A Method of Programming the Rolling Stock and the Board Personnel in the Urban Passenger Traffic

Toader GHERASIM
George Bacovia University, Bacau, ROMANIA

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Abstract: Due to the lack of uniformity in time and space of the request in the urban passenger traffic, both the passengers and the transportation companies have to suffer: the passengers shall never be able to get (practically) the full capacity they would need in transportation means during the rush hours (and on the busy routes) and the providers of transportation services shall suffer the negative effects of the immobilization of many units during slack hours. Moreover, the transportation companies shall experience big difficulties in organizing the board personnel's work according to the labour code, not having the possibility of programming all the activities not in one, nor two and not even in three normal shifts. This study puts forward a personal methodology which can be used for solving such problems for the benefit of both the passengers and of the transportation companies.

The fundamental characteristic of the urban passenger traffic is its non-uniformity both in time and space, as well as on circulation ways.

Its non-uniformity in time is firstly connected to the working hours of the companies in the county (which can be in one or more shifts), generating the traveling between homes and offices (both ways), as well as other needs of the population (the supplying with different types of goods, of spending leisure time, etc) which also have a non-uniform character.

Generally, in Romania, the distribution of the request of urban passenger traffic is done according to periods of the days, as shown below:

- 4^{00}-8^{00} the period of maximum solicitations (when the working hours of the companies with a first shift begin, as well as the ones of the public institutions);
- 8^{00}-13^{00} – the first period of the normal solicitations;
- 13^{00}-17^{00} - the period of time of the second maximal point of the request (when the working hours of the first shift end and the second shift begins);

- o 17^{00}-23^{00} – the second period of the normal request, when the population goes out shopping, or for spending their free time etc., or they go home from the second shift or even go to work in the third shift.
- o 23^{00}-4^{00} – the period of minimum solicitations – when people are resting.

Most of the times, *the spatial non-uniformity* (on traffic ways) coincides with the one of time, increasing its negative effects. During the rush hours, the request is very high on only one of the traffic ways (in the morning, on the one from home to work, in the afternoon on the other one, from work to people's homes), on the other traffic way the vehicles running almost in vane.

Due to the non-uniformity in both time and space of the request in the urban passenger traffic, both the passengers as well as the transport companies have to suffer: (practically) passengers shall never have the entire amount of transport means they would need during rush hours and on the busy traffic ways \, whereas the drivers shall have to suffer the negative effects of the lack of usage of their transport means during low traffic and on the traffic ways which are not intensely used. Moreover, the transport companies shall have very big difficulties in organizing the shifts for the board staff according to the labor code since there is no possibility of organizing their activity not in one, nor two and not even in three normal shifts.

The statistics of the transport companies regarding the solicitations from similar anterior periods of time and the estimations for the very next periods give rather accurate information about the level of the request from each of the five significant moments of the day. By knowing it, we could calculate the hourly number of the drives (n_c) on a certain route, like this:

$$n_c = \frac{N_{ch}}{q_v n_{cl}}$$

where : N_{ch} – the hourly number of the passengers transported on the busiest traffic way (the hourly passengers' traffic)

q_v – the medium loading capacity for a vehicle used by the company in the passengers' traffic (the maximum number of persons in the seats, or both on the seats and standing);

n_{el} – the medium number of passengers that can be transported successively, in a drive, on the same seat:

$$n_{cl} = \frac{l_c}{l_{cl}};$$

l_c ,l_{cl} – the medium length of a drive (for the vehicle), or for a route (km).

The number of the vehicles (N_v) needed in order to perform these drives can be determined like this:

$$N_v = \frac{n_c}{n_{cv}},$$

where : n_{cv} - the medium hourly number of drives that can be done with one vehicle

$$n_{cv} = \frac{60}{t_c},$$

t_c - the medium duration of a ride (hours) :

$$t_c = \frac{l_c}{V_t} 60\,(1 + k_{as}) + n_{ot} t_{ot} + t_{sct},$$

V_t the medium technical speed of the vehicle that has been programmed for the drives (km/hour) ;

k_{as} - the medium quotient of the stops during a drive (at the traffic lights, stop signs, etc), expressed in stopping minutes for an hour of effective driving;

n_{ot} - the number of stops in the bus stops; t_{ot} - the medium duration of waiting in a bus stop (minutes); t_{sct} -the medium waiting time of the vehicle at the end of the transport routes (minutes per drive).

