TRANSPORT PLANNING ON THE LIBERALIZED MARKET OF PUBLIC SERVICES

Ing. Vít Janoš, Ph.D., Ing. Karel Baudyš, Ph.D.
Czech Technical University in Prague, Faculty of Transportation Sciences, Czech Republic
E-mail: janos@fd.cvut.cz; E-mail: baudys@fd.cvut.cz

Abstract: *The importance of transport planning in public services gradually becomes to be fully appreciated in the context of the Czech Republic. Public transport such as investment and operationally intensive industries require a guaranteed long-term strategy, not only in the field of transport infrastructure, but also in the field of transport services. The first prerequisite for successful transport planning is the most accurate description of passenger flows, including the parameters affecting the choice of transport mode. These inputs are an important basis for additional steps: the creation of a line network, timetable design, creating circulation of vehicles and courses of staff, controlling, and any requests for infrastructure improvements. At the end of this article are referred specific practical examples, where thank to a compliance with the rules of theoretical transport planning it has been achieved the increased operational efficiency of public passenger rail-transport.*

KEYWORDS*: RAILWAY TRANSPORT, PUBLIC TRAFFIC, RAILWAY TECHNOLOGY, TIMETABLE DESIGNING, PERIODIC TIMETABLE, TRANSPORT PLANNING, TRANSPORT DEMAND ESTIMATION, VEHICLE CIRCULATION*

1. Defining the objectives of transport planning

Currently, the transport planning in the Czech Republic stands in their factual beginnings. Institutionally transport planning establishes the "Law on public passenger transport services" (194/2010 Coll.), and individual orderers of public transport are thus required to build transport plans for its scope. Public transport in the concept of quality of transport service is more than just a social service for those who have no other option but to achieve an overall transport accessibility of the region so that public transport represent an attractive alternative to individual transport. The law on public passenger transport services (194/2010 Coll.), Title I, § 2, defines the transport service as follows:

Transportation services means the ensuring of transport every day of the week, especially in schools and educational institutions, the public authorities, to work, to health facilities providing basic health care and to meet the cultural, recreational and social needs, including transportation back, contributing to sustainable territory development.

The interpretation of this provision is quite clear, because it does not specify objectives, waiting time, number of transfers, number of connections, the number of people with the same destination and purpose of the trip, walking distance or other parameters of transport services and thus depends entirely on the specific access of the orderer to public transport services. All these parameters of transport services must identify the orderer and transport services are defined as the transport plan.

It is clear that public transport cannot cover all the passenger flows, nor all the transport needs of individuals. Public transport with regard to the need for compensation (income from fares do not cover the cost of providing) must have elements of the mass. If in a particular place and time together transportation needs of individuals in a transport flow, then it can be addressed by public transport organized on a collective basis. With regard to the rational planning of public transport and the final volume of funds for compensation payments (compensation) cannot be on the one hand these resources inefficiently spent on transportation of individuals and on the other hand not to have the resources to ensure transport in relationships with much higher demand.

Theoretical public transport planning takes place at 7 classic steps:

1) Estimation of passenger flows, part of transport modelling

2) Formulation of the line network plans

3) Implementation line network to the infrastructure, revision modal choice

4) Timetable design

5) Circulation plans of vehicles and stuff courses

6) Evaluation of the operation performance, controlling

7) Defining the requirements for the infrastructure improvements

This article briefly summarizes selected procedures leading to greater operational efficiency. On the example of planned tender for a rail carrier in the regional transport on the selected lines in the Region Jihočeský kraj, it is shown, how the compliance with the theoretical rules can lead to a reduction in the number of operating rolling stock, while increasing the supply of the connections. Because the regions compete in a regular public transport by the so-called "gross principle", where the yield risk is on the side of the public authority, this article focuses primarily on such transport-planning processes that affect the cost side of the transport concept.

1.1. Characteristics of passenger flows

The information of passenger flows is currently available mainly from the CSO data - data on the number of permanent residents in the municipalities and their local areas, information about regular commuting. Further information is available from carriers - information about the load-factor, number of boarding and alighting passengers at each stops, shortly will be provided the origin-destination matrices. For more information on the origins and destinations relate mainly to number of employment opportunities (data from major employers) and regular commuting school children - these data are used in abundance in the case of larger optimization of timetables in the region.

