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SETTING UP OF AUTOMATIC TRAIN AND WAGON NUMBER RECORDING (READING), CONTROL AND TRACKING DEVICES AT SECTIONAL AND SORTING STATIONS, LATVIA

In the article the RFID System (Radio Frequency Identification) is presented.

INTRODUCTION

This project provides for setting up special automatic devices at the key railway junction stations of Latvia, where intensive operations of forming and breaking up of trains take place, i.e. in Riga, Daugavpils, Rezekne, Jelgava, Ventspils, Krustpils, and Liepaja, in order to read wagon numbers from a passing (travelling slower) rolling stock. The system is expected to read these numbers, enter them in a common data system, prepare an electronic train consignor list, and, following a specialist control and electronic verification, the prepared document is sent to the next train processing station. The introduction of the system in practice, as well as partial computerisation of railroad documentation would not only speed up the wagon number recording process, but would also facilitate and accelerate the wagon sorting and control processes, and would expedite cargo flows in the biggest railroad transit corridor of Latvia, i.e. Rezekne – Krustpils – Jelgava – Ventspils, as well as in other major cargo directions.

1. RFID SYSTEM

Radio-frequency identification (*RFID*) uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically stored information. Passive tags collect energy from a nearby RFID reader's interrogating radio waves. Active tags have a local power source such as a battery and may operate at hundreds of meters from the RFID reader. Unlike a barcode, the tag need not be within the line of sight of the reader, so it may be embedded in the tracked object. RFID is one method for Automatic Identification and Data Capture (AIDC).

RFID tags are used in many industries, for example, an RFID tag attached to an automobile during production can be used to track its progress through the assembly line; RFID-tagged pharmaceuticals can be tracked through warehouses.

System RFID (Radio Frequency Identification) — a method of automatic object identification, whereby, radio signals are used to read or record data stored in what are known as a transponder, or RFID tags. An RFID system consists of a reading device (reader, sensor) and a transponder (i.e., RFID tag).

Depending on the reading distance, RFID systems can be divided into:

- close-range identification (reading at a distance of up to 20 cm);
- medium-range (20 cm to 5 m) identification (system to be implemented);
- long-range identification (5 m to 100 m).

Most RFID tags consist of two parts. The first is an integral scheme (IS), which is intended for storing and processing information (it could contain data about the amount of cargoes in a specific wagon and other related information), for modulating and de modulating the radio frequency (RF) signal, and for performing some other functions. The second is an antenna to receive and transmit signals.

2. TAGS

A radio-frequency identification system uses *tags*, or *labels* attached to the objects to be identified. Two-way radio transmitter-receivers called interrogators or readers send a signal to the tag and read its response.

RFID tags can be passive, active or battery-assisted passive. An active tag has an on-board battery and periodically transmits its ID signal. A battery-assisted passive (BAP) has a small battery on board and is activated when in the presence of an RFID reader. A passive tag is cheaper and smaller because it has no battery; instead, the tag uses the radio energy transmitted by the reader. However, to operate a passive tag, it must be illuminated with a power level roughly a thousand times stronger than for signal transmission. That makes a difference in interference and in exposure to radiation.

Tags may either be read-only, having a factory-assigned serial number that is used as a key into a database, or may be read/write, where object-specific data can be written into the tag by the system user. Field programmable tags may be write-once, read-multiple; "blank" tags may be written with an electronic product code by the user.

RFID tags contain at least two parts: an integrated circuit for storing and processing information, modulating and demodulating a radio-frequency (RF) signal, collecting DC power from the incident reader signal, and other specialized functions; and an antenna for receiving and transmitting the signal. The tag information is stored in a non-volatile memory. The RFID tag includes either fixed or programmable logic for processing the transmission and sensor data, respectively.

An RFID reader transmits an encoded radio signal to interrogate the tag. The RFID tag receives the message and then responds with its identification and other information. This may be only a unique tag serial number, or may be product-related information such as a stock number, lot or batch number, production date, or other specific information. Since tags have individual serial numbers, the RFID system design can discriminate among several tags that might be within the range of the RFID reader and read them simultaneously.

