# A REVIEW OF TRANSPORT SYSTEMS MANAGEMENT APPLIED TO TRUCK OPERATIONS

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*ABSTRACT:* *With cutbacks in road construction funds, public reaction against large scale road construction, and a more critical evaluation of the economics of road improvements, transport authorities have been turning increasingly in recent years to techniques aimed at maximizing the efficiency of the existing road system.*

*Such an approach, which might be labelled Transport System Management (TSM) has included such techniques as car pooling, bus priority, demand responsive bus systems, and traffic management procedures such as reversible lanes and area traffic control. Almost invariably, however, the aim has been to improve the efficiency of the system with respect to the movement of passengers. The movement of goods has usually not been included, or if included at all, it has tended to be of secondary importance.*

*In this paper, the application of TSM to truck operations is reviewed. The paper examines selected existing TSM programmes and assesses their impact on truck operations. To the extent that TSM assists traffic flow generally, these programmes can be said to assist truck traffic. However, several TSM programmes give priority to certain classes of vehicle at the expense of other classes, and if trucks are included in the latter, these programmes are potentially disadvantageous to trucks.*

*The paper goes on to explore the possibility of developing TSM programmes aimed explicitly at reducing the costs of goods movement, as distinct from facilitating the movement of passengers. The possibility of including trucks in passenger-oriented TSM programmes is raised.*

*Finally, the paper addresses the question of transport policy with respect to including truck operations in TSM programs. The assessment of trade-offs between passenger-oriented and goods-oriented programs, and the problems of evaluating benefits of TSM are discussed.*

## 1. INTRODUCTION

The transport network does not exist to serve a single purpose. Rather it is called upon to perform a large variety of tasks, and if the planner or traffic engineer is concerned with ensuring the "best use" of the network, it may often (by accident or design) occur that one purpose or group of users is benefited at the expense of others.

A particular case in point is the urban movement of goods. Until recently, goods movement was virtually ignored in urban transport planning, and one of the justifications for so doing was that if a transport network could cater for peak hour passenger movements it could also cater for goods movements, the bulk of which were off-peak. Today, however, few people talk about catering adequately for peak hour traffic, and most accept that peak hour congestion is a fact of life and that off-peak conditions are likely to deteriorate also.

In these circumstances, the previous argument for ignoring goods movement simply does not apply. The movement of goods in the peak hour is still costly and time-consuming, and the surplus traffic capacity which goods movers were supposed to utilize in off-peak hours is vanishing. Hence it is necessary to look carefully at the movement of goods, and see how this particular function of the transport system is affected by the changing approach to transport systems planning.

More particularly, the effect of transport systems management (TSM) schemes on goods movement needs appraisal. The response to the aforementioned changing approach to transport planning has in many cities been to attempt better use of the system as far as the commuter is concerned, but it may be that some of these schemes make conditions worse for other users, perhaps including goods vehicles. Turning this around, the converse also applies; if TSM schemes for commuter travel are possible, perhaps there is scope for TSM schemes aimed at facilitating goods movement. Moreover, the movement of goods imposes certain costs on the community, including environmental costs and some of these can be reduced through TSM.

To a large extent, the state of the art permits an examination of these issues in subjective terms only. To approach the questions rationally it is necessary to go beyond that, and to attempt an objective evaluation of the costs and consequences of the existing situation and possible changes to it. Answers to questions such as the value of TSM for goods movement, and in what circumstances freight should be given priority over passenger movement, and vice versa, must await the development of a formal evaluation scheme.

These issues are discussed in this paper. To put them in context, a brief review of the significance of urban freight in economic and environmental terms is first presented.

## 2. COSTS OF URBAN FREIGHT

The function of the urban goods transportation system is to supply a transport service to meet the demand for goods movement generated within an urban area (Hicks, 1975). However, in supplying such a service the goods transport system imposes a number of "costs" on the economic and social system. Not all of these costs are internal to the transport system, and met by that system; some are met by the community at large.

