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# *Analysis of Regional Air Transportation System as Subsystem of Communicative Space*

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*Abstract*— **Air transportation systems are an important part of the regional economics. The analysis of regional air transportation systems gives the common trends of logistics in the region. On the other hand, it allows building different mathematical models to manage more effectively logistics policy under uncertainties and risks conditions. It is possible to provide this approach using Big Data concept and theoretic-information approach.**

***Keywords— regional air transportation system; efficiency; information model; decision making; Big Data***

## I. INTRODUCTION

The characteristic of transport and infrastructure communications as a social phenomenon is important from the point of view of tendencies that form and modify the social landscape of humanity in the context of post-industrialism and globalization [1]. In [2], the fundamental diversity of communicative spaces is described, and the authors put forward the idea of complexity and intermediality of social and communication environment.

In 1990, there were about 1,500 airports and landing sites in Russia, about 260 airports and landing sites in Russia at a time [3]. The fleet consisted of 35 thousand passenger aircraft, including helicopters, currently 2 thousand aircraft. The volume of passenger traffic in air transport was 140 million people a year. Today in Russia, this figure fell to 80 million people. As is known, over the past 15 years, investments from the federal budget for the development of the aerodrome network have doubled: from 20 to 40 billion rubles, 7 federal state-owned enterprises have been created, through which the state provides the current maintenance and development of local airports. A new fleet is actively being formed [3].

So we can see that diversity of communicative spaces in sense of air transportation systems as one of the aspects for research of communicative spaces in information society.

An air transport system can be considered as a large-scale system that must provide the efficient air transport services for passengers and freight. A large-scale system is a subclass of systems of systems class. System of System is a system that has: operationally independent sub-systems; managerially independent components and sub-systems; evolutionary development; emergent behavior; and geographic distribution [4].

Regional air transport system flows can be divided to passengers flow and freight flows. The directions of these flows depend on different economic conditions in the region economic portrait.

As it is known, the computer management system of an air transportation system is an important factor in determining the success of forecasting different operational costs. The decision making persons must manage a huge amount of data effectively in order to maximize its usefulness. Managing large amounts of data generated by computers, application of information from sensors and the data about state of business processes of different steps of business life cycle process nowadays can be based on Big Data technologies [5].

The main findings of the analysis undertaken in this area of research should be pointed as lack of effective management of different business models evolution in regarding regional air transportation system. It disables considering the air transportation system as a complex system in regional aspect. So, currently, it’s impossible to manage and develop the airline system integrally for regional cost optimization and profitability.

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## II. MODERN REGIONAL AIR TRANSPORTATION SYSTEM IS A COMPLEX LARGE-SCALE SYSTEM

The modern regional air transportation system is a complex large-scale system that includes cooperation with different regional transportation systems (Fig. 1). This system has a hierarchical structure as a complex management system with a lot of cross links.

Thus, it seems reasonable to provide information logistical support throughout the life cycle of single processes in this area. On the other hand, it allows building mathematical models to manage airline in real-time mode under uncertainties and risks conditions [6]. It is possible to provide using Big Data concept and information approach [5].

The concept of Big Data combines techniques and technologies that extract knowledge from huge data streams in real time. Active interest from researchers and practitioners in the field of aviation to Big Data technology due to the implementation of high-speed data channels for dynamic objects, the implementation of NoSQL technologies as well as Cloud Computing.

