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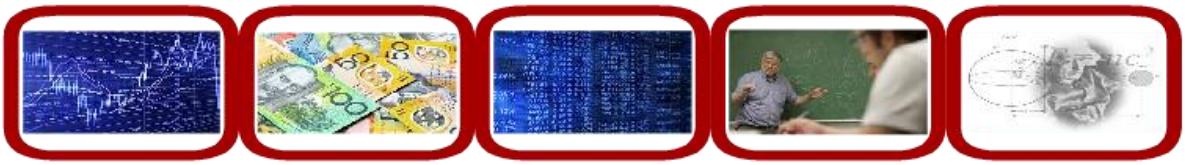

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ISSN: 1987-6521; E-ISSN: 2346 – 7541; DOI: 10. 15357; UDC: 551.46 (051.4) / B-64
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ORGANIZATION OF TRANSPORT LOGISTICS BASED ON THE CONCEPTS OF JIT AND JIS

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ABSTRACT

In the article the relevance of the development and the implementation of logistics concepts "just in time" and "just-in-sequence", the necessity of application of these concepts in the practice of planning, organizing and management processes of cargo delivery are substantiated. According to logistics concepts "just in time" and "just-in-sequence" the classification of supply chain management is represented. The characteristic of mono- and poly consignment supplies is given. A mathematical model of the process of cargo delivery in the direct supply chain in terms of using JIT and JIS allowing to obtain shift-daily delivery plan is described.

РЕЗЮМЕ

В статье обоснована актуальность развития и реализации логистических концепций «точно в срок» и «точно в последовательности», необходимость применения данных концепция в практике планирования, организации и управления процессами доставки грузов. Представлена классификация цепей поставок с учетом логистических концепций «точно в срок» и «точно в последовательности». Дается характеристика моно- и полипартионной доставки. Описана математическая модель процесса доставки грузов в прямой цепи поставок в условиях применения концепций «точно в срок» и «точно в последовательности», позволяющая получить сменно-суточный план доставки.

INTRODUCTION

In terms of competition, the adaptation to the customers' interests requires timely response to these requests from carriers. It leads to improving the quality of service, minimizing the order execution time and strict adherence of the delivery schedule. The focus must be on the customer orders execute on process. [6]

Delivery of products from producer to consumer "just in time" and "just-in-sequence" at a minimum cost of freight and material resources is the basis of transport logistics. The need to develop and implement the JIT and JIS concepts during transportation has appeared in consequence with the connection of delivery process by a certain time and a certain sequence. After some investigation of applications for the delivery of goods in [8], it was found that the main consumers' requirement for shipping transportation services is the implementation of the timing and sequence of the order: delivery of goods "just in time", "just-in-sequence".

Thus, the process of delivery in compliance with the conditions presented is in the spotlight of logistical management [7].

Currently, different approaches are used to solve problems of management and organization of the transport process with the use of logistic principles [4, 5]. Despite some positive results, the of the transport process planning problems are solved without taking into account all the requirements producible by participants of delivery process. Such logistics concepts like JIT and JIS allow to take into account the customers' requirements in delivering the goods "just in time" and "in sequence" when scheduling.

In Russia, the concepts of JIT and JIS used in transport logistics and distribution.

Since May 2003, JSC "Severstal" started to supply metal-roll to the LLC "Caterpillar Tosno" on the principle of JIT, i.e. the customer as needed in a particular material. In addition, in Russia JIT supply system is provided by the company Master-snab, a leading supplier of industrial equipment and the leader in integrated supply in markets of Tver and Moscow regions. The company "EUROSIB-Logistics" offers JIT delivery system for automotive components and large-diameter pipes. In the field of construction of the Russian-Czech construction company «U-Group» offers its services to clients in the design and construction using prefabricated steel structures using JIT [11].Bo Andersson, the president of AvtoVAZ, believes that the introduction of the concepts of JIT and JIS, would reduce the term from the date of delivery of automotive components to be mounted on the car trade; free storage space that can be redeveloped; to reduce over-production, reduce waste and unreasonable traffic. Ultimately, the company can achieve a substantial reduction in the cost of production [12].

IDENTIFICATION OF SUPPLY CHAINS IN TERMS OF JIT AND JIS

The consequence of imperfect organization of the delivery process, carelessness of vendors, problems in communication and imperfections of inventory management is the failure of delivery "just in time" and "just-in-

sequence" that can lead to decreased quality of logistics services, the failure of production, loss of goodwill and etc.

