STRATEGIC MAINTENANCE AND RENEWAL POLICY OF A

RAILWAY CORRIDOR, TAKING INTO ACCOUNT THE

VALUE OF CAPACITY

Yves PUTALLAZ
Robert RIVIER

EPFL-LITEP, Bâtiment GC, CH-1015 Lausanne, Switzerland
Tel: 00 41 21 693 24 79
Fax: 00 41 21 693 50 60
e-mail: yves.putallaz@epfl.ch
        robert.rivier@epfl.ch

Abstract

The paper presents a research [1]that aims to develop a methodology that supports the elaboration and the optimisation of long term maintenance and renewal policies for railway infrastructure (strategic planning level, up to 20 years). The elaboration process takes the capacity, in other words the costs of track possessions, into account.

The developed methodology is divided into two steps: the optimal track possession estimation and the maintenance and renewal policy elaboration.
A long term maintenance and renewal policy sets the decision framework that applies to the medium-term planning process, which defines the maintenance and renewal program (tactic level, up to 6 years). This decision framework avoids that planning works only focus on a medium-term optimisation, without considering the life-cycle and the long term evolution of the infrastructure (and thus leading to a fatal loss of substance). The decision framework sets the part of infrastructure that should be yearly maintained and renewed, at the corridor or network level, as well as the type of material to use at the time of renewing components.
The first step provides the track possession strategy that minimise the costs of the maintenance and renewal actions. The model receives as input the costs of the track possession, calculated with a capacity assignment model (see : "Capacity Evolution Modelling for Long Term Planning", Moreira N., et al), and the structure of the network. The track possession strategy defines then the costs of maintenance and renewal actions, including the track possession ones.

On the second stage, the long term maintenance and renewal policy is evaluated by applying the corresponding decision framework to a simulation of maintenance and renewal needs engendered by the traffic scenarios.

The paper includes some results from a case study where the model has been applied to a strategic railway corridor, in Switzerland, showing the impact of the cost of capacity (track possessions) over the long term maintenance and renewal policy.

Keywords

Railway infrastructure, Long-term planning, Maintenance and Renewal, Track possession, Policy simulation.

---

[1] Research undertaken within the European project IMPROVERAIL [1].

---

1. INTRODUCTION

1.1 GENERAL ASPECTS

The European transport policy as well as environmental concerns related to transport guide to a traffic increase on the main European railway corridors. A substantial growth of traffic on a railway corridor implies an increase of infrastructure wearing out and, logically, an escalation of maintenance and renewal necessary resources, in particular track possessions. This consequently reduces the capacity availability and contrasts with the traffic growth. Moreover, infrastructure managers experience pressures from train operators, who request more train-paths, at a lower price, whereas public entities, generally owner of infrastructure, tend to cut maintenance and renewal budget. Therefore, managers need to find a balance between availability (implying fewer track possessions) and quality (implying more track possession) of infrastructure.

1.2 FIELD OF STUDY

Although the infrastructure includes several elements, the developed model encompasses only three basic elements: rails, sleepers and ballast, leaving out bridges, tunnels, catenaries and other items. The reasons are:

- M&R data for rails, sleepers and ballast are sufficiently available,
- these elements usually represent the major part of M&R[2] costs,
- the engineering works related to these elements are more slot consuming than the others,
- bridges and tunnels should be seen as separate projects, where specific planning tools must be used (and already exist).

However, the methodology and approach proposed below should be suitable for any other elements for which a maintenance function (quantity of maintenance related to the age of the component) can be defined.

---

[2] M&R: Maintenance and Renewal.

Yves Putallaz / yves.putallaz@epfl.ch / http://litep.epfl.ch

2. STRUCTURING OF RAIL INFRASTRUCTURE MANAGEMENT

2.1 OVERALL APPROACH

This chapter briefly describes the structuring of rail network management used along this research.

A way of structuring the rail network management may to consider that the evolution of the rail infrastructure may be controlled trough three parameters: the capacity of the network, the substance[3] of the infrastructure and, finally, the geometric quality of the track. These three parameters should be adjusted in order to reach high network efficiency:

Parameter	Adjustment mean
Capacity	• Hard investment : construction of a new line or an additional track • Hard disinvestment : dismantlement of a line or a track • Soft investment : upgrade of signalling system (decrease of headways)
Substance	More or less renewal of components (sub-layer, ballast, sleepers and rails)
Geometric quality	More or less track maintenance (rails grinding and ballast tamping)

However, the three parameters can't be adjusted independently. There are strong links between them. The figure above describes this fact.
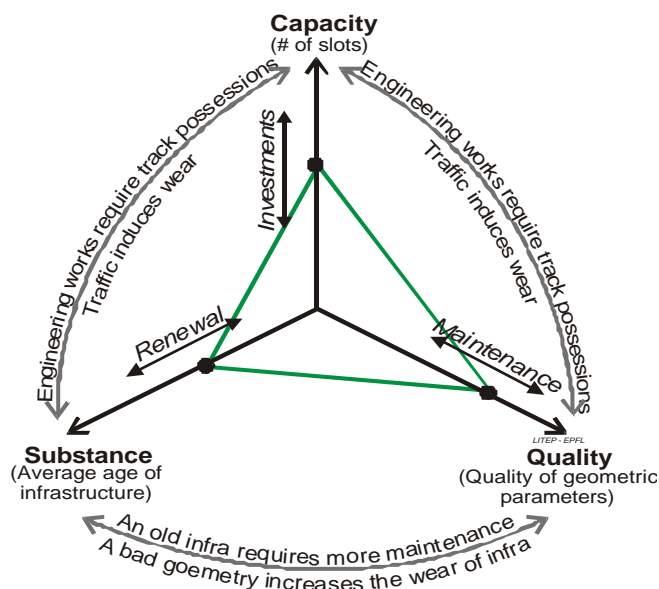

Figure 1: Engineering "macro" parameters of railways track.

The objective of the infrastructure manager is to find the optimal balance between the three parameters. As the rail infrastructure is characterized by a rather high planning inertia

---

[3] By substance, one means the remaining life time of components. A young infrastructure has a high substance.

(extension projects may take several years to be implemented), the management of the infrastructure must be based on a long term strategic plan, including a long term strategic maintenance and renewal policy.

