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Methodological Bases for Forecasting Passenger Flow on Regional Airlines

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Abstract: Air transport operation is a set of measures aimed at meeting the needs of air transportation. This complex includes measures to create demand for air transportation and satisfy it in order to generate profit. The successful functioning of the air traffic system in the region is largely determined by the accuracy and reliability of the forecast, which is especially important for socially significant routes.

The forecast results are used at all stages of planning and operations, i.e. from the design of the air network to the formation of flight chains. This makes it possible, to plan economic indicators (such as incomes, including subsidies, and expenses, including financial payments), which directly affects the choice of tariff policy. The process of justifying all managerial decisions made both at the regional level and at the level of the airline should be based on the results of a predictive assessment of external and internal factors.

Forecasting is a process that uses both past experience and current assumptions about the future to determine specific indicators in it. A set of methods is currently used to predict passenger traffic.

The article analyzes the methods of forecasting passenger traffic used by various authors and proposes a methodological approach to forecasting passenger traffic on air routes in the northern territories of the Krasnoyarsk Territory. Within the framework of the proposed approach, a method for forecasting passenger traffic has been developed, a feature of which is to take into account such important factors such as the paying capacity of consumers, the purpose of their travel, and the availability of transport services by income level. The use of the methodological approach will make it possible to determine the predicted passenger traffic in order to achieve the target indicators of transport activity with minimal budgetary costs, as well as improve the quality and efficiency of management decisions made in the field of forecasting and logistics management of transportation processes.

Keywords: passenger traffic; forecasting passenger traffic; regional air traffic system; northern territories; regional air transportation; local air transportation; provision of air transport; aviation mobility of the population.

INTRODUCTION

The economic and industrial development of the region is directly related to the development of its transport system, in particular, the air transportation system. Within the framework of this study, the 'region' is understood as the main territorial unit that applies to all branches of government; a synonym term is 'a subject of the federation'. The regions of the Russian Federation include republics, territories, regions, cities of federal significance, an autonomous region, and autonomous okrugs.

The typification of passenger traffic allows air transportation to be classified as regional and interregional. Interregional correspondence is a collection of passengers who departed from the airport of one subject of the Russian Federation to airports located within the borders of another region. Regional transportation is passenger transport flows that are closed within the borders of one constituent entity of the Russian Federation.

The task of developing regional air transportation becomes especially urgent within the borders of the Krasnoyarsk Territory as a region, a significant part of which is occupied by northern territories. Air transport is of great importance for the socio-economic development of the North, due to the climatic features, the point-like nature of the settlement, the extremely low population density, the concentration of economic activity on isolated areas of resource development, and traditional nature management.

The strategy of socio-economic development of the Krasnoyarsk Territory until 2030 states that '... in order to ensure the connectivity of the territory, transport accessibility and mobility of the population throughout the Territory, the implementation of measures aimed at the development of small aviation will continue, i.e. reconstruction and technical re-equipment of regional airports and updating the fleet of regional aircraft. Particular importance in the development of small aircraft will be given to remote and northern territories, for many of which air transport is the only year-round means of communication. To reduce the cost of air transportation in remote settlements, landing sites suitable for receiving light aircraft will be restored and put into operation, which will make it possible to stop using expensive helicopter transportation. As in the case of water transport, the state will retain the role of a guaranteeing carrier for these territories, complementing the capabilities of private companies' [10].

The implementation of such measures requires an assessment and analysis of indicators that determine the value of possible passenger traffic by air in the northern territories of the Krasnoyarsk Territory in the medium and long term, especially Taimyr and Evenkia.

It is known that the level of demand in the northern regions of the Krasnoyarsk Territory is limited. One of the reasons is the negative dynamics of the region's population. Thus, the population in the Taimyr Dolgan-Nenets District of the Territory has decreased from 38.4 thousand people in 2007 up to 31.6 thousand people in 2019 (by 17.7%), and the population in the Evenk region decreased from 16.98 thousand people in 2007 up to 15.7 thousand people in 2019 (by 7.5%).

Over the past decades, the segment of local air transportation has been in a state of stagnation. According to statistics, local air transportation often remains low profitable or planned unprofitable. At the same time, unprofitableness in this segment reaches from 75 to 80% of the prime cost, which is explained by their implementation of the most expensive transport, namely, helicopters [10].

