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## LOGISTICS OF INTERNATIONAL EXPRESS SHIPPING AND AIR TRAFFIC

### ABSTRACT

*The paper studies the relations between logistics of international express shipments and air traffic analysing the basic characteristics of international express shipments that are carried by combined transport, usually road vehicles and aircraft. The paper indicates the possibility of optimising individual technological processes in the logistic chain of express shipments distribution. It analyses the forms for the calculation of time slots in single logistic chain hubs of collecting and delivery of express shipments. It has been shown that the international distribution chains in the air express sector, related to the globalisation process, change the traditional functions of combined ground-air transport. Here, the increased investment into automation plays the crucial role in the development strategies of companies and in the operationalization of the quality policy of numerous carriers of express shipments by air.*

### KEY WORDS

*air transport, express shipments, logistic chains of distribution, transport quality*

### 1. INTRODUCTION

As science and activity, logistics has experienced very fast development and has become recognisable in the industrial sector, especially as interdisciplinary and multidisciplinary science which is studied and implemented in almost all the human activities. The interdisciplinarity of air transport technology and of

traffic science in general is connected with a number of scientific areas such as the technical, natural and social ones.

The globalisation process occurring worldwide has imposed at the same time the need to study and analyse the global logistic chains. The logistics of air traffic in thus set systems has become today the subject of many studies at the scientific and professional level. The studies have been primarily oriented to the determination of the methodology for the estimate and efficient design of air traffic logistic systems. Here, there is special development of the international logistic networks of express shipping in air traffic [11].

The shift from the existing traffic services to the logistic solutions of the problem is not characteristic just because of the method of wider product development, but rather at the same time also because of more comprehensive method of consideration. The logistics in air traffic includes all the activities and transactions related to passenger and freight traffic, i.e. planning, transport, finances, quality management, interpersonal relations, information and communication technologies, safety, health, environmental management, risk management, education and training [11].

Air traffic in logistic processes is required by many industries and services in order to supplement the distribution chain, since it provides fast delivery, lower risk of damage, safety, flexibility, accessibility and frequency. However, there is one drawback, and that is that this method of transport has a relatively high price.

## 2. CHARACTERISTICS OF INTERNATIONAL EXPRESS SHIPPING IN AIR TRAFFIC

Express shipments include usually vaccines, medicines, documents and contracts, securities, jewellery, works of art and similar shipments. However, in certain circumstances almost all types of goods may be characterized as express shipment. This is especially emphasised by the growth of the Internet sales, since the delivery of goods bought over the Internet usually has the character of express shipments. The most significant market segment characteristics of express shipments may include [9]:

- transport demand of express shipments is irregular, unpredictable, and occasional,
- it is difficult to plan the demand for transport of express shipments,
- express shipments require "door-to-door" handling,
- high frequency of flights on a certain destination is required as well as the availability of space in aircraft on a precisely determined flight until last moment,
- special treatment and priority in performing customs formalities is required,
- punctual arrival of the shipment to the destination should be guaranteed,
- at any moment from the submission to the receipt of the shipment precise and always up-to-date information on the shipment status is required,
- the market segment is relatively insensitive to the transport price; however, high level of service quality is imperative.

The activity of receipt and delivery, and the transport of express shipments relies more and more on air traffic offering consistent and reliable delivery of a wide range of products. Regarding the needs of the transport users and extremely competitive environment for express shipment transport providers in international transport, the companies that offer logistic services of transporting express shipments have to adapt continuously to variable economic and regulatory conditions, offering reliable high-quality and inexpensive services to their users, at the same time attempting to maximise their profit. In other words, logistic service should be organized so as to be competitive, continuing to be financially viable to the service providers themselves. From the aspect of quality costs this means their optimisation by investing into the improvement of service quality undertaken only up to the level to which the very service quality is increased. On the contrary there comes to the phenomenon of the transformation of costs for quality into the costs due to (un)quality. [7] The tendency should be towards avoiding defects in the delivery process

In order to increase their share on the international market the companies have to offer a wide range of

services defined by different time slots and methods of operation.

