Efficiency of using air transport during cargo transportation

O. Sokolova

ORCID 0000-0001-6341-0195

O. Soloviova

ORCID 0000-0002-7089-0067

I. Borets

ORCID 0000-0002-4477-4716

National Aviation University, Kyiv, Ukraine

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National Aviation University,
Kyiv, Ukraine

boretc.irina@gmail.com
elensol52@gmail.com
sokolovaelena89@gmail.com

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In the article, the author's vision on forming of multimodal cargo transportation systems is suggested. It is proposed to develop conceptual considerations on formation and practical recommendations regarding the choice of the optimal cargo delivery schemewhich includes air transport.

Keywords: air transport; multimodal systems; cargo transportation; technological operations.

Introduction

Under the terms of market relations, transport industry faces the challenges of speeding cargo delivery and minimization of transportation cost. A complicated system of transport relations between cargo manufacturer and consumer of cargo is developed. The system should provide a high level of transport service quality for the cargo owners.

International experience of cargo traffic management on both macro- and micro level shows that creation of multimodal transport systems is a promising direction of cost minimization and cooperation of the participants of cargo transportation process (Ariefiev, 2007). Such a type of transport systems allows transformation of competing transport modes into cooperating transport modes and is an efficient mean of cooperation for technical, operating and technological abilities of all participants in the supply chain. Participation of air transport in multimodal international joint cargo transportation enables speeding cargo dispatch and increasing efficiency, quality and development of foreign economic relations.

Therefore, the problem of forming multimodal cargo transportation systems (MCTS) which include air transport is acute and requires conducting a thorough research.

Theoretical foundations

The study of transport systems development and logistics, as well as research of modern technology of cargo transportation was the scope of attention for a wide range of researchers, including the personal input of: Sergieiev V.I., Mirotin L.B., Nersuh Yu.M., Nikolaiev D.S., Prokofieva T.A., Bakaiev O.O., Krykavskyy Ye.V., Yun G.M., Grygorak M.Yu., Postan M.Ya., Rezer S.M., Tarabanko V.V. and others. Individual aspects of multimodal transportation are studied in works by Pluzhnykov K.I., Myloslavska S.V., Troitska N.A., Tashbaieva I.E., Chubukov A.B., Shylimov M.V., Karavaiev V.I. and others. Among scientists, the issue of forming and development of MCTS tends to be piecewise. Hence, it needs to be further studied.

The goal

of the article is development of conceptual considerations on MCTS formation and practical recommendations regarding the choice of the optimal cargo delivery scheme which includes air transport.

Results and discussions

In general, *multimodal cargo transportation system* is an integrated and interrelated transportation system that is functionally aimed at speeding, cost-cutting and simplification of technological procedures along the whole "door-to-door" supply chain under organizational and technological interaction of all links in the transportation process.

Establishment of multimodal transport systems, first of all, is related with global development of container transportation and with transfer of carriers to the discrete type of account and management of cargo traffic (unified "unit load"). These factors influenced the increase in cost of transportation and need of forming modern infrastructure for different transport modes. All mentioned above affected the change of the specificity of cargo transportation process and setting of rigid requirements on the part of transport clientele to the range of services offered, level of service, time and cost of cargo delivery (Pasevich, 2002).

Multimodal cargo transportation system is based on the internal integration of various transport modes and other participants of the transportation process that interact with one another and perform their part of work within the framework of contractual relations under presence of the main controlling link, i.e. "main link". "Main link" is positioned either by the client, or the contractual decision of all participants of the supply chain is made using top-down approach. That is why majority of multimodal cargo transportation systems is characterized as interregional, international or cross-border formation (Ariefew, 2006). In this context, in settings of the responsibilities for the multimodal transportation process every participant is either limited, or totally abandons its autonomy (Pasevich, 2005).

