



TOPIC 5
TRANSPORT SYSTEM
MAINTENANCE (SIG)

ECOTRACK: RAILWAY TRACK MAINTENANCE AND RENEWAL PLANNING BASED ON EXPERT SYSTEM TECHNICS

ROBERT E. RIVIER

Swiss Federal Institute of Technology (EPFL)
Institute of Transportation and Planning (ITEP)
CH - 1015 Lausanne SWITZERLAND

Abstract

At the initiative of the International Union of Railways and the European Rail Research Institute, a Specialists' Committee, composed of specialists from ten railways, has developed a decision support system for permanent way maintenance and renewal (ECOTRACK) for the engineering and for the middle and long term management.

INTRODUCTION

The aim of the planner is to ensure on the long term and at minimum overall cost the necessary level of quality of track geometry and equipment; this necessary level of quality is generally between the desired comfort level and the safety level. He thus needs to ensure the optimum allocation of resources; by resources is meant the staff, material, machines (provided by the railways or by its subcontractors) and funds, as well as the track availability periods.

Planning permanent way maintenance and renewal means periodically deciding where the work is needed and when it must and can be carried out. This task is included in the following sequence of operations:

- *Monitoring* of track condition, involving the periodic measurement of the geometrical state of the track and the recording of the condition of track equipment.
- *Planning*, including the determination of track maintenance and renewal needs, the definition of necessary works and their degree of urgency, the evaluation of the proposals and choice optimising the allocation of available resources.
- *Scheduling* of the work, ie preparing programs and schedules for the implementation and the execution of the work on the network during a period.
- *Execution* of the work followed by technical and economical checks.

Within this cycle of operations, planning constitutes the core element. Planning requires knowledge of the interactions between the stresses to which the track is subjected, its geometrical condition, the condition of the track components and the effects of the means and methods of maintenance and renewal. However, since these interactions are highly varied and complex, the planners need to assemble and analyse a considerable mass of technical and economic information. The comparative analysis (qualitative and quantitative) of tens of thousands of track sections, necessary to ensure that the decisions are coherent, poses a severe challenge to manual methods. Consequently, over the past twenty years, R&D efforts have been based increasingly on computers. It was by drawing on all this R&D work, as well as on the recent experience gained by European specialists, that a decision support system capable of meeting the real needs of the railways should be formulated.

At the initiative of the International Union of Railways (UIC) and the European Rail Research Institute (ERRI), the ERRI D187 Specialists' Committee composed of specialists from ten railways has been collaborating since 1991 to pool their experience and to develop a decision support system for permanent way maintenance and renewal.

The prototype of this system, named ECOTRACK (Economical Track), is developed and based on modern diagnostic methods including expert systems for the engineering (analysis of track section geometry and equipment) and for the middle and long term management (planning and optimisation of available resources allocation).

AIMS AND SCOPE OF THE PROJECT

The increasing demands on the track as a result of higher speeds and heavier loads require improved knowledge of the process involved in track deterioration and restoration. The purpose of the project is to provide the methods and tools needed to ensure an efficient procedure, which will facilitate decision-making and the evaluation of the technical and economic consequences of track maintenance and renewal planning.

The objectives of the projects are as follows:

First phase (1991-1992)

To specify a decision support system for the technical and economic planning of track maintenance and renewal, which will meet the primary needs of planners; this system must be technically feasible, easy to implement and adaptable to different railways making use of the data available.

Second phase (1993-1995)

To design, develop and test on railways a prototype satisfying the requirements of the specifications, in order to formulate recommendations to the railways for an operational system.

Final phase (planned 1996-1997)

Most of the D187 Member Railways propose the development of an operational tool during the period 1996-1997, on account of the potential savings proved by the prototype in allocation of resources for maintenance and renewal of track.

The field covered by the project is extremely wide and was defined as follows for the prototype:

- from the *technical* standpoint, the study covers decisions on the maintenance and renewal of the track itself, excluding switch and crossing work;
- from the *economic* standpoint, the decisions to be supported by the prototype concern major and costly maintenance and renewal work, excluding urgent and spot maintenance;
- from the *spatial* standpoint, the project relates to the main line tracks (heavily loaded and/or high speed lines);
- from the *time* standpoint, the planning decisions involved relate to short-term, medium-term and long-term work (of the order of 3 months to 3 years in the case of maintenance, and 1 to 10 years, or more, in the case of track-renewal operations).

SPECIFICATIONS FOR ECOTRACK PROTOTYPE

User (s)

In current practice, the knowledge and experience of the planner play a decisive role in the formulation of decisions. A decision support system should thus enable the user to identify the maintenance and renewal needs and then to allocate resources in an optimum manner. This is a technical and economic management task (planning, managing and checking) which is the responsibility of the operational departments whose position within the general hierarchy lies between the general management of a railway and the production units responsible for the execution of permanent way work. Therefore, the *potential users* of a decision support system are the planners or the managers and their direct subordinates, who are responsible for the maintenance of several thousand kilometres of track.

Main qualities

If the support system for the operational planning of permanent way maintenance and renewal is to be a real tool for the planner, it is essential that:

- Its logic structure and its functioning should be tailored to the decision-formulation process used by the planners.
- The system should be an effective aid to the planner at each major stage in the process and the contributions it makes should be integrated.

- The planner should be able to apply his own knowledge and experience to improve the quality of the decisions taken.
- The system should be user-friendly and interactive, and should deliver the interim and final results in a form suitable for use by a planner who is not an expert in information processing techniques.