It is necessary to plan all logistics operations in space and time in order to organize effective delivery.

However, before planning logistics activities for the delivery of cargo and schedule, it is necessary to identify the supply chain (SC) on the basis of classification criteria. There are different approaches to the classification of SC. Classification of the supply chains, given in [10] is based on affiliations between participants; in [1] the classification is based on the multiplicity of application to vehicle capacity and types of branches of the system in which they operate; the basis of the classification given in [2,3] is the complexity of behavior of participants in the SC, the SC hierarchy. Thus, the SC can be generally grouped by the following characteristics: by mean for functional areas; by the structure of functional areas; by territorial boundaries. However, the approaches to the classification of the SC mentioned above do not include special features of the transport process of delivery of goods by road, for example, the regularities of transport process, multi-link structure of SC, the intensity of cargo flows in the SC, capacity of SC, etc. According to the studies [8] it is ascertained that supplies can be divided as mono- and polyconsignment.

Monoconsignment supplies delivery of cargo which is implemented within request for one consignment.

Polyconsignment supply is delivery in which the declared volume of cargo is shipped in several (n, n>1) consignments.

For example, according to the request the cargo is to be delivered to consignee. Total volume of cargo is 80 tons, but 20 tons must be delivered until 10.00 am, 30 tons – until 14.00 pm, 30 tons – until 18.00 pm. Thus, the delivery will be implemented in several consignments:

First shipment – 20 tons – until 10.00 am;
Second shipment – 30 tons – until 14.00 pm;
Third shipment – 30 tons – until 18.00 pm.

These types of supply can be classified according to the following characteristics of through-passing material flow in accordance with the terms of there quest, see Table 1.

Implementation of delivery on the principles of JIT and JIS is possible when there is a schedule of the SC, which takes into account all conditions and restrictions. Existing models and algorithms for scheduling the delivery process of goods in direct SC do not fully correspond with the concepts of JIT and JIS [3].Presently, there is no model or algorithm for scheduling the delivery process of goods in direct SC based on the concepts of JIT and JIS in urban environment. Therefore, there is a necessity for creation of a model and development of the algorithm.

THE DESCRIPTION OF MATHEMATICAL MODEL

Formulation of the problem of constructing the model is as follows: there is a direct SC with one loading center and one unloading center, the system is running one vehicle (automobile). Daily the goods are delivered within the system on the concept of JIT and JIS. As a result, the time and sequence of delivery for each consignment is different.

The assigned task of this paper is to develop a model that will allow schedule in the delivery process of goods by road on the basis of the concepts of JIT, JIS in direct supply chains. Fundamental factors taken into account in the model are time of delivery “on time” and compliance with certain sequence. The main objective of this model is to deliver goods in direct SC in compliance with JIT and JIS concepts. Thus, the model describes the functioning of the SC.

The model parameters are deterministic, character of the transport process is discrete, as proved by Professor V.I. Nikolin and the direct SC is linearly ordered structure, the transport scheme in the SC is pendulum route with unloaded reverse hauls.

The following designations are stated in the mathematical model:

1. Initial data:

Sn – quantity of consignments in request, *n* – sequence number of consignment, n=1,2,3…,N, where N – total quantity of consignments within one request;

T_{ot}^{1}–consigner’s opening time, hours;

T_{ct}^{1}– consigner’s closing time, hours;

T_{ot}^{2} -consignee’s opening time, hours;

T_{ct}^{2}– consignee’s closing time, hours;

T_{ot}^{3}– beginning time of work for automobile, hours;

T_{ct}^{3}– finish time of work for automobile, hours;

Q_o^{Sn} – ordered volume for n-th consignment, tons;

T_{jj} – *j-th* time of delivery «just-in-time» for *n-th* consignment, j=1,2,…J, hours. (depending on the conditions of there quest time of delivery «just-in-time» can be time of beginning or time of finish of *n-th* consignment delivery);

T_{fd}^{Sn} – delivery finish time of n-th consignment(until this time the delivery of n-th consignment must be finished according to the consignee’s request), hours;

