PROPOSALS FOR DEVELOPMENT OF KOŠICE INTEGRATED TRANSPORT SYSTEM BASED ON MULTI-CRITERIA DECISION-MAKING

Peter BINDZÁR, Daniel MAČUGA, Dávid HEINZ

Technical University of Košice, Košice, Slovakia, EU,
peter.bindzar@tuke.sk, daniel.macuga@tuke.sk, david.heinz@tuke.sk

Abstract

The publication focuses on the current state of urban mobility in the city of Košice. It describes the current state of solution of the integrated transport system in the Košice region. The result is the implementation of solutions that would have a positive impact on the development of the city, improvement, efficiency and greening of public transport in the city of Košice by designing new tram lines to the Košice airport and the quarter Ťahanovce.

Keywords: City logistics, urban mobility, Integrated transport, City public transport

1. INTRODUCTION

The ever-increasing traffic load and the removal of the population from towns to villages more than before force us to think about improving the city's transport services [1,2]. Demand for commuting could be reduced or turned into walking. Another option is to regulate transport in some way to reduce its negative consequences. This problem can be solved by a quality public transport offer, which the population itself will increasingly use because it freely chooses - it will be more profitable for people [3,4]. In this way it is possible to satisfy the increased transport demands with lower negative impacts on the environment [5]. To some extent, the mobility problem can be solved by the integration of public transport, which also results in higher cost-effectiveness [6,7]. Despite the long-term debate in the Košice region on the introduction of an integrated transport system, this system has not yet been applied. In Slovakia, the integrated system is fully functional only in the Bratislava region, while in the neighbouring Czech Republic, an integrated transport system has been introduced in almost all regions.

2. INTEGRATED TRANSPORT SYSTEM KOŠICE - KORID

Integration of public transport is the cooperation of their providers for the benefit of passengers using the system. This means interconnecting all types of urban and regional transport, providing 'one-cast' services to passengers in terms of tariff and transport conditions, coordinating timetables, information, marketing and so on. The integrated transport system is the highest and most elaborate form of cooperation in public transport, where, within the framework of cooperation between customers and carriers, the essential competences for the integration of more carriers are transferred to a legally independent coordinator who works with his own staff and assets.

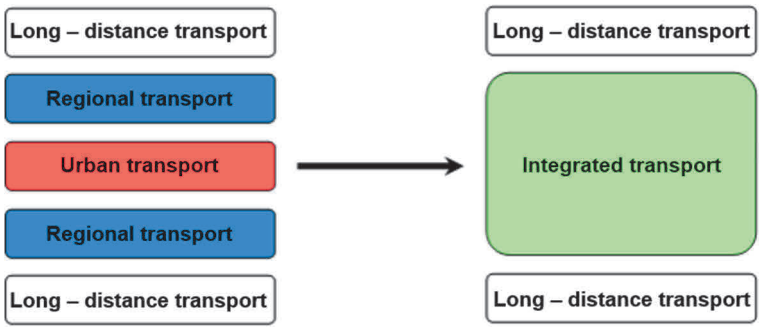

Figure 1 Integration of public passenger transport

Description of KORID

The city of Košice has been more intensively involved in the operation of integrated transport since 1992 and has undergone various stages of development and was originally intended mainly for the transportation of US Steel s. r. o. workers from and to the work. The result of this activity was a system of travel on one ticket and the transport of passengers served three different transport systems - public transport, bus transport SAD and railway transport ŽSR.

The Integrated Transport System (ITS) of the City of Košice and the Košice Self-Governing Region (KSK) under the single name KORID is a large-scale project that is currently in design and implementation. In order to reduce the negative effects of transport on the environment, the main element of the KORID system is rail transport. Due to its mobility, readiness and flexibility, road transport has gained wide representation, but its environmental impact is the most noticeable of the other modes of transport. Noise and atmospheric pollution increase from year to year just by increasing the number of cars on our roads. Road transport generates around 40 % of CO_2 emissions and another proportion of other pollutants that have a significant share in climate change.