Passenger traffic in air transport is formed depending on such factors as air mobility of the population, the scale of the region's economy, socio-economic and demographic characteristics of the region, and the availability of air transport.

The need for forecasting passenger flows of airlines is caused by the complexity of transport logistics tasks in the northern territory of the Krasnoyarsk Territory and the need to improve the quality of management decisions of forecasting and logistics management of transportation processes.

LITERATURE REVIEW

Forecasting modeling is essential for making accurate forecasts. Many works of domestic and foreign authors [1-3, 6-9, 11-12] are devoted to the issues of forecasting passenger traffic in transport, in which various approaches are used, including the use of adaptive methods and expert assessment methodology.

A special place among these works is occupied by works devoted to forecasting regional and interregional passenger traffic on Russian airlines. These authors agree that the study and forecasting of passenger traffic, take place in several stages, including not only the forecast of the transportation of passengers and cargo but also the forecast of passenger aircraft fleet development and the passenger aircraft market volume formation. As a rule, research in these works is reduced to the following stages, i.e. the study of the current state of the analyzed object; the study of predictable methods in a given or related field, and the development of our forecasting model.

In recent decades, researchers have attracted methods of quantitative forecasting of air transportation, which are presented in the form of econometric models, as well as time series and the corresponding methodology for their analysis. Most econometric models are focused on identifying the relationship between passenger traffic and the selected economic and social indicators of the region's development.

Russian studies of forecasting the demand for air transportation are the studies of the Aviation Center of the State Research Institute of Civil Aviation, based on the use of a regression model for forecasting air traffic.

Most of the studies [8, 12] are devoted to modeling the air transportation market, its segmentation, and structuring the demand for air transportation. An important characteristic of passenger traffic is the aggregate demand, which is based on forecasting passenger traffic at the nodes of the air transport network [9]. The possibility of influencing the demand for air travel is associated with an increase in the regional business activity of the population, which has an investment nature and is associated with plans to develop regional investment projects and improve the living standards of the population [4, 10].

The analysis showed that most of the models are regression in nature, trying to take into account the influence of various factors of an economic and non-economic nature, requiring a large amount of data. However, the passenger traffic on intraregional airlines is not always influenced by a large number of factors. The specifics of organizing passenger air transportation, for example, in the northern territories, require taking into account such factors as the type of aircraft used, the distance between settlements, special requirements for aircraft, airports, and landing areas. However, in our opinion, such factors as the purpose of travel, their frequency, and the availability of transport services concerning the income of the population come on top in modeling passenger traffic.

MATERIALS AND METHODS

The problem solution requires the use of a whole set of approaches and methods used in economics:

- a systematic approach and systemic analysis, which made it possible to provide a comprehensive consideration of the problem and highlight the main components of the regional air traffic system;
- methods of economic and statistical analysis, which made it possible to argue the conclusions on the main indicators for assessing passenger traffic;
- methods and techniques of empirical scientific research, including methods of comparative analysis, expert assessments, economic diagnostics, groupings, and revealing the specific features of the regional air traffic system;
- factor analysis highlighting the factors of influence on the passenger traffic formation on regional airlines.

In this study, several documents and materials were used such as information, analytical, methodological, and regulatory ones for organizing transport systems and regulating their activities, including air transportation, international organizations, and government agencies of Russia. The information base of the study was the program documents on the development of the transport system of both the Russian Federation and its subjects, the information contained in federal and regional information resources, including the official websites of the Federal Air Transport Agency and the Ministry of Transport of the Krasnoyarsk Territory.

RESULTS

Air traffic forecasting is an important part of the airline's strategic and tactical decision-making process. This helps airlines and civil aviation authorities to determine the future volumes of passenger and cargo flows that are required to support the planning process of air transport operations and the aircraft type choice involved in air transportation.

The problem of forecasting the demand for air transportation is complex, and many researchers propose to solve it in stages, taking into account general and particular factors affecting air transportation.

Let us consider the stages of solving this problem using the example of organizing the air transportation system in the Krasnoyarsk Territory. Forecasting and regulation of passenger and freight flow in a formalized form is presented in figure 1.

