FLEXIBLE PUBLIC TRANSPORT SERVICE – SOLUTION FOR LOW PUBLIC TRANSPORT DEMAND AREAS

Marián Gogola[1]

Abstract: This paper deals with problematic of implementation of flexible public transport service in low demand areas. In spite of many advantage, it is not such of type of public transport service implemented, even if the real reasons in operational and economical sense exist. In addition, the paper demonstrates these arguments on chosen PT lines.

Keywords: flexible public transport service, transport demand, low demand areas

1. INTRODUCTION

Public transport service (PT) is characterised by complex of technological and technical condition and requirements. In the last years, public transport have benefited from many physical and operational innovations but after socio-economical changes in society began the process of decreased usage of PT in the Slovak Republic, on the contrary the car ownership noted increasing trend.[7] A lot of projects, researches are still trying to find out the solutions for improvement and higher rate of usage of PT.[6] Because the main role of PT in general terms is to serve to public in order to satisfy its travel needs or provide the opportunity to travel from any origin to any destination for group of inhabitants who do not have any possibility of mode choice except PT. Naturally, the PT system needs for own operation to complete some requirements[5], which are the essential for right operation.

The most important requirement is to know and find out the stable volume of the potential passengers. Based on that is possible to choose the suitable PT mode. This explains the advantages and disadvantages of various types of PT modes as for instance railway which is more suitable for transport of huge volume of passengers, but it is not such flexible as bus. Of course also from the economical point of view it is important to know the volume of passengers in some areas. In high density areas where the usage of PT service is high, the operation costs and income are more –or – less in balance. But in less density or low PT demand areas an operation of PT service usually depends on public finance subsidies from self or state government. Here is one very important question to solve: How to provide a PT service in level which can satisfy the travel needs of inhabitants in low demand areas and don't invoke higher demand on public finance?

[1] Ing. Marián Gogola, University of Žilina, Fakulty of Operation and Economics of Transport and Communications, Department of Road and Urban Transport, Univerzitná 8215/3, 01026 Žilina, Tel. +421 41 513 35 37, E-mail: Marian.Gogola@fpedas.utc.sk

2. WHAT TO DO IF THE PASSENGER VOLUME IS LOW?

2.1. When flexible PT service is much ahead?

The experiences and data of PT carriers [8] show that except the morning and afternoon peak, the passenger flow is not stable and differs from area to area and from stop to stop. That means, some PT line e.g. usually in early/late morning/night hours or in far-away areas are significant by very low level of vehicle occupancy. These lines with vehicle capacity of 45 seats are often carrying from 2 to 6 passengers and in some days no one. One of the biggest problems is fact that PT demand in such type of areas is very difficult to estimate because of socio-economical or demographic features. Mathematically the low PT demand (LPTD) for vehicle can be formulated in following equations:

$$LPTD \leq 0{,}25 * C_{vehicle} \qquad (1)$$

where $C_{vehicle}$ is total vehicle kapacity

In fact, the fixed scheduled of PT line is not use in efficiency way. Such type of PT line is subject of public finance subsidies. Also the results show the ineffective way of public finance spending. In such case it will be probably better to implement the flexible PT service on demand. This type of PT service already has shown its advantage for older or handicapped inhabitants. But in general, there are two basic types of flexible PT service.

1. The PT line operates in some route, but it is able to change the route, if demand occurs.
2. The PT line is waiting in depot for direct demand, e.g. dial-a-bus.

For implementing flexible PT service it is necessary to know in advance:

- Identify the potential low PT demand areas
- Asses the principles of operation (Operational issues connected to flexible services include allocating schedule time between fixed-schedule and demand-responsive operation; reservations, scheduling, and dispatch for demand-responsive operation; contracting; driver selection and training; and vehicle selection.)
- Allocation of scheduled time (Flexible operation by its nature requires a fixed schedule that defines when vehicles will be at time points, but one that also leaves time for responding to demand-responsive service requests. The flexible service types can be ranked according to the degree of flexible and fixed-schedule operation inherent in their designs.)
- Assess the fare system.
- Identify the demand response system (This feature allows to identify if passenger will request line by phone call, internet, SMS or other technologies and ways.)
- Estimation of Route deviation - Route deviation is necessary to estimate in order to prepare for the line the “reserved amount of time” which must be taken into account in time-scheduling.
- Estimation of Time – schedule deviation – Time scheduled deviation provides basic information for waiting passengers at the stops in sense, how much they will wait for PT line.