The essence of the integration of public transport in the city of Košice lies in the use of rail transport as a supporting element of the whole system. Another great benefit is the fact that Košice has the same track gauge on tram tracks as on railway tracks, 1435 mm. The new hybrid tram system applied in the KORID system effectively solves the problem of “amphibian” on State railway transportation system and Košice public transport lines simultaneously. The new vehicle is a priority for KORID and solves the most serious problem, even though it will be the most expensive of other means of transport. The above-mentioned uniqueness of the city's rail system will allow the extension of KORID to the whole region by means of railway lines to nearby Prešov and its satellites.

Preferred building of systems combining tram and rail transport building of TT (tram-train) systems, which will bring rail transport closer to the sources and destinations of the roads, thus creating a prerequisite for the involvement of public suburban bus transport in ITS, where they will serve as a surface service of the territory with a link to the supporting rail network and the network of car parks, including individual car transport (Park & Ride, Bike & Ride, taxi services). Passengers using this system will be able to use ITS for transport in the city of Košice as well as for suburban and regional transport with service up to 100 km.

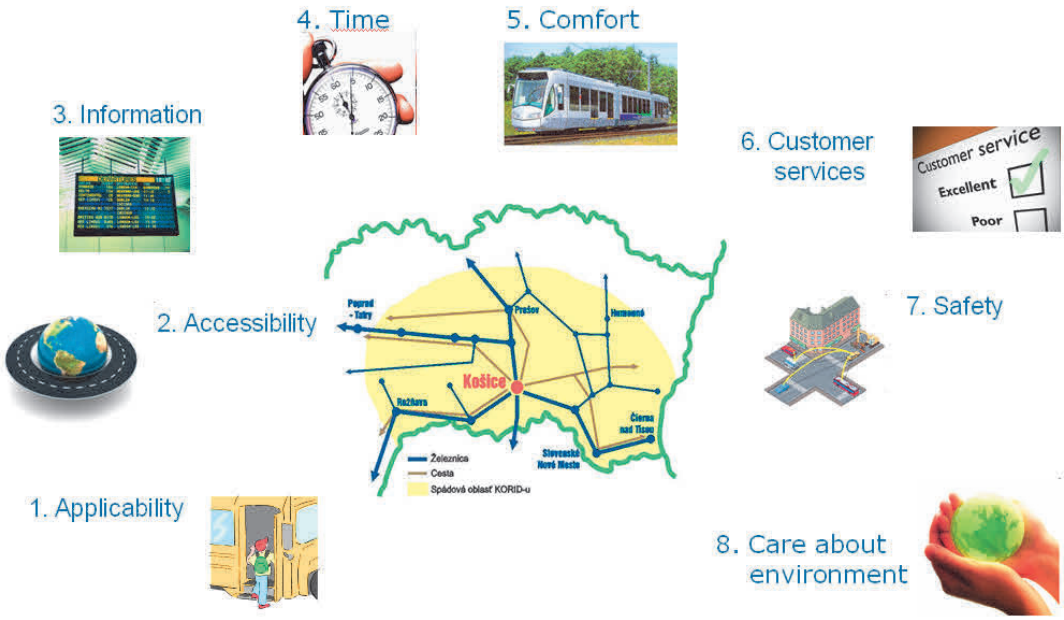

Figure 2 The scope of the integrated transport system KORID

3. SUGGESTIONS FOR RATIONALIZATION OF URBAN MOBILITY IN KOŠICE

3.1. Possibility to connect Košice airport and Pereš Industrial Park to the tram line

Tram connection of Košice International Airport will be solved in connection with the planned development of the IMMOPARK industrial park with relocation of the existing tram line through the airport. The proposed tram connection of Košice Airport to the network of the public transport - Moldavská - VA USS railroad should serve for direct transport service of Košice Airport and IMMOPARK industrial park. The site is located on the outskirts of the core city by the road I/ 50 E571 Košice - Zvolen - Bratislava. Direct communication connection to Košice International Airport is passing through this locality. It is an area of 190 ha with the possibility of further possible expansion, so far used as agricultural land and industrial area. The location has a good connection to the city's communication system and public transport. In the pre-press area, the tramway turnover and the continuation of the tramway along the Air Museum to the direction USS are proposed. In **Figure 3** it is possible to see the proposed connection of the tramway with the Košice airport. The relocation of the line envisages the preservation of the tram stops “Perešská” and “Poľov, rázcestie” on the high-speed line and also the preservation of the stop “Priemyselný park pri letisku” of the bus line 23. It is possible to consider transformation of bus line no. 23 into tram, which runs from the station square through the industrial park to the airport at hourly intervals. The expected capacity is 350 passengers per hour, the total transport capacity offered in one direction is 5,950 passengers per day, which is about 2 million passengers per year. In addition to this line, the R lines will also operate via the airport to US Steel.

