CHOICE OF THE BEST PUBLIC TRANSPORTATION SYSTEM FOR THE CITY OF CRACOW AND CRACOW DISTRICT

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ABSTRACT

A problem of public transportation system of the city of Cracow and Cracow district is dealt with in the paper. Application of a rapid railway service (KSKM) is proposed which would utilise present and planned railway network (Moryl, 1999; Moryl, 1999a). Integration of the service with other public transportation subsystems is also discussed. Results of system analysis of multi-dimensional benefits and costs of such system is presented.

Keywords: city, region, transportation, public, analysis, multiple attributes choice, AHP/ANP.

1. Introduction

Contemporary transportation system does not only deal with transfer of people, products, energy and information. It influences surrounding environment a lot. Quality of living space of people is thus influenced a lot. These problems are apparent in the case of city of Cracow and its environs. This is mainly because of insufficient road and railway transportation infrastructure and marginal links between different component subsystems. The problems can even escalate in the nearest future due to increase in a number of mobile workers, students, development of touristic and recreational activities and suburbanisation.

The paper is devoted to improvement of public transportation system for the city of Cracow and its district (Fig.1). Application of integrated transportation system based on utilisation of a rapid railway service is proposed with this regard.

2. Proposed transportation system

Considered system is of complex nature. Tracks comprise a backbone of the system. Two-system (rail and tram) light rail vehicles use them. There are common rail and tram/bus stops to facilitate passenger change. Areas of lower public transportation demand are served by local tram or bus lines. Their end stops allow change for KSKM. There are also Park & ride parkings which accompany SKM stations in less urbanised areas. The parkings encourage population to use public transportation instead private cars in downtown areas. The necessary conditions for successful system implementation include unification of transportation network parts structure, timetables and fares.

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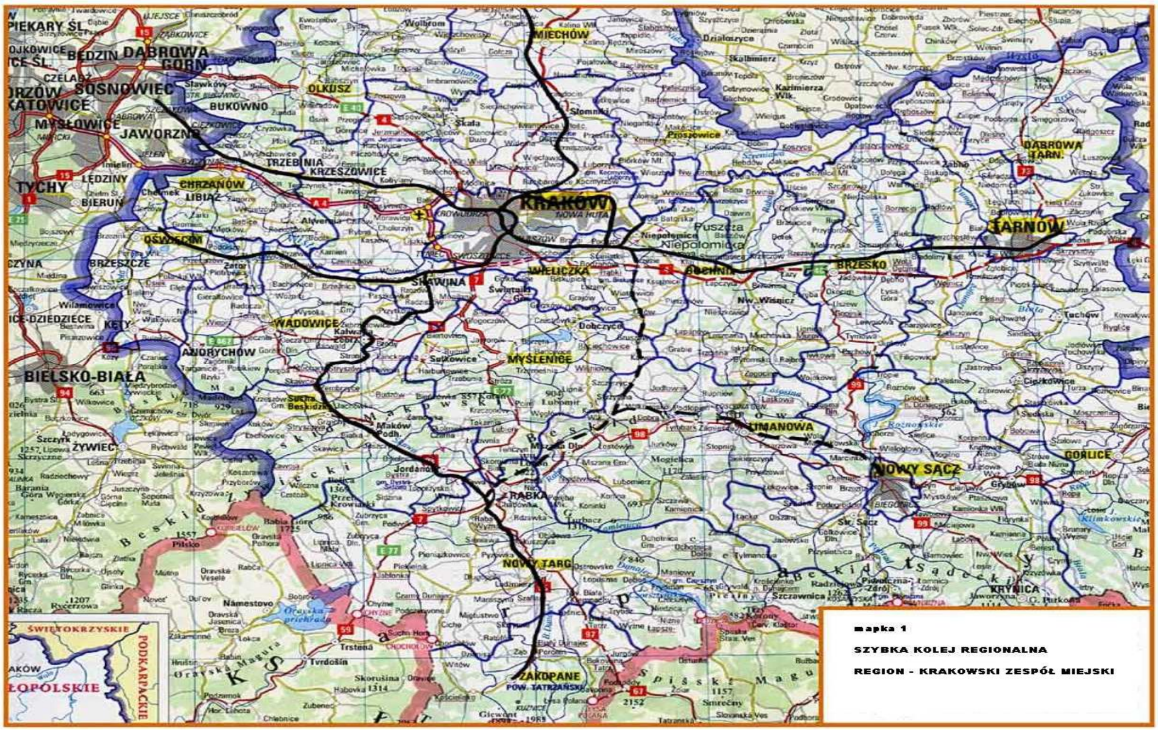

