SIGNALLING SYSTEM SOLUTIONS FOR SECONDARY LINES IN 2015

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Summary: Due to the current and general forecasted situation on secondary railway lines, the sustainability of many lines is endangered. Because of the use of uneconomical operations control and signalling systems the operations of many of these lines are unprofitable. The subject of the project introduced by this paper is to achieve basic approaches for a safety and economical operation of secondary railway lines. Therefore the identification of the real existent requirements for a system solution based on the analysis of the current and forecasted situation is carried out within the project.

1. The current situation on secondary railway lines and their possible future developments

The subject of this paper concerns the operation of secondary railway lines. Due to the fact that the meaning of the term "secondary line" is not definite and different comprehensions exist, first of all the meaning of this term and how it is used in this paper, has to be explained. The common characteristics of secondary lines shall be the following:

- Mostly single track (except the stations) and not electrified lines
- The maximum track velocities goes up to 80 or 100 km/h (sporadically 120 km/h)
- Many not protected level crossings in short distances to each other, protected level crossings are often manually controlled
- Medium or low density traffic lines

The technological innovations regarding new operations control systems were focused on high-speed and long-distance railway lines in the recent years. The development of new system solutions, which are up to standard for secondary lines, was rare and only a few system solutions were developed [1].

Therefore the common situation on secondary lines is still characterized by the use of over-aged equipment and high manpower requirements for the operations control. High operation and maintenance costs are the results. Oftentimes the costs can not be covered by the revenues and so the operation of these lines becomes uneconomical. Because of this many secondary railway lines have been closed.

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A forecast regarding the passenger loads on secondary lines shows a general tendency of regression [2]. Because of this the proceeds for the railway companies will decline as well. Considering constant costs for the operations control and signalling system, the profit margin will become smaller. For instance, profitable railway lines being confronted with decreasing passenger loads will start to be unprofitable at a certain point (see figure 1).

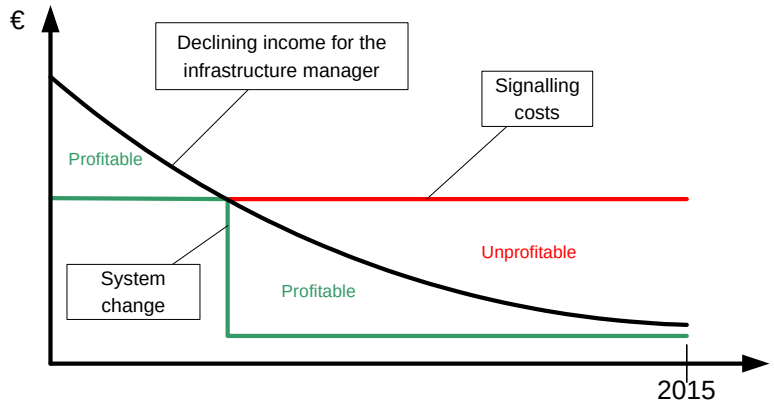

Figure 1: Economic efficieny depending on the operations control system

The liberalisation of the European railway market started in the 1990´s. Liberalisation means the change of former state-owned railway companies and monopolistic railway markets into privately organised railway and infrastructure companies based on competition. This development is seen as a necessary step to obtain the competition of railways with regard to other means of transportation. Nowadays, the liberalisation progress differs in the separate European states. Free competition of the railway markets is not yet established in all European states. Considering future developments, the liberalisation will be pretty well advanced by 2015.

An important result of the liberalisation is the separation of the train operations from the infrastructure management. On the one hand infrastructure managers, who own the tracks as well as the signalling and stations equipment, and on the other hand railway operators, holding the rolling stock (locomotives and wagons) are established. This separation based on the liberalisation can result in a large number of different infrastructure managers and railway operators in the future especially on secondary railway lines, illustrated in figure 2.
Because of that new future requirements for the operations control and signalling systems are suggested.

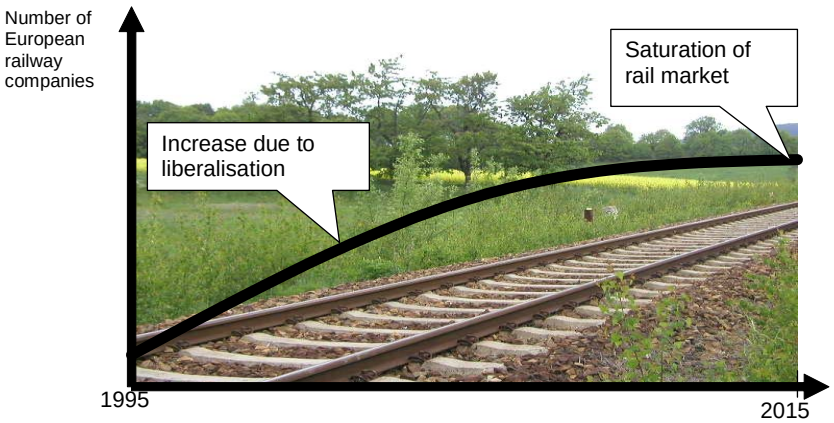

Figure 2: Increasing number of railway companies

In accordance with the advancing liberalisation the pressure regarding the costs of the operations control will be increased on the infrastructure manager and railway operators. To maintain or raise the market position on secondary lines, the railway companies have to provide a competitive and attractive railway service, which can only be realised by using an economical as well as safe operations control system.

