ACCURATE DATA ALLOCATION WITH THE "Rail-Reader"

Martin Novak, Prosoft Sued Consulting GmbH, A-1230 Steinergasse 11/5 Austria,
email: office@prosoftconsult.at

Keywords: RFID, Identification, Rolling Stock, Data allocation

Abstract

All stakeholders in the railway transportation sector are interested in keeping the costs low, the availability and transport quality at an high level and optimise maintenance and repair. This needs exact knowledge about the rolling stock's technical status. Normally a railway car has to receive an "renewal service" once all 5 years. This period is not reflecting the actual usage of the wagon and therefore its technical status. Valuable information can be gathered from the numerous wayside train sensing systems which are nowadays only designated for checking a passing train for safety operation. If the measurement values (bearing temperatures, weights, wheel condition, and more) can be allocated seriously to a specific wagon and its relevant parts, a upcoming service demand or defect could be detected long before the problem rise to a sever level. For exact allocation, a proper identification technology is needed! The proposed "Rail-Reader" RFID-System can ensure this exact data allocation und all conditions. The paper explains the proposed solution, gives an overview on further added value created and discuss some related issues concerning a cross network and cross operator wide approach helping to lower costs and increase efficiency and benefits in railway transport.

Introduction: The requirements of the stakeholder

Infrastructure managers (IM) are interested to tune their infrastructure network to maximize capacity and throughput, keep an high level of operational safety and ensure low running and maintenance costs.
Railway undertakings (RU) are interested to avoid stops and delays en-route and meet the agreements with their customers in terms of keeping the time schedule of the transport. They want to avoid "sick" wagons in their trains which might cause delays and unforeseen train stops.

Wagon holders respectively wagon operators require their rolling stock to be available and running with maximum availability and benefit. They are interested to have knowledge concerning upcoming maintenance requirements in advance to have enough time to dispatch the wagons to the workshop with minimum loss of time and transport resources.

Each time, a train has to be stopped en route unplanned for technical checks or a wagon has to be removed from a train, time and money is lost by all parties concerned.

The overall challenge is therefore to keep wagons in a good technical condition and the infrastructure at a high level of track-quality. As better the technical status of a railway car is, as less will be the wearing of the infrastructure sourced by this vehicle and therefore the effort for maintenance and availability of the railway infrastructure.

Therefore all parties have serious interest in keeping the rolling stock at a good technical shape.

Exact knowledge of technical status needed

Exact knowledge of the actual usage of a wagon, the driven distances (loaded and unloaded) and the collection of all available technical status information measured throughout the journey of a wagon, can help to significantly increase the efficiency and quality of rolling stock and its operation. But that needs exact and trustworthy allocated information to a specific wagon and its parts concerned. Important parts concerned are mainly bogies, wheel sets, bearing, axles and wheels.

If trustworthy information is available, slowly developing defects might be recognized at an early stage and the schedule for the service can be optimised so that loss of transport resources and service times can be significantly minimized. Moreover the wearing of the infrastructure(s) concerned can be minimized if a wagon will be send in for service long before he is in a status making damages to the infrastructure.

Information about the technical status of a wagon throughout the journey would be available coming from wayside train monitoring systems. This systems nowadays can only allocate the value to a specific "train axle" rather than to a uniquely identified wagon or its part.
Electronic wagon lists, which are "accompanying" a train's journey are not reliable enough to solve that problem. The goal is therefore to find a way for uniquely allocation of measured values and information to the concerned wagon and its part.

The Goal: change from "train-axle" allocated information to "wagon-axle" allocation

For the generation of an "wagon-axle" allocated information, first the wagon has to be identified uniquely. If the wagon axle can be identified, a information (e.g. noise, wheel temperature, etc.) can be allocated uniquely to that wagon and part.

The proposed solution is shown in figure 1. Based on an identification technology, which is capable to identify a railway car, its running direction and exact position within the train, information which is generated about a specific wagon and/or its relevant parts like bogies, axles or wheels can be allocated. So the "train-axle allocated information (which is sufficient for the safety check during operation) is transformed to a "wagon-axle" allocated information which is the minimum requirement for reliable analyses of historic data and for serious prognosis.

