



## THE ANALYSIS OF THE COLD SUPPLY CHAIN EFFICIENCY WITH THE USE OF MOBILE TECHNOLOGY

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**ABSTRACT. Background:** The efficiency of logistics processes is a very important decision-making aspect, both from financial point of view as well as in terms of processes at the operational level. Taking into account both the specific features of a cold supply chain as well as conditions of the comprehensive analysis of the efficiency of logistics processes, the significant aspect is the elaboration of the concept, which will allow to monitor and estimate realized processes with the possibility to obtain data in real time.

The aim of this paper is to present the concept of monitoring of processes performed in a cold supply chain.

**Methods:** The results of researches conducted in Polish companies in the first half of 2016 year as well as the literature review show the unsatisfied level of the use of the analysis of efficiency of logistics processes. These results were used to select conditions influencing the complexity of the analysis of efficiency of logistics processes. The researches were conducted in 152 logistics companies located in Wielkopolska voivodship.

**Results:** The business product BluTrack of the Blulog company is the result of the elaborated concept. Various variants of the implementation of this tool in practice served as the methodology of the verification of the complexity of the implementation of this concept in monitoring and management of the cold supply chain.

**Conclusions:** The analysis of efficiency of logistics processes is still not unambiguously defined despite many scientific studies. It causes problems in the business practice. The uniqueness of the cold supply chain introduces additional variables and criteria of estimation of efficiency of logistics processes. The presented study put the main focus on the use of mobile technologies for efficient monitoring and evaluation of efficiency of logistics processes in the cold supply chain. The result of the verification of the presented concept was the preparation of the tool, having the desired functionalities for the business practice.

**Key words:** logistics, efficiency of logistics processes, cold supply chain, mobile technologies.

### INTRODUCTION

The temperature is the main parameter of the estimation of the shelf life for cooled and frozen goods. The modern approach to the customer service level and the security system should consist of the provision of adequate quality level as well as safety of the supply chain by monitoring and management of critical parameters within the whole life cycle of the product, including also the post-production phase, through the storage in special conditions until its use by the final customer. The role of the logistics in

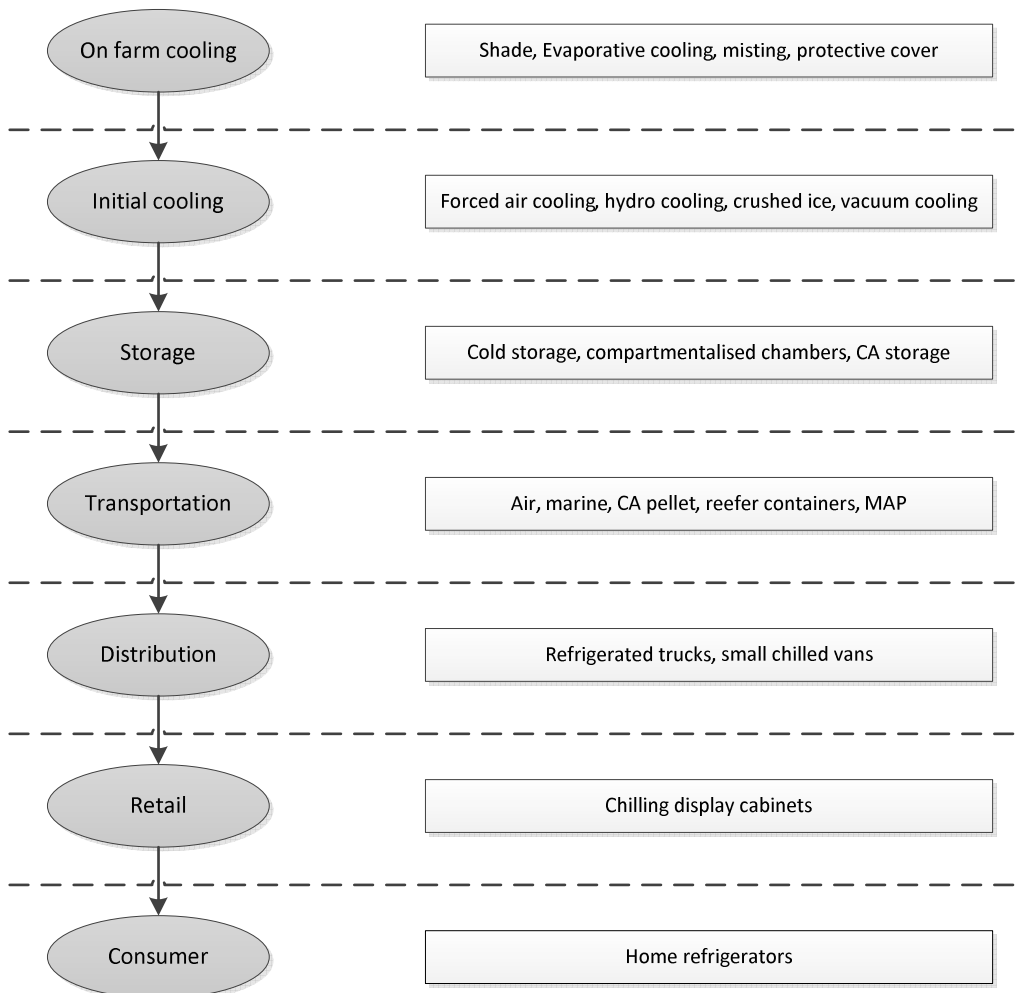
the transport, storage and handling in the cold supply chain gains more and more attention. The temperature conditions in processes of the distribution of cooled and frozen goods determine the potential risk of the discontinuity of the maintenance of the proper temperature and consequently the loss of final quality of products.