With the possibility of interconnection of the DPMK tram network with railway network of ŽSR in the area of the railway station Košice (Staničné námestie) will thus be able to consider direct train connection of Košice Airport from Poprad - Spišská Nová Ves - Kysak (Prešov) in the future. For this type of public transport within KORID, it is considered in the future to introduce a hybrid regiotram (TRAM-TRAIN), which can be operated on the ŽSR network and on city railways.

Figure 3 Relocation of the tramway through the airport

3.2. Interconnection of a quarter Ťahanovce with the city by tram

The interconnection of the rail network of the city public transport and ŽSR rail network at the terminal Sever node will be solved as a part of the tramway concept to the quarter Ťahanovce. The priority phase of the construction of this terminal is to build a stop on the existing double-track railway line and transfer links to the trolleybus stops on Hlinkova Street and the TESCO store. Part of the parking lot in front of the store is proposed

and reserved in P + R mode. It is important to deal with the terminal Sever area with regard to the mentioned links, to future additions of the tram line. The currently unused siding to the former magnesite plants, including a single-track bridge over the Hornád River, is proposed to be adapted and used as a tram line.

The track-side solution indicates that it will be possible to use the regional tram-train and suburban rail system in a versatile manner and in enough capacity for all combinations of relationships:

- Kysak - Košice, railway station (ŽSR only)
- Ťahanovce - Košice, NMM (tram only)
- Kysak - Kosice, NMM (railway - tram)
- Ťahanovce - Košice, railway station (tram - rail).

The basic criterion is a technically feasible rail connection to the existing railway line ŽSR and the newly established stop Košice - Sever. The main basis for designing the modified track route were maps and visual inspection of the proposed routes.

