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TRANSPORTATION OF PERISHABLE GOODS BY AIR: HANDLING PROBLEMS AT RUSSIAN AIRPORTS

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The article deals with the problems of perishable goods handling process at Russian airports on delivery in international supply chains (ISC). The investigation was carried out on the basis of operational analysis. The initial stage of the study, which was performed applying statistical analysis, revealed that the major category of perishable goods which establish air transportation demand into Russia is the fresh exotic fruits. The investigation was performed taking the mango supply chain as an example, due to its non-standard thermal and storage requirements. The second stage resulted in the perishable goods airport handling quality criteria set formation: the number of mandatory cargo while handling operations, the required time for these operations, the amount of paper work, the number of multi-temperature chambers at the airport and their area, ULD temperature storage system availability. The study revealed that about 90% of perishable goods, which are imported to Russia, are handled at the airports of Moscow aviation hub because other airports in Russia lack the temperature storage facilities infrastructure. This restriction raises the price of perishable goods logistics on the territory of the country considerably as well as reduces their quality. Four international airports of strategic importance outside the boarders of the central federal district which have the potential of forming central hubs for perishable goods handling as well as processing of transit and transfer flows were chosen in the context of this study. Among them are the airports of Novosibirsk, Vladivostok, Yekaterinburg and Krasnoyarsk. The airports of Moscow aviation hub were offered specialization on the subject of perishable goods export-import flow handling. The materials received from airlines, major cargo terminals at Russian airports, transport companies, specialized international air transport enterprises and logistics associations were exploited as the data for this study. The research registered that the deterrence to the speed of supply chain operation is the time of cargo ground service at Russian airports which considerably exceeds the cargo ground service time in the exporting country. The delays are connected with the poor development of perishable goods handling cargo terminals and also with loads of paper work because the system of electronic workflow and automated checking of markings doesn't exist. The model of electronic workflow in the International Supply Chain which utilizes pre-flight and pre-loading preliminary information about the cargo was offered. Block Chain system for checking the correct presentation of documents at all stages of the supply chain was introduced which reduces the total time of cargo ground handling process.

Key words: air transportation, cargo delivery technology, perishable goods, international supply chains, mango supply chains, marking of goods, airport cargo ground handling, electronic documentation, Block Chain Technology.

INTRODUCTION

At the time of the world's coronavirus pandemic spread and further termination of international passenger flights as a necessary measure, the airlines faced a burning issue of finding new sources of income. Under these conditions, most airlines, especially large ones, have taken the path of increasing the volume of cargo transportation. Pursuing this goal, passenger airplanes started being used for cargo transportation. According to the Federal Air Transport Agency, at the end of April 2020, seven airlines got the right to transport cargo in the passenger cabin. Aeroflot, Ural Airlines, Russia, Icarus, Nordwind, Azur Air, Royal Flight and S7 are among these companies. The cargo is allowed to be transported in the cabin on the condition that there are no passengers and the cargo centering rules and weight restrictions established by the aircraft designers are observed.

The increased capacity of airlines makes the competition in the air cargo market more enhanced. The competition is not only on cost but also on quality of the provided service, speed of delivery, compliance to the conditions of detention of goods in transit, security of goods. While transporting goods by air the mandatory participants in the supply chains are the airports that provide shipment services and deliver goods to the consignee in the destination country. The airlines and airports establish close and long-lasting business relations which in the end, effect the profitability of the both sides. On the one hand, quality and the airlines service cost determine the demand on cargo transportation and

consequently the demand on the cargo handling in the cargo terminal of the airport, which services the airline. On the other hand, the quality and cargo handling service cost at the airport effect the consignor's choice of the airline. To win in the rivalry for the freight traffic, the airlines and airports should join their efforts, giving consignors, while sending the freight, the required aggregation of quality level and cost. The airports authorities should not only consider airlines but consignors as well, as the source of main income.

According to the IATA data about 35% of international supply chains turnover in value and less than 1% in physical volume is delivered by air transport. It is determined by the high added value of the goods delivered by air transport. The high cost of the goods determines the rigid requirements of the consignors to the undamaged state of the goods while air delivery process.

The main category of goods which have the constant demand for air transportation are the goods which have the higher requirements to the delivery speed, such as pharmaceutical goods, animals, perishable goods, the goods of electronic commerce and post. The growing demand for air transportation comes from pharmaceutical goods, but its international turnover hasn't still reached any considerable volume. According to IATA, it makes 1,9% of the world's airlines turnover. At the same time we can observe a rapid growth of transporting volumes from electronic commerce goods and perishable goods. In 2016 the demand for perishable goods transporting increased by 140000 tons due to the increased volume of deliveries to China and it continued its growth in 2018. The annual growth has made up 6,17%[1]. According to the experts' esteems it is the perishable goods that are the drivers in the airlines turnover growth [1]. The greatest share of the whole perishable goods volume delivered to Russia by air is fresh fruit.

There is an objective necessity to buy foodstuff which can't be produced on the territory of the given country in some other countries as well as the science and innovation goods which are effectively used in the foodstuff production on the territory of the importing country. The current policy, which is implemented by the government of the Russian Federation, is aimed at the foodstuff goods import substitution. However, the consumption basket of the Russian citizenry contains some exotic fruit such as mango, avocado, papaya, guava which are impossible to produce on the territory of our country. The mentioned above fruits have a very short storage period, so speed and delivery conditions are the crucial factors while choosing their transporting method. The safety of perishable products has an impact on the income of all participants in the supply chain and also on people's health. According to the esteems of the World Health Organization, about 20% of perishable goods spoil during their transportation because of the cold chain breakage. The sale of perishable food products in developed countries, gives food retailers up to 40% of the profit, and in Russia the situation is approximately similar (37.8%)[2], but the losses of the goods in this category caused by the failures in supply chains reach more than 65% [2, 3]. It is possible to reduce the perishable goods loss share at the expense of the delivery time reduction and extension of the life span on the store shelves. These conditions make the air transportation in the international supply chains more preferable, especially in intercontinental communication [4].

Perishable goods make nearly 10% of the airlines total turnover and consequently it relates to the goods handling process in the airport terminals [5]. According to the leading airlines esteems the segment of perishable goods has a significant potential for their international transportation demand growth. One of the strategic goals for the airlines and airports is to remain competitive in this segment. For instance, according to the data received from Los Angeles airport, only fresh fruits, vegetables and

[1] World ACD and Technavio Global Report on Perishable GoodsD. Available at: https://www.iata.org/contentassets/4e4d3b50f3614011aef57357e594801e/perishables_track.pdf (accessed 10.03.2020).