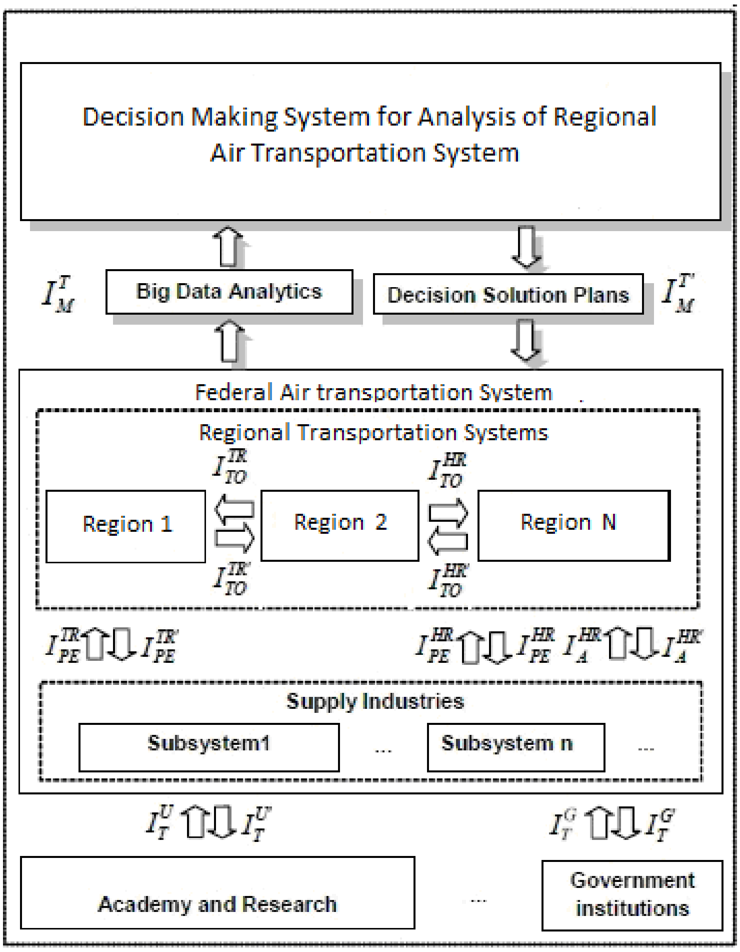

Fig. 1. Decision making system for optimazing air traffic flows in regions

The main idea of standardizing the exchange of information in the open system is based on some general system principles:

- the principle to reduce the entropy, i.e. bringing uniformity and standardization of a single form of objects and information about those objects;
- the principle of invariance, i.e. the identification of those requirements, which are necessary taking into account changes in the properties of standardized plants;
- the principle of preserving the viability of standardized requirements establishing reasonable limits of standardization.

An important place in the framework of standardization of business solutions based on the idea of open systems takes implementation of CALS technologies. It allows forming the basis for the creation and usage of the unified information environment during the life cycles of main business in the air transportation system.

## III. THEORETIC-INFORMATION APPROACH FOR ANALYSIS OF REGIONAL TRANSPORTATION SYSTEM

The application of Big Data as well as theoretic-information approach in airlines is a popular direction today. A large amount of statics data is stored in the databases of airlines and now is available from different data warehouses.

The decision making system in the case of large scale system can be applied (Fig.1). This system consists of information gathering subsystem, data bases, data centers and telecommunication channels. It depends on supply industries: fuel, operational services, etc. The base of this system is social background, such government institutions and academy and research. Information flows between subsystems are very complicated and can store hidden dependencies.

The decision making system applied Big Data analytics that can be based on the result of analysis of the structure of regional air traffic flows.

For example, in air transportation systems, service industries and supply industries may be allocated. Service industries interact with a product directly on the base of the different organizational technical system. Supply industries are related with product indirectly and include power engineering and so on. All these subsystems are connected with material and information flows. In this case, we need to minimize the risk of service failure. Interrupting the information flows or information lack or invalidation leads to increasing the risks.

Therefore, it is possible to provide decision making system for airline services as well as system information support through all the airline life cycle including business model evolution.

The core idea for decision making in our case is application of theoretic-information approach based on notion of transfer entropy. The transfer entropy extends the concept of mutual information to provide a direction sensitive measure of information flow between two time series. Formally, the transfer entropy from time series Y to X is given by

$$T_{Y\to X} = \sum p\left(x_{n+1}, x_n^{(k)}, y_n^{(l)}\right)\log\frac{p\left(x_{n+1}\middle|x_n^{(k)}, y_n^{(l)}\right)}{p(x_{n+1}|x_n^{(k)})}\ , \quad (1)$$

where $x_{n+1}$ is the value of X at time $n+1$, and $x_n^{(k)}$ is the $k(l)$ lagged values of X(Y) at time n.

