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LES TRANSPORTS DE MARCHANDISES EN VILLE : QUELQUES PISTES POUR UNE MODELISATION
SURVEY AND MODELLING IN URBAN FREIGHT TRANSPORT

A French contribution to simulation tools

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Introduction

The rise of congestion problems in urban surroundings and the environmental problems they induce, need the definition of a global policy including the freight.

For the last few years, several attempts have been done in some European countries to control the goods distribution in the cities :

- in Switzerland, the "Energie 2000" program includes a specific chapter about the goods in the city (City Logistik). Some studies are being driven in Basel and Zurich to limit energy consumption and environmental nuisances in this area,
- in Köln, Germany, a freight integration plan is being developed in their planning policy in collaboration with other important cities of the Ruhr,
- in Netherlands, in Belgium, the governments have launched several experimental experiences of "Urban Distribution Centres" (UDC's) in order to rationalize distribution and to reduce the number of vehicles per kilometer.

A real awareness of the different stakes is felt. However, most of the initiatives seem limited facing a task of importance and complexity.

The difficulties of modeling and the lack of data represent essential problems.

The weakness of models in urban goods transport

In France, as in the other European countries, urban goods transport studies seem inadequate.

Among the main French researches, two approaches can be distinguished :

The first one is a macro-economic approach. It puts together studies about inter-city flows.

The second one is a micro-economic approach : it combines specific studies about heavy goods vehicles traffic :

- at the level of firms
- at the level of activities areas.

Only the first approach allows to lead to traffic generation models. No durable implementation has been carried out for urban goods traffic modelling.

How to solve complexity

One must admit that various difficulties must be solved :

- the three following elements the urban structure context, the quality of transports, the diversity of the actors,
- choose the most accurate unit (products, vehicles, deliveries, liftings,...),
- Exclude the inconsistent variables (...),

These difficulties of modelisation underline the complexity and the irregularity of the goods moving :

- variety of request to satisfy,
- variety of goods transported,
- variety of vehicles used,
- variety of infrastructure used,
- variety of conditions of delivery on site or expedition
- variety of the interest of the actors.

All this makes it difficult to control the inconsistency of the rate duration of immobilisation - duration of routes of the vehicles, the splitting of the tonnage to transport or the nature of logistic chains.

Available data - needed data

These difficulties are increased by the lack of appropriated data.

The main French cities have "enquête cordon". These surveys provide a photography of the commuting and the transit between the city and outside the "cordon". This type of study doesn't provide any information on internal movements within the city.

There is no equivalent study to the ones made for urban passengers transport. The surveys in urban area try to describe either the routes of goods transported or commercial vehicle traffic.

The analysis of goods traffic flows doesn't allow to define a relevant unit for traffic congestion. It explains why we have decided to focus our research on the measure of traffic generated by the activities.

A suited survey methodology

An experimental city has been chosen among the most important in France, namely: Bordeaux, and complementary investigation have been carried out in a few other cities offering diversified features. We here present the quantitative survey methodology carried out end of 94 and the first results obtained. The survey technics usually chosen for medium and long distance goods transport are ineffective for the quantity and diversity of the flows generated in urban area.

It is this aspect which makes our survey method different. The methodology chosen is based on the follow-up of the movement of vehicles induced by the loading or unloading in urban zone. This follow-up is carried out through three surveys:

- a survey of the " firms " which turn out or receive the goods (industrial, commercial or tertiary activities) carried out by an investigator,
- a " driver-delivery person " survey of the persons having done the unloading or loading of goods at a site, self-administered ; the forms being returned by mail.
- a transporter survey of the transport companies hiring the drivers-delivery persons who have been surveyed this being carried out by an investigator.

The unit of observation we chose to single out, and which is a link between the three surveys is the *loading or unloading* of goods. The " company " survey enables us to describe the activity of the company. The driver survey describes the " rosters ". The transporter survey describes the transport chain organisation schemes.

The companies have been selected by mean of a stratified poll according to their activity and their size.