2.2 STRATEGIC MANAGEMENT

The strategic management of a railway infrastructure should be steering the evolution of the rail network by providing management rules to the tactical level. These rules are:

- Location and amplitude of capacity adjustments,
- M&R strategic policy, composed by three major rules: average substance of the infrastructure (or ratio between maintenance and renewal), type of component to use and quality of infrastructure.

These rules should be adapted regarding feed-backs provided by the tactical management.

2.3 ROLE OF THE PROPOSED MODEL IN THE STRATEGIC INFRASTRUCTURE PLANNING PROCESS

The long-term M&R policy elaboration is tightly linked with the long-term capacity needs evaluation as well as with the medium-term planning. This is obviously also the case for the proposed approach for modelling. The M&R policy elaboration model gets inputs from the capacity evolution modelling [2] and provides inputs for the medium-term M&R planning process (tactical level). There are also feedback loops between the medium term and the long term planning.

The basic structure of the long term M&R policy elaboration model has two stages: the M&R rules quantification, the optimal interval calculation (costs estimation) and the M&R simulation. These two stages will be detailed along the next chapters.
The following figure illustrates the role of the long-term policy elaboration within the strategic M&R planning process and shows the basic structure of the proposed approach.
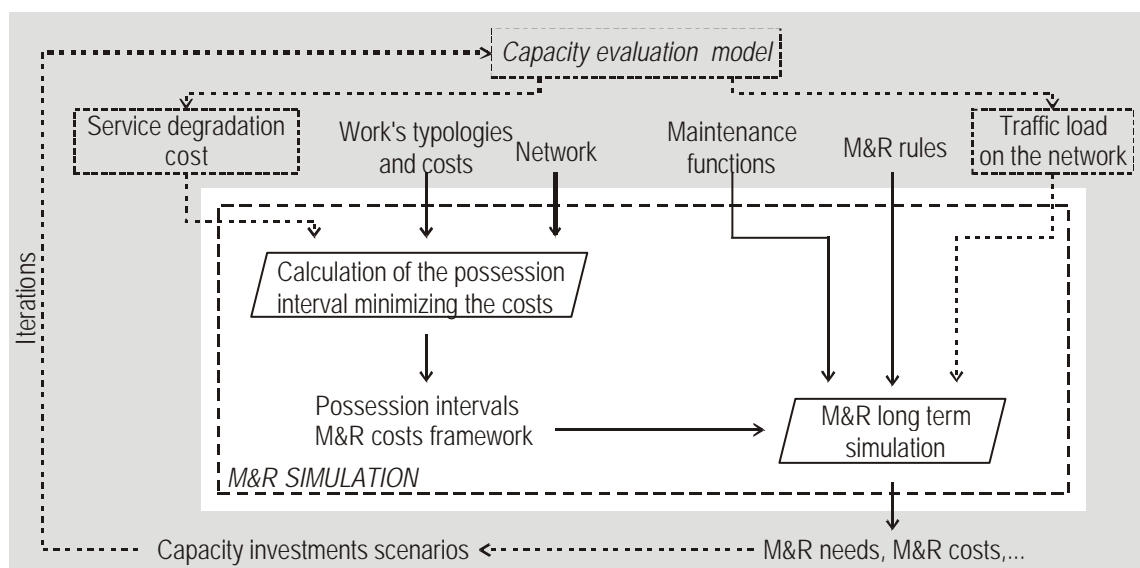

Figure 2: Role of long term M&R policy elaboration within rail infra strategic management.

Yves Putallaz / yves.putallaz@epfl.ch / http://litep.epfl.ch

3. PROPOSED APPROACH FOR MODELLING

3.1 HYPOTHESIS AND BASIC STRUCTURE OF THE MODEL

3.1.1 OBJECTIVE OF THE MODEL

The model aims to provide support to infrastructure managers when they elaborate long-term policies regarding maintenance and renewal of their railway network. The objective is to quantify guidelines (planning rules) for maintenance and renewal tactical management.

3.1.2 IMPORTANCE AND COST OF POSSESSION INTERVALS

Maintenance and renewal actions for rails, sleepers and ballast usually cause traffic interruptions. These track possession intervals restrict the availability of free slots for operators and, must therefore be taken into account when making the long-term M&R policy. For instance, unavailable slots on heavily loaded sections were likely to have been sold to an operator and, thus, the number of M&R interventions should be kept rather small in order to minimise the loss of earnings. Beside this, risks of traffic disturbance such as delays, rerouting and service cancellation are higher on those sections. The situation may be different on fairly loaded line, where the needs in free slots and the train density are smaller.

The proposed model deals with this fact trough the calculation of an optimal possession interval, minimising costs of capacity (rerouting of trains, delays, service cancellation) and costs of works. The model takes into account the value of capacity when simulating the M&R policy on the network.

A detailed optimal interval calculation is rather complex as several factors influence the costs. These factors are related to the type of intervention, to the mechanisation rate, to local conditions. Furthermore, the quantification of capacity costs is hard to undertake thoroughly. These aspects don't fit with the long-term planning activities, characterised by a high degree of uncertainty. Therefore, the model uses a simplified approach for capacity costing (see [2]) as well as for the cost structure of works (presented below).

3.1.3 DESCRIPTION OF THE INFRASTRUCTURE (HOMOGENEOUS SECTIONS)

The infrastructure to analyse is divided into homogeneous sections. Homogenisation criterion may vary from a network to the other but should reflect as much as possible infrastructure wearing factors. As criterion, one may adopt the type of components, the stability of the sub-soil, the track layout (radii), etc. Homogeneous sections may be rather small. One should keep in mind that the objective of the model is to evaluate M&R global need on a railways link, in the long term. The slicing into rather small homogeneous section is only a way to describe the infrastructure and to evaluate M&R needs. Homogeneous sections don't have any managerial meaning.

3.1.4 COMBINATION OF RENEWAL ACTIONS

Renewal or maintenance of rails, sleepers and ballast can't be considered separately as the possible combination of actions on these elements influences costs dramatically. Therefore, the simulation process considers the three components simultaneously. Then, the cost calculation and possible budget check is done for the combination of the works.

