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ATI - Applied Technologies & Innovations
Volume 8 | Issue 3 | November 2012 | pp.38-44
http://dx.doi.org/10.15208/ati.2012.15

Global position system technology to monitoring auto transport in Latvia

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This paper is the result of authors' activities in the field of research and implementation of global positioning system (GPS) technologies in the Latvian car industry. The subject of study is the characteristics of Latvian auto transport management. Topicality and importance of this issue are related with new GPS applications to auto transport monitoring. Principal practical application of this paper is reflected in the methodology developed by the authors in order to design, elaborate and introduce GPS systems.

Keywords: Monitoring, service, level, cycle, queuing

Introduction

At present there are at least three technologies of using GPS satellite systems in auto transport which are applied in Latvia.

First, where GPS receivers are installed in auto transport and the auto transport fleet operators can see ONLINE the location of the auto transport on an electronic map, actual route of the auto transport , the places and duration of the auto transport ' stops.

Second, apart from GPS receivers the operator uses a computer network which keeps and analyses auto transport' traffic routes. Furthermore the operator plots the route in advance, using data from GPS receivers.

Third, apart from GPS receivers auto transport are equipped with special sensors measuring cargo weight, fuel consumption, temperature sensors, door opening sensors, etc. In this case the operator, using sensors in the GPS system, can remotely operate auto transport en route.

In some cases installation of the monitoring system is carried out secretly from drivers, other managers conduct talks before or during the installation of the system. On a larger scale the economic effect ensured by implementation of auto transport GPS monitoring system can be seen in the improvement of the quality of servicing clients, decrease in the cost of services (and the prices thereof), and as a consequence - competitive growth in the market which results in a dominant position and profit growth. In other words, implementation of motor auto transport GPS monitoring system in Latvia enables increasing the quality of business, therefore the economic effect ensured by its implementation in the company will be notable within one or two years after implementation.

New servicing standards

Regular research carried out in Riga Technical University (Belinska, Boicov, and Kluga, 2008) present gradual criteria changes according to which the GPS service

is selected. Low price and high quality of goods are undoubtedly the most important ones on the list; however, those are not desired characteristics, but rather the mandatory standard of a competitive service instead. Nowadays consumers pay more attention to additional criteria, such as time of delivery, possibility of getting ordered goods in the determined period as well as high-quality information maintenance of order delivery process.

Nowadays not all companies are able to offer delivery of goods to their clients on the day of order receipt (common practice is delivery on the following day). However it is evident that presently service standards tend to become stricter and a company's position in the market depends on the ability to meet these standards.

We will try to analyse and identify the factors that determine the time for the execution of clients' orders.

Faster but more expensive or slower but cheaper

Interests of different departments within a company often collide when duration of "order-delivery" cycle is determined. In this case these are the interests of the marketing department and the transportation department.

Managers of the sales subdivisions have incentives to deliver goods from supplier to warehouse and from warehouse to buyers as fast as possible. At the same time employees of the transportation department try to organise the most economic route possible and tend to wait for the moment when the auto transport which delivers the goods is completely full. The opinion of both parties should be taken into account. Prosperity of the whole company depends on improvement of sales and competent transportation cost management may significantly influence the final cost of goods. Improvement of sales also depends on the price of goods.

The increase in the number of auto transport used is a logical consequence of reduction in the "order-delivery" cycle due to the extended haul to each client's location, a large probability of dispatch of several auto transport to the same point and incomplete use of motor auto transport resources. If auto transport use during the goods transportation is not optimised, the expenses can suddenly increase which eliminates the positive effect of the improved service level. Only application of modern logistic approaches allows finding a correct solution to this complicated multi-criteria task.

Number of requests and amount of orders

The number of requests per day and the average volume of an order are key parameters for determining duration of the "order-delivery" cycle. It is evident that the larger the orders are and the more requests are received during a time unit, the shorter is the optimal cycle, as the number of points in the route decreases. Furthermore, the specific expenses for delivery also decrease due to efficient use of motor auto transport resources. Corporate customers are much more predictable than the private ones, and the risk of a cancelled deliveries to offices are much lower than the ones to be delivered to apartments. However, the advantage of servicing individuals is a more flexible range of delivery time (boundaries for earliest and latest deliveries are extended). Furthermore, performance of orders can be postponed more easily in case of private customers if any problems arise. All of the above-mentioned parameters determine the number of stages of order processing and warehouse operation scheme. Duration

of the "order-delivery" cycle depends directly on operating speed of all functional divisions of the company and the level of action coordination. The list of eventual participants of the process and the standard sequence of their actions is as follows:

- marketing and financial departments forecast the volume of demand, in cooperation with the logistics department they determine the optimum schedule and smooth flow of orders, special events are carried out in order to stimulate consumers to observe the selected schedule;
- sales subdivisions process requests, verify whether they are filled in correctly, check the client's credit solvency and availability of the required amount of requested goods in the warehouse; if the order is accepted, the client is informed accordingly, and the order is registered in the information system;
- accounting department registers the concluded deal;
- warehouse carries out selection of goods and completes the order, notes relevant decrease in remaining goods, ensures labelling and packaging;
- shipping service processes batches for shipping, executes accompanying documents and loads the auto transport;
- shipping agent organises the delivery process and performs final execution of the accompanying documents which are submitted with the filled route list at dispatcher's office on the following day.

Calculations of the cycle

Calculations of the duration the "order-delivery" cycle which is optimal for the company are made as follows:

- list of the current operations taking into account the basic conditions and parameters of the services is stated as costs for each eventual option of the "order-delivery" cycle;
- forecast for sales growth of the client service is developed;
- optimum level is found in graphic form by plotting an integral curve which reflects changes of costs and income, depending on the growth in service level.

Generally, the decrease in duration of the "order-delivery" cycle goes lockstep with increase in costs related to increased efficiency in execution of the order on the one part and growth in income from growth of sales on the other part. In case optimal duration of the cycle has to be reduced, it can be done by shifting the cost curve to the left, i.e. by reducing costs for execution of the client's order. As it was mentioned above, improvement of transportation management technology plays a crucial role in reducing such costs. Division of routes into areas - AREA DIVISION, and monitoring these areas - PATROLLING and ROUTE OPTIMIZATION play a significant role in GPS use in transportation. A detailed explanation of each of these factors is given below.

Area division

Boundaries and location of service areas are determined based on such criteria as simplicity of driving on the road network within a given area and its dimensions depend on the maximum number of orders which can be served by one auto transport .

The task of supply department managers applying this method is not route planning (the driver determines himself the optimal sequence of delivery) but updating area's parameters. Moreover, experience proves that eventual incomplete use of auto transport capacity and body space is compensated by the increase in

the number of clients who receive the goods due to the decreased haul between two route points. However, the issue with incomplete load of the auto transport can be solved by adding orders from adjacent areas to the route.

A company can simultaneously use various schemes of area division for various types of delivery, particularly delivery by courier or auto transport . In some cases a courier can execute an order much faster involving lower costs. This is especially true in case of delivering an order to the central part of a big city where traffic congestions occur frequently and it is difficult to park a auto transport.

Patrolling

The auto transport carrying highly demanded goods leaves the warehouse in the morning and stays in a certain area all day in order to go to a client at any time after receiving a call from a dispatcher.

The same auto transport can also be used in case of a breakdown or an accident of another auto transport on routes that are closest to this area.

This method enables achieving the minimum time for delivering orders, however there is one significant disadvantage - the list of goods being delivered is considerably restricted.

Route optimization

Efficiency and optimization of route development along with minimization of labour input can be achieved by integrating warehouse product distribution management systems with one of the information applications or the information system.

Modern technologies for managing transportation in Latvia

The use of GPS requires availability of at least one manager in the planning department whose qualification should be sufficient for working with electronic directories and determining auto transport design speed coefficients depending on weather conditions. According to the specified "order-delivery" cycle the manager periodically initiates planning process and prints developed route lists.

The advantage of this method lies in reducing the time for planning hauls and elaborating the optimal route, taking into consideration many parameters which are difficult to take into account in case of manual calculations. The expenses for auto transport park service decrease due to application of the described method. Furthermore, the number of schedulers decreases and the efficiency of auto transport use increases.

Along with the decrease of the "order-delivery" cycle the probability that a auto transport leaving for its route is not completely full increases. Therefore the necessity arises to perform strict auto transport tracking and control over the delivery execution process in order to use a auto transport as soon as it is free. This task is solved by the use of navigation systems. In this case a auto transport is equipped with a special user's terminal which automatically connects with the GPS satellite global positioning system and determines the geographical coordinates of the object's location.

