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MODERN CONTAINER TRACKING SYSTEMS ON RUSSIAN RAILROADS: TECHNOLOGIES AND PROSPECTS

The present article is dedicated to the application of modern container tracking systems on Russian railways. It provides a brief description of the technical characteristics and the main pros and cons of such solutions as unified container numbers, barcodes, QR codes, as well as RFID and GPS container trackers.

INTRODUCTION

The EU /China container shipping market engaging Russian logistic companies and railroad capacities is constantly growing despite the global economic crisis and international policy risks associated with the EU sanctions against Russia (Fig.1). Indeed, Russian Railways JSC estimate the total volume of China- EU -China container transit on the Russian rail infrastructure in 2015 at 81 thousand TEU (twenty-foot equivalent unit), which is 83% more than in 2014, with 61% growth of China-EU shipment destination (from 32 to 52 thousand TEU) and 2.5 time growth for EU-China destination (from 12 thousand TEU in 2014 to 29 thousand TEU in 2015). Thus, future container market development will be followed by competition among the operators both in the container segment and between related freight market segments. Therefore, the quality of service provided by container operators to their clients becomes essential for the competitive success

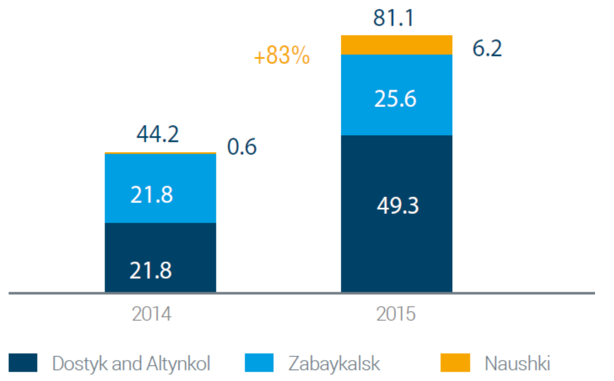

Fig. 1. *Transit transportation, China-EU- China (thousand TEUs) [1]*

1. CONTAINERS ROUTE TRACKING

One of the key competitive factors is to enable the customer to track the container with its cargo in as much detail as possible. Earlier, the development of such systems was difficult due to the lack of available data networks. Nowadays, the global Internet use in the developed countries (especially the wireless mobile Internet access) gave rise to a number of technologies that made possible the application of the container tracking tool with various degree of details.

The oldest technology, and nonetheless most used on the railroads in Russia, is tracking by the number of container (Fig.2). Containers are marked with numbers using a standard unified system (Fig.3). This article will not cover the details of marking or the types of standards, but confine to the process of container tracking by its number.

Fig. 2. *Sample of container labeling [6]*

Fig. 3. *ISO 6346 (BIC) Code [6]*

Initially it was assumed that, if necessary, the container number would be read manually by an operator who will enter the data into the system, or automatically by optical sensors with text recognition tools that will digitize it and put into the data system. However, this method is ineffective even for relatively small shipment volumes since the scanning and recognition take much time and extensive resources.

Therefore, it became necessary to convert the original container number into a format that can be directly computer- processed. The barcode or QR-code technology serves to convert alphanumeric container number into a computer-readable format. The barcode is graphic information printed on the surface, label or package of product item that is machine-readable through the sequence of black and white lines or other geometric shapes. Barcodes can be linear and two-dimensional (Fig.4). QR-code is a type a two-dimensional code, which unlike a barcode scanned with a thin beam, is recognized by a sensor or a camera as a two-dimensional image (Fig.5).

Fig. 4. Example of QR code with information about author's email

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Fig. 5. Example of bar code with information about author's email

2. RADIO FREQUENCY IDENTIFICATION (RFID) TECHNOLOGY

Therefore, to correct this drawback, since the mid-2000s RFID technology has been widely used in Europe to track container shipping. The Radio Frequency IDentification (RFID) is a method of automatic identification of objects that uses radio signals to read or record data which are stored in the so-called transponders or RFID-tags. Any RFID system consists of a reading device (reader or interrogator) and a transponder also known as an RFID-tag.