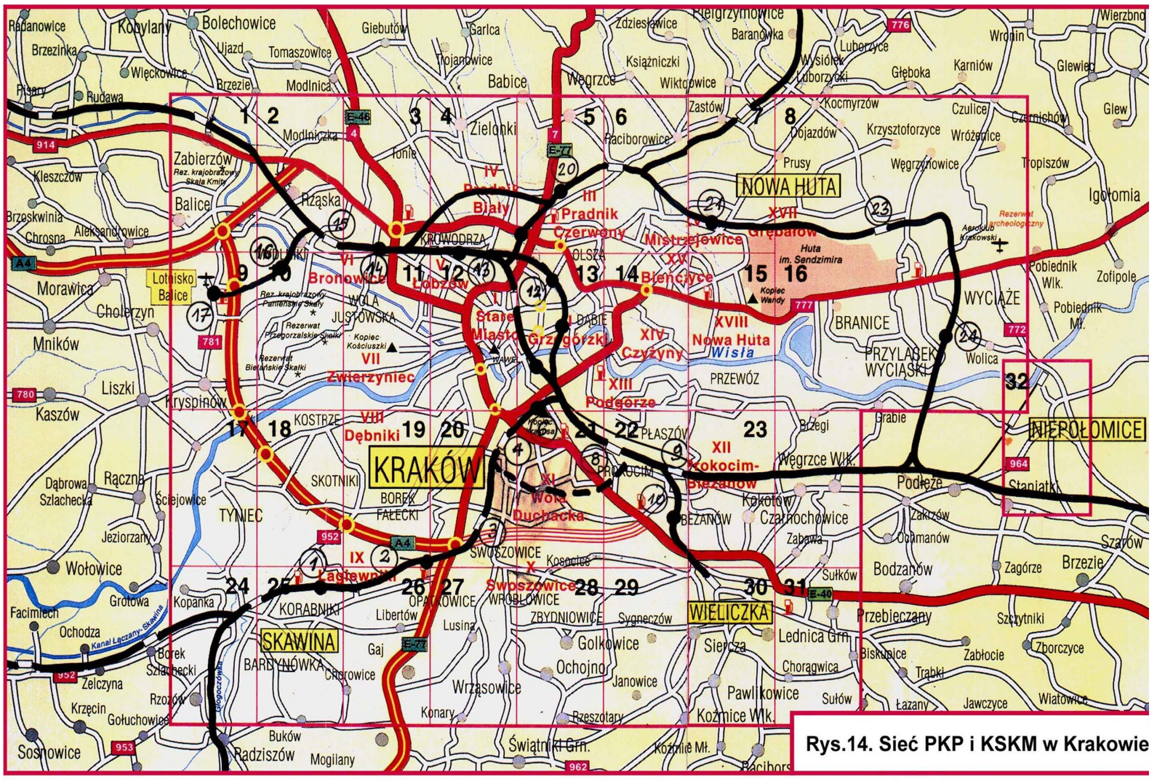

Rys.14. Sieć PKP i KSKM w Krakowie

Figure.1. Transportation system in city of Cracow and its closest environs

Application of rail transport as the main public transportation service seems to deliver several advantages: low energy consumption per passenger, high speed of travel in downtown area, security (small number of accidents), environmental friendliness (low influence level on environment).

AHP analysis is applied to show scale of advantages of proposed system implementation.

3. AHP analysis

The KSKM-based system is compared with three other applicable public transportation alternatives: railways, trams and buses. Three control criteria are utilised: functional, environmental and economic. Functional criterion is important for passengers because functional merits influence comfort of travel. The criterion groups the following covering criteria: intensity of service, service availability, time of travel (door to door), travel comfort, number of necessary passenger changes, security, punctuality and implementation difficulty. The group of environmental criteria addresses influence on surrounding environment. It consists of noise thread, pollution of atmosphere, pollution of water and soil, landscape disturbance. Economic control criterion is important for a different group of stakeholders, namely investors and owners of services. It groups the following covering criteria: construction cost, cost of equipment, operational cost, personal cost, possibility of multi-phase implementation, difficulty of demolition, accessibility to equipment, cost of dispossession. Applied AHP control hierarchy is presented in Fig.2.

Priorities of criteria and decision making alternatives with regard to covering criteria are obtained using 1-9 linear AHP scale. Right-hand eigenvector method is applied for estimation of partial priorities for criteria and decision alternatives. Judgments are provided by both authors. Their values correspond to compromise reached by the authors. Required consistency level *c.r.* < 0,10 is satisfied inside all considered groups of compared objects - criteria and decision making alternatives.