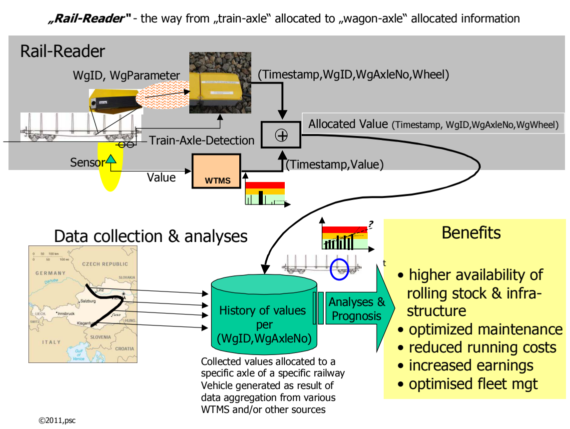

Figure 1: From "train-axle" allocated to "wagon-axle" allocated information

Abbreviations and terms used in figure 1:

WgID……….. Wagon Identification (12 digits register number)
WgParameter.. Technical parameter (see figure 2)
Timestamp…. Exact time of measurement
WgAxleNo… The "numbered" axle of wagon (figure 3)
WTMS……… Wayside Train Monitoring System
Train-Axle-Count…. Count of axle within the train

Knowing the technical parameters are important to double-check calculations done by the "Rail-Reader" based on the axle count and timing analyses, for the approval of a calculated wagon-sequence and for wayside train sensors or monitoring systems (WTMS) accompanied. Wagon ID and wagon side (left/right) seen by the "Rail-Reader" is the minimum needed information for proper identification of the "numbered" wagon axle (WgAxleNo) which is the primary key for the allocation.

Figure 2: Technical parameters describing a wagon

As shown in figure 3, two RFID-transponder are used, one on each side (according TSI), to identify the wagon within the train independent from its running direction.

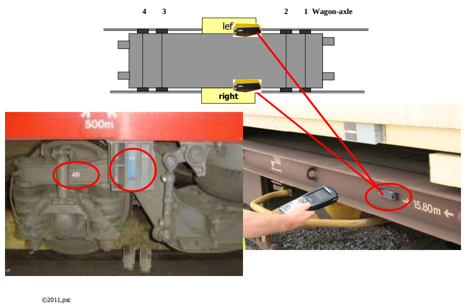

Figure 3: "Numbered" wagon-axle

Why "On-Site" identification is needed

A wayside measurement equipment (e.g. a Hot Box Detection Sensor) can allocate measurement values primarily only to a "train-axle", but has no possibility to uniquely identify a wagon or its "numbered axle". The electronic train list is not sufficient because

(a) the electronic train/wagon list indicates all wagon that belong to the train, but not necessarily their position within the train. Short term shunting can change the sequence of the wagons. Therefore a “wagon-axle” allocation of measured values cannot be done seriously with needed level of confidence – and -

(b) to allocate a measurement value to a specific axle of a wagon, the actual running direction of the wagon has to be known at the time of the measurement to allocate the value to the “numbered wagon-axle”.

The following figures show the evolution of the measured information from “train-axle” allocation to the wanted “wagon-axle” allocation. Figure 4 shows the state-of–the-Art of measurement allocation: after passing of the train, a list of measured values is allocated to each “train-axle”. Allocation to a specific wagon or wagon axle is not possible and not done.

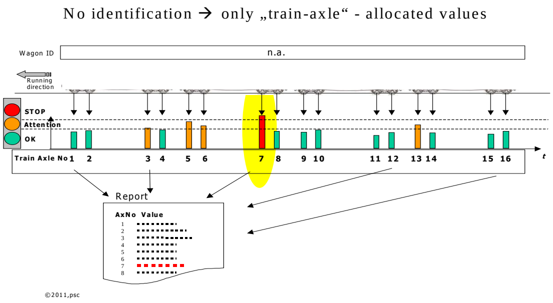

Figure 4: “Train-axle” allocation

Serious identification of wagons now can pinpoint the exact position of the rail car within the train, it’s identification (the vehicle’s register number) and find out the numbering of the “wagon-axles” (figure 5).