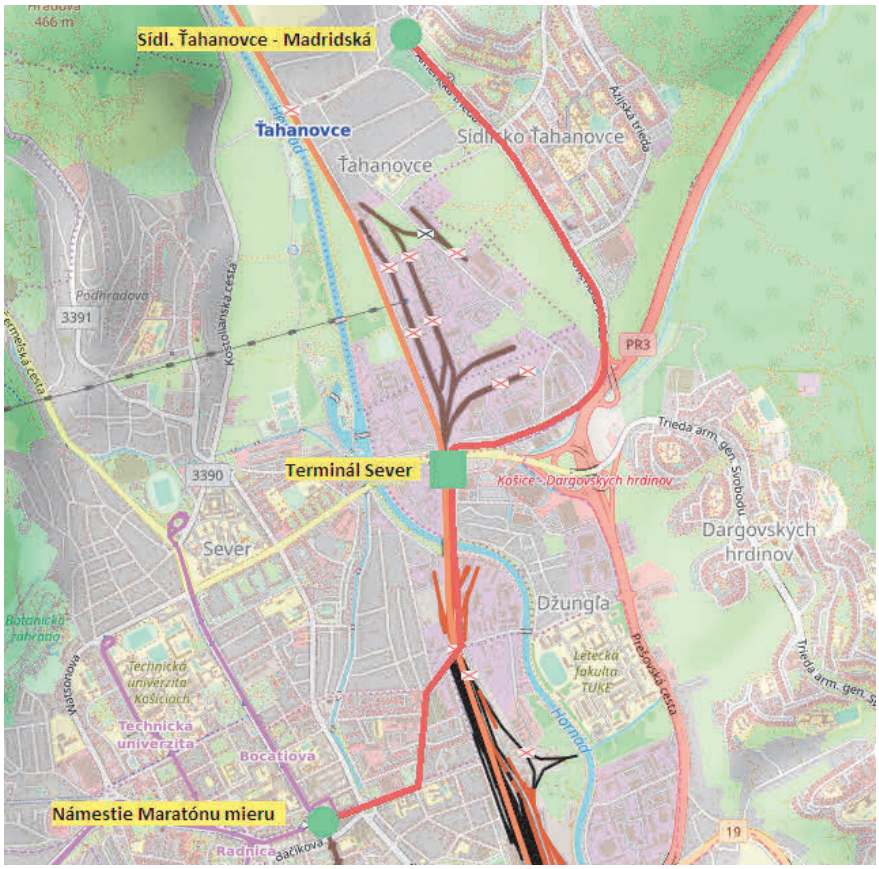

Figure 4 Connection of quarter Ťahanovce to rail transport

The proposed route of the new line

The route is 2,852 km long. From the connection to the railway station, the route runs under the overpass and leads through the space next to the road and industrial buildings, crossing the supply road to Ťahanovce. After shaking to Americká trieda, they join the existing intersection next to the church. It is also guided by a green belt separating two two-lane roads. The final stop is in front of the Americká trieda - Madridská junction. The route will leave the original stops - Church, Municipal Office, Overpass and Madridská. The proposed speed is 80 km/h. At the final stop, a simple rail connector is inserted into the track to allow the crossing of tram sets. In **Figure 4** shows the proposed connection of the quarter Ťahanovce to the network of urban railways with

connection to the ŽSR line in the terminal Sever. The proposed tram line is marked in red and starts with the connection to the existing tram line at the Námestie Maratónu mieru, continues on Hviezdoslavova Street, where it crosses a roundabout and then continues along Masarykova and Alvinczyho streets. At the end of Alvinczyho, it continues along Rampova Street, where it crosses the ŽSR line and along the ŽSR line enters the proposed stop Terminal Sever, which is designed as a transfer station with the possibility of the passage of railway vehicles on the ŽSR and public transport networks. From the Terminal Sever, it goes to Americka trieda at Ťahanovce quarter, to the final stop at Ťahanovce - Madridska.

4. LOCAL POPULATION SURVEY ON PROPOSALS

In the period from April 1, 2019 to April 22, 2019, a local population survey was carried out in the form of an electronic questionnaire in order to obtain an opinion of the local population regarding the satisfaction of urban mobility in Košice and new proposals for improving urban mobility in the Košice region. A total of 210 respondents were involved in the survey.

Of all the questions we have selected 2 which are related to this article:

1) Would you welcome the extension of the tram line to the airport?

This issue was monitored as effective would be to extend the tramway to the airport. Of the total number of 210 respondents, 169 respondents, which represents 80.5 %, would welcome the extension of the tram line to the airport. Twenty-seven respondents answered that they would not welcome the extension of the tram line and the fourteen could not comment.

2) Would you welcome the extension of the tram line to quarter Ťahanovce?

By this question was monitored as effective would be the extension of the tram line to quarter Ťahanovce. Of the total number of 210 respondents, 166 respondents, representing 79 %, would welcome the extension of the tram line to the quarter Ťahanovce. Twenty-six respondents said they would not welcome the extension of the tram line and eighteen could not comment.

5. EVALUATION OF PROPOSALS FOR RATIONALIZATION OF URBAN MOBILITY IN KOŠICE

5.1. Multicriteria evaluation

It is one of the methods of comprehensive assessment, which minimizes the degree of subjectivity in choosing the appropriate variant. The task of multicriterial evaluation of variants is to describe the objective reality of the selection using standard procedures and thus to formalize the given decision problem, i.e. to convert it into a mathematical model of a multi-criteria decision situation.

The aim of multicriterial evaluation is to assess several variants of solving a given problem according to selected criteria and to determine their order.

There are two ways to rate:

- Maximize - the better it meets, the more points.
- Minimize - the better it meets, the fewer points.

General procedure for solving tasks using multi-criteria decision-making:

1) defining the criteria by which the options will be evaluated,
2) determination of weights for individual criteria (standardized or non-standardized),
3) calculation of partial utility of variants for individual criteria,
4) calculation of the overall usefulness of the options,
5) selection, determination of optimal variant (max, min).

