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Development of a polyfunctional structure of transport hubs in Smart City

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Abstract. The development of the of transport hubs system, as a part of the urban passenger transport system, is one of the most important areas of urban development in large cities. Without observing these principles, the development of new kinds of cities – Smart Cities – is impossible. In this article the question of formation of a polyfunctional structure of transport hubs is considered. The issue of allocation of building volumes for various functional purposes within the hub is included in a range of topical problems of urban development. In the study presented by this article, a factor stochastic analysis was used. The relationship between various independent factors determining the operation of the transport hub, as well as the indices of the volume of development of various functional purposes, placed in the structure of the hub, was investigated. The analysis was carried out in order to reduce the number of factors considered and identify the most significant ones. All of the considered indicators are measurable on a metric level. The present study is the stage of a correlation-regression analysis. In the future, it is planned to supplement this study by analyzing the factors measured (allocated) at a qualitative level with the purpose of scientific and methodological justification of the formation of transport hubs in Smart City.

1. Introduction

1.1. The urgency of the development of passenger transport and the transport hub system

For effective work and sustainable development of the city, a developed transport infrastructure is needed. High concentration and multifunctionality of the development of large cities ensure high population numbers and mobility of citizens.

The development of the transport hub system, as part of the public transport system, improves the quality of passenger service, increases mobility and, ultimately, makes the city more convenient and cost-effective.

The development of passenger transport has always been among the top priorities for the leadership of Moscow. Intensively the development of documentation for the design projects of the territories of transport and transfer units. The construction of new lines and stations of the Moscow Metro is actively carried out, the passenger movement on the Small Ring of the Moscow Railway is open, the system of dedicated lanes for the movement of land passenger transport continues to develop. Purchased a new rolling stock that meets the most modern environmental requirements, ensuring maximum passenger comfort.

1.2. Prospects for the development of Smart City and the Intelligent Transport System in Moscow

Smart City is the concept of integration of information and communication technologies for managing the development of the city and creating a comfortable and safe urban environment. This includes data collected from citizens, devices, and assets that is processed and analyzed to monitor and manage traffic and transportation systems, power plants, water supply networks, waste management, law enforcement, information systems, schools, libraries, hospitals, and other community services. [1,2]. The smart city concept integrates information and communication technology (ICT), and various physical devices connected to the network (the Internet of things or IoT) to optimize the efficiency of city operations and services and connect to citizens [3]. Smart city technology allows city officials to interact directly with both community and city infrastructure and to monitor what is happening in the city and how the city is evolving.

Prospects for the introduction of the concept of Smart City in the life of Russian cities are discussed for several years. A variety of smart components have already been introduced into the daily practice of Moscow, such as the "Safe City", the intelligent transport system, the unified medical information and analytical system, the "Moscow Electronic School" and others. Current issues and prospects for smart city development are being actively discussed at business forums and various conferences.

Moscow authorities plan to use the concept of "smart city" on the territory of the Administrative and Business Center in Kommunarka (Novomoskovsky Administrative Okrug of Moscow) and in the city of Troitsk. For this purpose, the French company Engie is planning to be involved, she will act as a consultant, and in the future may become an investor of this project. The administrative and business center in Kommunarka will occupy a plot of 550 hectares. It is planned to build about 5 million square meters of real estate, including 1.6 million square meters. m of housing. The campus of the Moscow Institute of Steel and Alloys, a branch of the Russian State Library, as well as the prefecture of the Troitsky and Novomoskovsk administrative districts will be located on the territory of the center.

Intelligent transport system (ITS) is a component of Smart City. It is a control system that integrates modern information and telematic technologies and is designed for automated search and adoption for the implementation of the most effective scenarios for the management of the region's transport and road complex, a specific vehicle or group of vehicles with the aim of providing the required mobility of the population, maximizing the use of the road network, increase of safety and efficiency of transport process, comfort for drivers and transport users [4].

In Moscow, since 2011, the intellectual transport system is actively developing. ITS contains information about the download and status of road network, as well as software and hardware that ensure the collection, processing, storage, maintenance of the current information of this information and its provision to interested persons. The development of Moscow's intellectual transport system is aimed at resolving existing transport problems, including:

- reducing traffic congestion and reducing road congestion on the roads of Moscow;
- improving road safety for both motorists and pedestrians;
- informing the road users about the current traffic situation and optimal traffic routes (by car and public transport);
- ensuring the uninterrupted movement of urban land passenger transport.