Available CSO data are not broken down by mode of transport attributable to a specific origin-destination, because this is the information about the total passenger flows - across all modes of transport. On the contrary, data from carriers are related only to a particular type of service and thus have explanatory power only for passengers who already use the public transport.

For a description of all passenger flows in the region across all transport modes can only be used the theoretical transport models. Thus established passenger flows can be followed on the basis of the

availability of origins and destinations of share assigned to each mode of transport - theoretically calculated passenger flows thus assign theoretical modal split. It shows how important is the role of public transport in a whole transport system where there is generally a high demand for transport and the passenger flows which makes it suitable to be targeted and at the same time, in which relations there is a most unused potential for public transport.

Contemporary no region today has processed quality transport model, because the benefits of high-quality and comprehensive transport modelling in the Czech area are still not fully appreciated. What is missing, is a quality travel surveys, surveys on the transport behaviour and sensitivity of users to parameters of public transport offer. Finally, it is difficult, often impossible, to group the time incommensurable data needed for the transport model setting.

For the purpose of transport planning are so often used incremental theoretical gravity models of passenger flows in the region. The output of these models is the proportional comparison of significance of passenger flows, often associated with the theoretical calculation of the modal split.

From the gravity model taking into account the modal split can be seen, how the public transport is successful in individual relations. Clearly then follows the disproportion in the region and the relations that represent the greatest potential for growth in public transport. Juxtaposition of relations can also be inferred where is potential for core railway lines, collecting railway lines and core bus services.

All the above information is important for line network planning and timetable improvements. Outputs of gravity model introducing the core and collecting lines with high (not yet used) potential will be applied gradually to the ongoing optimization of individual areas in the region.

1.2. General rules for the ensuring of transport services

Definition of passenger flows form the first input for the formulation of the line network. The second input is the restrictive conditions, which formulates each individual public service orderer. These restrictive conditions usually relate to the minimum limit for operating public transport. From our experience, there is a "critical" size of settlements where the passenger flows are not possible to capture on the collective principle and where the providing of public transport is very inefficient. Operation of such settlements is left to individual transport, or social services, and in these cases there are not provided public transport services. They are defined as:

- Municipalities and local area without an operation of public transport (where it is possible to solve transportation services using e.g. subsidized taxi service, social services, etc.)

- Community and the local area that are served to a minimum - there is usually used the limit according the number of permanent residents, combined with the requirement of minimum average daily exchange of passengers at the bus stop

- Parameters of the hierarchical organization of other lines that make up the network core / superior and subsidiary network

It is clear that in regular commuting is the greatest potential for public transport and should thus concentrate on measures that affect the modal split in favour of public transport in just this type of passenger flows. The key is to make the public transport system so attractive that it will use and the passengers who are free in their choice of means of transport (driving license holders and owners of a car - referred to as *captive drivers* and *choice drivers*) and not only those who do not choice (e.g. school children - *captive riders*).

1.3. General rules for line-planning in public transport

When creating a line network plan is necessary to combine aspects of passengers and technological and operational aspects, which combine the need of such a proposal, on the one hand positively affects Modal-Split in favour of public transport and on the other hand, such a proposal will be operationally viable.

This combination includes consideration the most important factors monitored by passengers:

- can be used between all points "shortest time" path
- the minimum number of changes

and most important operating factors:

- similar need of the vehicle-capacity along the whole length of the line
- minimum number of vehicles on providing the required operation performance

Based on the generated line networks of public transport, it is necessary to proceed to the definition of each segment of transport services. In this step, the plan will specify the stop/service strategy of lines in the network and define the function of individual lines in parts of the network where multiple lines were proposed simultaneously. When positioning time slots of each connection of particular line are assayed assuming the achieving of certain nodes in the network.

The line draft must consider the needs of homogeneous groups of passengers, for which is the line intended in terms of segmentation.

The main modifiable criterion is travel time, which is mainly based on network suspended waiting time. Due to operational capabilities and transport requirements (mainly interconnections for transit passengers) there are produced technology links in the timetable, i.e. the time dependence between two connections, respectively systematically between the lines. Scheduled line network significantly influences the Modal-Split and so should be given to the preparation of appropriate attention.

