IT Solutions as an Important Instrument for Enhancing Competitiveness of the Logistics of Liquid Fuels in Poland

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The aim of the article is to present an innovative IT solution for monitoring transport in the process of fuel distribution, which was implemented in Lotos Paliwa in January 2013. Hardware and software requirements of the system, as well as the functional and task-oriented structure were described in the article. In contrast to other standard applications supporting the management of liquid fuel supply chain, it is a unique solution which considerably contributes to a significant reduction of the levels of losses and extraordinarily increases the safety and quality of delivered goods. It is a tool which may become an important source of competitive edge during stagnation in the market of fuels.

Keywords: IT Solutions, liquid fuels, logistics, ADR transport.

1. INTRODUCTION

In this article the author concentrates on the presentation of selected IT solutions which significantly influence the method of building competitive advantage for enterprises of liquid fuels market in Poland. The implementation of new solutions such as technological innovation, product and process innovation determined their condition and survival. Contemporary companies, in order to keep their competitive position and strengthen it on the domestic or international market, should think about building a competitive advantage based on innovation.[1] Due to increasing global competition and technological progress, gaining competitive edge requires more and more technologically advanced IT solutions.[2] This also applies to the sector of liquid fuels whose entities are manufacturers and distributors of diesel oil and petroleum. In the business breakdown structure of that sector the main players are the following concerns PKN Orlen, Grupa Lotos and foreign concerns supplying BP, Shell, Statoil and Lukoil petrol stations. This group serves almost 53% of the liquid fuel station market, and the remaining part of the retail market is occupied by private petrol stations. Additionally, pursuant to the data provided by Polska Organizacja Przemysłu i Handlu Naftowego (Polish Organisation of Oil Industry and Trade) a stagnation in the amount of sale and the number of petrol stations has been recorded in recent years. Table 1 presents basic statistical information concerning the fuel market in Poland.

Table 1. The number of petrol stations and the sale of liquid fuels in Poland in the years 2010-2012.

Year Details	2011	2012	2013
Number of petrol stations	6,771	6,756	6,746
Diesel oil sale	15,748	14,293	13,426
Petroleum sale	5,039	5,036	4,926

Source: POPHN and the Polish Ministry of Finance.

During stagnation in the market of liquid fuels, the strive for the increase of the market share by the biggest fuel concerns requires the implementation of similar IT solutions in order to integrate the whole supply chain. The common internet access, new technologies of automatic identification of goods, and satellite data

[1] Kształtowanie konkurencyjności i przewagi konkurencyjnej małych i średnich przedsiębiorstw, A. Adamik, Wydawnictwo C.H.Beck, Warszawa 2011.
[2] See e.g.: E- logistyka, ed. W. Wieczerzycki, PWE, Warszawa 2012.

transmission enable the information access and the coordination of flows though the supply chain from the procurement stage, through manufacturing and distribution to petrol stations. Taking over the responsibility for planning and the control of inventory at petrol stations in line with the VMI (eng. *Vendor Managed Inventory*)[3] principles is a particularly effective cost reduction tool. However, in order to secure supplies of goods of the same and high-quality characteristics, it is necessary to develop innovative IT solutions to monitor transport in the process of fuel distribution. It is particularly important, as the quality of logistic services and of the supplied fuel is becoming a key factor while choosing a supplier. Therefore, the main aim of the article is the presentation of unique IT solutions for monitoring and control of liquid fuels in the course of their distribution, which determins high-quality and safety of goods. In contrast with standard IT solutions regarding inventory management VMI, planning deliveries and HSSE[4], these are specific applications used for distinguishing the offer of Grupa Lotos not only in terms of the quality of logistic service offered to a station, but they are essential in securing the quality and safety of goods for end-customers.