The introduction and development of an intelligent transportation system in Moscow is currently carried out in accordance with the Resolution of the Government of Moscow No. 597 dated August 30, 2017 "On the intellectual transport system of Moscow".

The development of the Smart City concept and the Intelligent Transport Network can help in obtaining the data needed to study the current state of passenger transport and transport hub systems.

The active reconstruction of the transport and transfer hubs in Moscow gives particular urgency to the questions of the composition and type of devices in the territory of the transport hubs. The existing regulatory documentation does not provide an exhaustive answer to the composition and ratio of areas of various functional purposes, the placement of which is necessary as part of the transport hubs.

The regularly updated Decree of the Government of Moscow "On the formation of transport hubs in the city of Moscow" [5], provides for the placement of 11 types of technological buildings in the territory of the transport hubs. Commercial buildings, possible for placement, are registered in one paragraph: "administrative and business objects, educational and educational facilities, trade and utility facilities, medical and recreational facilities, sports and recreational facilities, social rehabilitation facilities and other facilities intended for placement in the composition of public-business zones."

In this regard, the issue of the need for further regulation of the composition of the transplant sites is important. One of its solutions could be the creation of special tables that determine the composition and the maximum possible indicators of commercial facilities, as well as the composition of technology in the territory of the interchange node. On the other hand, it is also possible to completely abandon the rationing in this area, which will significantly increase the role of land-use planning projects for the sites where the transport hubs development parameters should be determined.

2. Methods

In the study presented by this article, factor stochastic analysis was used. The relationship between various independent factors determining the operation of the transport hub, as well as the indices of the volume of development of various functional purposes, placed in the hub, was investigated. The analysis was carried out in order to reduce the number of factors considered and identify the most significant ones. All considered indicators are measurable on a metric level. The present study is the stage of correlation-regression analysis.

3. Theory and calculation

Let's consider in detail the issue of placing commercial and technological buildings in the territory of the transport hubs. The territory of the hubs is very attractive for their location, since on the one hand it is distinguished by high quality of transport services, on the other hand it is capable of providing a steady, significant flow of passengers. The placement of commercial buildings within the hub can facilitate the implementation of urban infrastructure projects. Commercial buildings located on the territory of transport hubs are one of the foundations of the formation of public spaces, it ensures the development of polycentric structure of the city.

At the same time, any commercial object becomes a new focus of gravitation and attracts additional passenger traffic, which can lead to a deterioration in the conditions of transport services for passengers.

The study examined the parameters of approved transport hubs planning projects. The total area of the planned development for the projects amounted to more than 1.8 million m^2 of various functional areas. The share of process facilities is 16% of the planned volume of development. At the same time, it should be noted that the commercial component is planned in 16 out of 22 transport-transfer nodes, provided with documentation on the territory planning (Fig. 1).