The best practise is to integrate flexible PT service in integrated public transport system. After that PT flexible services are able to be operated in conjunction with fixed-route services. This feature allows the passengers to transfer from one to other PT mode. Coordination is most important for demand-responsive connector services, which by definition have a connection to fixed-route service as one of their principal features.

3. MATHEMATICAL BACKGROUND FOR FLEXIBLE PT SERVICE

For mathematical modelling and simulation of flexible PT service are common to apply the Graph theory methods (e.g. Travelling Salesman Problem) and Vehicle routing problem (VRP) methods. [1-4] The formulation of the VRP follows: it considers the problem of routing at minimum cost ***c*** (see eq.2) a uniform fleet of K vehicles, each with capacity ***C***, to service geographically dispersed customers, each with a deterministic demand that must be serviced by a single vehicle. Let V be the set of n demand nodes and a single depot, denoted as node 0. Let d_i be the demand at each node ***i***. It considers the fully connected network, and denote the deterministic travel time between node ***i*** and node ***j*** by c_{ij}. The arc-based model considers integer variables x_{ij} which indicate whether a vehicle goes from node ***i*** to node ***j*** or not. In addition, the formulation includes continuous variables u_i for every $i \in V \setminus \{0\}$ that represent the flow in the vehicle after it visits customer ***i***. The constraints (3-6) are routing constraints and the constraints (7) and (8) impose both the capacity and connectivity of the feasible routes.

$$\min \sum_{i \in V} \sum_{j \in V} c_{ij} x_{ij} \tag{2}$$

With constrains:

$$\sum_{i \in V} x_{ij} = 1 \tag{3}$$

$$\sum_{j \in V} x_{ij} = 1 \tag{4}$$

$$\sum_{i \in V} x_{i0} = K \tag{5}$$

$$\sum_{j \in V} x_{j0} = K \tag{6}$$

$$u_j - u_i + C(1 - x_{ij}) \geq d_j \qquad i, j \in V \setminus \{0\}, i \neq j \tag{7}$$

$$d_i \leq u_i \leq C \qquad i \in V \setminus \{0\} \tag{8}$$

$$x_{i,j} \in \{0,1\} \qquad i, j \in V \tag{9}$$

4. PRACTICAL RESULTS OF PROPOSAL FLEXIBLE PT SERVICE

For demonstration of usage of flexible PT service there 2 examples of existing PT lines are in Žilina county to Čičmany and to Malá Čierna village. In both directions Rajec – Malá Čierna and Rajec – Čičmany are 5 lines. Only lines after 4 PM were considered. The real time-schedule is shown in Fig. 1, where red demonstrates a potential unused vehicle. There are significant the big time gap, cause by waiting of vehicle. The main aim of optimization is reduction of number of vehicles in operation and also waiting time of vehicles.

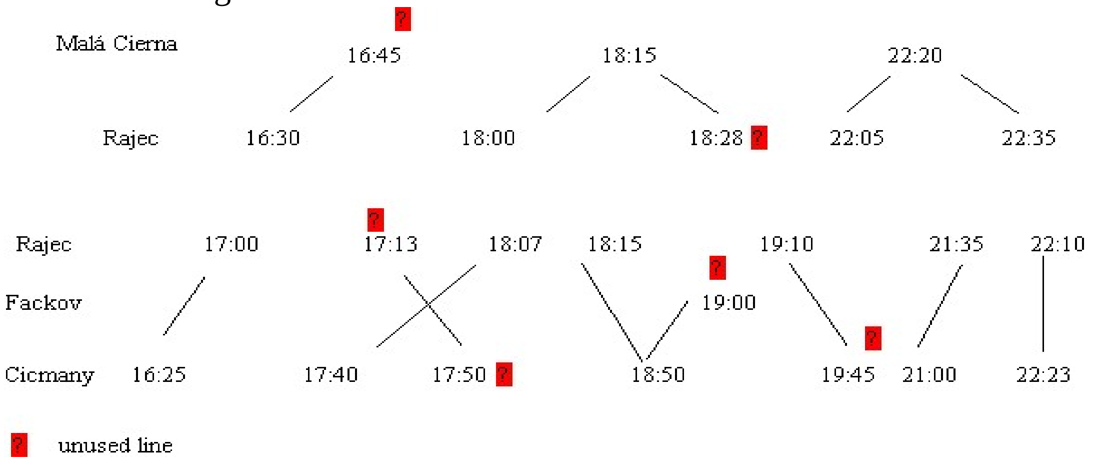

Fig.1 The real status of time-schedule with 2 vehicles in operation [9]