2. Already used system solutions and innovative ideas for the operations of secondary railway lines

Regarding the operations control and signalling system, three different systems are already in use [3], which are seen as an alternative solution in place of the cost intensive interlocking system. These alternative systems are:

- On Sight – The line ahead of a vehicle is controlled by the driver
- Direct Traffic Control – the train order is controlled by an external train controller, field elements are controlled by vehicles.
- Staff & Ticket – the Train order is controlled by the rule that only vehicles get movement authorities into a block section that possess a certain token.

All these three systems can be carried out by complete manual handling or can be supported by technical signalling systems. The scale of technical support depends on the required level of safety which again depends on the traffic density as well as the track velocity.
Besides these simplified systems for railway operations, different approaches regarding the improvement of the operations control system exist. Two approaches are explained in the following:

2.1 Train control systems with mobile on-board equipment

The infrastructure manager benefits most, if the trackside equipment of the operations control and signalling system is minimised and most of the system components are carried by the train. This transition is refused by the rolling stock owner, because of the resulting increase of locomotive costs.
A possible solution for this different position could be, to develop not an on-board system, which is installed in a fixed way but which is suitable for mobile and flexible use (see figure 3). The infrastructure manager can provide these mobile on-board equipments and the railway operator is nearly unaffected by the used system.

Figure 3: Mobile on-board equipment of an operations control system

The exchange of rolling stock between different infrastructure systems in a liberalised rail market would be less problematic by using mobile on-board equipment.

2.2 Verification of driver knowledge

Another innovative approach for an improvement regarding the operations of secondary lines is to provide a technical support system for the verification of the driver's knowledge.
Safe train operations with a minimum of technical signalling systems require good track knowledge by the driver. To ensure this, a database control system can be developed, which prevent drivers from running on tracks they are unfamiliar with (see figure 4). Before the start of mission the driver has to identify himself by fingerprint. A movement authority will only be send in the case of matching conditions: the driver is trained in handling the used operations control system and the driver is trained and familiar with local track particularities.

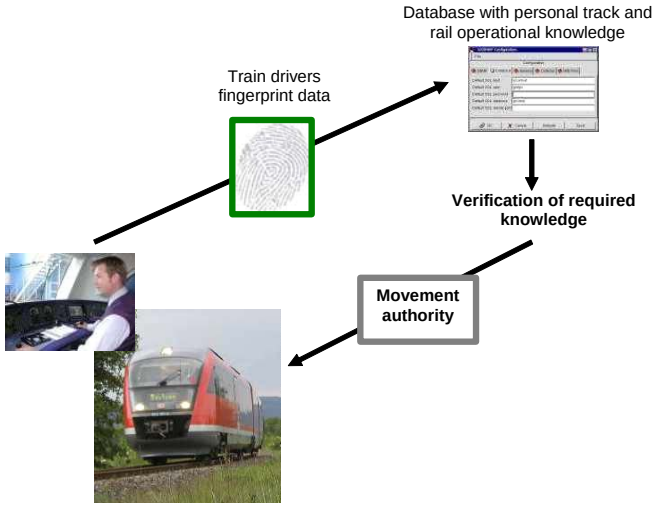

Figure 4: Supporting system for the verification of driver's knowledge

In order to verify, whether the existent alternative signalling systems and innovative ideas introduced above fulfil the current and forecasted future operational requirements on secondary lines the following project is carried out.

3. Subject of the project

The subject of the project is to achieve basic approaches for an economical and safe operation of secondary railway lines. Therefore the real existing requirements received from the infrastructure managers and railway operators are identified and according to these requirements the basic approaches for the signalling system solutions are produced. Based on the results of this project, the development of new products and the positioning of existent system solutions for the operations control can be supported.

Figure 5 illustrates the procedure within the project. Afterwards the single work steps are described in detail.

