International Journal of Engineering & Technology, 7 (4) (2018) 4514-4518

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET
doi: 19858
Research paper

Use of cargo delivery process model for the assessment of logistics service quality

Hanna Kyrychenko [1], Halyna Nesterenko [2], Svetlana Avramenko [2], Sergiy Lytvynenko [3] *, Peter Yanovsky [3], Larysa Lytvynenko [3]

[1] *State University of Infrastructure and Technology, Kyiv, Ukraine*
[2] *Dnipropetrovsk National University of Railway Transport named after academician V. Lazaryan, Dnipro, Ukraine*
[3] *National Aviation University, Kyiv, Ukraine*
**Corresponding author E-mail: sllitvinenko1982@gmail.com*

Abstract

The paper proposes the method of forecasting the time of operations with a wagon and a cargo, which is carried out using the cargo delivery process model taking into account possible scenarios of the process and deviation from the forecast and technological standards. One of the concepts of the model is the average deviation from the forecast. This method for the first time allowed considering the conditions of real operational work when forecasting control points of cargo delivery process stages. Data on deviation is proposed to be stored in the database of the automated system for forecasting. The paper also proposes an estimation of deviations at all stages of transportation using linguistic definitions of the states, which allows quantifying the indicator, such as the quality of transportation. The given method allows forecasting the time control points of the scheduled cargo delivery stages considering the conditions of real operational work. One of the prospects for using the above method is the ability of information interaction of the transportation participants, namely, in the part of exchange and processing of operation monitoring data, data on deviations from the forecast and standards, as well as the exchange of delivery quality assessment data.

Keywords: *Logistics Service; Cargo Delivery; Cargo Delivery Process Model; Forecast Deviation*.

1. Introduction

Business process management in cargo transportation involves the availability of information about the time, location and condition of the object. The use of information technology allows forecasting the time of operations in the delivery chains. The availability of information about the arrival of cargoes, the data of transportation and accompanying documents provide the opportunity for coordinating the actions of transportation process participant such as the border railway station, state control bodies and similar services of the adjacent administration to organize the passage of cargoes without delays.

2. Literature review and defining the problem

The problem of cargo delivery was actively investigated by domestic and foreign researchers, in particular, D. Adebanjo, D. Lomotko, E. Alyoshinsky, G. Zambrybor, J. Gou, T. Ma, J. Li, A. Nagurney, D. Li, P. Brandimarte, G. Zotteri, D. Teodorovic, M. Janic, T. Pohja, H. Min, G. Zhou, H. Karimi, N. Duffie, M. Freitag, M. Lütjen, M. Chadli, H. Kirichenko, S. Ovcharenko.

Logistics experts claim [1] that currently there is no business competition but competition of Supply Chain Management (SCM). SCM competition is directly related to the quality of service at each stage of delivery.

The paper [2] states that one of the ways of reforming and integrating the Ukrainian railways into the European transport system is connected with the implementation of logistics processes in all areas of the railway activity and the organization of the hierarchical network of logistic centres. It presents the model of transport system, part of which components are operators, whose functions are related to the control of transport processes and operations with objects in time. Creation of technology and structures of the operation of the railway logistics centres will allow the implementation of logistics processes when providing the services to the cargo owners according to their requirements.

Issues of customer service quality assessment are considered in the context of the integration strategy of logistics chains. The work [3] presents an integrated evaluation of the service cost model, which includes a logistics cost index, service time in the network and customer service quality level.

The paper [4] presents models and analysis of the systems of cargo delivery from place of production to the consumer, in this connection there is the problem of informational asymmetry associated with the fact that the manufacturer and the consumer have different levels of knowledge about the quality of products. It considers the abilities of assessment (by measured means) of the delivery system quality, in particular when quality of the system operation depends on the decision making by several persons.

Classification of forecasting means by classical statistical methods for modelling of cargo delivery processes is performed in the work [5]. It emphasizes the need to accurately forecast time points, in the work they are defined as transit points (LTg), pp. 342–343, especially in complex models of material resources management in multi-chained delivery chains.