For solving of problem mentioned above fixed PT service was implemented. The result shows Fig.2

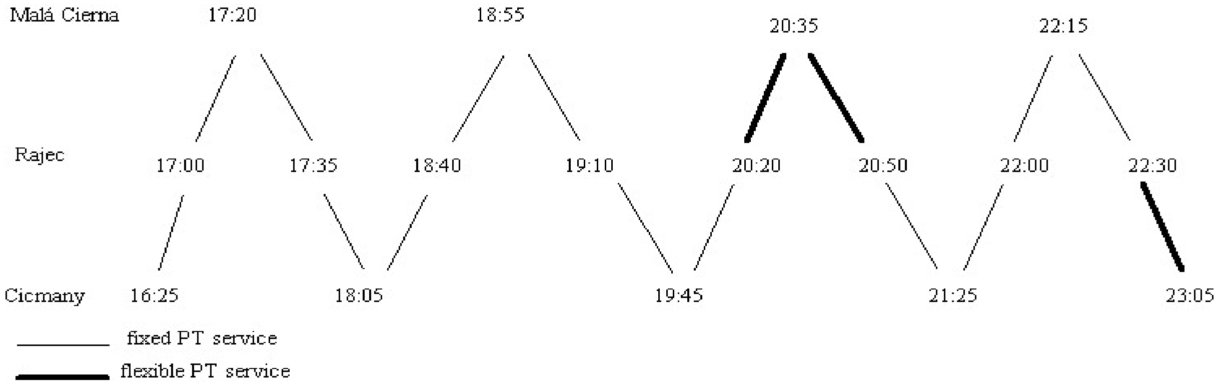

Fig.2 Proposal of flexible PT service of 2 routes [9]

The operation comparison is also shown in the Tab.1 where in comparison with present (6 – 9 vehicles) proposes only 1 vehicle with only design of 1 line. Proposal 2 shows the flexible PT service, if demand is not requested, vehicle stays in depot. Of course in the optimization process it is possible to choose more condition, which can have influence on results.

Tab.1 The comparison of indexes between present and proposal [9]

	Present	Proposal 1	Proposal 2 - Flexible
Number of line	13	16	13
Operated km	214	232	197
Cost in SKK (29 SKK/km)	6206 *	6728	5713
Number of vehicles	6	1	1

* not all cost on whole route

Proposal mentioned above is also possible to apply in case of fixed PT service. The vehicles which have a longer waiting time will be available as flexible PT line. That means if any demand is requested, the vehicle is available, if not, the vehicle will be in standby mode, see Fig.3.