In case of most of thermo-sensitive products like e.g. vaccines, even slightly damaged during the transport, handling or storage, their value and therefore the demand for them decreases practically to zero level. Even minimal or short changes in

the temperature can cause serious damages and therefore the loss of their market value. It can cause big losses for a provider of goods.

The term cold chain describes the series of interdependent equipment and processes employed to ensure the temperature

preservation of perishables from the producer to the consumer in a safe, wholesome, and good-quality state [Zhang 2007]. The figure 1 presents selected technologies enabling to maintain the cold supply chain.



Source: Mahajan, Frías 2012

Fig. 1. Components of the cold chain with different possible contributions to temperature maintenance  
Rys. 1. Składowe łańcucha zimna z różnymi możliwymi czynnikami utrzymywania temperatury

The systematic gathering of data indispensable for the identification and the assessment of limitation of cold supply chain for various kinds of cooled and frozen goods is necessary for both producers and vendors of food products, but it was not conducted sufficiently [Gogou et al 2015].

The storage, handling and transport of goods within the cold supply chain must always guarantee as follows:

- detailed identification of a product, a localization of its production and destination,
- protection of goods from mutual damage or theft,

- protection from harmful external factors and climatic conditions, especially too low or too high temperature,
- appropriate documentation and confirmation, that all safety conditions were assured.

The above-mentioned factors determine the concentration on the efficiency of undertaken actions both of information solutions, which enable to provide data in real time as well as the safety of goods flow by ensuring the maintenance the proper temperature continuously within the whole cold supply chain.

## **THE ROLE OF THE EFFICIENCY IN THE MANAGEMENT OF LOGISTICS PROCESSES**

The efficiency of logistics processes is an important decision-making aspect not only from financial point of view but also from process point of view at the operational level. The efficiency evaluation is a difficult topic due to the fact that there are many scientific publications presenting more and more sophisticated methods of its determination and evaluation.

The presented difficulties cause ambiguous evaluation of the profitability of planned investments but also of current evaluation of the efficiency of logistics processes. The management team is forced to use more and more complicated analytical tools to determine the efficiency of processes occurring in the company or in the whole supply chain.

The logistics issues are especially important part of the company management both at the operational as well as strategic levels but also from financial point of view. According to scientific literature, the following factors influence the efficiency of logistics processes:

- transformation of goods flow in time and space,
- integration of functions of planning, management, organization and control of logistics processes,
- assigning information flows to proper goods flows,

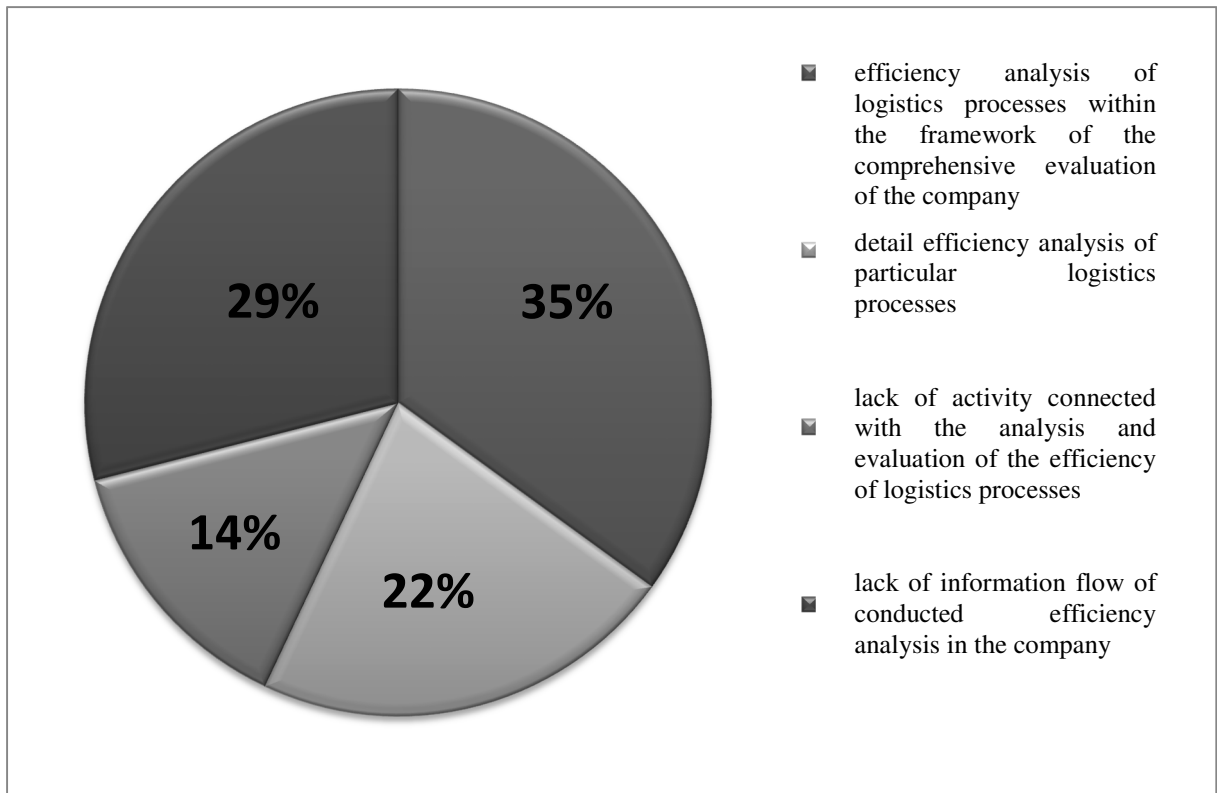
- orientation on the criterion of the efficiency of individual logistics tasks,
- separation of the scope of duties and structures of logistics activities.

