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MAXIMIZING THE USE OF TRACK POSSESSION: A CASE STUDY ON COORDINATED RAILWAY AND HIGHWAY MAINTENANCE WORKS

Vladimir VOICU, Alin GAUREANU, Nicoleta Paula NEAG, Anca DRAGHICI

Abstract: *This paper presents a practical case study regarding the additional use of a an already planned track possession over a longer period of time due to constructions works for a new highway bridge for the scheduling of selected grouped railway maintenance works. After a relevant literature review regarding railway maintenance and different scheduling principles, the key aspects of the project are presented, while highlighting efficiency gains through this bundling of highway construction works and railway maintenance works for the infrastructure management and the train operators alike. In the conclusions of the article, advantages and limitations identified during the case study, as well as further study directions on this topic are discussed.*

Key words: *railway maintenance, scheduling, efficiency, grouping, street works, track possession, bundling*

1. INTRODUCTION AND METHODOLOGY

While rail transportation offers important advantages recommending it as the predilect choice in many cases, it is also a complex system influenced by organizational challenges such as the conflict between the mutually exclusive objectives of operating and maintaining the necessary infrastructure [1]. With growing interest in rail transport the need for a competitive infrastructure arises as well – therefore an efficient and adeptly planned maintenance is essential [2].

The unsolved conflict resides in the fact that railway infrastructure is of course needed for train movements (goods and passenger transport) and the fact that most types of maintenance works (and sometimes inspections) cause it to become unavailable for traffic during this time. The relevant literature has recognized in the last several years, which treating these realities as two different aspects is not beneficial for the conflict resolution – see [3 - 5]. Traffic and maintenance must coexist and the solution to this matter can only be achieved through their simultaneous consideration.

The methodology employed in this research commences with a thorough examination of the existing literature, with a specific emphasis on the fundamental concepts governing railway maintenance scheduling. This step serves as a foundational base to establish context and identify current practices. Subsequently, an empirical case study is examined in which a predetermined track possession resulting from the construction of a road bridge was utilized simultaneously to facilitate collective railway maintenance activities.

A comprehensive evaluation was conducted on many critical elements of the project, encompassing planning, implementation, coordination, and monitoring. Data was gathered through project documentation, interviews with key stakeholders involved in both the highway construction and railway maintenance, and direct observation where feasible.

Throughout the study, emphasis was laid on identifying benefits and limitations of bundling these construction and maintenance tasks, especially from the perspectives of infrastructure management and train operators.

2. LITERATURE REVIEW

Railway maintenance can be either preventive (taking place before critical errors are detected) or corrective (after confirmation of necessary actions through regular inspections – as shown in [6]). For the corrective or reactive maintenance, the relevant literature also distinguishes between scheduled, plannable and unforeseen, spontaneous repair works (see [7]. While preventive maintenance and the scheduled maintenance allow for a consideration of the best options with respect to train traffic, the ad-hoc maintenance is the worst case from the point of view of customer impact, as the infrastructure is impaired with immediate effect (for instance through a speed limitation or a track closure), leaving virtually no possibilities to the railway operator (other than rail replacement services – alternative transport by busses).

For railway maintenance to take place, multiple factors must converge: a time frame without train traffic is needed, so that trained personnel with suitable materials and machines can conduct the necessary works [8]. In other words, it does not suffice to find an advantageous time frame for train traffic if at that point in time there are no resources (personnel, machines or materials). Conversely, maintenance works are possible if resources are available – however in the absence of a carefully planned time frame this has dramatic effects on train traffic and ultimately the end customer.

Multiple options for solving this challenge have been studied. One of the options is the introduction of traffic pauses into an existing traffic plan. This system requires minor changes to the traffic plan and only allows for short operation breaks (usually 2 to 6 hours), meaning that only select maintenance works can be conducted this way. This option is mainly used for the corrective scheduled maintenance. Relevant research on this matter was disseminated in [9], [10] or [4].

Another possibility is the artificial creation of a traffic pause through the (large or small scale) diversion of train journeys on other tracks. Preventive maintenance usually takes place in such constructed traffic pauses – this is possible as preventive measures do not have a fixed deadline and are usually known months in advance, as opposed to the corrective scheduled maintenance where a reaction within several weeks is needed. Studies analyzing the scheduling of preventive railway maintenance are [11 -13].

An important lever in the optimization of railway maintenance is grouping or bundling – the concurrent execution of preventive and/or corrective railway maintenance on one or more components situated in the same track segment [14].

As the fixed track-closure (or track possession) times are more generous, higher efficiency boosts can be achieved when combining renewal works with preventive or corrective maintenance works: [15, 16]. A 2017 study established that such combinations could reduce costs by up to 14% [17].

As not only possession times, but also machines and personnel are needed to perform maintenance work, the relevant scientific literature has also addressed these themes, also detailing optimal transportation routes to the work sites [18 - 21].