[2] Retail chains selling food and related products (FMCG) in Russia 2015. General business characteristics, regional analysis, industry development strategy. RBC Research. Available at: http://alfabank.rbc.ru/media/ research/file/ FMCG_%D1%81%D0%BF%D0%B5%D1%86%D0%B2%D0%B5%D1%80%D1%81%D0%B8%D1%8F.pdf (accessed 10.03.2020).

nuts make 15% in the weighing terms of the goods processing whole volume. The profit which airlines receive having transported this group of goods is insignificant because these goods don't have high added value. According to the Lufthansa airline it only makes a few percent for 1$ of the transported goods. However, this group of products allows airlines to earn additional profit from cheap passenger flights by filling the cargo compartment of a full passenger flight [6].

The organization of a coordinated science-based technology for the functioning of supply chains by all its participants will significantly increase their efficiency [7 – 9]. The closest cooperation should be reached between airlines and airports, as the quality of the service which they provide determines the demand for the transportation of perishable goods by air. According to the IATA esteems the goods spend at the airport from 30% to 50% of their transportation time. Technical and technological facilities of airports determine the goods preservation while being transported. The processing time of perishable goods handling extension at the airport leads to their reorientation to sea transport. The advent of new perishable goods storage technologies which apply specialized gaseous medium makes it quite possible. The last decade of years showed the redirection of large volumes of perishable goods different types from air transportation to the delivery by sea [10]. However, utilization of such technologies reduces the quality of goods, that's why the delivery rate by air extension especially at the airport handling stage will make it possible to return a certain part of this segment.

Russian airports lack the sufficient facilities and technological equipment to handle this category of goods. The main problem of perishable goods handling process in airports is the different temperature regime of storage and certain types of goods incompatibility, which requires a big number of multi temperature chambers. According to the IATA not a single airport in Russia has the status of the airport with specialized facilities to process perishable goods as well as the phytosanitary-inspection service. The situation has changed after modernization of the Moscow Cargo at Sheremetyevo International Airport, but the airport hasn't passed the Certification of compliance yet. As a result, 90% of airlines perishable goods turnover in international flights is handled at the Moscow aviation hub, mainly at Sheremetyevo International Airport, which limits the development of international supply chains for perishable products within Russia.

METHODS OF RESEARCH

This research has been carried out on the basis of the international supply chain perishable goods delivery technology analysis by air transport. The analysis is based on a process approach, since the number of participants in the supply chain may vary depending on the number of mediators, and the number of operations and processes that must be implemented for the supply chain to function is a relatively constant value [11]. The SCOR-model which is based on the principles of indivisibility of cargo and information flows as well as on functional integration was used for making analysis. Taking this model as a core the scheme of perishable goods processes indivisibility and interconnection was made up; the criteria of perishable goods at the destination airport technological operations effectiveness estimation were worked out; the factors which reduce the quality of goods while handling at the airport were determined; the best technological solutions of the most problematic processes were studied.

At the initial stage, with the help of statistical analysis the main categories of perishable goods which show the demand for air transporting while being delivered in Russia were revealed. Further on they examined the requirements of International and Russian Standards to their transportation and the reasons why these requirements while handling the goods at the airports of Moscow aviation hub are broken. The following criteria for fruits processing technologies at the airport analysis were used: the number of compulsory while-handling operations, the time necessary for these operations, meeting the standards requirements to the storage and handling conditions, the amount of paper work. The research was carries out using the mango from Brazil by-air delivery example, as fresh fruits make the biggest share of perishable goods delivered to Russia by air, while mango is the most particular to the delivery

conditions. The second stage of investigation dealt with the analysis of technological facilities for perishable goods handling at the largest airports in Russia, the main centers which have strategic importance for the hubs which service transit air transport flows development. Some technological solutions aimed at the quality and periods of perishable goods handling increase in the cargo terminals at Russian airports were offered.

The materials from Russian airlines, largest cargo terminals in Russia which have the strategic importance for the perishable goods supply chains development, transport companies, ICAO (The International Civil Aviation Organization), IATA (The International Air Transport Association) and TIATA (The International Air Cargo Association), FIATA (International Federation of Freight Forwarder Association), ACA (Airport Council Association), ACI (Airports Council International) were used, the results of the scientific research and the results of the interviews which were carried out by the author with the airports and airlines cargo terminals authorities were published.

PERISHABLE GOODS WHICH MAKE A DEMAND FOR AIR TRANSPORTATION TO RUSSIA AND THE INDUSTRY STANDARDS

After having conducted the analysis of the international supply chain it is possible to pick out the following categories of perishable goods which make a potential demand for air transportation.

- vegetable products: fresh fruits, berries, vegetables, and herbs, except the heavy, cheap vegetables and fruits that can easily be transported by sea, they make up the largest share of perishable goods delivered to Russia, and make the most strict requirements for the conditions of transportation;
- animal products: animal genetic material, incubator eggs, fertilized eggs, refrigerated meat and poultry, refrigerated fish, refrigerated caviar;
- processed products: expensive frozen fruits and vegetables, meat and sausage products, cheeses;
- live plants, flowers, seedlings, tubers, seeds;
- live fish planting material (fry, under yearlings, etc.);
- food additives: enzymes, ferments, dye stuff, etc.

The Russian market is ranked fifth in the world in terms of food imports. The share of import among all consumed agricultural products and food is more than 35%. Food products and agricultural raw materials (group 01-24 of Commodity Nomenclature of Foreign Economic Activity) are one of the key commodity groups imported to the Russian market, whose share in total imports in 2017 and 2018 is 12.7% and 12.5%, respectively. In monetary terms this group import volume amounted to $ 29.74 billion in 2018, compared to $ 28.95 billion in 2017. According to Russian Statistics Committee - Rosstat, imported food products make up 27% of the total retail food products turnover. The government of the Russian Federation conducts an active import substitution policy, however, the import of several products is an objective necessity dictated by the peculiarities of the country's natural and climatic conditions. “Fruit and nuts” is the most significant category of food products imported to Russia, its share in the total volume of food and agricultural products in 2018 made up 17,14% of the total import structure in the monetary expression, and in 2019 it made up 46,2% of the total vegetable products import volume. If nuts are not related to the perishable goods category and can be delivered by sea then fruits are much more sensitive to the period of delivery. Air transport is used for the delivery of exotic fruits which bring the most rigid demands to the terms and period of delivery such as: persimmon, dates, avocado, fig, mango and mangostan, pine apples, kiwi fruit, guava, pawpaw, which are delivered all the year round or seasonally. The total volume of the fruits importation in this category amounted to 6,6% (332,1 thousand tons) in 2018. Since this category of perishable goods establishes greatest demand for delivery by air it is exactly this category which was studied in this research.

