LogForum

2014, 10 (1), 31-41

> Scientific Journal of Logistics <

http://www.logforum.net p-ISSN 1895-2038 e-ISSN 1734-459X

REAL TIME MODEL FOR PUBLIC TRANSPORTATION MANAGEMENT

Ireneusz Celiński, Grzegorz Sierpiński

Silesian University of Technology, Katowice, Poland

ABSTRACT. Background: The article outlines managing a public transportation fleet in the dynamic aspect. There are currently many technical possibilities of identifying demand in the transportation network. It is also possible to indicate legitimate basis of estimating and steering demand. The article describes a general public transportation fleet management concept based on balancing demand and supply.

Material and methods: The presented method utilizes a matrix description of demand for transportation based on telemetric and telecommunication data. Emphasis was placed mainly on a general concept and not the manner in which data was collected by other researchers.

Results: The above model gave results in the form of a system for managing a fleet in real-time. The objective of the system is also to optimally utilize means of transportation at the disposal of service providers.

Conclusions: The presented concept enables a new perspective on managing public transportation fleets. In case of implementation, the project would facilitate, among others, designing dynamic timetables, updated based on observed demand, and even designing dynamic points of access to public transportation lines. Further research should encompass so-called rerouting based on dynamic measurements of the characteristics of the transportation system..

Key words: public transportation, management model, transportation fleet.

INTRODUCTION

The organization of public transportation is one of the basic fields of activity comprising the logistics of public transportation. This is due to the fact that its organization directly impacts traffic conditions of every transportation network. Poorly organized public transportation causes an increase in the volume of private transportation, the observable outcome of which is traffic congestion [An et al. 2009, Kauf 2010, Mallinckrodt 2010, Pawlak 2012]. This in turn has a negative impact on all aspects of logistics, including: transportation, freight forwarding, warehousing and safety [Szymczak 2008, Kauf 2010]. Public transportation, in the form developed in the 20th century, is inadequate in relation to the social expectations voiced today. The observed dynamics of social and economic changes that have taken place within the last two decades have led to the situation that public transportation, based on determined characteristics of demand and supply, cannot successfully compete with individual forms of commuting. This pertains to practically all determined aspects of public transportation: a fixed transportation fee, predetermined distribution, fixed points of access to the transportation network, fixed public transportation route along the transportation network, lack of justified variability of fleet capacity, unvarying quality of provided services, etc. The article focuses on such characteristics of public transportation supply as: carriers' time and spatial schedules as well as fleet capacity. Public transportation supply,

Citation: Celiński I., Sierpiński G., 2014, Real time model for public transportation management. LogForum 10 (1), 31-41

URL: http://www.logforum.net/vol10/issue1/no4

Accepted: 30.10.2013, on-line: 30.12.2013.

offered on hitherto principles, is unable to satisfy fluctuating demand due to the lack of spatial and time uniformity of the latter. Currently observed commuting behavior, especially in large towns and agglomerations, reflect social and economic changes. The number of trips realized on a 24-hour and weekly cycle, so-called mobility, is increasing. This is due to an increase of trips to and from work. The road-traffic structure in urban areas is also undergoing changes. This is linked with, inter alia, suburbanization and a change in the spatial distribution of those participating in traffic. The hitherto cure for this dichotomy between demand and supply in public transportation, in the form of traffic research (KBR and others), does not keep up with the dynamics of observed changes [Celiński and Sierpiński 2012, Pawlak 2011, Szymczak and Sienkiewicz-Małyjurek 2011]. The mobility of a city's residents is also increasing, mainly as a result of easier access to individual forms of transportation. Public transportation, despite being endorsed by national and international policies, is experiencing stagnation; this especially applies to railroads [Our Common Future 1987, White Paper 2001, White Paper 2011]. Solutions to the problem must aim to implement the accomplishments methods of Intelligent Decision Systems in Transportation (genetic algorithms, neural networks, expert systems etc.). The following may serve as a means of achieving balances supply and demand in public transportation: monitoring, telemetric and telecommunication systems. These systems include: GPS (Global Positioning System), GSM (Global System for Mobile Communications), wireless networks and CCTV (Closed-Circuit Television). A solution implementing intelligent demand monitoring in railway transportation was presented in issue 3/2012 of LogForum [Celiński and Sierpiński 2013]. The right and legitimate implementation of the abovementioned technology may permit:

- design of dynamic timetables, updated based on observed demand;
- design of dynamic access points to public transportation lines (variable spatial distribution of access points, virtualization of access points);
- design of dynamic public transportation routes based on road networks (means of transportation with their own transportation roads or tractions are less susceptible in this case: railway transportation, trams);
- optimized capacity of means of transportation based on demand characteristics.

