The Quality Management System Projects Transport Interchanges

M Panteleeva¹, S Borozdina²

¹PhD in Economics, Department of Economics and Management in Construction, Moscow State University of Civil Engineering, 129337, 26, Yaroslavskoye Shosse, Moscow, Russia
²PhD in Economics, Department of Economics and Management in Construction, Moscow State University of Civil Engineering, 129337, 26, Yaroslavskoye Shosse, Moscow, Russia

E-mail: anteikom@yandex.ru

Abstract. The transport industry of the Russian Federation in recent years has received significant technological development. The use of modern innovative solutions in the organization of the management process allows you to create SMART-type transport highways, that is, highways for which the social significance of the project is the main criterion for its quality. In this article the quality of the design solution for modeling the transport interchange is considered in two aspects: 1) the quality of the project, independent of its subject area; 2) the quality of the project product, determined by its subject area. At the same time, the critical moment of the quality management of the transport interchange project is the translation of the needs, desires and expectations of participants into requirements (criteria), which must be taken into account when planning the content of the project and its executors. The article proposes the author’s quality management system projects transport interchanges, which operates on the reconciling the needs and expectations of all the project’s stakeholders basis principle and the quality criteria achieved at different phases of the project life cycle. This model can significantly reduce the cost of implementation and future operation of the traffic intersection, since from an economic point of view it becomes, in fact, a self-sustaining subject of urban space.

1. Introduction
World practice in the field of road construction shows that modern transport interchanges combine the results of the creative work of talented architects, designers and engineers to achieve one global goal: increase in the usable area of the surrounding space usage with the constancy of the urban areas’ boundaries. Every year, hundreds of amazing road junction projects appear in different countries of the world: an underwater tunnel in Japan, the city of Tokyo; one of the highest bridges in the world named - Si Du, which is located in the People's Republic of China; the Dutch aqueduct Veluwemeer, an amazing architectural structure that connects two artificial lakes; the Krabbersgat aqueduct is the world's first unique mega-project with a tunnel for traffic, which was created in order to reduce the load on the transport bed; Puxi Viaduct – one of the largest interchanges in the world, located in Puksi, the historical centre of Shanghai. It consists of six levels and skips thousands of cars per hour; Oyamazaki Interchange roundabout is located in Osaka, Japan; The Businovskaya interchange, located
at the intersection of the North-Eastern Chord along with the head section of the Moscow-St. Petersburg highway and the Moscow Ring Road, was built in 2014. This is the first five-level transport interchange in Russia [1, 2].

All these examples prove that the breadth of engineering has no boundaries and can solve many problems associated with the congestion of highways and their individual nodes, and the lack of additional space for the construction of new roads. However, creating such unique facilities is not always possible to meet the needs of all stakeholders of the project implemented, especially in the context of the world automobile park rapid growth. According to the World Automobile Manufacturers Association (OICA), the production of motor vehicles in the world in 2014 increased by 3% compared to 2013 and by 34% compared with the 2005 result, reaching 89.5 million units. The number of cars in Russia increased in the period 1990-2014. from 11.9 to 48.4 million units. The average world number of vehicles per 1000 inhabitants is currently 174 units, which is 21% more than in 2005. For the EU, this figure is 590 vehicles for 1000 people, and for Ukraine - 204 vehicles for 1000 inhabitants.

As a result of this process, there is an ever-widening gap between the demand for the use of the road network and the supply volumes of the indicated public good [3, 4]. Demand is formed by citizens of nearby areas, who are affected by all the negative consequences of such an impressive construction, and the proposal is formed by design bureaus creating new projects, and historians-architects who struggle to preserve the historical appearance of urban space.

Academician G.P. Peredery said that the bridge as a transport structure should be strong, durable and beautiful. Only then can one demand economics. Using proportions, rhythm, scale, texture, color, nuance and contrast techniques and other means of architectural and artistic expression, the designer can create a structure in which functional and technical feasibility is combined with artistic completeness [5].

