PRIME

Platform of Rail Infrastructure Managers in Europe

PRIME Thematic Deep Dive on Network condition

Study summary

Brussels, January 2024

European Commission

civity Management Consultants

Study Summary

This summary presents the main findings of a deep dive study on network condition within PRIME, the Platform of Rail Infrastructure Managers (IM) in Europe. The study was commissioned by the European Commission DG MOVE. With the study, PRIME intends to increase visibility of network condition and its reciprocal relation to maintenance & renewal (M&R). Network condition assessment methods of the infrastructure managers were compared and analysed with regards to effects on maintenance & renewal approaches and a continuously good network condition.

The following insights are based on a survey on network condition assessment and reporting, numerous expert interviews on the interplay of network condition and maintenance & renewal as well as a series of workshop discussions.

1. The creation of a network condition report has strategic and operative benefits for the Infrastructure Managers and informs maintenance & renewal needs and funding requirements.

Most IM started to produce a network condition report (NCR) over the last decade. The reports are considered a valuable strategic management tool, improving reporting, and understanding of asset condition and clarifying maintenance & renewal and funding needs. Further benefits highlighted by IM are, amongst others, enabling a holistic view on network condition and an accepted reporting format throughout all company levels.

Network condition reports tend to be produced annually. Most network condition reports are not public, some are compulsory. Figure 1 below shows the number of IM producing a network condition report has starkly increased in recent years. The targeted audiences are regulatory authorities and IM management. As an instrument to monitor network condition, the reports provide information for maintenance and/or renewal plans and funding requirements, thus supporting strategy definition in the areas of asset management, maintenance and renewal and investment.

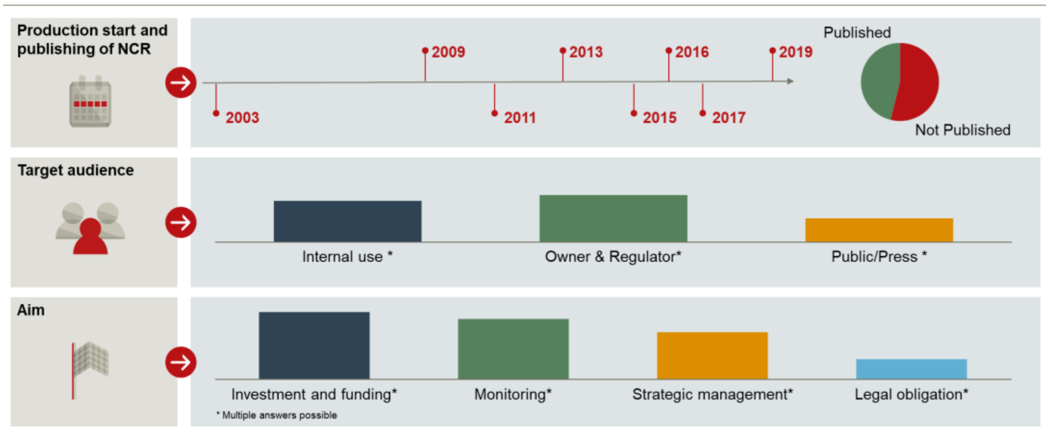


Figure 1: Current state of network condition reports

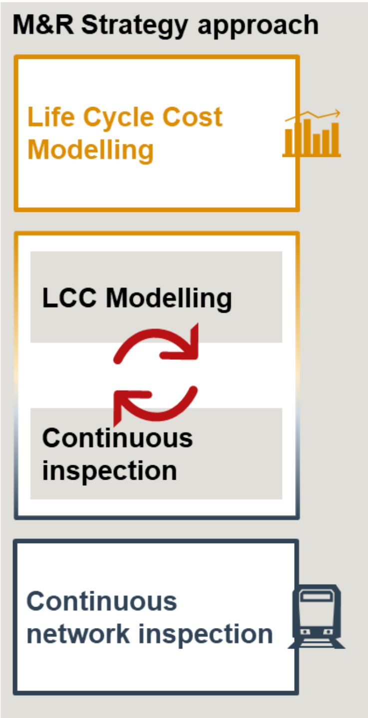
Maintenance and renewal of the reporting year is included in most network condition reports. Past and future maintenance & renewal plans are largely not included, as is information on related backlogs. Some IM refer to financial, annual or separate backlog reports and multi-annual contracts for such long-term maintenance & renewal information.