From this angle, the suggested technology should be used to obtain maximum precision in identifying time and spatial parameters of demand for public transportation. This also applies to identifying the nature of demand (type and direction structure) [Celiński and Sierpiński 2013].

The article outlines chosen aspects pertaining to the description of supply and demand in such a system, as well as a model and chosen scenarios. An important premise for implementing such a system is the sustainable development policy in the field of transportation [White Paper 2001, White Paper 2011].

DEMAND AS WIDE TRANSPORTATION SYSTEM CUSTOMERS EXPECTATIONS

What parameters characterize present-day demand for public transportation? We can willfully state that there are various parameters while they are all characterized by an observable increase in dynamics. This dynamics is increasing at a more and more intense pace, which is an unfavorable phenomenon [Karoń et al. 2009, Pawlak 2012]. A change in the professional profile of almost all age groups has been observed [Celiński and Sierpiński 2012]. It is becoming the norm to have two, at times three, sources of income. The flexibility and scope of business hours is also changing, regulated by new employment regulations [Directive 2003/88/EC, Wratny 2010]. The first aspect leads to lack of spatial uniformity of travel distribution, the second to lack of time uniformity. The way people spend their leisure time is also changing. From the point of view of traffic organizers, the significance of the distinction between obligatory and facultative travels is decreasing. The first are no longer a dominating and "easy" element when shaping communication order in urban areas. This is the result of substantial defragmentation. The entire "view" of public transportation is additionally complicated by a series of other, unfavorable, phenomena: suburbanization, seasonal work, spatial fluctuations and fragmentation of business entities, telecommuting, etc. As the demand for public transportation is changing spatially and temporally, to an extent that has not been observed within the last century, we may formulate the following question: are hitherto forms of satisfying demand justified? According to the authors of this article, the answer is: no. The description of demand for public transportation should no longer be limited solely to characteristics of increased travel to and from home, often determined for a couple of years at a time. Demand for public transportation should be presented in the form of spatial 3D functions, described within a transportation network. For simplification, the description of demand contained in the article is expressed in figures. Furthermore, these functions should not be described discretely - limited solely to geometric parameters of transportation networks. Demand for public transportation services should be observed, to the extent possible, along the entire transportation network area. It is possible to adjust supply to meet demand in a flexible manner, based on observations of the values of 3D functions expressing demand for transportation. This can be carried out not only by changing timetables, but also the routes of urban public transportation lines. The basic problem is determining (simplifying) the discretization of 3D functions expressing the characteristics of demand for public transportation. It is obvious that a continual description is not necessary in this case. It is possible to define a certain increase (Δl) for both dimensions (length and width) of area S occupied by the transportation system, with the principle of approximating values of the demand for public transportation function. For determined delimitation parameters of area S, it is possible to define certain decision criteria. As an example, in the case of bus lines, distances should not be greater than the distance of road sections (or group of sections), due to the economic aspect of breaking and accelerating between two stops (greater fuel use). This is a typical economic limitation, imposed on public transportation. Losses linked with traction characteristics of vehicles should define the smallest possible interval in this scope. The same goes for railway traction (although in this case there are greater infrastructure-related limitations). This function can be expressed with the support of matrix A (square or rectangular):

$$PTZ_c = A = [a_{ij}] \qquad (1)$$

where:

PTZ_c - total size of demand for public transportation, expressed by matrix *A*,

a_{ij} - element *ij* of matrix *A*, describing the value of demand for public transportation in the spatial regime containing *ij* coordinates for the network area of the transportation network. Delimitation of the transportation network's area into its width (x) and length (y) with the value Δl creates a spatial regime matrix with *i x j* dimensions. The division can also take under consideration divisions that are not uniform $\Delta l_x \neq \Delta l_y$, in extreme cases a division based on the area of asymmetric figures. In the case of demand measurements based on the characteristics of cellular networks, the matrix can be described as the area of circles representing BTS (Base Transceiver Station) range. Dimensions of *i* and *j* are, accordingly, the number of spatial regimes describing the analyzed area using vertical and horizontal coordinate descriptors ($W_x^{a_{ij}}$ and $W_y^{a_{ij}}$, accordingly - or: longitude and latitude).

The *ij* parameters indicate the spatial regime of the area; descriptors their geographical dimensions. The dimensions of matrix *A* are directly linked with the assumed manner for calculating area width and length of the transportation network $\Delta l_x = W_x^{a_{ij}} - W_x^{a_{i+1j+1}}$, accordingly: $\Delta l_y = W_y^{a_{ij}} - W_y^{a_{i+1j+1}}$. The values of Δl_x and, accordingly, Δl_y may be different, depending on the uniformity of the transportation network. *A* type of matrix can be used, despite its discrete nature, to describe the area of the transportation network in its constant form.