Another statement can be found in the scientific literature, that the customer service should be treated as the most important element of the efficiency of the modern logistics [Beamon 1999; Li, O'Brien 1999]. The significance of the factor of the customer service is determined mainly by growing globalization and the implementation of new strategies of the customer service. All activities distinguishing the methods of the customer service influence the market position of the company.

The efficiency of logistics processes is an important issue from a point of view of the organization of processes occurring within a company as well as a supply chain. The concept of the efficiency is difficult to define it unambiguously. The proof of these difficulties can be found in numerous publications on the subject of the efficiency of logistics processes within the supply chain [Mishra 2012; Lichocik, Sadowski 2013; Geunes et al. 2016; Brandenburg 2016; Sohrabpour et al. 2016].

The research studies conducted in logistics companies confirm the presented theoretical contemplations. The questionnaire researches were conducted in first quarter of 2016 year in 152 logistics companies in Wielkopolska voivodship. These companies represented both small companies as well as big ones. The details of the use of the efficiency analysis of logistics processes in the practice are presented in the figure 2.

Base on the conducted researches it can be concluded that more than a half of questioned companies conduct the efficiency analysis of logistics processes. On the other side, most of companies use only the general analysis of the efficiency of the business and only to a limited extent use the complex analysis of individual logistics processes. Due to the fact, that there is a big number of companies which do not conduct any efficiency analysis or are not conscious of that, the described situation is unsatisfactory.



Source: own work

Fig. 2. The level of the use of efficiency analysis of logistics processes in practice

Rys. 2. Stopień wykorzystania analizy efektywności procesów logistycznych w praktyce

The main goal of these researches was the identification of the key functionality, necessary for comprehensive efficiency analysis of logistics processes. The proposed set of the functionalities of such analysis was based on the conducted expert interviews and the literature review. Each of examined company could point out such functionalities.

There was also a possibility to propose different aspects of the approach to such efficiency analysis of logistics processes. The table 1 presents the percentage share of identified key functionalities of the comprehensive efficiency of logistics processes.

Table 1. Main functions necessary for comprehensive efficiency analysis of logistics processes  
Tabela 1. Podstawowe funkcje niezbędne do kompleksowej analizy efektywności procesów logistycznych

Functionality	percentage of indications
computerization of analysis of process efficiency	92,76%
data acquisition in real time	79,61%
monitoring of the stage of process realization	87,50%
implementation of mobile technology for control purposes	72,37%
comparison of present data with historical ones	98,03%
others	10,53%

Source: own work

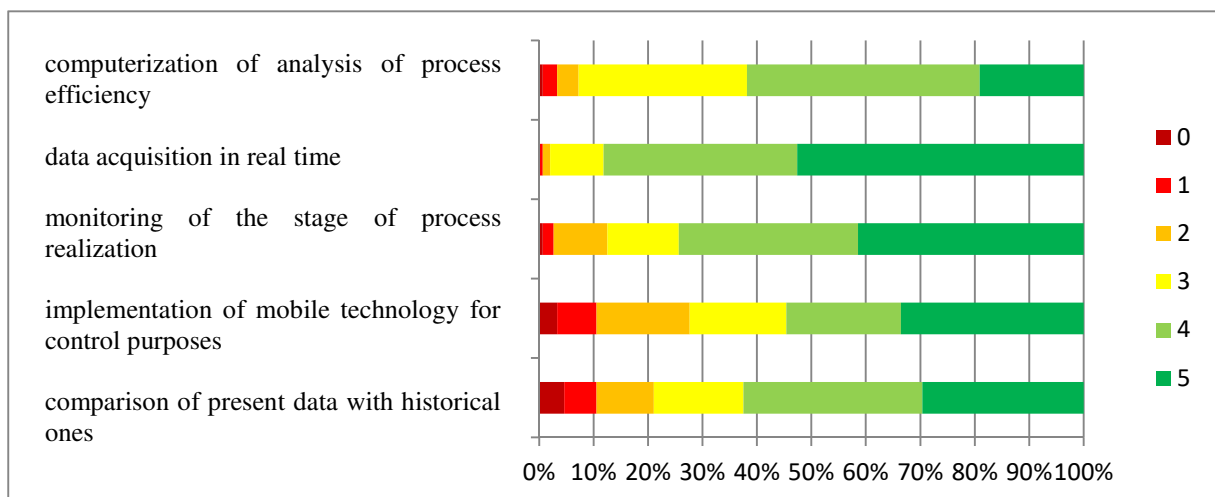
It should be emphasized, that more than 70% of all examined companies decided, that all proposed functions should be included into the comprehensive efficiency of logistics processes. The last aspect of this analysis was the significance of individual functions of the efficiency analysis.