The basic volume of exotic fruits comes from Costa Rica, Israel, Brazil, Peru and Iran.

The largest part of the exotic fruits delivered to Russia is processed at the airports of Moscow aviation hub, mostly at Sheremetyevo International Airport and partly at Moscow Domodedovo Airport and a minor part is delivered at Pulkovo Airport in Saint Petersburg. Such international fruit direction control is connected with infrastructural restrictions in Russian airports. Concentration of incoming flows in the central region leads to the rise in prices of the internal logistics of fruits. In 2003, the members of the perishable goods market felt the urgent necessity to work out international standards and regulations for perishable goods delivery. The Cool Chain Association was created with the exactly this purpose. At present, this association works in close cooperation with the International Air Transport Association (IATA) and The International Air Cargo Association (TIACA). The main document, which determines the perishable goods delivery technology requirements by air transport at international level, is the current version of industry standard of IATA Perishable Cargo Regulation [12]. The purpose of this standard is to create the common regulations of perishable goods transportation for all participants of the air transportation market, to improve the speed of technological processes, to increase the quality and transparency of the delivery process, to upgrade the communicational processes between the members of supply chains. Besides, the IATA publishes expert examination results of the main airlines that control the live animals and perishable goods transportation (LAPB). In addition to the mentioned above document, the IATA worked out an additional standard “Temperature Control Regulation” for temperature controlled goods. The latter standard reflects the requirements to the prior cargo handling at the airport as well as to transporting, refrigerating, to temperature control during delivery by road and preserving the goods value added. The IATA standard reflects the innovative international practices of technical and technological solutions used by airlines and airports. There is no practice of developing such standards at the national level.

There are Federal Aviation Rules that function in Russia. “The General Rules for passengers, baggage and cargo air transportation and the requirements for passengers, shippers, and consignees servicing” adopted by the Ministry of Transport, No. 82 of 28.06.2007 is one of them. The “Manual on Domestic Airlines of The USSR Cargo Transportation” (Cargo Transportation Guide-85)” adopted by the Ministry of Civil Aviation of the USSR on August 20, 1984 N31/I is among them. However, the national rules assume the regulations for perishable goods service conditions during the air delivery process, in accordance with the terms of contracts between the shipper and the airline. Meanwhile, according to the guidelines, perishable goods are ready for transportation in case the sender submits quality certificates or certificates of the fixed form. As a rule, perishable goods are transported by direct flights. In exceptional cases, with the prior consent of the transfer airport, it is possible to accept perishable goods with one overload on the way.

The experience of Russian and international airlines shows that the most difficult thing to determine in the supply chain is the level of losses at the stage of transporting, as they are often connected with the infringements at the previous stages of the supply chains. In this regard, the ISO 22000 standard-"Food and Food Safety Management System – Requirements for Any Organizations in The Supply Chain" – is applied at the international level for food products. The national standard: "The System of Food Products Safety Management. Requirements for Organizations Involved in The Food Production Chain” - GOST R ISO 22000-2007 was worked out in Russia. Another international standard is HACCP (Hazard Analysis and Critical Control Points), which is the food stuff quality control system. Standard GOST51705.1-2001 – Food Products Quality Management Based on The HACCP (Hazard Analysis and Critical Control Points) principles operate on the national level. Enterprises located on the territory of the Russian Federation have the independent right to choose the standard for the food safety management system development.

According to the IATA manual, the most rigorous requirements to the temperature regime have fresh fruits and vegetables, as some of them increase the respiration intensity (climacteric fruits) when temperature rises, which leads to the increased amount of carbon and further production spoilage. Be-

sides, fruit require separate storage due to the different intensity of ethylene release and sensitivity to its concentration (tabl. 1). Taking these biological peculiarities as a basis the IATA worked out compatibility and incompatibility tables for different fruit and vegetables.

Table 1

Temperature storage conditions for fresh fruit delivered to the International Supply Chain by air

Perishable goods	Temperature storage conditions	Temperature effect on respiration intensity
Avocado	+5,0…+12,0	yes
Guava	+4,5	yes
Mango	+10,0…+13,0	yes
Mangostan	+4,0…+8,0	yes
Raspberry	-0,5…0,0	yes
Strawberry	0,0	yes
Papaya	+7,0	yes

The majority of perishable goods delivered by air have the range of temperature storage from 0-+5°C, while exotic fruit require a higher temperature conditions and separate storage conditions. Therefore a high quality perishable goods servicing at the airport requires a certain amount of separate temperature chambers with an adjustable storage regime. Besides, according to the WHO esteems, a frequent temperature impairment happens on the runway during loading-unloading processes at the airports as well as while unloading the motor transport at the ramp.

TECHNOLOGICAL CAPABILITIES FOR PERISHABLE GOODS HANDLING PROCESS AT THE AIRPORTS OF RUSSIA

The airlines have managed to work out the methods for products cooling and refrigerating which make it possible to deliver the goods more cost-beneficially in a special packaging. The temperature conditions in the cargo compartment on board a plane are provided by circulation of cold external air. The temperature is set by the captain of the aircraft. The problems arise in case the goods which require different temperature conditions are placed in the cargo hold of the plane. To maintain different temperature conditions, delivery is carried out in specialized aviation refrigerated containers, which completely solve this problem. A more complex issue is maintaining the temperature regime at all stages of cargo handling at the airport. The main advantage of perishable goods delivery by air is the rate of transportation however, this benefit reduces because of the technological shipping process extension. According to the experts' esteems the most problematic link in the perishable goods International Supply Chain is the ground handling at the airport of shipment and destination airport.

The complexity of perishable goods handling process organization at an airport is conditioned by the following peculiarities:

- A short expiring period;
- Seasonal transport volumes;
- Different requirements to temperature storage and transportation conditions for different categories of perishable goods;
- The process of phytosanitary control and customs procedure;
- The necessity of using ULD (unit load device) with temperature control;
- The goods quality dependence on great number of supply chain participants, (fig. 1).