In the course of research, it is determined that the necessary prerequisite for provision of multimodality is inclusion of the whole range of operations of warehousing, storage, transshipment, insurance, customs clearance, informational support of cargo delivery, etc. into the transportation process. It should be highlighted that presence of one operator of transportation and logistics services and specific peculiarities of such a mode of cargo delivery management allow attainment of several advantages of the multimodal cargo transportation system when compared to common transportation system, in particular:

- 1) provision of long-term and wide range of quality services according to international standards;
- 2) presence of one management body – "main link" in the supply chain (operator of transportation and logistics services) with the functions of control, forecasting, monitoring, management, coordination and implementation of the transportation process;
- 3) cargo delivery management along the optimal route "door-to-door" and "just-in-time";
- 4) optimization of total cost within the supply chain;

5) optimization of organizational and technological procedures of the transportation process aimed at minimization of time and cost of cargo delivery;

6) organization of win-win partner relations of all cargo transportation process participants;

7) optimal usage of transport means and objects of transportation and logistics infrastructure which allows complex application of various transport modes;

8) efficiency of control system on tracking and security of cargo;

9) implementation of modern transport technologies;

10) establishing of favorable conditions for development of competition between domestic and international carriers;

11) attracting additional investment;

12) increase in fiscal revenues to local and state budget;

13) provision of complex development for transportation and logistics sector of the country and other subsystems and elements of the market infrastructure;

14) increase in the level of ecological safety of the transport complex operation.

Based on the global practice, under effective management multimodal transportation systems present high value and ensure social and economic development of individual regions and the state on the whole.

The main task in the process of forming a multimodal transportation system is the complex development of all its subsystems and elements. Hence, from the point of view of systems approach, a multimodal cargo delivery system should be regarded as a subsystem of the transportation and logistics system of the country which includes:

- 1) multimodal transport network (network of various transport modes that serve for multimodal transportation);
- 2) multimodal (international) transport corridors;
- 3) objects of multimodal transport infrastructure (multimodal transport nodes).

It should be noted that a special place in the multimodal transportation system of the country is occupied by the objects of transport infrastructure which support performance of the technological processes of cargo handling in the course of transportation process and should meet the following basic requirements:

1) location on the crossing of several transportation ways of different transport modes (road, railway, waterway, air and pipeline transport);

2) development of various transport modes on the territory of formation of the multimodal transport node);

3) presence of a significant warehouse and terminal complex for processing of different cargo types and cargo units including containers;

4) presence of customs infrastructure that is able to provide customs support of cargo flows;

5) presence of financial infrastructure (bank branches, insurance companies) for provision of insurance and financial services;

6) availability of developed informational infrastructure for informational support and control of technological processes of cargo handling, etc.

Multimodal transport nodes as component elements of the individual multimodal transportation system significantly differ one from the other by their importance, level of cargo flows concentration and territory of influence.

Such a distribution depends on their location, passing of the transport corridors in the area of influence, geopolitical location not only of the transport node but also of the territory where the transport node is located.

In view of these facts, when the multimodal transport node is formed as the node able to perform the function of the transportation and logistics center, it is necessary to solve a large number of tasks that are related with improvement of the cargo transportation management system and effective development of the capacities of the objects in the transport node according to the volume of cargo flows.

Taking into account systems theory, for forming MCTS it is necessary to study various aspects, especially: macro- and micro scale, hierarchical, functional and process-related (Golikov, Purlik, 1993) Given that, in view of the process-related aspect, MCTS is considered as a dynamic object, whereas others regard it as a static system (Golikov, Purlik, 1993; Shabanov, 2001; Naglovskiy, 2002; Mironyuk, 2005).

The macro scale view on MCTS allows regard it as a component of the transportation and logistics systems of the state (region), identify and analyze the relationship with external environment, and also design strategic directions of development within the transport concept of the state.

The micro scale view on MCTS is formed based on the study of MCTS as the totality of subsystems and elements, and relations that exist between them. Such a view enables evaluating the parameters of internal environment of the system and developing an effective control system for the MCTS.

Functional approach is aimed at defining MCTS as a whole of activities (functions) necessary for implementation of the transportation process. According to this view, management of the system's operation is provided through optimal interaction of the elements, including: buildings, facilities, technical means, equipment and personnel.

Hierarchical view on MCTS is based on its vision as a totality of units that compose the systems hierarchy. With regard to this view, there are such levels, subsystems and elements of MCTS: subsystem of MCTS control, operators and suppliers of transportation and logistics services, objects of transportation and logistics infrastructure. Every component has its functional specification in MCTS on the whole, but, at the same time, they have specific, normative, organizational background and types of supply that require their own design and planning.

