

## EVALUATION CRITERIA FOR DEMAND RESPONSIVE TRANSPORT – THROUGH THE ANALYSIS OF DOMESTIC AND INTERNATIONAL SYSTEMS

*György Sárközi, PhD<sup>1</sup>; Márton Tamás Horváth<sup>2</sup>*

*<sup>1</sup>Senior expert, <sup>2</sup>Innovation expert*

*<sup>1,2</sup>National Mobile Payment Plc. (Nemzeti Mobilfizetési Zrt.)*

### ABSTRACT

This article aims to present evaluation criteria of different stakeholders in order to help to identify under what circumstances can demand responsive transport services be involved in the state transport service.

### KEYWORDS

Demand responsive transport, evaluation criteria, different stakeholders, ITS

### INTRODUCTION

Sustainability, financial viability and passenger friendly operation are core requirements of public transport. Its goal is to satisfy users' needs as much as possible using cost-effective solutions. Demand responsive transport (DRT) can be an option to meet these requirements by reducing the overall cost and increasing flexibility as a complementary or substitute service of conventional public transport, especially in low-density areas. The basic concept of DRT is that vehicles serve either flexible routes or flexible timetables, it is an operation mode between car-based services (e.g. taxi, car-sharing) and regular public transport service [1] (see the figure below).

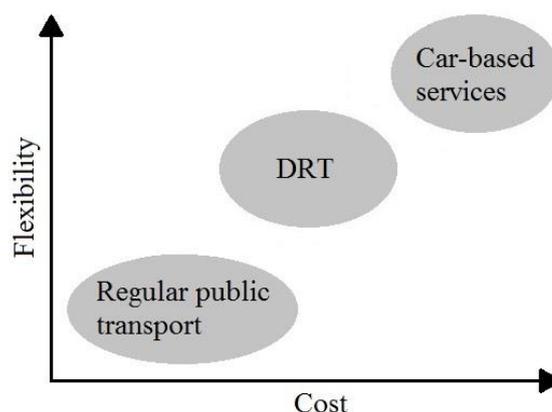


Figure 1. Cost and flexibility differences of transport modes (based on [1])

However, the definition of demand responsive transport is included in the Hungarian law on passenger transport (2012/XLI.), the formal technical rules for the execution of the law have not been evolved yet. At the same time, as a reaction for passenger demands, novel, sharing economy-based, kind of demand responsive services

evolved such as Uber or Motar carpooling system (Oszkár Telekocsi). Even though these solutions might not always be in line with the law, they definitely show the claim to demand responsive transport services. The Mobility as a Service vision, a concept for a scalable door-to-door mobility service without having an own car, can be another step in a process that new technologies enable people to generate the whole transport system and they will no longer be only the customer in it [2]. These processes establish the need both for a legal and for a technical framework, with which the evaluation criteria introduced in this article are in connection.

Considering the previously introduced factors this article aims to set a comprehensive evaluation system that shows the preferences of passengers, service providers, customers and maintainers. The evaluation criteria involve the latest trends and developments of transport.

More design guides or summaries of key lessons learnt from DRT implementations have been released in the recent decade, most of them in connection with research projects. The MASCARA project [3] aimed to provide a detailed evaluation and design guide of DRT services generally in Europe. The project also included a few DRT feasibility studies as implementation examples, one of them was for the Hungarian town, Győr, although the system has not been built so far. An evaluation of publicly-funded DRT schemes for England and Wales was provided in [4], another evaluation that focused on the market potential in England in Wiltshire for DRT services was published in [5]. Country-wide DRT planning guides usually contain evaluation factors that help identifying the appropriate service type that should be implemented. Such recommendations are available not just in Europe but in other parts of the World as well, for example in the US [6] or in Australia [7].

## DRT SYSTEMS

In order to get an overview on DRT as a task of logistics, this chapter summarises the concepts of service design, focusing especially on route and timetable concepts, which are the bases of DRT. Although different sources, among others [6][8][9][10] classify DRT in different ways the main route and timetable categories can be defined as it is the following table. It shows some examples from Hungary and Europe.