This information is transferred in the form of text messages to the dispatcher office where it is automatically depicted on the maps. Not only is the system able to transfer the information on the route, it also can take readings from sensors of

virtually all electronic systems of a auto transport. Using a common computer connected to the Internet, a dispatcher can track the movement of a GPS-terminal holder in real-time mode. Modern GPS-terminals can provide data about the object location with the accuracy of 3 m. From the technical point of view, the GPS-system consists of an antenna, a set of sensors and receivers which enable transferring information about the condition of the auto transport and cargo (cargo weight, attempts to open it, refrigerator temperature, etc.) to the dispatcher office, on-board controller which processes the information from GPS and various sensors as well as radio stations which ensure communication with the dispatcher office.

When the estimated and actual data are compared, deviations from the auto transport schedule on the route can be recorded and assessed; this is the implementation of so called transport monitoring system. On the basis of the available information a specialist can take some operative measures in case of emergency situations (e.g., reschedule the haul or call an extra auto transport if there is a delivery failure risk; i.e., implement the approved transport control system).

The main technical requirements imposed in case GPS-programmes and the transport navigation systems are used are as follows: accuracy of clients' addresses for correct and quick assignment of geographical coordinates, availability of complete and accurate data about the weight and volume of the goods to be delivered, and the presence of formalized signs determining special delivery conditions in the requests.

New opportunities

Dispatcher services using the abovementioned modern systems obtain the following options for managing motor auto transport:

- analyse information and take decisions based on the data shown on the scalable electronic map;
- store data on the movement and status of the objects under control and prepare reports based on this information, including the data visualised on an electronic map;
- receive detailed reports about non-routing and emergency situations requiring operative response.

Furthermore, in case of an incoming call from a client the dispatcher has complete information about the status of the order at the present moment and is able to answer any questions, including the estimated time of arrival (this information can also be shown online, thus clients can get free access to it).

As a consequence the efficiency of auto transport use increases, transport logistics improve; transport management is carried out, strict control is implemented over improper auto transport use and the number of failed deliveries decreases which enables the company to reduce the "order-delivery" cycle and improve the level of services provided to the clients accordingly.

Problems with evaluating efficiency of motor auto transport monitoring systems by using GPS

One of the main problems in improving the efficiency of GPS use in the motor auto transport is the problem related to evaluation of efficiency of such systems. Efficiency of these systems can be evaluated by mathematical calculations using

queuing systems. The auto transport GPS signal receivers as such can be interpreted as separate systems of queuing which receive queries about their locations from the system dispatcher. GPS signal receivers can generate queries to the system dispatcher. Queries are managed on a first in, first out basis in rotation and return from GPS receiver to a dispatcher, then they are transferred back to GPS receivers from a dispatcher. One of the characteristics of this query management scheme is the availability of different rules on query management by GPS receivers. This diversity on one part can be explained by diversity of queries and the diversity of the receivers' characteristics. Unfortunately, in terms of applying queuing systems, the network device diversity is recorded extremely rarely or considered if there is a correlation between the rules on query behaviour when queuing for service and the diversity or with other queues (Boicov, 2011; Boicov, 2012). As to GPS efficiency evaluation, cases should be taken into consideration when the types of queries do not depend on the status of query in the queue. Therefore this research suggests characteristics calculation method for GPS systems on the basis of the assumption that management in the network nodes is subordinated to management rules. Approbation for use of this method for corporate computer network analysis is reflected in various works of the authors (Boicov, 2009). Along with analytical researches presented below, the authors carried out the experimental methods of GPS system assessment (Boicov and Zivitere, 2010) and the researches based on simulation modelling methods (Boicov, 2005). This research suggests selecting the mathematical tool of queuing stochastic networks as a basis for studies of the characteristics of GPS receiver network consisting of several nodes. In these networks, queries can select a network node for management randomly. It is suggested to perform the analysis of computer networks first based on the fundamental queuing system with the hyper-exponential management law and the superposition of Poisson query stream acting at the system input and then a transition to a stochastic network of queuing systems takes place. This method enables studying the networks with hierarchical organisation of the structure where subnets can be used as service units.

Conclusion

The polls carried out show that the use of modern positioning systems for transport and motor auto transport control systems is economically feasible.

Thus it is evident that the economic effect from their implementation in large companies performing thousands of deliveries every day will definitely exceed the costs for its purchase, implementation and maintenance. Furthermore, it will be much easier to manage the transportation company.

Development of an integrated transport management system enables to solve a local task of reducing the "order-delivery" cycle and creating a positive image for the company in the eyes of the clients due to accurate execution of undertaken obligations related with order execution terms, minimization of the delivery failure risk and the opportunity of creating a flexible feedback system.

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