In the second stage, the accumulated data is sorted by categories of passengers. Thus, the 'residents' category makes up about 70% of the total passenger traffic. It is important to organize reservations for upcoming trips for this category of passengers. Among the residents, one can distinguish the category of 'schoolchildren'. These are seasonal passengers and their number is required to schedule additional flights for these periods. Schoolchildren, about 70% of them go on summer or winter vacations, and 30% prefer to stay at home and help their parents. The share of tourists is no more than 7%, and for this category of passengers, not only regular flights should be planned, but also additional for sightseeing flights. Information on the categories of passengers like 'business travelers' and 'transfer passengers' is more often received through booking channels and is more organized. A small category of 'other' passengers finishes the list of air passengers. The classification at the second stage ends with a list of cargoes that are potential for air transportation, i.e. the cargo of traditional crafts, products of individual entrepreneurs, goods, and other cargo for the local population and postal cargo. The classification of cargo by mass is taken into account in the case of additional loading of air transport or when performing only cargo flights.

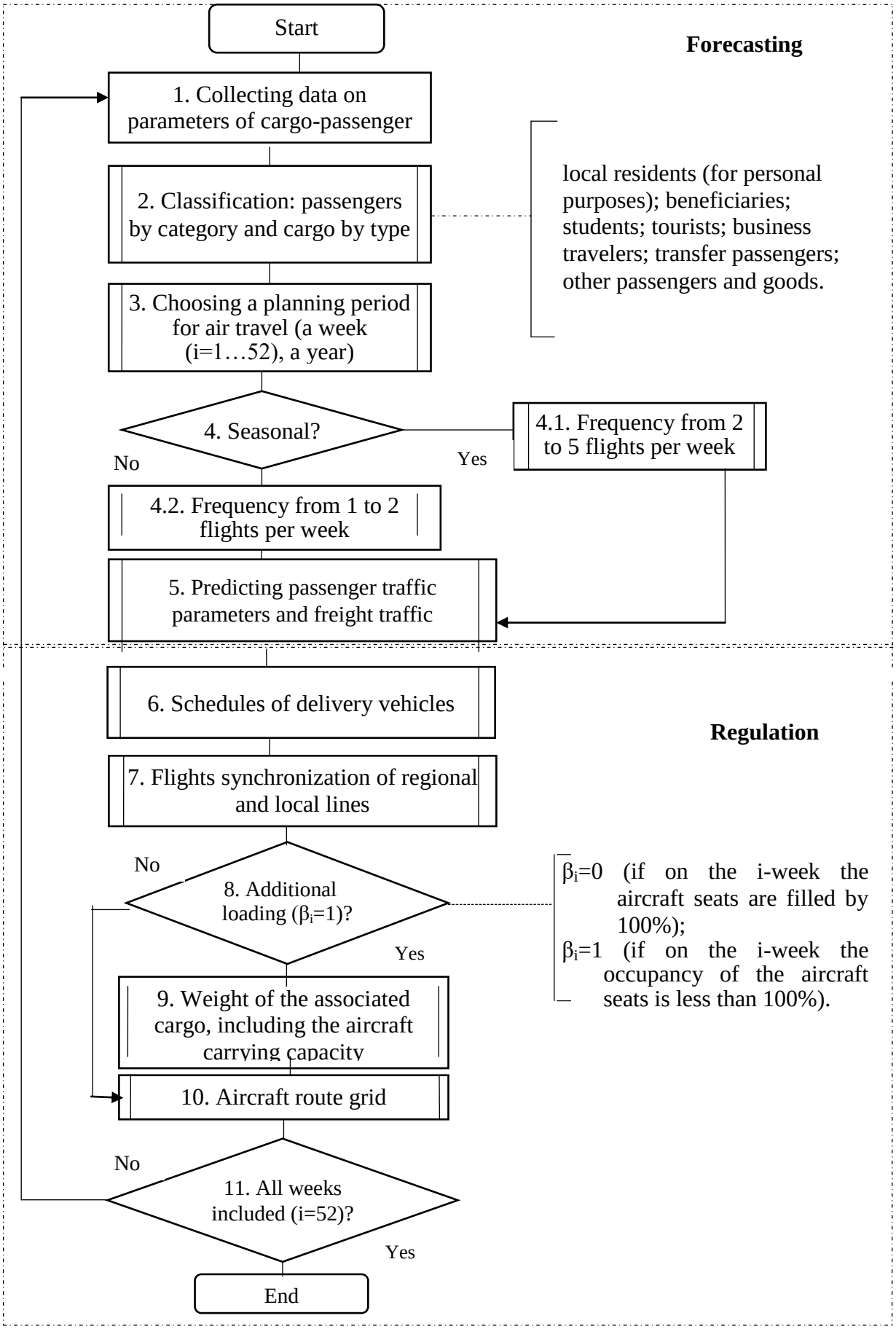
Start
Forecasting
1. Collecting data on parameters of cargo-passenger
2. Classification: passengers by category and cargo by type
local residents (for personal purposes); beneficiaries; students; tourists; business travelers; transfer passengers; other passengers and goods.
3. Choosing a planning period for air travel (a week (i=1…52), a year)
4. Seasonal?
Yes
4.1. Frequency from 2 to 5 flights per week
No
4.2. Frequency from 1 to 2 flights per week
5. Predicting passenger traffic parameters and freight traffic
Regulation
6. Schedules of delivery vehicles
7. Flights synchronization of regional and local lines
No
8. Additional loading (βi=1)?
βi=0 (if on the i-week the aircraft seats are filled by 100%);
βi=1 (if on the i-week the occupancy of the aircraft seats is less than 100%).
Yes
9. Weight of the associated cargo, including the aircraft carrying capacity
10. Aircraft route grid
No
11. All weeks included (i=52)?
Yes
End