The definition of transfer entropy assumes X as Markov process. The transfer entropy measures the additional amount of information Y, contains about X over the information contained in the Markov embedding.

As it can be seen, such the approach requires huge information content processed at regional and federal levels.

Herewith, the following important tasks may be allocated for transportation and communication flows processing:

theoretic-information approach as the tool of analysis of information exchange between traffic flows for neighborhood regions;

building a large amount data warehouse for storing data from information systems of different regions;

forecasting and optimizing processes in air transportation system as communication mechanism for social and economical systems.

## IV. EXAMPLE OF REGIONAL AIR TRANSPORTATION SYSTEM ANALYSIS

Let us discuss the example of application of theoretic-information approach for analysis of air traffic between different regions for analyzing the diversity of communicative spaces, complexity and heterogeneous of social and communication environment of these regions (Fig 2 [7]).

As the air transport hubs, Moscow airports were chosen: Vnukovo, Domodedovo and Sheremetyevo. The airports of Ufa, Yekaterinburg and Chelyabinsk were chosen as regional airports.

The statistic data for passengers flow and freight flow for these airports (from January to August, 2018) are presented in Table 1 and Table 2 [8].

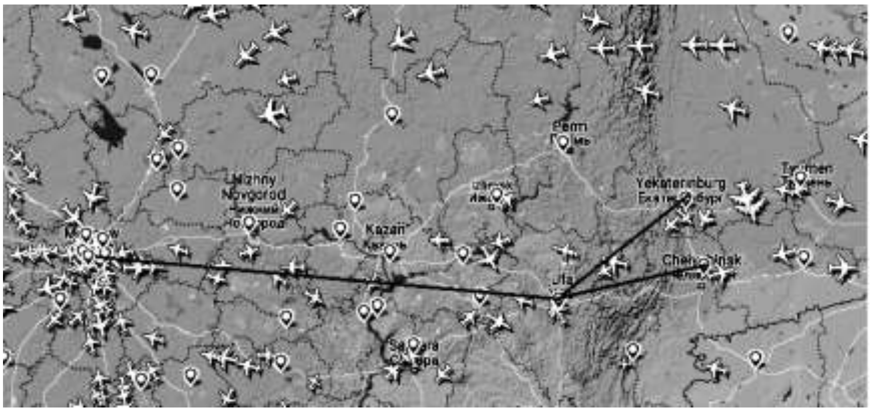

Fig. 2. Air traffic for Moscow, Ufa, Chelyabinsk, and Yeketerinburg

TABLE I. Passengers flow for 2018 [8]

| Airport | January | February | March | April | May | June | July | August |
|---|---|---|---|---|---|---|---|---|
| **Yekaterinburg (Koltsovo)** | 381763 | 336695 | 392808 | 421672 | 485899 | 629099 | 657294 | 672918 |
| **Chelyabinsk (Balandino)** | 110571 | 96025 | 107748 | 116923 | 139647 | 173873 | 185743 | 183138 |
| **Ufa** | 220199 | 197567 | 216207 | 228911 | 289878 | 323439 | 342056 | 344004 |
| **Moscow (Vnukovo)** | 1355451 | 1215640 | 1371392 | 1524207 | 1770032 | 2182303 | 2432103 | 2439290 |
| **Moscow (Domodedovo)** | 2070002 | 1773283 | 2065279 | 2201021 | 2536179 | 3006178 | 3277260 | 3304305 |
| **Moscow (Sheremetyevo)** | 3025847 | 2756906 | 3238461 | 3492370 | 3606478 | 4172700 | 4675714 | 4706521 |

TABLE II. Freight flow for 2018 [8]

| Airport | January | February | March | April | May | June | July | August |
|---|---|---|---|---|---|---|---|---|
| **Yekaterinburg (Koltsovo)** | 1078 | 1954 | 1486 | 1601 | 1468 | 1404 | 1462 | 1615 |
| **Chelyabinsk (Balandino)** | 201 | 233 | 250 | 271 | 224 | 221 | 262 | 255 |
| **Ufa** | 275 | 249 | 528 | 556 | 376 | 424 | 345 | 448 |
| **Moscow (Vnukovo)** | 3722 | 5222 | 5558 | 5522 | 4936 | 5227 | 5493 | 5730 |
| **Moscow (Domodedovo)** | 8302 | 10126 | 9755 | 9397 | 11327 | 9622 | 10301 | 10308 |
| **Moscow (Sheremetyevo)** | 21305 | 19179 | 24479 | 24709 | 25152 | 30203 | 26345 | 26060 |

