COST EFFECTIVENESS OF WAYSIDE DERAILMENT DETECTION

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Wayside train monitoring systems are an important issue of modern railway operation due to the fact that more and more stations will become remote controlled by an operation centre. Therefore the task of monitoring fault states on moving vehicles has to be overtaken by autonomous sensor systems. Based upon the background of liberalized railway market it cannot be guaranteed that every vehicle is equipped with necessary sensors for fault state monitoring when passing the network of an infrastructure manager. Therefore each infrastructure manager has to install wayside equipment to check passing vehicles for fault states occurrences. The worst case scenario of not recognized fault states in time is a derailment. If preventing monitoring systems are not able to detect derailment indications in an early stage, the derailment itself must be identified by dedicated devices e.g. wayside derailment detectors. For safety related usage in a whole railway network the number of necessary wayside installations has to be identified in context to financial feasibility. To solve these questions a methodology was developed at Vienna University of Technology to estimate the potential costs and benefits under consideration of operational boundary conditions. Costs are directly related to the number of implemented derailment detectors, whereas benefit can be argued by reduced length of destroyed superstructure in case of a derailment. The braking behavior of different trains and the points on a line are the boundary conditions for practical implementation of this approach.

Key words: wayside train monitoring, derailment detection

1 Introduction

The ongoing liberalisation of the railway sector leads to a separation of infrastructure manager and railway undertaking. Although responsibility for operational safety is given mainly to railway undertakings, infrastructure manager have to guarantee the availability of their networks. Therefore it is also necessary to install wayside train monitoring systems under consideration of economical aspects. The local position of installation has to be chosen to allow stopping a train with a recognised fault state before reaching a risky element of infrastructure (e.g. tunnel, cross-over, bridge). This functionality demands an intervention of signalling or control technology and can be realised by so called „Checkpoints“ [3]. To gain economical benefits the use of such safety measures has to be planed according to the specific characteristics of the railway system, whereas the modular concept of Checkpoints helps to implement such an optimized design.

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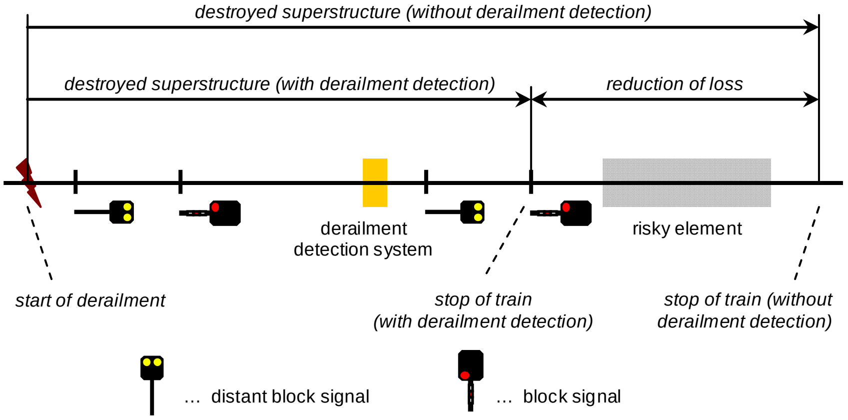

Fig. 1: Reduction of loss by usage of wayside derailment detection system

Considering a derailment in front of a risky element of the infrastructure on a free line (e.g. tunnel, cross-over), if the train driver is not able to recognise the derailment, the train will probably be stopped due to an accident at the risky element. With an installed wayside detection system, the distance of derailment can be shortened and the train can be stopped in front of the element (Fig. 1). Thereby a heavy accident can be avoided and the costs for reconstruction of the destroyed superstructure can be reduced. This can be interpreted as direct benefit of such an installation. According the approach of protecting risky elements of infrastructure [1] only these elements have to be identified by a risk analysis. So the quantity of required components can be estimated under consideration of a general cost-benefit-analysis [2].

Beside elements at the free line also railway stations have to be analysed for applicability of derailment detection. Cross-overs at the beginning and the end of a station must be protected because derailments in these areas lead often to high damages and costs. But within a station the installation of wayside derailment detection is not applicable because it is not possible to stop an already derailed train before reaching the cross-over zone. Thus the cross-over zones of a station can only be protected against derailments occurring on the free line (Fig. 2).