Fig.1: Structural - logical scheme of forecasting and regulation of air cargo and passenger traffic in the northern territory of the Krasnoyarsk Territory: Aircraft (BC rus) - aircraft; βi- a given coefficient in the i-week of the planned year

At the first stage of the structural and logical scheme, it is envisaged to organize the collection of data, necessary and sufficient information on the parameters of cargo and passenger flows in the northern territory of the Krasnoyarsk Territory, including information on potential air passengers and cargo by planning periods for the use of air and supply modes of transport.

In the third step, the annual planning period is broken down into 52 weeks, and for each week, aggregated data are compiled up to a year.

At the fourth stage, it is established that the current week is related to the seasonal period, and is it necessary to increase the number of aircraft flights? The result of this stage is the determination of flight frequency per week.

At the fifth stage, according to the data of the previous stages, planning the number of air passengers and cargo transported, as well as the choice of an aircraft, is carried out.

At the sixth stage, the work schedule of the supplying transport is determined to timely deliver potential passengers to the planned flights of aircraft.

At the seventh stage, a joint work schedule for air transport is drawn up to synchronize the flights of regional and local lines.

At the eighth stage, a check is carried out (by the i-week) that the aircraft seats are filled by 100% ($\beta i = 0$), otherwise, the aircraft is reloaded with cargo ($\beta i = 1$) from the list of the second stage, that is, cargo-passenger flights are performed (stage 9).

At the tenth stage, the schedule of aircraft flights for the northern territory of the Krasnoyarsk Territory is drawn up according to planned weeks with an increase of up to a year.

At the final eleventh stage, it is determined how many weeks of the planned year have already been taken into account; then the calculation cycle is repeated for a new week and ends when the number of weeks coincides with their annual number. The start of the phased work of the scheme is repeated for the new planned year. The set of stages from 1 to 5 is combined into the 'forecasting' function, and stages from 6 to 13 are 'regulation'.

Prediction of passenger traffic is carried out for the selected categories of passengers, taking into account the purposes of their travel (figure 2). Passengers presented above (i.e. local population, business travelers, etc.), 'residents' is the most difficult to predict, accounting for 70% of the total passenger traffic. To solve the problem of forecasting passenger traffic in this category, it is proposed to distinguish the following groups such as preschoolers and primary school children, schoolchildren, students, working population, and pensioners. Conducting a survey of the population about the frequency and purpose of travel will allow us to build a matrix (table 1), which will take into account the frequency (Nij) and purpose of travel for each selected group. When filling out the matrix, it should be noted that for the first group, 'Preschoolers and primary school children', the frequency of travel should be doubled, since children need to be accompanied by an adult. Among the purposes of the trip are such as treatment, study, recreation, organizational and legal ones, etc.

Table 1: 'Objective is the number of trips by population groups' Matrix

Objectives / Population groups	Organizational and legal	Therapy	Study	Rest
Preschoolers and younger students	N_{11}	N_{12}	N_{13}	N_{14}
School students	N_{21}	N_{22}	N_{23}	N_{24}
Students	N_{31}	N_{32}	N_{33}	N_{34}
Working population	N_{41}	N_{42}	N_{43}	N_{44}
Pensioners	N_{51}	N_{52}	N_{53}	N_{54}

Determination of potential passenger traffic (PPF) based on this matrix is carried out by adding potential passenger traffic for selected population groups:

$$PPF = \sum_{i=1}^{n} PPF_i, \quad (1)$$

PPF_i – passenger traffic in the i-population group;

i=1….n, n – number of population groups.