To do so, for any three nonlinear "points" (a_{ij}) describing demand in the analyzed area, and described coordinates, e.g.: $P_1^{a_{ij}}(x_{1,}y_1,z_1), P_2^{a_{i+1j+1}}(x_{2,}y_2,z_2), P_3^{a_{i+1j-1}}(x_{3,}y_3,z_3)$ (e.g. centers of spatial regime areas), an $\Re^3$ surface can be formed: $Ax+By+Cz+D=0$. Intermediate points, describing demand between the elements of matrix *A*, can be approximated to values described with such a surface. Due to the fact that the above description may differ as a result of: means of transportation, motivation, equation (1) can be expressed as:

$$PTZ^* = A^* = [a_{ij}^*] \qquad (2)$$

where:
(*) signifies the value of demand for public transportation expressed by matrix A* in relation to: travel motives, means of transportation, etc. In this sense $PTZ_c = \sum_* PTZ^* w^*$, where (*) signifies shares of percentages of individual travel motives or means of transportation for observed trips within a transportation network. As an example, if a public transportation vehicle is a bus, matrix *A* should be based on *Δl* resulting from existing tracts or spatial distribution of the bus stop network. In the case of the dynamic approach - resulting from planned or potential network of such objects. When it is possible to identify motives for travel, the value of *Δl* should be the result of the distribution of infrastructure linked with the motive. Travel motives can be identified based on GSM networks described in the publications [Sierpiński and Celiński 2012]. When considering the fact that observations of demand parameters can be realized in Δt, demand can be described as: $PTZ_c = A = [a_{ij}]\Delta t$. The value of Δt is linked directly with the possibilities of the technology used to monitor the demand for public transportation services within a given population.

SUPPLY AS LIMITED SYSTEM RESOURCES

A transportation carrier/operator's limited services possibilities are always a critical element. This is a result of limited resources, mainly the number of vehicles at a carrier's disposal. The prices of means of transportation, as well as access to public transportation infrastructure (fees, licenses, taxes, etc.) are systematically increasing. In the presence of decreasing demand for public transportation, despite sustainable development policies, the right management of limited resources gains even greater significance than it ever has before [White Paper 2011]. In practice this signifies the necessity to implement the only rational solution - adjustment of supply to demand to the maximum extent. Often public transportation operators are comprised of entities called to life by local authorities. Keeping in mind the currently observable financial situation of local authorities, the possibility of offering sustainable supply is additionally curbed, even given such policies. On the other hand, supply is also limited as a result of increased road congestion. Solutions that prioritize public transportation (on the infrastructural, organization and traffic steering levels), are rather unpopular. These solutions furthermore have other shortcomings on levels not discussed in this article. Carriers also have limited staff (drivers, mechanics) as a result of substantial migration within these professional groups in Poland.

In contrast to demand for public transportation, which can be substantially described as a spatial distribution of lodged requests, supply should be described in the form of modified equation (1), where the interval between regimes/regime central points that describe supply is expressed as follows:

$$\Delta l_{x,y} = W_{x,y}^{a_{kl}} - W_{x,y}^{a_{k+1k+1}} = \text{const} \to 0 \qquad (3)$$

Delimitation of the transportation network in this case aspires toward a continuous distribution, along with the technological progress of monitoring systems. In practice the interval (*Δl*) described by equation (3) should stem directly from the interval between possible "windows of data transfer" linked with the technological possibilities of communication/identification of vehicle location within the transportation network. In the case of GPS, precision in practice is a few dozen meters [Borriello et al. 2005]. In the case of GSM, precision is limited in the simplest cases by the cellular sector's area of operation [Rashid et al. 2005, Tarumi et al. 2004]. This interval should make it possible: for public transportation vehicles to stop on demand, alter their routes, give vehicles the possibility to refuel when necessary, change drivers, etc. An additional parameter describing supply in the system should be vehicle capacity and technical possibilities (e.g. low-floor vehicle, bike rack, etc.):

$$PDTZ_c = A' /_{B,C,D...} = [a'_{kl} /_{B_{kl}}, _{C_{kl}}, _{D_{kl}} ....] \quad (3)$$

where:

$PDTZ_c$ - total size of public transportation vehicle expressed by matrix A which defines the location of vehicles within the analyzed area, with conditions expressed by matrixes B (capacity); C (technical parameters), D (passengers on board), etc.

A fundamental difference between the matrixes describing supply and demand (A' and A, accordingly) in the system is their size (*ij*≠*kl*). Along with an increase in the precision of demand measurements, in order to balance the dynamics of changes in matrix dimensions expressed by (1), the values *ij* and (2) *kl* should become similar.

