Echo from the data forest – smart data requires quality

From technical train formation control to electronic train composition

Fig. 1: RFID tag on a freight wagon

Rail freight companies are increasingly realising that digitisation of the railway is vital for survival in competition with road freight traffic. SBB is trialling the intelligent 5L freight wagons[1], DB is operating "TechLoks"[2]. Private rail freight companies are digitising their value creation processes with integrated software solutions for rail logistics (such as zedas®cargo) and asset management (such as zedas®asset). On the rails, high speed cameras document vehicle damage. Trains are weighed in transit and wheel flats are thus detected. The condition of points and wheel dimensions is recorded using wayside data collection. The question of the quality and reliability of the data collected is critical for the success of digitisation. In the worst case, a lot of money is invested in digitisation projects which result in additional effort to correct the process errors caused by unreliable data. What considerations are required in order to prevent this? This is demonstrated below in the practical example of RFID-based train formation detection.

The principle of formation detection

The principle of formation detection using RFID seems very simple. The rolling stock is equipped with RFID tags (see fig. 1). This doesn't cost much and, since they are passive tags with no battery, is almost maintenance-free. They can be read using a mobile handheld reader or on a stationary RFID reader as they travel past (see fig. 2). With its radio waves, the reader supplies the energy that a tag requires in order to send the information stored on it, e.g. the vehicle or wagon number.

Fig. 2: RFID antenna on the track

The order of the vehicles travelling past corresponds to the order of the vehicle numbers received from the tags. Taking a few technical constraints into account, the process is practical and proven.

When processing the data obtained, the (error) devil is in the detail here too. A train formation is typically saved in electronic systems beginning with the front of the train. This is generally understood to be the locomotive position. During shunting, the “front of the train” can quickly change. RFID formation detection provides an inverted order for a train which is pushed or pulled as applicable. Thus, the fifth wagon in the train formation in a 16-wagon train is detected in position 11 in the direction of travel when pushed.

Just a single incorrectly read or unread tag results in the formation information being wrong from this point in the train. The assignment of the information “wheel flat on the twelfth axle on the right in the direction of travel” may result in the withdrawal of the wrong wagon.

Technical train formation control versus electronic train composition

There is a fundamental difference between whether digitally recorded data is “only” used for reporting and thus to support the human working processes, or whether it is used directly as input for cyber physical systems in the process chain. In train formation, this is the difference between technical train formation control and automated, electronic train composition.

In the first case, a person validates the technically collected RFID data against the prior registered train formation and corrects any errors which occur. Positive economic effects are possible because this manual inspection can be foregone if it is technically determined in advance that they agree.

In the case of electronic train composition, the formation data goes immediately and digitally into subsequent processes. The wheel flat on the twelfth axle of the train is directly linked to the technically recorded train formation, the load in the third wagon is directly linked with the job. Since manual observation and correction is entirely foregone here, the expected positive economic effect is greatest.

Quality and reliability of data

At this point, the quality and reliability of the technically collected data gains vital importance. It is the latest point for these questions:

- What causes result in incorrect data?
- What are the effects of incorrect data in the downstream process steps?
- What measures are necessary to ensure the data quality?
- How are data errors promptly detected?
- What do process workflows look like at a manual fall-back level?

The causes of errors in formation detection using RFID are more diverse than the mechanical or electronic failure of a tag. **Technical errors** also include incorrect or imprecise time stamps for data collection, as well as temporary unavailability of the hardware and software systems.

The particularities of wireless technology lead to **process errors**. Shunting in vicinity of the RFID reader results in incomplete, partial train formations. On double-track stretches, in the vicinity of points or parking areas, vehicles which are part of other trains can affect recording whether as a result of their tags or through reflections.

Even **human error** cannot be ruled out. Improperly coded tags or installation of tags on the wrong vehicle are well known in practice.

In the modern era, consideration must also be given to the deliberate or accidental **manipulation of the data**. Jammers or external tags in the reader area cannot be ruled out.

With the increasing networking and integration of electronic systems from rail freight companies, freight forwarders, workshops, loaders and unloaders, customers, and suppliers, the effects of incorrect data are increased.

Mobile repair crews which are sent out as a result of false alarms cost money, as do vehicles which are sent to the workshop despite being in working order.

The correction of information which has been forwarded cannot be guaranteed for all recipients and in dynamic processes. Data therefore needs to be high quality and reliable.

Measures for ensuring data quality

In the example of detection of the train formation using RFID, ensuring the data quality and reliability requires some measures which turn the simple principle into a complex task:

- Selection of the reader location according to process and technical criteria (distance from the track, train speed, antenna characteristics, interference)
- Equipping the vehicles with RFID tags on both sides (and redundant tags)
- Indication of the vehicle side (-1/-2) in the RFID vehicle code
- Reading the RFID tags on both sides as the train travels past
- Sample inspection of the time response as the train travels past (time difference between detection of the tags)
- Validation of the wagon number from secondary systems (e.g. axle counter, in transit weighing system)

- Verification of the vehicle numbers against master data or secondary systems (protection against manipulation)
- Checking for doubling of vehicles in different trains (unique tag checking)
- Use of a reliable time source for readers and IT systems
- Monitoring of the hardware and software functions and alerting in the case of an error
- Definition of the manual fall-back level (e.g. mobile reader, manual input)

On the one hand, the data quality is established by the choice of technical solutions. On the other hand, ongoing validation of the data with regard to discrepancies and errors is unavoidable if it is to be the basis for Rail Freight 4.0.

Echo

In practice, investment in technically collected, high quality data will pay off in the future. On the road to direct interaction between the cyber physical systems of Industry 4.0, it is the “digital raw material” for production. How efficient this will be is significantly shaped by how well the “digital twin” reflects the reality.

The modernisation of the railway cannot be limited to plastic brake blocks and WiFi on regional trains. Before the buzzwords and the brave new world of digitisation, attention must be paid to the quality and reliability of the data used. Railway workers who are used to designing systems “on the safe side” should be particularly able to bring their strengths to bear here.

Sources:

[1] http://blog.sbbcargo.com/23464/5l-zug-der-traum-vom-zukunfts-gueterwagen-wird-wahr/, 30/06/17 at 09:20
[2] http://digitalspirit.dbsystel.de/en/keeping-tabs-on-all-machine-data-with-a-single-solution/, 30/06/17 at 09:20

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