WAYSIDE DERAILITY DETECTION AND ITS INTEGRATION IN THE OPERATION MANAGEMENT

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The new operating management system of Austrian Federal Railways (ÖBB) aims to increase quality and safety and at the same time to reduce operational costs. However, this centralization leads to station inspectors being withdrawn from the field and concentrated at a limited number of locations. This in turn entails a reduction in manual train supervision. To ensure an increase in safety despite this effect, an automated technical replacement is needed; these are the so-called CheckPoints. With this solution a detection of damaged rolling stock is as possible as the detection of already derailed vehicles. This leads to a reduction of accident costs caused by derailed vehicles.

1. Motivation

As a result of the modernisation and centralization of traffic controlling and the ongoing reduction of station inspectors, the railway system started to loose a decisive link of well-established organisational and technical processes. Originally, station inspectors were not the only employees among those responsible for the operation of trains who had to deal with train supervision. Interlocking, block and/or level-crossing attendants had to monitor the condition of the rolling stock, too. The locations for this task had been defined alternately, thus enabling train supervision to be carried out on both sides of the track. The disappearance of mechanical signalling equipment was the first cause for a reduction of posts for the train supervision.

Technological progresses resulted in a further acceleration of this trend. By introducing management operation systems, the network of posts to observe trains, which was initially very dense, was reduced again. So technical systems for automatic train supervision which are able to check both sides of the train at the same time are necessary.

Their locations do not have to be set up according to the original locations for traditional train supervision. These advantages will result in a lower number of locations needed for automatic train supervision. In addition to that, the technical systems used for automatic train supervision are able to detect faulty conditions of the rolling stock that cannot be discovered even by well-trained station inspectors.

These so called CheckPoints can be defined as trackside locations containing an accumulation of technical systems, which are required to enable the substitution of the traditional train supervision. From today's point of view, seven sensor systems are needed for this task. They can be divided into two groups: Damage-reducing and/or event-avoiding systems. For both groups, all environmental requirements have to be met taking into consideration that these systems will be passed by trains with a speed of up to 250 km/h. Even under harsh environmental conditions, these systems have to supply reliable information regarding the train state. In addition to that, all data collected must be processed in the shortest time possible by using appropriate tools for analysis.

2. Deraiment detection

As mentioned before wayside train observation plants can be divided into two groups. For the issue of derailment detection a dynamic scale is one of the event-avoiding system. Several dynamic scales are currently passing the transition phase from a prototype development to a series production. As a rule, these systems obtain the necessary data from strain gauges, which are positioned either on the rail or in the sleeper. Their distortion can be used for the calculation of the rolling-stock’s weight and/or the detection of displaced cargo. Moreover, certain dynamic scales can detect flat wheels and various other irregularities in the contact area of wheel and rail.

If it is not possible to prevent a derailment by measuring Y and Q forces on a dynamic scale, an already derailed axle has to be detected as early as possible. Therefore a consortium was founded by the Austrian Ministry of Transport (bmvi) in the R&D-programme called „Intelligent Infrastructure“ to develop a wayside derailment detector for already derailed axles. The project team comprises employees of Thales Rail Signalling Solutions GesmbH the former Transport Solutions Division of Alcatel Austria AG, the ÖBB Infrastruktur Betrieb AG, the Institute of Electrical Measurements and Circuit Design and the Institute of Railway Engineering, Traffic Management and Ropeways. Both institutes are located at the Vienna University

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of Technology. The result of the project was the integration of the developed derailment detector into the worldwide first CheckPoint in Himberg near Vienna on the Vienna - Budapest line.

Figure 1 gives an example of the functionality of event-avoiding and damage-reducing systems in case of a derailment. The length of destroyed superstructure can be divided into two parts: the first section can only be reduced by preventive measures like dynamic scales or hot box detectors. The second one shows the useful implementation of a wayside derailment detector. In this example a cross over on a high speed line is defined as risky element of infrastructure that should be protected by wayside train observation plants according to the concept developed within the framework of a thesis submitted at the department of Railway Engineering, Traffic Economics and Ropeways at the Vienna University of Technology.

![Fig.1. Example for feasibility study for wayside derailment detectors](image)

3. Derailment detection and its integration into the operation management system

Vehicle derailment detection can be classified in detecting vehicles with trend towards derailment because of fault conditions of the rolling stock or irregular loading and in detecting already derailed vehicles. For this reason it is extremely important not only - for instance - to detect such situations before a derailed vehicle enters a tunnel or a bridge, but also to avoid high costs by detecting derailed vehicles before they destroy kilometres of infrastructure. Therefore a very simple and cheap detector was developed to give the possibility to put many of them into the railway network to detect derailed vehicles very reliable.

![Fig.2. Two derailment detector prototypes and real derailment tests](image)

The first step to integrate the derailment detector into the operating system is to integrate the derailment detector into the CheckPoint solution. A "CheckPoint" is an accumulation of different trackside sensor systems for automatic train condition monitoring.