OPERATING SCENARIOS FOR TRANSPORTATION OPERATORS

Previous sections proposed a description of public transportation demand/supply distribution using two matrixes (1) and (3). Matrix A or A' contains values for supply or demand within a given (different) spatial regime. The supply matrix will generally be determined with greater precision than the demand matrix, as a result of the size of the population and used identification techniques. If the dimensions of the demand matrix *ij* are a multiple of the supply matrix kl, the latter may be aggregated in order to resize *kl* to *ij*. In this case demand in a certain transportation network location (*ij=n*kl*) can be directly compared with supply (comparison within two equivalent spatial regimes). A simple balance of supply with demand within a given transportation network can be conducted this way, in every spatial regime:

$$\sum_{ij} ([a_{ij}] \quad - [a'_{ij}]) \cong 0 \qquad (4)$$

where:

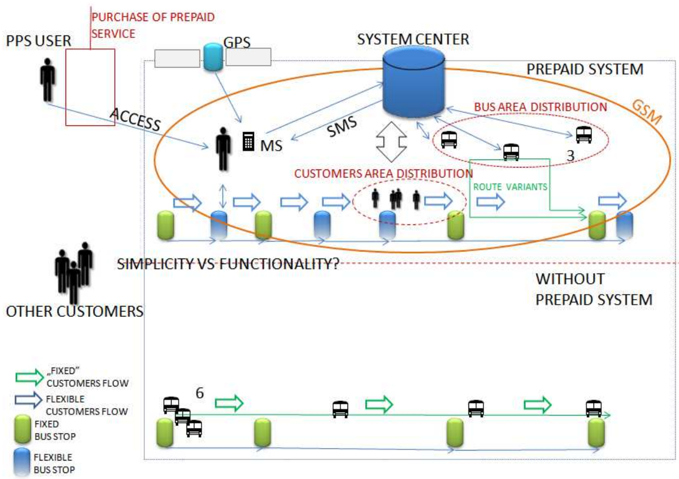
a'_{ij} - demand in *n kl* spatial regimes aggregated to the dimensions of regime *ij*.

Optimization of the transportation system in this aspect will entail finding the minimal value of the equation (4). In practice, even given considerable dynamics of system data updates, there will always be an observable error: $\zeta_{ij} = ([a_{ij}] \quad - [a'_{ij}])$, linked with the aggregation of the demand matrix, due mainly to: determining motivation, localizing vehicles and public transportation clients, assessment of vehicle parameters (fuel reserves, number of passengers on board, etc.).

The suggested model offers a few operating scenarios for public transportation operators. These scenarios, when implemented, should lead to optimization of values expressed by equation (4). It is assumed that, based on the proposed dynamic solution, the public transportation system can also be implemented based on scenarios without predefined timetables. The entire system operates similarly to the principles of "Just in time". Whenever demand changes, it is immediately satisfied by updated supply. The first activity undertaken to meet this activity can be variation of vehicle travel speeds. If greater demand appears at "location" a_{ij}, vehicles at "locations" $a'_{i(+1,-1)\,j(+1,-1)...itd.}$ increase their speeds, if possible, to permissible limits in order to satisfy a need for services as quickly as possible. If this is not possible (road congestion), all neighboring locations with the possibility of route variants are analyzed. The vehicle intended to "balance demand" should have appropriate parameters, depending on the number of passengers on board and its technical parameters. Another variant (scenario) of this type is flexibility (virtualization) of public transportation access points. Paradoxically, this approach might be problematic, especially in the case of railroads, where location and construction of stops require specific technical conditions. In the case of busses it is possible to place numerous access points along roads. Assuming the high dynamics of the suggested system, including shorter waiting periods, access points would not require the installation of bus shelter. Access points could be marked by a single vertical sign with communication module. In the case of serial production it would be possible to saturate the entire transportation network with stops of this kind. In the case of two-way communication between carrier and client, it would be possible to "virtualize" the distribution of access points. This approach would increase accessibility to transportation in an unprecedented way. This system has yet another benefit - if demand in a certain area falls (for certain periods/days), courses could be cancelled from the route of rerouted. This would lead to significant savings and optimal management of public transportation fleets. Yet another important feature of the system is minimization of duplicating services along the same points, as a result of the suggested dynamic demand monitoring technique. If demand drops in "location" a_{ij}, vehicle routes can be altered and vehicles can be rerouted to neighboring locations (algorithm for finding the shortest path within a network) in order to minimize a carrier's operating costs. Hence the benefit of the proposed system is an increase of communication availability in an urban area. Virtual (variant) stop locations can be implemented as part of the system.