The passenger traffic for the i-population group (PPF_i) is determined by the following formula:

$$PPF_i = P_i \times \sum_{j=1}^{m} N_{ij}, \quad (2)$$

P_i – number of people in the i-population group;

N_{ij} – the number of trips to the j-target in the i-population group; j=1…m.

Potential passenger traffic is the total number of desired rides. A passenger is guided by their financial capabilities. In this regard, in order to predict the amount of passenger traffic, it is necessary for each group of the local population to distinguish categories according to the level of income per each family member. For example, up to 50,000 rubles per year; from 51,000 to 100,000 rubles per year; from 101,000 rubles per year.

The income level influence on transport accessibility is based on the calculation of transport costs coefficient (k_{cov}), which is determined by the following formula:

$$k_{cov} = (C - D) \times N/V, \quad (3)$$

C – ticket price, rub.;
D – amount of subsidy, rub.;
N – number of trips;
V – average annual income per family member.

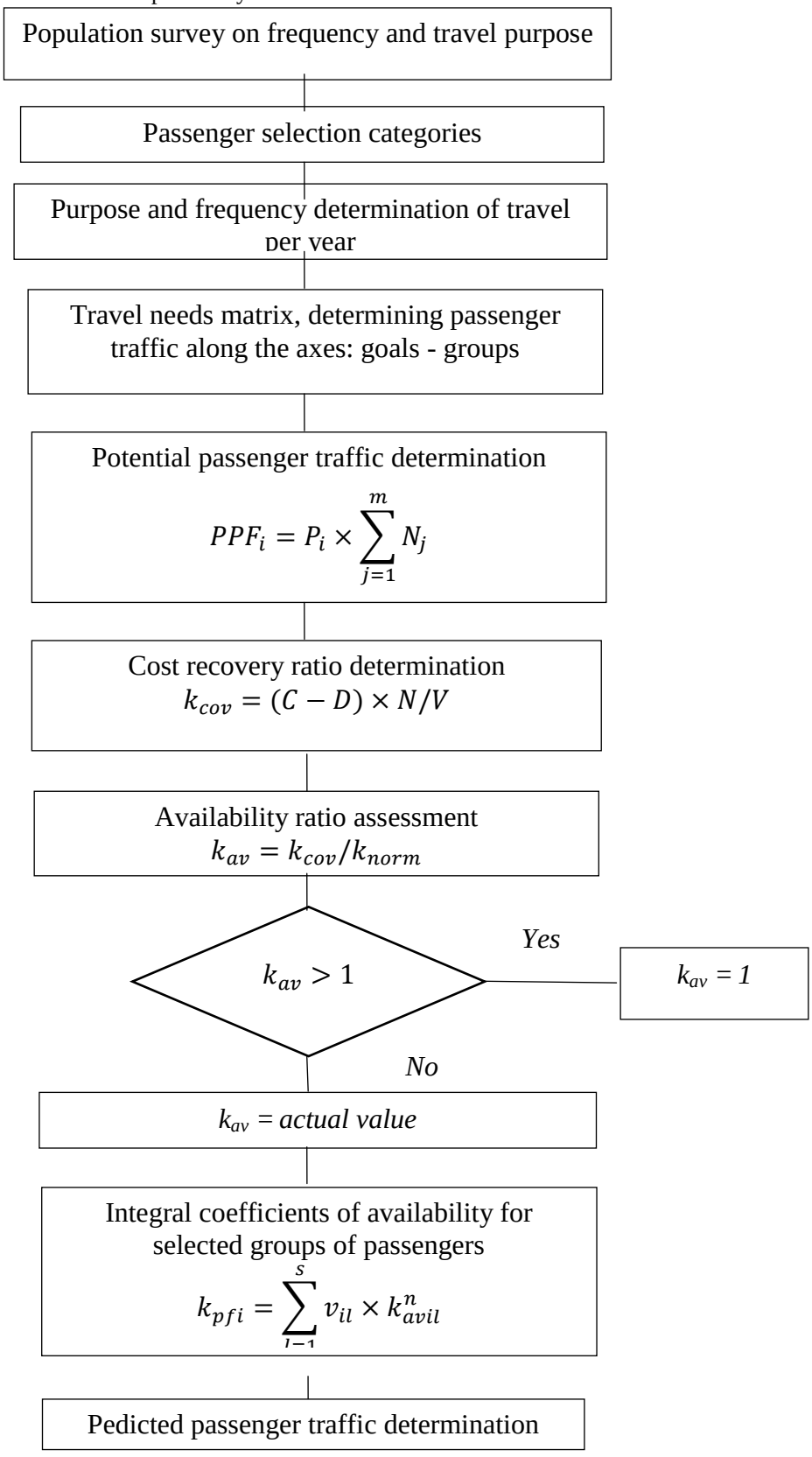

Fig.2: Main stages for determining the predicted passenger traffic

The coverage ratio assessment is necessary to determine the transport services coefficient availability of (k_{av}) for selected groups of the population and categories of profitability, which is calculated as the ratio of the coverage ratio to the standard coefficient determined at the state level, taking into account the experience of other countries:

$k_{av} = k_{cov}/k_{norm}$, (4)

k_{norm} – standard coefficient or norm.

If k_av> 1, then the level of accessibility of the transport service is sufficient for making trips and their number is not limited by the cost of tickets, and, therefore, when calculating the predicted passenger traffic in the vector of coefficients, this coefficient can be taken equal to 1. If k_av <1, then the level of accessibility of the transport service not sufficient for travel and their number is limited by the cost of tickets. Therefore, when calculating the predicted passenger traffic, this coefficient must be taken equal to the actual value.

Population categories by income level for each selected group of local residents are presented in table 2.

Table 2: Categories of local residents by level of average annual income per family member

Local groups	Average annual income per family member, rubles		
	Up to 50000	from 51000 to 100000	from 101000
Preschoolers and younger students	k_{av11}^{cal} / v_{11}	k_{av12}^{cal} / v_{12}	k_{av13}^{cal} / v_{13}