But today there is no way to completely agree with this statement, since it practically omits the question of the social effect of the project. Unconditionally, the manufacturability and functionality of an engineering structure is important, as is its cost-effectiveness. But do not forget that the elements of road construction are long-term projects and they must take into account not only the existing infrastructure, but also the future development of the urban space, taking into account the interests of citizens and other stakeholders of the project.

To neutralize this omission, special attention should be paid to the quality management process of the design solution for transport interchanges, which should have a systematic approach. The desire to apply a qualitative approach in construction projects is also associated with the active work of the public sector to tighten requirements for the safety of life and health of citizens and property.

2. Materials and methods

When creating the necessary quality management tool for the traffic intersection modelling design solution, two aspects must be taken into account: 1) the quality of the project as a whole, independent of its subject area; 2) the quality of the project product, determined by its subject area.

The first aspect should take into account the following quality requirements of any project: a) suitability for purpose or scope; b) meeting the reasonable needs and expectations of stakeholders; c) compliance with laws and regulations; d) compliance with the requirements of the company; e) compliance with the requirements of ecology and environmental protection; f) competitively priced sales; g) cost-effectiveness in terms of production costs of the project [6, 7].

The second aspect is directly related to the transport interchange project, as a construction and architectural object. The decision on the choice of these projects transport interchanges always depends on a set of determining factors, such as the power of intersecting traffic flows; the location of the transport hub - within the city or outside the city; the presence of foot traffic and public transport; the presence or absence of various kinds of communications; climatic and soil-hydrological conditions, etc. At the same time, in addition to the main transport component, they should also carry a
unique architectural image that improves or emphasizes the surrounding landscape of the area or the existing architectural composition of the residential territory, to produce an aesthetic impression [8, 9].

To manage all the above factors and criteria that determine the quality of the transport interchange project, it is necessary to create a quality management system (hereinafter QMS). Such a system should help the project to increase customer satisfaction and, as a consequence, increase its profit and increase efficiency. Since the needs and expectations of consumers (citizens and car drivers) are changing, and companies implementing construction projects are constantly under pressure due to competition, technological progress in the field of road construction, and changes in legislation, then organizations must constantly improve their projects and their processes based on the implementation of a quality management system [10].

The impact of the QMS on the profit from the implementation of the investment construction project is mainly indirect (decrease in the level of production defects, reduction of non-production costs, increase in the level of staff competence). But at the same time, only this system allows you to control various areas of the project’s influence (technological, architectural, economic, environmental, social), capitalizing the efforts made in profit.

3. Results

Transport interchange projects have a lot of features, both as building structures, and as social objects, and therefore the QMS should be a strict procedural mechanism (Fig. 1) [11, 12, 13, 14, 15].

Authoring QMS consists of five blocks:

BLOCK 1. Mechanism for assessing the potentials of the components providing the proposal. Within this unit analyzes the components of the road designs market that provide an offer (the length of new interchanges, consistently used by motorists). The second procedure is the assessment of potential supply volumes (the potential length of new interchanges, taking into account all options for reconstruction and new construction).

BLOCK 2. Mechanism for assessing the potentials of the components providing the demand. This mechanism allows the analysis of population groups that provide demand for new or reconstructed interchanges, and an assessment of the need for motorists in interchanges. In addition, an assessment of solvent demand for paid and budgetary interchanges is made.

BLOCK 3. Investment valuation. The block assesses the optimal investment volumes in the transport interchange project on the basis of the of demand equal potentials components principle (motorists' ability to use different types of interchanges by type and subject of financing) and supply (the length of new interchanges). The essence of the principle is that when assessing the permissible amount of financial resources to stimulate demand for transport interchanges, the potentials of the components providing supply and demand in the field of road construction must be balanced [16].

BLOCK 4. Assessment of funding. Assesses the amount of financing the demand for transport interchanges on the formation of resource sources: budgetary and extra budgetary funding [17, 18].