Process-related approach to forming of MCTS suggests considering the system as a total of processes that provide for its operation and development.

Processes of operation are identified from the point of view of implementing MCTS's general aim – support of cargo transportation. Development suggests implementation of processes against the ways of forming and development of MCTS (reconstruction, extension, increase in the throughput, etc.), and other factors that affect their putting into practice.

Process of forming MCTS must be focused on effective and quality service of the system and includes the following stages (fig. 1) that enable evaluation of the state and potential opportunities of MCTS's elements and identify the optimal prospects for its development.

Fig. 1. Stages of forming and development of MCTS

Processes of forming and development of MCTS should cyclically and continuously embrace all the stages of the life cycle of MCTS with account of the new external conditions.

In the course of forming MCTS implementation of individual stages (procedures) can be performed without the fixed order but very often the stages are carried out on

par with one another. Given that, the results of the conducted studies on every stage are subject to correction depending on the change of the parameters of external and internal environment.

During the investigation it was concluded that air transport plays an important role in the system of goods distribution. Modern stage of development of air transport is characterized by the increase in the traffic.

Such an increase in traffic is justified by the expansion of international trade with goods of high degree of processing and scientific products with prices that are not significantly influenced by the cost of air fares. This fact is related to the increased requirements from cargo owners to time of delivery and security of cargo en-route. Air transport is widely used in international joint transportation with the use of modern technology, in particular, during container transportation. The leading types of freighters in the world are freight models of Boeing-747 and DC-8. Air transport of Ukraine and the countries of the CIS also enters the global market of cargo transportation. Such aircraft models like An-124 («Ruslan») and An-225 («Mriya») do not have equivalents in the world by cargo lifting and cargo carrying capacity. These aircraft are capable of transporting oversized cargo that is a very valuable service on international market of transportation. Although air cargo transportation is mainly carried out by airlines which are basically specialized at passenger transportation, there are companies in the world that are focused on cargo transportation.

According to the experts, today air cargo transportation is a stable and dynamically developing industry of air transportation from which the carriers profit 50-60 bln USD annually. The long-term forecast for cargo traffic shows that in 20 years volume of cargo transportation will grow on average 6-7% per year. This means that in 10 years the amount of cargo transported will double (Gorokhova, 2000).

An important detail in development of air cargo transportation is entering of air cargo into the system of "door-to-door" delivery, i.e. from the point of origin of the cargo to the point of its consumption. This suggests presence of the accurate interaction and coordination on the national and global scale of airlines and other representatives of the transportation services market, including the companies that represent other transport modes (mainly road transport).

Given that, under harsh competition global air carriers put tremendous effort to reduction of their cost, especially, by using optimal combination of transport modes in the joint transportation chain. In such a supply chain, participation of air transport in long-haul transportation can lead to reduction of total cost for the carrier. Hence, on some routes joint air-maritime transportation help reduce the transportation cost by 50%, when compared to air transportation, and by 75%, when compared to maritime transportation. Joint type of transportation can be found on such routes as Western Europe-Far East, Western Europe-Australia, Western Europe-USA, and Japan-Western Europe (Gorokhova, 2000).

Distribution of cargo transportation by transport modes depends on the peculiar features of the given transport mode and its economic advantage. In this case, in order to obtain an optimal scheme for interaction of different transport modes in the course of cargo delivery mathematical, graphical, graphical and analytical, analytical, statistic and matrix models can be developed.

Methods of network planning do not provide for the mathematical optimization in problem-solving that occurs during the process of planning, management and control of simple works. However, these methods allow making a significant improvement into the quality of the performed works by means of additional search of reserve time, labor and material resources.

To estimate the efficiency of air transport in the system of multimodal transportation it is suggested to use the methods of network planning and criteria of decision-making in the process of choosing the optimal transport and technological schemes of cargo delivery en-route (Ürümqi (China) – Kyiv (Ukraine) – Lviv (Ukraine)).

As object of transportation in the given delivery cargo pieces of rectangular form, dimensions 11cm x 11cm x 8cm, weight – 350g per piece are taken and composed into a cargo shipment. Cargo transportation is performed in standard carton boxes with dimensions 0,5m x 0,5m x 0,5m. Every box contains 96 units of cargo weighing 34kg. It is necessary to transport 1920 units of goods (20 boxes with total weight 680kg). Cost of goods unit is equal to 380 USD. Initial data for the proposed routes of cargo delivery and transportation management are suggested in Table 1.