Therefore, the analytical relation used to calculate the number of vehicles N_v for each of the five moments of the day shall be like this:

$$N_v = \frac{\frac{l_c}{V_t} 60\,(1+k_{as}) + n_{ot} t_{ot} + t_{sct}}{60}.$$

When programming the activity of the vehicles one must pay attention to the fact that each of them shall be consecutively used according to the following working hours:

1) one full day (three normal shifts);
2) two complete shifts (the first shift, from 4^{00} to 13^{00} and the second shift from 13^{00} to 23^{00});
3) one shift and a round;
4) two rounds usually lasting together 8 hours (coinciding with the two periods of rush hours: 4^{00}-8^{00}, and 13^{00}-17^{00});
5) one round (corresponding to the morning rush hours).

The number of vehicles to which the first daily exploitation regime is applied (of 24 hrs/day) (N_{v1}) is determined according to the lowest traffic level of the day (usually, according to the level of the traffic between 23^{00} and 4^{00}):

$$N_{v1} = N_{vIII,}$$

Where : N_{vIII} – is the number of vehicles that are to be used during the entire third shift.

The number of vehicles that are being applied the second exploitation manner (n_{v2}) shall be calculated in the following manner:

$$N_{v2} = N_{vsmin} - N_{v1},$$

Where: N_{vsmin} – the number of vehicles that corresponds to the lowest traffic level recorded in the two complete shifts of the day.

I n order to calculate the number of vehicles to be used in the third exploitation manner (n_{v3}) we shall use the following relation:

$$N_{v3} = \left| N_{vsI} - N_{vsII} \right|,$$

Where: $N_{vsI} - N_{vsII}$ – is the number of the vehicles that are to be used during the entire first shift, respectively, during the second one, calculated according to the lowest level of the traffic from the 1^{st} and, respectively, the 2^{nd} shift.

Finally, the number of vehicles to be used in the fourth and the fifth exploitation manner (n_{v4} , n_{v5}) is calculated with the following relations:

$$N_{v4} = min\,(N_{vr1}\,,\, N_{vrII}),$$
$$N_{v5} = \left| N_{vr1} - N_{vrII} \right|,$$

Where:

$$N_{vrI} = N_{vmaxI} - N_{vsI} \quad if\ : N_{vsI} > N_{vsII}$$
$$N_{vrI} = (N_{vmax1} - N_{vsI}) - n_{v3}\,, \quad \text{if}\ : N_{vsI} < N_{vsII}$$
$$N_{vrII} = (N_{vmaxII} - N_{vsII}) - n_{v3}\,, \quad \text{if:}\ N_{vsI} > N_{vsII}$$

Where: $N_{vr1,}$ N_{vrII} - the number of vehicles that shall be exploited in the round of the first shift, respectively, of the second one; N_{vmaxI}, N_{vmaxII} - the number of vehicles determined according to the highest level of traffic from the 1^{st} , respectively, the 2^{nd} shift.

Thus, if, for example, according to the periods of the day, in a certain city, the data regarding the number of the vehicles that have to be in use in order to satisfy the demand on a certain route is like in Table 1, then:

The vehicles needed in order to satisfy the demand

Table 1

No.	Significant periods of the day	The number of vehicles needed on the route
1	4^{00} -.8^{00}	N_{vmaxI} =35
2	8^{00} -.13^{00}	N_{sI} =25
3	13^{00} -.17^{00}	N_{vmaxII} = 33
4	17^{00} -.23^{00}	N_{vsII} = 30
5	23^{00} -.4^{00}	N_{vIII} = 10

$$n_{v1} = N = 10; \quad N_{v2} = 25 - 10 = 15; \quad N_{v3} = |25 - 30| = 5;$$
$$N_{vrI} = (35 - 25) - 5 = 5; \quad N_{vrII} = 33 - 30 = 3; \quad N_{v4} = min(5;3) = 3;$$
$$N_{v5} = 5 - 3 = 2,$$