CRITICAL REMARKS ABOUT MONITORING SYSTEMS

The proposed concept is based on the possibilities of localizing the distribution of supply and demand throughout the transportation network. Supply does not pose greater technical difficulties as it is limited in relation to demand. GPS technology is already being utilized to monitor public transportation (various examples throughout the world). It may be, however, problematic to add additional functions to the system, such as: dynamically determining vehicles' technical parameters, capacity, etc. Modern fleets fulfill these technical requirements [websites: ENTE, ALSTOM and PESA]. Especially rolling stock has good systems for calculating capacity [websites: ENTE, ALSTOM and PESA].



Source: Author's research

Fig. 1. Prepaid system compatible with proposed concept
Rys. 1. System pre-paid spójny z proponowaną koncepcją

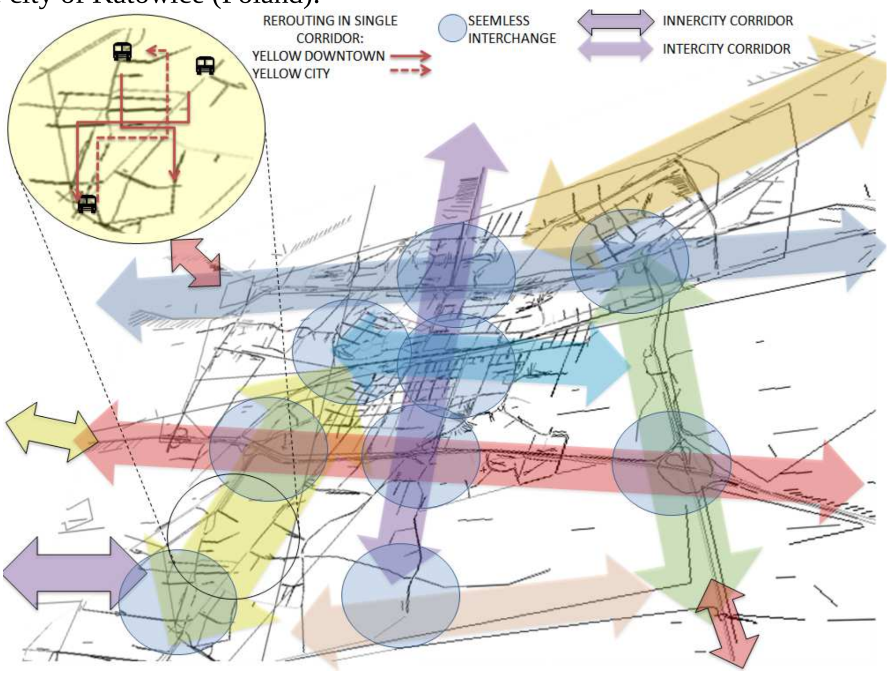
Determining time and spatial distribution is considerably more problematic. Researchers have on numerous occasions suggested utilizing cellular phone networks to do so [almost all publications quoted by this article]. This can be obtained with or without the collaboration of existing GSM network providers. The latter might require constructing a special telemetric system. Measuring the signal does not mean decoding it - only confirming the presence of a user in a given spatial regime.

A prepaid network based on precise GPS technology in combination with the functionality of a cellular phone network would be the simplest means of implementing the system. Users (ultimately all those using public transportation) could be located in urban terrain via GPS while the functionality of the solution could be integrated with GSM in the form of text message services. This system would work best if services were provided by many providers at the same time. Technical support would not pose a problem. In Poland in 2013 the number of MS (Mobile Station) subscribers and pre-paid users exceeded 54.9 million [Central Statistical Office 2013] (total Polish population less then 37 million).

Figure 1 shows a prepaid system for identifying demand for public transportation based on GPS technology and GSM systems. The main benefits of the system are an improved balance of demand and supply as well as increased accessibility to the network. Difficulties include system implementation and social acceptance. This pertains mainly to a conflict on the simplicity/functionality axis. Benefits are the outcome of: dynamic variation of public transportation routes and flexibility linked with the localization of a greater amount of access points and adjusting fleet size to existing needs.

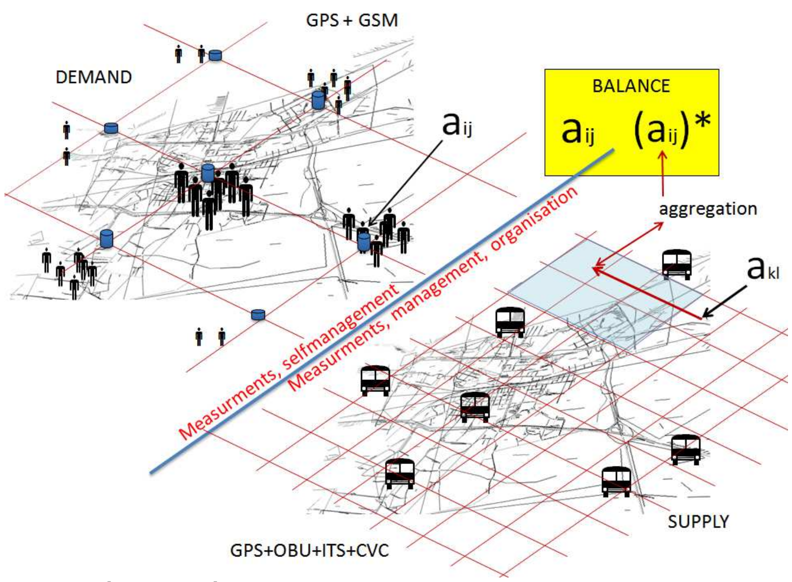
MODEL CONCEPT - WHERE DO YOU WANT TO GO TODAY?

