Track monitoring smartphone app

Many railroads worldwide use measuring trains to regularly inspect tracks. Continuous monitoring of all tracks, for example in the form of a daily measurement run, is of course not possible with these trains. This stands in contrast with devices such as smartphones with their integrated sensors, which can be used as a cost-effective and portable solution for track monitoring. The associated possibilities were successfully demonstrated in a practical implementation at SBB.

1. Introduction

Greater environmental awareness, reliability, safety and comfort are important factors that affect a traveller's decision to travel by rail. In addition to the actual vehicle, the last two aspects are ensured especially by the rail infrastructure. The tracks must therefore be regularly checked using special measuring trains or with manual track inspections. Such measurement trains are not only expensive, but their slower operating speed in comparison with that of regular trains also results in undesirable impediments to regular operations. But manual track inspections also entail disadvantages. In addition to the known track closures, there is a further potential hazard for personnel on the track. An approximately continuous track measurement in a daily or weekly cycle by these two approaches is thus inconceivable.

In recent years, regular vehicles have increasingly been equipped with sensors so as not to take up the capacity of the track for regular operations. This enables measurement and monitoring of the tracks during the significantly more frequent regular operations. However, it is often expensive and time-consuming to retrofit sensors. Freedom from feedback interference is usually also a critical issue. Sensors cannot be installed without verification of this. Finally, vehicle safety cannot be affected by the equipment or the integration of additional sensors.

Because of the continuous development of smartphones, these devices are now equipped with high-performance sensors and are capable of recording and processing large quantities of data [1]. The potential for using a smartphone for track monitoring was first mentioned in 2017 [2]. Development has now progressed so far that smartphones represent an easily implemented, cost-effective and portable supplement to existing measuring equipment. The appropriate use of smartphones also enables continuous track monitoring. [5] This method is further explained below.

2. Railigent as basis for the track monitoring smartphone app

Railigent® is the Siemens Mobility application suite providing digital solutions such as the track monitoring smartphone app. Railigent also functions as a platform and thus enables the establishment, provision and operation of digital services. Railigent intelligently uses data from the rail installations and presents the information obtained in applications. Railigent is usable for both trains and for the infrastructure, with the result that it can benefit different participants (rail operators, maintenance specialists, fleet and systems managers etc.) in the rail environment. By using various data from railway installations such as interlocking systems, points or grade crossings and the associated early fault detection, Railigent supports a higher system availability, improved operating procedures, shorter times in the depot and optimization of costs. The purpose of the track monitoring smartphone app integrated in Railigent implementation as well as features such as points monitoring is to improve track availability.

The track monitoring smartphone app was developed to enable the use of smartphones for track monitoring. The solution essentially comprises two elements. One is a smartphone app for data acquisition and data transfer and the other is a Railigent application for analysis and provision of the acquired information to the user. The smartphone app enables the recording and use of all relevant data from the smartphone sensors (e.g. Global Navigation Satellite Systems sensor (GNSS), accelerometers and gyroscope) during regular train operation. The optimum use of a smartphone for detecting faults in the infrastructure also requires the combination of additional external and freely available information with the sensor data. For example, the track monitoring smartphone app uses the OpenStreetMap map material [3] that is integrated through a special interface. The sensor data recorded with the app during train operation as well as external information must then be securely transferred from the smartphone to central data storage. Railigent provides the central