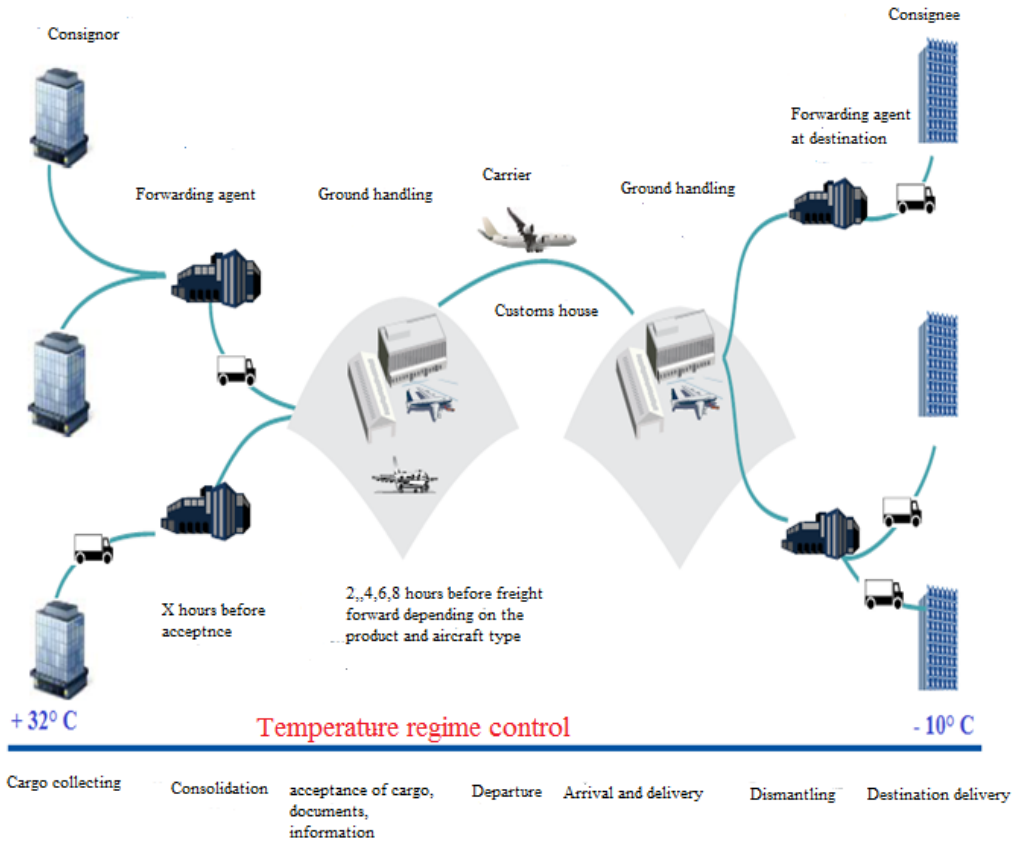

Fig. 1. Participants of perishable goods international supply chain

The following parameters have a great impact on the perishable goods quality while being handled at the airport [13]:

- the cargo quality status at the time of shipment is controlled according to certificates and quality certificates, but it's often impossible to detect the violations of the goods maintenance conditions at the previous stages when the goods are loaded to be transported by air, so all responsibility falls on the load carrier or the airport;
- the cargo preparation for storage and transportation - the system of cargo refrigerating;
- the packaging and packing are chosen by the consignor of goods;
- the temperature and storage conditions, including the ones at the airport;
- the humidity conditions of storage and transportation, including the ones at the airport;
- air circulation and ventilation in the sites of cargo storage and transportation;
- air purity and sanitary condition in the storage chambers and vehicles capacity, including the ones at the airport;
- the ways of products distribution in them;
- storage and transportation period.

When transporting perishable goods, the climatic conditions of the shipment and transportation areas should also be taken into account as the external temperature while unloading the aircraft and internal temperature in the cargo terminal of the airport depend on these conditions. The requirements to the vehicles used on the territory of the airport are put forward taking climatic conditions into account. Pursuing this purpose, according to the IATA manual, it is recommended to use ULD containers with temperature regulation. At the same time the total time of the flight and ground handling of perishable goods at the airport shouldn't exceed 48 hours.

The Moscow Cargo Terminal at Sheremetyevo International Airport meets the most complete requirements of international standards of technological equipment for processing perishable products. The terminal area is 42,300 m^2, the throughput capacity is 380 thousand tons per year, and the volume of transit cargo handling in 2017 was 445.2 thousand tons. After modernization, the terminal is equipped with 26 multi-temperature chambers for perishable goods storage with a total volume of 3,845 m^3. In addition, an automated ULD container storage and processing zone has been put into operation, which is equipped with 60 thermal cells with the temperature kept in the range of +4...+8 °C and an online monitoring system for temperature sensor readings. The terminal also has thermal equipment to work on the ramp. Together with Air Bridge Cargo, the Moscow Cargo Terminal allows you to arrange the delivery of transfer cargo within 48 hours, as it is required by the IATA standard.

At other airports of the Moscow Aviation Hub the situation is worse. The area of cargo terminal of Domodedovo airport is 13600 m^2, its throughput capacity is 200 thousand tons per year. The terminal is equipped with two temperature chambers: a freezing chamber with temperature range -13…-20^0 and a cooling chamber with temperature range +2…+8^0, which doesn't allow you to store incompatible goods separately. Moreover, some perishable goods which require a higher temperature storage conditions can't be processed in this airport (exotic fruits, medical products). The terminal doesn't have the ULD storage system with temperature maintenance. The similar situation takes place in the cargo terminal of Vnukovo Moscow International Airport which area equals to 13000 m^2, total storage area is 4560 m^2 and throughput capacity is 150 thousand tons per year. The cargo terminal is equipped with a freezing chamber which total area is 256,3 m^2. According to the Federal Air Transport Agency, other airports on the territory of the Russian Federation do not have the equipment to maintain various temperature storage conditions. Seventeen airports are supplied with thermal chambers. The infrastructure for handling temperature cargo at Russian airports availability analysis is shown in Figure 2.