2. GENERAL CONCEPT OF MONITORING TRANSPORT PROCESSES

In road transport of liquid fuel in tanks a deterioration of the quality of goods as a result of so-called micro-mixing and mixing[5] is usually observed during loading, unloading and the carriage itself between terminals. The allowed levels of inculpable and culpable level of mixing (so-called level of INL and CNL)[6] are set regulatory norms, which stimulate innovative IT solutions. Programmes implementing new technologies to provide high quality and safety of products are supported also by POPIHN. Therefore, all domestic and foreign concerns look for new hardware-software solutions, which could work effectively in order to prevent the deterioration of quality characteristics of fuels in the course of their distribution. Unfortunately, a several-year-long analysis of offers of IT services market did not let Grupa Lotos choose a tenderer and purchase a standard application, which would guarantee an effective security of load, and in particular would limit human errors during loading and unloading in terms of the correctness of connection of the tank to the station storage tank with the same product. The additional requirement the application had to meet was the electronic security of fuel, from loading up to the unloading at destination place, monitoring of complete empting of the tank chamber with a possibility to manage these elements *on line* and a possibility to conduct an analysis of historical data *off line*. As there was no tenderer who could meet the described requirements, the company Lotos Paliwa, a member of Grupa Lotos, started its own project of remote SPDS & RMPS transport monitoring system, the essence of which is presented in the Figure 1.

[3] Information and communication technologies supporting joint management of inventory in supply chains were described in detail e.g. in: G. Knolmayer, P. Mertens, A. Zeiser: Supply Chain Management Based on SAP Systems, Springer – Verlag, Berlin – Heidelberg 2002 and J.Witkowski: Zarządzanie łańcuchami dostaw. Koncepcje, procedury i doświadczenia. PWE, Warszawa 2010.

[4] HSSE – Health, Safety, Security, Environment.

[5] Micro-mixing – occurs when at least 5 liters of one type of fuel remain in the tank chamber, i.e. petrol and the chamber is re-filled with a different type of fuel, i.e. diesel oil, which consequently lowers one of the significant quality characteristics, namely the flash point, which pursuant to PNEU amounts to at least 55º C. Mixing is a result of unloading of one type of fuel i.e. the whole road tanker chamber into the petrol station tank for another product (i.e. 5,000 petrol 95 into 23,000 diesel oil). Concern procedures specify that such product ought to be withdrawn from the market and utilized.

[6] INL – mean inculpable natural loss, the amount of which is stipulated by the Ordinance of the Minister of Economy for petroleum-derivative products for engine petrol amount in total 0,18% plus +/- 0,5% measurement error for flow measuring devices for liquids other than water (such loss include the release from terminal, transport and storing in the station tank).