Hicks (1975) has suggested that the costs of urban freight can be divided into four elements as follows:

(a) transport operation costs, which are essentially the direct costs of transporting goods;

(b) external costs, which include environmental impacts, and interactions with other vehicles and pedestrians;

(c) commuity costs, which are costs incurred by governments in assuming responsibility for freight transport activities;

(d) urban structure costs, which are a special subset of the external costs, and relate to the interaction between freight facilities and urban structure.

To a greater or lesser extent, each of these is affected by road traffic conditions, and thus TSM techniques have a potential application in reducing each of these cost elements.

## 2.1 TRANSPORT OPERATION COSTS

In a study of urban transport efficiency in Canada carried out for the Ministry of Transport (1971), the total direct costs of person and goods transport were estimated for three representative centres. The results, in 1966 dollars per head of population, are shown in Table I.

There are three important points to be drawn from this table. Firstly, the absolute cost of urban freight is significant - 6% of income in the smaller city, and 18% of income in the larger city. Improvement in freight transport efficiency thus has the potential of significantly improving the standard of living or urban residents.

Secondly, the total cost of urban goods transport in these cities was nearly as much as the total cost of urban person transport. This suggests that the movement of goods deserves serious consideration alongside the movement of people in urban transport systems planning and operation.

Thirdly, while the cost per head of person movement did not vary very much with city size, the cost of urban goods movement increased markedly with city size.

Similar conclusions were reached in an American study of the relative costs of urban goods movement (U.S. Dept. of Transportation, 1973). The relative cost index per unit mass in the various city groups studied is shown in Table II. The study concluded that "there seems to be a positive correlation between urban goods movement costs and population, overall development and age of the city".

The aforementioned Canadian study went on to simulate the transport costs in the various representative cities, and this enabled the cost components to be isolated. In the case or urban freight the cost profile shown in Table III was established (these costs are in 1966 dollars per head). Bearing in mind that these data are for Canadian cities of over a decade ago, the table nevertheless suggests that operating costs (maintenance, fuel, tyres, sales tax, etc.) were the largest single component. The effect of adverse traffic conditions on these cost elements is obvious, as is their effect on labour productivity.

TABLE I

URBAN TRANSPORT COSTS, CANADA

| CITY SIZE | COST OF TRANSPORT* | | | |
|---|---|---|---|---|
| | Person | Goods | Access | Total |
| City A (pop: 125,000) | 226 | 123 | 15 | $364 |
| City B (pop: 500,000) | 230 | 173 | 15 | $418 |
| City C (pop: 2,000,000) | 239 | 371 | 15 | $625 |
| Canada National Urban | 234 | 242 | 15 | $491 |

*in 1966 Canadian dollars per head of population in the relevant city size group.

Source: see text.

TABLE II

VARIATION OF FREIGHT COST WITH CITY SIZE
SELECTED U.S. CITIES

| URBAN AREAS | RELATIVE COST INDEX PER 100 lb. SHIPMENT |
|---|---|
| New York City | 5.7 |
| Chicago, Cleveland, Pittsburg, St. Louis, Washington, D.C. | 3.0 |
| Providence, Sacremento, Binghampton, Tulsa, Wilmington | 2.0 |
| Nashville, Norfolk, Tallahassee, Peoria, Reading | 1.0 |

Source: see text.

## 2.2 EXTERNAL COSTS OF URBAN FREIGHT

Externalities in transport systems can be defined as "costs which are imposed on others as a result of the transport facility or of transport movement to which they are not a party "(Wohl and Martin, 1967). In any urban transport situation there are many externalities, but two types of externality associated with urban freight transport are particularly relevant to TSM. These are, firstly, the interaction between freight vehicles and other passengers and vehicles using the road system, and secondly, environmental effects, particularly noise and air pollution.

### Interaction between Goods and Passenger Traffic

Goods and passenger traffic, including vehicles and pedestrians, may interact with each other on any way or terminal that they share. In most cases, this interaction is detrimental. At the present time, most interaction between goods and passenger vehicles occurs on streets and highways where trucks, cars, buses and pedestrians compete for space and priority. Congestion is thus a double-edged sword; trucks are responsible for delay to other road users, and the presence of those other users causes delay to trucks.

