Modern Methods of Project Management in Road Traffic Organization

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Abstract. Transport service of the population is a difficult task. The efficiency of transportation processes depends on the road traffic organization. The road traffic organization requires modern approaches to solve the tasks and emerging problems. The concept «Lean Six Sigma» could be one such approach, which will be new tool to solve the road traffic organization problems. The article describes the example of improving the road traffic organization with using the concept of «Lean Six Sigma» on the street and road network section. The used tools in each phase of the «Six Sigma» project life cycle are listed.

1. Introduction

The road traffic organization is one of the most serious tasks of our time. The decrease of the average delivery speed, transport difficulties in critical and emergency situations, the steady increase of the transportation costs and many other problems are caused by the urbanization and motorization processes, which are characteristic of our time [1]. At the same time, the extensive way, which consists in development of the city street and road network, is almost everywhere exhausted and does not justify itself. An increase of transport offer leads to an increase of transport demand. The intensive way is a qualitatively new solution of traffic problems, which requires application of new approaches allowing to optimize the use of available resources and to improve the processes of the road traffic organization. The concept «Lean Six Sigma» may become a new approach to solve the problems of the road traffic organization.

The road traffic is a complex process of the traffic flows movement on specially designated ways, which are called the street and road network. The need for movement of users of the street and road network generates traffic demand. The transport offer is the ability of street and road network to satisfy the needs for movement of users of the street and road network (the street and road network capacity) [2]. The traffic capacity depends on the width of the roadway, the number of traffic lanes and the used means of the road traffic organization. The facilities of the road traffic organization are particular importance at intersections. The street and road network capacity decreases at intersections. It leads to congestion, increasing of delivery time of goods and passengers, rising fuel consumption and vehicle emissions.

2. Methods

The street and road network sections can be considered as the production line within framework of the concept «Lean Six Sigma». In this case, the intersections are production machines for processing goods, which are transport flows.

The structure of the «Six Sigma» project is a cycle DMAIC (Define, Measure, Analysis, Improve, Control). Each stage corresponds conducting the certain works and the use of certain methods.

The typical purpose of a traffic project is to increase the efficiency of the road traffic organization at an intersection. The project can be performed with the help of concept «Lean Six Sigma».
3. Results and Discussion
The use of the concept «Six Sigma» in the road traffic organization is considered by the example of the project to improve the efficiency of the transport process on the street and road network section of the Tyumen city. The street and road network section of the Republic street – Old Tobolsk tract street – Yalutorovsky tract street is shown in Figure 1.

![Figure 1](image-url)

**Figure 1.** Scheme of the street and road network section of the Republic street – Old Tobolsk tract street – Yalutorovsky tract street.

The phase «D» (define) corresponds the determination of the problem and the boundaries of the project. This stage includes conducting primary studies and a compilation of process flowcharts.

The problems detection, primary (preliminary) studies were conducted. They allowed to define the directions of the main transport demand, to reveal the problems arising on the street and road network section. The main diagnosed problems are:

– increasing transport demand in the direction from Republic street to Old Tobolsk tract street and Yalutorovsky tract street (morning);
– increasing transport demand in the direction from the streets of Old Tobolsk tract and Yalutorovsky tract to the Republic street (evening);
– insufficient capacity of key intersections and its entrances. This is especially evident when the street and road network capacity depends on additional factors such as precipitation, fog, ice-storm, etc. Traffic jams quickly reaches the maximum in these conditions. The possibility of implementation of the transport demand do not exist.

Preliminary studies include collecting data on traffic flows. The main indicator is the intensity of traffic flow or the volume of transport demand (intensity plus the number of cars in the queue forced to stop after the end of the main permitting cycle of traffic light) [3-10].
The passage of any of the regulated intersections is carried out in the permitting cycle of the traffic light. The flowchart of the intersection passage is shown in Figure. 2.
Figure 2. The flowchart of the intersection passage.

From the point of view of road users, the only valuable actions in the road traffic organization are those at which you can safely cross the intersection without braking and at the speed that the driver chooses at his discretion [11-14]. All the others actions (at which the driver is delayed waiting for the permission signal of the traffic light or reducing the speed for various reasons) does not add value to the process.