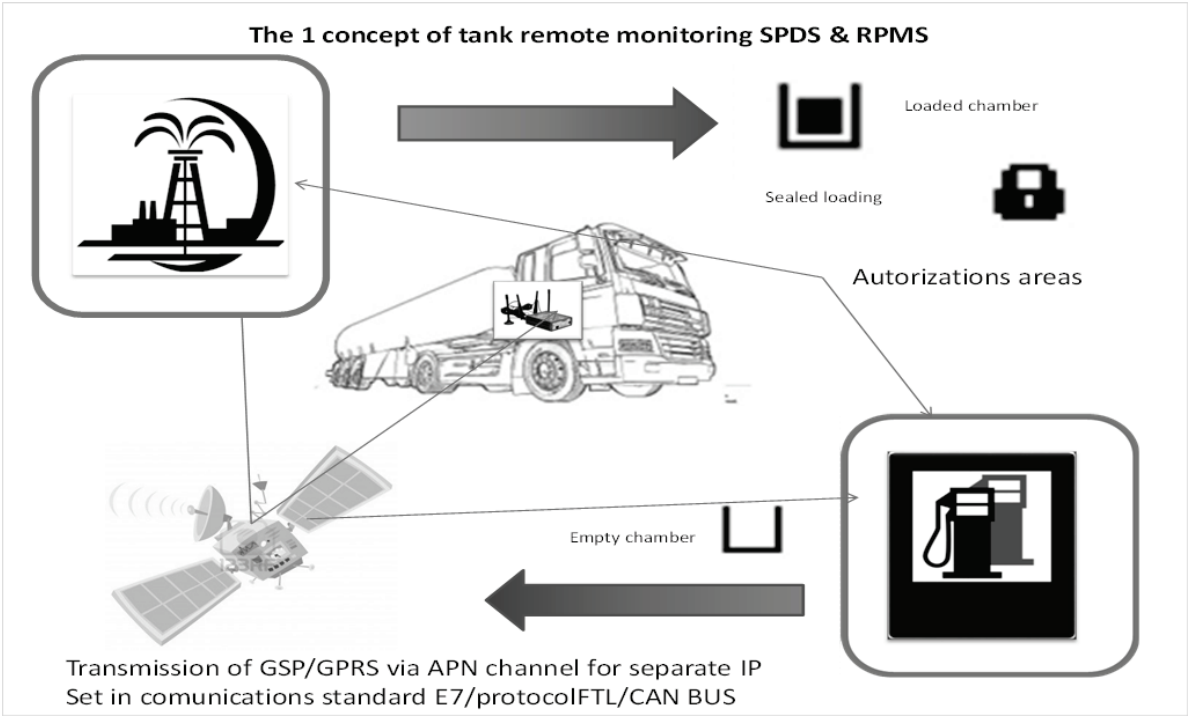

Fig. 1. The 1st concept of a tank remote monitoring SPDS/RPMS.
Source: Author's elaboration.

In the first stage of the project a supplier of hardware was selected. The system DTMQ[7] was chosen, of a German manufacturer Hawr, including the following functional and task-oriented modules:

- SCDS (*Sealed Compartment Delivery System*) in other words a module for electronic securing of a load in a chamber, pursuant to EN 15208,
- RPMS (*Remnants Product Monitoring System*) in other words a module monitoring the remains of fuel in each chamber and in the installation of a tank carrying the goods,
- COP (*Cross Over Prevention*) in other words a module preventing blending during carriage and loading operations. The module has not been implemented yet due to the lack of coding devices in all loading terminals and at the same time the lack of decoding equipment at petrol stations.

For test purposes, the purchased hardware was installed on a road tanker transporting liquid fuel. During a two-year test on a one road tanker, the lack of remote communication with the system is admissible, in a project encompassing the whole fleet of several dozen of vehicles delivering to all petrol stations of a concern, the solution would require the integration of all these elements into one module, and the possibility of remote management of them from the level of web application. According to the concept of supply chain management, where different internal and external processes as well as chain links are integrated, it is difficult to manage and use data from different sources without a system of transferring them into one integrated application. Therefore, before it was decided to expand the project onto the whole fleet, a next device was added as a module transmitting data to the web application, also constituting the main platform of system management. Once changes have been made in operation of the devices, and once a sequential algorithm was added, a tool enabling the implementation of the concept presented in Figure 1 was obtained.

3. DETAILED HARDWARE AND SOFTWARE REQUIREMENTS

To have a well-functioning remote system of fuel distribution it was necessary to meet hardware requirements, which in particular take into consideration the type and equipment of the fleet of vehicles:

[7] DTMQ – (Devices for Transferring Measured Quantities).

- All road tankers with five compartments enabling hermetic bottom loading and exclusively one side used for loading-unloading.
- Monitoring the opening of each bottom valve and the opening of unloading API coupler.
- Connecting opening and closing of bottom valves with a dynamic level indicating a continuous reference point for the bottom valves position in relation to allowed level of deviation of a particular chamber during unloading.
- A GPS device for the transmission of data from the device called XMaster[8] in format E7/protocol FTL/CAN BUS.

At the same time, the following essential requirements were adopted with regard to software:

- An application integrating and visualising the operation of the SPDS/RPMS system,
- Monitoring of alarms triggered by the algorithm of an unfulfilled criteria sequence operating in the background,
- An interactive sheet allowing the communication of all system users.