Network condition reports usually mention the underlying causal link between maintenance & renewal and network condition. Direct and quantified linkages between specific maintenance activities and resulting network condition are however rarely pointed out. Such cause-effect relations between network condition and maintenance seem difficult if not impossible to be depicted in an annual or even short-term perspective. So far, information about the long-term maintenance & renewal strategy along with measures to improve and sustain network condition is not a standard in most network condition reports.

Data quality and availability are still a key challenge for IM in the generation of network condition reports. Demanding issues mentioned are incomplete asset registries, insufficient inspection data, large but unstructured data sets and a lack of digital data availability. However, in the big picture the effort involved in creating network condition reports seems to be countered by the above-mentioned similar benefits.

2. Data-driven life cycle cost modelling in combination with continuously updated inspection data create a basis for optimized strategic maintenance & renewal decisions.

IM increasingly seek to develop and to refine their maintenance and renewal strategy in order to allow for less corrective, more preventive and efficient maintenance & renewal. As illustrated in figure 2, two sources of information are used to create a maintenance and renewal strategy: the theoretical Life Cycle Cost (LCC) modelling[1] and the condition-based inspection data.



In the top-down approach of LCC modelling the calculated theoretical lifetime of the assets is used to determine the maintenance & renewal activities planned. The bottom-up approach of network inspection bases the planning of maintenance and renewal activities on condition data generated by continuous asset assessment with measuring trains and on-site inspections.

IM strive to combine both types of condition input data and combine calculated theoretical lifetime and current inspection insights to assess the expected remaining lifetime of the assets in an iterative process. Such asset information allows to determine frequency and timing of inspections as well as condition adapted maintenance and renewal works even better.

Figure 2: Linking life cycle cost modelling and continuous network inspection

Due to growing amounts of inspection data collected and the increased use of software-based asset models, an advanced level of digitalization is helpful for this approach.

Well-developed LCC models reflecting current asset values along the life cycle while continuously being updated by inspections and modern diagnostics provide reliable information to develop a maintenance and renewal strategy that can assure a permanently good network condition.

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[1] Life Cycle Costing (LCC) means considering all the costs that will be incurred during the lifetime of the product, work, or service.

3. Expenditure on maintenance and renewal averaging about 40% of total expenditure are substantial for IM. Deferring M&R for budgetary or other reasons does not usually lead directly to a loss of quality in the short term. However, it shows that in the longer term this approach increases overall rail infrastructure spending and is not sustainable.

For all Infrastructure Managers, asset condition depends on the following influencing factors: asset age, asset utilization and the extent of maintenance and renewal provided to sustain the asset condition and lifetime, as shown in figure 3 below. Network utilization reduces the asset's lifetime and its condition while maintenance and partial renewal improve the condition and extend the asset's lifetime. With a full renewal, the asset lifetime ends, and a new asset is installed.

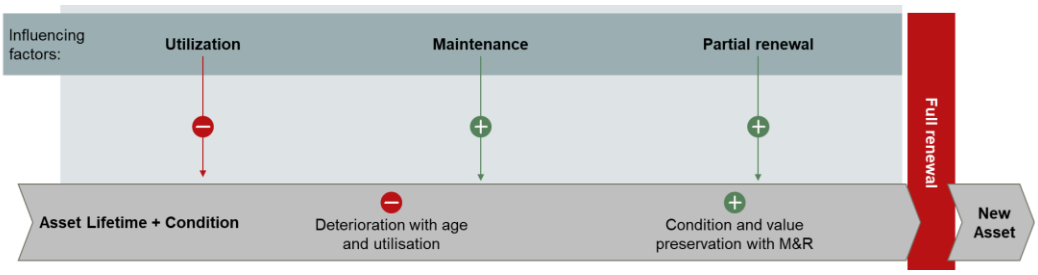

Figure 3: Influencing factors on asset condition and asset lifetime

Keeping up a good network condition calls for appropriate maintenance and renewal measures, which increase safety, as well as measures that sustain the asset's optimal lifetime and optimize the total life cycle cost of the asset. The interdependencies of these factors are highly complex, calling for a clear focus for an IM' s maintenance and renewal strategy. The majority of IM primarily focus their M&R activities on safety. M&R strategies that prioritize sustainable asset condition and optimize life cycle cost are rarely found. The reason for this strategic focus seems to be a lack of, or uncertainty about sufficient maintenance and renewal budget.

In three spotlights the study highlights how purely focusing on safety and reducing the amount of preventive maintenance can reduce expenditures in the short and mid-term of the asset life. However, it can also be shown that these short-term savings are not sustainable as they cause higher maintenance and repair expenditures in the future and shorten the life of the assets, which results in even higher future renewal expenditures.