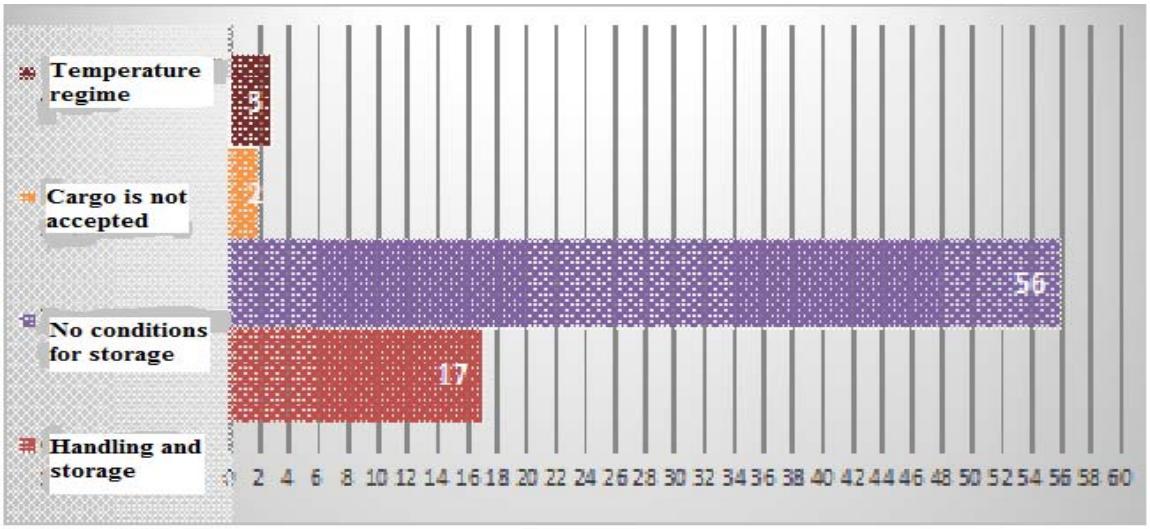

Fig. 2. The number of international airports in Russia which have technical and technological facilities for perishable goods handling process

The logistics efficiency of perishable goods delivered in Russia by air increase can be reached by creating several hubs on the territory of the country which will make it possible to unload the Moscow Aviation Hub, which currently handles about 90% of the perishable goods total volume. In this regard, it is advisable that Moscow Aviation Hub airports specialize in servicing export-import flows, and the processing of transit and transfer flows should be concentrated in several major international airports outside the Central region. This direction of airport infrastructure develop-

ment conforms to the Decree of the President of the Russian Federation dated May 07, 2018 "On National Goals and Strategic Objectives For The Development Of The Russian Federation For The Period Up To 2024", as one of the priority tasks which defines “the development of transport corridors "West-East" and "North-South" for cargo transportation, also through the establishment of central cargo multimodal transport and logistics centers. It is proposed to use the country’s busiest airport cargo terminals, which have the greatest potential for processed cargo flow increase and development of ground infrastructure as central hubs. The dynamics of cargo handling volumes at the largest airports in Russia is shown in Table 2.

Table 2

Volumes of cargo handling dynamics at the largest Russian airports in international and domestic traffic in tons*

Airports	2014	2015	2016	2017	2018	2019
Moscow (Sheremetyevo)	197 782,50	178 167,50	231 249,90	293 972,50	617 368,80	329 817,20
Moscow (Domodedovo)	162 163,03	133 182,65	119 039,44	122 862,35	240 708,34	105 862,72
Moscow (Vnukovo)	37 195,93	36 707,12	44 153,22	58 493,98	125 208,90	48 890,91
Saint Petersburg (Pulkovo)	25 360,00	22 535,00	25 381,00	28 751,00	54 990,00	27 411,00
Novosibirsk (Tolmachevo)	25 073,10	19 670,10	16 962,20	22 012,50	49 281,80	26 558,90
Vladivostok (Knevichi)	28 930,00	21 455,77	21 642,10	23 317,20	49 172,24	21 441,61
Khabarovsk (New)	29 173,52	22 621,23	22 580,50	24 075,79	43 694,60	19 404,90
Yekaterinburg (Koltsovo)	22 190,95	18 366,75	20 045,82	19 340,27	36 852,06	17 196,81
Krasnoyarsk (Yemelyanovo)	16 041,40	12 877,71	12 483,21	13 852,29	31 013,64	15 448,14
The total amount of cargo handled by the largest airports in Russia	543 910,43	465 583,83	513 537,39	606 677,88	1248 290,38	612 032,19
The cargo handled at Russian airports total volume share, %	70,3	68,5	70,3	73,0	81,0	80,0
The total volume of goods processed at Russian airports	**773 377,87**	**679 621,76**	**730 606,50**	**831 070,48**	**1 540 755,93**	**764 606,27**

* Calculated by the author on the basis of the data from Federal Air Transport Agency (Rosaviatsiya)

The table data, allows us to conclude that it is advisable to develop the airports of Novosibirsk, Vladivostok, Yekaterinburg and Krasnoyarsk as transfer hubs. According to Federal Air Transport Agency, all these airports have facilities for processing and storing perishable products, but they do not have the ability to maintain different temperature regimes. Characteristics of cargo terminals are shown in Table 3.

Table 3

Characteristics of airport cargo terminals for creating perishable cargo transfer hubs*

Index	Novosibirsk airport	Vladivostok airport	Yekaterinburg airport	Krasnoyarsk airport
Warehouse area	6 733,3 m^2	5 425,8 m^2	14 000 m^2	6 265,0 m^2
Freezing chamber volume/capacity	220,3 m^2 (t +15…-18 °C)	20 m^3 (t -18…-20 °C)	22 m^2 (t 0…-20 °C)	40m^2 (t -18…-20 °C)
Cooling chamber area		Three chambers 8 $м^2$ (t -5…+8 °C)	137,2 m^2 (t +2…+8 °C)	80 m^2 (t 0…+8 °C)
ULD storage with temperature maintenance	No	No	No	No

*The data was submitted by airports authorities

In addition to the absence of separate multi temperature chambers the storage problems often arise due to the low quality of information exchange system. Technological scheme in the International Supply Chain of perishable goods transportation by air includes the following stages (fig. 3):

1. Reservation of the goods cargo capacity only after coordination with the carrier the possibility of this cargo type transportation. Documents: air waybill, safety Declaration.
2. Passing through phytosanitary/veterinary control. Documents: phytosanitary/ veterinary certificate. When sending plants from the territory under quarantine, you must obtain a permission to send an individual shipment and quarantine documents.
3. Obtaining Customs permit for cargo transportation (clearance of cargo). Documents: customs declaration.
4. Unloading of cargo from the vehicle that delivered the cargo to the airport, presenting the cargo for transportation. Documents: confirmation that the cargo won't lose its quality during the set time of transportation; invoice indicating the temperature of the cargo when loading into the vehicle.
5. Weighing and volume measurement.
6. Marking of cargo.
7. Storage and keeping custody with liability on the territory of the airport and having preflight check. Documents: power of delivery, air invoice with the seal confirming the check.
8. Transportation charge.
9. Completion of cargo loading on the departure flight (consolidation of cargo, pallets and containers formation).
10. Transportation from the warehouse to the aircraft stand.
11. Loading.
12. Cargo berthing.