4. FUNCTIONAL AND TASK-ORIENTED STRUCTURE OF LIQUID FUEL DISTRIBUTION SYSTEM OF LOTOS PALIWA

Fulfilling the described hardware and software criteria enabled monitoring of the course of distribution, according to the guidelines presented in Figure 1:

a) a vehicle having entered the loading terminal (an authorisation area) is continuously monitored by SPDS/RPMS with the use of web application,
b) a driver, after loading of each chamber with appropriate product, assigns suitable symbols with regard to the loaded product and the type and status of sealing/ securing the load,
c) having left the loading area (an authorisation area), when the system does not register the right status of the load (a broken seal, an interference into the amount of the product), the system will define it as unauthorised activity and will assign the alarm status until it is accounted for from the level of web application, to which the driver has granted access,
d) during the transport, if a vehicle stops and a sensor is activated (bottom valve, API coupler) the system will also register it as an interference into the product and as unauthorised activity and through GPRS/GPS data transmission the system will activate the alarm to be accounted for by the driver,
e) continuous monitoring after the arrival at a petrol station and if a tank chamber has not been emptied, namely, the bottom valve exceeded the allowed deviation level, the driver can lock such a valve in a way enabling the system the recognition of its appropriate levelling.

In service, having logged into the web application, accessible for the forwarder, carrier and recipient of the product, (each of them has own access codes and different authority to use the application) work in two modes is possible. In *online mode* the system enables:

- a precise geolocation of a vehicle,
- speed control, which in transport of dangerous goods, fuel Class.3 according to ADR[9], and HSSE policies applied by concerns is a very important factor,
- monitoring of fastening driver's seatbelts on the way,
- monitoring the status of order completion (loading, transport, unloading) against the indication of sensors registered by SPDS/RPMS.

Additionally, in *off line* mode it is possible to:

- analyse data concerning any recorded period,
- verify any route, the work of a combination: a vehicle and a driver,
- generate reports (for example if in the whole country transport is performed by a few carriers, it is possible to asses quickly on the basis of alarm reports, which of the carriers offers the best quality of transport services).

[8] XMaster – a device steering and recording changes of the SPDS/RPMS installation statuses.

[9] ADR – (fr. L' Accord européen relatif au transport international des marchandises Dangereuses par Route) an international convention concerning the International Carriage of Dangerous Goods by Road was done in Geneva on 30 September 1957. It was ratified by Poland in 1975. The provisions of ADR agreement are amended every two years. The agreement is currently in force in 46 countries.

The possibilities of monitoring vehicles in real-time are presented in Figure 2.