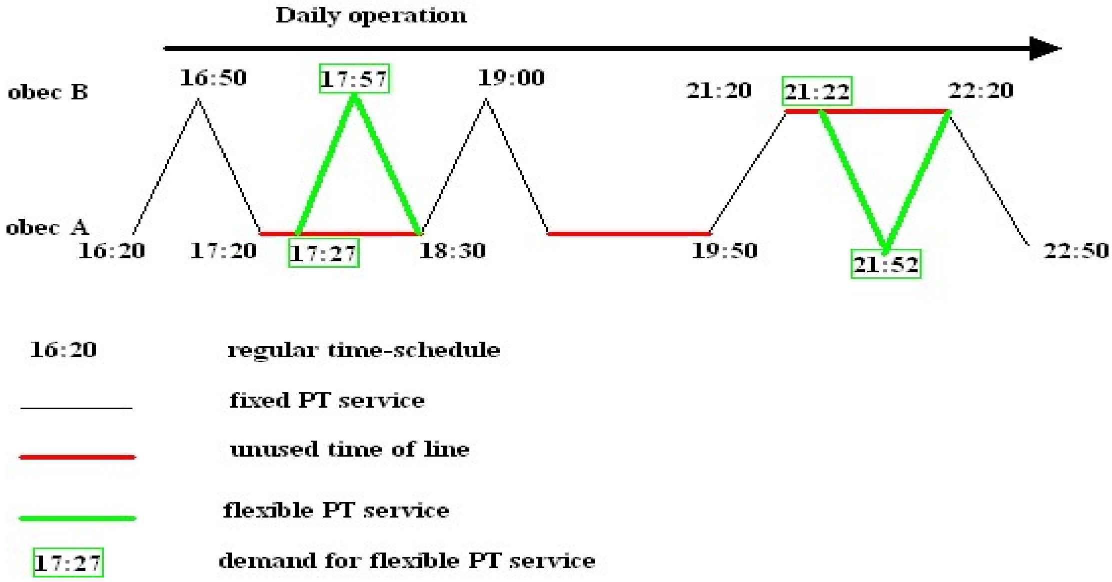

Fig.3 Schematic proposal of usage the flexible PT service

[9]

Flexible service is another option to provide PT service mainly for areas with low demand (e.g. mountain village, terminal village). One of the most important advantage of flexible service are operation cost and also cost on side of passenger. The Tab. 2 shows the passenger demand costs comparison among Flexible PT service, Car and Taxi. It is clear that total Flexible PT demand costs are lower than cost of Car or Taxi.

Tab. 2 Passenger Cost Comparison among Flexible PT service, car and taxi in route Žilina - Hôrky. [9]

	taxi	car	Flexible PT		Total Flexible PT
Line length (km)	10	10	10		
Total passenger cost (SKK)	300	29	phone	1,9	15,9
			SMS	2	16
			cell phone	7,9	21,9

Legend:

car with average fuel consuption 8l(petrol) /100km

fuel price 36,2 SKK/l 21.11.2006

price for 1km of taxi service : 30 SKK /km

price of 1 minute - phone: 1,90 SKK

1.price 1 minute - cell phone:7,90 SKK

2.price 1 minute - cell phone:7,90 SKK

SMS : 2 SKK

tariff price to 10 km: 14 SKK

5. CONCLUSION

This paper aimed to propose a flexible PT service for low demand areas. The main argument of implementation such type of PT service is a fact that flexible service responds to really passenger demands in these areas where others forecasting and estimating methods are unuseful. Additional the level of operation flexible PT line costs is lower than operation of unused fixed line. In spite of these facts, a few barriers for implementation such of type service exist in condition of the Slovak Republic. These barriers have mainly unsubstantial arguments because the flexible PT service can be an useful tool to serve to inhabitants with minimal requirements of public finance subsidies.

REFERENCES

[1] Černý, J. – Kluvánek, P.: Základy matematickej teórie dopravy (*in English*: The Foundation of Mathematical Transport Theory), VEDA Bratislava 1991, ISBN 80-224-0099-8

[2] Janáček, J.: Optimalizace na dopravních sítich (*in English*: Optimalization in Transport Network), EDIS, Žilina, 2003, ISBN 80 -8070-031-1

[3] Larsen, A.: The Dynamic Vehicle Routing Problem, University of Denmark, LYNGBY 2001, ISSN 0909-3192

[4] Löbel, A.: Solving Large-Scale Real World Minimum-cost problem by a Network Simplex Metod, Konrad-Zuse Zentrum fűr Informationtechnik Berlin, 1997

[5] Surovec, P.: Technológia hromadnej osobnej dopravy (*in English*: Technology of Public Transport), University of Žilina, EDIS, 1998

[6] Surovec, P., et al.: The Economic Model of Sustainable Mobility in a Conurbation, Grant project VEGA MS SR and SAV c.1/2623/05, University of Žilina, 2005

[7] www.telecom.gov.sk – official web site of Ministry of Transport, Post and Telecommunication of Slovak republic

[8] Vuchic R.V: Urban Transit – Operation, Planning and Economic, John Wiley &Sons, Inc., USA, 2005, ISBN 0-471-63265-1

[9] Gogola M.: Modelling Public Transport Service in Region, PhD thesis in review, University of Žilina, 2006

Reviewer: prof. Ing. Pavel Surovec, CSc.