3.1.5 TIME COHERENCE OF ACTIONS

The time coherence of actions is checked, section by section. For instance, at the time of rail renewal, the simulation process controls the state of sleepers and ballast. If any of these elements reaches its respective threshold, the model launches its renewal as well. So, for instance, the process avoids non-coherent cases where sleepers are renewed one year after rails.

Yves Putallaz / yves.putallaz@epfl.ch / http://litep.epfl.ch

3.1.6 SPATIAL COHERENCE OF ACTIONS

The process outputs a list of homogeneous sections that should be renewed. As homogeneous sections are rather small, the one which must be renewed must be clustered into larger worksites. In order to fine tune the estimation, the clustering takes into account a maximal length of worksite. If the total length of track to be renewed is larger than the maximal length of one worksite, the process generates another worksite(s). The maximal length of worksites could be chosen as the average length of actions that have been undertaken in the past.

3.1.7 M&R RULES

M&R rules are guidelines for tactical planning of the infrastructure M&R. Infrastructure managers may use many rules and it is difficult to encompass all of them. Thus, the approach considers three basic M&R rules:

1. Renewal threshold: this is a certain amount of traffic, expressed in UIC fictive tons[4], or a certain number of years after which a renewal action should be launched.
2. Type of components that must be used at the time of renewal.
3. Quality of infrastructure (quality of the geometry).

The value of these rules, namely values of thresholds and type of components, will be considered as variables and their combined variation may lead to a minimal total of M&R actions over the planning span.

Annual length that should be renewed and maintained: these 2 values set the target of any medium term M&R planning or optimisation processes. This is rather crucial as models dealing with medium term optimisations may lead to "only maintain" policy, the railway infrastructure having a high inertia.

3.1.8 QUALITY OF INFRASTRUCTURE – MAINTENANCE FUNCTIONS

The quality of the infrastructure plays a key role in the whole railway system. The quality and reliability of the operator's services as well as the wearing of rolling stocks and infrastructure itself depends on the quality of the infrastructure. The model takes into account this key input through the maintenance functions. The latter characterise every type of element and give the length that must be maintained as a function of the age (expressed in UIC fictive tons or in years) of the component. Obviously, a higher maintenance rate should lead to an increase of quality.

3.1.9 PLANNING HORIZON

The objective of the model is long term oriented, long term being defined as the time period between 6 and 20 years ahead. The length of the planning range engenders the risk that the amount of information required by the simulation method grows tremendously. Therefore, the model uses a simple approach that ensures a reasonable amount of data while keeping the quality of results at an acceptable level, as the uncertainty related to long-term planning is usually rather high.

---

[4] UIC code 714-R

3.2 FIRST STAGE: OPTIMAL INTERVAL CALCULATION

3.2.1 CONCEPT OF THE MODEL

The capacity evolution modelling [2] first assigns the forecasted demand on the considered network. It provides the traffic (number of trains per category) on the links and information on the saturation of the network. In a second phase, new assignments are undertaken but with increasing possession intervals on a specific link. This step is repeated for each link and the whole process provides the costs of interval possession time over the network. These costs are composed of the cost of re-routing train, the cost of delays and costs related to the cancellation of services.

Costs of interval possession and traffic flows are then used for the calculation of the optimal interval possession. Thus, they bring to the infrastructure's engineering side the value of the capacity. The following figure illustrates the concept of the process.
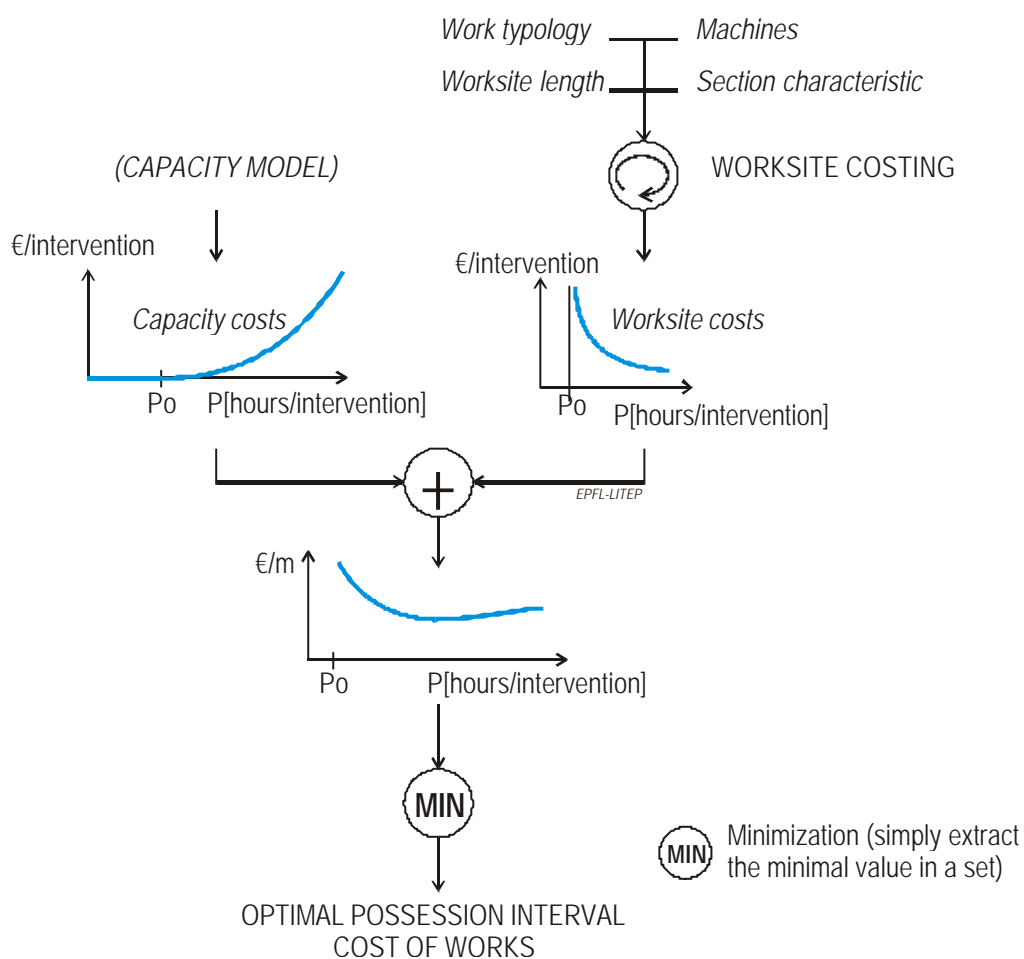

Figure 3 : Concept of the optimal interval calculation model.