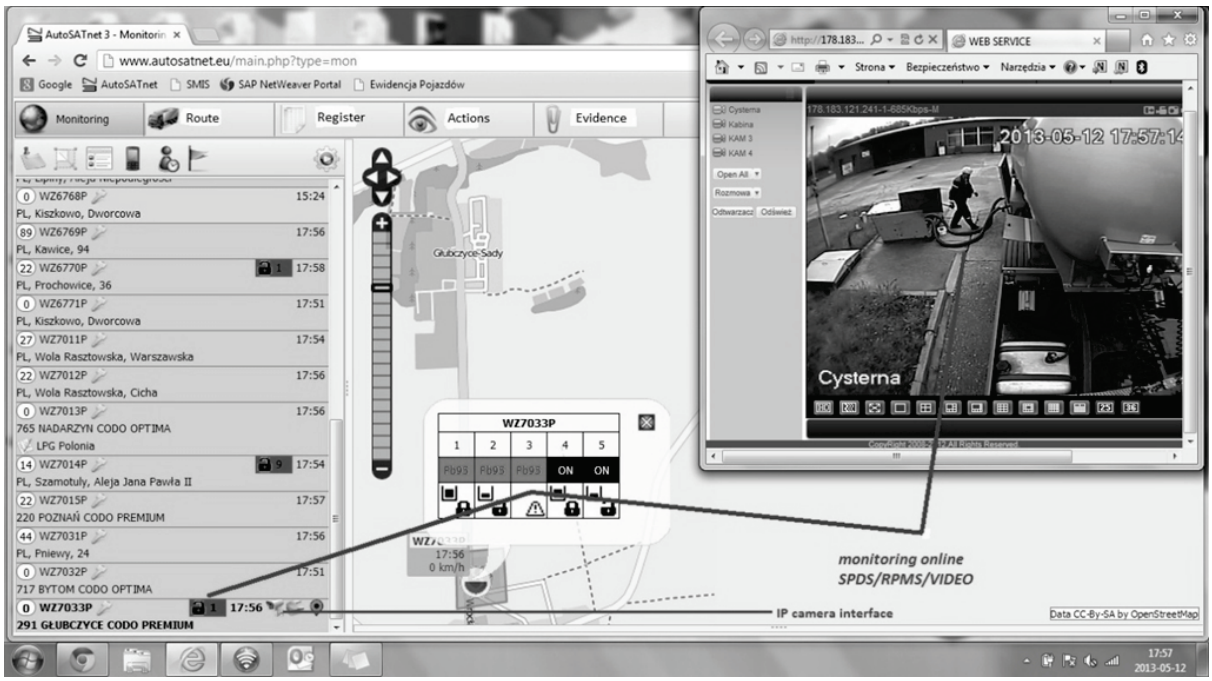

Fig. 2. Aplication on website autosatnet.com.pl / the remote monitoring of a tanker during unloading.
Source: Web application of ATROM. Zakład Elektroniczny (Electronics Manufacturing Plant) Mirosław Morta.

On the left-hand side of the screen there is a list of the vehicles monitored by the system. The first vehicle at the bottom of the list was chosen to be watched, which at the point of generating the screenshot was being unloaded at one of the concern's petrol stations. Once a vehicle is chosen the system sends a signal to establish communication with the vehicle and update the filling level in particular chambers of the tanker, which the system illustrates as a unfolded field with the information. In this example it is possible to notice that having emptied the diesel oil at the station from chamber 1, the system assigned it the proper status of an empty chamber. At the same time chambers 2,3,4 are still loaded and the seals securing the load are intact. Whereas chamber 5 is in the middle of unloading, which the system indicates by means of the status of violation of the load and breaking electronic seal. Figure 2 illustrates the state as expected by all links participating in the process of distribution.

Unfortunately, technical and economic limitations preventing the implementation of full DTMQ system have not allowed a completed elimination of weak links, which may lower the quality of rendered services and deteriorate the range of losses and the quality of delivered product. The implemented system SPDS/RPMS is a sufficient tool for the purposes of securing the goods in terms of quality and amount during transportation from the departure terminal to the arrival at a petrol station. However, without video monitoring the course of loading at the terminal and unloading at a petrol station is still unknown. Therefore the system was expanded by adding a video monitoring through equipping the tanker with:

- A mobile recorder,
- An IP Router,
- A GPS as the second, independent one in a vehicle,
- A camera inside the cabin and an outside camera.

In line with the principle of integration and unification the functions of the web application used currently were successfully modified in such a way that having chosen a particular vehicle and the camera icon, the system redirects the hyperlink on IP address of the vehicle, thus enabling the monitoring of the area during loading and unloading of the vehicle. An additional security is provided by an algorithm recording the image every 10 seconds all the time the vehicle is immobilised.