3. SIGNALING

Signaling between the reader and the tag is done in several different incompatible ways, depending on the frequency band used by the tag. Tags operating on LF and HF bands are, in terms of radio wavelength, very close to the reader antenna because they are only a small percentage of a wavelength away. In this near field region, the tag is closely coupled electrically with the transmitter in the reader. The tag can modulate the field produced by the reader by changing the electrical loading the tag represents. By switching between lower and higher relative loads, the tag produces a change that the reader can detect. At UHF and higher frequencies, the tag is more than one radio wavelength away from the reader, requiring a different approach. The tag can backscatter a signal. Active tags may contain functionally separated transmitters and receivers, and the tag need not respond on a frequency related to the reader's interrogation signal.

An Electronic Product Code (EPC) is one common type of data stored in a tag. When written into the tag by an RFID printer, the tag contains a 96-bit string of data. The first eight bits are a header which identifies the version of the protocol. The next 28 bits identify the organization that manages the data for this tag; the organization number is assigned by the EPCGlobal consortium. The next 24 bits are an object class, identifying the kind of product; the last 36 bits are a unique serial number for a particular tag. These last two fields are set by the organization that issued the tag. Rather like a URL, the total electronic product code number can be used as a key into a global database to uniquely identify a particular product.

Often more than one tag will respond to a tag reader, for example, many individual products with tags may be shipped in a common box or on a common pallet. Collision detection is important to allow reading of data. Two different types of protocols are used to "singulate" a particular tag, allowing its data to be read in the midst of many similar tags. In a slotted Aloha system, the reader broadcasts an initialization command and a parameter that the tags individually use to pseudo-randomly delay their responses. When using an "adaptive binary tree" protocol, the reader sends an initialization symbol and then transmits one bit of ID data at a time; only tags with matching bits respond, and eventually only one tag matches the complete ID string.

4. EPC GEN2

EPC Gen2 is short for EPCglobal UHF Class 1 Generation 2.

EPCglobal, a joint venture between GS1 and GS1 US, is working on international standards for the use of mostly passive RFID and the Electronic Product Code (EPC) in the identification of many items in the supply chain for companies worldwide.

One of the missions of EPC global was to simplify the Babel of protocols prevalent in the RFID world in the 1990s. Two tag air interfaces (the protocol for exchanging information between a tag and a reader) were defined (but not ratified) by EPC global prior to 2003. These protocols, commonly known as Class 0 and Class 1, saw significant commercial implementation in 2002–2005.

In 2004, the Hardware Action Group created a new protocol, the Class 1 Generation 2 interface, which addressed a number of problems that had been experienced with Class 0 and Class 1 tags. The EPC Gen2 standard was approved in December 2004. This was approved after a contention from Intermec that the standard may infringe a number of their RFID-related patents. It was decided that the standard itself does not infringe their patents, making the standard royalty free. The EPC Gen2 standard was adopted with minor modifications as ISO 18000-6C in 2006.

5. SYSTEM RFID FOR RAILROAD TRANSPORT

The systems offer a set of equipment for RFID railroad transport — for creating identification system: RFID radio signs, RFID readers, gauges, controllers. By using the RFID system, rail transport identification at a distance of 2 to 100 and more metres, detection of the train speed, control of railroad crossings, integration of the offered equipment with other railroad systems can be carried out. Furthermore, RFID transmitters are installed on each vehicle, train or wagon, but the TagMaster reader is set up on the road of the rolling stock trajectory. The reader can recognise radio signs with speed of over 300 km/h. Railroad operators will be able to read not only the train composition or wagon individually, but also to detect dynamics of shifts of transit transport or other train compositions along the railroad network.

RFID technologies allow measuring the key diagnostic parameters, which are necessary for ensuring security on railroad, as well as analyse data received from the measured objects in real time and are connected to the precise location of each wagon.

Fig. 1. *Train car mounted RFID tag*

Fig. 2. *Platform-mounted RFID tag*

Calculated project costs: standard Gen2 signs are now already significantly less expensive than the previous generation signs. This also renders their application more desirable, but in most cases first generation equipment (readers) are required for work with new standards only for internal re-programming of the integrated programme.

RFID tags, which have become a standard for such companies as Wal-Mart, Target, Tesco in Great Britain, Metro AG in Germany and the US Department of Defense, have the lowest price of about

5 cents per tag by SmartCode company (when buying 100 million pieces or more).

This means that our calculated costs, upon introducing the system in practice and equipping the aforementioned stations with it, could reach about 100 million euros. However, taking into account the cargo flows and further applicability of tags also in other transport types, the return of this investment is expected to be achieved within 2–4 years.