Yves Putallaz / yves.putallaz@epfl.ch / http://litep.epfl.ch

3.2.2 THEORETICAL ASPECTS

The first part of the methodology consists in the determination of the optimal track possession interval minimising the sum of costs of works and the costs of possession intervals. The following chapter describes a process that will be used.
One has to keep in mind that the process should deal with the long-term planning. This implies some basic assumptions and some simplifications that shouldn't be made in an operational planning step but that are adequate for strategic planning.

Following factors play a key role in the cost function:

- Type of work to be undertaken
- Used technology and worksites organisation
- Layout of the network in the worksites region

Type of work to be undertaken

Obviously, the type of the intervention that must be done on the network influences the costs of the work. Some actions are very cost extensive.

Used technology and worksites organisation

The technology used for a specific intervention affects several cost drivers such as the cost of machines, the cost of manpower, the cost of interval possession,… Worksites organisation plays also a key role in the costs. However, it is very difficult to predict the way worksites will be organised in 20 years.

Layout of the network in the worksites region

When the track has to be freed for traffic, machines must be shunted to a siding. This requires a certain time, depending on the velocity of machines, and implies a specific cost, both of them depending on the distance separating the siding to the worksite. Obviously, a "slim" network – with few sidings – means bigger shunting time, decreasing the available time for the work and thus increasing related costs.

Description of work processes and modelling

Railways engineering is characterised by the multiplicity of technologies used for maintenance and renewal activities. Networks often have developed their own technology, in collaboration with machines suppliers, usually in connection with the methodology they apply on their network. It is therefore rather hard to define exhaustive generic worksites typologies. However, in order to carry out case illustrations, three basic typologies have been defined. Obviously, a possible final version of such a decision tool may include a "typology editor", where the user could define its own worksites typologies.

3.2.3 MODELLING WORKSITES

The modelling description uses the following basic parameters. Variations may be introduced and will be related to worksites typologies diagrams.

Costs:
Ctot   [€]   : Total cost of a maintenance or renewal action, including track possession related costs
Cact   [€]   : Cost of a maintenance and renewal work action
Cint   [€]   : Cost of the possession intervals for the whole action
cw   [€/intervention]   : Cost of one work intervention
cint   [€/intervention]   : Cost of one possession interval
clin   [€/m]   : Linear cost of one work action (cost of laid equipment, for instance)

Time:
tint   [h]   : Track possession interval during one intervention
twork [h]   : Real available time for the work
tmove [h]   : Required time for shunting the machines from sidings to the worksite
Tinst [h]   : Required time for the preparation5 of the machines on the worksite

Lengths:
Lact   [km]   : Length of the track where a maintenance or renewal action must be done
lwork [km]   : Length that can be handled during one intervention (one possession interval)

Others:
nint   [-]   : Number of work intervention (or number of required possession intervals) to fulfil the action
Vwork [km/h] : Work speed of the considered machine
Vmove [km/h] : Machine velocity when shunting
dsid   [km]   : Distance separating the siding from the worksite
Lsec   [km]   : Length of the section between two sidings

Three generic worksites have been defined:
- worksites with one machine doing one run (example: tamping),
- worksites with one machine doing several runs (example: grinding),
- worksites with two machines doing one run (example: track renewal).

Figures below describe the three generic worksites. Mathematical formulation will be shown only for the "one machine, one run" case.
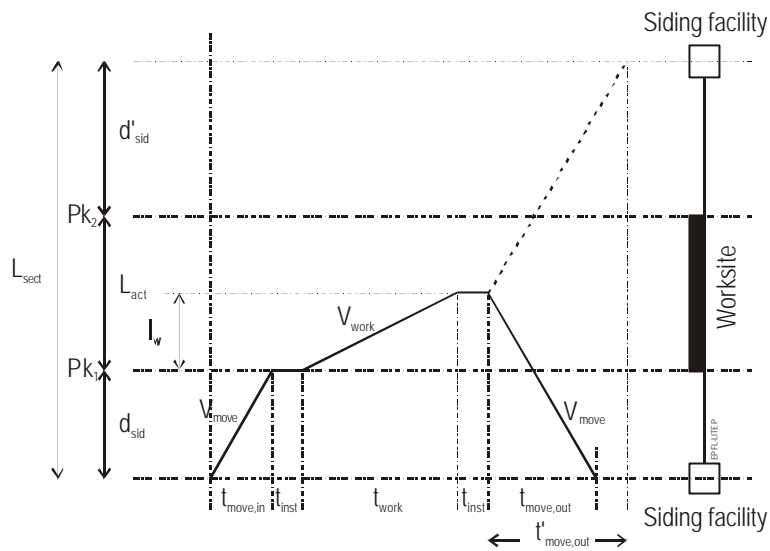
---

[5] before and after the work

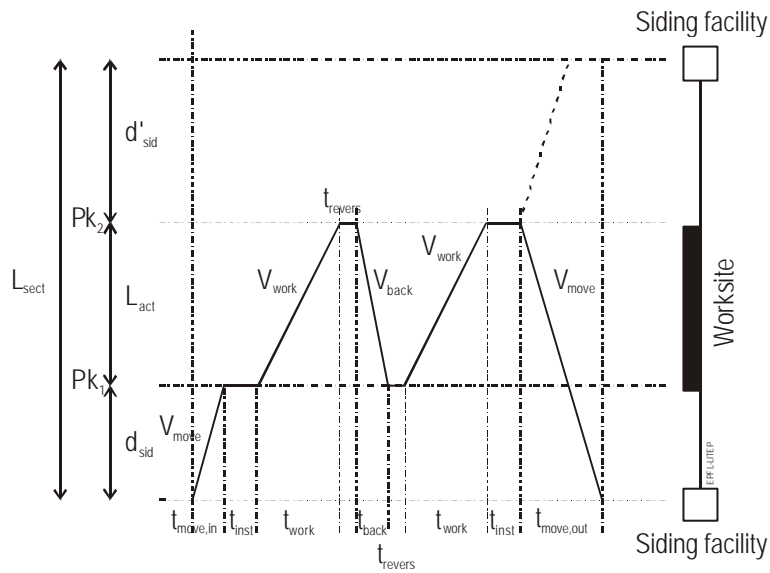*Figure 4 : Generic worksite: one machine, one run case*