There are several types of products or services, defined according to the speed of the required service. Considered more widely, the services can be categorized in two groups: *express services* and *delayed services*, in which the former usually understand a service within 24 hours.

The objective of each organization that is involved in organizing the transport of express shipments is to minimize the costs of the carriage of shipments from the origin to the destination, with very narrow time slots of services, limited capacity of the parcel sorting areas and a limited number of ground vehicles and aircraft [8].

The delivery process starts with the user's request specifying the places of origin and destination, type of the required service, size and weight of the shipment and the time slot for the pick-up, which represents the input parameters into the business process of delivery, *Figure 1*.

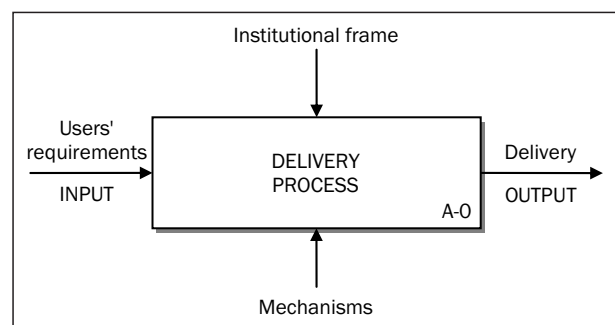


Figure 1 – Delivery process context diagram

*Institutional frame* represents the rules according to which the process is performed, which means transformation of the input values into output international standards, national laws, by-laws, procedures, working instructions, methodologies, criteria, contracts, etc. *Mechanisms* represents resources that are needed and that are used in the process: humans, working environment, equipment, software, hardware, financial means, material, etc.

The fleet of ground vehicles is used as reaction to the set requirements and the shipments are transported to the sorting areas at the closest airport, where the shipments are sorted according to the destinations and the type of service. Since air transport is relatively expensive, the tendency is, as much as possible to deliver the shipments to some destinations by surface transport. However, because of the given time limits and the planned penalisation if the service is not realized, surface transport can be used only for destinations that are geographically close to the origin, i.e. for delayed services where the time limits are longer. The exception for the usage of air traffic for some orders of delayed services is when there is an excess

of capacities in the aircraft after having fulfilled the requirements that refer to the capacity necessary for express services.

The air transport service in the carriage of shipments can be for a specific purpose or commercial, where the former is performed by the fleet of aircraft of the organization specialized for this type of transport, and the latter includes the use of commercial aircraft. The services of express delivery are based on direct flight transport strategy, with "hub-and-spoke" system or the combination thereof for the delivery of shipments from the origin to the destination airport. There may be more than one destination airport, if this meets the time restrictions. The "hub-and-spoke" system requires that all the shipments are consolidated at the distribution centre (hub), sorted, labelled, and delivered to the destination airports. Each of the above operative strategies has its advantages and drawbacks, depending on the requirements. Direct delivery flights can lead to the usage of a large number of flights that operate below their capacity, whereas "hub-and-spoke" system represents loss of time, since it includes sorting at the centre, and the parcels arrive to the destination by indirect connections.

Related to the logistic companies that offer transport services of small shipments, the globalisation trend leads to the conclusion that the bigger the openness of the global market, and the stronger and more numerous the competition, the inter-company relations in the development of business and logistic activities in the widest sense are more intensive, and the efficiency and/or effectiveness of independent business operation of any organization reduced to a minimum.

### 3. LOGISTIC CHAINS OF EXPRESS SHIPPING IN AIR TRAFFIC

The optimization of the logistic chains of the international express shipments distribution belongs to the class of mathematical combinatorial skills with a large number of combinations whose algorithms for solving real problems belong to the so-called non-polynomial hard problems. The final objective of optimization is finding the movement of shipments at minimal cost from their origins to the destinations, with the given very narrow time slots of service, limited capacity of the parcel sorting areas and a limited number of ground vehicles and aircraft.