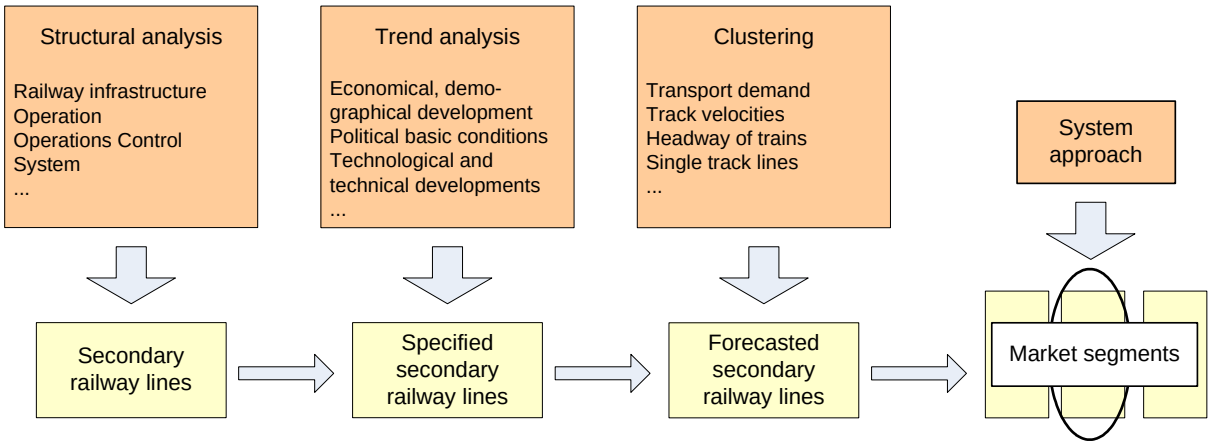

Figure 5: Illustration of the work procedure within the project

3.1 Analysis of the current railway situation and trend analysis of future developments

In the first work step the current situation on secondary lines is analysed. In addition the trends for development of these lines for the years 2015/2020 are estimated. Based on this analysis, the requirements for an operations control system can be identified. At first the investigation is focused on the secondary lines in Germany. But an extension to other European states is planned. The first work package is divided into two parts – a structural and a trend analysis.

Contained by the structural analysis, first characteristics, which can be used for the description of the current railway situation, are identified. These characteristics are combined into different fields like infrastructure, operations, operations control systems, organisation, etc. Figure 6 shows some exemplary characteristics. Afterwards the current situation can be analysed by use of these characteristics.

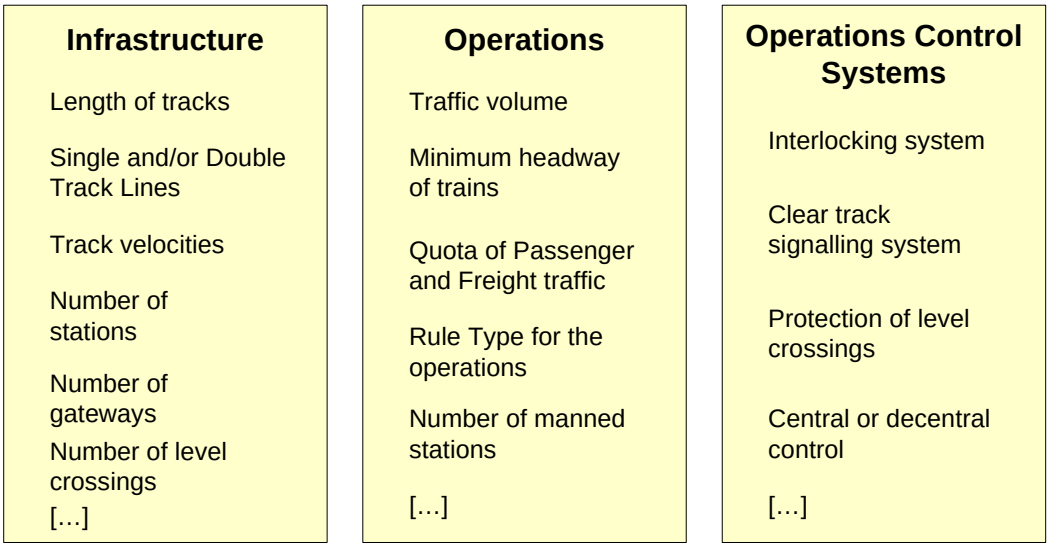

Figure 6: Exemplary characteristics for the description of the current railway situation

The objective of the trend analysis is to find out the future developments of secondary lines. Based on studies about demographical and structural developments as well as about the forecasted mobility behaviour and transport demand, impacts on the operation of secondary lines can be derived.

In addition to a literature and internet research expert interviews are realised. Therefore a questionnaire was worked out and sent to different railway experts like infrastructure managers, railway operators, railway surveillance authorities and orderer of railway services. A following expert workshop offers the possibility to discuss the current problems in order to identify changes for an economical operation on secondary lines.