Figure 5 : Generic worksite: one machine, several runs case
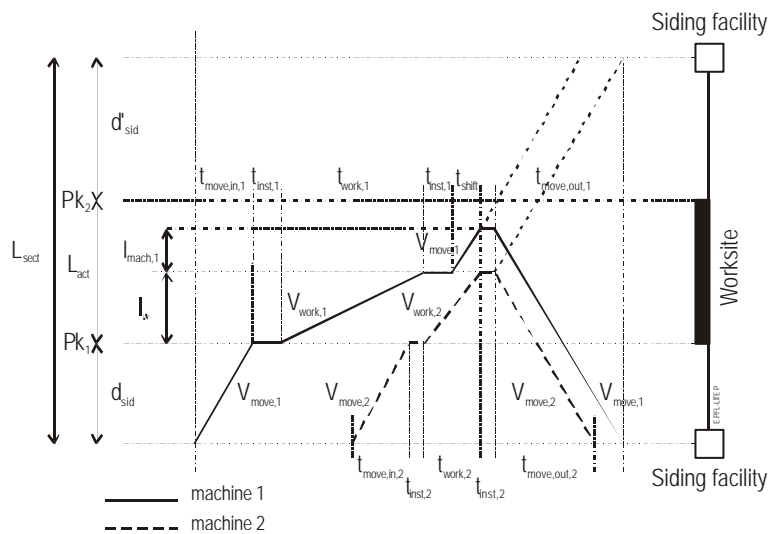

Figure 6 : Generic worksite: two machines, one run case

1.1.1.1 Mathematical formulation: "one machine, one run" case

The interval possession may be expressed as the sum of the time to move the machine to the worksite and back to the siding, the time to install / uninstall the machine for the work and the time when the machine is properly working. One gets:

$$t_{\text{int}} = t_{move,in} + t_{inst} + t_{work} + t_{inst} + t_{move,out} \qquad (1)$$

With V_{move} and V_{work}, one gets:

$$t_{\text{int}} = \frac{d_{sid}}{V_{move}} + T_{inst} + \frac{l_{work}}{V_{work}} + T_{inst} + \frac{(d_{sid} + l_{work})}{V_{move}} \qquad (2)$$

where T_{inst} is considered as a constant (dependant of the machine). This equation can be rewritten:

$$t_{\text{int}} = 2 \cdot T_{inst} + 2 \cdot \frac{d_{sid}}{V_{move}} + l_{work} \cdot \left(\frac{1}{V_{work}} + \frac{1}{V_{move}} \right) \qquad (3)$$

The number of interventions that are necessary to achieve the work actions is:

$$n_{\text{int}} = \frac{L_{act}}{l_{work}} \quad (4)$$

and with (3)

$$n_{\text{int}} = L_{act} \cdot \left(\frac{\dfrac{1}{V_{move}} + \dfrac{1}{V_{work}}}{t_{\text{int}} - 2 \cdot T_{inst} - \dfrac{2 \cdot d_{sid}}{V_{move}}} \right) \quad (5)$$

Costs of engineering works may be split into linear costs (c_{lin}) and intervention unit costs (c_{int}). In our approach, linear costs include only construction material (namely ballast, sleepers and rails). Intervention unit costs include the machines and the labour. In fact, however large is the interval possession, workers must be paid more or less 8 hours. Moreover, one has to think about the costs of overtime work and other facts that are relevant to the law regulating conditions of work in the country. An example of cost definition appears within the real case illustrations.

The cost of the work action is given by:

$$C_{tot} = C_{act} + C_{\text{int}} \qquad (6)$$

where C_{act} represents total engineering costs and c_{int} the cost of one possession interval and is given by the capacity modelling method as a function of the possession time (t_{int}). C_{int}, the total cost of traffic alteration (during the whole period of engineering works) is:

$$C_{\text{int}} = c_{\text{int}} \cdot n_{\text{int}} \quad (7)$$

C_{act} is given by:

$$C_{act} = c_{work} \cdot n_{int} + c_{lin} \cdot L_{act} \quad (8)$$

Combined with equation (5), (8) gives:

$$C_{act} = L_{act} \cdot \left[c_{work} \cdot \left(\frac{\dfrac{1}{V_{move}} + \dfrac{1}{V_{work}}}{t_{int} - 2 \cdot T_{inst} - \dfrac{2 \cdot d_{sid}}{V_{move}}} \right) + c_{lin} \right] \quad (9)$$

Finally, using equations (6), (7) and (9), one gets :

$$C_{tot} = L_{act} \cdot \left[(c_{work} + c_{int}) \cdot \left(\frac{\dfrac{1}{V_{move}} + \dfrac{1}{V_{work}}}{t_{int} - 2 \cdot T_{inst} - \dfrac{2 \cdot d_{sid}}{V_{move}}} \right) + c_{lin} \right] \quad (10)$$

1.1.1.2 Example of result

This paragraph just shows an example of output, extracted from the real case illustration elaborated within the IMPROVERAIL project.
The figure below presents different costs related to a 525 metres ballast screening action, in function of possession interval duration. This worksite occurs within am engineering section of 8650 meters. An engineering section is the portion of line between two sidings.