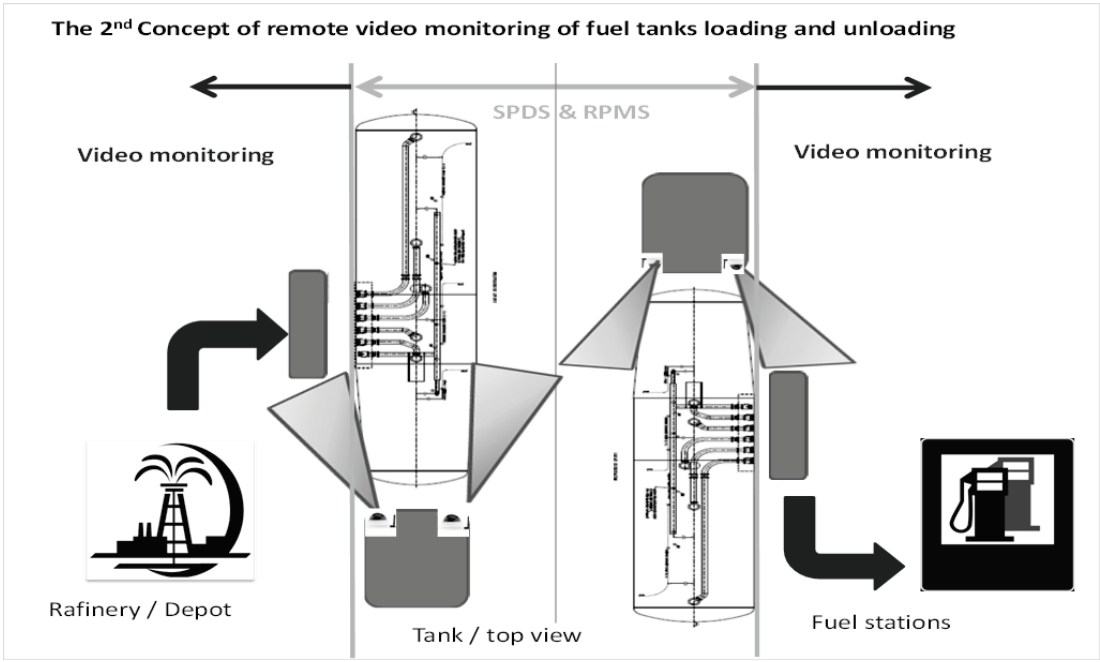

Fig. 3. The extended concept of remote video monitoring of fuel tanks loading and unloading.
Source: Author's elaboration.

The presented integration of hardware-software solutions secures the load from the release at loading terminal, through transport, until the reception into the station warehouse.

The web application also allows a mutual communication among the participants of the process through an interactive sheet (Figure 4). If an alarm is activated on any of the vehicles (as in Figure 3 with regard to the third vehicle from the top), the owner of the vehicle is obliged to account for the causes of the activation. On weekdays an alarm should be accounted for within 24 hours, on weekends and on holidays the time span for accounting for the alarm is extended to 48 hours. Later, the alarms are moved to the archive, where the Principal can either accept or reject the explanation. If the alarm is rejected, the system moves it to the rejected issues which results in charging the carrier for the detected loss in the delivery in terms of quantity and value.