Table 1

Description of variants of cargo delivery

Nº	Route details	Scheme of cargo delivery
1.	Ürümqi (A) - Kyiv (B) - Lviv (C)	Air + Rail
2.	Ürümqi (A) - Kyiv (B) - Lviv (C)	Air + Road
3.	Ürümqi (A) - Almaty (A1) - Kyiv (B) - Lviv (C)	Rail + Air + Rail
4.	Ürümqi (A) - Almaty (A1) - Kyiv (B) - Lviv (C)	Road + Air + Rail + Road

Initial data for the performed technological operations for various variants of cargo delivery and the estimated parameters for their further optimization are summarized in Table 2.

In Table 2, main technological operations that are performed during cargo delivery along the investigated routes are listed. These operations are characterized by two criteria: time and cost.

Table 2

Main technological operations performed during cargo delivery

№ of operation	Name of operation	Cost, USD	Time	
			Days	h, min
1	Customs clearance of cargo in point A	158	0,125	3 h
2	Documents processing and loading on road transport in point A	158	0,0625	1 h 30 min
3	Documents processing and loading on air transport in point A	358	0,0625	1 h 30 min
4	Delivery by road from point A to point A1	6808	6, 558	-
5	Delivery by air from point A to point B	8508	0,408	-
6	Delivery by air from point A1 to point B	208	0,0833	2 h
7	Customs operations in point A1	2408	0,225	-
8	Customs clearance of cargo in point B	358	0,125	3 h
9	Documents processing and transshipment to road transport in point B	108	0,0625	1 h 30 min
10	Documents processing and transshipment to rail transport in point B	88	0,0625	1 h 30 min
11	Delivery by road from airport in point B to final destination C (to the consignee)	188	0,34	-
12	Delivery by road from airport in point B to railway station in point B	58	0,0225	-
13	Delivery by rail from point B to point C	108	0,5	-
14	Documents processing and transshipment from rail transport to road transport in point C	68	0,0625	1 h 30 min
15	Delivery by road from airport in point C to the consignee	58	0,005	-

Decision-making regarding the optimal scheme of cargo transportation is carried out using the integral indicator that accounts of the two parameters at once and is calculated by formula 1:

$$C^* = (C_g + C_t)(1 + i)^n, \quad (1)$$

Where C_g – purchase cost of goods; C_t – cost of transportation; $(1+i)^n$ – multiplier of percent increase using the interest rate $i = 15\%$ for n periods; $n = T/365$; T – total time of transportation en-route.

Network model of cargo delivery variants en-route Ūrümqi – Kyiv – Lviv is presented in Fig.2.

Fig.2. Network model of cargo delivery variants en-route Ūrümqi – Kyiv – Lviv

Thus, as a result of construction of the network graph 6 variants of cargo delivery are obtained. These variants include various transport modes. Parameters against criteria of time and cost are calculated (Table 3).

Table 3

Parameters of transport and technological schemes of cargo delivery

№	Scheme of delivery (with identification of works follow-up)	Total cost of service, C	Total time of route, T	Integral indicator, C *
1	0, 1, 2, 4, 6, 7, 8, 10, 13, 14, 15	10420	7,81	15832
2	0, 1, 2, 4, 6, 7, 8, 9, 11	10394	7,58	15370,2
3	0, 1, 2, 4, 6, 7, 8, 12, 13,	10264	7,70	15610,7
4	0, 1, 3, 5, 8, 9, 11	9678	1,12	15597,3
5	0, 1, 3, 5, 8, 10, 13, 14, 15	9704	1,35	2735,42
6	0, 1, 3, 5, 8, 12, 13	9548	1,24	2517,15

Continuation of calculations using the criteria from Table 3 was performed through transforming the parameter values into specific values (Table 4).