At every location of delivery  $D$  the earliest times of shipment delivery ( $NR_D$ ) and the latest times of shipment delivery ( $NK_D$ ) are assigned.  $NR_D$  denotes the times when the parcels will be available to be picked up at the delivery location.  $NR_D$  is planned as late as possible in order to provide enough time for the preparation of the issuing of shipments.  $NK_D$  denotes the times by which all shipments are to be delivered in

order to satisfy the delivery standards, i.e. the quality of service. The latest time of delivery is usually the element of agreement on the express service and is contracted as "time demarcation".

The procedure of international express shipment delivery usually consists of three main phases: *phase of pick-up*, *phase of sorting at the main distribution centres*, and *phase of delivery*. Each phase may contain different combinations such as collection and delivery of shipments by road vehicles to local distribution centres, direct or combined flights from the main distribution centre; and all this with the aim of reducing the costs and times of shipment delivery.

The airports are assigned time slots that mark the time of the beginning and end of sorting. The transportation chain can be divided into two components: 1) receipt of the shipment, and 2) delivery. The receipt of the shipment usually begins at the airport in the early evening, covering a set of airports before ending at the destination airport (in case of direct flight network) or the main distribution centre (when referring to the network with the main distribution centre and local distribution centres). The delivery begins at any airport (in case of direct flight network) or at the main distribution centre (in case of a network with the main distribution centre and local distribution centres) usually in the early morning and delivers the shipments at some destination airports. The aircraft may perform also an empty flight to an airport if this were to optimize the procedure of collecting parcels.

### 4. DETERMINING TIME SLOTS IN INTERNATIONAL EXPRESS SHIPMENTS

As previously mentioned the delivery process starts with the user's request. Then, implementing the ground vehicles the transportation organizers react to the given requirements estimating the capability of their business processes for their fulfilment, and they process all the shipments in the sorting area of the nearest airport. As the result of technical specification the logistic system of international express shipments is defined by the following elements:

- **Location of collecting shipments (S)**, with times: *earliest time of collecting shipments* –  $NR_S$ , *latest time of collecting shipments* –  $NK_S$ , *time slot* [ $NR_S$ ,  $NK_S$ ], *time of transportation by road vehicles from the location of collecting shipments to the origin airport (P)* –  $t_{SP}$ .
- **Origin airport (P)**, with times: *earliest time of collecting shipments at origin airport* –  $NRZL_P$ , *latest time of collecting shipments at origin airport* –  $NKZL_P$ , *time slot* [ $NRZL_P$ ,  $NKZL_P$ ], *time of sorting and consolidation* –  $VS_P$ , *time of transport by road vehicles from the origin airport (P) to the destination airport (O)* –  $t_{PO}$ , i.e. *time of transport by air*

craft from the origin airport ( $P$ ) to the destination airport ( $O$ ) –  $T_{PO}$ .

- **Transit airports (T)**, if commercial flights are used for the transport of express shipments, and there is no loading or unloading of express shipments at an airport, then these are for the express shipments the transit nodes. However, if the flight ends before the main distribution centre or due to limited capacities or time, the shipments may be unloaded.
- **Destination airport (O)**, with times: *earliest time of delivery at destination airport (O)* –  $NR_{ZO}$ , *latest time of delivery at destination airport (O)* –  $NK_{ZO}$ , *time slot* [ $NR_{ZO}$ ,  $NK_{ZO}$ ], *time of sorting and consolidation* –  $VS_O$ , *time of transport by road vehicles from the destination airport (O) to the delivery location (D)* –  $t_{OD}$ .
- **Delivery location (D)**: with times: *earliest time of delivery* –  $NR_D$ , *latest time of delivery* –  $NK_D$ , *time slot* [ $NR_D$ ,  $NK_D$ ].

Here, the times the *earliest time of delivery* –  $NR_D$  and the *latest time of delivery* –  $NK_D$ , are the most important times for the users of express shipments in the Service Contract. The mentioned times are at the same time also important elements for the service quality assessment. The earliest and the latest time of collecting the shipments are calculated from  $NR_D$  and  $NK_D$ .