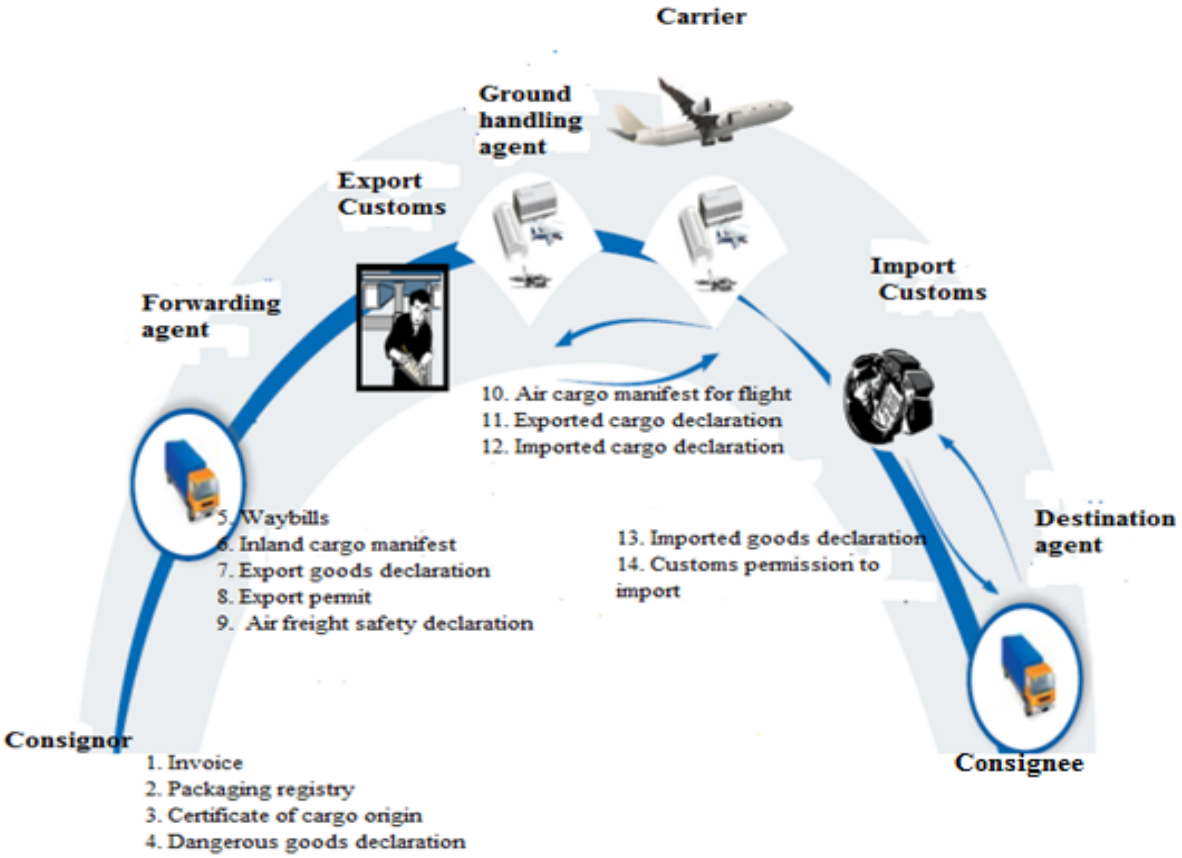

Fig. 3. Documents which must be processed while shipping perishable goods via International Supply Chain[3]

The long procedure of registration and cargo dispatch leads to the fact that the cargo doesn't spend more than 30% of the total delivery time on the plane, the remaining time is spent on cargo processing at the airport terminals, paperwork, and customs control [4]. This time expenditure can and should potentially be reduced.

According to the World Bank 2018 assessments, Russia is the 75-th among 160 countries by the quality of logistics service. The composite score of Logistics Performance Indicator, – LPI is 2,76. For comparison, Russia has been left behind by such countries as: India (the 44-th), LPI makes 3,18; Bulgaria is the 52^{-nd}, (3,03); Brazil is the 56^{-th} (2,99); Columbia is the 58^{-th} (2,94); Kazakhstan is the 71^{-st} (2,81). Among the six indicators used for LPI formation, the lowest one in 2018 in Russia was the quality of Customs service - 2,42 (the 97^{-th} position), further is the quality of international supplies - 2,64 (the 96^{-th} position) and tracking shipments in the supply chain - 2,65 (the 97^{-th} position). The time spent on Customs clearance doesn't depend on the quality of the airport infrastructure, however, the cargo safety during this procedure is determined by the availability of necessary infrastructure of warehouses for temporary storage, as the results show this infrastructure is not developed enough. The average time of imported goods delivery in the supply chain by air transport at the distance of 2646 kilometers equals to 5 days. Considering, that according to IATA standards, this time must be equal to 48 hours. The average time of Customs clearance with the physical inspection makes 4 days. The top position belongs to the index of delivery timeliness-3,31 (the 66^{-th} position), Figure 4.

[3] Air Freight: A Market Study with Implications for Landlocked Countries. Transport Papers. The World Bank Group, 2019. 115 p.