Towards a simulation model

We consider this survey as a basic step to a simulation model

First input of the global model concerns the activities locations. Several factors can explain them : proximity of transport infrastructures, land use, environmental disturbance and urban congestion, spatial division of labour, the possible courses of action.

Second input takes into account undertaking logistic transformations : vehicles fleet, number of movements, covered kilometres, rosters organization, number of transfer centres.

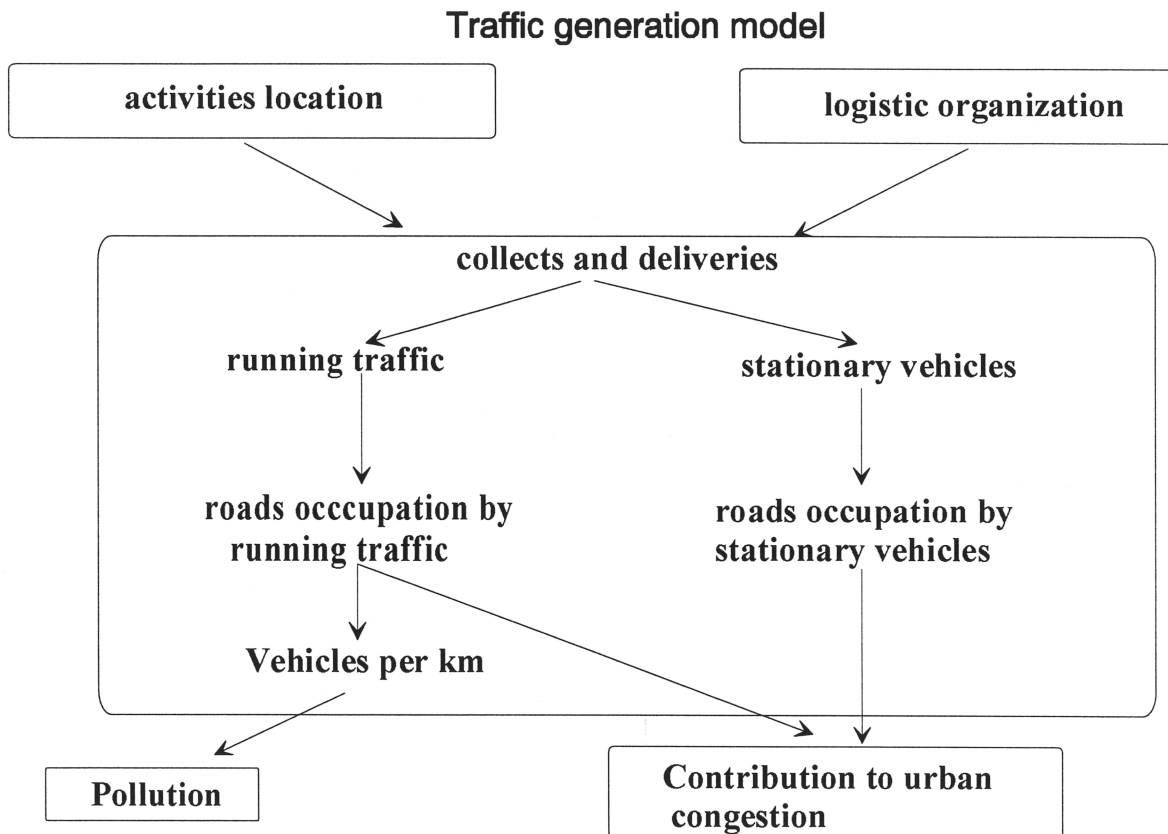
Two output components are :

- estimation of urban congestion by knowledge of road network loading in each zone,
- appraisal of energy consumption by knowledge of vehicle.km .

Finally, a central component : the movement generation model.

The movement generation model

n°8



Estimation of congestion can be considered as the strategic output. It is briefly described as an intensive loading of roads,

In a given time, on a given zone, the participation of goods vehicles to congestion results from the number of standing vehicles and running vehicles. Standing vehicles are generated by the activity of the zone. Among the running vehicles, a distinction will be made between movements generated by activities of an area and through traffic.