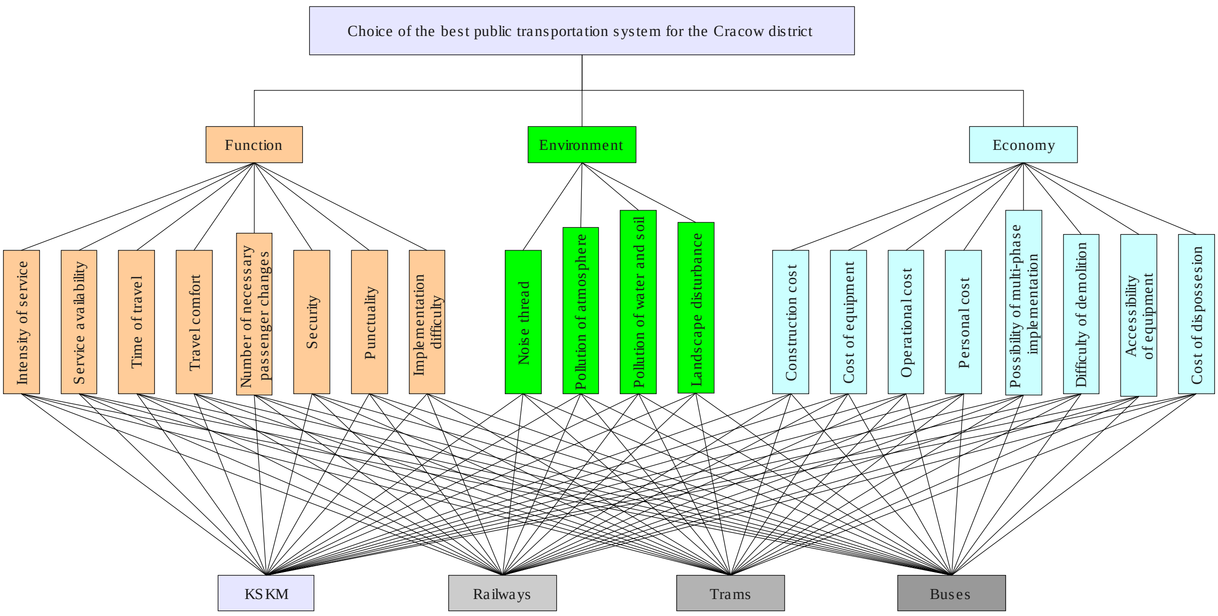

Fig.2. Applied AHP control structure

Analysis is conducted for different assumptions with regard to priorities for criteria. Basic results are obtained using fixed and equal control criteria priority levels presented in Tab.1. Final priorities obtained for considered public transportation mode alternatives are also included in Tab.1.

Table 1. Basic results

Control criterion	Function	Environment	Economy	
Priority	41.3 %	32.7 %	26.0 %	Results
Transportation mode	SKM	Railways	Trams	Buses
Normalised priorities	34.2 %	27.1 %	20.8 %	17.9 %
Ideals	1	0.79	0.61	0.52
Rank	1	2	3	4

A sensitivity analysis is also conducted. The sensitivity analysis allows to draw conclusions about robustness of considered transportation alternatives. Four different sets of criteria importance levels are assumed. The first one pertains to a scenario with small differences in control criteria priorities (balanced scenario). Three remaining sets are devoted to scenarios of a single criterion dominance over two other criteria. The first of them deals with dominance of the functional criterion, the second one pertains to dominance of the environmental criterion while the last one is devoted to dominance of the economic criterion. All four sets of criteria priorities are presented in Tab.2 and global priorities for transportation modes are included in Tab.3 and Fig.2.

Obtained results confirm conclusions made in the case of equal priority levels of all three control criteria. It is evident from presented results that KSKM alternative dominates other alternatives in any scenario. It profits by both functional and environmental criterion. Ranks of other alternatives are also consistent. The Railways constitute the second best alternative. The Trams are the third best alternative followed by the Bus alternative. Static nature of mentioned order of alternatives is supported by small differences in alternative priority values due to changes of control criteria priorities. The Buses alternative profits by only economic criterion.

Table 2. Normalised criteria priorities for the scenarios

Scenario name		Function	Environment	Economy
Balanced	[%]	41.3	32.7	26.0
Functional	[%]	60.0	22.3	17.7
Environmental	[%]	33.7	45.0	21.3
Economic	[%]	22.3	17.7	60.0

Table 3. Final normalised (and ideal) priorities for transportation modes obtained for different scenarios

Scenario name	KSKM	Railways	Trams	Buses
Balanced	34.0 % (1.00)	27.8 % (0.82)	20.6 % (0.61)	17.6 % (0.52)
Functional	34.7 % (1.00)	28.0 % (0.81)	20.7 % (0.60)	16.6 % (0.48)
Environmental	34.1 % (1.00)	27.8 % (0.82)	19.8 % (0.58)	18.3 % (0.54)
Economic	31.2 % (1.00)	27.5 % (0.88)	22.3 % (0.71)	19.0 % (0.61)