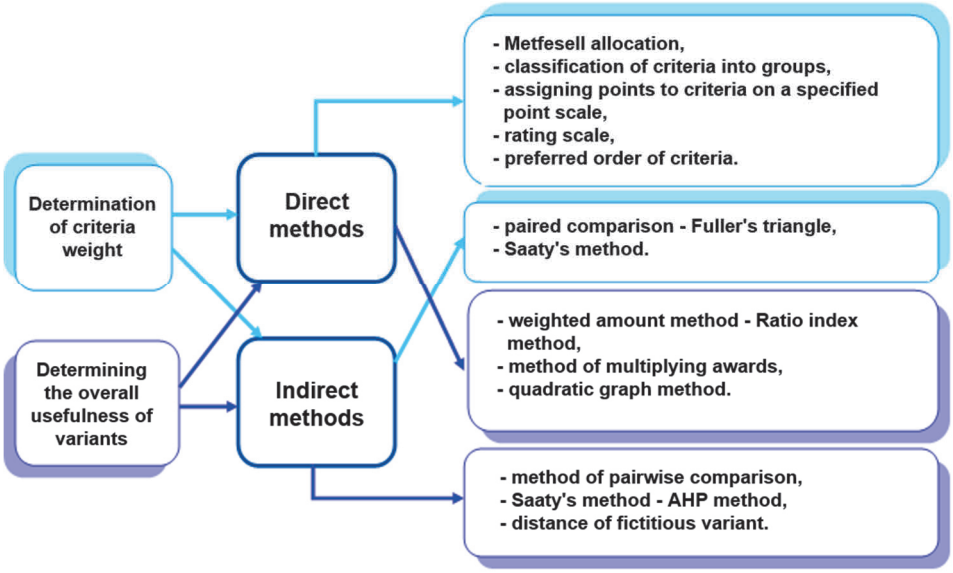

Figure 5 Multi-criteria evaluation methods

Determination of criteria weight

- Group determination of criteria weights, expert approach (heuristic approach),
- Application of indirect methods - determination of criteria weights (mathematical approach),
- Gradual change of weight values of individual criteria, resp. using several methods and comparing them (combination approach),
- Weights express the importance of the criterion, but also indicate the ratio of importance between the criteria,
- It is recommended that the balance is equal to 1.

Expert approach to weighting criteria (non-standard)

- Weights are determined by experts based on their experience in the range of values,
- Criteria are evaluated in a pre-defined interval of so-called. cardinal rate <1, K>,
- Cardinal rate, i. the rating range defines the sensitivity of the method.

5.2. Evaluation of proposals

Two proposals were proposed to improve urban mobility in the urban area of Košice, namely:

- Proposal 1 - Connection of Košice Airport and Pereš Industrial Park to the tram line.
- Proposal 2 - Interconnection of quarter Ťahanovce with the city by tram.

The multicriterial method was used. Weights were given for the selected criteria [7,8]. The sum of the weights is 1. The improvement of mobility as the most important criterion was determined by the weighting 0.3. The technical solution and the construction costs were determined by the weighting 0.2, as these aspects play an important role in planning and building important transport constructions. Ecologicality was determined by weighting 0.1. The social importance is important [9,10] and therefore weighted by weighting 0.2. The weights of the individual criteria were multiplied by the degree of alternatives of the individual criteria, based on expert opinions and the output of the local population survey. Alternative levels were set from 1 to 10. Where 1 is the minimum and 10 the maximum.

In **Table 1** is processed using the multi-criteria decision-making method between two proposals. Proposal No. 2, the interconnection of the quarter Ťahanovce with the city by tram track reached the most points, 8,1, and therefore the city of Košice and the competent authorities should deal with this proposal as a priority. The second one is proposal No. 1, connecting Košice airport and Pereš Industrial Park to the tram line, which reached 7.4 points.

Table 1 Multicriterial decision making of proposals

Criterion	Weight	Proposal 1		Proposal 2	
		Points	Result	Points	Result
Improving mobility	0.3	7	2.1	10	3
Technical solutions	0.2	8	1.6	7	1.4
Ecologicality	0.1	7	0.7	9	0.9
Construction costs	0.2	8	1.6	6	1.2
Social importance	0.2	7	1.4	8	1.6
TOTAL	1		7.4		8.1
RANK			**2**		**1**

6. CONCLUSION

The article dealt with urban mobility in the city of Košice. Solutions were proposed for the rationalization of the mobility of the population in Košice, two proposals were proposed, namely the connection of Košice airport and Pereš industrial park to the tram line and connection of the quarter Ťahanovce to the system of city railways. In conclusion, the work was evaluated and a proposal to improve the mobility of the population in the city of Košice was selected using the multi-criteria decision-making method, which should be addressed as a priority.

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