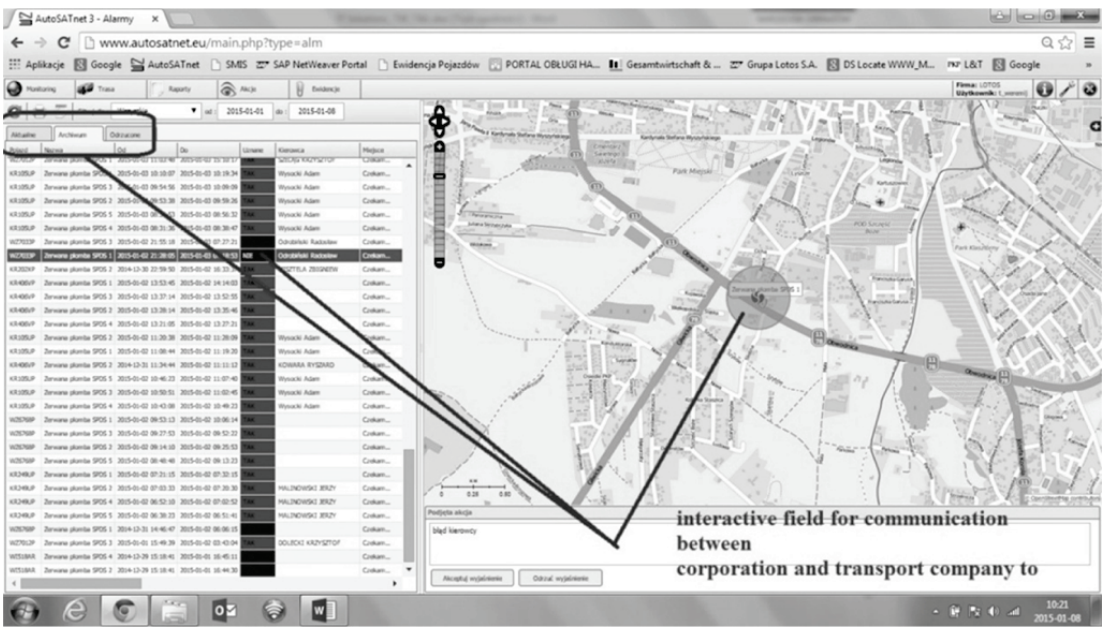

Fig. 4. An interactive sheet enabling communication among the participants of the process and accounting for the alarms.
Source: Provider of the Web application autosatnet.com.pl ATROM, Zakład Elektroniczny (Electronics Manufacturing Plant) Mirosław Morta.

5. CONCLUSIONS

The presented IT solution is used by concern Lotos Paliwa for the purpose of distribution of fuels in the whole network of their own stations, beginning from January 2013. A considerable decrease in the levels of fuel losses was noted already in the first quarter of 2013, which confirmed the reasonableness of the implementation of the solution described herein. The said application has also contributed to the increase of the safety level and the provision of the quality of fuels in the process of their distribution in the final links of liquid fuels supply chain. Although particular independent modules of the presented solution used separately are not a novelty, in such a combination it is the first solution of that type implemented in Europe. Therefore, the principles of the system of monitoring transport have been presented to other entities in the oil industry by POPIHN and recommended to be implemented by other concerns.

REFERENCES

[1] E-logistyka, red. nauk W. Wieczerzycki, PWE, Warszawa 2012.
[2] G. Knolmayer, P. Mertens, A. Zeiser: *Supply Chain Management Based on SAP Systems*, Springer – Verlag, Berlin – Heidelberg 2002.
[3] J.Witkowski, *Zarządzanie łańcuchami dostaw. Koncepcje, procedury i doświadczenia*. PWE, Warszawa 2010.
[4] K.Schori, A.Roch, *Innovationsmanagement fuer KMU*,Haupt Verlag 2012.
[5] N. Hermans, *Neue Konzepte im Gueterverkehr*, Grin Verlag fuer Akademische Texte,2004 Norderstedt Germany.
[6] M. Bohl, *Risikomanagement in KMU*, Grin Verlag fuer Akademische Texte,2008 Norderstedt Germany.
[7] P. Wittenbrik, *Transportkostenmanagement im Strassengueterverkehr*, Gabler Verlag, 2011
[8] J. Schumpeter, *Theorie der wirtschawtlichen Entwicklung*, Dumcker & Hublot Verlag, Berlin 2006.
[9] K. Kolterman, *Innowacje technologiczne w procesie budowy technologicznej MSP*, Difin, Warszawa 2013.
[10] W. Janasz, *Innowacje w zrównoważonym rozwoju organizacji*, Difin, Warszawa 2011.
[11] A. Adamik, Kształtowanie konkurencyjności i przewagi konkurencyjnej małych i średnich przedsiębiorstw, Wydawnictwo C.H.Beck, Warszawa 2011.

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