When choosing a means of transportation, a client considers various criteria. We will be overlooking the aspect of a choosing directly between public and individual transportation, which boils down to owning a passenger car and, at times, traffic conditions or fuel prices. The client mainly considers: service realization time, service reliability, service accessibility and safety of services [Sierpiński 2011]. The proposed system places an emphasis on three of the aforementioned aspects: service realization time, service reliability and on increasing the accessibility of services. Decreasing service realization time is, in this case, directly linked with the system's basic objective: prompt balance of dynamically identified demand (fig. 3). This is possible via rerouting and virtualization of network accessibility points. Shorter service realization periods, including waiting time, are possible via a simplification of access points (bus stops), and in practice: in increasing their number. This is possible thanks to a simplified infrastructure (no roofed structures, no bays). Structures are not necessary due to shorter waiting periods on stops; bays are not necessary due to shorter boarding times. A significant problem for the model is posed by formalizing route variant procedures based on time and spatial parameters of identified demand. Balancing supply and demand in the system is possible mainly by creating route variants to spatial regimes where a greater demand for public transportation services is lodged. The manner in which the system functions is not simple or clear from the point of view of the user (even when disregarding the aspect of virtualizing access points). The system should maintain an organization structure that allows for information clarity while simultaneously maintaining high service frequency. Functionality can be implemented based on predefined transportation corridors located throughout the city. A commuting client is not "forced" to use a fixed line number when using the system. He or she must only know which corridors to take to reach a destination and in which direction. Every vehicle operating within the system would only be marked with the corridor's color and direction. The concept of a road network divided into corridors is illustrated based on the city of Katowice (Poland).



Source: Author's research

Fig. 2. Dynamic rerouting in proposed concept.
Rys. 2. Dynamiczne zmiany tras w proponowanej koncepcji



Source: Author's research

Fig. 3. Balance of supply and demand in proposed concept (OBU-OnBoard Unit, CVC- central vehicle computer, ITS- intelligent transport system)).
Rys. 3. bilansowanie popytu I podaży w proponowanej koncepcji (OBU-OnBoard Unit, CVC- centralny komputer samochodowy, ITS- inteligentny system transportowy)).

Figure 2 shows the road system in Katowice divided into eight inner-city transportation corridors, marked in different colors. Each corridor is marked with its own color and contains a description of direction. The illustration shows direction as downtown and city, depending on the vehicle's path in relation to the city's center. The upper right hand corner of Figure 2 contains example of route variants for one corridor. Instead of several independent lines operating within a single corridor, there is only one line and its routes depend on demand lodged in the system. The width of the corridor makes it possible for a client to access a line of a certain color, choose the correct direction, arrive at his or her destination within a distance proportionate to the width of the corridor (on Figure 2 this distance is up to a few hundred meters, 500-900). The system considerably simplifies the organization of public transportation within a given city. The eight corridors shown on Figure 2 replace a few hundred lines organized by multiple regional public transportation carriers. If the solution was implemented, then - in the case of the yellow corridor and given the current distribution - a few dozen buses could be used to prepare route variants. The difference is that, in contrast to fixed lines, the variants would be adjusted to meet lodged demand within a given transportation corridor.

A detailed description of organization structure and rerouting algorithms goes beyond the framework of this article.

DISCUSSION AND CONCLUSIONS

The model outlined at a glance in the article comprises a new approach to managing public transportation fleets. It places greater emphasis on the needs of passengers (including potential passengers), and simultaneously takes under consideration ways to optimize the use of fleets owned by public transportation companies. Full integration may enable, inter alia, planning dynamic timetables based on observed demand, and even the design of dynamic access points to public transportation lines. Routing along public transportation corridors, without lines in the classic sense, should enable fleets to bypass road congestion (as they could, to an extent, avoid congested routes). Another benefit of the system is the increase of transportation availability in urban areas.

In method proposed in the article, fleet management system assumes the use of transport corridors describing the area of the city. The idea is reasonable in the case where the width of the corridors are not too large (approx: 2x500 meters from the axis of the corridor - 5 minutes walking an average speed of 1.66 m/s). Too large width of corridors demonstrated in Figure 2 significantly increase the arrive at and leaving times people residing (or working, studying etc.) in their area.