The earliest time of collection at the collecting location, for road transport from origin airport to destination airport is calculated as follows:

$$NR_S^1 = NR_D - t_{OD} - VS_O - t_{PO} - VS_P - t_{SP} \quad (1)$$

or for air transport from origin to destination airport

$$NR_S^2 = NR_D - t_{OD} - VS_O - T_{PO} - VS_P - t_{SP} \quad (2)$$

In a similar manner the latest time of collecting at the collecting location is calculated, for road transport from origin airport to destination airport:

$$NK_S^1 = NK_D - t_{OD} - VS_O - t_{PO} - VS_P - t_{SP} \quad (3)$$

i.e. for air transport from origin airport to destination airport

$$NK_S^2 = NK_D - t_{OD} - VS_O - T_{PO} - VS_P - t_{SP} \quad (4)$$

Certainly,  $NR_S^2 < NR_S^1$  and  $NK_S^2 < NK_S^1$ , at a higher price of air transport. If one wants to reduce the time of the *earliest and the latest delivery in the delivery location* in every phase of the technological process better solutions should be found, such as the improvement of the automation procedure of sorting and consolidating the shipments. The technological improvements, i.e. the optimisation of the business process, represent the basic assumption for the achievement of higher level of the quality of service.

The total operative costs of the international express shipments depend on: the demand, transport means capacities, contracted time of delivery, limitations of distribution centres and airports. The mathematical model of the transport of express shipments

i.e. parcels on the transport air network is considered as a mixed integer problem [11]. For the given mathematical model the function of objective is the overall operative costs that are to be minimized.

Another approach to organizing international express shipments is the reduction of time of the last delivery  $t_{ij}$  (from any origin  $i$  to any destination  $j$ ) so that the function of objective of the mathematical model is

$$\min \max t_{ij}$$

with the given restrictions.

## 5. INTERNATIONAL DISTRIBUTION CHAINS FOR AIR EXPRESS

International distribution chains of the air express sector in the given environment change the traditional functions of combined ground-air transportation. The distribution processes of air express carriers have recently experienced expansion, and in the developed countries there are additional investments into integrated storage, distribution facilities on the ground and at airports. The traffic network ground-air hubs which served previously for sorting and transloading of small parcels and documents represent now logistic centres of complete service for the processing of orders, consolidation, labelling, packaging and transport upon demand. Individual governments as well as public/private partnerships try to ensure the resources through traffic infrastructure in order to attract additional capital and to generate local and regional development [6]. In order to emphasise the role of express shipments network development in certain regional and international programmes of airport development it is necessary to analyse specially the networks for international air express per phases as presented in Figure 2.

Generally, in cargo traffic context, two types of cargo airports are considered: *traditional and network hub*. At traditional airports, the primary function is the flow of passenger traffic whereas the cargo traffic is secondary. Usually cargo transfers from aircraft to aircraft or to collective car-transport are operated by contractors who provide ground services to operators and carriers at the airport [11]. This often represents difficulties for air carriers and operators who face increased volumes of express shipments. On the other hand, the network hub terminals for air express have been designed and developed with the purpose of cargo accommodation. An example of such global transport network with super hub in Memphis is the network of the FedEx courier company.

In order to improve the efficiency of express shipments transport, parallel with insuring “door-to-door” principle the express shipments are collected and distributed by road vehicles that take the goods to regional airports i.e. regional air traffic network hubs.