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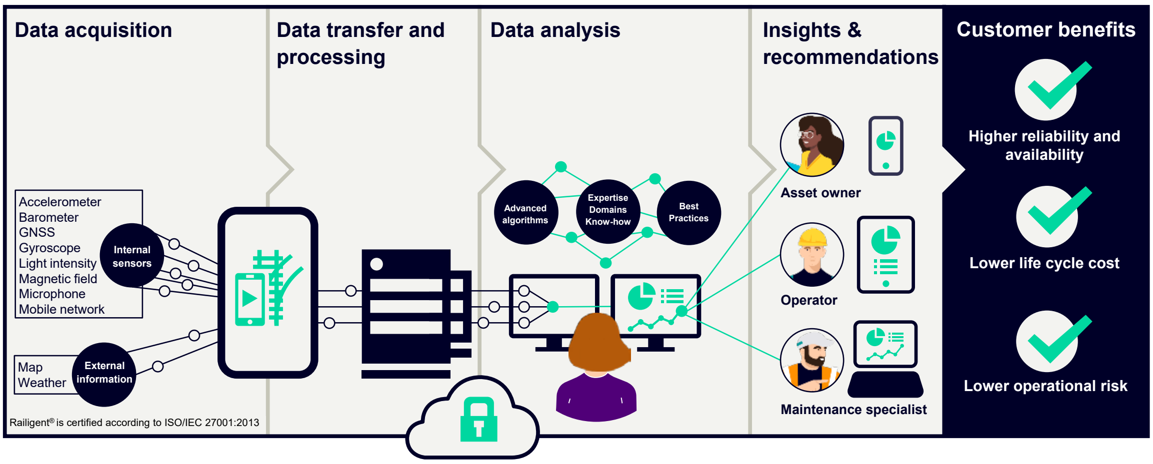


1: Operating principle of the track monitoring smartphone app

data storage. The data is analysed there to detect anomalies and to determine information on the condition of the tracks. The results are then visualized in the form of recommended actions. The track monitoring smartphone app processes internal and external information sources during regular train operation to monitor tracks and detect deviations from normal conditions (Fig. 1) [5].

A modern iOS or Android smartphone is placed in the driver's cab for data acquisition. The smartphone is aligned parallel to the longitudinal axis of the vehicle to rule out the generation of any significant deviations between the coordinate systems of the vehicle and the smartphone. The smartphone can be secured in order to ensure constant uniform positioning. The smartphone app provides additional support for correct positioning and configuration. The system queries key positioning parameters and operating conditions at the start of each measurement run in order to ensure correct evaluation and subsequent comparability of the data. The parameters and conditions queried include positioning within the vehicle, vehicle utilization or the exact positioning location. Data recording starts immediately after configuration [5].

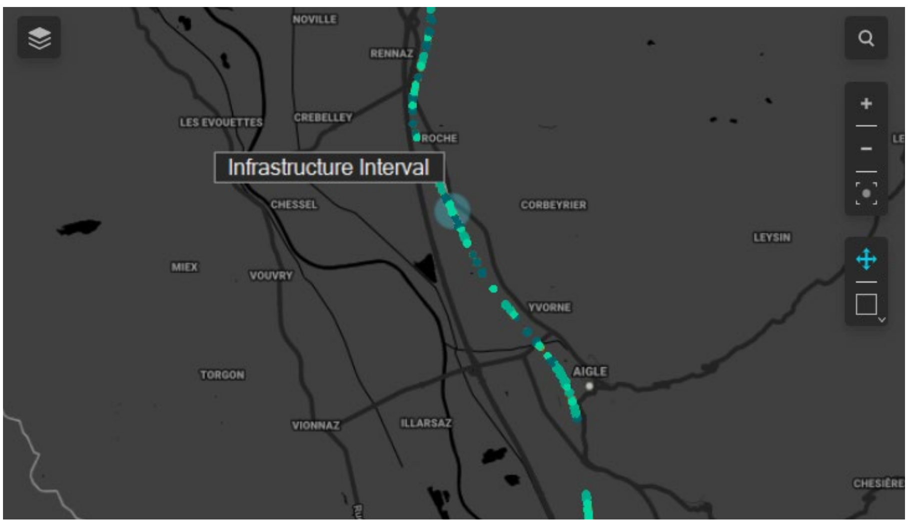
The recorded data is analysed on Railigent for monitoring of ride comfort. Ride comfort evaluates passenger comfort during train operation and is thus also an indication of both track condition and passenger satisfaction. The track monitoring smartphone app uses the acceleration and location data from the smartphone and map material from OpenStreetMap to determine ride comfort in accordance with DIN standard EN 12299 [4]. This is followed by visualization on a map, including corresponding colour coding from „very comfortable" (light green) to „very uncomfortable" (dark green) (Fig. 2). The Railigent application for ride comfort analysis provides early detection of anomalous track sections with no significant effort. This information can be used to better target the planning and implementation of track maintenance. The time factor is especially important in the analysis. If an uncomfortable situation always results in the same location, the algorithm generates a cluster at this point (blue circle in Fig. 2). In combination with a worsening condition over time (trend analysis), this cluster provides the starting point for maintenance.