Involving a company for this project that can install such equipment it is necessary to take into account that the Latvian railroad can be trusted to do this for rolling stock. About one year is required for inspection and maintenance staff to do preparatory works and erect capital structures. By this time the system can be implemented but another 6 months are necessary for programming and after that it can start functioning in test mode. Therefore the system will start fully function about 2 years after the beginning of project realization.

The SJSC "Latvian Railway" benefits from the project owing to the possibility to increase the cargo flow with the currently available infrastructure, which would be based on faster operations with trains and wagons. Likewise, the work of human resources and time consumption would be improved; very accurate automatization of sorting processes and locomotive brigade control are possible.

The most significant risks related to the project implementation are low, but it is possible that full practical applicability of systems of this type in railroads due to its innovations is not fully appreciated. When implementing the project, increased return-on-investment time of up to 5 years is possible, along with reduced human resources upon the implementation. Furthermore, in case the system is damaged, it would be necessary to switch back to the existing system, and, since the number of staff would already be reduced, it might be complicated, thus, in case of system failure, the capacity of a station might be considerably reduced — more than at this time.

Additional remarks:

Annual savings per train car after the system is introduced:

$$I^{gada} = \frac{\left(t_{veca} - t_{jauna}\right) \cdot N_{saksk} \cdot V_{sk} \cdot e \cdot 365}{60 \cdot 100} \qquad (1)$$

where:

- V_{sk} - number of wagons;
- $N_{sas.sk}$ - number of train compositions to be processed in 24 hours;
- e - expenserate, (EUR).

Operational costs:

$$E_{izm} = \Sigma C \qquad (2)$$

General annual economic costs:

$$V_{ekiz} = I^{gada} + E_{izm} \qquad (3)$$

Curtailing capital investments from curtailing cargo costs at a station

$$\Delta C_{km} = \frac{\Sigma_{vag} \cdot P_{vagsl} \cdot \left(t_{veca} - t_{jauna}\right) \cdot C_{km} \cdot K_{tuks}}{24 \cdot 60} \qquad (4)$$

where:

- Σ_{vag} - number of wagons per day;
- $P_{vag.sl}$ - average train car load;
- ($t_{veca} - t_{jauna}$) - time old / new;
- $C_{k.m}$ - average price per 1 tonne of cargo;
- $K_{tukš}$ - proportion of empty wagons in a station.

Period of return on capital investments upon introducing a new system:

$$T_{atm} = \frac{K - \left(\Delta u_{pn} + \Delta C_{km}\right)}{V_{ekiz}} \qquad (5)$$

where:

- T_{atm} - ROI time;
- K - capital investments for system management;
- $V_{ek.iz.}$ – general annual economic costs;
- $C_{k.m.}$ - price per cargo mass;
- vdp - wagon working fleet.

CONCLUSION

After the project is completed, the system could function indefinitely, subject to annual technical maintenance of equipment and devices and daily monitoring of their condition; moreover, the system can be easily reconstructed, improved and technically modernized.

The strengths of the project are that the system would facilitate and accelerate the wagon sorting and control processes, and would expedite cargo flows in the biggest railroad transit corridor of Latvia, i.e. Rezekne – Krustpils – Jelgava – Ventspils, as well as in other major cargo directions.

BIBLIOGRAPHY

1. И.Б.Сотников,Взаимодействие станций и участков железных дорог (Исследование операций на станциях), Москва «Транспорт» 1976;
2. М.С.Боровикова, Организация движения на железнодорожном транспорте, Москва 2003;
3. Техника – молодежи, №962, www.technicamolodezhi.;
4. LDZ statistikas dati (statistical data from the State Joint-Stock Company Latvijas Dzelzcels);
5. Informācija no LDZ (information from the State Joint-Stock Company Latvijas Dzelzcels);
6. http://www.itproject.ru/otraslevye_resheniya/rfid_system_arhiv/biblioteka_rfid

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Scientific publications

- «Improvement of Train Control System in Ziemelblazma - Skulte Section, Latvia», Szcyrk, Poland, 2016. g. (ISSN 1509-5878; e-ISSN 2450-7725)
- «Analysis of Park Kundzinsala (spur track of the Riga Krasta station, Latvian railway) railway infrastructure capacity», Szcyrk, Paland, 2016. g. (ISSN 1509-5878; e-ISSN 2450-7725)