The number of movements in the town (which can be breakdowned in three elements : deliveries, collections, mixed operations) is adjusted from the survey according to :

- class of activities,
- weight class of vehicles,
- which operator (own account -shipper or consignee-, carrying company)
- which kind of organization (direct delivery, roster).

and is dependent to

- location,
- several periods (week, day, time period),

The occupancy of public ways by parked vehicles

Number of movements generated in each zone

Each loading or unloading of goods is associated to the parking of a vehicle either on public ways, or private ways. S_z enables us to measure the number of movements generated in each zone. In the same way, we can define the quantities S_p , S_k , S_c , which respectively designate the movements generated by the period, type of activity and vehicle category.

The total number of movements realized in the city is obtained by appraisal of the number of movements generated by the one thousand and five hundred companies surveyed, according to their type of activity, and their size in each zone. The average number of movements per participant highly depends on the sector of activity and size of company.

S_{zp} designates the total number of movements realized during a p period ; S_{kp} and S_{cp} will be calculated in the same way. Let A_{zp} the number of vehicles parked on public way during the period p .

Let A_{zt} be the average number of vehicles parked on public way at any t instant of this period. Its determination involves a stability of the period considered relatively to the number of movements in the zone.

Two periods will be singled out : morning and evening rush hours revealed by survey, which are strategic for a good understanding of the congestion phenomena

$$A_{zt} = A_{zp} \cdot am / p$$

In which am designates the average parking-time, that is the quotient of the total number of surveyed stops by the total number of movements on the zone and p period considered.

The average stop time is calculated from the time spent in each reception or delivery written on the slips descriptives of movements, if necessary corrected on the basis of the disparities found with the statements of stop times by the driver-delivery persons.

The occupancy of public ways by running vehicles

This phenomenon is slightly more complex : we measure here the occupancy of the zone by the running vehicles , that is the average number of goods vehicles running in a zone during a period. The whole of the vehicles which run in a zone z consists of vehicles in through movements and those carrying out at least a delivery or loading of goods in the zone.

a/ The occupancy of a zone z by the vehicles generated by the activities in a period p .

Two main periods of activity : morning with a majority of inner -city deliveries, and afternoon, a longer period, mainly concerning the movements generated by the urban periphery.

Each movement done in the course of period p is associated to the route r of a vehicle (in a roster or not). The analysis of the driver's routes enables us to measure the time of driving d_{rp} (time of route r done in period p , with the deduction of stops) and distance l_{zrp} covered in each zone by the vehicle.

This quantity is obtained by the reading of the routes chosen by the drivers. In fact, it is possible to measure for about one thousand routes, the distance covered by the vehicles in each of the zones. In the hypothesis that the repartition per zone of the routes described by the survey is representative of that of the whole of the routes in the considered periods. An average speed V_{zp} on each zone is deduced by summation on the whole of the routes, thus :

$$V_{zp} = \frac{\sum_r l_{zrp}}{\sum_r \frac{d_{rp} \cdot l_{zrp}}{\sum_z l_{zrp}}}$$

The average distance covered by a vehicle generated by a stop s in a zone z is written thus :

$$\delta_{sz} = \frac{\sum_r l_{zr}}{S_z}$$

T_{zp} the total time of occupancy of public way by the whole of the vehicles in movement generated by the activities in a zone z and a period p :

$$T_{zp} = S_{zp} \cdot \delta_{sz} / V_{zp}$$

with S_{zp} the total number of stops done in that zone for period p .

The average number of vehicles in movement, generated by the activity of zone z in period p can be expressed :

$$O_{zp} = T_{zp} / p$$

This quantity supplies a measure of the occupancy of public ways by the vehicles running in a given zone z and period p .