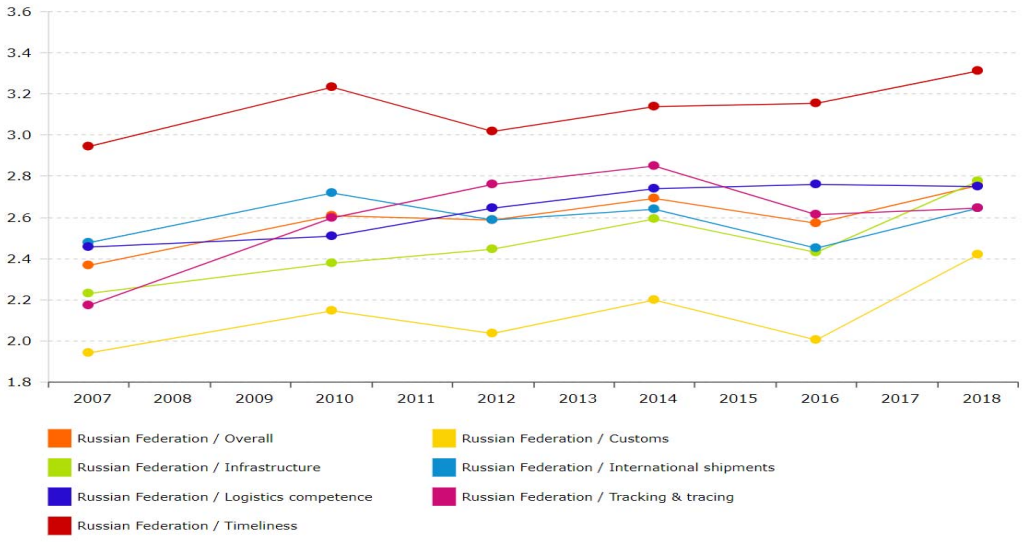

Fig. 4. Logistics effectiveness dynamics index (LPI) and its indicators in Russia[4]

Survey of the "Moscow Cargo" specialists carried out by the author of this study revealed that the average time of perishable goods handling at the airport makes 5 hours and 15 minutes disregarding the Customs clearance time. Relying on specialists' esteems the average Customs clearance time should make 2 hours. All that exceeds 6 hours is considered to be ineffective[5]. Exceeding the time of customs clearance operations and passing phytosanitary control at Russian airports leads to a delay of cargo in warehouses which increases the cost of products and often leads to its damage due to the lack of a sufficient number of multi-temperature temporary storage warehouses.

As far as the majority of perishable goods in International Supply Chain is handled at Sheremetyevo International Airport, it provided the data for analysis of the perishable goods handling time taking the lot of mango as an example, because it has the highest temperature storage regime, which can be maintained by the temperature chambers with adjustable storage regime.

Mango belongs to the category of climacteric fruits, which respiration intensity increases while ripening. Ethylene production at the initial stage of storage causes a sharp increase of respiration intensity. Climacteric fruits have a good ability to ripening and it is widely used in logistics. Fruits collected at the stage of medium maturity are delivered only by air transport. On average, the acceptable shelf life of mango at an optimal temperature of +12...+14°C and relative humidity of 90-95% is 30 days. Extreme cooling of mango in the initial stage of ripening occurs at temperatures below +12° C. As the ripening stage increases, the mango resistance to lower temperatures increases, but cooling below +10°C is not recommended. Since mango is harvested at the stage of incomplete ripening, the stage of its ripening is mandatory in the supply chain, which occurs at the temperature of +15.5...+30°C, the optimal temperature is +20...+22°C [14].

There are enough multi temperature chambers for separate storage of perishable goods in the modernized cargo terminal Moscow Cargo at Sheremetyevo International Airport. Temperature chambers in temporary storage warehouses at Moscow Domodedovo Airport and Vnukovo Moscow International Airport maintain the temperature of +2...+4°C, since most imported berries, fruits and vegetables are processed at exactly this temperature, and specially allocated warehouses are not provided. Storing mango at this temperature for more than a day leads to its hypothermia, loss of ripening ability and spoilage.

[4] International LPI. Country Score Cards [Электронный ресурс] // World Bank. Available at: https://lpi.worldbank.org/international/scorecard/line/254/C/RUS/2018#chartarea (accessed 20.12.2019).
[5] Perishable Cargo Regulation. International Air Transport Association. Montreal. Geneva, 2015. 232 p.

The research showed that the average time of mango supply chain operation in Russia is from 12 to 55,5 days at the permissible storage time of 30 days, which is determined by the delays in mango handling at the destination airport. The flight time and the time of mango processing at Sheremetyevo International Airport makes up from 47,5 hours to 10 days (tabl. 3), while the IATA standard defines the time limit of 48 hours [12 – 13]. The most problematic operations while processing the cargo at the airport are Customs clearance, phytosanitary and quarantine checks because of low quality document exchange between the consignor of goods and airport services. As soon as the goods arrive at the destination airport, the cost of each cargo handling hour increases dramatically, since it reduces the life cycle of the goods on the store shelves [15 – 16].

Table 4

Flight time and the time of mango processing at Sheremetyevo International Airport

№	Process	Time of performance in hours	Quality impact
1	Flight to Sheremetyevo International Airport	17,5	High
2	Airplane unloading at Sheremetyevo International Airport	1 – 2	Medium/high
3	Customs clearance and phytosanitary checks	5 –7 2	High
4	Quarantine control performed by Federal Service for Veterinary and Phytosanitary Surveillance (for sub quarantine goods) and obtaining quarantine permission	20 – 120	High
5	Unpalletization at Sheremetyevo International Airport	3 – 6	High
6	Storage at the temporary storage warehouse	1 – 3	High

*Author's personal calculations

The most often delays and disturbances in perishable goods handling process at the airport happen because of [17–18]:

- The cargo is not declared as perishable (marking mistake);
- The cargo is stored in inappropriate temperature conditions;
- The cargo is delivered in inappropriate packaging;
- Some technical delays occur while handling the cargo;
- The wrong performance of loading and freezing (doesn't follow instruction).

PROPOSALS FOR IMPROVEMENTS OF PERISHABLE GOODS GROUND-BASED HANDLING TECHNOLOGY AT THE AIRPORT

The main criteria for perishable goods International Supply Chain functioning is the speed of handling. The longest delays happen during ground handling of cargo at the destination airport [19]. Exporting countries which are aimed at stimulation of outgoing cargo flows, invest much money into development of ground infrastructure and modern informational technologies application, which allow them to reach the optimal time for operations performance. It is connected with the necessity to develop new markets and increase export volumes. As far as perishable goods export volume from Russia is insignificant, the infrastructure for handling this category of cargo in Russian airports remains low and has poor support from the government. Due to this fact the ground handling rate of perishable goods international supply chain functioning slows down in cargo terminals of Russian airports. As the crite-

rion for evaluation of airport facilities for perishable goods supply chains handling, it is possible to use the number of multitemperature chambers at the airport, their area, the temperature storage system ULD availability, the amount of time which perishable goods are at the airport. The following is offered to solve these problems:

1. Establish additional cargo areas with specialized temperature chambers for separate storage of goods which require different temperature conditions and are incompatible due to biological peculiarities in the cargo terminals of the appointed airports (central hubs) which process the perishable goods International Supply Chain, the airports of Novosibirsk, Vladivostok, Yekaterinburg and Krasnoyarsk.