Table 4

Specific values of parameters for transport and technological schemes of cargo delivery

№	Scheme of delivery (with identification of works follow-up)	Total cost of service, C	Total time of route, T	Integral indicator, C *
1	0, 1, 2, 4, 6, 7, 8, 10, 13, 14, 15	1,1	6,97	6,29
2	0, 1, 2, 4, 6, 7, 8, 9, 11	1,09	6,77	6,11
3	0, 1, 2, 4, 6, 7, 8, 12, 13,	1,07	6,88	6,20
4	0, 1, 3, 5, 8, 9, 11	1,01	1	6,20
5	0, 1, 3, 5, 8, 10, 13, 14, 15	1,02	1,21	1,09
6	0, 1, 3, 5, 8, 12, 13	1	1,11	1

In order to identify the optimal cargo dispatch scheme, criteria of decision-making under uncertainty, i.e. criteria of Laplace, Wald, Hurwicz and Savage, were calculated.

Therefore, the obtained results of calculations of

parameter values for every transport and technological scheme (TTS) allow defining the optimal variant of cargo delivery among the proposed alternatives (Table 5).

Table 5

Choice of optimal TTS for cargo delivery en-route «Ürümqi – Kyiv – Lviv» against decision-making criteria

№	Laplace criterion	Wald criterion	Savage criterion	Hurwicz criterion
1	4,035	6,97	5,97	4,035
2	3,93	6,77	5,77	3,93
3	3,975	6,88	5,88	3,975
4	1,005	1,01	0,01	1,005
5	1,115	1,21	0,21	1,115
6	1,055	1,11	0,11	1,055

Thus, the estimations show that the optimal transport and technological scheme for cargo delivery against all criteria is route №4: transportation of piece cargo is performed from Ürümqi (China) to Kyiv by air transport; from Kyiv to Lviv cargo is transported by road transport, inclusive of customs clearance and documents processing in Ürümqi (China) and Kyiv.

Conclusion

So, an effective way to optimize the transportation process and create the competitive market of transportation and logistics services is to form multimodal cargo transportation systems. MCTS ensures unifying the commercial and legal

terms; is a complex solution to financial and economic problems with the purpose of providing sustainable development of the system; provides coordination and organizational and technological interaction of all links within the supply chain; allows complex development of infrastructure and resources of various transport modes, etc.

Conducted estimations demonstrate that the optimal transportation and technological scheme of cargo piece delivery against all criteria is the route which includes air and road transport. The following stage of the scientific research shall be development of the methodological basics of forming and development of multimodal cargo transportation nodes (centers).

References

- Ariefiev, I.B. (2007). *Determination of a transport unit technical efficiency integral coefficient*. — St. Petersburg: MAT. — P. 64-65.
- Pasevich, V. (2002). *Estimation of a transport hub behavior probabilistic function classification*. — St. Petersburg: SZTU, «Aps-2002». — P. 168-172.
- Ariefiev, I. (2006). *Problems and prospects for the development of transport systems in multimodal process «East-Europe»*. Program UE «Autostrady Morske». Porty Morske. Y1 Mindzenarodowa konferencia «Porty morske». — Szczecin: AM. — P. 17-23.
- Pasevich, V. (2005). *Transport systems analysis and forecasting (Bayesian approach)*. — St. Petersburg: «System». — 84 p.
- Golikov, E., Purlik, B.M. (1993). *Logistics basis and business*. — Moscow: REA. — 161 p.

- Shabanov, A. (2001). *Regional logistic systems of public transport: forming methodology and management mechanisms*. — Rostov-on-Don: SKNC VS. — 205 p.
- Naglovskiy, S. (2002). *Logistic of planning and management of the industrial and commercial systems*. — Kaluga: Manuscript. — 336 p.
- Mironyuk, V. (2005). *Methodological aspects of the logistic systems forming at regional level*. — Rostov-on-Don: Rostov state university of civil engineering. — 332 p.
- Gorokhova, M. (2000). *Increasing efficiency of air transport in cargo transportation of export trading in joint connection*. Retrieved from: <http://www.dissercat.com/content/povyshenie-effektivnosti-ispolzovaniya-vozdushnogo-transporta-pri-perevozkakh-gruzov-vneshne#ixzz5JuYFF9g7>
- Models and methods of intermodal transport logistics: modern state and prospects*. Retrieved from: <http://simulation.su/uploads/files/default/ikm-mtmts-77-82.pdf>.