The congestion caused by trucks is due firstly to their physical presence on the road. Trucks typically comprise 15%-20% of the vehicles in the traffic stream (see for example, SATS, 1974). The contribution of trucks to congestion may be magnified by their greater size and slower accelerations, although this is not always the case, since many trucks are in fact light commercial vehicles with performance characteristics similar to that of the passenger car.

The more significant contribution to congestion by trucks is probably that due to parked trucks - trucks moving into or out of the traffic stream, reversing into delivery bays, negotiating sharp corners, or double parking to pick up or deliver goods.

The reverse side of the coin - delays experienced by trucks due to traffic congestion - is more readily recognized as a real cost. For example, Barnstead (1970) has reported the following costs of operating a truck in various parts of Toronto in 1968:

| | |
|---|---|
| Suburbs | \$0.78 cents/mile |
| Inner suburbs | \$0.97 |
| CBD fringe | \$1.24 |
| City Centre | \$2.06 |

This variation in cost was mainly the result of congestion, since "stops and starts attributable to congestion were about three times as high in the city centre as in the fringe. Forty percent of all traffic stops in the city centre were caused by congestion".

These data suggest that the effect of traffic congestion on moving trucks is to increase their operating costs by 100% or more, as compared with truck operation in non-congested areas.

### Noise

A significant cause of concern about urban freight is the level of noise which its operations generate - particularly that associated with heavy trucks. The level of truck noise is a function of the proximity of people to the noise

TABLE III

ELEMENTS OF URBAN FREIGHT COST, CANADA

| CITY SIZE (see Table I) | FREIGHT COST ELEMENT* | | | |
|---|---|---|---|---|
| | Operating | Labour | Depreciation & Overhead | Total |
| City A | 80 | 57 | 4 | $141 |
| City B | 109 | 84 | 8 | $201 |
| City C | 240 | 188 | 12 | $440 |

*in 1966 Canadian dollars per head of population in the relevant city size group.

Note: The figures in the "total" column do not agree exactly with those in Table I because the above were based on a simulation of the cost structure.

Source: see text.

TABLE IV

DISTRIBUTION OF SOURCES OF TRANSPORTATION AIR POLLUTANTS, BY MODE, NEW YORK CITY.

| SOURCE MODE | POLLUTANTS | | |
|---|---|---|---|
| | Hydrocarbons | Carbon Monoxide | Oxides of Nitrogen |
| Automobile | 58.9 | 55.3 | 45.7 |
| Petrol Truck | 21.6 | 25.0 | 5.3 |
| Diesel Truck | 1.6 | 0.4 | 10.7 |
| Bus | 2.5 | 0.6 | 18.5 |
| Taxi | 15.4 | 18.6 | 18.3 |
| Total | 100.0% | 100.0% | 100.0% |

Source: see text.

source, the acceleration and deceleration requirements of the traffic stream, and the extent to which buildings, walls and other screens deaden the noise. Psychological effects include the expectation of the level of noise (high levels of noise are expected on downtown streets, low levels in suburban residential streets), and whether the noise source is visible or not.

For these reasons, setting an "acceptable" level of noise, and measuring "typical" noise levels are both difficult tasks. However, a recent report on problems in urban freight concluded that "noise levels attributable to trucks in the traffic stream suggest that truck noise is sufficiently great so as to constitute a significant problem". (Simons *et al.*, 1972)

## Air Pollution

Transportation has been identified as a major source of several air pollutants. The contribution of urban trucks to the total urban air pollution varies with the type of truck (light vs. heavy, petrol vs. diesel), the conditions under which it operates, and the proportion of truck-km to total vehicle-km. For example, petrol powered light trucks are comparable in their emissions per km to passenger cars, but medium trucks emit about 50% more pollutants, and heavy trucks about twice as much pollutants per km under typical urban traffic conditions (Hedges, 1971).