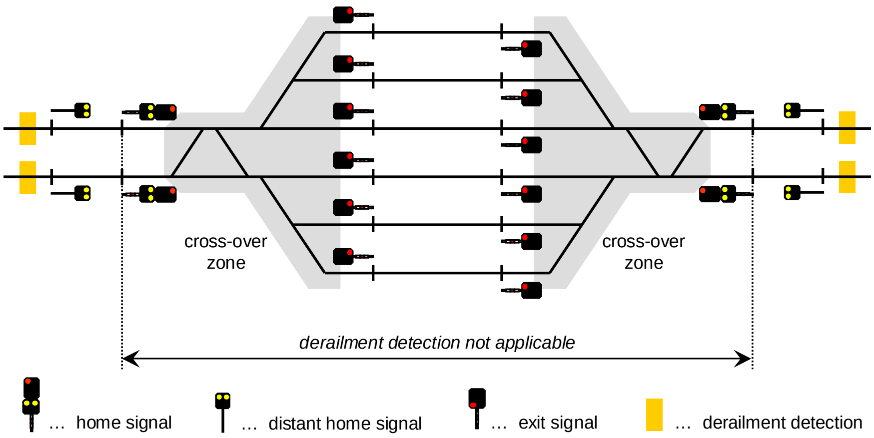

Fig. 2: Derailment detection of a railway station

2 Estimation of the required quality

If a railway system is controlled by a block system, there are three areas, which are different suitable for the installation of a derailment detection system. To stop a train before a block signal, the train driver has to recognize the stop aspect shown by the distant block signal at least at the view point. This means that the distance covered during the processing time of the derailment detector at highest allowed speed and the maximum train length defines the end of the area, where the detection is expedient (green area in Fig. 3). If a detector is installed beyond this point, the timely showing of the stop signal can not be guaranteed (orange area in Fig. 3). Especially if the detector is located after the view point of the distant block signal, even under the best measurement conditions (short processing time, slow train, derailment of one of the first axles), the stop signal can never be shown. Thus an installation of a derailment detector, which aims to stop the train before the following block signal, is not applicable (red area in Fig. 3).

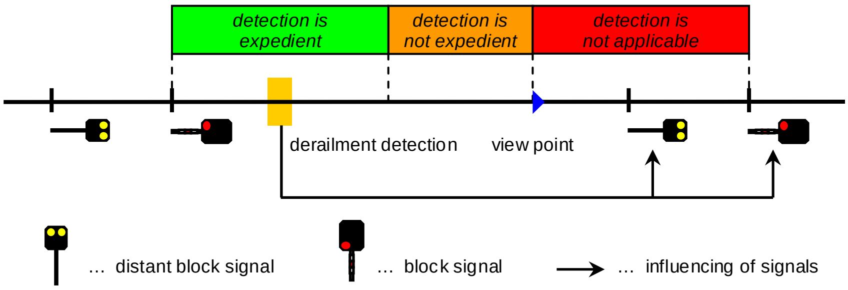

Fig. 3: Classification of areas of derailment detector installation

In the next step a double track line between two stations without further block signals is considered. Here the derailment detectors must be connected to the entry signals of both directions. There can also be the three areas identified for stopping a derailed train before the entry signal (Fig. 4).

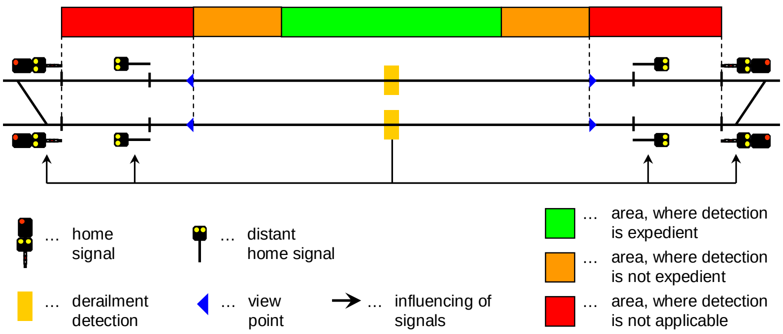

Fig. 4: Application of derailment detection on a double track line between two stations

Normally, there will be some block signals between two stations for capacity reasons. In the following a station entry with several blocks on the free line is investigated. The installation of the derailment detection in the near of block signals has economical advantages because power supply and network already exists. Regarding this, the areas of possible installations in front ob a railway station are shown in Fig. 5.

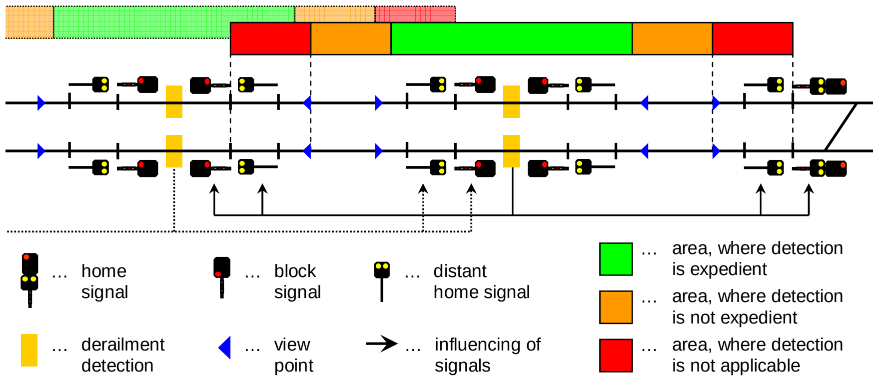

Fig. 5: Application of derailment detection in front of a station on a double track line with several blocks