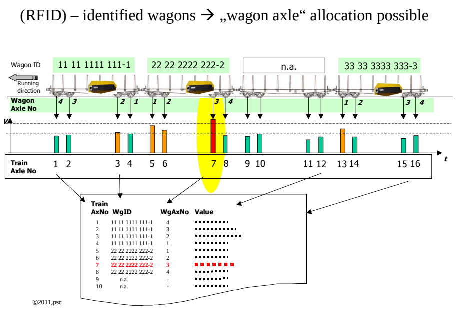

Figure 5: “Rail-Reader” allocate numbering of the “wagon axles”

Figure 6 shows the potential of a unique identification: if the wagon chances his running direction between two measurements, the “train-axle” number of an appropriate measurement changes. Therefore a proper allocation needs knowledge about the “running direction” of the wagon to avoid misallocations.

With proper knowledge, a value measured at a specific “train axle” can be allocated to an specific “wagon axle”. In this way, changing the running direction of a wagon has no influence to the allocation. The value can be allocated to (“wagon register no” / “wagon-axle”) (f.e. (“83 81 1234 5678-9” / “Axle#3”) as shown in figure 6.

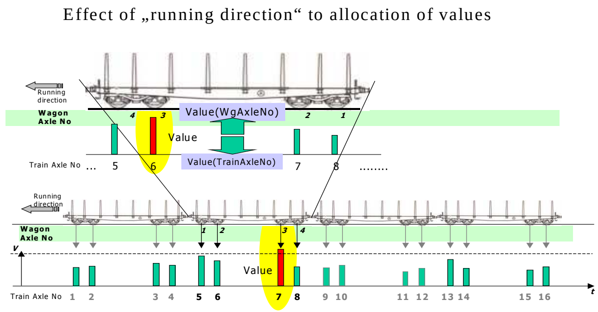

Figure 6: Handling different situations of running direction

Allocation of sensor and WTMS-information uniquely to specific wagons or their parts is either done by an PC-based application situated on-site or by an server based application. Next generations of the “Rail-Reader” solution will also include embedded sensors and will be capable to handle all issues of data allocation directly onboard. This will bring a further reduction of the costs of field equipment and its operation. The System is directly capable to display the actual train composition with the identified (RFID-equipped) wagons with their running direction and not identified (not equipped with RFID) vehicles as shown in figure 7.

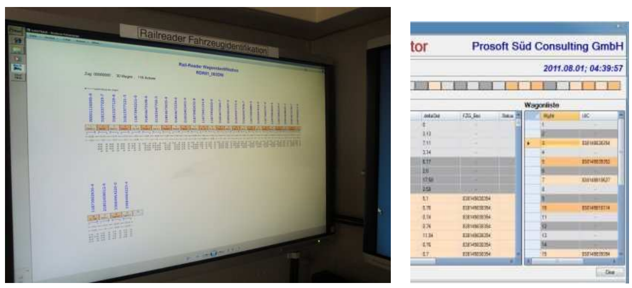

Figure 7: Examples of visualization

The premise: an accurate identification solution

The premise is a wagon identification equipment which can uniquely identify an appropriate wagon of a train at full driven line speed directly on-site and just in time!

Such solution can help to
(a) detect the development of slowly developing defects and upcoming problems at an early stage,
(b) collect wagon-axle allocated information from more than one infrastructure operator,
(c) know the technical status of a wagon BEFORE the wagon enters the infrastructure network,
(d) inform the wagon holder respectively the responsible person for the technical status very early about upcoming defects,
(e) support the dispatcher to react in time and send the wagon to the service in an cost saving way,
(f) support the workshop to optimise their plans thus minimizing repair and/or service time.

Moreover, new services and business opportunities are generated with these capabilities.

Additional Value Added Output

As a further added value, the information submitted by the "Rail-Reader" system can also being used to inform terminals or border crossing stations in advance about the actual wagon sequence and their running/loading direction, expected time of arrival, and more. Specially for car transports and other transports with special loading requirements, the information are very helpful to arrange and prepare fast handling of loading or unloading when the train arrives.

