ESTIMATION OF SPATIALLY DIVERTED TRAFFIC ON BUCUREŞTI - CONSTANȚA A2 HIGHWAY

Oana Maria Dinu, Cristina Ştefănică
University Politehnica Bucharest, Transport Faculty

ABSTRACT: The main focus of the paper is to point out the constituents of a highway design traffic volume, to identify the individual behaviour reactions upon new infrastructure opening to traffic and to propose a simplified model for traffic assignments in this specific conditions. In the absence of traffic measurement data, the estimation of spatially diverted traffic on Bucureşti - Constanța A2 highway from DN2A and DN3A is realised by means of diversion curbs, logically developed from a consideration of driver behaviour.

1. CONSTITUENTS OF A HIGHWAY DESIGN TRAFFIC VOLUME

At some stages in the planning of a road it will be necessary to carry out traffic studies to estimate the volumes of traffic that will have to be considered in a design year. Traffic data are also required for economic and environmental assessments in relation to the justification, scale and location of scheme alternatives.

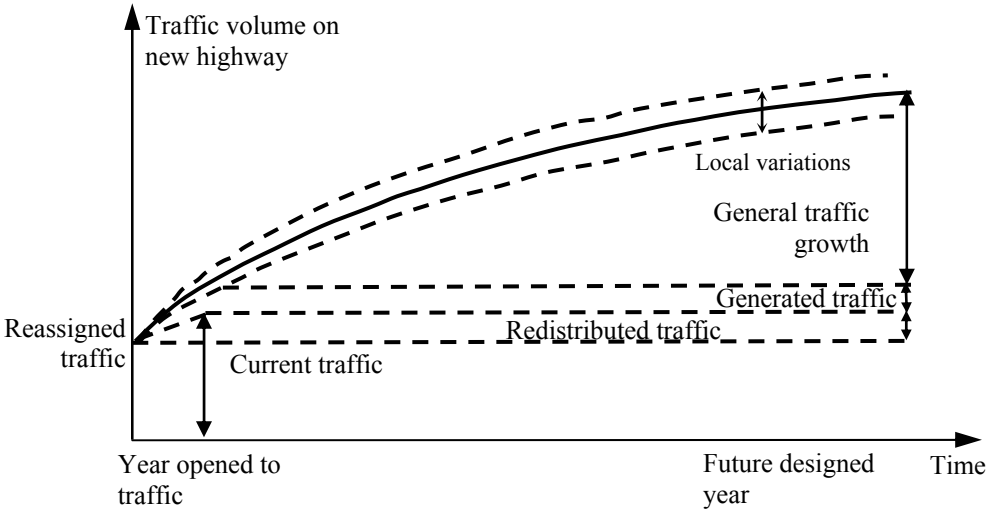

Fig.1 Traffic volume evolution on new infrastructures

Traffic volumes for some future design year are derived from measurements of current traffic and estimates of future traffic. The basic constituents of the design volume for an individual road are shown in figure 1.

1.1 Current traffic

By *current traffic* is meant the number of vehicles that would use the new road if it were open to traffic at the time the current measurements are taken. Current traffic is composed of reassigned traffic and redistributed traffic

- *Reassigned traffic*
- *Redistributed traffic*

Reassigned traffic is the amount of existing same-destination traffic that will immediately transfer from the existing roads that the new road is designed to relieve.
Redistributed traffic is that which already exists on other roads in the region but which will transfer to the new road because of changes in trip destination brought about by the new road's attractiveness.
On low-volume roads in rural areas, classified traffic count data alone may be sufficient to evaluate the current traffic volumes. The numbers of vehicles attracted to the new/improved road may be estimated adequately if of local traffic and travel conditions are known.

However, with high-volume rural roads or bypasses around smaller urban areas, the situation becomes more difficult and more rigorous techniques are required to validate the estimates of current traffic patterns. Information regarding journey times is normally also needed to estimate the traffic likely to be attracted to the new/improved road; the greatest number of vehicles will be attracted when the travel time and/or distance savings are significant.

1.2 General traffic growth

General traffic growth is the increase in traffic volume due to the cumulative annual increases in the numbers and usage of motor vehicles. That is why care must be taken in deciding which equation is the most appropriate to describe the trend line, considering that an infrastructure project is developed on long time scale (some times even 30 years). The annual evolution of vehicles volume for Romania is presented in table 1.