TABLE III. The results of calculation of transfer entropy for statistics data sets

|  | Yekaterinburg | Chelybinsk | Ufa | Moscow (Vnukovo) | Moscow (Domodedovo) | Moscow (Sheremetyevo) |
|---|---|---|---|---|---|---|
| **Ekaterinburg** | - | - | 0.4 / 0 | - | - | - |
| **Chelybinsk** | - | - | 0.1 / 0 | - | - | - |
| **Ufa** | 0 / 0.2 | 0 / 0/3 | 0 / 0 | 0.3 / 0,53 | 0.3 / 0.56 | 0.5 / 0.2 |
| **Moscow (Vnukovo)** | - | - | 0 / 0 | - | - | - |
| **Moscow (Domodedovo)** | - | - | 0/ 0 | - | - | - |
| **Moscow (Sheremetevo)** | - | - | 0 / 0 | - | - | - |

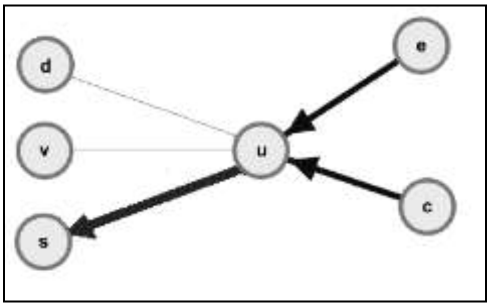

Fig. 3. Transfer-Entropy graph for total movement, air transport movements, terminal passengers

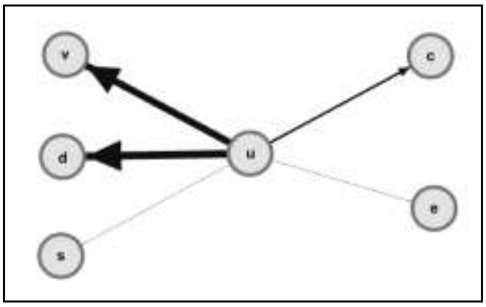

Fig. 4. Transfer-Entropy graph for total movement, air transport movements, freight

The calculations of transfer entropy (1) on the basis of statistics data from Table 1 and Table 2 were fulfilled. Table 3 presents the results of transfer entropy calculation for the given statistics data sets. The illustration of obtained results as a graph model is presented in Fig. 3 and Fig. 4.

So, we can see from Fig. 3 and Fig. 4 there is some kind of heterogeneity of communication spaces for air transportation hubs of Moscow (d – Domodedovo, v – Vnukovo, s – Sheremetyevo), Ufa (u), Yekaterinburg (e) and Chelyabinsk (c). It follows from directional flows of passengers and freight by the example of Ufa air transportation hub. The analysis shows the following results.

The flows of total movement of terminal passengers from Yekaterinburg and Chelyabinsk airports through Ufa airport are directed to Sheremetyevo airport (Moscow) in sense of communicative space.

The flows of total movement of freight from Ufa airport are mostly directed to Domodedovo airport (Moscow) and Vnukovo airport (Moscow) in sense of material communicative space.

## V. CONCLUSION

Air transportation systems are an important part of the regional economics. The analysis of regional air transportation system as a subsystem of communicative space with application of theoretic-information approach is provided. The tendency of large-scale systems development can be federal wide integration of its elements on the basis of common information space.

The example of application of theoretic-information approach for analysis of air traffic between different regions for analyzing the diversity of communicative spaces, complexity and heterogeneous of social and communication environment of these regions is discussed.

Some kind of heterogeneity of communication spaces for air transportation hubs of Moscow, Ufa, Yekaterinburg and Chelyabinsk was discovered.

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