In 1970, the New York City Department of Air Resources measured the contribution of the various transportation modes to pollution in Manhattan. The results for the three major transportation-related pollutants are shown in Table IV (Arrow *et al.*, 1974).

These results indicate that for Manhattan as a whole, about one-quarter of each of the transportation pollutants was produced by trucks. However, the paper also showed that in the downtown CBD, the proportion rose to over two-thirds in the case of hydrocarbons and carbon monoxide, and to over one-half for nitrogen oxides.

While these results for Manhattan are probably not typical of other urban areas, they clearly indicate that trucks are responsible for a very high proportion of urban air pollution.

Finally it should be noted that the air pollution problem is related to the congestion problem. It has been estimated, for example, that a reduction in average truck speed from 40 km/hr to 24 km/hr increases carbon monoxide emissions by 47% and hydrocarbon emissions by 56%. Conversely, an increase in average speed to 66 km/hr would yield only a 22% reduction in both pollutants (Simons *et al.*, 1972). It follows from this that any measure which improves traffic congestion, particularly in its most severe forms, will also decrease vehicle air pollution.

## Other External Costs

In addition to the above, there are several other external costs, some of which may be relevant to TSM in a particular situation. These costs include, for example, personal injury and property damage due to trucks involved in traffic accidents, damage to buildings due to vibration, and depression of property value because of the presence of trucks or freight terminals.

## 2.3 URBAN STRUCTURE COSTS

Another cost element relates to the interaction between freight facilities and urban structure. The costs in this area are very difficult to enumerate and allocate, but clearly goods transport does have an effect upon the structure of urban society. A city could not exist that did not allow for the inflow of food, energy and raw materials, the outflow of industrial products and waste, and the movement of commodities within the urban area. As such, goods movement is an essential component of the urban development process.

It is important to recognize that there are costs associated with a poor integration of land use and freight transport facilities. Once installed, new urban development and related transport facilities will remain in service for decades. Consequently, as Simons *et al.* (1972) have pointed out "whatever transport inefficiencies and negative externalities are built-in initially also may be promulgated for decades". Many of today's urban freight problems stem directly from poor location and design decisions made in years past.

Perhaps the most important aspect of this impact of freight on urban structure, from the viewpoint of transport systems management, is related to the effect of goods transport on the location of urban activities. The location of freight terminals and interchanges is an obvious case in point. These are of significant local importance because of their effect in terms of aesthetics, noise, traffic congestion, air pollution, etc. Terminals may also affect urban structure through their influence on the location of other freight generating land uses.

Freight may affect the urban economy in a direct way through its contribution to the viability (or lack of viability) or marginal industries, particularly in the city centre. It may be that by reducing freight costs, marginal industries can remain viable and if the preservation of these industries is desirable on employment or other social grounds, the transport system can have a positive role to play (see Berkowitz *et al.*, 1973 for a discussion of goods movement in the New York garment centre).

In summary, it is clear that there is an interaction between freight transport and elements of urban structure. This interaction provides an opportunity to reduce the costs of one or other or both. There is at present little information about the costs of poor integration of land use and freight transport, nor about the extent of "savings" which might be possible if they were better integrated. It is possible, however, that TSM may have an important role in reducing costs of this type.

## 2.4 COMMUNITY COSTS

Community costs are costs incurred by governments in assuming responsibility for various freight activities. The most important community costs in urban freight are the costs associated with the construction, maintenance and administration of urban roads.

It is clear that a significant proportion of the total construction and maintenance cost of such roads is directly attributable to urban freight, since heavy vehicles require extra road expenditure which in the absence of those vehicles would not be incurred. These freight-specific expenditures include the need to provide deeper pavements, wider lanes, shallower grades, longer curves and higher bridges, as well as the need for more frequent maintenance.

Various attempts have been made to estimate the proportion of total road construction and maintenance costs attributable to heavy vehicles (e.g. Haritos, 1973; U.K. Ministry of Transport, 1968). These studies will not be reviewed in detail here because unlike the other elements of costs which have been discussed, they are not usually directly relevant to TSM schemes.