When creating the structure and hierarchy we can use a variety of terms that are easy to characterize a soft system (for example "regional services"), but if we want to project these concepts into a hard system, we are dealing with certain problems, since in the fully deterministic system is not possible to use intuitive definitions that work with the majority interpretation.

Building the structure of the public transport system must follow the hierarchy downwards, i.e. building the functional core systems. The reasoning used model layers (segments) of public transport, which together form an integrated structure. Segmentation method clarifies the structure of public transport.

Segmentation according to transport functions:

- Rapid transit between agglomerations (A)

- Rapid transport service between regions and within regions (B)

- Core regional transport (C)

- Collecting/distributing regional transport (D)

- additionally it could be considered an alternative segment (E) of additional transport systems

The individual operating segments have with regard to the time competitive with individual transport general recommended length of intervals based on general assumptions that the mean waiting time for a service should not be longer than the actual travel time. In the segmented system by transport function is very difficult to define the concept of regional transport, which is essentially perceived very intuitive. In practice, although institutionally defined by another orderer, but the actual impact of passenger flows this definition does not logically.

Regional transport we can delineate the way that a regional transportation means all that falls within the daily commuting. The structure and size of the confidence ellipse can be so intuitively define the concept of regional transport, while regional transportation is implemented in this concept across all segments A - E.

1.4. General principles of timetable design

Timetable of public transport is a direct result of the application of transport planning in the area and determines the structure and form of the offer.

The distribution of types of timetables for timetables without a fixed interval and with fixed period so there is a choice of type:

- Classic commercial timetable (connections are spread in the projected traffic demand)

- Interval schedule (fixed intervals always unchanging within part of the operational period, without a broader network of interconnections)

- And integrated periodic timetable (systematic coordination of timetables of individual lines, which are used in the selected interconnected periodic nodes to achieve maximum of optimal connections, to create a coherent network-wide interconnected periodic timetable. Unified cycle time on all lines is observed throughout all the civil day. Local requirements are addressed beyond periodic system by additional special connections)

The following figure expresses general applicability of different types of schedules depending on demand and interval combination:

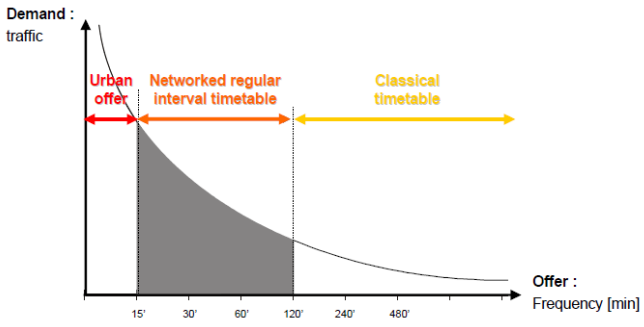

Fig. 1: *Models for the three levels of offer and demand (SMA und Partner)*

In the concrete operational level is not easy to find a specific time / place to change the type of schedule, because if the individual lines are hierarchically interconnected, then the change type between fixed and without a fixed interval almost always at the expense of transfer relations.

In the case of scheduled commercial applications are usually mostly covered with rush hours, which clearly determines the number of necessary sources (vehicles, staff), which are then often during the day unused. Commercial timetable means at our conditions almost always less operation performance than in periodic timetable and its ensuring is so associated with a relatively high proportion of fixed costs. The unit's performance is usually very expensive.

The transition from a commercial timetable to periodic in the initial phase all of the vehicles needed to ensure the transport peak in the intervals seeded throughout the operational period. So decreases the relative loss per unit of output, even though the variable costs are rising. Increasing offer leads to a progressive increase in the number of passengers carried and thus a more favourable development of revenues and reduce pressure on operating compensation payments.

The main benefit of integrated periodic timetable is consistency of public transport offer for passengers. Simplicity, ease of memorability, transfers without undue delay, and above all territorial and network availability. The concept of periodic and integrated periodic timetable is particularly appropriate where there are large passenger flows without clearly grasp time requirements (as in the commercial timetable), while the frequency of operation cannot be so high as to be able to give up on interchange links (as in the interval schedule). The concept of integrated periodic timetable is currently the highest possible level of public services offer.