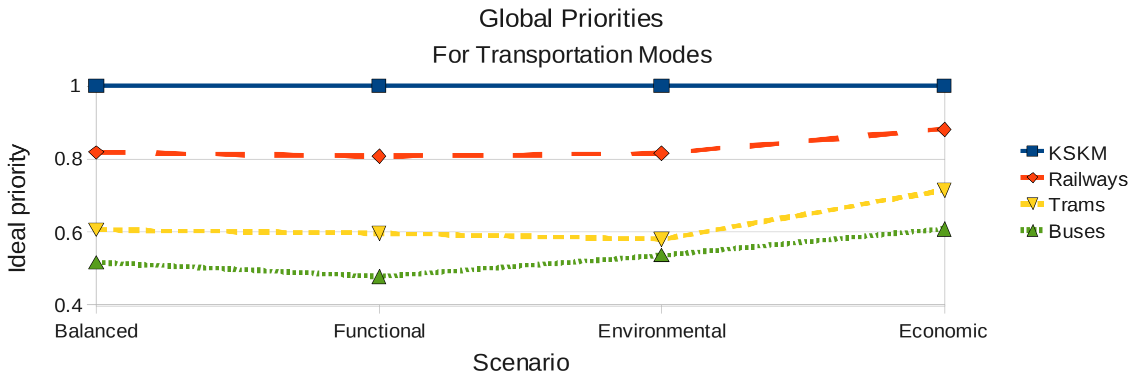

Fig.2. Results of a sensitivity analysis

4. Conclusions

The analysis reveals superiority of the KSKM-based system. Its advantage over other alternatives results mainly from noise thread, atmosphere pollution, travel time, service availability and security. Differentiation of control criteria importance doesn't influence advantage of SKM-based alternative a lot. Its advantage over other alternatives seems, however, to diminish a little in the case of high importance of economic criterion.

Obtained results make it possible to draw interesting conclusions e.g. with regard to desired share of services in both downtown and suburban areas. The bus services appear to be the most interesting complementing subsystem alternative to KSKM subsystem in both cases.

Expected effects of proposed system include:

1. Reduction up to one third of automobile transportation amount inside city borders and up to one fourth of automobile transportation outside the borders. The reduction will considerably shorten travel time inside the city. It will result in abandoning of a rapid tram line building project. It is also good for integration of the city and its environs.
2. A considerable shortening of regular travel from suburban areas.
3. A through improvement in environment state (reduction of noise, air and soil pollution).
4. Improvement in travel safety. Reduction of standard tram lines and introduction of new traffic lines for buses, emergency and fire brigade services in the city center. Decrease in number of accidents, casualties and resultant costs.
5. Cancellation of severe restrictions to private transportation in the city center.
6. Increase in touristic attractiveness due to improvement in accessibility.
7. Exceptionally short travel time from and to Cracow airport. This is important for because of touristic and business development.
8. Creation of advantageous conditions for bicycle transportation due to bicycle parkings situated near perspective KSKM train stations.
9. Limitation of demand for new car parking in the city center and pressure to equip perspective KSKM stations with car parkings.
10. Facilitation of shopping and other public services thanks to locating public services near perspective KSKM stations.
11. Increase in attractive areas for erection of buildings in vicinity of perspective KSKM stations. The increase will result in additional income for local communities. The income can be utilised for investments in municipal transportation infrastructure.

12. Decrease in building and operational costs comparing with other considered public transportation alternatives. Potential savings result from avoiding considerable costs of realisation of a 5 meter deep and 400 meters long tunnel for a rapid tram line in the highly urbanised city center area and costs of extension of bus transportation lines in areas which will be served by KSKM lines.
13. Creation of many new work positions in industry and public services in the city and its environs due to improvement in comfort of regular travel.
14. Development of civil engineering outside highly urbanised areas but within reach of KSKM services. Taking away troublesome plants outside the city.
15. Reduction of considerable spending for extension and utilisation of a road infrastructure.
16. Rapid access to the city center. This will result in advantageous placement of vital services e.g. hotels, campings, sports facilities, dormitories outside the city center but within reach of KSKM services.
17. Interception of unprofitable links from public railway services by municipal carrier. Improvement in profitability due to increase in number of passengers.
18. Improvement in reliability and punctuality of public transport services thanks to application of services which use devoted collision-free tracks.
19. Reduction of costs and decrease in disruption of public transportation operations which result form winter season conditions.
20. Improvement in access to existing and future recreational and rest facilities.
21. Decrease in investment and operational costs comparing with range of services delivered by concurrent transportation alternatives.

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