Sources of information from wayside condition monitoring systems

Relevant wayside condition monitoring systems are:
(a) hot axle box detection/hot wheel detection systems measuring the temperatures of the bearing, the axle boxes and wheels,
(b) dynamic scales returning wagon- and axle specific weight-measurements,
(c) wheel set monitoring systems detecting wheel defects, out of roundness, measuring Q/Y-forces, analysing the running stability and much more. These sources will become a more and more important source of data for long term analyses,
(d) noise monitoring systems returning the emitted noise of a railway vehicle or their parts,
(e) other wayside monitoring systems like profile checking, antenna- and pantograph monitoring.

Today, the gathered measurements are only checked for operational safety against relevant limits and are afterwards more or less discarded. In some approaches the information is collected and delivered to a network control centre of the infrastructure manager for further handling and investigations, in some pilots a exchange of data between neighbouring infrastructure managers is under development.

The scientific challenges

To receive a list of wagons, which are equipped with an RIFD-device, the challenges are more technically than scientific. The metallic environment is critical to all radio based communication, but can be handled.
The system approach of the "Rail-Reader"-solution is based on some requirements received from a big infrastructure manager (OEBB Infrastructure AG) which have some more aspects than only simple technical ones:
(a) the system must have an reading reliability of 99.95% minimum at all line speeds driven up to 230 km/h and more and must be useable for all kind of rolling stock,
(b) the communication has to work properly under all conditions evident in an railway environment,
(c) the transponder's lifetime hast to cover at least 5 years,
(d) The full report of identified rail cars has to be available latest 4 seconds after the last axle has passed the reader!
(e) The installation must be energy aware,
(f) the amount of information stored in the vehicle's transponder has to cover all written information seen on the wagon's plate.
(g) the information has to be available directly On – Site. No call back to other sources or decoding using external databases is allowed,
(h) the trackside installation must be simple, vandal proof and accessible for maintenance without need to closing down the track, means must be situated beneath the tracks, not within the rails,
(i) the installation of the RFID-transponder on the rail cars must be fast and easy and without any further modification done on the wagon (welding plates, etc.) so that it can be done on a yard while wagon is waiting for loading,
(j) information stored in the transponder must be secured against modification or deletion.

The scientific challenges are mainly implied in topics (a) to (e). Main challenges are saving energy resources without reducing the reading reliability, ensuring accurate reading results over the full range of driven line speeds and overcome the different mounting situations for a RFID transponder on the various rail-cars , which have significant impact to the radio communication from/to the trackside reading system. Last not Least a proper and accurate timing of the axle counting and RFID-reading module is critical and was solved using interrupt driven subroutines.

Keeping the power awareness requirements, the firmware of the Rail-Reader system was implemented on an low power embedded core using an industrial real time operating system. The speed of the core processor (50MHz) together with the architecture of the operating firmware and the application is critical to return proper results. The decision also leads to a small mechanical layout, no need for air condition and therefore low costs. A typical installation is shown in figure 8.

Figure 8: Typical “Rail-Reader” field installation

The processing speed and also transmitting speeds of the radio interface and Air wire protocol (115 kB per seconds) of an transponder has an impact to the amount of information which can be received and handled during passage of a train.

RFID-Technologies concerned

Two relevant RFID technologies have been considered:

(a) *passive RFID-Technology*: Passive RFID-transponder have no own energy source. They receive their energy by radiation from the antenna of the trackside reading system to afterwards return with the information contents. The communication distances ranges around 2m. Length of information consists of few digits. Actually they can cover the wagon’s register number and a few more parameters only.

(b) *Active RFID-technology* is using an small internal battery when sending their information. Thus the proper reading distance ranges up to around 60+ m. Also the amount of data which can be transferred is much more compared to passive RFID transponder and there is no dependency on the speed driven. The transponders can be used on goods wagons travelling about 120 km/h as well as on intercity coaches travelling up to 200km/h and more. The limited lifetime of about 5 to 6 years is no disadvantage as RFID transponders are regularly exchanged by a new one at the wagons 5 yrs service.

The “Rail-Reader” Solution

The “Rail-Reader” was first developed for using active RFID technology. A Generation 2 will also be capable to handle passive RFID as well. This is according the development in the market where also wagon fleets are now in some projects equipped with passive RFID technology based transponder (EPC-Gen2).

The development of the “Rail-Reader” solution was based on the before mentioned requirements which are all covered.