It was assumed for the purposes of this research that the concept of the significance expresses the level of the respondent's conviction about the correctness of used function in the comprehensive efficiency of logistics processes. The consistent method of their evaluation was defined based on 5-level Likert scale, extended with zero value. According to many authors, analyses based on

Likert scale are of quantitative nature [Elliott and Woodward 2007; Gamst et al. 2008; Gatignon 2013]. Respective values meant:

- 0 – no significance,
- 5 – very big significance.

The analysis of the significance of various functions show that all examined elements were declared as significant one. The average of all examined elements above 3,0 (average significance) was accepted as the decision threshold. The significance of various functions of the efficiency analysis of logistics processes is presented in the figure 3.



Source: own work

Fig. 3. The analysis of the significance level of functions of the comprehensive efficiency evaluation of logistics processes

Rys. 3. Analiza stopnia ważności poszczególnych funkcji kompleksowej oceny efektywności procesów logistycznych

Taking into consideration the specific character of the cold supply chain as well as the conditioning of the comprehensive efficiency analysis of logistics processes, the essential aspect is the development of the concept enabling monitoring and evaluation of realized processes together with the possibility of data acquisition in real time.

## MONITORING AND PROCESS EVALUATION TOOLS IN COLD SUPPLY CHAIN

Taking into consideration the above mentioned circumstances for the necessity of the comprehensive efficiency analysis of logistics processes, as well as the specific character of the cold supply chain, the concept to connect technological and computerized solutions of a company with the organization

provided monitoring and management of the cold supply chain was elaborated. The presented conception is related to the implementation of mobile technologies to improve the monitoring process of the continuity of goods flow and to allow the monitoring in real time. The concept considers the use of already known technological solutions like RFID and VFC [Coskun et al. 2013], concentrating on the optimization of logistics processes and their instant monitoring. The presented concept is an original solution of Blulog company, implemented in the BLUTRACK tool. The designed communication devices, recorders with innovation functionalities (patent rights) as well as flexible functional and stable

database allow the usage of any parameters. The small electronic module, integrated with the transport container or pallet is responsible for the provision of information. The data are transmitted to the database by the use of radio waves. Another method is the direct reading of parameters by the use of smartphone using NFC technology (Near Field Communication). The recorder is the device allowing the recording of results of temperature measurement in real time and simultaneous radio transmission. Thanks to that solution, the user obtain the approach to both present and historical data, e.g. to make their visualization. The principles of operation of this measurement instrument are presented in the figure 4.

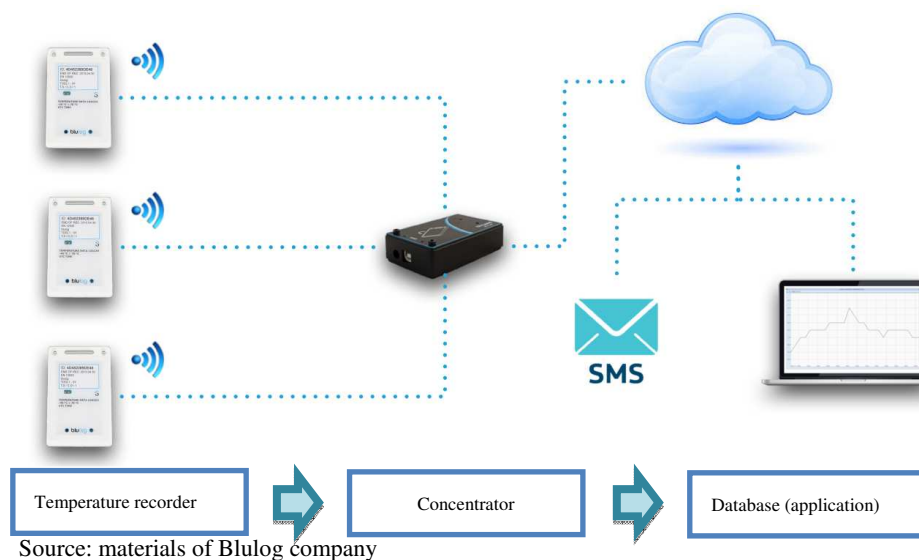


Fig. 4. The principles of operation of the measurement instrument  
Rys. 4. Zasady działania narzędzia pomiarowego

The results of periodical measurements performed by Blulog recorder are stored in internal memory of the device. Additionally, data (containing temperature and time of the measurement – timestamp UTC/GMT) are transferred to the application via the concentrator. The data visualization is performed in real time in the computer or any other mobile device having the installed application delivered by the producer. The backup of data are performed parallel in three places:

- recorder,
- concentrator,
- database (e.g. computer).

In case, the database has a connection with Internet, there is a possibility to monitor the temperature from any localization as well as obtaining alerts about undesired cases (e.g. reaching the temperature threshold defined by a user) by e-mail or SMS. The data stored in nonvolatile memory of a device is protected from modifications, which excludes the possibility of any manipulation. It allows to store data from the beginning to the end of the period of the validity of a device plus additionally three months, during which the recorder stores data but does not send them through radio transfer (only infra-red or NFC

reading). After that time, the recorder stops to work. It stores only previously recorded data and can be sent to the recalibration.

During the literature review regarding the evaluation of the innovation value of the presented device [Abad et al. 2009; Cyplik and Patecki 2011; Prakash et al. 2012; Kang et al. 2012; Lorite et al. 2017] the comparison with

already known and used technologies should be conducted: RFID (Radio Frequency Identification) and RTLS (Real-Time Location Systems).