In [6], the authors argue that there is objective presence of deviations, p. 346, in the organization of traffic flows in the railway network and the need to control time parameters such as the time

of shipment, stopping, and arrival in real time. Traffic flow planning and control are related to the analysis of not only the characteristics of the railway infrastructure, supporting transport services, but also with the analysis of the workload of train dispatchers.
The paper [7] considers the structure of supply chain organization and the ARA-model of interaction with partners. It is noted that technology and planning of integration involves the use of computing system data, as well as the existence of the structure of intellectual exchange of delivery chain data with customers.
When modelling processes in delivery chains, the work [8] considers competition, demand and distribution planning, as well as the use of data about cargoes' location and movement. It is important to choose information technologies as modelling tools. The success of the interaction depends on the synchronization of information and its exchange in real-time mode, p. 237, between the participants in the delivery chains and the recipients of the cargoes. Such information includes data on the location of cargo, technology, planning actions with cargo. Real events do not always accord with the planned ones, since their implementation depends on the decision-making of staff at different levels. Accuracy, quantitative effectiveness, according to p. 155 of the work [9], of the modern delivery of cargoes is a function of reliability and speed of goods replenishment in warehouses, adherence of delivery terms, minimization of losses during transportation and storage in warehouses, etc. The time, as noted therein, is the most important factor in the management of logistics processes, if we look at minimizing the full-time costs when moving goods from the production point to the end user through all process chains.
The work [10] mentions the necessity of using the process modelling methodology for optimization and control of the operation of logistics networks by means of the following methods – intellectual approaches, such as fuzzy logic and network methods, mathematical modelling, stochastic optimization of logistic processes, forecasting and its consideration during planning.
In order to control the cargo delivery by rail, a method of time-control points was developed in [11] based on the developed schedule and delivery technology for a specific cargo. This method allows forecasting the flow of traffic, control the compliance with delivery terms, analysing the time of the delivery schedule deviation.
The model proposed in [12] is used to forecast time-control points in the cargo delivery process. The transportation process data, including the off-forecast deviation data (Δt_i^n) are accumulated in the existing information base for the next process modelling, as close as possible to real conditions.
However, these research papers do not contain cargo delivery process modelling, taking into account possible scenarios of the process and deviation from the forecast and technological standards.
The railway dispatching services control the movement of trains according to the established traffic schedule, but currently there are no "tools" that control and assess the quality of cargo delivery. On the other hand, transparency of action and compliance with logistic principles during cargo delivery are required from the railways as from the business environment service, especially when it concerns transportation related to receipt and transfer of cargo abroad or to other modes of transport. The quality of the cargo delivery service is conditioned by observance of the established time parameters, which are stipulated by the agreement between the participants of transportation. Determining the time of cargo transfer to the client is associated with accurate forecast of the time of cargo operations during transportation.
Unfortunately, at the moment it is possible to estimate the service quality only indirectly, by analysing the number of detained train cars and cargoes at the transfer points, borders and ports, and their idle time, as well as the number of detained trains at the approaches to the destination station. Only in 2016 at the borders approximately 176 thousand train cars were detained, which is 14% of the total amount and more than in the previous year.
The trend in the growth of the number of stopped train cars in the conditions of reduction of the cargo flow exchanged by carriers demonstrates the need to use the "tools" for managing the business processes of interaction with European carriers and public authorities, throughout the cargo delivery chain. On the other hand, the mathematical description of logistic systems, such as the border transfer station, is too complicated when using traditional mathematical methods.
In this case, the principle of incompatibility appears to a sufficient extent, according to which the complexity of the system and the accuracy with which it can be described contradict each other. But the problem can be solved with the help of information systems and process simulation.

3. Research aim and objectives

The aim of the given study is development of the method of forecasting the time of operations with a wagon and a load is carried out using the cargo delivery process model, considering possible scenarios of the process and deviation from the forecast and technological standards.
To attain the aim, the following objectives were identified:

- To forecast the time of operations with a wagon and a cargo, it is expedient to use the cargo delivery process model, including that at the borders;
- To estimate deviations at all stages of transportation using linguistic definitions of the states, which allows quantifying the indicator, such as the quality of transportation;
- To assess the quality of the logistics service of cargo delivery.