3. Tests performed

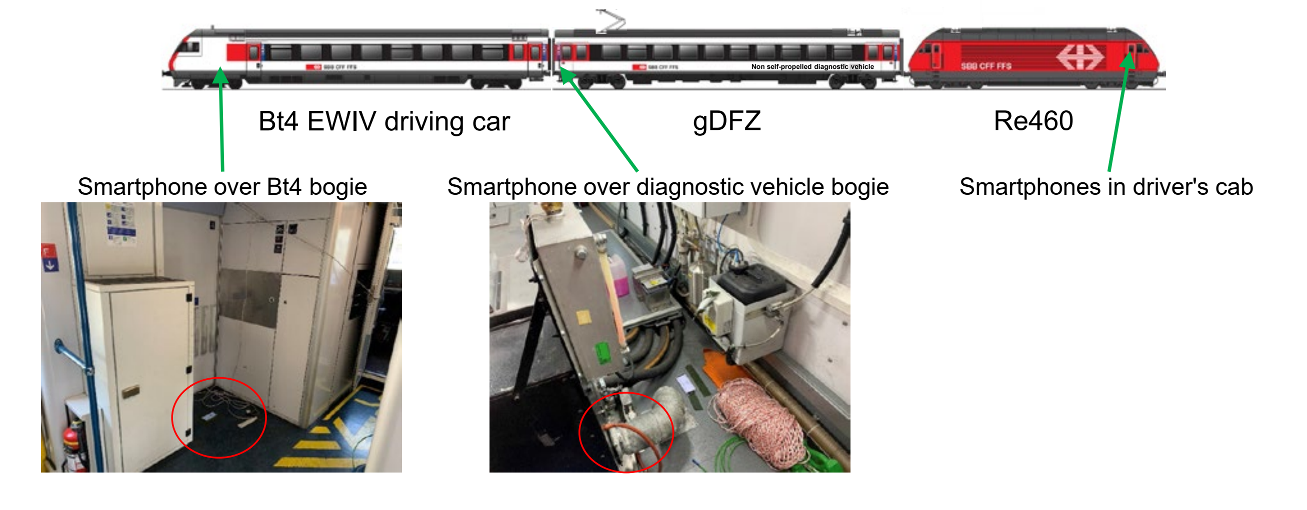
The usability of the track monitoring smartphone app was demonstrated in a test in the regular operation of SBB's non self-propelled diagnostic vehicle (gDFZ) over a distance of approx. 120 km between Berne and Saint-Maurice. The train composition used for the measurements comprises a driving vehicle, the non self-propelled diagnostic vehicle and a locomotive and has a length of 71 m and a weight of 186 t and reaches a maximum speed of 140 km/h. This train operates on tracks with standard gauge width.

Three Samsung Galaxy S20 smartphones with an appropriate mobile phone contract were used for the measurement runs. The smartphones were placed in different locations in the train - in the cab of the driving vehicle and the locomotive and over the bogie in the non self-propelled diagnostic vehicle (Fig. 3).

The described test setup shows that the track monitoring smartphone app can be implemented within a few minutes and does not require any intervention whatsoever