The results of the comparison of BLUTRANS system with RFID and RTLS systems are presented in the table 2.

Table 2. The comparison of the application of BLUTRANS system with RFID and RTLS systems  
Tabela 2. Porównanie zastosowania systemu BLUTRANS z technologią RFID i RTLS

Functionality	Identification of objects / products	Localization of objects / products	Possibility to add additional information about objects / products	Possibility of integration with computer system	Possibility of data acquisition in real time	Possibility of automatic measurement of external parameters (e.g. temperature, moisture)
RFID	X		X	X	X*	
RTLS	X	X	X	X	X	
BLUTRACK	X	X	X	X	X	X

Source: own work

The presented comparison does not include the localization as RFID functionality, due to its specific characteristics in other compared technological solutions. RFID shows the general localization but in comparison with RTLS and BLUTRACK does not allow the precise localization of an object or a product. Additionally, the significant feature differentiating these technologies is the possibility to access information in real time. In case of FRID it is possible only in situation when the object passes the gate with a reader and it is not possible to obtain details regarding the changes of the object's localization among readers.

## **INFLUENCE OF MONITORING AND PROCESS EVALUATION IN COLD SUPPLY CHAIN ON THE EFFICIENCY OF LOGISTICS PROCESSES – CASE STUDY**

The main purpose of this paper was the identification of dependences of the influence of the implementation of a tool for monitoring a cold chain on the efficiency of logistics processes. In order to reach this goal, the Authors decided to perform the case study. This method allows the deeper view of examined issue comparing to qualitative researches, which could only suggest some conclusions. The case study in comparison to

other research methods offers wider range of techniques and tools for data acquisition and analyzing. The data sources can be observations, interviews, data and documents obtained from company, press information, questionnaires. The wide range of possibilities of data acquisition determines that from the methodology point of view, the method of a case study is not limited in the area of data analysis. This method should be treated as a single and limited research process having a goal of detailed analyze using many research techniques in a long period of time [Maylor and Blackmon 2005].

The research methods based on a case study are not subject to the representativeness evaluation of a sample [Siggelkow 2007]. The purpose of a case study is to present the dependencies between phenomena occurring in described processes. The quantitative methods, base on statistically representative sample, do not allow to conduct such analyzes. Based on the literature review, there are various opinions on the number of necessary number of variants, which should be performed in order to obtain representative scientific results. Usually, the four to ten case studies are suggested [Eisenhardt and Grabner 2007; Yin 2009]. Taking into account the specific features of the efficiency of logistics processes in the cold supply chain, the Authors decided to use four variants for the analyze of

the influence of the usage of BLUTRACK tool on the realization of logistics processes. The research was concentrated to estimate the influence of the usage of BLUTRACK tool in such areas as: logistics processes in e-commerce, application of intelligent packages, efficiency of the usages of resources and logistics infrastructure and the quality confirmation of offered products and services from marketing point of view.

The **first case study** concerns the specific character of e-commerce in the realization of logistics processes. The sector of e-commerce consists of transactions, which are performed based on IP protocols through networks. The goods and services are ordered directly (on-line) but the delivery and payment could be performed both within the network and outside it. It should be pointed out that, the orders placed by phone, fax or e-mail are not considered to belong to the e-commerce. The efficiency of logistics processes within the e-commerce sector and principles of monitoring of their separate stages should be indicators during organization of these processes. It includes the selection of proper key indicators, methods of their measurement, frequency of their measurement and responsibilities. Such approach allows the instant monitoring of realized processes as well as the implementation of proper recovery actions in case of deviations from accepted plan [Kolinska et al. 2017].

Allowing the clients an access to terminal parameters in the packaging together with products in real time, companies providing goods within the cold supply chain, authenticate the high quality of their service. Each container with in-built electronic system has an individual identification number and by the radio channel transfers information about internal temperature and location to the database. The clock system with UTC time, implemented in the electronic system of the recorder is an additional additive of this solution. Consequently, all date stored by the recorder are unambiguously placed in time system, which allows subsequent analyses. This feature assures that data stored in the recorder are identical in any time zone all over the world.

Beside the radio connection, data from the recorder integrated with a container or a pallet can be read by the use of any smartphone equipped in NFC technology (used widely in contactless payment).

The additional functionality of the electronic module is the possibility to inscribe by the use of mobile technologies such information as descriptions of a product, producer's data, receiver's data, bill of lading, e-mail to deliver a report, acceptable external parameters during logistics process as well as geographical coordinates of storage localization. Data read by the smartphone can be sent in a form of a report to the database and make them accessible for authorized persons.

The implementation of BLUTRACK tool can have following consequences:

- enabling the recording of temperature measurements in real time and parallel data transfer by radio channel,
- possible access to current and historical date, e.g. for visualization by the use of Internet or mobile technologies,
- use of unlimited number of devices cooperated with the concentrator and application,
- increased security of data without the possibility of their modification,
- increase of the speed of information transfer about transported goods,
- increase of efficiency of monitoring of transported goods,
- possibility to monitor on-line a status of an order by a client (in e-commerce),
- identification of weak stage of the logistics process, e.g. break of a cold chain,
- increase of warranty of keeping the correct storage conditions,
- possibility to monitor on-line the quality of separate shipments within the cold supply chain,
- increase of client's service level by securing the safety of transported goods.