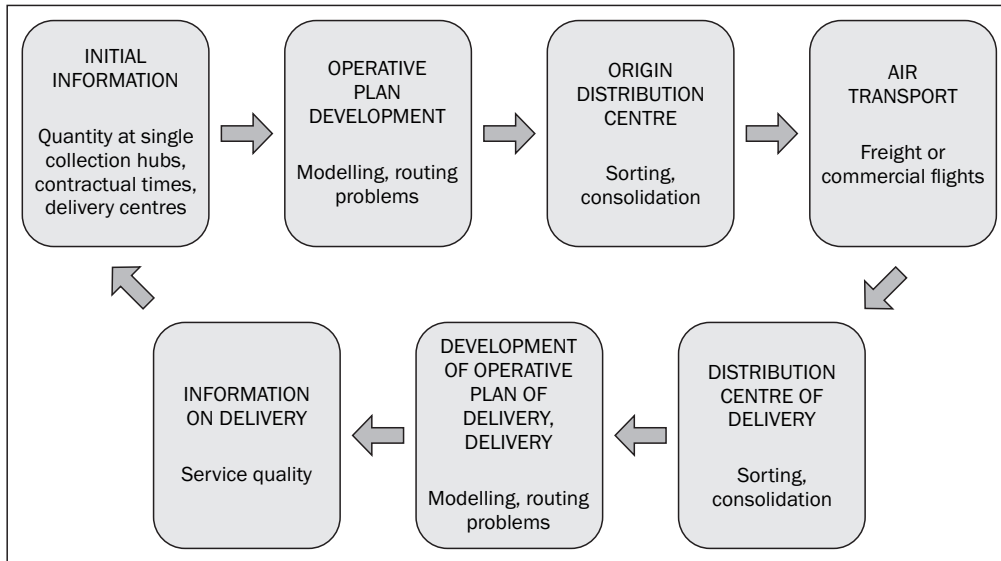


Figure 2 – Phases of international air express

Here, the air carriers can also be the owners of road vehicles for the transport of express shipments. The cargo is transported from the regional hubs to the international hub, and the consolidated cargo is loaded at international hubs, usually into bigger aircraft in order to reduce the transport costs. The system is symmetric, and the collection and distribution areas can be exchanged, which makes it possible for the air express carriers to increase the frequency number as well as the utilisation percentage of the cargo space. The international hubs are interesting for the development of individual regions, and the regions therefore tend to increase the capacities of their airports and the fleet in order to become international hubs. In the globalisation process the decisions are made at the international level.

The sorting of parcels and packaging is usually performed within a narrow time slot of 4 to 5 hours, usually around midnight. The networks of express deliveries have the drawback that the majority of companies dealing with the transport of express shipments use their fleet 3 to 4 hours daily, compared to the traditional carriers whose average use of fleet is 8 to 10 hours per day. High capital costs of aircraft in combination with their loading capacities will probably influence the carriers and the terminals to expand the range of goods that they will accept. Here, numerous carriers have increased the level of fleet utilisation by expanding the services of road collective transport and by adding daily sorting. Besides, the multifunctional use of network hubs for parcels as well as the need for clients with contracted logistic services has resulted in significantly bigger annual volume of cargo.

With the realised growth and expansion of logistic services and networks for air express, the yet unstudied problem is their influence on the distribution in relation to the employment and infrastructure in different

places. At the local level, the potential total effect of the new distribution strategies, such as “just-in-time” fast reaction and the strategies of direct supply can favour the reduction of space size of the storehouse and the volume of distribution services.

Instead of reducing the infrastructure distribution, it happens that individual producers and retailers relocate certain activities in order to be in the close vicinity of their selected integrated logistic providers and the ground/air transport. Especially in case when the companies are partners with the carrier, the vicinity of network nodes or network facilities allows further shortening of the transit time, which represents a significant contribution to the quality of the process, and consequently also to the result materialized in the service and costs of movement among hubs.

Since time has become an important factor in international competition the majority of producers locate their production plants in the vicinity of airports because of the possibility of fast delivery.

With the increase in the weight limit of shipments and potentially sensitive materials, higher capital investments into automated collection systems and coded sorting systems increase the efficiency of the distribution facilities, whereas at the same time they minimize human errors and the operating costs [6]. One of the guidelines is the introduction of the equipment which automatically determines the size and weight of the parcel on a conveyor belt and sorts them according to the given criteria, and the second one is that the carriers have developed automatically controlled vehicles, cranes, conveyor belt systems controlled by information in their distribution facilities that accelerate the flow of cargo between the vehicles and the aircraft at the sorting facilities.

The service providers of express shipping are present also on the Croatian market, i.e. at Zagreb Airport.