Decisions

So, for continuous permanent way maintenance and renewal operations, a distinction may be made between decisions relating to the correction of geometry (NDB), those relating to rail grinding (MR), and those relating to the continuous permanent way renewal operations; the distinction to be drawn is between complete renewal of the superstructure (RI) and partial renewal of one or more components: rails (RR), sleepers and fastenings (RTA), rails-sleepers-fastenings (RRTA), ballast with or without cleaning of the substructure (RB).

A decision support system should therefore make it possible to locate those sections where one or other of these operations need to be carried out, since the decisions to be made are based:

- on an analysis of each track section, and
- on an economic assessment of the urgency and the feasibility of the work.

For each requirement detected by the systems on a track segment (for example 200 m or 500 m), ECOTRACK gives the type and the date of the next maintenance and renewal work with the reliability of the diagnosis depending on the rules used and on the data available.

ECOTRACK SOFTWARE PROTOTYPE

System functions and process

To cover the functions of the planner or the manager, the structural arrangement of the ECOTRACK system is divided into five principal application functions, one for each level providing a gradually more detailed view of the functional model (see Figure 1).

Level 1: First diagnostic

Maintenance and renewal needs per track component. This level is fully *automatic*, for each segment of track the system, based on 52 sets of rules undertakes a diagnostic procedure and shows the basic requirements (NDB, MR, RR, RTA, RB) and the additional data required for the detailed diagnostic of track segments needing a renewal work.

Level 2: Detailed diagnostic

Works necessary per track components. This level is based on additional data and 43 sets of rules; *the procedure is a man-machine dialogue*.

Level 3: Coherence of the elementary works

This level is fully *automatic*. The work operations necessary in connection with level 2 are subjected to a coherence analysis based on 58 sets of rules (space and time coherence, coherence between maintenance and renewal operations); the result is a *proposed planning*.

Level 4: Optimisation of resources allocation

This level is based on an *iterative man-machine process*. It estimates the cost plan and makes an optimisation of the selected track maintenance and renewal works on a 20 years planning (20 sets of rules). Costs of continuous and spot maintenance, renewal works and speed reduction are

included. The user chooses the best alternative in accordance with the railway maintenance and renewal policy.

Level 5: Overall network management

This level provides a set of tools that are necessary to the planner for the optimum management of the maintenance and renewal of the network:

- to guide the long-term technical and economic choices involved (statistics);
- to evaluate the components of the track and methods of works; and
- to simulate maintenance and renewal planning programmes (“what if” simulations of maintenance and renewal policy adopted; limitations of resources, ...).

ECOTRACK: PLANNING SYSTEM for TRACK MAINTENANCE and RENEWAL

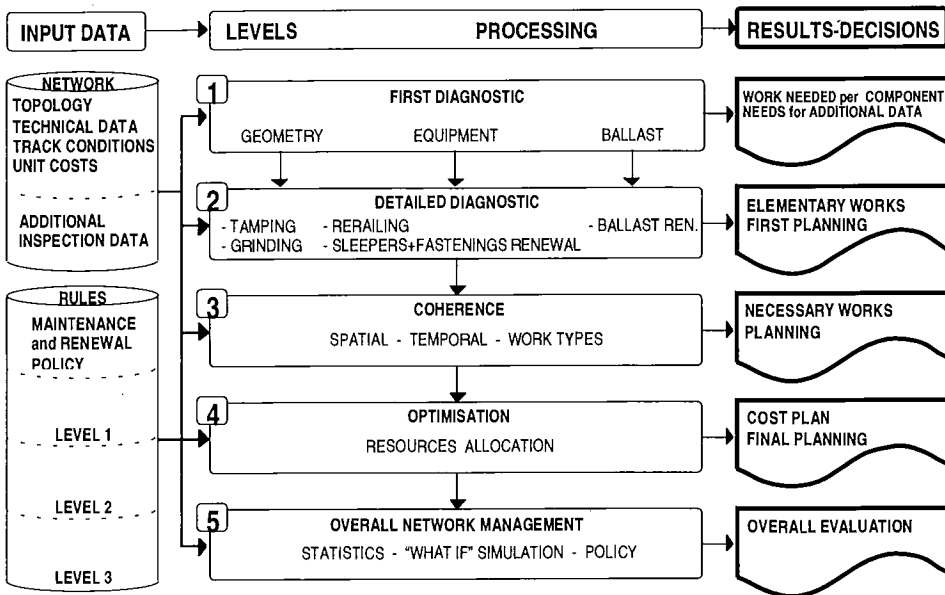


Figure 1 ECOTRACK: Planning system for track maintenance and renewal

Technical characteristics of ECOTRACK

The ECOTRACK prototype uses third party software:

- relational database: SQLBase of Gupta Technologies
- graphical interface: AIDA and MASAI of ILOG
- expert system: SMECI of ILOG
- programming language: LELISP of ILOG
- operating-system: MS-DOS and MS-Windows

ECOTRACK rights are propriety of ERRI-UIC.

CONCLUSION

The international collaboration initiated by the International Union of Railways with a view to the pooling of specialist experience and the development of this highly interactive decision support system for permanent way maintenance and renewal, will thus advance knowledge in the more scientific administration of permanent way maintenance and in the more objective planning of permanent way work, an area in which the stakes are high for the railways who need to minimise their production costs in order to remain competitive.

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