The «spaghetti chart» tool is often used at this stage of «Lean Six Sigma» projects. For the road traffic organization projects, the «spaghetti chart» can be replaced by a traffic intensity diagram. The following tool, which is called «Critical to quality characteristics tree», allows you to identify the characteristics of the process. In our case, the process is evaluated by the following characteristics:

1. Value of delay time (The best value is zero):
   - one vehicle when passing the area (sec);
   - total traffic flow per hour (h).
2. Average speed of traffic flow, km/h (The best value is 60 km/h. This is permitted speed on this street and road network section).
3. The number of conflict points on the intersection (the best value is zero):
   - number of conflict points between traffic flows;
   - number of conflict points between traffic and pedestrian flows.

The phase «M» (Measure) involves the data collection for analysis and decision-making. This stage includes:

- determination of the parent population and sample size;
- description of the data collection methods and their statistical processing. This is calculation of basic statistical characteristics (example in Figure. 3) and modeling (in particular, it is simulation modeling which is an integral part of modern projects in the road traffic organization);
- calculation of process characteristics such as sigma-level process (Table 1), process capabilities (Table 2). The calculation of sigma of the process for continuous data is presented in Table 1.
Figure 3. Bar chart of data distribution and basic statistical characteristics for selected traffic flows in the morning «rush hour» at one of the intersections of the study object.

| Table 1. The calculation of sigma of the process. |
|-----------------------------------------------|
| Parameter | Calculation result | Explanation |
|-----------|-------------------|-------------|
| ZUPPER    | 10.6              | number of standard deviations between the middle and upper limit of requirements |
| ZLOWER    | 0.4               | number of standard deviations between the middle and upper limit of requirements |
| Z₁        | 100%              | Percentage of observations located to the left of the upper limit / requirements |
| Z₂        | 33.7%             | Percentage of observations located to the left of the upper limit / requirements |
| Zₘᵩₜ     | 0.4               | The smallest of the available ZUPPER and ZLOWER |
| Percent   | 66.3%             | The percentage of observations located in the limits (Z₁ - Z₂) |
| Sigma     | 0.42              | Sigma of the process (Cpk·3) (The calculation does not take into account the shift of 1.5 Sigma) |
| Sigma     | 1.92              | Sigma of the process (Cpk·3+1,5) (The calculation takes into account the 1.5 Sigma shift) |

The obtained data indicates an unsatisfactory condition of the process. The sigma value is between the middle and the nearest (lower) preset limit (0.42) (minimum realizable speed set at 20 km/h). This indicates the need for corrective actions in the road traffic organization.

The $P_p$ index is above than 1. The process is within the preset requirements. However, the $P_{pk}$ index indicates that the process does not satisfy the requirements at the proper level. The nearest boundary is less than three sigma value from the middle value.
Table 2. The calculation of process capabilities.

| Parameter | Calculation result | Explanation |
|-----------|--------------------|-------------|
| \(P_p\)   | 1.84               | Coefficient of conformity assessment of requirements width to process width \((USL - LSL)/(6\times s)\) |
| \(P_{pk}\) | 0.14               | The coefficient estimates of output over the near border to the middle value \((Z_{min}/3)\) |

The phase «A» (Analysis) allows you to determine the reasons for the discrepancy between the initial and target levels of the process, as well as to confirm the impact of the selected reasons on the result of the process. For this purpose, «the method of statistical hypothesis testing» should be used.

In our example, the hypothesis is tested, according to which the elimination of traffic light regulation at the intersection significantly affects the change of the main characteristics of the process, in particular, the change in the average vehicle speed in the flow.

We formulate the null hypothesis. The difference between the average values of the traffic flow speed in the initial and the change transport situation made is zero. The significance level is 0,1 \((\alpha=0,1)\). This means that the hypothesis will be accepted or will be denied with a 90% probability. The overview of the results of the hypothesis test is presented in Figure 4.

Figure 4. The overview of hypothesis testing results.
The test statistics value does not exceed the range of critical values in accordance with the tested alternative (bilateral alternative hypothesis). The null hypothesis cannot be rejected.

According to the calculated data, the p-value are greater than α. The null hypothesis cannot be rejected in favor of the alternative hypothesis.

Thus, we accept the null hypothesis, since the value of Δ0 is within the confidence interval. The measure of the elimination of traffic light regulation affects the road traffic indicators in the studied section of the street and road network.

In phase «I» (Improve), the best solutions are proposed and are selected for solving the problems, pilot launch of solutions is performed, and a full-scale solution launch plan is developed [15-17]. For this purpose, the methods of group decision-making, various methods of generating ideas, methods of multi-criteria selection of the best solution are used.