T_{bd}^{Sn} – delivery beginning time of n-th consignment (this time the delivery of n-th consignment must begin according to the consignee’s request), hours;

t_l – loading time, hours;

t_u – unloading time, hours;

Table 1

Classification of supply chains in terms of JIT and JIS

№	CLASSIFICATION CRITERIA	DESCRIPTION
1	Quantity of SC links*(N)*	- without intermediaries– direct SC, (*N=1);* - including intermediaries– echelon SC(*N>1)*.
2	Intensityof material flow in the SC(Q_{mt})	- if Q_{mt},<W_{ts}, then A_v=*1;* Q_{mt}– intensity of material flow, W_{ts} – output of transport system, A_v – required quantity of vehicles; - if Q_{mt},>W_{ts}, then *Ac>1*; - if Q_{mt},= Q_{cs}, thenT_d=*1,* Q_{cs} – capacity of SC system; T_d – required quantity of days for delivery implementation; - if Q_{mt},>Q_{cs}, thenT_d>*1*.
3	Quantity of consignments in supply within one request (*Sn*). *Sп* = 1,2,3….k, where k – quantity of consignments within one request	- if *Sп=1*, then supply is monoconsignment; - if *Sп>1* , then supply is polyconsignment
4	Volume of cargo in one consignment (*Qoc*)	- with fixed volume of cargo in one consignment– *Qoc=const;* - with unfixed volume of cargo in one consignment– *Qoc≠const*.
5	Consignee's latency period for next consignment (*TSlp* .)	- with equal latency period $\sum_{i}^{n} TSlp. = const,$ *i* – sequence number of consignment *n* – last consignment; - with different latency period $\sum_{i}^{n} TSlp. \neq const$.
6	Vehicle's latency period for the beginning of consignment implementation ($t_{lp.a.}$)	- without latency period $\sum_{i}^{n} t_{lp.a} = 0;$ *i* – sequence number of consignment *n* – last consignment; - with equal latency period $\sum_{i}^{n} t_{lp.a} = const$, - with different latency period $\sum_{i}^{n} t_{lp.a} \neq const$
7	Time limitation for start and finish of consignment delivery(Tl.)	- with time limitation for start of consignment delivery (To.d.) - Tl.=To.d.; - with time limitation for finish of consignment delivery (Tcd.) - Tl.= Tcd; - with time limitation for start and finish f consignment delivery- Tod=Tl.,Tcd.=Tl.
8	Nomenclature of cargo (Hi – nomenclature of i-th consignment)characterized by the number of cargo nomenclature units in the i-thconsignment. This feature is important to comply with the terms of delivery on the concept of JIS. For the i-th number of the consignmentthe nomenclature may be different	- Hi =1 – monocargo; - Hi>1 – polycargo.

l_r –route length, kilometers;
l_{wh} – haulage without cargo, kilometers;
l_{wc} – haulage with cargo, kilometers;
l_{zf} – zero haulage, *f*– sequence number of zero haulage, f=1,2,…F, kilometers;
q – capacity of the automobile, tons;
A_q – quantity of automobiles, units;
V_m – average technical velocity, kilometers per hour;
P_l – quantity of loading posts, *p*-sequence number of post, p=1,2,…P, piece;
P_u – quantity of unloading posts, *r*-sequence number of post, r=1,2,…R, piece;
T_d – time on duty, hours.

2. Calculation part:

Rsc – rhythm of work of loading and unloading posts:

$$R_{sc} = \frac{t_{l-u}}{P_{l-u}}, \quad (1)$$

$T_{sc.}$ – supply chain working time, hours

$$T_{sc.} = T_{ct}^{2} - T_{ot}^{1} \quad (2)$$

$Z_{c\max}$ – maximum quantity of car-hauls, which can be service don post with rhythm R:

$$Z_{c\max} = \left[\frac{T_{sc}}{R_{sc}} \right], \quad (3)$$

W_c – capacity of SC, tons.

$$W_c = Z_{c\max} * q * \gamma \quad (4)$$

Z^{Sn} - quantity of hauls for *n–th* consignment, y=1,2,3…,Y.

$$Z^{Sn} = \left[\frac{Q_o^{Sn}}{q} \right] \quad (5)$$

Z_c^M - maximum possible quantity of haulsin SC:

$$Z_c^M = \left[\frac{T_{sc}}{t_t} \right], \quad (6)$$

W_c^f – fact capacity of SC, tons.