![Fig.3. Stand alone CheckPoint](image)

Thus each sensor system is used to monitor one or more fault conditions on trains. To increase the value of collecting these single measurements, a conjunction of the data collected from the different sensors is provided. For example, the average temperature of an axle bearing is related to the axle load. Hence higher loads imply higher average temperatures or a faster increase in bearing temperature. However, measuring only the axle temperatures can lead to misjudgements. Warmer bearings do not always mean damaged bearings but can also result from high wagon or axle loads. So a conjunction of the different sensor systems can establish the possibility to adjust the warning limits for each situation individually.
This data collection, data conjunction and rule definition for each situation is carried out in the core of each CheckPoint, the so-called data concentrator. Figure 3 shows the functionality of a stand-alone CheckPoint. Besides data collection and data conjunction, the data concentrator also has the task to decide if it is necessary to create a warning or an alarm when a fault condition is detected. Furthermore, the data concentrator decides on the handling of alarms and warnings. Non-critical warnings are provided to the station master to inform him and suggest an adequate response. Safety-critical alarms such as loading gauge alarms, fire alarms and detected derailed vehicles are not only provided to the station master, but also the control system or interlocking is informed to stop the train immediately.

The CheckPoint concept described above provides a solution for a single point in the railway network. It enables a rail network operator to monitor trains at a given location and derive actions in the surroundings of the CheckPoint.

In a network there will be several of these CheckPoint stations situated to guard points or areas of high risk in the network, e.g. tunnels or bridges. All of these CheckPoints monitor trains for their technical status and take actions upon detection of fault states. When travelling along its corridor, a train will usually pass several CheckPoints and will be checked for fault states at every point in the network where a CheckPoint is situated. Looking at the technical parameters of a train, there are several that do not tend to change significantly while the train is travelling, for example the weight of wagons. It is not necessary to measure the weight of the train at every single CheckPoint. But there are some exceptions where measuring weight and weight distribution is necessary (for example after track sections with a lot of curves), as weight distribution may change because of cargo having shifted inside wagons.

This observation leads to a more sophisticated and cost-effective approach in the equipment of CheckPoints. On the other hand, if CheckPoint data storage is decentralized, the major benefits of data correlation are restricted. To keep the high quality of data evaluation by conjunction of single measured characteristics from different sensor systems it is necessary to bring the measurements from a given train to CheckPoint sites lacking this type of sensor system.

To achieve this goal a networked solution has to be developed. The strategy for the CheckPoint solution was elaborated from the beginning with networking in mind. The goal is to maximize the benefits from the data gathered by the CheckPoint sites in the field, besides increasing operational safety. The first benefit of a networked CheckPoint solution is to overcome the lack of measurement data when reducing sensor system equipment to an affordable amount. The CheckPoint system is capable of so-called "virtual sensors". This means that data gathered from a train that is not subject to significant change while the train is travelling along its corridor is propagated to a CheckPoint lacking this type of sensor. The Thales CheckPoint solution in general works with so-called "anonymized characteristics", which means that gathered data is transformed into characteristics that are independent of a specific sensor or a specific sensor system. This allows easy expansion of local CheckPoint sites with new sensors, as only a new interface for the specific sensor is needed. The conjunction, rule evaluation and action part of the system remains the same even with new sensor systems. The anonymized characteristics are available in the CheckPoint Master Node for each train. A train is first recorded when it passes the first CheckPoint along its corridor. Typical entry points to the operator's network where new trains enter the operation are equipped with CheckPoints that measure all vital characteristics of a train. The gathered data is linked to the train number that is provided by the operator's information systems. Every subsequent CheckPoint gathering can now access the measurements of the previous CheckPoints by defining virtual sensors that get their data from the measurements available at the CheckPoint Master Node. The costs for wayside equipment can be reduced dramatically as it is no longer necessary to have all sensor systems at each CheckPoint site using this data.

Fig. 4. CheckPoint network
Another benefit of a centralized solution arises from the possibility to detect and interpret trends in train characteristics. For example, assume that a train travelling along its corridor has slight damage to a wheel-box and therefore develops a hot box. The development of such a hot box cannot be foreseen when evaluating only the measured box temperature at single points in the network. An alarm is not raised until the first measurement exceeds the given warning or alarm threshold. In a networked CheckPoint solution, the CheckPoint Master Node monitors the temperature of this box over several measurements that are taken along the train’s corridor. The CheckPoint Master Node allows definition of trend analysis parameters, evaluation against thresholds and actions that arise if a threshold is exceeded. Using this technique, a fault state can be detected before it leads to a hazardous condition on the train and the personnel can be informed in a timely manner.

The available field data from the CheckPoint pilot project in Austria underlines the potential benefits and advantages for modern railway infrastructure organisations and rolling stock operators. There is no doubt that the Thales CheckPoint will form an integral part of a modern railway infrastructure in the foreseeable future.

5. Conclusions

- track side derailment detection makes early detection of derailed vehicles possible
- all derailed vehicles which are passing a derailment detector are detected
- CheckPoints detect also vehicles which are endangered for derailment before critical situations
- CheckPoint is a modern solution for train supervision with automatic engagement into the signalling system.

4. References

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