Table 1 – Transport of express shipments via Zagreb Airport in 2009 and 2010

Service provider	2009 (kg)			2010 (kg)		
	Import	Export	Total:	Import	Export	Total:
DHL	939,582	278,228	1,217,810	960,027	285,251	1,245,278
UPS	396,712	35,040	431,752	389,132	47,866	436,998
TNT	252,345	24,858	277,203	169,974	25,346	195,320
FEDEX	59,110	73,206	132,316	8,430	58,011	66,441
Total:	1,647,749	411,332	2,059,081	1,527,563	416,474	1,944,037

Source: Statistika Zračne luke Zagreb (Airport Zagreb Statistics)

According to the data in Table 1 the distribution services via Zagreb Airport are performed by the biggest providers of these services: DHL, UPS, TNT and FEDEX. A significant contribution to the optimization of the processes of express shipping through shortening of the handling time, reduction of costs, which also means increase in the users' satisfaction is the construction of infrastructure that will allow receiving of shipments in departure and arrival, sorting, control audit/inspection, and distribution, in such a manner that the facilities at which these activities are performed have access from the *landside* and exit on the *airside*, in the vicinity of aircraft.

Some studies [7] forecast that the international air express sector will increase its share on the world market of air cargo from 4.7% in 1994 to 31.4% in 2014.

## 6. CONCLUSION

The quality of international express delivery is evaluated, among other things, by the contracted time parameters: *earliest time of delivery*  $NR_D$  and *latest time of delivery*  $NK_D$ . They represent the elements of the delivery process quality which is of importance both for the service user and for the service provider of express shipping since they form a component of the service contract signed by the parties. Poor-quality service understands the need to invest into quality improvement, and often penalization as well; thus having direct negative financial impact on the business.

If the time of the earliest delivery and the time of the latest delivery at the delivery locations for every phase of the technological process of international express mail is to be reduced, it is necessary to find better solutions, such as the introduction of more automation and robotization of sorting and consolidation of parcels. One of the highest-quality solutions is the construction of infrastructural facilities at the airport itself, with access from the *landside* and exit on the *airside*, in direct vicinity of the aircraft. Besides, in the process of collecting and delivering of parcels, the existing software routing problems need to be used, and further developed.

Logistic processes of international express deliveries on the global logistic chains are becoming today

the subject of many studies at the scientific and professional level. In air traffic which has the advantage over other traffic branches regarding fast delivery of goods, the entire delivery process has to be continuously followed and analyzed, from the aspect of "door-to-door" treatment and regularity of flights as a special factor of quality. Considering air cargo traffic the application of the concept of intermodality is in fact given and understood.

In the chain of international air express, the terminal hubs of single phases have time slots. They are defined by the earliest and the latest time of shipment delivery. The earliest and the latest time of shipment delivery is the element of the contract between the carrier and the express shipment user. Using the models of time slots the service user defines the contract according to the given time of delivery.

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## SAŽETAK

### LOGISTIKA MEĐUNARODNIH EKSPRES POŠILJAKA I ZRAČNI PROMET

U radu su obrađene veze između logistike međunarodnih ekspres pošiljaka i zračnog prometa istražujući osnovne karakteristike međunarodnih ekspresnih pošiljaka koje se prevoze kombiniranim transportom, najčešće cestovnim vozilima i zrakoplovima. Ukazano je na mogućnost optimizacije pojedinih tehnoloških procesa u logističkom lancu distribucije ekspresnih pošiljaka. Razrađeni su obrasci za računanje vremenskih prozora u pojedinim čvorovima logističkog lanca prikupljanja i dostave ekspresnih pošiljaka. Pokazano je da međunarodni distribucijski lanci u sektoru zračnog ekspres, vezano uz proces globalizacije, mijenjaju tradicionalne funkcije kombiniranog prijevoza zemlja-zrak. Pritom povećano ulaganje u automatizaciju ima ključnu

uložu u strategijama razvoja poduzeća i operacionalizaciji politike kvalitete brojnih prijevoznika ekspresnih pošiljaka zračnim prijevozom.

### KLJUČNE RIJEČI

zračni promet, ekspres pošiljke, logistički lanci distribucije, kvaliteta transporta

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