School students	k_{av21}^{cal} / v_{21}	k_{av22}^{cal} / v_{22}	k_{av23}^{cal} / v_{23}
Students	k_{av31}^{cal} / v_{31}	k_{av32}^{cal} / v_{32}	k_{av33}^{cal} / v_{33}
Working population	k_{av41}^{cal} / v_{41}	k_{av42}^{cal} / v_{42}	k_{av43}^{cal} / v_{43}
Pensioners	k_{av51}^{cal} / v_{51}	k_{av52}^{cal} / v_{52}	k_{av53}^{cal} / v_{53}

The final formula for calculating the predicted passenger traffic in the i-group (FPF_i) will look like:

$FPF_i = PPF_i \times k_{pfi}$, (5)

k_{pfi} – integral coefficient for i-group.

$k_{pfi} = \sum_{l=1}^{s} v_{il} \times k_{avil}^{n}$, (6)

v_{il} – share of the population in the i-income group l;

k_{avil}^{n} – normalized availability ratio.

$k_{avil}^{n} = \frac{k_{avil}^{cal} - k_{avmin}}{k_{avmax} - k_{avmin}}$, (7)

k_{avil}^{cal} – calculated value of availability coefficient;

k_{avmin} - minimum value of the availability factor;

k_{avmax} - maximum value of the availability factor.

The total calculation of the predicted passenger traffic for the selected groups is determined by the formula:

$FPF = \sum_{i=1}^{n} FPF_i = \sum_{i=1}^{n} PPF_i \times k_{pfi}$ (8)

This calculation of the predicted passenger traffic must be performed for the regional route network, for example, Krasnoyarsk - Kodinsk, Norilsk - Dudinka, etc.

CONCLUSION

The presented article proposes a methodological approach to the parameters formation for predicting and regulating cargo and passenger flows of air transportation in the northern territory of the Krasnoyarsk Territory. The forecasting method proposed within the framework of this approach makes it possible to form the parameters of the passenger traffic of specific correspondence, taking into account the availability of transport services for residents of the northern territories through the coverage coefficient calculation of the transport costs, including the subsidized component. The use of the methodological approach will make it possible to determine the predicted passenger traffic to achieve the target indicators of transport activity with minimal budgetary costs, as well as improve the quality and efficiency of management decisions made in forecasting and logistics management of transportation processes.

From our point of view, it is necessary to assess the air travel impact demand on the increase in the regional business activity of the population, which has an investment nature and is associated with plans to develop regional investment projects and improve the living standards of the population.

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