Table1. The annual evolution of vehicles volume in Romania

Year	1998	1999	2000	2001	2002	2003	2004	2005
Cars	2447087	2594517	2777594	2881191	2973390	3087628	3225367	3363779
Freight vehicles	390181	405743	427152	437968	447299	463099	482425	493821

**Source: TEMPO INS data base*

1.3. Generated traffic

By *generated traffic* is meant future vehicle trips that are generated anew as a direct result of the new road.
Generated traffic is generally considered to have three constituent components:

- induced traffic;
- diverted traffic;
- development traffic.

Induced traffic consists of traffic that did not exist previously in any form and which results from the construction of the new facility, and of traffic composed of extra journeys by existing vehicles as a result of the increased convenience and reduced travel time via the new road.
Converted traffic is that which results from changes in mode of travel; for instance, the building of a motorway may make a route so attractive that traffic which previously made the same trip by bus or rail may now do so by car (or by lorry, in the case of freight).
Development traffic is the future traffic volume component that is due to developments on land adjacent to a new road over and above that which would have taken place had the new road not been built. Increased traffic due to 'normal' development of adjacent land is a part of normal traffic growth and is not a part of development traffic.

If the journey time by the new road divided by the time by the quickest alternative route is high it can be expected that the amount of induced traffic will be low. The amount of converted traffic is mainly dependent upon relative travel costs, convenience and journey times. Experience with highly new major roads suggests that adjacent lands with ready access to them tend

to be subsequently developed more rapidly than normal; consequently the amount of development traffic generated depends upon the type of development and the extent to which the planning authority encourages/allows it to take place.

2. ESTIMATION MODEL FOR SPATIALLY DIVERTED TRAFFIC ON BUCUREŞTI – CONSTANȚA HIGHWAY

Figure 3 shows an existing road network (full lines: A2 highway and DN2A, DN3A), an existing railway corridor (dashed line) and nodal points, which to simplify are also singular creators of traffic (sources and destinations).
At time t_A a new road (green line) is opened to enhance the attractiveness of the infrastructure.

Figure 2 and 4 shows in graph form the changes in traffic volume V [traffic units/time unit], for differently delimited corridor cross sections (A) to (E) to illustrate the stages of interpretation following on from one other. Figure 2 illustrates:

V_{o2A}, V_{o3A} – baseline volume on DN2A and DN3A;
V_{a2A}, V_{a3A} – general traffic growth on DN2A and DN3A;
dV_{2A}, dV_{3A} – diverted traffic from DN2A and DN3A;
V_{A2}, $V_{A2'}$ – new traffic on A2 highway

We first limit our considerations to a corridor (A) that consists only of the existing road (DN3A). After the new relief road A2 comes into operation, the trend in traffic volume on DN3A can be registered as in figure 2A.

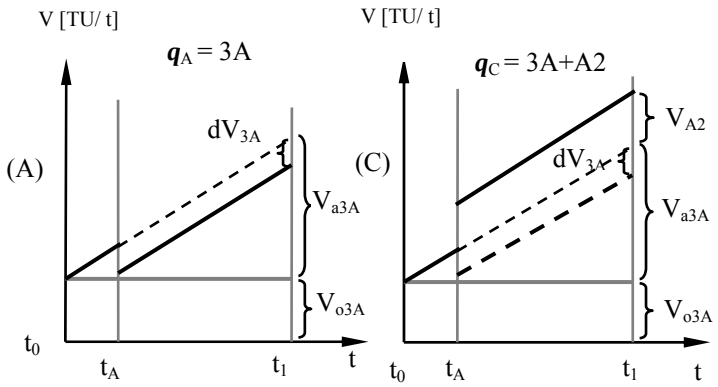

Fig.2 Traffic volume trend for differently delimited corridor crossings (A) to (C)