The **second aspect** of the use of this tool is its implementation in intelligent packaging. The intelligent packaging are innovative type of packaging equipped in indicators responsible for monitoring of definite

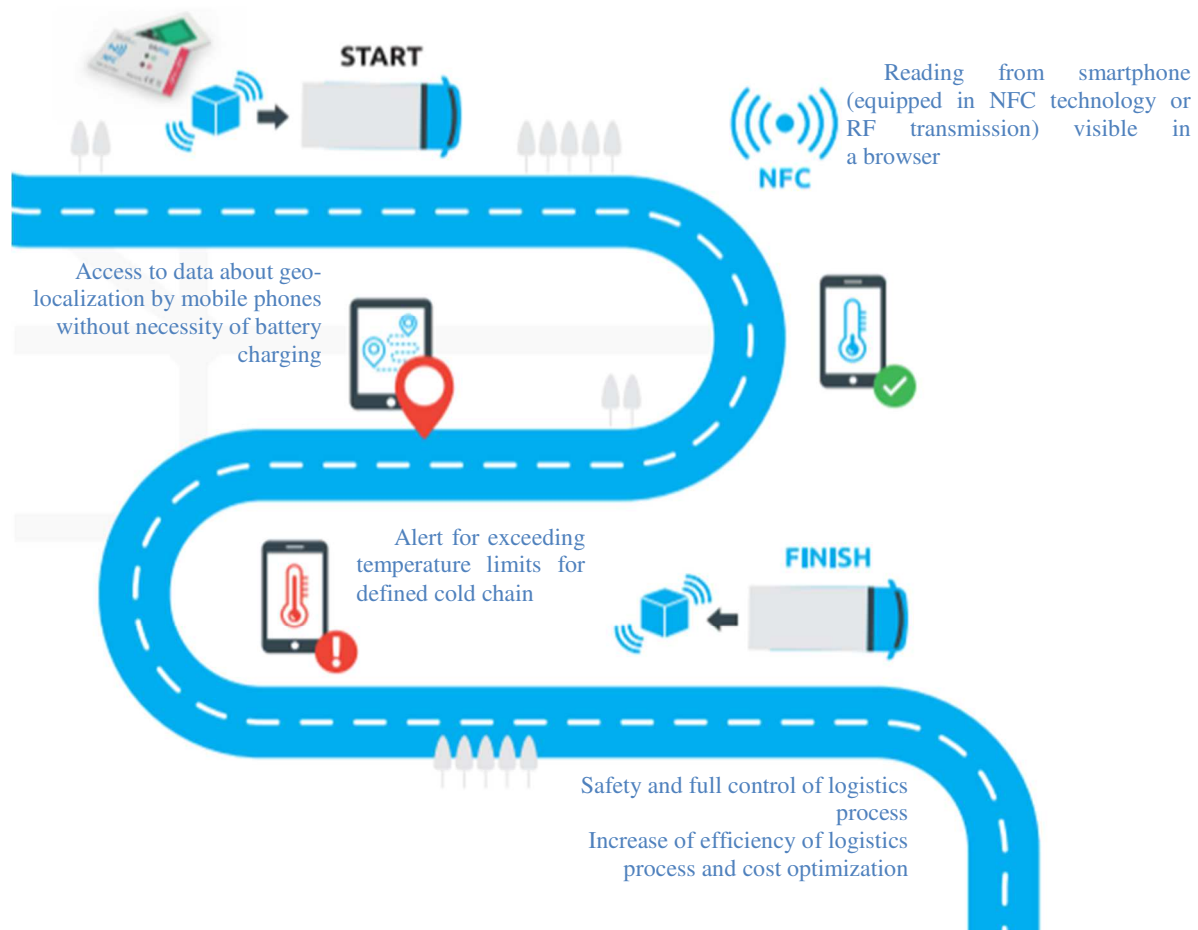


atmosphere (air) parameters both inside and outside the package in order to provide information about the condition of the goods.

An intelligent packaging system is capable of detecting, sensing, recording, tracing or communicating information about the quality and/or the condition of the product within the whole food chain [Yam et al. 2005]. The package provides information not only about the product itself (origin, theoretical expiration date, composition) but is also able to inform about the history of the product e.g. storage conditions, headspace composition or microbial growth [Realini and Marcos 2014].

Intelligent packaging is generally classified based on the type of sensors used such as:

Time Temperature Indicators (TTIs), gas sensors and biosensors. Conventionally, the shelf life of food products or their freshness is determined based on selected marker substances, such as vitamins, color or flavor change, enzyme activity, etc. by the use of predictive models based on accelerated shelf-life tests. However, in reality thermal fluctuations and unpredicted events do not often obey the predictions, which may significantly change the quality of the food product [Yucel 2016]. TTIs are based on chemical, enzymatic, mechanical, electrochemical processes or microbiological reaction systems, as a result of which the substance contained in the indicator (after activation) undergoes an irreversible change [Korzeniowski and Cierpiszewski 2016].



Source: materials of Blulog company

Fig. 5. System of the use of intelligent packaging in logistics processes  
Rys. 5. Schemat wykorzystania inteligentnych opakowań w procesach logistycznych

The system BLUTRACK allows a remote control and steering of all types of containers, pallets and other bins equipped in the electronic module. If they are installed in logistics centers or on clients' side, HUBs connected to Internet provide on-line information about the localization of a specific product. The schema of BLUTRACK system used in management of packaging in logistics processes is presented at the figure 5.