This approach forces the use of a large number of closing to each other corridors in a limited area. This narrows down their use for close city centers, densely populated suburban areas or corridors organized within the urban main roads. Low population density, particularly heterogeneous in suburban areas, complicated variants of the routes of public transport vehicles in such cases. In these cases appear to be reasonable traditional timetables and organization of public transport. In these cases, should also expect significant instability in the qualitative and quantitative parameters for passenger traffic. This requires further work, especially micro-simulation modeling to accurately identify and examine the proposed method.

Subsequent research should focus on so-called rerouting based on dynamic measurements of the characteristics of the transportation system.

REFERENCES

An W., Zeng D., Tao S., 2009, Recognition and Analysis of Traffic Congestion Level. In: Liu R.; Zhang J., Guan Ch. (Eds.) Logistics: The Emerging Frontiers of Transportation and Development in China, 3871-3877

Borriello G. et al., 2005, The disappearing computer: Delivering real-world ubiquitous location systems. Communications of the ACM, 48, 3, 36-41.

Celiński I., Sierpiński G., 2012, Opór przestrzeni dla alternatywnej realizacji podróży. [In:] Modelowanie podróży i prognozowanie ruchu [Space impedance for alternative travel]. Zeszyty Naukowo-Techniczne Stowarzyszenia Inżynierów i Techników Rzeczpospolitej Polskiej Oddział w Krakowie, 2, 98/2012. Kraków, 49-86.

Celiński I., Sierpiński G., 2013, A dynamic management of a public transportation fleet, LogForum 9 (3), 135-143.

Central Statistical Office, 2013, Number of mobile users at the end of the first quarter of 2013.

Directive 2003/88/EC of the European Parliament and of the Council of 4 November 2003 concerning certain aspects of the organization of working time.

Karoń G., Janecki R., Sobota A., Celiński I., Krawiec S., Macioszek E., Pawlicki J., Sierpiński G., Zientara T., Żochowska R., 2009, Program inwestycyjny rozwoju trakcji szynowej na lata 2008÷2011. Analiza ruchu. [The investment program tramway development for the years 2008 ÷ 2011. Traffic Analysis.] NB-67/RT5/2009.

Kauf S., 2010, Logistyka jako narzędzie redukcji kongestii transportowej w miastach, LogForum 6 (1), 37-46.

Mallinckrodt J., 2010, VCI, a Regional Volume/Capacity Index Model of Urban Congestion, Journal of Transportation Engineering, 136 (2), 110-119.

Our Common Future. Report of the World Commission on Environment and Development, Transmitted to the General Assembly as an Annex to document A/42/427 - Development and International Co-operation: Environment 1987 [online], 1.02.2013, http://www.un-documents.net/wced-ocf.htm

Pawlak Zb., 2011, The dynamics of the population flows in metropolitan areas, LogForum 7 (2), 1-15.

Pawlak Zb., 2012, Efficiency of urban congestion problem solving, LogForum 8 (2), 151-156.

Rashid, O., Coulton, P,; Edwards, R., 2005, Implementing Location Based Information/Advertising for Existing Mobile Phone Users in Indoor/Urban Environments. In: IEEE Proceedings of the 4th International Conference on Mobile Business (ICMB'05), Sydney, Australia, 377-383.

Sierpiński G., 2011, Travel behavior and alternative modes of transportation. In: Mikulski J. (Ed.) Transport Systems Telematics. Communications in Computer and Information Science, 239, 86-93. Springer - Verlag Berlin Heidelberg

Sierpiński G., Celiński I., 2012, Use of GSM Technology as the Support to Manage the Modal Distribution in the Cities. In: Subic A., Wellnitz J., Leary M., Koopmans L. (Eds.): Sustainable Automotive Technologies 2012. Springer, Heidelberg, 235-244.

Szymczak M., 2008, Logistyka miejska. Wydawnictwo Akademii Ekonomicznej w Poznaniu, Poznań.

Szymczak M., Sienkiewicz-Małyjurek K., 2011, Information in the city traffic management system. The analysis of the use of information sources and the assessment in terms of their usefulness for city routes users, LogForum 7 (2), 37-50.

Tarumi, H., Matsubara, K., Yano, M., 2004, Implementations and Evaluations of Location-Based Virtual City System for Mobile Phones. In: Proceedings of the IEEE Global Telecommunications Conference Workshops. Dallas, USA, pp. 544-547.

Website of Alstom, [online], 7.08.2013, http://www.alstom.com/poland/pl/

Website of ENTE, [online], 7.08.2013, http://ente.com.pl

Website of Pesa, [online], 7.08.2013, http://pesa.pl

White Paper: European transport policy for 2010: time to decide. COM(2001) 370.