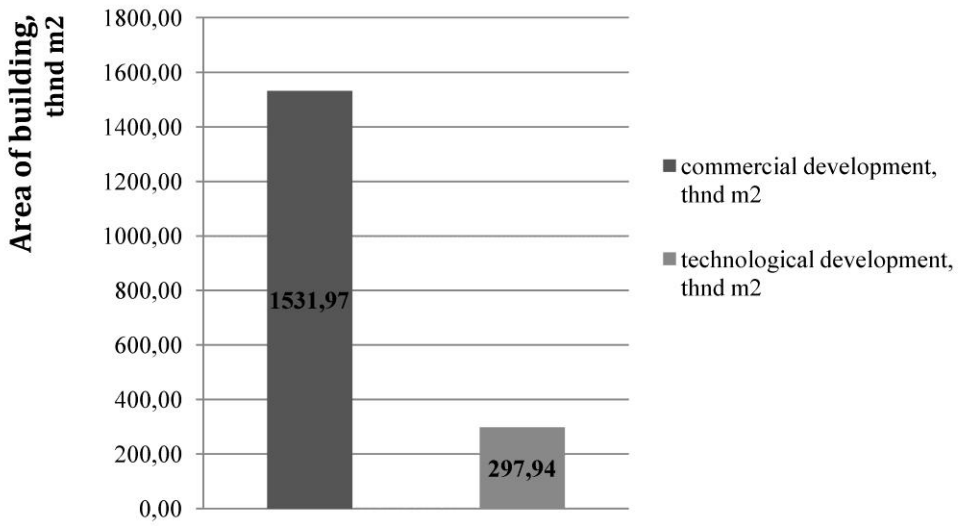

Figure 1. The graph of distribution areas of commercial and technological buildings (according to the approved plans for the layout of transport and transfer points in Moscow)

On the basis of generalized data, graphs of various types of distributions were constructed and regularities between various indicators were estimated: indicators of the volume of various buildings, hub territory, passenger turnover and the distance of the transport node from the center. The graphs of the ratio of the area indicators of transport hubs buildings to various parameters were constructed on the basis of completely relevant calculation data used in the development of the design plans for the SUE "Research and Project Institute of General Planning for the city of Moscow" and have the form of a parabolic curve.

The nature of the change in the parameter of the "technological development" relative to passenger turnover is more uniform than the parameter of the "commercial part", the graph of which has more pronounced curvature (Fig. 2). This is due to the relatively small difference between the minimum and maximum indicators of the area of the technological buildings. Also it is worth noting the general lower values of the areas of technological buildings of transport hubs in comparison with the values of the areas of commercial buildings. The explanation for this can serve several facts: insufficient consideration of the need for the placement of transport facilities in these planning projects; lack of a clear list of transport infrastructure facilities, the placement of which should be envisaged in the development of planning documents; not solved the question of the development of a system of incentive parking in the transport hubs, despite a significant number of studies that justify the development of this type of parking space [6].

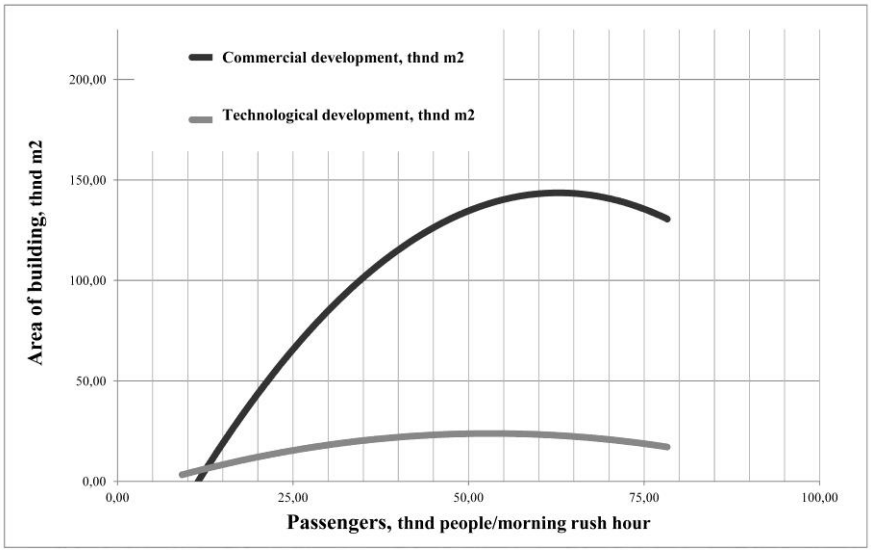

Figure 2. The graph of the ratio of passenger turnover of transport hubs to the area of buildings located on the territory of the hubs

Data on the area characteristics of the commercial component can be used as a nomogram for the preliminary determination of the commercial component of the transplant sites in preparation for the development of spatial planning documentation and the planning of the territory of the transport hubs. For this, further research is needed on the nature of the distribution.

Earlier we proposed an empirical nomogram for determining the maximum possible volume of a commercial component, the location of which is possible within the boundaries of the interchange node (Fig. 3). The determining factor is the intensity of passenger turnover of transport hub and the ratio of commercial and technological areas located on the site.