Suppliers and receivers of products delivered by the use of such infrastructure have the direct access to information about the status of the shipment. Additionally, owners of containers or pallets have full information about their equipment. It allows them to protect these tools in a better way. The module for the realization of goals of BLUTRACK system is a device of a disposable kind. Its exploration period ranges between 5 and 15 years depending on the type of a device. The module is resistant on most external factor such as water, low temperatures, shocks, electromagnetic field and integration of third party (hackers). The transmission to a database and within the radio channel is encrypted with the AES 128 protocol. The database implemented in this project is authorized to be used in pharmaceutical industry for sensitive data.

The implementation of BLUTRACK tool allows:

- monitoring of quality changes of packaging,
- extension of shelf life,
- reduction of costs of introduction of an intelligent element in the package,
- improvement of the comfort of use of a product together with a package,
- protection against lost, damage and robbery,
- identification of items responsible for the loss of logistics infrastructure or a shipment.

The third variant of the implementation of BLUTRACK system is the possibility to optimize the infrastructure and to use the resources for the realization of logistics processes. The optimization of the

infrastructure could be concurrent with assumptions of intelligent packaging. Based on the observations of business practice, many companies have high costs connected with replenishment of bin packages. The management teams complain often about lack of possibilities to monitor the localization of bins in real time, which increases the risk of losses of packages and necessity to purchase new ones. Such situation influences costs of realization of logistics processes as well as decreases the clients' service level due to small availability of packaging necessary for shipment processes in right place and at right time. The use of mobile technologies in this solution allows also savings in other areas of business activities. The possibility to monitor the temperature in shop refrigerators in real time together with the use of Internet and mobile technologies reduces the physical monitoring of these devices. Therefore the number of visits of sales representatives to individual shops could be reduced only to sales visits and eventually to service ones, without the necessity of control visits.

The fourth variant of the implementation of BLUTRACK system is a complex connection of functionalities presented in above mentioned variants, completed with marketing aspects of the realization of distribution and sales processes.

One of innovative solution enabling the implementation of BLUTRACK system in marketing aspect is the use of PRP packaging (Retail Ready Packaging). Retail ready packaging (RRP) is a form of transport packaging designed not only for transportation purposes, but also to ease and to facilitate the process of in-store replenishment as a supply chain function [Dujak et al. 2014]. The use of such type of packaging in connection with BLUTRACK system could be an effective system of packing and exposition of products, which enables easy and quick identification of a product in shops. On the other side, it facilitates the transport of packed goods as well as easy and comfortable opening of the packaging, placing it in the refrigerator and constant monitoring of the storage temperature. The access for the client to information about temperature in shop refrigerators in real and

historical times increases the safety of realized purchasing, which on the other side, increases the loyalty of a client for a mark or a shop. The client has a possibility to analyze temperature changes in the refrigerator, where the product, he plans to buy, is stored. It increases also the warranty of the quality of stored products as well as specific characteristics of a product. Additionally the use of mobile technologies together with BLUTRACK system can be used to optimize the use of logistics infrastructure and resources, reduction of costs of monitoring of a storage process as well as the market and demand analyses. Offering an application "cold drink" to a client allows him not only to check the temperature of the drink but additionally in a form of a contest or a game, it is possible to encourage a client to give a feedback concerning:

- client's preferences to other products,
- eventual change of demand trends for products,
- other products located in the specific refrigerator in the specific shop (and therefore to control the proper utilization of the refrigerators according to agreements) which influences the efficiency of the utilization of infrastructure available in shops and decreases costs connected with physical controls by a distributor or a producer.

From marketing point of view the use of BLUTRACK system allows the increase of efficiency to obtain data and information in B2C relations, increases the efficiency of management of relations with clients (CRM) as well as enables to obtain operational data, facilitating the realization of logistics and sales processes at the level of the supply chain.

## CONCLUSIONS

The analysis of efficiency of logistics processes is still not clearly defined, despite many research works conducted. It causes difficulties in its implementation in the business practice. The specific features of cold supply chain give some additional variables and criteria of the evaluation of efficiency of logistics processes. The paper focuses mainly on the concept of the use of mobile

technologies in order to efficiently monitor and evaluate the efficiency of logistics processes in the cold chain. The verification of presented concept resulted in the development of a tool for the realization of assumed functionalities in business practice.

The main functionality of BLUTRACK system is to monitor the location and quality of technical parameters of any shipment within the logistics process. Besides data consisting of geographical localization of a shipment, additional information about condition in which the shipment is transported (temperature, moisture) is provided to a client. Such information is essential to ensure the quality of transported goods and to improve logistics processes. Monitoring of logistics infrastructure and surrounding parameters by the use of Internet in real time allows to reduce costs of maintenance of this infrastructure and when necessary to find persons responsible for its devastation or damage.

The designed communications devices, recorders with innovative functionalities (protected by patent rights) as well as flexible functional and stable database (able to accept any parameters) make these devices unique in their configuration all over the world. Functionality of presented concept and developed tool allows to built a new quality in logistics, not only in business practice of local, regional or global range but also in the aspect of development of theoretical knowledge in the area of management science.