3. RAILWAY MAINTENANCE DURING A HIGHWAY CONSTRUCTION SITE

In select situations, railway maintenance works can be also planned under the cover of an existing track closure not necessarily stemming from other railway renewal or maintenance activities, but from construction sites of other railway track adjacent infrastructure owners. This was the case in the practical case study to be presented in this paper. At the end of December 2022 and beginning of January 2023, a previously manufactured concrete bridge for the still-under-construction A49 federal highway was to be pushed into its final location in the embankment of the Main-Weser railway (DB track 3900, Kassel-Frankfurt, see figure 1). Currently, the A49 connects Kassel to Neuental; an extension to Gemünden (Felda) and a link to the existing A5 federal highway are proposed [22].

Since it was obviously known early that the rails of the railway line in the area were to be dismantled and the railway embankment was to be removed over a length of more than 45 meters for the bridge installation, this meant that no continuous railway traffic from Kassel to Frankfurt would be possible during the 108 hours of track closure. Furthermore, the railway company DB Netz AG decided to not only restrict traffic on the affected section of the track, but to impose a large-scale diversion of freight- and long-distance-trains on other tracks.

Figure 1. Concrete bridge construction site for the federal highway A49 [23]

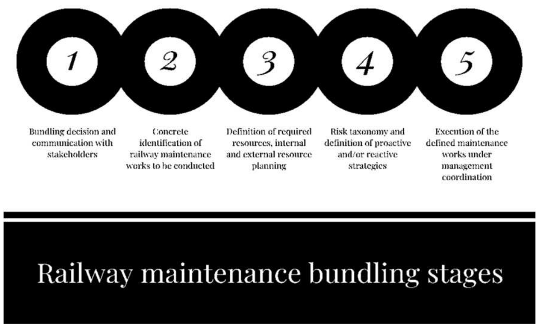

Figure 2. Stages of grouped railway maintenance planning (own representation)

These steps were taken to allow a synergy effect through the concomitant use of the track closure for an extensive railway maintenance program (dubbed “Project FIT 3900”) not only in the bridge works area, but rather on a section of about 90 km roughly between the stations Baunatal - Guntershausen and Marburg (Lahn). The argumentation behind this decision was the necessity of improving the general condition of this line, which, due to long-planned construction work on parallel lines, will have to withstand an increased number of trains in the near future. As the decision regarding the program implementation was taken more than six months before the track closure, this allowed for a careful planning and execution process to be set into motion as shown in Figure 2. The process of this project can be divided into five stages.

In the first phase, all affected railway traffic companies are informed of the track closure in the future, so that the final customer (for both goods transport and passenger services) can be advised, and rail replacement services can be installed for the time of the track closure. Local authorities and local media should also be involved in a timely manner - a higher level of public acceptance can be expected, if information is provided in good time.

In the second stage of the planning process, appropriate railway maintenance works were identified and then ranked by their importance and urgency. 190 different maintenance and prevention activities regarding track superstructure, tamping or grinding, track signals and overhead lines, vegetation, drainage or construction waste disposal were identified at this point. Because of the high urgency, three of these activities regarding the renewal of thousands of rail sleepers in three different sections of the track were defined as anchor operations – the most important activities strictly requiring execution in the given time frame.

The third stage of the process required the determination of the necessary resources – personnel with various competences and qualifications (track builders, welders, train drivers, supervisors), materials and machines (tamping or grinding machines, track maintenance vehicles).

Step four also involved resource planning and saw the procurement of the identified resources – by formulating capacity inquiries to external companies and by an internal review of staff availability.

These tasks proved to be relatively difficult, because of the unfavorable time of year with many internal and external employees on their year-end vacation. In addition, in this step of the process a detailed construction schedule including all actions and resources was designed.

As maintenance operations could be organized on every track subsection of the 90 km section, the schedule was constructed based on the available resources (for instance – number of available workers during a given day or night shift, availability of tamping or grinding machines), while also taking logistical aspects (material delivery, optimal transportation routes) into consideration.

Table 1

Risk taxonomy of the project "FIT 3900".

Type of risk	Countermeasure / Course of action
Bad weather (low temperatures, fog, precipitation)	• Prioritization of anchor operations (if technically and logistically possible) • Rescheduling of anchor operations, so that completion is still possible during the track possession
Employee absence due to illness	• On-call concept in order to activate other employees • Rescheduling of operations
Machine failure	• Logistical concept for the supply of replacement machines • Rescheduling of operations
Work accidents, derailments	• Rescheduling of operations • Replacement machines (if necessary)

Quintessential to the planning process was also the correct identification of risks for the completion of the project on time and appropriate countermeasures should the risks ensue (stage four of the process). Table 1 shows the risk taxonomy and the defined courses of action.