$$W_c^f = Z_c^M * q * \gamma, \quad (7)$$

Q_o^t - total volume of all consignments in order:

$$Q_o^t = \Sigma Q_o^{Sn}, \quad (8)$$

t_{wc} - time of haul with cargo, hours;

$$t_{wc} = \frac{l_w}{V_T} \quad (9)$$

t_c - time of haul, hours;

$$t_c = \frac{l_c}{V_T} + t_{l-u} \qquad (10)$$

t_h - time of haul without cargo,hours;

$$t_h = \frac{l_{wh}}{V_T} \qquad (11)$$

t_t - time of turnaround, hours;

$$t_t = \frac{l_r}{V_T} + t_{l-u} \qquad (12)$$

$t_{z.}$- time of zero haulage, hours:

$$t_{z.} = \frac{l_{z.}}{V_T} \qquad (13)$$

t_{od1}^{Sn} - time of beginning of*1-th* loadin *n-th* consignment:

$$t_{od.1}^{Sn} = T_{jit} - t_{wc.} - t_{l.} - (Z-1) * t_t, \qquad (14)$$

$t_{od.i}^{Sn}$ - time of beginning of *i-th* load *n-th* consignment, i=2,3…,I, гдеI – quantity of loads in *n-th* consignment, hours:

$$t_{od.i}^{Sn} = t_{od1}^{Sn} + (i-1) * t_t, \qquad (15)$$

$t_{ctd.i}^{Sn}$ - time of finish of *i-th* load *n-th* consignment, hours

$$t_{ctd.i}^{Sn} = t_{od.i}^{Sn} + t_t, \qquad (16)$$

$t_{ou.k}^{Sn}$ - time of beginning of *k-th* разгрузки *n-th* consignment, k=1,2,3…,K, гдеK – quantity of unloads in *n-th* consignment, hours;

$$t_{ou.k}^{Sn} = t_{ctd.i}^{Sn} + t_{wc} \qquad (17)$$

$t_{ctu.k}^{Sn}$ - time of finish of *k-th* load in *n-th* consignment, hours

$$t_{ctu.k}^{Sn} = t_{ou.k}^{Sn} + t_u \qquad (18)$$

$t_{owc.b}^{Sn}$ - time of beginning of *b-th* haul with cargo in *n-th* consignment, b=1,2,3…,B, where Bis the last haul with cargo in *n-th* consignment, hours

$$t_{owc.b}^{Sn} = t_{ctd.i}^{Sn} \qquad (19)$$

$t_{ctwc.b}^{Sn}$ - time of finish of *b-th* haul with cargo in *n-th* consignment, hours

$$t^{Sn}_{ctwc.b} = t^{Sn}_{owc.b} + t_{wc} \quad (20)$$

t^{Sn}_{owhd} - time of beginning of *d-th* haul without cargo in *n-th* consignment, d=1,2,3…,D, where Dis the last haul without cargo in *n-th* consignment, hours;

$$t^{Sn}_{owh.d} = t^{Sn}_{ctu.k} \quad (21)$$

$t^{Sn}_{ctwh.d}$ - time of finish of *d-th* haul without cargo in *n-th* consignment, hours;

$$t^{Sn}_{ctwhd} = t^{Sn}_{owhd} + t_{wh} \quad (22)$$

t_{wcs} – time of withdrawal of automobile from car station, hours

$$t_{wcs} = t^{S1}_{od1} - t_{z.} \quad (23)$$

t_{re} – time of return of automobile to car station, hours

$$t_{re} = t^{S1}_{ctwh1} + t_{z.} \quad (24)$$

The following limitations and conditions are accepted in the model:

1. Limitation on the quantity of automobiles. According to the conditions of the model designed, there must be one automobile in SC:

$$Aq = 1 \quad (25)$$

2. Limitation on the quantity of loading posts:

$$P_l = 1 \quad (26)$$

3. Limitation on the quantity of unloading posts:

$$Pu = 1 \quad (27)$$

4. Limitation on the system's capacity. Capacity of SC(W_c) must be more or equatol fact capacity, and fact capacity must be more or equal to total order volume.
5. Condition of compatibility observance for working hours of automobile and working hours of SC. Working hours of automobile must be less or equal to working hours of SC.
6. Condition of compatibility observance for working hours of consigner, consignee and automobile. Working hours of automobile must be more or equal to the beginning of working hours of consigner and consignee and less or equal to the finish of working hours of consigner and consignee.
7. Condition of compatibility observance for time of beginning of the first load of the first consignment and working hours of automobile. Time of beginning of the first load of the first consignment must be less or equal to finish of working hours of automobile and more or equal to beginning of working hours of automobile.
8. Condition of compatibility observance for time of finish of the last un load of the last consignment and working hours of consignee. Time of finish of the last load of the last consignment must be less or equal to finish of working hours of consignee and more or equal to beginning of working hours of consignee.
9. Condition of compatibility observance for time of beginning of delivery of *n-th* consignment and time of beginning of delivery next consignment *n+1* time of beginning of delivery of *n-th* consignment must be less than time of beginning of delivery next consignment *n+1*.
10. Time of beginning of *i-th* load consignment must be less or equal to difference between time of beginning of load *i+1*andtime of turnaround.

It should be noted that the limitation on the quantity of automobiles in the SC, the quantity of loading posts, the quantity of unloading posts, the system's capacity must be implemented at the stage of forming a delivery schedule, because in the case of not implementing at least one of the limitation simple mentation of the schedule of the SC is obviously impossible. Another calculation model considering mechanisms of transportation and delivery processes in such transportation scheme must be designed.

CONCLUSIONS

Summarizing the results of the research we can state the following conclusions:

1. The necessity of application logistics principles of JIT and JIS in the practice of planning, organizing and controlling processes of delivery is substantiated. Topicality of development and implementation of the "just in time", "just-in-sequence" concepts in transport logistics is due to the fact that in only in such a system the process of delivery becomes manageable. Such system improves relationship with customers, the market position of the

companies, their financial condition and increases competitiveness.

2. The classification of mono- and polyconsignment supplies according to certain parameters is given. All SC (mono- and polyconsignment supplies) are characterized by certain classification features that must be considered when planning the system of delivery of cargo;

3. A mathematical model describing the process of cargo delivery in the direct SCin terms of JIT and JIS is designed, allowing to obtain shift-daily delivery plan.

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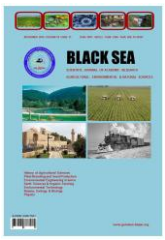

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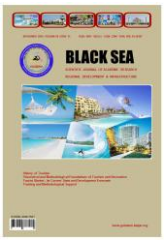

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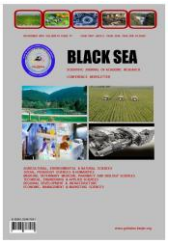

MULTIDISCIPLINARY JOURNAL

ISSN: 1987 - 6521, E – ISSN: 2346 - 7541
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Registered address: Representation of Azerbaijan International Diaspora Centre in Georgia
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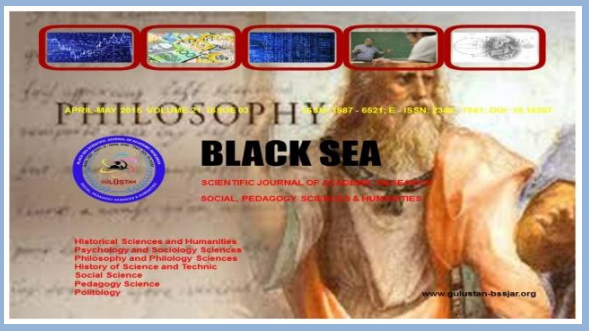
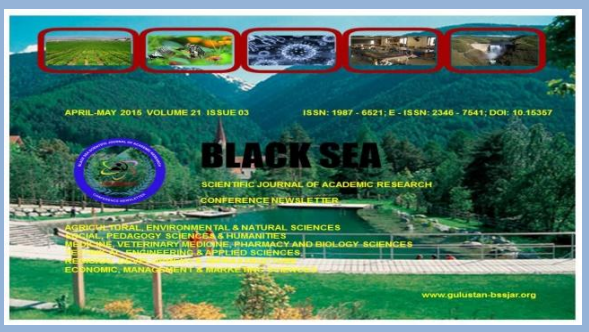
JANUARY 2016 VOLUME 27 ISSUE 01 ISSN: 1987 - 6521; E - ISSN: 2346 - 7541





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