3.2 Clustering of railway market segments

The objective of this work step is to summarise all railway lines, which have the same requirements for the operation, within the same railway market segment. Thus all railway lines clustered in the same market segment can be operated by the same identified system solution and no cost intensive single solutions for separated lines have to be generated.

Different criterias are identified for the clustering. For example, the maximal track velocity is a criteria for the clustering because depending on the value of the track velocity specific requirements for the operation exist[4].
After the clustering the attractiveness of the market segments according to the development of new and innovative system solutions is evaluated.

3.3 Identification of functionalities

Derived from the requirements for the railway operations specific functionalities, which have to be provided by the system, can be identified within different fields of activity (Figure 7). The functionalities can be realized using different technologies and technical components. By that way different approaches for a system solution can be generated.

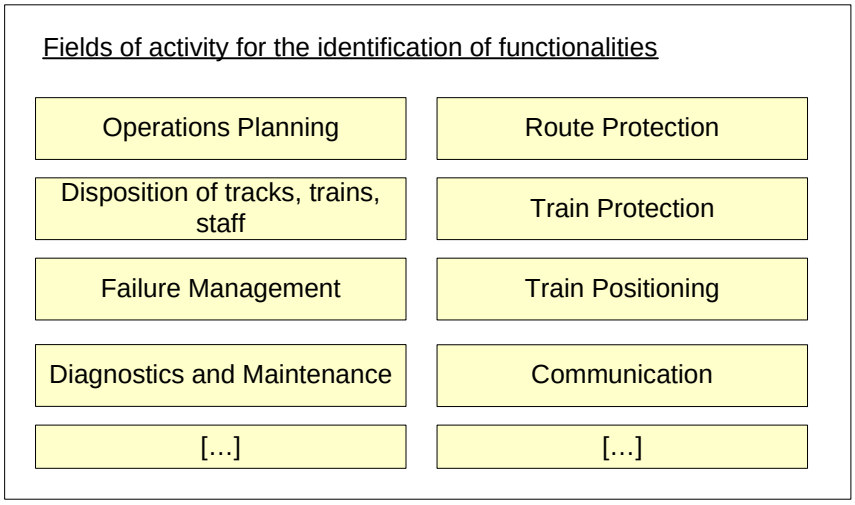

Figure 7: Exemplary fields of activity for the identification of functionalities

3.4 Safety analysis and economic efficiency

The three main factors, which define the use of a system solution are the capability, the aspects of reliability, availability, maintainability and safety (short: RAMS), and the resulted costs [4]. These factors influence each other. The relationship between capability, RAMS and costs is illustrated in figure 8.

[4] In Germany, starting with a track velocity of 100 km/h an intermittent automatic train-running control is specified by law.

The interest of this work step is to achieve boundary conditions regarding safety and costs for a required capability within the defined market segments.
Therefore a simplified safety analysis and an examination of the economic efficiency are carried out for each system approach, which is identified to cover the necessary requirements for the railway operation. Already used system solutions as well as new approaches for a system solution are analysed in that way.

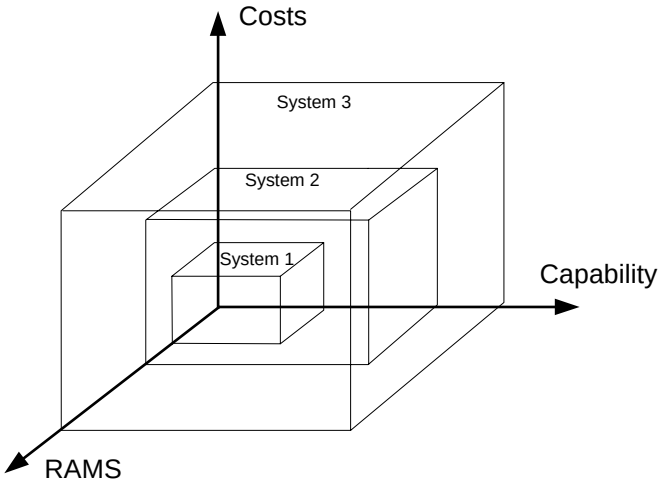

Figure 8: Qualitative illustration of the interrelations between capability, RAMS and costs [4]

4. Conclusion

Within the project, basic approaches for the development of system solutions for secondary railway lines in 2015/2020 are generated. By this way an improvement of the situation on secondary lines shall be achieved. Based on the results of the project, the development of system solutions can be initiated and different profitable effects arise for the railway system participants – infrastructure managers, railway operators and industry. These are for instance: the infrastructure managers can realise an economical operations control with a scalable signalling system. The railway operators can realize an easier access to the railway network and the train operations on the railway lines become economically prized. The manufacturers of technical components for the operations control can optimise the specific efforts for the development of system solutions and the development costs can be reduced, because of the use of standard components and standard technologies.

5. References

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