In contrast to signal based train control systems, modern technology enables continuous supervision (e.g. LZB system or ETCS Level 2). Thus, the installation differs from conventional supervision. On the free line the density of detectors can freely be chosen according to the calculated demands. To protect cross-overs of a

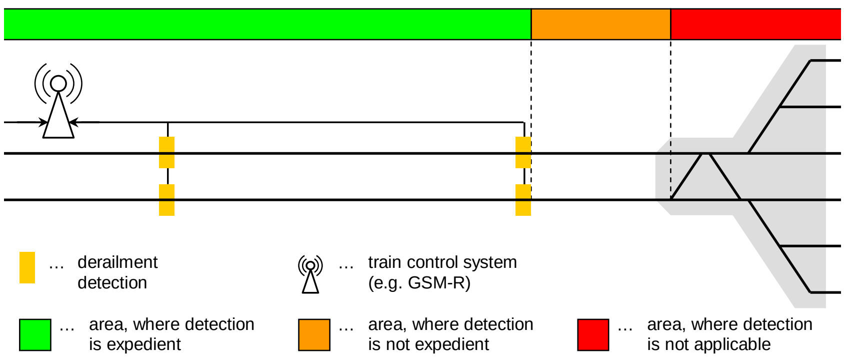

Fig. 6: Application of derailment detection on a double track line in front of a station with radio based train control

station, the detectors have to be situated right in front of the station. Thereby the distance covered during the processing time, the maximal train length and the maximal braking distance have to be taken into account (end of the green area, where detection is expedient). Fig. 6 shows an example derailment detector installation with radio based train supervision in front of a station.

3 Cost-Benefit-Analysis

The occurrence probability of a derailment is the first input parameter of a benefit-analysis and can be estimated by an analysis of the accident data base of an infrastructure manager. Furthermore, from the total quantity of derailments only long derailments (e.g. >1000m) are important for these considerations. Shorter derailments mostly happen in shunting yards. But also on the free line the short length of such derailments follow from an immediately recognition by the train driver or from a splitting of the train set. In both cases the train will be stop and a derailment monitoring by detectors is needless.

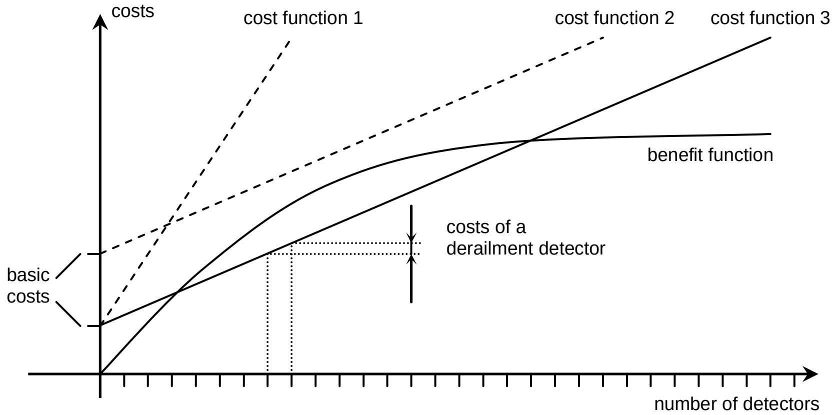

Fig. 7: Cost-benefit-analysis for damage reducing strategy

The benefit of using derailment detectors results form the reduction of destroyed track. Thus, for referencing the average repair costs of a track without derailment monitoring have to be calculated by using the occurrence probability of a long derailment, the distribution of the length of derailments of the past and the average repair costs of the track. Afterwards with variation of the number of used detectors a similar calculation has to be done, which considers the shortening of long derailments. Fig. 7 shows the resulting benefit function quantitatively.

The cost-analysis focuses on the investments of the detectors, which increase linearly with the number of installed sensors. Before the first installation of a derailment detector it is also necessary to establish an environment for the operational integration of data to the railway system. For instance, the Checkpoint system [3] is able to handle and process the output data of the detectors and to generate alarms. Thus basic costs must also be taken into account.

Fig. 7 depicts three different cost functions. Function 1 illustrates low basic costs but high costs per detector unit, which leads to a comparatively fast increase of the total costs. In contrary, function 2 represent high basic costs and low detector unit prices. Due to these properties both functions are located above the benefit function and do not touch or cross it. Thus, in these both scenarios the costs will always be higher than the investments.

Cost function 3 shows the combination of low basic costs and low unit costs. Here an economical feasible zone can be found, which should be reached with an implementation of wayside derailment detectors. As suggested in Fig. 7 there will be a significant area of optimal benefit where the difference of costs and benefit has a global maximum. From an economical point of view an infrastructure manager should take care, that the number of installed detectors is in this range.

4 Conclusion

The developed methodology allows making a cost-benefit-analysis for the implementation of wayside train monitoring system under consideration of operational handling and prevented damages of superstructure. Based on its accident data base every infrastructure manager is able to use this approach considering his specific boundary conditions.

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