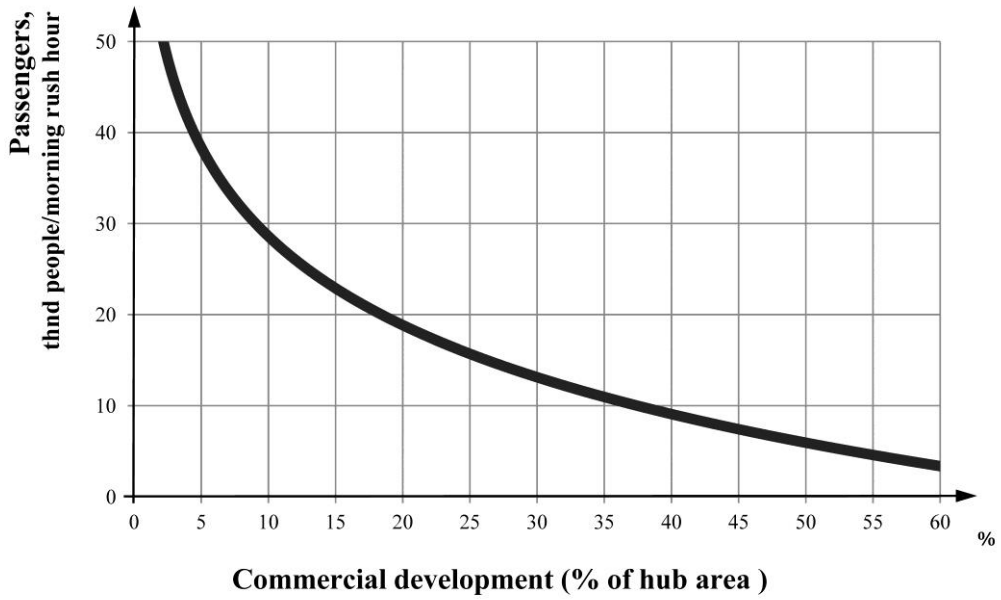

Figure 3. Empirical nomogram for determining the area of the commercial component located in the territory of the transport hub

4. Results

The analysis of the approved draft plans showed a slightly different picture and questioned the further use of this ratio as a basis for rationing. The graph, constructed according to the approved design plans (Fig. 2), shows that with passenger turnover of more than 50 thousand passengers per rush hour, the placement of technological buildings in the transport hub is not required. This is obviously an incorrect statement. In this regard, further use of the graph "passenger turnover - the ratio of areas in the territory of transport hub" requires further study and to date is not applicable.

5. Discussion

The analytical method used above has a number of shortcomings, the most important of which is that the analysis of approved documents reflects today's, momentary attitude to the development of transplant sites. In this regard, it is more promising to create a model that allows to take into account the entire set of urban, socio-economic, infrastructural and financial factors.

In the future, it is possible to study the system using system analysis. One of the promising directions is cluster analysis of the system, which will allow to divide the entire system into clusters, for each of which it is possible to determine the possibility of placing, limiting indicators and functional purpose of commercial buildings.

A variant of clustering the system is shown in Fig. 4. The possibility of placing commerce is determined by the ratio of three integrated factors: 1). transport - an integrated indicator should take into account the available reserves of the road network and public transport networks; 2). socio-urban factors - the main indicators that need to be taken into account are listed above in this article; 3). financial factors - take into account the balance of the expenditure and income parts of the project.