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## ANALIZA EFEKTYWNOŚCI ZIMNEGO ŁAŃCUCHA DOSTAW (COLD SUPPLY CHAIN) Z WYKORZYSTANIEM TECHNOLOGII MOBILNYCH

**STRESZCZENIE. Wstęp:** Efektywność procesów logistycznych jest bardzo ważnym aspektem decyzyjnym nie tylko w ujęciu finansowym, ale również w ujęciu procesowym na poziomie operacyjnym. Uwzględniając zarówno specyfikę cold supply chain, jak również uwarunkowania kompleksowej analizy efektywności procesów logistycznych, niezmiernie istotnym aspektem jest opracowanie koncepcji umożliwiającej monitorowanie i ocenę realizowanych procesów z możliwością pozyskiwania danych w czasie rzeczywistym. Celem artykułu jest przedstawienie koncepcji monitorowania procesów realizowanych w cold supply chain.

**Metody:** Wyniki badań w polskich przedsiębiorstwach przeprowadzonych w I półroczu 2016 roku oraz badań literaturowych, świadczą o niezadowalającym stopniu wykorzystania analiz efektywności procesów logistycznych. Na ich podstawie dokonano wyboru i zestawienia czynników wpływających na kompleksowość analizy efektywności procesów logistycznych. Badania w 152 przedsiębiorstwach logistycznych z województwa wielkopolskiego.

**Wyniki:** Wynikiem opracowanej koncepcji jest produkt biznesowy BluTrack firmy Blulog. Poszczególne warianty zastosowania tego narzędzia w praktyce gospodarczej posłużyło jako metodologia weryfikacji kompleksowości zastosowania niniejszej koncepcji w monitorowaniu i zarządzaniu łańcuchem zimna.

**Wnioski:** Analiza efektywności procesów logistycznych pomimo licznych odniesień literaturowych, wciąż jest niejednoznacznie zdefiniowana. Utrudnia to jej wykorzystanie w praktyce gospodarczej przedsiębiorstw. Specyfika łańcucha zimna wprowadza dodatkowe zmienne i kryteria oceny efektywności procesów logistycznych. W niniejszym artykule skoncentrowano się na prezentacji koncepcji wykorzystania technologii mobilnych w celu skutecznego monitorowania i oceny efektywności procesów logistycznych w łańcuchu zimna. Weryfikacja przedstawionej koncepcji skutkowałą opracowaniem narzędzia, realizującego założone funkcjonalności w praktyce biznesowej.

**Słowa kluczowe:** logistyka, efektywność procesów logistycznych, łańcuch zimna, technologie mobilne.

## DIE EFFEKTIVITÄTSANALYSE DER KALTEN LIEFERKETTE (COLD SUPPLY CHAIN) MIT ANWENDUNG VON MOBILEN TECHNOLOGIEN

**ZUSAMMENFASSUNG. Einleitung:** Die Effektivität logistischer Prozesse stellt einen sehr wichtigen Entscheidungsaspekt dar, und dies nicht nur aus finanzieller Sicht, sondern auch aus der Sicht der betreffenden Prozesse auf der operativen Ebene betrachtet. Bei der Berücksichtigung sowohl der Eigenart der kalten Lieferkette (cold supply chain), als auch der Bedingungen für die Durchführung der Effektivitätsanalyse logistischer Prozesse, scheint die Ausarbeitung eines Konzeptes, das die Verfolgung und Bewertung von realisierten Prozessen sowie die Ermittlung von Daten in der Echtzeit ermöglicht, ein sehr relevanter Aspekt zu sein. Das Ziel des Artikels ist es, das Konzept für die Verfolgung der innerhalb der kalten Lieferkette realisierten Prozesse zu projizieren.

**Methoden:** Die Ergebnisse der im ersten Halbjahr 2016 in polnischen Unternehmen durchgeführten Forschungen und der betreffenden Fachliteraturbetrachtung zeugen von einem nicht zufriedenstellenden Niveau der Inanspruchnahme von Analysen der Effektivität logistischer Prozesse. Auf Grund dessen erfasste und wählte man die Faktoren aus, die die Komplexität der Effektivitätsanalyse der logistischen Prozesse mit beeinflussen. Die betreffende Erforschung erfolgte in 152 in der Woiwodschaft Großpolen befindlichen Logistikunternehmen.

**Ergebnisse:** Das Ergebnis des ausgearbeiteten Konzeptes ist ein Bussines-Produkt namens BluTrack von der Firma Blulog. Die einzelnen Anwendungsvarianten des betreffenden Tools in der Wirtschaftspraxis dienen als die einschlägige Methodologie für die Verifizierung der Komplexität der Inanspruchnahme des genannten Konzeptes für die Verfolgung und Verwaltung der kalten Lieferkette.

**Fazit:** Die Effektivitätsanalyse der logistischen Prozesse wird trotz zahlreicher betreffender Literaturhinweise immer noch nicht eindeutig definiert. Dies beschwert deren Anwendung in der Wirtschaftspraxis der betreffenden Unternehmen. Die Eigenart der kalten Lieferkette bringt zusätzliche Variablen und Kriterien für die Bewertung der Effektivität der logistischen Prozesse mit ein. Im vorliegenden Artikel konzentrierte man sich auf die Projizierung des Konzeptes für die Anwendung von mobilen Technologien zwecks einer effizienten Verfolgung und Bewertung der Effektivität der logistischen Prozesse innerhalb der kalten Lieferkette. Die Verifizierung des dargestellten Konzeptes hatte die Ausgestaltung eines die angenommenen Funktionalitäten in der Wirtschaftspraxis ausübenden Tools zufolge.

**Codewörter:** Logistik, Effektivität logistischer Prozesse, kalte Lieferkette, mobile Technologien.

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