Spotlight 1: Effects of preventive maintenance on steel bridge lifetime

Regular preventive maintenance and repair prolongs the lifetime of assets and helps to control the total life cycle cost of the assets. This is illustrated based on the example of a new steel bridge, in figure 4 below. If the bridge is built well structurally, which should be inspected within the first five years, it has the potential to last up to 150 years. If a preventive anti-rust steel coating is applied every 25 years, the bridge is able to reach this potential. However, if this preventive maintenance is skipped or postponed, corrosion will start to set in starting from approximately year 25. Once corrosion has appeared, corrective maintenance can only slow down the degradation, not return lost condition. With time, parts of the bridge or its entirety will need to be renewed due to rust and corrosion damage. A steel bridge will reach approximately 100 years of age before the need for renewal if no preventive maintenance has been performed. Shortening the bridge life by one third means a considerable loss in value of an expensive asset, which far exceeds the preventive maintenance cost (anti-rust steel coating) avoided.

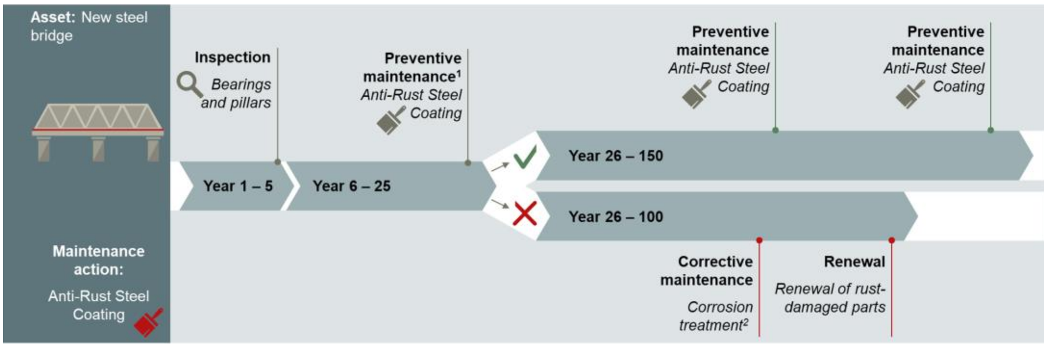

Figure 4: Effect of preventive maintenance on the lifetime of a steel bridge

Spotlight 2: Effects of preventive maintenance on track lifetime

A study on tamping frequencies and their effect on track condition was conducted by the TU Graz in 2022[2] and it provides data supporting the observation that

[2] (S. Marschnig, G. Neuper, F. Hansmann, M. Fellinger, J. Neuhold "Long Term Effects of Reduced Track Tamping Works", Applied Sciences Jan 2022, https://www.mdpi.com/2076-3417/12/1/368)

preventive maintenance increases asset lifetime and reduces the frequency of the expenditure over the lifetime of an asset, as described in spotlight 1.

Tamping is the most important and most costly maintenance action in ballasted railway track. Based on data, the study evaluates and compares different tamping regimes and their long-term consequences. The study models different scenarios. In a scenario 1 trough-going line tamping is carried out right from the beginning of the track lifecycle. Ultimately this scenario leads to a service life of 49 years. In scenario 2, line tamping as a preventive maintenance activity only starts in year 10 of the track life. Until year 10 safety limits are complied with by spot tamping activities only. Spot tamping concentrates on repairing failures. The track quality level provided by spot tamping remains below the quality level that is achieved with line tamping though. This leads to relevant short-term savings in maintenance budget in the first ten years. After the first 10 years, however, the maintenance expenses increased considerably and even exceed the expenses of the first scenario due to a quality catch-up effect. Ultimately this second scenario leads to a total service life of 43 years. The study concludes: short term savings and pure focus on safety ultimately result in both (12%) shorter service life AND (20%) higher total maintenance costs.