4. Overview key findings

4.1. Development of cargo delivery process model

It is expedient to forecast the time of operations with a wagon and a cargo through forecasting the time of the transfer of cargoes and wagons in contact charts, taking into account the actual events of the operational process, namely to determine the time control points (TCP) of cargo transportation.
The model of the delivery process should be presented as:

$$M_1 : Op \times Ob \times Sb \times Sc \times St \times T \rightarrow TCP^n \times T \quad , \qquad (1)$$

Where: Op – set of operations of the cargo delivery process, including operations for the transfer of wagons and cargoes;
Ob – set of stationary objects (railway tracks and facilities, sections);
Sb – set of subjects performing managing and decision making in the logistics process;
Sc – set of scenarios of cargo delivery processes (CDP);
St – set of spatial states of cargoes;
T – real time.
It should be noted, the scenario Sc of cargo delivery (CDP) is one of possible variants to implement the hypothetical, logical sequence of situations of the cargo delivery process in the form of declarative and graphical description compiled by heuristic method based on expert assessment or on the analysis of past operations and events with cargo and wagon. The scenario is not a time function, i.e. the sequence of situations is not superimposed on the time axis.

Table 1: The List of Events for Compiling the Delivery Process Scenarios

#	Arrival Sb_1	Technical inspection Sb_2	Formation Sb_3	Driving the car with cargoes to depart Sb_4	Locomotive driving up Sb_5	Cargoes shipping Sb_6	Beginning of the car delay due to the clients' fault Sb_7	End of the car delay Sb_8	Time T
S_C 1	×					×			
Time (Tsc)	*					*			*
S_C 2	×	×	×	×	×	×			
Time ctp	*	*	*	*	*	*			*

The disclosure of Sc model for a set of CDS has the following form:

$$M_2 : Op \times S \times D \to Sc \ , \tag{2}$$

Where: S – set of CDP situations; D – set of events in the cargo delivery process, Sbi .
Disclosure of S model is as follows:

$$M_3 : Ob \times Op \times \Delta T \times t_n \times T \to S \times T \tag{3}$$

Where: ΔT – set of time intervals to perform CDP operations; t_n – set of time intervals between events ($t_n = t_i \pm \Delta t_i^n$); Δt_i^n – average (forecast) deviations from the normative time, according to ΔTCP data by events.
Disclosure of the model Cm is as follows:

$$M_4 : D \times On \times I \to Cm \ , \tag{4}$$

Where: I – information.
Information ΔT , $t_n = t_i \pm \Delta t_i^n$ about events with objects of management (trains, wagons and cargoes) is accumulated in the database of the automated system.

4.2. Information database on the actual traffic creation

The presence of the information on the actual traffic (monitoring), the lagging behind the forecast and regulatory time control points in the database will allow taking them into account at the next stages of the forecast and assess the quality of the logistics service of cargo delivery. Below, Fig. 1 presents the content of the database fragment concerning monitoring of movement of the loaded cargo wagon and the deviations from the forecast and the delivery schedule.

N_Vag	Kod_Stan...	Oper_vag...	T_Ktch	T_Oper_Norm	T_Oper_real	Delta_Norm	Delta_Fakt	Delta	Delta_Ktch
54754395	467201	1	2017-05-01 06:50:...	2017-05-01 07:03:...	2017-05-01 07:21...	NULL	0,18	NULL	0,31
54754395	467201	311	NULL	2017-05-01 07:13:...	2017-05-01 07:40...	0,1	0,19	0,09	NULL
54754395	467201	312	NULL	2017-05-01 07:33:...	2017-05-01 08:15...	0,2	0,35	0,15	NULL
54754395	467201	300	NULL	2017-05-01 07:15:...	2017-05-01 08:00...	0,1	0,39	0,29	NULL
54754395	467201	301	NULL	2017-05-01 07:35:...	2017-05-01 08:40...	0,2	0,4	0,2	NULL
54754395	467201	313	NULL	2017-05-01 08:00:...	2017-05-01 08:45...	0,25	0,25	0	NULL
54754395	467201	4	NULL	2017-05-01 08:15:...	2017-05-01 09:10...	0,15	0,3	0,15	NULL
54754395	467201	314	NULL	2017-05-01 08:30:...	2017-05-01 09:40...	0,15	0,5	0,35	NULL
54754395	467201	315	NULL	2017-05-01 10:00:...	2017-05-01 10:30...	1,3	3	1,3	NULL
54754395	467201	698	2017-05-01 08:50:...	2017-05-01 12:00:...	2017-05-01 13:30...	2	1,3	0,3	4,4
54754395	467201	697	2017-05-01 21:00:...	2017-05-01 20:00:...	2017-05-01 21:30...	8	0,3	7,3	0,3

Fig. 1: Information on the Actual Progress of Transportation_T3.

