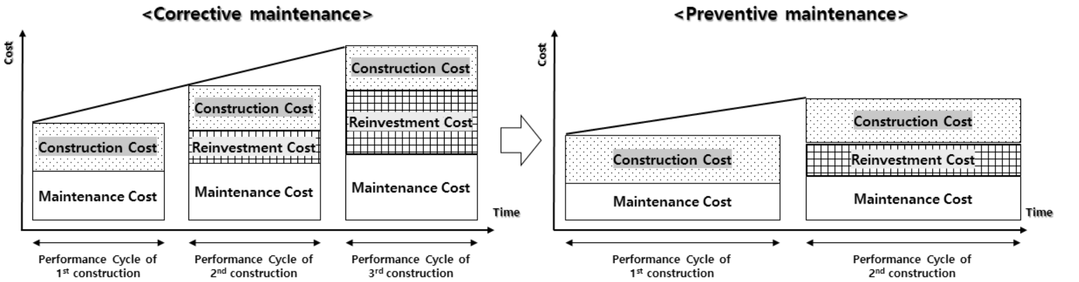
A research about future investment cost of road bridge network in South Korea

Jaehoon Lim[1], *Soo-Jin* Park[2], *Yangrok* Choi[1], *Sungyeol* Jin[1], *Joowon* Cho[1], and *Jung Sik* Kong[1,*]

[1]School of Civil Environmental and Architectual Engineering, Korea University
[2]Department of Energy Policy & Engineering, Kepco International Nuclear Gradute School
*Corresponding author: jskong@korea.ac.kr

ABSTRACT:

Today the ageing of social infrastructures has been grown globally, and many policy researches are being actively progressed. In Korea, roughly 42% of total bridges were built from the 1970s to the 1999s, and this rapidly construction growth will cause huge reinvestment costs suddenly. However, many researches were focused on the future investment cost for new road bridge construction, and the research of large-scale reinvestment cost for old-aged road construction is not considered.
For the reasons, this research will discuss the future investment cost including construction, maintenance and reinvestment costs. First, for a comparison between preventive maintenance and corrective maintenance, this study confirms cost effect and life extension effect according to preventive maintenance of bridges on a project level. Moreover, using these results, the project bridge network level is expanded to a Korea bridge network level. In this study, historical data of past bridge maintenance are adopted to confirm cost effect about preventive maintenance and predict the bridge life. Second, the reinvestment cost is defined as demolition costs and reconstruction costs when a bridge has reached the end of its life. To calculate the reinvestment cost, this study used unit cost data about the demolition and reconstruction costs using other previous studies.



1) Reducing effect of annual maintenance cost
2) Increasing effect of the budget utilization due to postpone of reinvestment cost
3) Reducing total investment cost by increasing SOC performance cycle.

Fig. 1. *Overview of the effects about changes in the maintenance paradigm*

Acknowledgements :
This research was supported by a grant (17SCIP-B128492-01) from Smart Civil Infrastructure Research Program funded by Ministry of Land, Infrastructure and Transport of Korean Government.

References:

4. Seung-Tae Lee , Dae-Wook Park, Jose Leo Mission, 2013. Estimation of pavement rehavilitation cost using pavement management data. Structure and Infrastructure Engineering, 9:458-464.
5. Jong-Wan Sun, Dong-Yeol Lee, Min-Jae Lee, Kyung-Hoon Park, 2013. Development on Reconstruction Cost Model for Decision Making of Bridge Maintenance. Journal of the Korea Academia-Industrial cooperation Society, Vol.17, No.9: 533-542.
6. Yo-Seok Jeong, Woo-Seok Kim, Il-Keun Lee, Jae-Ha Lee, Jin-Kwang Kim, 2016. Definition, End-of-life Criterion and Prediction of Service Life for Bridge Maintenance. Journal of the Korea Institute for Structural Maintenance and Inspection, Vol.20 No. 4 : 068-076
7. Soo-Jin Park, 2017, New SOC investment paradigm and strategy, Construction & Economy Research Institute of Korea

LCM 2019 WORKSHOP — iaLcce —

Workshop on
Life Cycle Management
27-29 October Rotterdam

InfraQuest
COMPETENCE CENTRE FOR ROADS & STRUCTURES

Modular design for renewable cross-passage walls incl. fire doors in railway tunnels

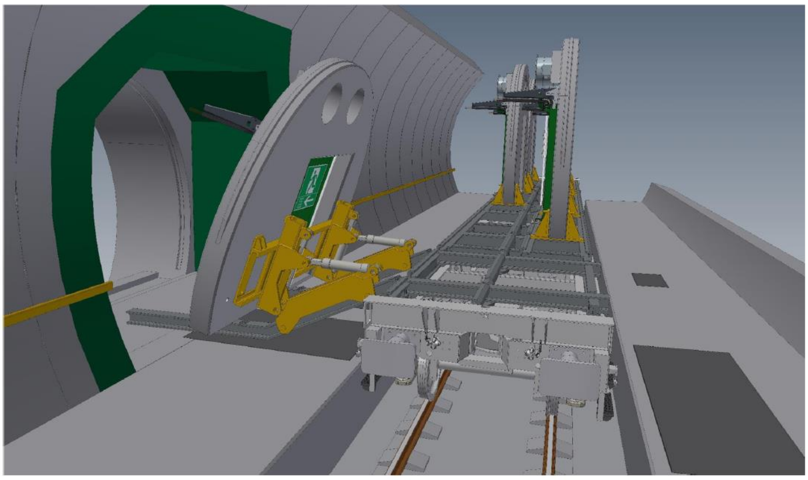
Thomas Thaller[1 *], Hannes Kari[1]

[1] ÖBB Infrastruktur AG, Austria
[*] Corresponding author: thomas.thaller@oebb.at

ABSTRACT

WHAT IS THE PROBLEM?
Tunnel equipment in railway tunnels, like escape doors, are dynamic high stressed parts. For this reason the emergency exit doors as well as the associated cross-passage wall however have a lower lifetime of up to 30 respectively 60 years. The exchange of such fire doors with a weight of about 700 kg (sliding doors) requires installation work for about 4 days in the cross-passages, which for long tunnels, such as the Semmering base tunnel with nearly 130 sliding doors, would lead to significant restrictions on operation.

WHAT IS THE SOLUTION?
Using an expanded modular design, in which the cross-passage wall is already made precisely for the initial installation as a precast concrete element and the emergency exit door is mounted in the plant or in a mobile factory hall by the door manufacturer, the following installation in the railway tunnel can shuttles be done in a short time by using a manipulator (sh. *Plug-in crosscut element*, see below).



In the context of an ÖBB Infrastruktur research and development project the constructive design of the concrete joint between the cross-passage wall and cross-passage vault is tested for the practical application as well as for the dynamic loads resulting from rail traffic. The construction process has also to be expanded for the future dismantling in the inventory and to be constructive and mechanical optimized for an exchange time period of approximately 3 hours (track lock in the night from 01:00 – 06:00).

WHICH ADDITIONAL BENEFIT BRINGS THE IDEA?
An additional benefit of the idea arises from the fact that the qualities of all components by the "industrial production" and the associated quality assurance are much higher than usual. The resulting higher reliability of the door system is responsible for less restrictions on operation and thus an increased availability of the tunnel system respectively the railway as a result.
The developed approach should be applied in the future also for existing railway tunnels.