This solution is applied for container tracking with the use of the following components: an individual transponder installed on each container; an active or passive reader located at the important points of cargo route (for example, at intermediate stations); intermediate IT infrastructure that receives, processes and presents the cargo tracking data in a user-friendly form. The IT infrastructure is usually composed of the following components: a server (Logistics Information Server) with a database (DB) that contains information required for the cargo tracking; a Web server that maintains a Web site where the end-user can do the tracking; a middleware (the RFID Middleware) that converts the reader data into a DB-writable format, and a network infrastructure (wired or wireless) which ensures the physical data transmission from the reader to the Logistics Information Server. Either optical data transmission channels and wireless networks (e.g. Wi-Fi) or cell communication provided by third-party operators (GPRS, UMTS, LTE) may serve as a data transmission medium. While the active reader itself is a Wi-Fi access point or contains an embedded cell network access unit, the passive reader is designed only to read data from the tag, and to transfer the information out it needs independent network devices (for example, a router) (Fig.6).

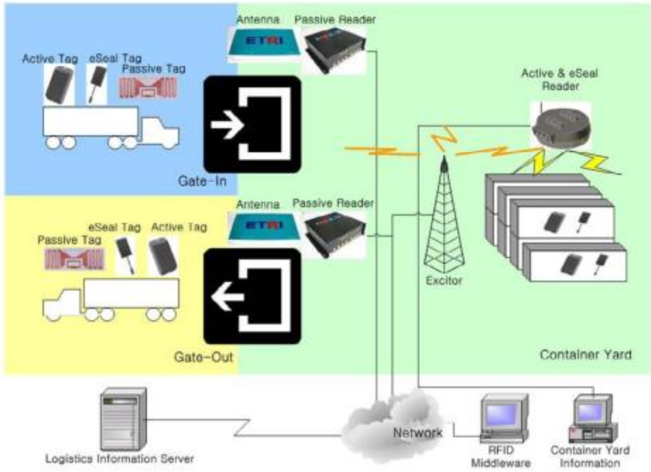

Fig. 6 The structure of container tracking system with RFID Technologies [2]

At the same time, since every RFID-tag is also a small capacity storage device (as a rule up to 512 kilobytes), its entire travel path on control points is also stored in the internal memory and can be read at its arrival at the final destination. This is important insofar as any data transmission medium is never fully fail-safe. Hence, it is important to have the tools of redundancy of the network-transmitted data (Fig.7).

Fig. 7 One example of RFID lock [3]

3. GPS (GLONASS) TECHNOLOGY FOR CONTAINER MONITORING

GPS (GLONASS) trackers represent another technology for container monitoring. A GPS (GLONASS) tracker contains a GPS (GLONASS) receiver used to identify its location and a transmitter based on the cellular communication provided by third-party operators (GPRS, UMTS, LTE) or satellite communication through which the data are transmitted to the server center equipped with special software for satellite monitoring. In addition to GPS (GLONASS) receiver and transmitter, an important technical element of the Tracker is a GPS (GLONASS) antenna (which can be both external and embedded into the tracker), an accumulator and a built-in memory (Fig.8).

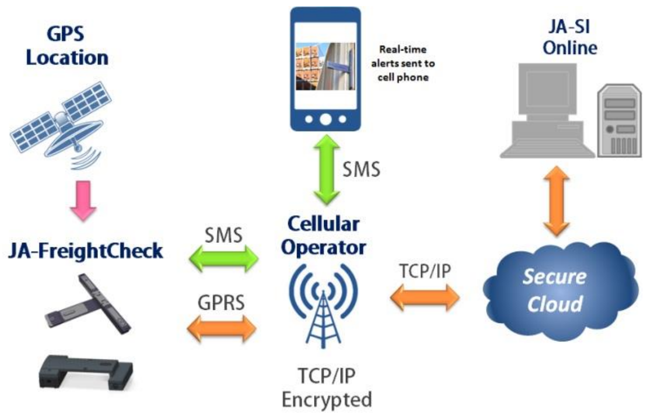

Fig. 8. The structure of container tracking system with GPS technologies [5]