The Fig. 1 data include:
N_Vag – loaded wagon number,
Kod_Stan – railway station code by the Unified Network Marking (EMR),
Oper_vag – code of the operation with wagon and (or) cargo by AS codification,
T_Ktch – time control points (TCP) during cargo transportation, anticipated in the model,
T_Oper_Norma – time of operations according to the technological process of transportation,
T_Oper_real – time of operations in the real process,
Delta_Norma – normative time between events, standards for the technological process of objects,
Delta_Fakt – time between the events of the real operational process, $t_n = t_i \pm \Delta t_i^n$, the AS data;
Delta – time difference between the normative execution of operations and the real operating time, deviation (or advance) from the normative execution of operations in the process of transportation $\pm\Delta t_i^n$.
This method allows forecasting the control points of the cargo delivery stages TCP^n in the model M_1, whose concept is a set of scenarios Sc , the modelling of which depends on a set of situations S , model of situations M_3 includes deviations Δt_i^n , recorded as "Delta" data in Table 2.
Thus, the current AS data on real time parameters of the operational process, their deviations from forecast and normative parameters are taken into account in the forecast model in the future TCP^n .

Table 2: Assessment Matrix of Transport Stages of Operations with Wagon and Cargo

Quality markers / Assessment	Cargo pick-up	Cargo shipment	Cargo movement	Non-process operations	Arrival	Control (border)	Cargo drop-off
1. Just in time	$10 < \Delta_{11} \le 10$	$10 < \Delta_{21} \le 10$	$10 < \Delta_{31} \le 10$	-	$30 < \Delta_{51} \le 30$	$60 < \Delta_{61} \le 60$	$30 < \Delta_{71} \le 30$
2. Normal	$11 < \Delta_{12} \le 30$	$11 < \Delta_{22} \le 30$	$11 < \Delta_{32} \le 30$	$0 < \Delta_{42} \le 30$	$31 < \Delta_{52} \le 60$	$61 < \Delta_{62} \le 120$	$31 < \Delta_{72} \le 60$
3. Retention	$31 < \Delta_{13} \le 50$	$31 < \Delta_{23} \le 50$	$31 < \Delta_{33} \le 60$	$31 < \Delta_{43} \le 60$	$61 < \Delta_{53} \le 120$	$121 < \Delta_{63} \le 180$	$61 < \Delta_{73} \le 120$
4. Advance	$31 < \Delta_{14} \le 50$	$31 < \Delta_{24} \le 50$	$31 < \Delta_{34} \le 60$	-	$121 < \Delta_{54} \le 180$	$61 < \Delta_{64} \le 180$	$121 < \Delta_{74} \le 180$
5. Retention with viola-	$51 < \Delta_{15} \le 90$	$51 < \Delta_{25} \le 90$	$61 < \Delta_{35} \le 120$	-	$121 < \Delta_{55} \le 180$	$181 < \Delta_{65} \le 240$	$121 < \Delta_{75} \le 180$

tion							
6. Advance with violation	$51<\Delta_{16}\le 90$	$50<\Delta_{26}\le 90$	$60<\Delta_{36}\le 120$	-	$181<\Delta_{56}\le 240$	$181<\Delta_{66}\le 240$	$181<\Delta_{76}\le 240$
7. Precritical	$91<\Delta_{17}\le 120$	$91<\Delta_{27}\le 120$	$121<\Delta_{37}\le 180$	$61<\Delta_{47}\le 120$	$181<\Delta_{57}\le 240$	$241<\Delta_{67}\le 300$	$181<\Delta_{77}\le 240$
8. Critical	$121<\Delta_{18}\le 180$	$91<\Delta_{28}\le 120$	$181<\Delta_{38}\le 240$	$121<\Delta_{48}\le 180$	$241<\Delta_{58}\le 300$	$301<\Delta_{68}\le 360$	$241<\Delta_{78}\le 300$
9. Over critical	$180<\Delta_{19}$	$180<\Delta_{29}$	$241<\Delta_{39}$	$181<\Delta_{49}$	$301<\Delta_{59}$	$361<\Delta_{69}$	$301<\Delta_{79}$

4.3. Estimation of the time deviations when carrying out operations with wagon and cargo

Based on the existing data on the deviation (or advance), the authors developed a transportation stages assessment matrix. The time deviations when carrying out operations with wagon and cargo from the norm or from the forecast are estimated on the basis of expert assessments, the values of which are presented in Table 2. Dimensions are given in minutes.