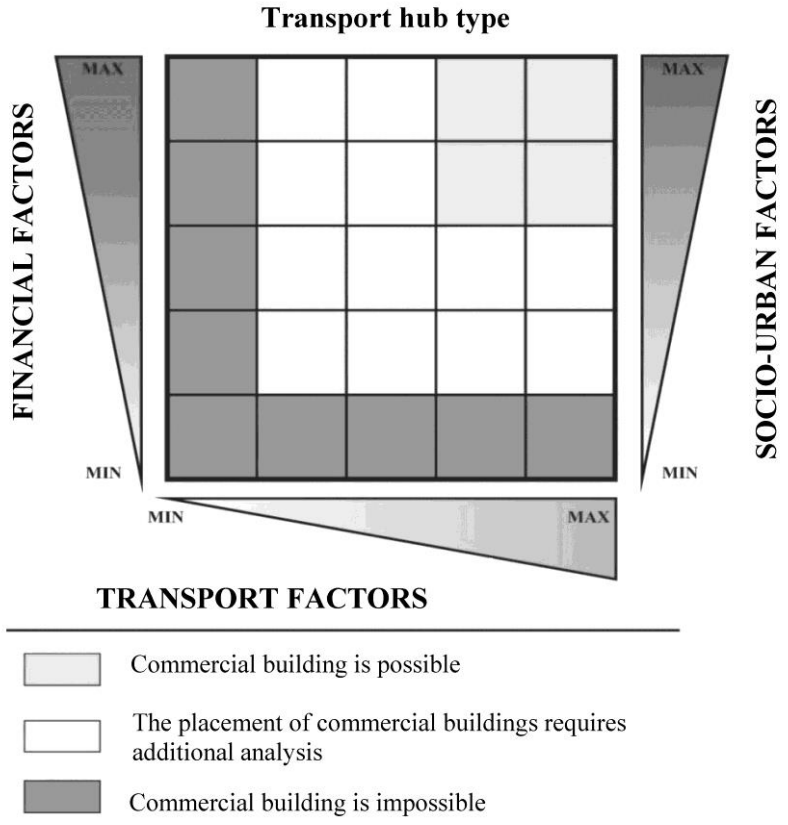

Figure 4. A multifactor system for determining the area of a commercial component located in the territory of a transport hub

In the future it is necessary to build a tree of system properties, to conduct a cluster analysis by one of the known methods, which will allow to formulate systematic requirements for the placement of a commercial component in the transport hubs.

The analysis shows that the presented direction of research is one of the most promising in the development of multifunctional transport hubs of public transport. In the future, it will be more detailed to consider the development of the commercial component in the transport hubs, the development of the technological component of hubs.

In addition, the work carried out showed that the approved parts of the planning projects for the territory of the transport hubs often have different forms, different terminology, different units for estimating the area of the buildings. In this connection, it is necessary to develop a unified approved part of the design of the transport hubs.

6. Conclusions

1. The development of the Smart City concept and the Intelligent Transport Network will help in the study of the existing state of public transport and transport hub systems.

2. It is necessary to define and clearly fix the composition of the objects of the transport hub in normative documents.

3. The analysis showed the presence of regularities between the volume of passenger traffic in the transport hub and the area characteristics of the objects located on the territory of the hub. The obtained regularities can be used in the development of transport hub planning projects.

4. Analysis of the indicators of approved planning projects, showed that further use of the relationship graph "passenger turnover - areas buildings of transport hub" requires further study and to date is not applicable.

5. The study of the relationship graph "passenger turnover - areas buildings of transport hub" is a promising direction of research, and it can also provide a nomogram for assessing the commercial potential of a hub in modern conditions.

6. To determine the composition of commercial buildings offered for placement in the territory of transport hubs, it is possible to use several methods, in particular: analytical (analyzing the currently approved plans for the planning of transport hubs) and theoretical (for example: cluster analysis).

7. The article proposes a multifactor model of the system of transport hubs, which can be investigated using cluster analysis, with the purpose of developing a system of requirements for the placement of a commercial component in the hubs.

References

[1] McLaren D, Agyeman J 2016 Sharing Cities: A Case for Truly Smart and Sustainable Cities *MIT Press* p 34

[2] Musa S 2016 Smart City - A Roadmap for Development *Journal of Telecommunications System & Management* vol 5 nom 3

[3] Peris-Ortiz M, Bennett D and Pérez-Bustamante Yábar D 2017 Sustainable Smart Cities: Creating Spaces for Technological, Social and Business Development *Springer International Publish. Switzerland* chapter 2 pp 15-29

[4] National standard of the Russian Federation 2016 GOST R 56829-2015 Intellectual transport systems - Terms and definitions p 1

[5] Decree of the Government of Moscow 2017 No 413 On the formation of transport hubs in the city of Moscow pp 29-30

[6] Vlasov D and Danilina N 2013 Scientific and Methodological Basis of Development of the Park-and-Ride Facilities in the Intermodal Transport Hubs of Moscow Agglomeration. *Advanced Materials Research* vol 869-870 pp 201-204