A DECISION-MAKING SUPPORT SYSTEM FOR LOW-DENSITY TRAFFIC RAILWAY LINES MANAGEMENT

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In recent years, the issue of closing down or revitalisation of low-density traffic railway lines in Poland has become increasingly important. These decisions are usually taken without undertaking precise analysis, due to the difficulties inherent in cost calculation. Furthermore a distinguishing feature of this category of lines is that budget limitations and low profits are more critical factors than travel time and traffic frequency.

The paper outlines the main assumptions for the establishment of a software-based system that will support the decision-making processes concerning the revitali-zation of existing low-density lines, its maintenance and operation management. The system, which can be useful for infrastructure managers, railway operators as well as local authorities, is currently being developed within the R&D project undertaken in Poland in 2008.

Key words: low-density traffic railway lines, modelling transport system, decision-making support, maintenance, cost calculation model

1 Introduction

In Europe, the active stage of creating railway infrastructure was finished in mid-1950s. During the last thirty years the new railway lines were built only as high-speed train connections or commuter railways within urban agglomerations. Meanwhile, many sections of secondary lines (named also local or regional) were closed down. However, railway lines, commonly called „low-density”, are still used for freight and passenger traffic in many European countries, including Poland.

For low-density traffic line exploitation speed is not a critical factor. The main problem is high life-cycle costs (i.e. signalling maintenance, track modernization operation and maintenance). Their managers have often limited budgets as they have lower income than mainline ones. Worldwide, an estimated length of this type of lines amounts to about 300,000 kilometres [1].

In the last decade different countries undertook projects aimed to reduce operational costs of low-density lines. Most of them were concerned with low-cost train control systems, i.e.:

- 5th FP LOCOPROL – LOw-COst satellite-based train location system for signalling and train PROtection for Low density traffic railway lines,
- COMBAT – COmputer and Microwave Balise Aided Train control system [2,3].

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There are also several advanced tools for rail traffic modelling and simulation, like OpenTrack (developed by OpenTrack Railway Technology Ltd.), Rail Traffic Controller (by Berkeley Simulation Software), RailPlan (by Funkwerk). All of these tools help to make mainly operational decisions (for example adjustment of timetables or rolling stock and staff planning).

Another group of developing tools is decision support software for maintenance and renewal of infrastructure. Any reduction of these costs has a significant impact on the overall efficiency and management of railway lines. Ecotrack (developed within 5th FP IMPROVERAIL project) is the example of a tool which provides a solution for maintaining of track on the required quality level at a minimum cost [4].

However, there are no tools yet for supporting strategic, long-term decisions containing both operation and maintenance costs. In addition, in case of revitalization of existing low-density lines, capital expenditures must be considered. Recognizing the increasing role and importance of revitalization process of regional and local railway lines in Europe, several Polish universities, private consultants as well as other stakeholders from the railway industry, have launched a new R&D project. The project name reflects its objective: "Local railway modelling and simulation as a decision support tool in the management of regional development".

2 Definition of low-density traffic railway lines

There exists more than one definition of low-density traffic railway lines (LDTL). In European countries railway lines are divided into separate categories based on three main technical and operational parameters: annual traffic intensity, maximum technical speed and axle load. Signalling systems, line maintenance cycle and its funding are dependent on line categories.

Most of LDTL are single tracked with an average traffic of fewer than two trains per hour. Nevertheless criteria which define the LDTL must be adapted to national railway market specifics.

Polish railway network managed by PKP Polskie Linie Kolejowe S.A. (Polish Railway Lines) consists of 19,200 km of lines, which are divided into four categories: Class 0 (main lines), Class 1, Class 2 (secondary lines) and Class 3 (local lines). Total length of low-density lines is estimated at about 4,600 km (almost 25% of total network length). In Polish conditions, low-density lines can be characterized by following parameters:

- single (or double) tracked line;
- 12-15 trains per day, not more than 3-5 trains on the line simultaneously [at the same time], not more than 2-3 trains per hour;
- passenger, freight or mixed traffic;
- maximum speed less than 80 km/h.

Another approach is applied in the U.S., where a revenue-based definition for freight railroads categories is used. Regional railroads (Class II), as defined by the Association of American Railroads (AAR), are railroads with annual operating revenue between USD 40 million and the Class I revenue threshold (USD 346.8 million). All other small railroads are classified as short line railroads (Class III). More than 550 short lines and regional railroads, which operate over 50,000 miles of track (nearly 30 per cent of the country's total railroad mileage), employ nearly 20,000 people and support local economies by providing competitive rates and fuel efficient shipping to businesses around the country (in 49 states). Short lines are a feeder system for the large Class I railroads, picking up or delivering one out of every four rail cars moving on the national freight rail network. They serve over 13,000 facilities and haul over 14 million carloads per year [5].

3 LDTL system assumptions and cost calculation model

The main objective of creating LDTL system is to establish a tool that would allow modelling and simulating behaviour of low-density line in its various element states (different variants of railway line configuration and conditions, scope of rail track modernization and maintenance cycle, type of rolling stock etc.) and support the decision-making processes of beneficiaries.

Like every system, the LDTL consists of groups of interacting, interrelated, or interdependent elements forming a complex whole. The system key elements are: User – Track – Vehicle.

In general, decision-support systems are made up of three components: data, dialog and model [6]. A model has been defined as a simplified representation of part of the real-world which concentrates on certain elements considered important for the analysis from a particular point of view [7]. The LDTL system can be described by following models:

- Railway Network, i.e.:
    - Track,
    - Signalling and telecommunications,
    - Station facilities,
    - Tunnels and bridges;
- Rolling Stock;
- Service;
- Costs.

The system must be able to:

- provide for users a modern graphic interface that will allow creating, editing and managing various track section’s attributes;
- create libraries of standard modules of railway elements;
- simulate train traffic;
- estimate power and energy consumption of train services;
- estimate and predict operational, modernization and maintenance costs;
- estimate optimal modernization and maintenance programming within the technical requirements;
- evaluate effectiveness of variants and help user to identify an optimal solution.

In the LDTL project costs are modelled within six main modules: track, signalling, stations, tunnels and bridges, rolling stock, services and administration. Cost can be defined as the amount of available resources spent in conjunction with the construction or operation of railway activity [8].

The concept of life-cycle cost (LCC) for calculation model was adapted [9], excluding external costs and effects.

Developing costs calculation model required defining for each module:

- categories of railway costs: investment expenditure, operation costs, maintenance and renewal costs [10];
- factors of production (such as materials, equipment, locomotives, cars, consumables, employees etc.);
- input variables;

- output variables;
- methods of LCC formulation for costs categories;
- description of costs algorithm rules.

Creating a computer-based system with correctly mirrored interactions between User, Track and Vehicle requires high level integration of a number of functional target elements. In such a case, composing unitary descriptive method and record of model is not a trivial problem. In order to resolve it the project team decided to use the UML (Unified Modelling Language). The UML as a general-purpose visual modelling language that is used to specify, visualize, construct, and document the artefacts of a software system provides many benefits in the system development process. The overall system design described in UML will dictate the way the software is developed so that the right decision would be made early on in the process. This reduces software development costs by eliminating re-work in all phases of the life-cycle.

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