4.4. Discussion of research findings

In our opinion, the quality of cargo transportation is the set of time and safety characteristics of the cargo delivery process which correspond to the logistic concept “just-in-time” according to actual needs of the cargo clientele and restrictions of the delivery operational process. Criteria for ensuring the quality of transportation may also be different.

Directly for the cargo clientele in each specific delivery, the importance of the criteria for its implementation is different. For individual customers, the importance of delivery speed of is a key criterion, for the second group of clients the delivery price is a priority, for the third one the safety of delivery is a basic criterion.

The forwarding agent and the carrier, as a rule, are faced with the problem of solving this multi-criteria task, taking into account the interests and wants of the cargo clientele. Frequently, the optimization of these criteria for all parameters simultaneously is impossible, respectively, the task of delivering each specific cargo is solved within the framework of the priority parameters.

The process of cargo delivery varies significantly on different modes of transport. It also essentially depends on whether it is a general cargo or a special cargo.

As a rule, special categories of goods have additional specific properties that complicate the process of their delivery or require acceleration of its organization. In addition, the specifics of delivering special categories of cargoes implies additional formalities and, as a result, costs increase, however, these categories of cargoes are delivered at higher tariffs, which makes them attractive for freight forwarders and carriers in general. Consequently, they are interested, primarily, in increasing the cargo traffic of these particular categories of cargo.

Railway transport in Ukraine is experiencing very big problems when it is included in the delivery chain. The key problem is the lack of ensuring delivery terms while it is very important for the delivery chain.

This problem as a whole is not new, but for each country there are peculiarities of its solution. For Ukraine, the problem of participation of rail transport in the delivery chain is particularly acute due to inefficient mechanisms of its operations, unreliability of delivery chains with its participation, existence of unlawful interference acts, theft, cargo damage.

That is why the authors have focused precisely on time factors in modelling. In world practice, more categories of cargoes can be delivered by rail and with this in mind, if Ukraine wants to be an active participant in global delivery chains, it simply has to develop effective mechanisms for assessing the quality of logistics services in rail transport. One of these mechanisms are the authors’ proposals given in this study.

Characteristics of retentions or advances from normative and forecast TCP^n are assigned with the linguistic definitions of transportation states St, which correspond to the categories of thinking of the dispatching apparatus, controlling the cargo delivery progress. Linguistic definitions contain the process semantics and the instructional meaning of the need for managerial influence; they form the vertical of the matrix in Table 2.

The main stages of the delivery process, such as cargo pick-up for carriage from the client, departure from the station, cargo movement, and others, are indicated in the horizontal matrix of Table 2. Deviations Δt_{ij}^{n} from the forecast (or normative time) at acceptable intervals compose the data matrix.

The assessment of the "Cargo movement" stage is detailed in case of need for operation with a wagon and a cargo. "Non-process operations" include operations and events with a cargo not provided for by the technological process of the railway, such as the train stop at the approaches to the destination station for various reasons, in particular due to the fault of the client.

Comparison of the AS current data of the delivery process Δt_{i}^{n} in Fig. 1 (Delta column) with the data of the deviation assessment matrix Δt_{ij}^{n} in Table 2 provides an opportunity to assess the quality of the delivery process, including by its components.

According to this scale, sufficiently high quality of transportation is ensured with estimates "exactly in time", "normal", "retention" or "advance" in all events of the delivery process, except for "non-process operations". The proposed assessment of meeting the planned schedule (with forecast of the control points of transportation events) is carried out as deviation analysis and is given as an instruction in a linguistic form to the traffic control office for decision making. The proposed estimation of deviations at all stages of transportation allows us to estimate such indicator as the quality of transportation, using the quantitative characteristics. Forecasting of TCP^n is carried out in $M1$ model, which concept is a set of scenarios Sc, the modelling of which depends on a set of situations S, $M3$ model of situations includes deviations Δt_{i}^{n}. Thus, the current AS data on real time parameters of the operational process, their deviations from forecast and normative parameter are taken into account in the TCP^n forecast model in the future.