BLOCK 5. Assessment of the financing structure. This procedure is carried out in parallel with the assessment of financing volumes and involves the assessment of the optimal volumes and structure of transport interchange projects' financing and financing of projects providing energy resources and increasing the capacity of construction organizations implementing transport interchange projects [19, 20].
Figure 1. The QMS model of the transport interchange project, allowing to take into account the needs and expectations of all the project stakeholders [compiled by the authors].

The QMS model proposed by the authors needs to be specified and capitalized. To do this, the authors propose to evaluate the quality of the project based on the net profit margin, which will receive a construction company as a result of one year of the project, and the availability of a breakeven point between supply and demand in the road market. In this situation, the breakeven point (condition \( Q_S = Q_D \)) will be direct evidence of all the project stakeholders’ needs and expectations interconnection. To calculate the net profit from the implementation of the QMS, the authors propose the following system of equations (1).
\[
\Pi_p = \left\{ \left[ Q_{\text{cmp}} + Q_{\text{cmp}} \sum_j \Delta Q_j \right] \cdot \sum_j \Delta T C_i + \left( Q_{\text{cmp}} + \sum_j \Delta Q_j \right) \cdot R \cdot (1 - Y_P) - \left( Q_{\text{cmp}} + \sum_j \Delta Q_j \right) \cdot \sum_j \Delta Z_j - K \right\} \cdot (1 - H_n)
\]

\[
Q_S = T C_k \cdot \alpha + c
\]

\[
Q_D = \left( \frac{p_{\text{max}}^D - p_{\text{min}}^D}{N_D} \right) \cdot \delta + \gamma
\]

Where \(\Pi_p\) – the annual profit of the construction company, resulting from the implementation of the quality management system procedures [hereinafter QMS], in million rubles.; \(Q_{\text{cmp}}\) – the annual volume of construction and installation works of a construction company, in million rubles.; \(\Delta Q_j\) – increase in construction and installation work when implementing the j-th procedure of the quality management system by 1 million rubles, in million rubles; \(R\) – planned profitability of the construction company, \%; \(Y_P\) – risk level of lost profits by a construction company, \%; \(\Delta Z_i\) – cost increase during the implementation of the i-th procedure of the quality management system by 1 million rubles, in million rubles; \(H_n\) – income tax, in \%; \(Q_S\) – proposal (length of new and reconstructed road junctions) in km; \(TC_k\) – costs of creating 1 km of transport interchange, in million rubles; \(c\) – minimum bid price (minimum cost of the implementation of the transport interchange project), in million rubles; \(\alpha\) - the coefficient of change in the supply volume when the price changes; \(\delta\) - coefficient of change in demand when price changes; \(\gamma\) - the maximum possible demand for the use of transport interchanges, in million rubles; \(p_{\text{max}}^D, p_{\text{min}}^D\) - maximum (minimum) demand price, in rubles.; \(N_D\) – number of consumers, in pieces.

The proposed system of equations allows you to manage various criteria that affect the quality of the transport interchange project, starting from technical characteristics and ending with social significance. In addition, this system takes into account future procedures that were not planned when creating the transport interchange project.

4. Conclusion

The existing global world problem of cities and settlements with regard to the annual reduction of free spaces for laying motorways, as well as the accelerated motorization of the population and business (more than 4 times in the past 25 years), require the creation of a tool to manage this process in the context of the quality of the facilities being created. For this, the authors of the article developed the quality management system projects transport interchanges, which even at the planning stage of the project allows determining the profit from their implementation on the basis of the principle of equal potentials of market supply and demand components.