Table 1. Examples of DRT service modes

	Fixed timetable	Semi-fixed timetable	Flexible timetable
Fixed route with fixed stop points	Conventional public transport	RufBus Odenwaldkreis (D); Budapest BKK Telebusz lines 297, 298 and 65, 157 (intermediate destination with DRT extension) (H)	
Semi-fixed corridor service	Taxibus Vlotho (D)	LincolnshireConnect (GB), Semi-Flexible CallConnect (GB); Taxibus Köln (D)	

	Fixed timetable	Semi-fixed timetable	Flexible timetable
Flexible routes with a fixed origin	MeiBus Poysdorf (A)	Anrufsammeltaxi Köln (188) (D); Anrufsammeltaxi Bocholt (D)	ASTAX Vienna (A); BelBus Belgium; Budapest BKK Telebusz line 219 (H)
Flexible area service		Connect2Wiltshire (some subcontractors) (GB)	Publicar Switzerland; Regiotaxi, the Netherlands; AirportShuttle Minibus, Budapest
Flexible door-to-door service			Transport for London Dial-a-Ride (GB); Bettembourg, Luxemburg; Budapest BKK Midibus service (H)

Certainly, there are much more existing DRT systems in the world including variants of DRT in developing countries, even though these are not complementary services to the conventional public transport in time or space, they are rather higher quality public transport services that, on the other hand, provide additional capacity [11]. This article focuses on DRT as the logistic means of involving vehicles for conventional public transport service. Demand, whether it is qualitative or quantitative, in this context is considered to be something that can be served and that is maintainable, namely work, education, healthcare and social services. We define demand responsive as something to which the society reacts (and that reacts to the society), therefore it is a way of capacity extension. In order to involve service providers for this extension, technical and legal conditions must be fulfilled in connection with the service expected. From the point of view of logistics, the required technical and human conditions should be evaluated.

## INFLUENCING FACTORS OF SERVICE DESIGN

The demand for transport services is influenced by the features of the service area and by the service itself. The core aspects of the service area are the following [12],[13]:

- ◆ Geography and structure of settlements. If the service area is in the suburb of a metropolis, it differs from the case when it is in the countryside with small villages that are far from each other.
- ◆ Economic factors, industry and household incomes. People with higher income have different demands, they require a higher level of service than people with lower earnings who probably do not have any alternative options to satisfy their mobility needs. If there are industrial zones in the service area, demand concentrates around them according to shifts.
- ◆ Demographic factors. Age and population density. The latter one is usually in connection with the structure of settlements. The number and the proportion of students, active workers, pensioners and physically challenged citizens determine the volume of school, work, shopping, social and healthcare traffic,

which have different characteristics and travellers have different demands and expectations of the service.

These core factors of the service area determine the potential demand for the transport service (and the service design as well, see table 1), but at the end the service provided determines whether this demand can be exploited or not (see the figure below). The evaluation criteria presented in this paper aim to provide a framework for designing DRT services that can exploit this potential demand.

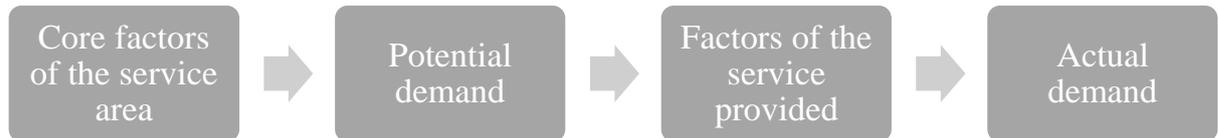


Figure 2. Factors influencing service demand

Certainly, there can be other specific influencing factors that are only considerable locally.

## EVALUATION CRITERIA

Core aspects of the DRT evaluation framework are telematics and the IT developments of recent years that strongly influence transport. Even though a significant proportion of DRT systems use conventional technologies like receiving demands only by telephone or combining routes manually, the potential ways of development should be taken into account when creating the framework. On the one hand, the application of real-time information makes it possible to handle user demands fast, therefore, the time elapsed between the occurrence of the demand and the start of journey can be reduced. At the same time, electronic payment methods, like debit cards, mobile applications or mobile payment, are preferred instead of cash-usage. Therefore, IT security has a significant role not only in transport itself but also in paying its fares.

These real-time processes generate big data that must be managed and processed. Since DRT systems in developed countries are usually subsidised by the state, the data can be published as open data at a later stage so that everyone could freely use these pieces of information.

DRT is connected to such key topics of improvement like Smart City and ITS. Basic principles of smart cities are in connection with basic principles of DRT, like minimising the usage of resources by running small capacity vehicles, maximising efficiency by operating according to flexible timetables or like exploiting the latest technology in future developments. DRT is connected to ITS through its telematics systems and Cooperative ITS that involves all actors of the transport system in data exchange.

Certainly, DRT as a public service has a significant role in designing seamless transport systems including lower density areas and physically challenged people.

A considerable part of the evaluation criteria is based on conventional public transport performance measures whereas some others are only in connection with DRT.

Different stakeholders have certainly different preferences, therefore a factor that is important for one can be irrelevant for another one. Users' needs are in the centre, no service can operate with no passengers. Users' needs influence the preferences of stakeholders that are responsible for ordering and financing the transport system. The preferences of the previous parties together influence the preferences of the service provider. This hierarchy is shown in the figure below.

