VEHICLE- AND STAFF PRODUCTIVITY IN BUS URBAN TRANSPORT

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Abstract: *In each transport system are for its total costs key the fixed costs, deriving from regular deployed number of vehicles and drivers, related to the overall transport performance. Fixed, periodic and systematic linkages in the operational concept can achieve higher productivity of vehicles and personnel. Article explains the application of these techniques in the optimization of urban bus transport in the Czech town Jindřichův Hradec.*

KEYWORDS*: PUBLIC TRAFFIC, TRANSPORT TECHNOLOGY, BUS TRANSPORT, URBAN TRANSPORT, TIMETABLE DESIGNING, TRANSPORT EFFICIENCY, TRANSPORT PLANNING, TENDER FOR CARRIERS, VEHICLE CIRCULATION*

1. Introduction

Bus urban transport in the Czech Republic is currently ordered in many towns. The smallest Czech town with regular public bus urban transport is Přelouč (8 200 Inhabitants).

For decision, to order or not to order bus urban transport in concrete town is the town structure, distance between transport main sources and destinations in the town and the whole attractiveness or emissivity of the town (how many people are travelling from / to the town, how important is the internal mobility).

There is a big difference in planning the operational concept of urban traffic in the big city and small town.

In large cities, it is crucial to ensure appropriate intervals in the strongest transport directions and the key issues include sufficient capacity and sufficient speed for longer distances within the city.

In smaller towns there is very wide number of traffic flows, but these traffic flows are considerably smaller and, therefore, from the perspective of public services much harder to grasp. Additionally, there are many local transport requirements - typically tied to school or significant employer - which mean subsequently fixed points, which are necessary to be served in concrete times. The result is a combination of lines with interval operation (route directions and the general demand) and lines of operation purely purposeful.

The situation is different in addition the fact that whereas in larger cities, there is usually a transport company owned by the city, which has long provided transportation services in the city (and thus falls into the category of so-called. Internal operator), in small towns such an operator usually is not, and if the volume of traffic performance exceeds 300 thousand bus km per year, is there necessary to compete these performances.

2. Structure and configuration of operational file in bus urban transport

In the case of urban bus transport - unlike regional bus services - falls away a question of the method of determining the structure of operational file, based on the geographic or on technological clustering. Since the space of the town, the city with its wider hinterland, or agglomeration is exactly geographically defined, remain as technological clustering by type and number of vehicles - as in bigger cities may eventually open the possibility of entering more operationally homogeneous files, in smaller towns situation leads always to formulate of just one operational file and to award of one contract.

The authors of this article have participated in the preparation of the technological structure of the operational file of bus urban transport in Czech town Jindřichův Hradec. Jindřichův Hradec is south-Bohemian town with 21460 inhabitants.

2.1. Operational structure before the competition

The original transport concept of urban operation in Jindřichův Hradec valid until December 31. 2015 represented a transport volume of approximately 330,000 km per year and was scheduled for 7 buses in regular circulation.

The line plan contained 5 lines with round and half round character, with different time variations and routes variations, while on any of the lines was not offered a regular interval of connections.

The entire operation of urban transport was necessary to systematically define and grasp to be able to define it in the form of a comprehensive operation file for need of competition - in terms of technical and technological parameters.

2.2. Operational file parameters for competition

Preparing of a new contract associated with necessity of the competition of transport carrier used the town to fundamental changes in the concept of bus urban transport. New functionality demanded by the town were as follows:

- direct leading of the lines in most important directions

- minimization of detours and higher unification of routes of single lines

- expanding operations in local parts of the town, extended operation in off-peak hours (early morning, evening hours..) and on weekends

- regular intervals on single lines; between the largest housing estates to the town center all-day basic interval of 30 minutes and in peak hours interval of 15 minutes

- creation of systematic linkages with trains at the railway station

Processing of these requirements led to a significant increase in transport performance - namely 450 000 km per year. At the same time, there was abided boundary condition, that the new concept must be able to work still with 7 buses in regular circulation. It was really such a complex combinatorial problem.

3. *Technological structure of traffic performance in operational file*

The specific content of each operating file are concrete lines, their timetables and the resulting number of vehicles, which is necessary to ensure the required transport performance .