Engineering vs service degradation costs :
worksite length : 525 m, engineering section length 8'650 m, year 2001
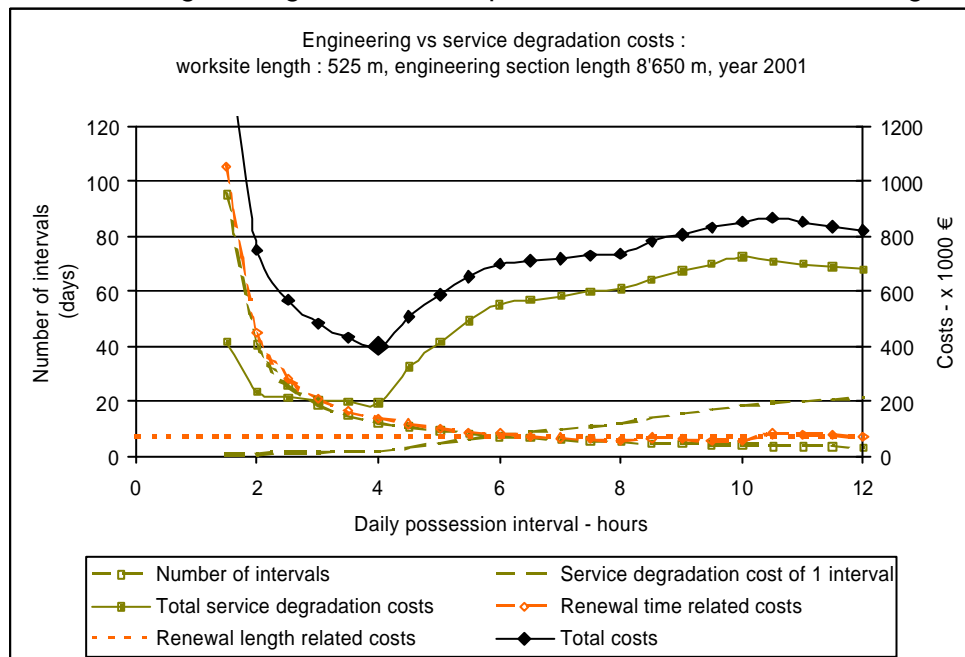
The optimal interval is 4 hours during 12 days. The number of intervals obviously decreases with the duration of one interval. Renewal time-related costs are track engineering costs that are related to the time (labour, machines, etc) The renewal time related cost curve looks similar to the one of interval number. The offset at 10 hours represents extra costs due to a second work team. Renewal length related costs are costs that specifically depend on the length of the worksite, such as the cost of material.

3.3 SECOND STAGE: SIMULATION OF THE LONG TERM M&R POLICY

3.3.1 CONCEPT OF THE M&R SIMULATION PROCESS

The process simulates the maintenance and renewal actions engendered by the wearing of the infrastructure due to traffic. These actions correspond to a maintenance and renewal policy that is defined according to the know-how of the infrastructure manager.
In a second phase, maintenance and renewal actions are again simulated but with adapted maintenance and renewal policies. This step-by-step adaptation constitutes the optimisation process of the policy elaboration. The best maintenance and renewal policy minimises the costs over the long-term planning period but ensures the required level of quality of the infrastructure.

3.3.2 PROCESS OF SIMULATION
This paragraph describes the simulation steps.

1. Application of the first M&R policy rule: the maximal age threshold. This allows steering the average age of the infrastructure, in other words, the substance of the infrastructure. The age, here expressed in cumulated gross train tonnages (or UIC cumulated fictive load) of components are compared with limits set by the policy. If a component has reached the threshold, its renewal is launched.
2. Then, a work combination takes place (time coherency). The process checks if other components have reached or nearly reached their respective thresholds. This is done through the use of a margin, which is added to the current accumulated load, and the comparison of this sum to the respective thresholds. This allows the time coherence of renewal actions, avoiding for instance, that a ballast renewal is launched one year only after a rail renewal. Once the combination done, the process chooses which kind of action should be undertaken (integral renewal, rail renewal, etc.).
3. The process repeats the two above mentioned steps until the end of an engineering section is reached. Then, the model sums the lengths of launched renewal and generates worksites (spatial coherency). If the total length of sections that must be renewed is bigger than a certain threshold, it is divided into more worksites. This step is crucial as the cost of worksites strongly depends on its length.
4. The renewal cost calculation is undertaken on the basis of these generated worksites.
5. If there is a budget restriction and the budget isn't sufficient, renewal actions on the engineering section are cancelled.
6. If there is enough budget or there is no budget restriction, the "renewal is achieved", in other words the assets database is updated, according the second M&R rule, the type of component to use at the time of renewal.
7. If no renewal has been launched, the process calculates the length of track to be maintained, using maintenance functions. The length is determined for each homogeneous section, as the product of the section length and the maintenance probability given by the related maintenance function. These maintenance lengths are summed for each engineering section and aggregated into worksites (with the same principle as 3)).
8. Then, the model calculates maintenance costs.
9. Finally, after every engineering section, calculated values are stored in a table. The latter will be used by queries and routines to build the outputs.

The following figure shows the simulation concept.
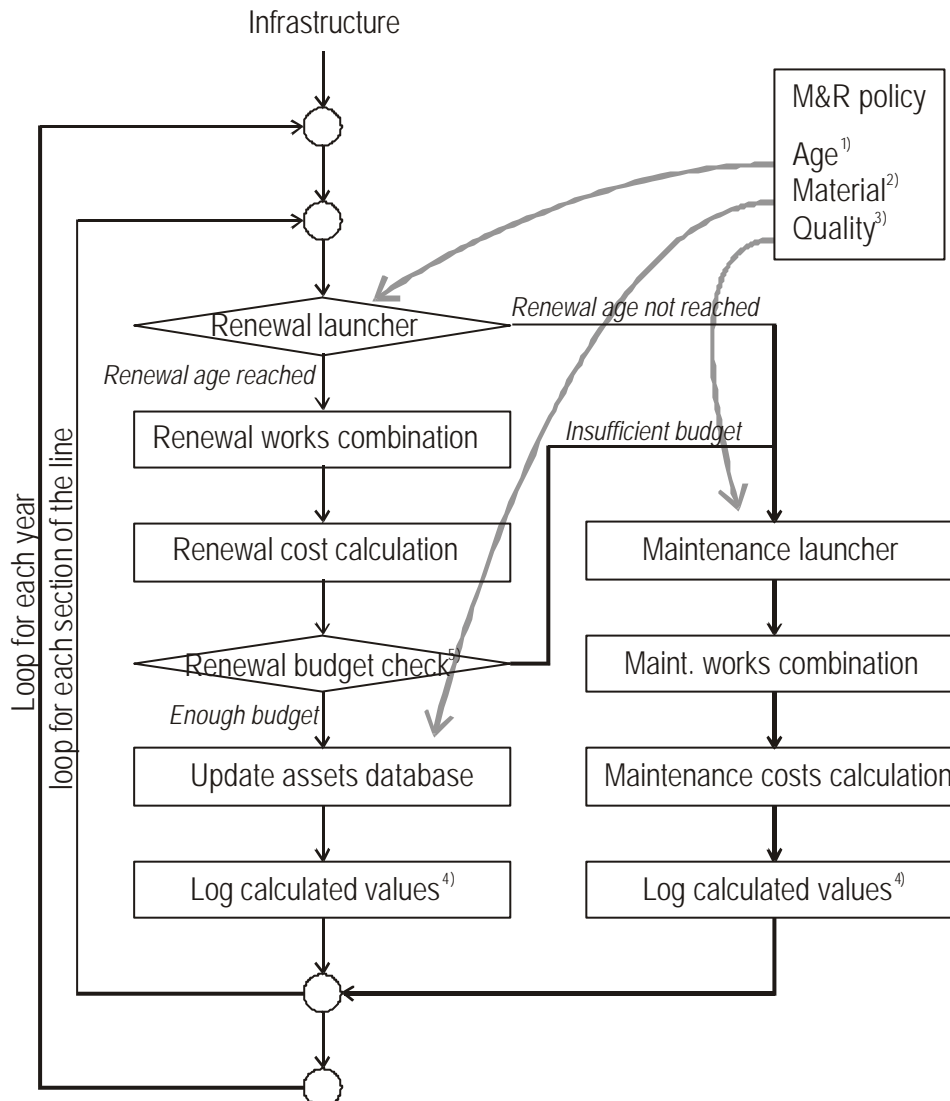
1) Expressed in cumulated gross train tonnages or UIC fictive tons
2) Type of rails, type of sleepers, type of ballast
3) Quality thresholds (geometry). These thresholds are considered through
maintenance functions
4) For each link, for each year : length and cost of M&R actions, average age of infrastructure,...
5) Optional