Which means that out of the 35 vehicles to be used daily, in order to satisfy the demand for every moment of the day including the round of the maximum demand – without having to deal with over-solicitations or sub-usages of the capacity - , 10 shall be exploited 24hrs/day (in three normal shifts, of 8 hours per shift), 15 shall be used both in the 1st shift as well as in the 2nd shift (10 hours, respectively 9 hours per shift, that means 19 hrs/day) , 5 shall be exploited only in the 2nd shift and in the first round (14 hrs/day), 3 shall be used in two rounds of 4 hrs each, thus 8 hours/day (4 hours in the morning, 4 hours in the afternoon), and 2 of them shall be exploited 4 hrs per day.

The number of the days per each month when the vehicles shall be used in every manner of exploitation *i(i=1,2,3,4,5)* is established with the following relation:

$$N_{zi} = Z_1 \frac{N_{vi}}{\sum N_{vi}},$$

where: Z_I = the number of working days in a month; N_{vi} – the number of vehicles being exploited during that time of the day when traffic reaches the considered level.

Using the data from the example taken, in the case of the months with 30 working days, we shall have the following results:

$$N_{z1} = 30\frac{10}{35} = 8; \qquad N_{z2} = 30\frac{15}{35} = 13;$$
$$N_{z3} = 30\frac{5}{35} = 4; \qquad N_{z4} = 30\frac{3}{35} \approx 3; \qquad N_{z5} = 30\frac{2}{35} \approx 2$$

Thus, each of the 35 vehicles from the medium rolling stock active each day, in a month there will be an exploitation of the following manner:

- 24 hrs/day, 8 days;
- 19hrs/day, 15 days;
- 14 hrs/day, 4 days ; 8 hrs/day 3 days;
- 4 hrs/day 2 days.

The results of all the calculations done up to this point are shown in Table 2.

The schedule of the vehicles' exploitation

Table 2

No.	Working programme	Periods of exploitation	The number of vehicles needed in traffic	Time of daily usage (in hrs)	Number of days each month
1	Three shifts	4^{00} -.4^{00}	10	24	8
2	Two shifts (I and II)	4^{00} -.13^{00} and13^{00} - 23^{00}	15	19	13
3	First round and 2nd shift	4^{00} -.8^{00} and 13^{00} - 23^{00}	5	14	4
4	Exclusively in two shifts	4^{00} -.8^{00} and 13^{00} - 17^{00}	3	8	3
5	Exclusively in the 1st round	4^{00} -.8^{00}	2	4	2

After such calculations, we shall have all the data needed for the schedule of the utilization of the active rolling stock, being able to plan the daily interchange of the five exploitation periods of each vehicle in such a way that the days with less exploitation hours would be interfused with the ones with a large number of hours, in order to create good conditions for the maintenance and the servicing of the vehicles, thus respecting the *rotation principle.* Accordingly with the vehicles' exploitation regime, several ***board staff utilization regimes*** can be adopted.

According to the working regime they have, the board staff is organized in the following manner:

- (N_{p1}) personnel, who gets to work 9 hours continuously in the first shift (from 4^{00} to 13^{00});
- (N_{p2}) personnel, who gets to work 10 hours continuously in the second shift (from 13^{00} la 23^{00});
- Personnel who works in two rounds, (4^{00} - 8^{00} and 13^{00} - 17^{00}), that means only during the rush hours of the two shifts of the day – together making a total of 8 hours per day (N_{p4});
- Personnel working only in one round, 4 hours a day (N_{p5}) – from 4^{00} to 8^{00}.

In each of the three shifts (I, II and III), the number of the drivers (N_{p2}, N_{p3} *and* N_{p1}) equals the number of the vehicles that must be in traffic, according to Table 1, during the entire shift, which means that:

$$N_{p1} = N_{vI} = 25; \quad N_{p2} = N_{vII} = 30; \quad N_{p3} = N_{vIII} = 10.$$

For the rest of them, the following relations are valid:

$$N_{p4} = N_{v4} = 3; \qquad N_{p5} = N_{v5} = 2.$$

Thus, in order to exploit the 35 vehicles from the active rolling stock, there will be necessary: 10 drivers in the night shift, 25 in the morning shift, 30 in the afternoon shift, 3 during the rush hours from the tow day shifts and 2 during the rush hours from the busiest shift, that means a total of 70 workers.