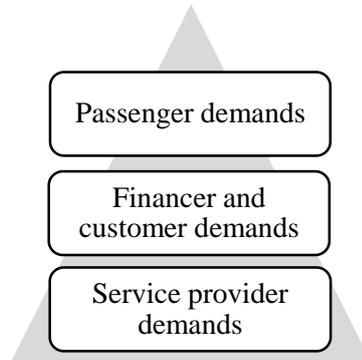


Figure 3. Hierarchy of demands

Passenger preferences in DRT are quite similar to the preferences of conventional public transport users, actually for citizens it does not really matter what the category of the transport service is, they just want to get from the origin to the destination in the fastest, cheapest and most comfortable way. The evaluation criteria of users are shown in the table below, based on [12].

Table 2. User specific evaluation criteria

User criteria	Description	Evaluation method
Accessibility	The service (including every process in connection with booking, travelling and payment) is usable also for people with disabilities (including space for wheelchair and guide dog)	Tests and surveys
Demand request	How easy it is to book a seat and how many platforms are available (e.g. mobile app, internet, telephone)	Surveys
Flexibility	Minimum time that must be elapsed between booking and departure and length of the guaranteed time period the vehicle arrives at a stop (e.g. the vehicle arrives 15 min before to 15 min after the target time)	Statistics
Approach	How easy it is to get to the stop point (walking distances and obstacles from door to stop)	Observation and calculation
Time of operation	Operation time periods during the day and operation days of the year	Calculation
Coverage	Density of possible stop points	Calculation

User criteria	Description	Evaluation method
Frequency	Waiting time between two subsequent service journeys	Calculation
Travel time	Compared to other modes of transport	Statistics
Reliability	Difference between scheduled and real travel times	Statistics
Seamless transport	Integration with other transport modes, generation of travel chains	Statistics and observation
Fare	Compared to other modes of transport	Calculation
Payment options	How one can pay the fare, especially by cashless methods	Statistics
Tracking	The ability to follow vehicle positions on-line accurately	Observation and statistics
Communication	How easy it is to get in touch with the centre if passengers do not find their vehicle	Surveys
Information	How easy it is to be informed about travel conditions and to recognise the service vehicles and stops	Surveys
Safety and security	Both in the vehicle and in the stops while waiting	Surveys and statistics
Comfort	What it feels like to travel in the vehicles (e.g. cleanliness, enough space)	Surveys
Extra services	E.g. wi-fi, electricity supply	Surveys

Stakeholders ordering and financing the transport system, of which the most important one is usually the state in Hungary, have to consider passenger demands since they order it for the citizens, but apart from that they have other preferences that are mostly in connection with viability. Certainly it is not possible to satisfy all passenger dreams and maintain viability at the same time. The criteria of the state are shown in the table below.

Table 3. State specific evaluation criteria

State criteria	Description	Evaluation method
Economic viability	Cost must be affordable and lower compared to other modes of transport	Calculation
Technological viability	Having the potential of integration with other systems and development	Calculation
Environmental viability	Environment friendly operation, especially pollution, emission, noise and vibration	Calculation
Transparency	The financer must see what they spent the subsidies on, publishing open data if possible	Statistics

State criteria	Description	Evaluation method
Ensuring basic state transport service	Fulfilling the requirements of law	Yes/no analysis
Chance equality	Ensure access to transport modes apart from private transport in low density areas and for physically challenged people	Calculation and statistics

The key factor for service providers is profit but certainly they must meet the criteria of passengers, customers and the financier as much as possible. (Sometimes these criteria are contradictory.) Apart from that, service providers have their other own criteria as well as shown in the table below.

Table 4. Criteria of service providers

Service provider criteria	Description	Evaluation method
Profit	Maximising revenues and minimising expenses	Calculation
Transparency	The company must know exactly when and what its employees do	Calculation
Data analysis	Real-time collection and analysis of data from the vehicles and traffic as well, big data analysis might be required	Statistics and analysis
Communication and connectivity	Communication with own vehicles and with other actors of transport as well, including infrastructure (C-ITS, V2V, V2I communication)	Statistics
Safety and security	Passengers, vehicles and every process	Statistics
Quality	E.g. length of time-window, number of unserved bookings, number of refused bookings	Statistics
Conventional public transport eval. criteria	E.g. vehicle utilisation, number of passengers, cost per km, cost per passenger	Statistics
Meeting legal requirements	The service provider must be capable according to the law as well	Yes/no analysis

## CONCLUSIONS

This paper presented evaluation criteria for demand responsive transport systems considering the latest trends of public transport. These criteria can be the basic inputs for evaluation models for stakeholders so that they can analyse the service they provide or plan to provide, using their own preferences.

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