The operation mechanism of this technology is very similar to the one of RFID. The difference is that GPS (GLONASS) tracker maintains a constant connection with the GPS (GLONASS) satellite and detects its position by measuring the time of receiving synchronized signal from navigation satellites and the antenna of the GPS (GLONASS) tracker. The data about exact coordinates and time are recorded into the tracker memory and duplicated by the communication of third-party cellular operators with a server that processes this type of requests. The data are then processed, aggregated and provided to the client through the Web server in a form convenient for tracking. To facilitate the application, enhance cargo safety, and reduce costs, the GPS (GLONASS) tracker is usually embedded into the container locking device (Fig.9).

Fig. 9. TRX-800 Container GPS Tracking Device [4]

The main advantage of this solution is that, if needed, the shipping can be tracked continuously in real time - except for railway tunnels impenetrable for the satellite signal - which enables the system installation in containers with high-value or high-hazard cargo.

The downside of the solution is first of all a very high cost of its introduction primarily due to the high price of GPS-GLONASS tracker (typically from 100 to 300 USD per piece depending on the manufacturer and functionality) that are fairly sophisticated devices unlike e.g. passive RFID tags with wholesale price less than several dozen cents. The GPS (GLONASS) tracker also consumes a lot of power, which reduces the time its off-line operation or sometimes even requires feeding from the onboard train network

All in all, considering the features of RFID and GPS systems, it should be said that the effectiveness of their implementation and operation largely depends on the quality of cellular communication in the regions on the route of the rolling stock that carries the tracked cargo. As state previously, indeed, in case of a temporary cell signal loss the systems are able to function offline, independently record container tracking data into their memory, and after the reconnection simultaneously send all accumulated data to the server. However, to ensure a real time container tracking it is nonetheless highly preferable to renovate the cellular infrastructure along the railroads to ensure maximum coverage at any traffic speeds. In perfect compliance with the above requirements, the global data transmission system GSM-R introduced in the Moscow region in 2014-2016 enabled to interconnect Oktyabrskaya, Moskovskaya, Gorkovskaya, and South-Eastern Railways, and ensured a reliable connection to the cellular network at the speed up to 600 kph. In the future it is planned to introduce this system in other Russian railway networks, including the Trans-Siberian Railway. The container-tracking application issue may arise as far as presently GSM-R is used only to transfer information for ALS 400 Train-Track traffic safety system. To gain access to this system, third-party logistics companies (e.g. Transcontainer) will need to make additional agreements with Russian Railways JSC.

CONCLUSION

In conclusion, it should be noted that on the one hand, at the moment, unfortunately the container tracking on Russian railways is mainly based on the container number with no tracking tools in any way standardized for all container market players, while the introduction of the modern systems is in its rudimentary stage. At the same time, this opens up great prospects and for Russian logistics companies. While Chinese and primarily European partners are closely tied to outdated or rapidly aging technologies or solutions introduced a long time ago, Russian companies can without turning back introduce and apply cutting-edge, breakthrough technologies and thus become market leaders in a short time. The only question is the willingness and funding.

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Nowoczesne systemy śledzenia ruchu kontenerów na kolejach rosyjskich. Technologia i perspektywy

W artykule opisano problemy związane z wykorzystaniem nowoczesnych systemów śledzenia ruchu kontenerów na kolejach rosyjskich. Opisano cechy techniczne oraz główne zalety i wady istniejącej technologii, takich jak znormalizowane kontenery, Bar i QR kody, a także technologie RFID i GPS śledzenia ruchu ładunków.

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