In summary, the material presented in this section, although cursory and somewhat superficial, suggests that the movement of goods deserves consideration in the planning and implementation of TSM schemes.

## 3. THE IMPACT OF EXISTING TSM SCHEMES ON TRUCK OPERATIONS

Having made a case for considering goods movement in relation to TSM, it is useful to examine the impact of existing TSM schemes on truck operations. As pointed out earlier, freight considerations are rarely if ever taken into account in the design and implementation of such schemes, and it is necessary to investigate whether existing TSM schemes tend to hinder or facilitate truck operations.

Clearly, whether a particular TSM scheme does, in fact, hinder or facilitate truck operations depends very much on the local conditions which apply. For this reason, few generalizations are possible, and so rather than present a general discussion, three types of TSM schemes are examined and their potential impact on freight operations is discussed. These three schemes are clearways, priority lanes and closure of residential streets. Discussion of these will serve to illustrate the point that there are conditions under which trucks can be both hindered and aided.

### 3.1 CLEARWAYS

The establishment of clearways involves the prohibition of kerb parking along arterial roads for the duration of the peak period (or maybe for a longer period). By making this kerb lane available for traffic flow a greater effective road capacity is provided. It also reduces the risk of accidents between parking and through traffic.

As far as moving or through traffic is concerned, clearways can be said to benefit both passenger and frieght movement. However, the same cannot be said of trucks which have to service frontages along the clearway. Unless off-street loading and unloading space is available, those frontages can only be served by trucks in non-clearway periods. These periods may be quite short in that clearway restrictions may often continue till 9.30 a.m. for the morning peak and recommence at 3.30 p.m. for the evening peak. Thus the effective working day for deliveries is reduced to six hours. This disruption is particularly acute for those frontages which absolutely require truck servicing during the peak periods. Examples of outlets requiring peak period servicing are shops selling baked goods which require deliveries in the morning period, and mail and courier services which are keyed to late afternoon and evening peak periods (Levinson, 1976).

### 3.2 PRIORITY LANES

Another TSM scheme which may interfere with kerbside loading and unloading is the provision of priority lanes for buses and high occupancy vehicles. Because of passenger loading considerations, the kerb lane is normally chosen for priority lanes. In many cases the priority lane was formerly a parking lane. Conversion of the parking lane to a priority lane has meant non-priority through traffic is not disadvantaged by the introduction of the priority lane (so moving trucks are not hindered, and may even receive an advantage).

However, again the delivery of goods to frontages along the roadway is disrupted. Not only is kerbside loading interfered with, but access to off-street loading facilities may be hampered if the truck has to travel in or across the priority lane to reach the off-street loading facility entrance. This is a particular problem if permanent physical barriers are used to separate priority from non-priority traffic (e.g. Lane, 1973). To overcome the problem of access to frontages along a priority lane a special truck loading lane may have to be provided (Feather *et al.* 1973).

Priority lanes also have the potential of facilitating goods movement, at least so far as through (i.e. non-stopping) trucks are concerned, by considering them as a priority vehicle. Initially, only buses were considered as receivers of priority treatment. However, to justify a bus-only priority lane, a bus flow in the vicinity of 30-60 buses per hour is required (FHWA, 1970; Feather *et al.*, 1973; Levinson, 1975). In view of the limited number of roads carrying such bus volumes, other vehicles may be considered as priority vehicles to fill in the gaps between the buses. To date, this extension has mainly involved high occupancy vehicles, but in many situations there is no reason why commercial vehicles could not be similarly treated.

## 3.2 CLOSURE OF RESIDENTIAL STREETS

A TSM technique that has become increasingly popular in recent years is the closing of residential streets. This has involved, in some instances, the closure of a street to through traffic to eliminate the disamenity caused to residents of the street by fast-moving vehicles. In other instances, one leg of a four-leg residential street intersection has been closed to reduce the number of conflict points at the intersection and hence improve the safety of the residential street system.