5. Conclusions

The given method allows forecasting the time control points of the scheduled cargo delivery stages considering the conditions of real operational work. Information ΔT, $t_n = t_i \pm \Delta t_i^n$ about events with objects of control (trains, wagons and cargoes) is accumulated in the database of the automated system. These data are taken into account in the delivery process model. One of the concepts of the model – the average (forecast) deviation $t_n = t_i \pm \Delta t_i^n$ from the automated system database allows considering the impact of possible factors and conditions of real operational work. Forecasting with the use of the above models $M1$; $M3$ will allow determining the pick-up and drop off time for cargo and wagons, taking into account the actual events of the operational process. The assessment of the quality of the cargo deliver logistics chains is carried out using linguistic definitions. The analysis of deviations is provided as information on the assessment of the transportation stages to the dispatching apparatus for decision making and allows the transition to the formation of databases and the creation of intelligent systems.

One of the prospects for using the above method is the ability of information interaction of the transportation participants, namely, in the part of exchange and processing of operation monitoring data, data on deviations from the forecast and standards, as well as the exchange of delivery quality assessment data of the monitored process.

References

[1] D. Adebanjo, An investigation of the adoption and implementation of benchmarking, International Journal of Operations & Production Management, Vol. 30, No. 11 (2010) 1140-1169, https://doi.org/10.1108/01443571011087369.

[2] D.V. Lomotko, E.S. Alyoshinsky, G.G. Zambrybor, Methodological Aspect of the Logistics Technologies Formation in Reforming Processes on the Railways. Transportation Research Procedia, Vol. 14 (2016) 2762-2766, https://doi.org/10.1016/j.trpro.2016.05.482.

[3] J. Gou, T. Ma, J. Li A research on Supply Chain Integration Strategy Based on Virtual Value Net, Research and Practical Issues of Enterprise Information Systems II, Vol. 2 (2007) 887-891, https://doi.org/10.1007/978-0-387-76312-5_11.

[4] A. Nagurney, D. Li, Competing on Supply Chain Quality: A Network Economics Perspective, 2016; 85-101, https://doi.org/10.1007/978-3-319-25451-7.

[5] P. Brandimarte, G. Zotteri, Introduction to Distribution Logistics. 2007; 91-113, 116-185, 335-345.

[6] D. Teodorovic, M. Janic, Transportation Engineering: Theory, Practice and Modeling, 2016; 346-347.

[7] T.L. Pohja, Some theoretical foundations of Supply Chain Management and Supply Networks: the role of social networks in selecting partners. The paper was published at the 20th IMP-conference in Copenhagen, 2-4.9, 2004.

[8] H. Min, G. Zhou, Supply chain modeling: past, present and future, Computers and Industrial Engineering – Supply chain management, Vol. 43 (2002) 231-249.

[9] Dr. Rajagopal, Systems Thinking and Process Dynamics for Marketing Systems: Technologies and Applications for Decision Management, 2012, 301 p., https://doi.org/10.4018/978-1-4666-0969-3.

[10] H.R. Karimi, N. Duffie, M. Freitag, M. Lütjen, M. Chadli, Modeling Planning, and Control of Complex Logistic Processes, Mathematical Problems in Engineering. Article ID 184267, 2 pages, 2015, https://doi.org/10.1155/2015/184267.

[11] H.I. Kyrychenko, S.M. Ovcharenko "Rozrobka metodu kontrolno-chasovih tochok dlya kontrolyu grafikiv dostavki vantazhu" [In Ukrainian: Development of the method of control points for controlling delivery schedules], Problemi transportu, Vol. 10 (2013) 112-118.

[12] H.I. Kyrychenko, Applying processes modelling to manage goods delivery, III International Scientific and Practical Conference «Modern Scientific Achievements and Their Practical Application», No. 5 (21), Vol.1 (2017) 53-55.