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IT Solutions in Transport Management of Liquid Fuels. Case Study of Grupa Lotos

1. Introduction

Due to increasing global competition and technological progress gaining competitive edge requires more and more technologically advanced IT solutions¹. The computer-based information transparency is particularly important and usually beneficial for all participants involved in supply chain management processes. Information transparency which can be defined as „the degree of visibility and accessibility of information”² enables integration and coordination of business processes between supply chain partners from manufacturing and logistics sectors. Typical functional structure of the computer aided Supply Chain Management systems consists of the group integrated applications related to the different logistics areas, including transportation activities. Contemporary emerging SCM class of IT solutions are technologically

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1 See e.g., E-logistyka, ed. W. Wiczerzycki (2012), PWE, Warszawa.

2 Zhu K.X. (2004), Information Transparency of Business to Business Electric Markets: A Game – Theoretic Analysis, „Management Science”, Vol. 50, No. 5, May, p. 670.

advanced systems based on standard Enterprise Resource Planning (ERP) systems with extension of their coverage outside the individual company³. Even if transportation decisions and activities are important area in logistics and supply chain management, Transportation Management Systems (TMS) are not computer applications with top priority for large standard ERP systems providers. According to the survey in 2012 by Peerless Research Group⁴ TMS are often implemented by small and independent software companies. Those TMS providers use „Software as a Service” model and they are more responsive to rapid changes of their customer transportation needs and quality expectations. Therefore, the main aim of the article is the presentation of unique IT solutions for monitoring and control of liquid fuel in the course of their distribution, which decide on high-quality and safety of goods. In contrast with standard IT solutions regarding inventory management, planning deliveries and HSSE (eng. Health, Safety, Security, Environment), 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. Role of IT solutions during stagnation in market of liquid fuels in Poland

The global financial crisis and increasing competition effected IT value creation in the Polish 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 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.

3 Chwesiuk K. (2012), Computer Aided Mangement in Logistics, „International Journal on Marine Navigation and Safety of Sea Transportation”, Vol. 6, No. 3, September, p. 417.

4 www.peerlessresearch.com

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

Year Details	2010	2011	2012
Number of petrol stations	6755	6771	6756
Diesel oil sale	14614	15748	14289
Petroleum sale	5782	5039	5024

Source: POPHN and the Polish Ministry of Finance

One of the major findings from the empirical study done by S.Dong, S.X.Xu and K.X.Zhu is the conclusion that „competition shapes IT value creation”⁵. During stagnation and strong competition 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 transmission enable the information access and the coordination of flows through 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 principles VMI (eng. *Vendor Managed Inventory*)⁶ 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.

5 S. Dong, S.X. Xu, K.X. Zhu (2009), Information Technology in Supply Chains: the Value of IT - Enabled Resources Under Competition, „Information Systems Research”, Vol. 20, No 1, March, pp. 18-32.

6 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 (2010), Supply Chain Management Based on SAP Systems, Springer - Verlag, Berlin - Heidelberg 2002 and J.Witkowski: Zarządzanie łańcuchami dostaw. Koncepcje, procedury i doświadczenia. PWE, Warszawa.

3. 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 micromixing and mixing⁷ 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)⁸ 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 fuel 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. An additional requirement the application had to meet was the electronic security of fuel from loading up to the unloading at destination place, the monitoring of complete emptying 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.

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7 Micromixing – occurs when at least 5 liters of one type of fuel remains 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 55° 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.

8 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).

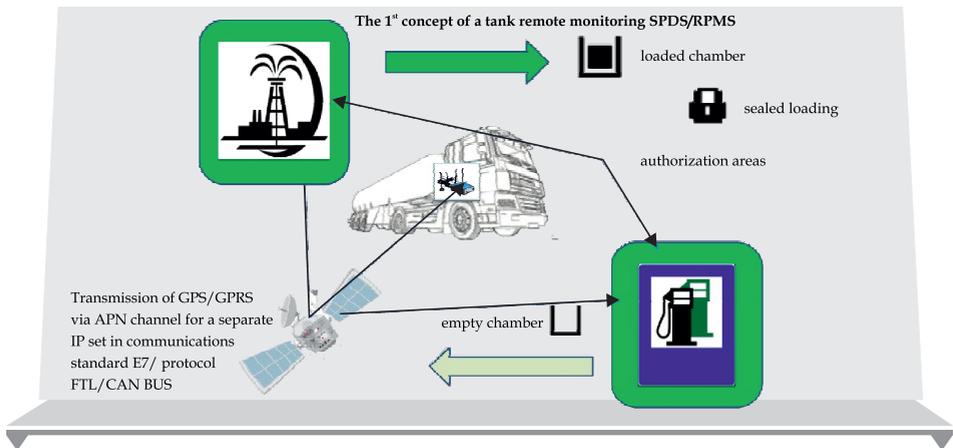


Figure 1. The 1st concept of a tank remote monitoring SPDS/RPMS

Source: author's elaboration

In the first stage of the project a supplier of hardware was selected. The system DTMQ⁹ was chosen, of a German manufacturer Hawr, including the following functional and task-oriented modules:

- SCDS (eng. *Sealed Compartment Delivery System*) in other words a module for electronic securing of a load in a chamber pursuant to EN 15208,
- RPMS (eng. *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 (eng. *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. While in a two-year test on 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

⁹ DTMQ - (ang. Devices for Transferring Measured Quantities) czyli urządzenie do transferu zmierzonych ilości.

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 data 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.

4. 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 regarding the type and equipment of the fleet of vehicles:

- 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 XMaster¹⁰ in format E7/protocol FTL/CAN BUS.

Whereas, 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 a unfulfilled criteria sequence operating in the background,
- an interactive sheet allowing the communication of all system users.

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¹⁰ XMaster – a device steering and recording changes of the SPDS/RPMS installation statuses.

5. Functional and task-oriented structure of liquid fuel distribution system of Grupa Lotos

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 is granted access,
- d) during 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 ADR¹¹, 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.

11 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 at 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.

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

- analyse data concerning any recorded period,
- verify any route, the work of a combination 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).

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

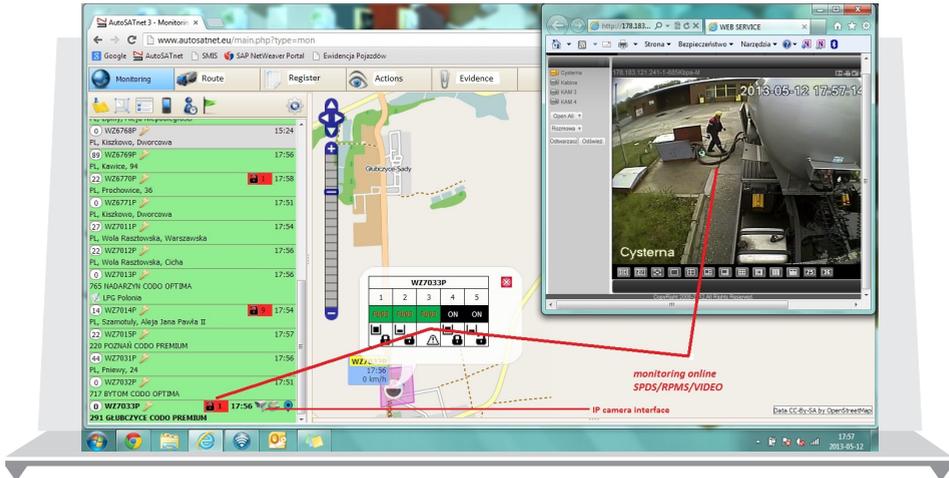


Figure 2. Application on website autosatnet.com.pl /the remote monitoring of a tanker during unloading

Source: Web application of ATROM. Zakład Elektroniczny 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 an 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:

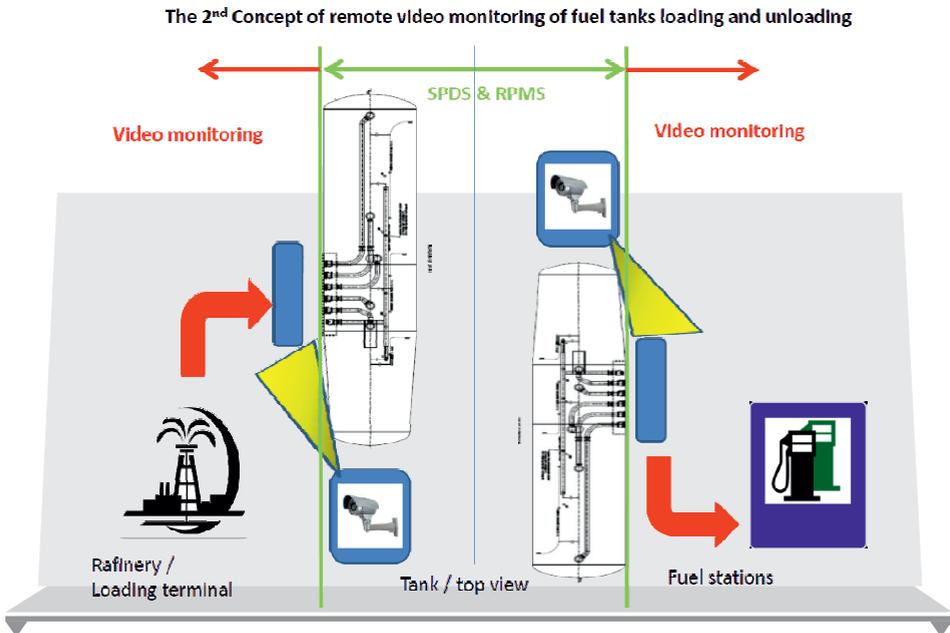


Figure 3. The extended concept of remote video monitoring of fuel tanks loading and unloading

Source: author's elaboration

- 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.

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 between 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

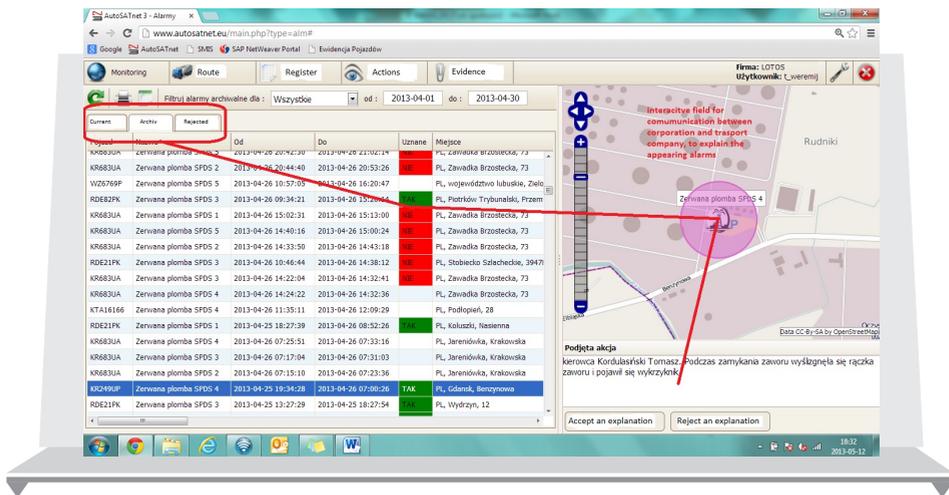


Figure 4. An interactive sheet enabling communication between the participants of the process and accounting for the alarms

Source: provider of the Web application autosatnet.com.pl ATROM, Zakład Elektroniczny Mirosław Morta

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 Manager 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. In that sense the managerial skills are very important not only in the stage of the TMS implementation but also during its operational utilization.

6. Conclusions

The presented IT solution is used by concern Grupa Lotos for the purpose of transportation of fuels in the whole network of 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 level safety 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.

The Lotos case study also confirmed the findings of previous empirical study that in highly competitive environments IT solutions in B2B relations should work together with managerial resources which are critical success factor for value creation in supply chain.¹² As illustrated by Lotos in the era of intensive competition and market stagnation the companies must develop not only IT innovations but also managerial skills in order to reduce cost as well as increase the quality of product and logistics services.

Abstract

The aim of the article is to present innovative IT solution for monitoring transport in the process of fuel distribution, which

12 S. Dong, S.X. Xu, K.X. Zhu (2009), Information Technology in Supply Chains: the Value of IT - Enabled Resources Under Competition, „Information Systems Research“, Vol. 20, No 1, March, pp. 29-30.

was implemented in Grupa Lotos 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 with 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.

Key words: *distribution logistics, IT technologies, liquid fuels market.*

Streszczenie

Celem artykułu jest zaprezentowanie innowacyjnych rozwiązań informatycznych do monitorowania transportu w procesie dystrybucji paliw płynnych, które zostały wdrożone przez GRUPĘ LOTOS w styczniu 2013. W artykule opisano wymagania sprzętowe i oprogramowanie oraz scharakteryzowano strukturę funkcjonalno- zadaniową systemu. W odróżnieniu od innych standardowych aplikacji wspomagających zarządzanie łańcuchem dostaw paliw płynnych jest to rozwiązanie unikatowe, które przyczynia się do znacznej redukcji poziomu ubytków oraz ponadprzeciętnego zwiększenia bezpieczeństwa i jakości dostarczanych produktów. W warunkach stagnacji na rynku paliw jest to narzędzie, które może stanowić istotne źródło przewagi konkurencyjnej.

Słowa

kluczowe: *logistyka dystrybucji, technologie IT, rynek paliw płynnych.*

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