TSM schemes of this nature are quite effective in achieving their desired aims. They are certainly capable of reducing the undesirable environmental impact of vehicles (including trucks) on a residential neighbourhood. However, in so doing, they may create a severe problem for those trucks which have a legitimate business in the area. Vehicles which do not regularly visit the area, such as furniture vans or emergency vehicles may become "lost", or have difficulty in manoeuvring in streets which have not been designed to facilitate u-turns by large vehicles. This problem is exacerbated in the period following the street closure when the closure is not shown in street directories. This period can last for several years, because of the temporary or experimental nature of many such schemes.

Similarly commercial vehicles on regular routes within a residential street system (e.g. milk runs, bread deliveries, garbage collection) have a more circuitous route to complete their tasks, following the introduction of the street closure scheme. Not only do they need to change their routes but, in some cases, where a through street has been converted into a cul-de-sac, the operator is required to switch to small vehicles because it has become impossible for large commercial vehicles to enter a street because of the difficulty of turning around or manoeuvring. Clearly, an analysis of possible circulation patterns within the residential unit by commercial vehicles should be conducted before the street closures are made.

These three schemes (clearways, reserved lanes and street closures) are examples of TSM schemes which impact truck operations. Others with obvious effects include turn bans, stop and give-way signs, parking restrictions, traffic signals, median strips and pedestrian crossings. The main reasons for TSM impact on truck operations are, firstly, the differing physical operating characteristics of trucks and other vehicles (e.g. size, acceleration, braking) and secondly, the requirements of trucks at terminal points.

## 4. OPPORTUNITIES FOR REDUCING GOODS MOVEMENT COSTS THROUGH TSM

The previous section has reviewed the impact of some currently-used TSM schemes on truck and goods flow. In this section the reverse side of the coin is examined - how TSM can be used to reduce the costs of goods movement, bearing in mind that TSM can be used for both reducing the direct costs of moving goods, and also for reducing the external costs associated with those movements.

Broadly speaking, TSM can be used for this purpose in four ways:

(a) improvements at a network level;

(b) improvements at a local level;

(c) facilitating vehicle parking and loading;

(d) removing physical deficiencies in the street system.

### 4.1 NETWORK IMPROVEMENTS

Improvements at a network level can be effected by means of truck routing, or by introducing bans on access for certain classes of vehicle.

#### Truck routes

Routes designated as truck routes are designed and laid out to ensure that geometric or physical design features do not restrict truck flow. The concept has a limited application in Melbourne, for example, with its "over-dimensional" truck route system. In some overseas cities, the concept is used to keep trucks out of residential areas, which is an example of a ban on vehicle access (see below).

The concept can be extended to give priority to trucks in much the same way as priority can be given to buses at intersections, freeway entrances, toll plazas, etc. (Levinson, 1975). The potential for designating lanes for exclusive use by buses and trucks has been discussed in the preceding section.

#### Access Bans

Bans on access may be introduced with the intention of reducing the environmental impact of trucks. They may take the form of peak hour bans, where trucks are not permitted to use a street or an area during designated hours, or a restriction on vehicle size. Another variation, as noted above, is to introduce a "no entry except for access" restriction, which confines trucks to certain routes except when actually completing a pick-up or delivery. In some cases, this regulation can be applied to a whole metropolitan area, with the effect that all trucks must bypass the area unless they have a reason to enter it; these restrictions are common in Britain (GLC, 1976; Hitchcock *et al.* 1974).

In certain areas of very intensive truck activity, it may be possible to introduce the reverse type of ban - a ban on passenger vehicles! Such a ban has been tried in the New York garment centre (Berkowitz *et al.*, 1975).

## 4.2 LOCAL IMPROVEMENTS

Local improvements principally involve changes to intersection design and operation to facilitate truck movement, and often involve nothing more than taking specific account of the particular needs of heavy vehicles. Attention to signals, signs and intersection layout are important.