Before assigning single lines to single operational files it is usually appropriate to revise leading of lines, not only for transportation reasons, but also for operational reasons. In the current conditions of Czech Republic, there´s line management in many cases "historic", regardless of economic, socio-economic and demographic trends.

Based on the review of known facts of the various transport relations should be applied methods of line-planning leading to maximizing of the number of direct-travelling passengers.

After creating the line leading follows usually next step - forming a timetable. In urban traffic is so needful to take into account necessary intervals on lines, according to anticipated demand, and by smaller towns with longer intervals also take into account other requirements (eg. connections on trains and regional buses, the required linkages between the lines, etc.).

The standard follow-up step after creating a timetable would be to create cycles of vehicles and personnel. In this case, it is then also possible to use well-known optimization methods to minimize the number of deployed vehicles.

The author´s team new approach is, that already when the timetable proposal is created, combines the operational concept with cycles of vehicles, in mutual repeating iteration steps.

After designing of the line-network and basic structure of the timetable can be done minor changes in the timetable raster, in order to allow implementation of atypical combinations of crossing vehicles under extreme time demands in the morning peak hours. 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). At the same time, during the morning peak hours was usually a timetable structure preserved primarily in the main transport directions and main change linkages, while in the opposite direction (contrary to a major transport streams) were used differing routes, atypical crossings between the lines, as well as pragmatic time positions, 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.

Approach to the timetable creating is as follows:

1) defining IPT nodes and intervals, calculate the number of vehicles for "basic periodical operation"

2) defining a specific operation in the morning peak hours and minimizing the number of vehicles in this period; ideally for the number required in previous point 1

3) after the arrival of school busses, as soon as possible "timetable transition" to defined structure of periodical timetable

4) operational optimization and ensuring operational efficiency (breaks for drivers, refueling buses...)

5) adaptation of timetables in the evening hours (to minimize the number of vehicles, reduction of total working time of drivers)

The aim is to ensure maximum operational efficiency within a defined operational file.

The following figure expresses the fixed costs of the bus relative to the average daily performance.

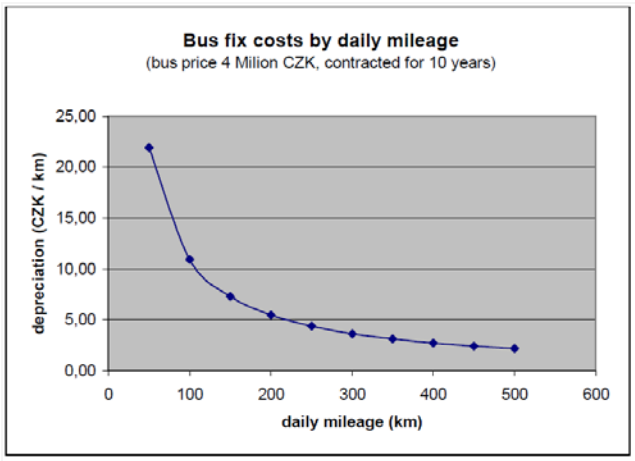

Fig. 1: *Bus fix costs (depreciation) by average daily mileage*

Currently, the regional bus services in the Czech Republic has held daily vehicle mileage normally about 60-130 km, in urban transport sometimes even lower. From the above figure it is apparent, that the cost curve is broken in the space daily performance of 200-300 km, which corresponds to an annual mileage of a vehicle about 70 000 to 100 000 km.

In no operational file are these limit values reached in the beginning. It is natural, since the beginning sort of performance into operational files is usually made by current timetables, which has been usually no optimized before.

3.1. Case of optimized operational file of bus urban transport Jindřichův Hradec

Applying the above general approach to the optimization of the specific case of urban transport in Jindřichově Hradci went so, that it was necessary to take into account the factors listed below:

- basic interval for the peak hour (15 min) and off-peak hour (30 min) on most important lines

- determination of basic vehicle size corresponding to the capacity needs of the most occupied connection in the morning peak hour (approximately 70 passengers, which corresponds to a city bus of the 12m length)

- even though with a new concept was introduced a transit fare, the character of the line network remained as branched network (with a higher bid direct connection in most directions, at the expense of connection in a shorter interval but associated with passangers change)

The most complicated combinatorial task was assembly operational concept. The operational concept elements were tight time-anchored (eg. a request connection to trains), elements whose position directly resulted from the other of the fixed elements (eg. a requirement length of interval when a specific time slot joints unfolded from connections with rigid bonds), and finally elements whose time position was not fixed (eg. connection of smaller town parts). The operating concept was created with a direct link to the circulation of vehicles, as required with a view to achieving high operational efficiency, where was aimed to maintain 7 planned scheduled busses for regular circulation.