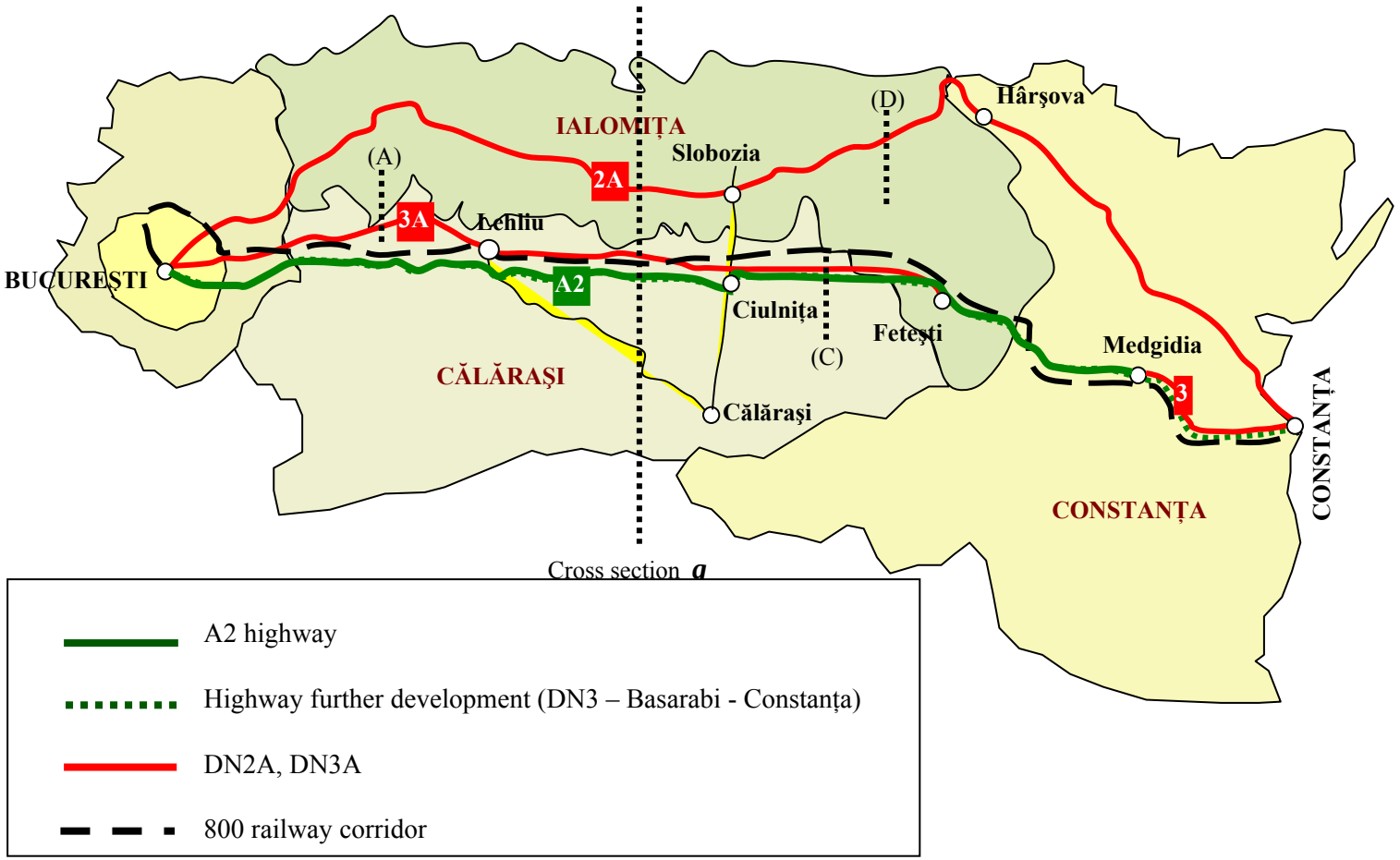

Fig. 3 Schematic representation of studied transport network area

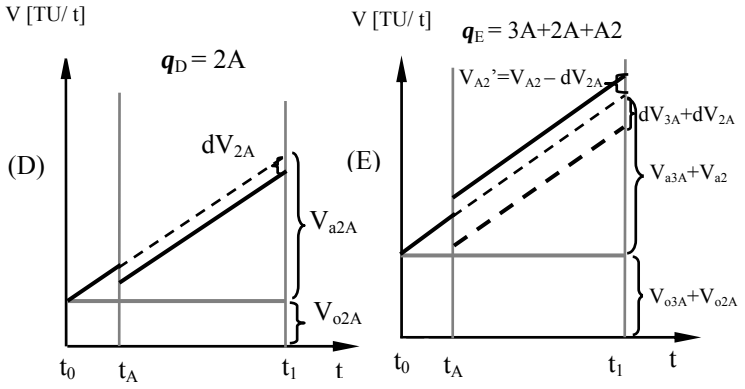

Fig. 4 Traffic volume trend for differently delimited corridor crossings (D) to (E)

Similarly, the trend in traffic volume on A2 highway itself is assumed to be constant over time. Most of the traffic studies base their statements on cross section (C), witch presents divert from (A) and (B) to (C) – the existing road DN2A and its new relief road A2 highway are combined into a more complex cross section.

V_{A2} is designated the new traffic volume and the quotient p_{A2} the new traffic share.

$$p_{A2} = \frac{V_{A2}}{V_{o2A} + V_{a2A}}$$

A step further in our interpretation, section (D) (figure 4) shows the possible trend in traffic volume on road DN3A before and after the opening of A2. In figure 4 (E) shows the switches from (C) and (D), by considering them as simultaneous events.