Figure 7 : Strategic maintenance and renewal policy simulation process

3.3.3 SOME RESULTS

A real case illustration has been undertaken within the research project. The model has been applied on the North-South Swiss corridor and specifically on the Gotthard line. The figure below provides calculated lengths of maintenance (tamping and grinding) and renewals (integral and rails only) for a given traffic scenario.
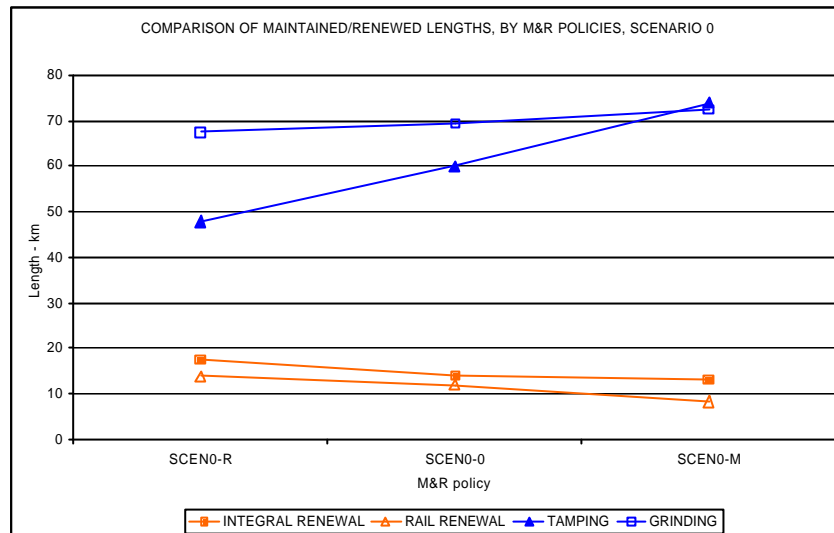

Figure 8: Calculated lengths of maintenance or renewal (average annual values).

The graph shows the clear signification of the simulated M&R policies. The "R" policy foresees more renewals (lower renewal thresholds) as the "M" policy foresees more maintenance (higher renewal thresholds). Beside this, as the quality is meant to stay constant, much more maintenance is necessary when there is less renewals.

The figure below compares simulation results to values extracted from the Swiss Railways M&R database. Simulation results are rather close to the reality, especially if one takes into account that the proposed approach is a "draft" and that some other decision parameters should be implemented into the model.
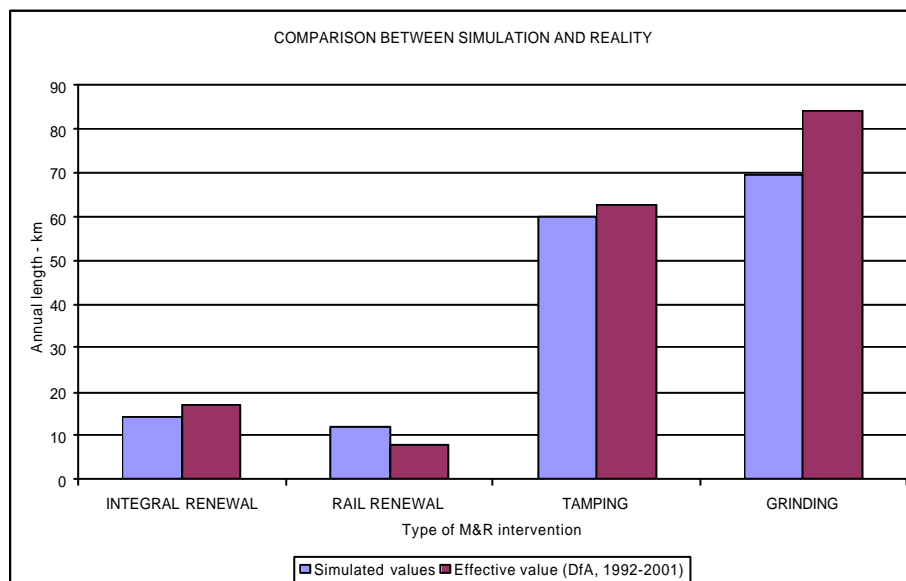

Figure 9 : Comparison of lengths resulting from the simulation and length provided by the database. The simulation is based on demand scenario 0 (constant) and the M&R policy 0.