### Signals

Heavy trucks, with slower acceleration and larger physical size, take longer to accelerate and clear an intersection. This affects such things as the operation of vehicle-actuated traffic signals, which should be designed to ensure that a slowly-accelerating truck can actuate the vehicle detector before the "vehicle extension" time is reached and the lights turn amber. The longer time to clear an intersection, particularly by a right-turning truck, needs to be taken into account in signal timing. Closely spaced unsynchronized signals can be synchronized to reduce the cost, hazard and driver task associated with trucks operating in stop-start conditions. A right-turn phase can be introduced at intersections where there are significant numbers of right-turning trucks; the use of passenger-car equivalents to investigate the need for such a device may underestimate the benefit to trucks and other vehicles arising therefrom.

### Signs

Drivers of delivery vehicles must rely on street signs to find a required address; where such signs are sparse or non-existent extra time and cost can be spent in finding a particular street.

Warrants for stop and give-way signs should recognize the extra cost and time involved in bringing a truck to a standstill; sometimes a stop sign is used when a give-way sign would suffice.

### Layout

There may be scope for facilitating the movement of left-turning vehicles by redesigning the kerb-line at intersections where there are heavy truck volumes. For right-turners, the introduction of a right turn lane (for example by creating a fifth lane in a 4-lane undivided road) would assist both truck and passenger vehicles. For roads passing through commercial or industrial areas where there are substantial numbers of right-turns into premises, a continuous central lane for right-turning vehicles only can be introduced.

## 4.3 PARKING AND LOADING

TSM techniques related to truck parking and loading principally involve the designation of no-parking (clearway) zones or loading zones. A related option is the provision of truck parks. [The benefits to through trucks and the disbenefits to stopping trucks resulting from the introduction of a clearway have been discussed in the preceding section.]

### Loading Zones

Where on-street parking and loading is permitted, there is a need to ensure that there is an adequate number of loading zones to prevent the need for double parking, repeat calls, or cruising. Enforcement of the regulations is essential to prevent excessive duration of stops and illegal use of the zones by passenger vehicles.

### Truck Parks

Truck parks are a means of getting trucks which are not in use off the streets. In some situations, overnight parking of trucks is hazardous and detracts from the amenity of an area and it may be desirable to provide a truck park for these vehicles (see for example GLC, 1976). In other situations, for example where trucks are waiting to be loaded or unloaded at a terminal or interchange, it may be worthwhile to introduce off-street truck parks to prevent the accumulation of trucks on the street.

## 4.4 PHYSICAL DEFICIENCIES

The final aspect of the use of TSM to facilitate truck operations involves a consideration of the impediments to the movement of heavier, larger and slower vehicles through the street network. In many cases, there are physical deficiencies in the network, which if removed could be of benefit to these trucks.

Examples include

- lanes which are too narrow;
- absence of pavement markings or lane markings;
- poor maintenance of road pavement;
- poor road geometry - left and right turns at intersections;
- sharp bends, excessive or incorrect road camber and superelevation;
- poor visibility at level crossings, etc.;
- sub-standard clearance on overhead bridges;
- poles, signs, hydrants, shop awnings, etc. which are too close to the kerb;
- overhanging trees;
- trees and poles placed in the road pavements.

This discussion of the opportunities for facilitating goods movements by the use of TSM has been necessarily brief. More explicit attention to the needs and problems of moving and parked trucks is needed to establish the applicability and range of options which are available.

# 5. EVALUATION OF TRUCK ORIENTED TSM SCHEMES

From the previous sections of this paper, it is clear that commercial vehicle operations are a significant part of the total transport task, that they can be sometimes subject to negative impact from TSM schemes, but are also in a position to benefit from redirected TSM schemes.

In many cases, this "redirection" may involve little more than a recognition on the part of the planner or traffic engineer that vehicles other than automobiles use the road. Goettee (1977) has stressed the need for traffic planners to become familiar with the problems experienced by shippers, receivers and carriers, since "many freight distribution problems can be traced to a lack of consideration for the unique characteristics of different freight distribution practices and a variety of freight carrying vehicles".

However, apart from such circumstances, the introduction of a TSM scheme oriented towards freight should be preceded by a thorough evaluation of the "costs" and "benefits" of the proposed scheme. Ideally, this should encompass all affected groups, including all classes of road user. Such an evaluation framework, capable of assessing the value of TSM with respect to commercial vehicles, does not yet exist, so it is appropriate to conclude this paper with a few remarks on what such a framework might comprise.