2. Create the systems of temperature storage ULD at the selected airports taking into account the prognostic demand for their handling.

3. Organize 24-hour operation of all services which are involved into ground handling of perishable goods at the airport (Customs house, representation of Federal Service for Veterinary and Phytosanitary Surveillance, phytosanitary control laboratories).

4. Use the experience of the leading airport cargo terminals on electronic cargo certification while receiving the safety declaration (eCSD).

5. Implement the digital system of document circulation (compiling the digital invoice), which will allow to synchronize the electronic freight and processing of import documents. The model of material and information flows organization in International Supply Chain applying EDI (Electronic Data Interchange) and scanned documents is shown in Figure 8.

6. Simplify customs clearance for cargo flights at destination airports by implementing preflight preliminary information about the cargo (ACI) in accordance with the framework of standards (SAFE) of the World Customs Organization and Pre-Loading Advance Cargo Information (PLACI). Application of this information is only possible on having the digital (electronic) document circulation between all the members of International Supply Chain.

7. Implement the Block-Chain system to follow all operations in the International Supply Chain. This technology allows to fix information about every displacement of cargo in the cloud system by means of creating a corresponding note [20 – 22]. Such type of notes is impossible to be broken or changed as they have decentralized structure of storage system. The principle of the system operation is the following: each member of the supply chain receives the information about any displacement of the cargo, but the process itself is not monitored. This system will simplify the process of documents check and finding errors in these documents mainly when checking the marking and customs clearance.

The introduction of pre-shipment advance cargo information will allow customs authorities to: focus on more detailed verification of high-risk shipments safety; reduce delays in customs clearance for low-risk shippers; flexibly adapt to different models of international supply chain organization while ensuring a comparable level of security; simplify the process of goods displacement in global supply chains which are characterized by complex cross-border and multimodal transport.

The implementation of the Block Chain system combined with modern technologies will simplify the process of document circulation as well as the quality of required shipment conditions observed by each member [23]. Linux Foundation Company organized a project for perishable goods transportation quality analysis. To achieve this goal they created a network of sensors which were attached to the products and recorded a wide range of telemetric parameters such as: time, location, temperature, humidity, knocks and slopes. Sensors of such kind make a 100% precise record of delivery conditions breakage time and identify the agent in the supply chain, who is responsible for the breakage [4].

Fig. 5. Electronic workflow organization with synchronization of electronic freight and registration of import documents according to WCO recommendations

The governments of many countries such as France, South Korea, Australia, have already started spending hundreds of millions of dollars on implementation of these technologies and increasing transportation transparency. According to the esteems of the largest technological IBM Corporation, as soon as this technology is implemented by the majority of market participants, shippers will be able to reduce the actual cost of physical transportation by about 20% [24], by filtering unreliable carriers and eliminating the risks of cargo damage throughout the supply chain [25].

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ПЕРЕВОЗКА СКОРОПОРТЯЩИХСЯ ГРУЗОВ ВОЗДУШНЫМ ТРАНСПОРТОМ: ПРОБЛЕМЫ ОБРАБОТКИ В РОССИЙСКИХ АЭРОПОРТАХ

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В статье рассмотрены проблемы обработки скоропортящихся грузов в российских аэропортах при доставке в международных цепях поставок (МЦП). Исследование проведено на основе операционного анализа. На первом этапе с помощью статистического анализа было выявлено, что основной категорией скоропортящихся товаров, предъявляющих спрос на воздушные перевозки при поставке в Россию, являются свежие экзотические фрукты. Исследование проводилось на примере цепи поставок манго, так как он предъявляет нестандартные требования к температурному режиму хранения. На втором этапе был сформирован набор критериев для оценки качества обработки скоропортящихся грузов в аэропортах: число обязательных операций при обработке груза, время выполнения этих операций, количество оформляемых документов, количество мультитемпературных камер в аэропорту, их площадь, наличие системы температурного хранения ULD. Исследование показало, что около 90% скоропортящихся грузов, поставляемых в Россию, обрабатывается в аэропортах МАУ из-за отсутствия необходимой инфраструктуры температурных складов в остальных аэропортах страны. Данное ограничение существенно удорожает логистику скоропортящихся грузов по территории страны и снижает их качество. В рамках данного исследования были выбраны четыре международных аэропорта за пределами ЦФО, имеющие стратегическое значение и потенциал для формирования центральных хабов по обслуживанию скоропортящихся грузов и обработке транзитных и трансферных потоков. Среди них аэропорты Новосибирска, Владивостока, Екатеринбурга и Красноярска. Для аэропортов МАУ предложена специализация на обслуживании экспортно-импортных потоков скоропортящихся грузов. В качестве данных для проведения исследования были использованы материалы авиакомпаний, крупнейших грузовых терминалов российских аэропортов, транспортных компаний, специализированных международных организаций воздушного транспорта и логистических ассоциаций. Исследование показало, что сдерживающим фактором повышения скорости работы ЦП является время наземного обслуживания грузов в аэропортах России, которое значительно превосходит время обслуживания в стране-экспортере. Задержки связаны с неразвитостью инфраструктуры грузовых терминалов для обработки скоропортящихся грузов и сложностью процедур документального оформления из-за отсутствия систем электронного документооборота и автоматизированной проверки маркировки. Предложена модель формирования электронного документооборота в МЦП с применением предполетной и предпогрузочной предварительной информации о грузе и внедрение системы BlockChain для проверки правильности оформления документов на всех стадиях в цепи поставок, что позволит сократить общее время наземного обслуживания грузов.

Ключевые слова: воздушный транспорт, технология доставки грузов, скоропортящиеся грузы, международные цепи поставок, цепи поставок манго, маркировка грузов, наземное обслуживание грузов в аэропорту, электронный документооборот, технология BlockChain.

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