References

[1] Vramkakh 368-go zasedaniya Soveta Federatsii Federal'nogo Sobraniya Rossiyskoy Federatsii 25 fevralya 2015 goda analiticheskiy vestnik 3(556) (M.: Analiticheskoye upravlenieyie Apparata Soveta Federatsii) 64 p

[2] 2009 Programma deyatel'nosti Gosudarstvennoy kompanii "Rossiyskie avtomobil'nye dorogi"
na dolgosrochnyy period (2010-2020 gody) (Mintrans RF, Moskva) 

[3] 2008 Strategiya sozdaniya seti avtomagistralei i skorostnykh avtomobil'nykh dorog v rossiyskoj federatsii do 2030 goda Mintrans RF (Moskva) 

[4] Gafprova K E 2016 Ekonomika i biznes: teoriya i praktika 2 55 

[5] Yudenko M N 2015 Upravleniye kachestvom v stroitel'stve: praktikem (Rostov n/D: Feniks) 77 p ISBN 978-5-222-22780-0 

[6] Gibshman Ye M 1986 Ob'yekty arkhitektury Gibshman (M.: MADI) 123 p 

[7] Kartopol'tsev V M 2002 Konseptual'nye osnovy i znachimost' arkhitektury Problemy inzhenernogo obrazovaniya: materialy region. nauch.-metod. konf. (Tomsk) Tomsk: Izd-vo Tom. gos. arkhit.-stroit. un-ta pp 65-73 

[8] Transportnaya strategiya Rossiyskoy Federatsii na period do 2030 Mintrans RF (Moskva) 

[9] Lovin B A, Kazaryan R R, Chulkov V O 2019 Infografija antropotekhnicheskogo menedzhmenta Modul'nyy kurs lektsiy: uch.pos Pod red. D-ra tehn. Nauk, prof V O Chulkov (Moskva: Rossiyskiy universitet transporta (MIIT)) ISBN 978-5-7473-0939-5 T 2 Funktsional'nyye modeli Moduli 31 p 60 308 p ISBN 978-5-7473-0941-8 

[10] Chulkov V O 2007 Infografija Tom 4: Mnogourovnevoe infografichesko modelirovanie SvR-ARGUS (Moskva) 

[11] Gonga S B, Zhuravlev Yu A 2013 Regulirovaniye prostranstva rynka zhiloy nedvizhimosti: Monografiya (M.: INFRA-M; Krasnoyarsk: Sib.feder.un-t) 96 p DOI 10.12737/352 ISBN 978-5-16-006367-6 (INFRA-M.) 

[12] Panteleeva M S, Borozdina S M MATEC Web Of Conferences 106 08047 

[13] Panteleeva M S, Borozdina S M MATEC Web Of Conferences 106 08048 

[14] Panteleeva M S, Borozdina S M 2018 MATEC Web Of Conferences 193 01011 

[15] Panteleeva M S, Borozdina S M 2016 MATEC Web Of Conferences 193 05006 

[16] Bogonosov M N 2016 Otsenka sotsial'nogo effekta. pri obosnovii effektivnosti stroitel'stva avtomobil'nykh dorog Izdatel'skiy Dom «Nauka» (Moskva) 

[17] 1985 VSN 21-83 Ukazaniya po opredeleniyu ekonomicheskoy effektivnosti kapital'nykh vlozheniy v stroitel'stvo i rekonstruktisuiy avtomobil'nykh dorog Transport (Moskva) 

[18] 1980 Rekomendatsii po uchetu vnetransportnogo effekta pri planirovanii seti avtomobil'nykh dorog Minavtodor RSFSR (Moskva) 

[19] 1985 Rekomendatsii po planirovanii ocherednosti stroitel'stva i rekonstruktisii mestnykh avtomobil'nykh dorog s primeneniem EVM Minavtodor RSFSR (Moskva) 

[20] Kats V 1980 Effektivnost' stroitel'stva avtomobil'nykh dorog mestnogo znacheniya Transport (Moskva) 

[21] 2004 Stroitel'nye normy i pravila Avtomobil'nye dorogi (SNIP 2.05.02-85) Gosstroy Rossii (Moskva) 

[22] Ryzhkova V V, Petrov V V 2014 Monografiya (M.: RIOR: INFRA-M) 127 p DOI 10.127/457 ISBN 978-5-16-009075-7 (INFRA – M)