In order to provide a regular working schedule, the public transport companies may use as drivers during the rush hours, a number of $N_{p4} + N_{p5}$ workers form other sectors (maintenance, servicing, etc), this providing the board staff with a regular working regime in three shifts (two of 9 hours and one of ten hours);

The number of the days (in a month) when each driver gets to work in the three (or five) regimes ($N`_{zj}$), shall be calculated with the following relation:

$$N'_{zi} = Z'_1 \frac{N_{pi}}{\sum N_{pi}},$$

Where Z_1 represents the number of monthly working days for a driver.

If $Z_1 = 20$, then from the given example we could conclude that :

$$N_{z1} = 20\frac{10}{70} = 3; \qquad N_{z2} = 20\frac{25}{70} = 7; \qquad N_{z3} = 20\frac{30}{70} = 9;$$

$$N_{z4} = 20\frac{3}{70} = 1; \qquad N_{z5} = 20\frac{8}{70} = 2.$$

The activity of the workers as well as the free days during the month is also programmed according to the rotation principle.

Some other organizational methods can be adopted in programming the use in time of the vehicles and of the board staff.

Being the most important elements of the operative exploitation plan, the ***circulation programmes*** ensure the distribution of the daily active rolling stock on each route, as well as the distribution on hours per day of the activities of the rolling stock for each route, these being characterized by a special flexibility.

The circulation schedules are established on routes and they contain a series of data regarding: the numbers of the vehicles in traffic during characteristic periods of time; the stationing time at the end of the routes; the spells between the rolling vehicles (the traffic flow); the board estimates (the number of the hours worked on the way) etc. These schedules are correlated on the routes and they are at the basis of the drawing up of the circulation charts.

The circulation charts are the organizing instruments which help establishing the definite assignments for each vehicle from the active rolling stock and for each driver, comprising the following important data: the length and the duration of the zero route; the duration needed in order to cover the ground for which they have been established, the exploitation speeds during rush hours and during the rest of the day; the duration of the exploitation during characteristic periods of time; the stationing hours at the end of the routes; the hour when they left the garage; the hour when they left the traffic; the number of the drives to be performed; the hours of fuelling, etc.

The working hours and the circulation charts are established for each day of the week (Monday-Friday; Friday-Saturday; Sunday).

In order to avoid the jam up, by means of the circulation charts, we intend to maintain some equal spells between the vehicles that cover the same route, spells (of time)(t) whose duration is thus calculated:

$$t = \frac{60}{n_c} = \frac{60}{N_v n_{cv}}$$

Where : $n_{c;}$ n_{cv} – is the total number of hourly drives, respectively the medium hourly drives per vehicle; N_v the number of vehicles on the considered route.

The duration of this time spell changes from one day to another.

The reverse of the *t* spell (*l*/*t*) means the *traffic frequency* in a random point on the route (expressing the medium number of vehicles – from those that are allotted to the considered route – which drive, in the same direction, through that point in a minute).

If the circulation charts are not respected, this generates negative effects on the quality of the services offered, any delay growing exponentially from one stop to the other.

The introducing of the *dispatcher* in the urban passenger transport is a very useful organizational solution meant to prevent and avert any of the (very frequent, actually) obstacles that disturb the fluency of the traffic.

Bibliography

Caraiani. Gh. 2002. *Tratat de transporturi*. Bucharest: Editura Lumina Lex

Dinu, S. V., Panaitesu, Gh. 2001.*Transport rutier şi impact ecologic*. Bucharest: Editura Transport Rutier

Dobrotă, S. 1994. *Transporturi rutiere internaționale*. Bucharest: Editura Transport Rutier

Fistung,D. 1999. *Transporturi. Teorie economică, ecologie, legislație*. Bucharest: Editura All Beck