2: Ride comfort assessment with clusters

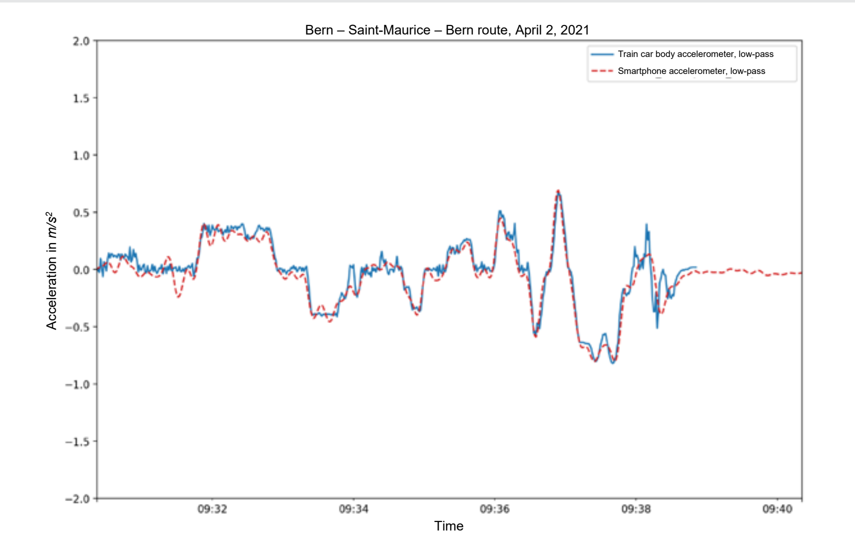


3: Location of smartphones within vehicles

in the vehicle system. The generated data, which was recorded in both operating directions on the same line and with the same train composition, is sent via the smartphone app in appropriately-sized data packets to the database in Railigent®. The data is transferred via a secure connection following a requisite authentication of the device in the back-end system.

3.2 GB of data was recorded in the measurement performed with SBB. The recordings with the track monitoring smartphone app took several hours. The trial period was one day. The tracks were traversed a total of two times (out and back).

The practical implementation enabled SBB and Siemens to collect further data with the track monitoring smartphone app. The resulting recorded data was visualized in an easily understandable form in a web application in Railigent® through analysis, processing and visualization for ride comfort and curve radius. A special focus in the trial was on the operation of the smartphone sensors in comparison with the professional measurement technology in the non self-propelled diagnostic vehicle. In addition to the centre smartphone, a high-performance accelerometer is installed in the non self-propelled diagnostic vehicle that subsequently served as a reference for the recorded data. The subsequent qualitative comparison of the data yields a pattern similar to that shown in the following figure (Fig. 4). Valid use of the data can be established based on the good qualitative comparability of the smartphone data with that of the accelerometers in the train vehicle body. Ride comfort analysis identified 8 deviations and assigned them to the respective causes (infrastructure, vehicle or operating behaviour).



4: Qualitative comparison of smartphone sensors with a sensor installed in the train vehicle body

4. Summary and benefits in practice

Track condition assessment is typically associated with very high personnel costs or with extremely expensive measurement technology. A cost-effective, continuous and minimally invasive monitoring method is needed to resolve this problem. The track monitoring smartphone app is based on commercially available smartphones

The qualitative comparison between the smartphone and professional sensors shows that a smartphone can create valid data for ride comfort calculation. (SBB) (iOS or Android) and can be implemented in all fleets. It can be used on a daily basis even in different vehicles without significant expenditure. This provides rail operators with a means of assessing and also directly improving passenger comfort. The solution also represents an objective alternative to the perception of the train driver who normally reports track defects during operation.

The solution can also be advantageous in some areas where a diagnostic train cannot currently be implemented. For example, this may be the case in areas of low capacity utilization or poor local accessibility. Further reasons for implementing the track monitoring smartphone app are potential large interruptions in the timetable or large resource requirements for performing an inspection.

With the solution presented, smartphones can be easily placed in a vehicle at any time, with the result that track condition can be continuously monitored by the track monitoring smartphone app as necessary. This enables the operator of the infrastructure to continuously monitor the condition of its line and to initiate corrective measures at the right time. The analysis also makes the effect on ride comfort clear and indicates the effectiveness of the implemented maintenance measures.

5. Outlook

Further investigations have shown that the track monitoring smartphone app is also suitable for estimating track superelevation in addition to curve radius. In the future, both curve radius and track superelevation will be implemented as a supplement in the existing dashboard. However, the accuracy of the calculation must be further improved in order to achieve reliable conclusions regarding these parameters. In addition to the infrastructure, there are also initial considerations regarding implementation of the solution for determining wheel condition. The installation location is currently the limiting factor here. The solution can only provide information on the bogie located beneath the equipment. The wide range of further use cases illustrates the further potential of the solution.

Link to website:
https://www.mobility.siemens.com/global/en/portfolio/rail/services/digital-services/smart-measurement.html

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