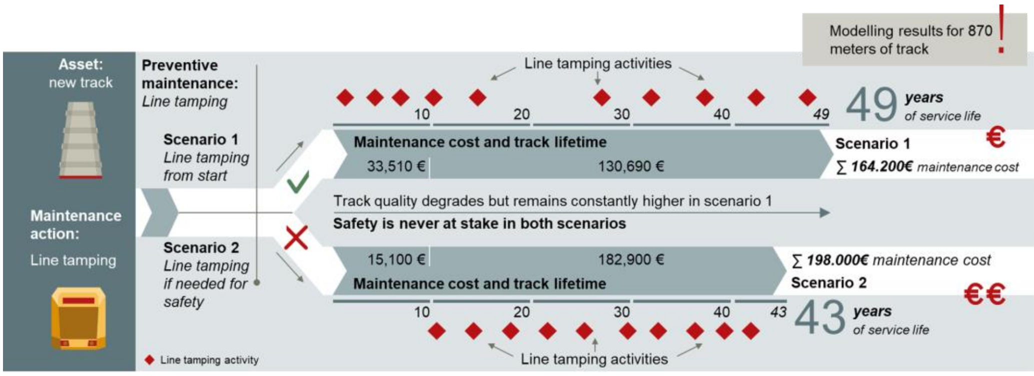

Figure 5: Long term effects of reduced track tamping works

Spotlight 3: Effects of preventive maintenance on extreme weather resistance

The statement that maintaining a good asset condition is more economic than the costs of future negative effects caused by the lack of sufficient M&R becomes even more relevant in the face of surging extreme weather events which put an increased strain on infrastructure systems. This is illustrated by the example of track maintenance in figure 6 below.

The cleaning of the track drainage systems is a preventive maintenance that assures adequate track drainage in case of rain, becoming crucial in cases of heavy rainfall. In dry years, the lack of preventive maintenance on the drainage systems is unlikely to have negative effects on the track condition and no additional costs are created. In years with heavy rainfall however, the track becomes flooded if the preventive maintenance of cleaning the drainage systems was not properly performed. The IM now has two choices in order to restore the track for safe train operation: performing corrective maintenance or putting speed restrictions in place. If ballast cleaning or renewal is performed as a corrective measure, the track is restored to good condition. If speed restrictions are placed, the effects of the flooding continue to accelerate the deterioration of the track condition, resulting in the need for asset renewal.

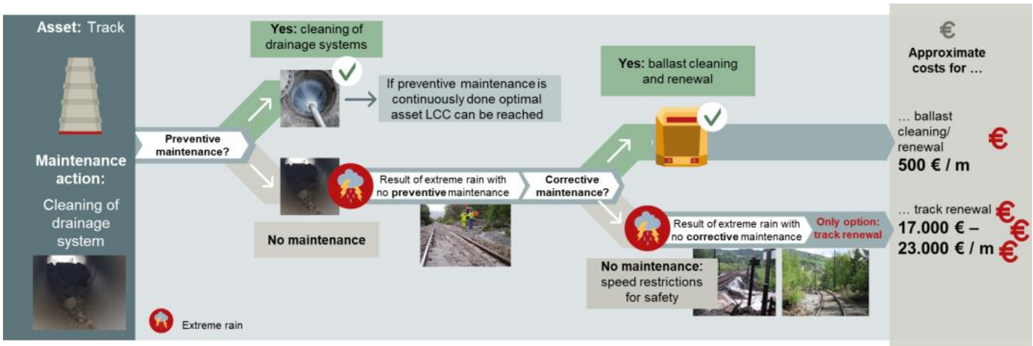

Figure 6: Effect of preventive maintenance on extreme weather resistance

This spotlight illustrates, how not only preventive but also corrective maintenance can have a significant impact on reducing overall lifecycle costs. If ballast cleaning or renewal is performed as a corrective measure after track flooding, the costs are 40 times lower than expenses for a track renewal which is needed if no maintenance is done. It should be emphasised that the best case is to have a preventively maintain track condition, which is robust enough to resist extreme weather. With poor asset condition the robustness of track to handle such build-in weather resilience is limited as is depicted in the example of figure 6 above. However, the next best measure after preventive maintenance in calm weather, is to carry out corrective maintenance as soon as the first damage occurs.

Thus, from a long-term perspective, budgetary reasons seem to speak in favour of an M&R strategy that focuses on sustainable asset conditions rather than failure repair and ultimately safety only. However, with very high M&R budget requirements, which might even be increased in view of existing backlogs, it can still be difficult for IM to implement a strategy that is economical in the long term.

To conclude: It is generally recognized that the condition of railway infrastructure depends crucially on (the extent of) continuous preventive maintenance and repair. Due to the longevity of railway infrastructure however, preventive maintenance may be deferred and reduced to corrective measures for a certain time without any immediate impact on safety and the quality of service.

Such reduction only backfires with a time lag, after which the total cost of maintenance often exceeds the initial savings, the service quality deteriorates and the need for earlier renewal pushes up expenses even more.

A conflict of interest exists for all those in charge of railway infrastructure between short-term saving opportunities in maintenance operations and an economically sustainable infrastructure maintained in the long-term. Obtaining long-term funding commitments combined with incentives to maintain an economically viable network on an ongoing basis offers a way out of this conflict.