The installation of the transponder on the rail cars is also held simple and fast. The (active) RFID-Transponders can store all requested information of about 50 characters including:

(a) the 12 digits registration no of wagon and type,
(b) length of wagon,
(c) count and distances of axles,
(d) weights (empty, loaded, max load),
(e) speed limit matrix,
(f) revision date,

together with some technical parameters of the transponder itself.

Figure 10 show a typical installation at an high-speed line. Speed driven are up to 200+ km/h. During the passage of a transponder even at such speed 3-5 transmissions between the onboard RFID-transponder an the trackside reading equipment take place.

Figure 10: "Rail-Reader" detection an high speed passenger train

Reports and allocation of measurement values

After the train has passed, a report is generated which is then used e.g.. together with an wayside train monitoring system for allocation of measured values, transmitted to a terminal reporting the train's actual sequence of wagons or for arrival aviso-information. The report layout can be configured as needed. All information is collected by the Rail-Reader On-Site. No information have to be collected by other sources. The report's protocol is plain text and XML. For communication, wired (LAN) and wireless communication (GSM/3g4g) can be used. An example of an plain text report is shown in figure 11.

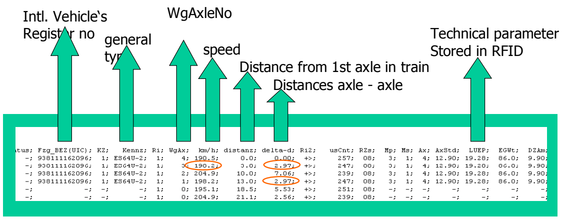

Figure 11: Part of plain text-report

Monitoring of the identification equipment

To ensure proper functioning also a technical monitoring service was developed to keep an eye on the technical status of the identification onboard units and the trackside equipment. Improper functioning is automatically detected and reported. . Figure 9 shows part of an graphical analyses of transponder readings of a train. The trackside equipment is remotely monitored and configured. A database stores all status and events for technical analyses. The programming of the RFID-transponder for the wagons is simple using a specific rail oriented programming tool. It can be done at the railway workshop or on the yard just before mounting the transponder.

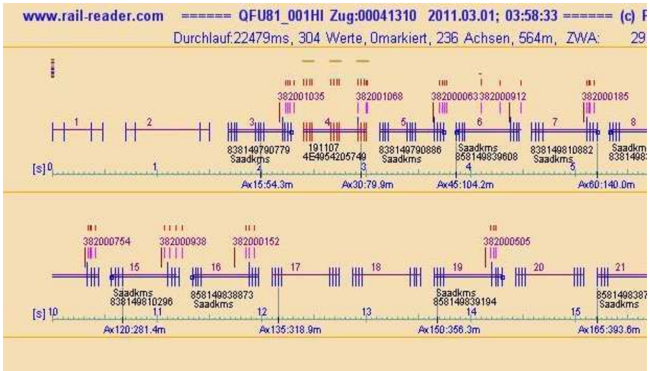

Figure 9: Graphical analyses of transponder readings

Cross-Network wide activities.

As already stated, a cross network wide and cross operator wide collection and handling of information is essential. First activities are already in progress in northern Europe and Austria[1]

Harmonization Issues: Content and structure of information stored in a RFID onboard-transponder

For an cross-network wide usability it has to be specified WHICH INFORMATION should be stored in an RFID onboard device and presented to the trackside reader and HOW should the structure of the information should looks like. Depending on the used RFID technology, relevant information possible can range from just wagon register number or an unique asset identifier up to all written information visible on the wagon itself. The data structures may range from pure ASCII-presentations to external encoded (f.e. GIAI) representation. In cooperation with other system integrators the "Rail-Reader" approach tries to stimulate an open readable format for this "electronic number plate" for rolling stock, but a final decision has to be done by the railway community !

Acknowledgements

We address our thanks to Mr. Wolfgang Zottl and Johannes Stephanides and colleagues from the R&D-Department of the Austrian Railways Infrastructure AG

[1] www.rdsa.at, telenor traxion

for their clear definition of requirements. Also many thanks to the People of the railway operators ROLA, RCA and WLC, which took actively part in the development by contributing railway cars for the development tests and trials.

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