1.5. Methods of circulation of vehicles and staff courses

There are many methods of production cycles of vehicles and staff courses. In the methods of operations research, this is called the assignment problem to be addressed such as the Hungarian method, which is generally known, and therefore will not be reported in detail.

Number of vehicles on the line does not be in itself determinative of their circulation. In any software solution assignment problem is passed optimization confronted with the need for operational maintenance. Existing software currently cannot take into account the operational maintenance in a particular location in the network after driving certain number of kilometers necessary for operating the maintenance. Number of possible combinations gives rise to NP-hard problems. Most software allows you to manually enter the transition vehicle (connection/connection) - so if there is circulation, which is at the normal operating maintenance option noticeable time vehicle downtime for this maintenance, then the transition will be set manually and optimization of the number of vehicles will take place again with this restrictive condition. But this is a manual intervention, which must always be done by the user. In an extreme case, this intervention leads to an increase in the number of vehicles. Operating maintenance options and associated increases the regular number of vehicles, as well as the extent of empty runs are directly associated with the location of depots/service centers. Choosing the appropriate service center for line servicing is connected to the schedule - his appearance, scheduled downtime of connections etc.

2. Application methods of transportation planning to the operating area of Šumava

On the concrete case of the operating regular public transport in the area Šumava in the region Jihočeský kraj were in the operational planning previous general principles applied. Jihočeský kraj is one of 14 regions in the Czech Republic responsible for ordering of public transport. Operating area Šumava is now generally geographically bounded by the towns of České Budějovice – Strakonice – Volary – Český Krumlov. Operational performance of around 1,38 million train-km per year providing 12 trainsets (vehicles), the average daily run of one vehicle is about 315 km in a day. This value is low and

create opportunities for increase. The costs associated with the vehicle (depreciation, maintenance), personnel costs (salaries, payments) and traction costs (fuel, electricity) are generally usually more than two-thirds of the total costs of transport capacity. When designing the most realistic operational concepts, from the outset attempt to apply maximum operating efficiency.

Operating concept Šumava is characterized by containing performances, that have character of purely regional transportation with daily commute, and performances, that are mostly tourist. Seasonality of several trains is so high, that in the summer, occupancy of individual connections are reaching to quadruple levels than during the off-season.

Based on the review of known facts about the occupation and load of individual train connections and CSO data were applied methods of timetabling leading to shorten of transfer- and travel times, with the following modifications:

- narrowing of transfer connections in the nodes
- introduction of fast regional trains in the peak tourist season (as a substitute for some of today's passenger trains)
- introduction of new embedded connections during the downtime of vehicles
- reducing the travel times during the tourist season contributed to the shortening of the vehicle-circulation-time, which extended the combinatorial possibilities for creation of their circulation and helped to reduce their number
- definition of the two-stage operation concept with identical demand of the number of the vehicles (where the second concept defined the requirements for modification of the infrastructure - with particular benefits to additional travel time reducing)

After designing of the basic structure of the periodic timetable and IPT-junctions were made minor changes in the raster of periodic timetable. In the morning peak hours were separately taken into account the requirements of the local time (starting times by significant employers, beginning of school hours) and the structure of IPT was often partially deflected. At the same time, during the morning peak hours was usually a structure of IPT preserved primarily in the main transport directions and main change linkages, which led to the minimization of the number of vehicles in the morning peak hour of the workday. It is just a morning peak hour of the working day, which determines the number of vehicles. The total volume of operational performace has been increased to 1,57 million train-km per year.