It was so composed a "time raster", in which were primarily occupied fixed times and requirements were subsequently occupied by combinatorial other elements with a higher degree of freedom. This process included several iterations.

Every assembly draft operational "time raster" was verified by personnel efficiency. Within the operational concept was monitored specificity consisting in fixed boundation between driver and vehicle. In the Czech environment between operational staff there is seen as a great advantage, if it is possible this boundation between driver and bus (the drivers during a work shifts do not change vehicles and every driver has "his own" bus). Although fixed bond between driver and vehicle is very strong boundary condition, which potentially hides inefficiencies, this condition was kept. Within the operational "time raster" had been as well taken into account mandatory breaks for drivers. However in the peak hours was the time for breaks utilized for embedded links (transitions and combinations of vehicles), in which by the imaginary allowed length of the drivers operation was suggested their change. Also in these combinations were used for crossing vehicles (and empty runs), since in general, empty runs can in some cases reduce the number of planned vehicles.

Single iterations during the assembly of operation "time raster" consisted in eliminating atypical combinations and subsequent reminimize empty runs. To achieve the desired result was required 5 iterations. In the resulting "time raster" operating buses are not tied to individual lines, but on individual final stops are changing between the lines.

After the formation of the final operating "time raster" were assembled circulation plans for vehicles - emerging on the principle of cyclic repetition of time raster. This laid due fixed boundation driver / vehicle the foundation for circulation plans for drivers.

The last group of optimization measures was minimizing of staffing needs. Because the proposed operational "time raster" included time for breaks for drivers, could be by using rebase "parts" of circulation plans (including the use of additional empty runs) go in selected cases to the very time-limit length of drivers work-shifts and were so composed shifts with as much time length (for two drivers alternating), and shifts to the length corresponding to the permissible driving time for one driver (without changing). These rebasings of operation "time raster", to achieve optimal results in personnel efficiency, entailed 4 iterations

The overall result is an extremely high vehicular and personnel productivity. From the original value of the average daily performance of 129 km / bus was reached 176 km daily performance / bus. On working days is deployed 7 busses and 12 drivers, on free days then 4 buses and 6 drivers.

In so comprehensively prepared form (timetables, vehicle- and drivers circulation plans) was contract for urban transport in Jindřichův Hradec tendered.

4. Conclusion

The first method focused on cost reduction should take the form of increasing productivity by reducing the number of regular operated vehicle and reducing the regular number of staff - particularly the decline in fixed cost components in such a way as to prevent deterioration of service and managed to keep the revenue.

The second approach is the offensive offer where the existing resources in the field of rolling stock and staff are used to create higher level of service, while the growth of variable cost components must be covered by additional revenues - and just this approach was used in bus urban transport in Jindřichův Hradec.

For the operational concept in bus urban transport was a complex preparation of the contract for the tender for new carrier - bus operator.

While in the case of internal (town-owned) operator there is possible to increase operational efficiency continuously, in case of the tenders must be the operational parameters set correctly from the beginning.

This situation is in many ways even for new by bus operators participating in the tenders too, because the demands on the operational concept and quality are predetermined from the orderer. The carrier has already no possibility to optimize (or partially) operational concepts according to its operational needs. The role of carriers in this regard is already seemingly passive - however numerous carriers orient already in the new circumstances and focus their activities on the rationalization measures that allow them to cope with the prescribed requirements at the lowest cost. After the carriers have no opportunity to enter timetable preparation and requirements during the tender, they are focusing on typical operating area (suitable dislocation vehicles and personnel for contract performance, placement of technical and technological background, optimal mode of refueling buses, reduction of personnel time losses etc.)

On the example of the urban bus transport in the Czech town Jindřichův Hradec was shown, that a good and thorough preparation of a tender in public bus urban transport can significantly rise vehicle and staff productivity. With the same numbuer of busses was created brand new timetable, with the increase in transport performance by 40%.

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