The final step in the process is the execution of the defined maintenance works under careful supervision of the railway infrastructure company's management. The main purpose of the management's attention is the possibility of reacting in case of unforeseen complication, as well as guaranteeing correct and timely communication with the stakeholders. Based on the identified risks, it was determined that the 190 maintenance actions would be coordinated by a construction control center or control room located at the headquarters of the infrastructure company. The control room was staffed 24 hours a day in a multi-shift system by managers of the infrastructure company with authority to make decisions, so that any potential project delays may be addressed.

With respect to the communication formats used in the project, three workshops with all stakeholders were organized in the six months leading up to the track's closure. The first workshop roughly covered the conclusion of the second stage and partly the third stage (definition of the works to be conducted and first draft of available resources), while the other two were used for detailed resource planning and strategy discussions (steps three and to some extent four). Other than that, two weekly meetings with project leaders and sub-project leaders were called in order to quantify the project's progress continuously.

4. CONCLUSIONS

The project FIT3900 was ultimately successfully completed by conducting 164 railway maintenance and prevention works with an identified need for track possession of almost 900 hours (with independent planning) in only 108 hours of track closure at a customer-friendly time of the year with low impact for the railway companies and their clients, especially because the track possession was already planned for the highway bridge installation. The resulting synergy effect is remarkable: by utilizing a structured approach, both the bridge installation and nearly all planned railway maintenance works (164 from 190 – over 85%) were carried out in the most customer-friendly manner possible.

The highest risk identified was the risk of bad weather – as German railway regulations do not allow superstructure works under a rail temperature of 3 degrees Celsius. The materialization of this risk would have meant that many of the identified maintenance works would not have been completed – even with the prepared countermeasures listed in table 1. While in the case of the FIT 3900 case study, the mild winter weather allowed a high number of maintenance work sites to be completed, the outcome could have been entirely different in the case of a winter onset with lower temperatures and/or precipitations. For this reason, the authors recommend choosing a different time of year respecting the same customer-friendly conditions (low traffic values, school vacation).

Another aspect of our project analysis regards the available resources at this time of year. If the project had occurred at a different time of year, it would have most likely been possible to find more available employees and machines – this in turn would have probably meant that an even larger number of maintenance and prevention works could have been completed.

Financial analysis conducted after the completion of the project has confirmed that the bundled railway maintenance works have led to cost savings of about 30%. In addition, the savings in track possession hours (a fraction of only approximately 12% of the total) have a beneficial financial impact due to the increased track revenue made possible by the shorter track closure.In conclusion, the FIT 3900 project has greatly improved the quality of the concerned railway track infrastructure; therefore, it is likely that fewer track possessions will be required in the next years. This hypothesis must be validated by further research on this matter.

While at present there are many instances when railway maintenance works are often conducted under the cover of a track possession planned with years in advance for bigger railway projects (such as track renewals), we find that the use of track closures caused by other construction works implemented by other stakeholders is a solution not widely used at the moment, which can almost always prove useful in reaching a satisfactory solution for the eternal conflict between operating and maintaining railway infrastructure.

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Maximizarea eficientei închiderii de linie: un studiu de caz privind lucrările coordonate de întreținere a căilor de comunicație terestre

Acest articol prezintă un studiu de caz practic privind utilizarea suplimentară a unei închideri de linie deja planificate pe o perioadă mai lungă de timp datorită lucrărilor de construcție pentru un nou pod de autostradă pentru programarea unor lucrări de întreținere a căii ferate selectate și grupate. După o analiză detaliată a literaturii privind întreținerea de cale ferată și diferite principii de programare a lucrărilor de cale ferată, aspectele cheie ale proiectului sunt prezentate, subliniind câștigurile de eficiență prin această grupare a lucrărilor de construcție a autostrăzii și a lucrărilor de întreținere a căii ferate atât pentru compania de infrastructură feroviară responsabilă, cât și pentru operatorii feroviari afectati. În concluziile articolului, avantajele și limitările identificate în timpul studiului de caz, precum și direcțiile ulterioare de studiu pe această temă sunt aratate.

Vladimir VOICU, PhD Student, Politehnica University Timisoara, Faculty for Management in Production and Transports, Remus str. 14, 300191 Timisoara, Romania, vladimir-virgil.voicu@student.upt.ro

Alin GAUREANU, PhD, Lecturer, Politehnica University Timisoara, Faculty for Management in Production and Transports, Remus str. 14, 300191 Timisoara, Romania, alin.gaureanu@upt.ro

Nicoleta-Paula NEAG, PhD Eng., Politehnica University Timisoara, Faculty for Management in Production and Transports, Remus str. 14, 300191 Timisoara, Romania, nicoleta.neag@student.upt.ro

Anca DRAGHICI, PhD, Professor, Politehnica University Timisoara, Faculty for Management in Production and Transports, Remus str. 14, 300191 Timisoara, Romania, anca.draghici@upt.ro