This reckoning can be done either globally in each zone or on the basis of a typology of companies the behaviours of which are homogeneous for quantities T_{zp} and S_{zp} . Thus it is possible to calculate the multiplicative coefficients adapted to the activity specific of each zone.

b/ The occupancy of public ways by vehicles through-movements

The part of through movements is obtained by calculating the kilometers covered by each vehicle in each zone. In the hypothesis in which the vehicles stay in a zone during a period proportional to the kilometrage covered in the zone (constant speed in the zone), we can indeed calculate :

- the total number of kilometers Lt_{zc} covered in the zone by the vehicles of category c . Because of the regulation constraints, the nature of the public way and the activities carried out there, each zone is covered by vehicles of specific categories. That is why we introduce here the sign c .
- the number of kilometers L_{zc} generated by the whole of the movements done in a zone. This number is also deduced from the analysis of the driver's rosters.
- for each roster, an average length δ_{zc} of distance generated by each movements done in a zone.

The total sum of those distances for the whole of the rosters is equal to the number of kilometers researched L_{zc} .

The ratio $\rho_{zc} = (L_{zc} - L_{zc}) / Lt_{zc}$ represents the part of kilometers covered by the vehicles in zone through movements, in the whole of kilometers covered. In the hypothesis of a stability of speeds in the considered zone, this kilometrical rate will be identical to a rate of public way occupancy by the vehicles in zone through-movement, on the whole of the vehicles in movement.

If π_{zc} represents the proportion of vehicles of category c set in motion by the movements generated by the activities of zone z , the quantity $\Omega_{zpc} = O_{zp} \cdot \pi_{zc} / (1 - \rho_{zc})$ designates the average occupancy of public ways by the whole of the vehicles of category c running on the zone and time considered.

At this level, we obtain a measure of the occupancy of public ways by the running vehicles according to the space-time parameters z, p and according to the generating activities and the characters c of

vehicles in through movement or carrying out an operation in the zone, whether at a stop or running. The two measures of occupancy obtained (average occupancy of public ways by vehicles stopping or running on the way) enable us to estimate some indicators of the occupancy of public way by delivery vehicles at rush hours, which can be confronted to occupancy coefficients calculated by means of aerial views observations.

The implementation of a global simulation tool, at last, passes by the integration of the central module the main lines of which have been outlined in a broader system the functional relations of which remain to be detailed more precisely.

The vehicles-kilometers covered

This third indicator is obtained fairly simply from the number S_z of stops done in each zone, from the proportion π_{zc} of the average length δ_{zc} of the distances generated by the movements done in each zone and from the through-movements rate relative to each zone. Indeed, the total number VK of vehicles.km per zone and per category of vehicle is calculated this way

$$VK_{zc} = \delta_{zc} \cdot S_z \cdot \pi_{zc} / (1 - \rho_{zc})$$

The total number of kilometers generated by the activity of the whole of the city can be obtained still more simply :

$$VK_c = \delta_c \cdot S \cdot \pi_c$$

In fact, by the city standards, the zone through-movements of vehicles unloading or loading in the city become nil.

Conclusions and expected prolongations

We have thus offered the sketch of a model of generation of the occupancy of public ways by delivery-vehicles in city ; The methodology presented is transferable to other cities : a number of parameters is transferable to other cities submitted to the same conditions of organization and regulations. In France, a protocol of a simpler survey is in flux in order to adapt the results obtained here to each local situation.

O/D flows of trucks in the city are very sensitive to the management of the rosters and to urban planning. The two main interests we found of this shape of generation model of public ways occupancy is that this approach does not need O/D traffic flows and takes the parked vehicles into account. It seems thus easier to simulate the both effects of measures of regulation and of new logistic organisation (rationalization of rosters, new urban freight centers, new vehicles...).

The most promising prolongation, actually, is to contribute to the elaboration of a global model of generating traffic jams in urban zones which might enable us to introduce the transport of goods in city and which must reach a better knowledge of the delivery vehicles, to urban congestion and their influence on the environment. Such a model could thus constitute a simulation tool of the measures of regulation as well as urban planning, in view of a lasting development.