3.3.4   SOME WORDS ON MAINTENANCE FUNCTIONS

The maintenance function characterises the influence of the traffic (load) on the maintenance actions that should be undertaken on the infrastructure. The more traffic a section gets, the more maintenance should be done on it. Maintenance functions are expressed as a percentage of length to be maintained in function of the accumulated load or the age of the considered component:

$$L_M = \sum_{comp\_type} a_{comp\_type}(age\_cat) \cdot L_{comp\_type, age\_cat}$$

with L_M : length to maintain, $\alpha(age\_cat)$ maintenance function for one type of component of a certain age category and L the total length of track composed by a certain type of component of a certain age category.

These functions allow the calculation of a trade-off between renewal and maintenance expenditures. Logically, the less a network is renewed, the more it should be maintained, in order to keep a constant quality. So, one could expect that decreased renewal costs implies increased maintenance costs as the average networks category of age depends on the renewal policy. Somewhere in between there must be an optimal ratio.

But above all, maintenance functions reflect the quality policy applied by the infrastructure manager. If quality standards are high (for instance geometric faults tolerance are small), it is foreseeable that, for a given infrastructure, more maintenance should be done. Therefore, maintenance functions contain the information of the quality of the infrastructure.

These maintenance functions should be extracted from the history of maintenance interventions of the infrastructure. Thus, they reflect the M&R policy that has been used during the past on the considered network.

$$a_{comp\_type} = \frac{\sum_{network} Lm_{comp\_type, age\_cat}}{\sum_{network} L_{comp\_type, age\_cat}}$$

with L_m: maintained length of track, composed by a certain type of component of a certain age category. This analysis should be done on a large sample (several years) and aggregated.

Next graph shows the tamping function obtained on the basis of the Swiss Federal Railways Assets database.
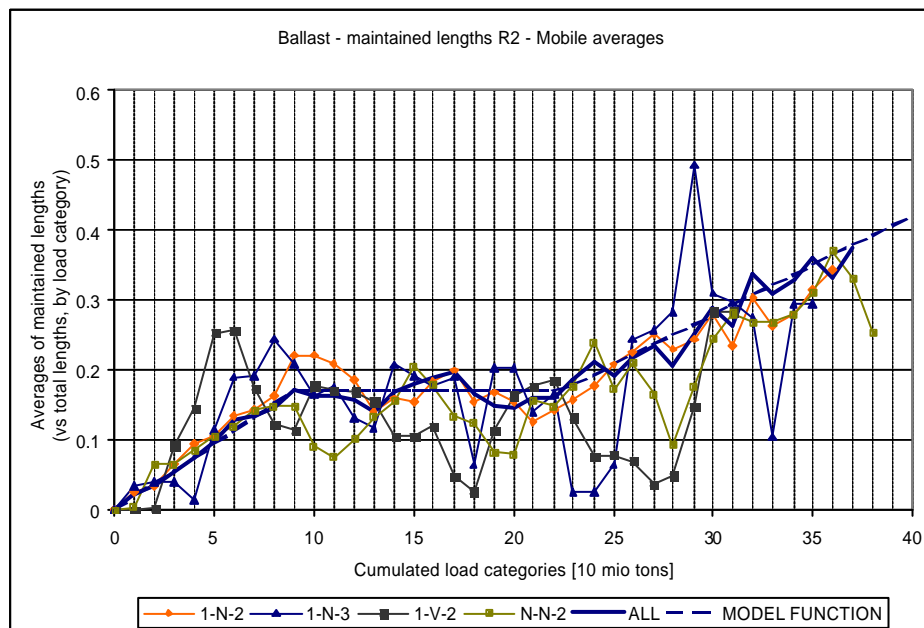

Figure 10 : Average length of ballast tamping, for each cumulated load category, in comparison with the total length of ballast of corresponding load categories

4. COMMENTS

First of all, the approach allows having a clearer idea on various strategic aspects of network management. The method provides precious information on the long term impact of a traffic growth on global infrastructure costs. It underlines variations of track possessions costs, maintenance and renewal costs and, finally, basic saturation costs (without any M&R track possessions).
These costs play a key role at the time of capacity investment decision making. Once capacity investment scenarios elaborated, one can simulate the traffic routing on "updated" networks and estimate M&R and saturation costs. This may be the base of a cost-benefit analysis.
Finally, the approach provides a mean to estimate long term effects of renewal budget restriction on the substance of the infrastructure as well as on maintenance costs. This might be interesting to show to national decision makers at the time of state budget allocation.

However, the proposed approach, as presented in this document, is subject to various limitations:

Possession strategies:
The approach only deals with daily traffic interruptions shorter than 12 hours. Thus, any engineering works requiring more than 12 hours need to be split over several days. Many infrastructure managers use (or at least start to consider to) extended track possession intervals, lasting several days or several weeks. Therefore, the service degradation calculation model (task 5.1) as well as the optimal possession calculation model should be extended. However, the methodology should still be applicable.

Maintenance functions:
Maintenance functions – functions linking the age of the infrastructure (expressed in cumulated gross tons) to the needs in maintenance works – represent the core of the M&R policy simulation tool. They are therefore very important.
The paper bases the elaboration of those maintenance functions on statistical analyses. That implies the availability of coherent, rather elaborate complete registers containing an accurate log of works undertaken in the past as well as an assets database. The latter should also keep track of the infrastructure in the past.
The real case illustration is based on maintenance functions elaborated on a basis of an assets database only providing the state of the infrastructure in 2001. Thus, maintenance works carried on between 1980 and 2000 couldn't be compared with the age of the corresponding infrastructure. Therefore, maintenance functions have been elaborated only on year 2001 data. This implied that maintenance functions had to be generalized. That is to say, there is one maintenance function for all type of a component as samples were too small to get credible functions.
Infrastructure managers should be aware of the importance of keeping track of the evolution of their assets as well as of past M&R actions. This is the only way to efficiently set up and control M&R policy.

Calibration of models
Once a model elaborated, it should be carefully calibrated in order to fit to the context where it is used. As the calibration of a rather complex approach takes a considerable time, the real case illustration couldn't include a proper model calibration. However, some calibration simulations have been executed and allowed a first tuning of the model.

Reference

[1]:"Methods for Capacity and Resources Management", Deliverable D6, IMPROVERAIL, European project, 5th Framework, 2003.
[2]:"Capacity Evolution Modelling for Long Term Planning", Moreira N. et al, WCRR 2003.