White Paper: Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system. COM(2011) 144.

Wratny, J., 2010, Elastyczne formy zatrudnienia w perspektywie polskiego prawa pracy, In: Sadowska-Snarska C. (red.) Elastyczne formy pracy, Wydawnictwo Wyższej Szkoły Ekonomicznej w Białymstoku.

DYNAMICZNE ZARZĄDZANIE FLOTĄ TRANSPORTU ZBIOROWEGO

STRESZCZENIE. **Wstęp:** Artykuł prezentuje koncepcję zarządzania flotą transportu zbiorowego w aspekcie dynamicznym. Współcześnie istnieje wiele możliwości technicznych identyfikacji popytu w sieci transportowej. Można również wskazać zasadne podstawy szacowania i sterowania podażą. Artykuł ten jest opisem ogólnej koncepcji systemu zarządzania flotą transportu zbiorowego w oparciu o bilansowanie popytu i podaży.
Metody: W prezentowanej metodzie wykorzystywany jest opis macierzowy popytu na transport w oparciu o dane z systemów telemetrycznych i telekomunikacyjnych. Skupiono się głównie na ogólnej koncepcji pomijając sposób pozyskiwania danych opisany w innych opracowaniach autorów.
Cele: Wynikiem działania przedmiotowego modelu jest budowa systemu zarządzania flotą w czasie rzeczywistym. System taki ma również zapewniać optymalne wykorzystanie ilostanu środków transportu pozostającego w gestii przewoźników funkcjonujących na rynku usług transportowych.
Wnioski: Prezentowana koncepcja umożliwia inne spojrzenie na problem zarządzania flotą transportu zbiorowego. Projekt w przypadku wdrożenia powinien pozwolić m. in. na projektowanie dynamicznych rozkładów jazdy, aktualizowanych na bazie obserwacji popytu, a nawet projektowanie dynamicznego rozkładu punktów dostępu do linii transportu zbiorowego. W dalszych pracach należy zwrócić uwagę na problem tzw. reroutingu tras pojazdów transportu zbiorowego na podstawie dynamicznych pomiarów charakterystyki systemu transportowego..

Słowa kluczowe: tranport, zarządzanie flotą transportową, model zarządzania.

DYNAMISCHE FUHRPARK-VERWALTUNG IM MASSENVERKEHR

ZUSAMMENFASSUNG. Einleitung: Der Beitrag stellt ein Konzept für Management einer Massen-Transportflotte in dynamischer Hinsicht dar. Heutzutage bestehen zahlreiche Möglichkeiten für technische Identifikation der Nachfrage in Transportnetzen. Man kann natürlich auch begründete Grundlagen der Schätzung und Steuerung des Angebotes vorweisen. Der vorliegende Beitrag beschreibt die allgemeine Idee eines Systems für Management einer Flotte im Gruppentransport anhand einer Nachfrage- und Angebotsbilanzierung.
Methode: Die vorgestellte Methode nutzt die Matrixbeschreibung der Transportnachfrage anhand der mit Hilfe von telemetrischen und telekommunikativen Systemen generierten Angaben. Der Fokus richtet sich auf die allgemeine Idee. Die Art der Gewinnung von Angaben wird jedoch außer Acht gelassen, da sie von anderen Autoren bereits beschrieben wurde.
Ziele: Das Ergebnis des gegenständlichen Modells ist die Ausgestaltung eines Managementsystems für Transportflotten in der Echtzeit. Dieses System soll auch eine optimale Nutzung des Bestandes von Transportmitteln, der den auf dem Markt tätigen Transportunternehmen zur Verfügung steht, gewährleisten.
Fazit: Die vorgestellte Idee ermöglicht es, das Problem des Managements von Transportflotten für den Gruppentransport aus einer anderen Perspektive zu betrachten. Das Projekt sollte im Falle seiner Einführung u.a. das Entwerfen von dynamischen Fahrplänen, die anhand von Nachfrageanalysen aktualisiert werden, und von dynamischen Plänen der Zugangspunkte zu Gruppentransportstrecken ermöglichen. In der weiteren Bearbeitung sollte man sich mit dem Problem des sog. Rerouting von Gruppentransportmitteln anhand dynamischer Messungen von Kennlinien und -ziffern eines Transportsystems beschäftigen.

Codewörter: Transport, Fuhrpark-Verwaltung, Modell des Managements.

Ireneusz Celiński, Grzegorz Sierpiński
Silesian University of Technology
Faculty of Transport, Department of Traffic Engineering

Krasiński 8 Str., 40-019 Katowice, Poland
e-mail: ireneusz.celinski@polsl.pl, grzegorz.sierpinski@polsl.pl