This reveals that what was originally interpreted as new traffic volume V_{A2} was falsely labelled as new traffic and should be, in fact, reduced with traffic volume diverted from DN3A, dV_{3A}. At the same time, the denominator of our fraction increases from $V_{o2A}+V_{a2A}$ to $V_{o2A}+V_{a2A}+V_{o3A}+V_{a3A}$ so that including the correction for DN3A, the new traffic share becomes:

$$p_{A2} = \frac{V_{A2} - dV_{3A}}{V_{o2A} + V_{a2A} + V_{o3A} + V_{a3A}}$$

With the inclusion of DN3A it is already questionable whether we can speak of a "corridor section" This would be meaningless if we take a step further and include all the possible road links to A2, also railway line B as competing links, from which, the opening of A2 highway, switches traffic.

This final situation is shown in figure 5 and the originally suspected new traffic share p_{A2} turns into:

$$p_{A2}' = \frac{V_{A2} - dV_{3A} - dV_B}{V_{o2A} + V_{o3A} + V_{a2A} + V_{a3A}}$$

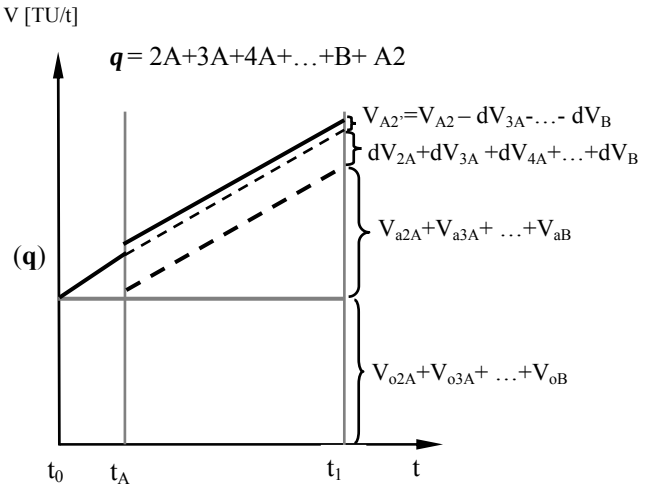

Fig. 5 Traffic volume trend for an extended corridor cross section, **q**

3. ESTIMATION OF SPATIALLY DIVERTED TRAFFIC ON BUCUREŞTI - CONSTANȚA A2 HIGHWAY FROM DN2A AND DN3A

Diversion curves are constructed for determining the traffic ratio that uses a new route. Those curves are constructed either from an analysis of "before and after" surveys of the use of alternative routes or logically developed from a consideration of driver behaviour.

The variables used include travel distance, travel time and travel cost in the form of ratios, e.g. distance (or time) on new route/distance (or time) on old routes. Only those parts of a route, which are not common, need to be measured in the point of choice method.

In applying diversion curves care must be taken to ensure that the basis of measurements is the same and that the route conditions are similar. Some drivers will always select the quickest route in time, irrespective of distances, while others will take the shortest distance. Figure 6 illustrates the various types of diversion curve referred to above.

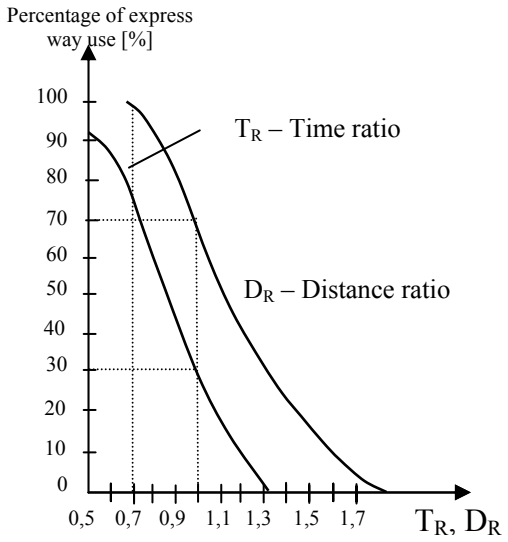

Fig.6 Diversion curves (Hobbs, 1979)

Several parallel routes can also be compared using diversion curves by nominating the shortest of them as a reference base to estimate the relative time and distance differences between them. The next stage is to determine from the values the proportion of diverted traffic from a diversion curve and then to weight each route according to the traffic assigned to it expressed as a fraction of that not assigned to it.

The studied transport network area is situated in the SE of Romania, connects two of the most important trip generation nodal points: Bucharest and Constanta and benefits from A2 highway development.