The scheme of movement on «ring» type is chosen as the best decision in the project. The scheme is shown in Figure. 5.

![Figure 5. The scheme of the road traffic organization in the study section of the street and road network.](image)

The pilot launch of the solution was made on the basis of the simulation model of the street and road network section.

The final phase «C» (Control) is performed to support and strengthen the results which were obtained in the improvement of production processes. For this purpose, predicting future improvements, visual inspection and failure prevention systems are used.

4. Conclusions

The street and road network section was considered by analogy with the production line in the framework of the concept of «Lean Six Sigma». The «Lean Six Sigma» concept allowed:

- to identify the main problems in the street and road network section. This is uneven traffic flows and insufficient capacity of the street and road network section;
- to calculate the sigma value of the process for continuous data. The calculated data indicated the unsatisfactory condition of the road traffic process;
- to determine the reasons for the discrepancy between the initial and target levels of the process, as well as to confirm the impact of the selected reasons on the result of the process;
- to choose the best solution in the project.

References

[1] Panuccio P, Amodeo L, Lamari D and Scattarreggia T 2015 Urban Regeneration and smart sity
according to EU strategies: an urban distribution center in city logistics WIT Transactions on The Built Environment 146 pp 313-324

[2] Masek P, Masek J, Frantik P, Fuji daki R, Ometov A, Hosek J, Andreev S, Mlynk P and Misurec J 2016 A Harmonized Perspective on Transportation Management in Smart Cities: The Novel IoT-Driven Environment for Road Traffic Modeling Sensors 16 pp 208-231

[3] Russo F, Rindone C and Panuccio P 2014 The process of smart city definition at an EU level WIT Transactions on The Built Environment 191 pp 979-989

[4] Abouhassan M 2018 Urban Transport System Analysis WIT Transactions on The Built Environment 176 pp 57–68

[5] Ntzeremes P, Kiri topolou K and Tatsiopoulos I 2016 Management of infrastructure’s safety under the influence of normative provisions WIT Transactions on The Built Environment 164 pp 51-59

[6] Langeland A 2015 Sustainable transport in cities: learn in from best and worst practice? WIT Transactions on The Built Environment 146 pp 93-103

[7] Ramadhani F, Bakar K A, Hussain M A, Erixno O and Nazir R 2017 Optimization with traffic-based control for designing standalone streetlight system: A case study Renewable Energy 105 pp 149-159

[8] Jacyna M and Merkisz J 2015 Estimations in real urban traffic conditions as a determinant of shaping sustainable urban development WIT Transactions on The Built Environment 146 pp 219-231

[9] Magaril E 2015 Increasing the efficiency and environmental safety of vehicle operation through improvement of fuel quality International Journal of Sustainable Development and Planning 10 pp 880-893

[10] Kazopoulos M, El-Fadel M and Kaysi I 2004 Emissions Standards Development for an I/M program WIT Transactions on The Built Environment 74 pp 475-484

[11] Ertman S A, Ertman J A and Zharov D A 2016 Adaptation of urban roads to changing of transport demand E3S Web of Conference 6 pp 84-91

[12] Zhankaziev S V 2017 Current trends of road-traffic infrastructure development Transportation research pro cedia 20 pp 731-739

[13] Anisimov I A, Ivanov A S, Chikishev E M, Chainikov D A, Reznik L G and Gavaev A S 2017 Assessment of adaptability of natural gas vehicles by the constructive analogy method International Journal of Sustainable Development and Planning 12 pp 1006-1017

[14] Ertman J A, Ertman S A, Anisimov I A, Chainikov D A and Chikishev Y M 2015 Complex characteristic estimation of vehicle adaptability for low temperature operation conditions Research Journal of Pharmaceutical, Biological and Chemical Sciences 6 pp 1761-1770

[15] Zhao Y, Pan L, Yuguang C, Hao Y 2012 Can left-turn waiting areas improve the capacity of left-turn lanes at signalized intersections Procedia Social and Behavioral Sciences 43 pp 192-200

[16] Zakharov D, Karmanov D, Fadyushin A and Chistyakov A 2018 Simulation modeling of traffic for various types of traffic light’s regulation in conditions of intensive traffic of vehicles Journal of Mechanical Engineering Research and Developments 41 pp 58-61

[17] Soares G M, Almeida P S, Braga H A C 2017 A Fully Digital Smart LED Luminaire with Remote Management and Embedded Power Quality Analysis System International journal of control automation and systems 28 pp 644-653