To minimize the number of vehicles in the network was used authors-own heuristic procedure, which can achieve such solution that takes into account the specifics of the operational processes (or as refueling or changing staff in a specific place, etc.). This procedure has 6 basic steps:

1) for every point in the network, where are starting or ending courses of single lines in the operational area, is created table of arrivals / departures
2) create a sets of "network conditional transitions" (such transitions of vehicles between course to course, whose failure leads to necessary occupying the default connection of an additional vehicle)
3) from these sets of network conditional transitions are by a sequence of courses created integrated continuous strings (the string terminates just at such place and time, when the vehicle has equivalent combination, crossing to another string - i.e. there does not arise network conditional transition)
4) individual strings are evaluated by its kilometric (for an operating treatment, or tanking) or time (in case of deployment of personnel and compliance with time breaks) length
5) thereafter follows coupling of strings into the complex circulation (for vehicles), or stays (for staff)
6) if the fact, that a string exceeds the beginning of the specified limit (the mileage or time duration), it is obvious, that it is necessary to use additional vehicle / personnel, which will further extend the possible combinations

This approach is equally usable for the production cycles of vehicles on road and rail, as well as for creating personal session. The procedure itself does not guarantee the creation of an optimal proposal (in terms of steady running vehicles, or optimal use of staff), provides however, that will be deployed only the minimum number of vehicles (or staff) in compliance to the boundary conditions. Limit to the number of vehicles in the application of this procedure lies in manual processing of approximately 30 vehicles, which from experience usually leads to the need for a combination of about 60-150 strings.

Application of these principles fully reflected in the operation costs. In operational area Šumava was the number of operating vehicles reduced by optimizing from 12 to 11, while the average daily running of the vehicle has increased from the current 315 km/day to the proposed 390 km/day. Since the extent of ordered transport was limited, it was not possible to further enhance the performance of vehicles. Such modified operational concept is prepared for the tender of Jihočeský kraj for selecting new rail-carrier.

3. Conclusion

The overall problem of transportation planning is very extensive. The aim of this article is not to describe in detail all the procedures and methods, which hides behind each step of transportation planning. Transportation planning as such is a complex task that is involved in many scientific disciplines. Individual tasks are closely related and cannot be resolved individually, without overlap in the overall context of the transport plan. The aim was to go through the steps that are necessary from the initial entry, the need to create operational concept to final product, including its timetable technical support. It was also the purpose to show, that the theoretical rules compliance can be achieved by increasing operational efficiency.

On the specific case of the operating area Šumava in the region of Jihočeský kraj, these principles fully take effect, when the current number of vehicles has been reduced, performance volume slightly increased, and additionally it was observed shortening travel times. The operating concept was also prepared for two states of operation - without modification of the infrastructure, and with infrastructure modifications. To ensure upward compatibility are both operational concepts optimized for the same number of vehicles, and the differ is in benefits in the region in the travel times. Thus prepared optimized operational concept is ready for the competition on the rail-carrier. In the case of market opening of public services should be preparation of the operational concept performed together with operational optimization. It´s one of the few ways to ensure long-term sustainability of public rail services. In a liberalized bus market in the

Czech Republic, the optimizing procedures of the operation brought the transport price reduction by 10-25 %. These savings were reinvested back into enhancing the quality of public service. It will be interesting to see, whether similar results come even in regional rail transport.

REFERENCES

1. Janoš, V. - Baudyš, K.: Transport Planning of Public Services. In *Proceedings of the 11th European Transport Congress*. Praha: České vysoké učení technické v Praze, Fakulta dopravní, 2013, . ISBN 978-80-01-05321-8
2. Janoš, V. - Baudyš, K.: Development of Periodic Timetable in the Czech Republic. In *Road and Rail infrastructure II*. Zagreb: University of Zagreb, 2012, p. 869-873. ISBN 978-953-6272-49-5
3. Janoš, V. - Baudyš, K.: SYSTEM DEVELOPMENT OF PUBLIC RAILWAY SERVICE AND OPEN ACCESS IN THE CZECH REPUBLIC. In *Symposium Proceedings EURO ŽEL 2012*. ŽILINA: ŽILINSKÁ UNIVERZITA, 2012, p. 135-141. ISBN 978-80-263-0242-1
4. Baudyš, K. - Janoš, V.: Relation between Modal-Split and transport planning. In *Udržitelná příměstská doprava*. Praha: ABF a.s., 2007
5. Janoš, V. - Baudyš, K. - Vichta, F.: Financing the Public Transport in the Sphere of Regulated Competition. In Sborník konference Euro Traffic 2006. Praha: ABF a.s., 2006, s. 7. ISBN 80-86905-15-2. (in Czech)