For the considered transport network we choose to estimate the A2 diverted traffic using the time (distance) ratio diversion curves. To be able to use those ratios, we need the distance and time for every route (table 2).

Table 2 Transport network characteristics

Nr.crt	Route	Distances characterised by low speed	Distance [km]	Time [min.]
1	**A2: Bucureşti - Constanța**	DN3 Medgidia Constanța 37km – one roadway	225	210
2	**2A: Bucureşti** - Slobozia - Hârşova - **Constanța**	Țăndărei – Bucu 16km – infrastructure rehabilitation, maximum speed 20km/h	266	290
3	**3A: Bucureşti** – Lehliu – Ciulnița - Feteşti - **Constanța**	DN3 Medgidia Constanța – 37km – one roadway	232	240
4	800 railway corridor: **Bucureşti -Constanța**	Railway rehabilitation	225	280

The analysed routes are:

A2 highway and DN 2A have the same origin in Bucureşti and the same destination in Constanța, figure 7;

A2 highway and DN 3A have the same origin in Bucureşti but not the same destination. DN 3A ends in Feteşti, figure 8

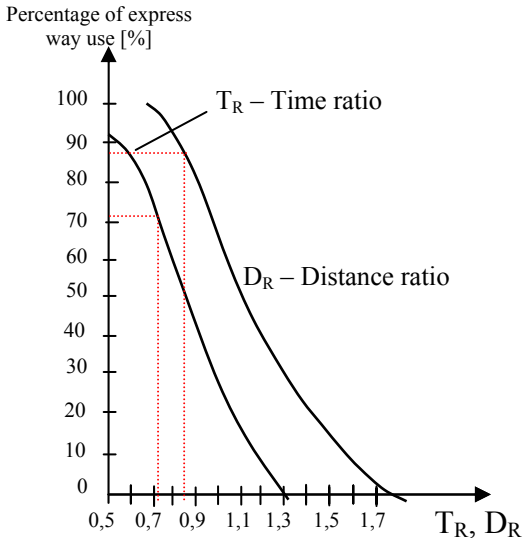

Fig.7 Percentage of diverted traffic from DN2A to A2

Table 3 Percentage of diverted traffic from DN2A to A2

Route	**Distance** [km]	**Time** [min.]	**T_R Time ratio**	**D_R Distance ratio**	**Percentage by time**	**Percentage by distance**
A2	225	210	0.72	0.84	71%	87%
2A	266	290				

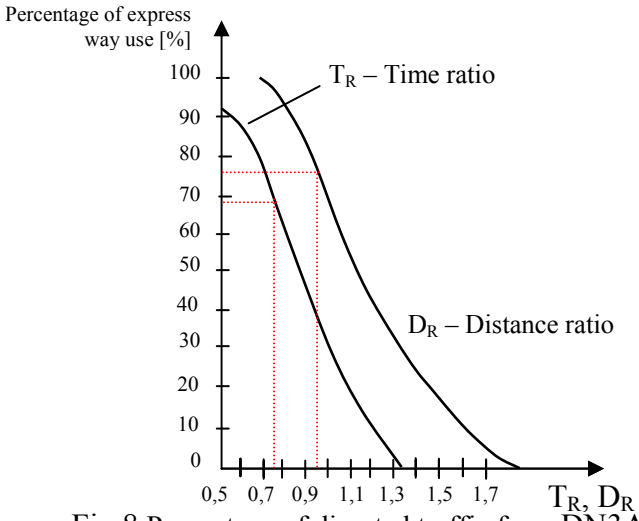

Fig.8 Percentage of diverted traffic from DN3A to A2

Table 4. Percentage of diverted traffic from DN3A to A2

Route	Distance [km]	Time [min.]	T_R Time ratio	D_R Distance ratio	Percentage by time	Percentage by distance
A2	135	90	0.75	0.95	69%	76%
3A	142	120				

4. CONCLUSIONS

In the absence of traffic measurement data, the estimation of spatially switched traffic on Bucureşti - Constanţa A2 highway from DN2A and DN3A is realised by means of diversion curbs, logically developed from a consideration of driver behaviour. The proportion of diverted traffic to the new constructed highway can be estimated from the point of view of time saving or distance saving. As shown in figure 7 and figure 8, the expected percentage of traffic diverted by time savings from DN 2A is 71%, from DN 3A is 69% and by distance savings the expected percentage of traffic diverted is 87% respectively 76%; an inadvertence easy to understand if we take into consideration that an individual can except even longer trips but on improved infrastructures.

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