In a previous report (Richardson and McKenzie, 1976), a conceptual framework for the evaluation of bus priority schemes was proposed. This evaluation framework considered various evaluation methodologies as being within a three-dimensional space (see Figure 1). This space, with dimensions of breadth, width and depth, defined the complexity and completeness of the evaluation procedure. The breadth of the evaluation referred to the number of groups in the community included in the evaluation. The width of the evaluation referred to the geographical area over which the evaluation extended. The depth of the evaluation referred to the number of factors considered within the evaluation.

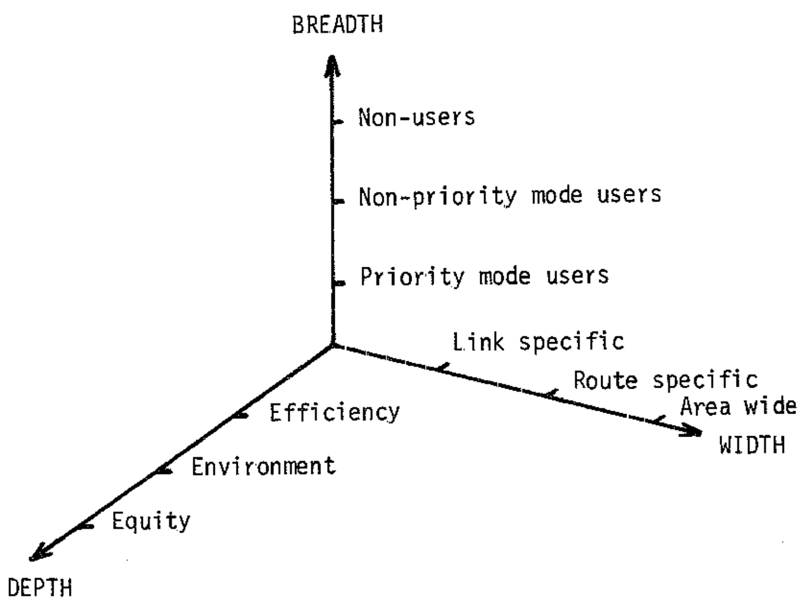


Fig 1 - Dimensions of Evaluation Methodologies

In the evaluation of TSM schemes with explicit consideration of commercial vehicles, it would appear that the most critical dimension of the evaluation process is the breadth of the study. In the evaluation of existing passenger-based TSM schemes, it is obvious that both priority and non-priority traffic should be included in the study. In most studies (e.g. Coombe *et al.*, 1974; Capelle *et al.*, 1971), the assessment of trade-offs between priority and non-priority traffic has been limited to the comparison of passengers' time spent on priority and non-priority modes. However, if explicit recognition is to be given to commercial vehicles, either as priority or non-priority traffic, then the travel time (or cost) of commercial vehicles must be included in the analysis.

In attempting to include both passenger and commercial vehicles in the evaluation process, a difficulty is to enumerate the trade-offs between them. The unit of analysis for passenger vehicles is generally taken as passenger-minutes, but this is not particularly meaningful for commercial vehicles. It is not sensible for example, to trade-off a minute saved by a passenger vehicle against a minute lost by a commercial vehicle. Similarly, a minute saved by one type of commercial vehicle is not comparable with a minute saved by another type.

Ideally, to make comparisons between passenger and commercial vehicles, or between different types of commercial vehicles, such savings must be expressed in terms of cost savings. This, unfortunately, is not a straightforward exercise. For passenger vehicles, operating cost savings, resulting from time savings, can be determined by means of an operating cost function (as described by Ridley *et al.* 1973) while passenger time savings can be converted to cost savings by means of a value of time coefficient. Time savings to various commodity flows, however, cannot be converted to cost savings in isolation from the physical distribution system within which transport is but one component. It may be, for example, that time savings made in the transport sector will be offset by costs incurred at the terminal points of the trip. Alternatively, time savings made on the trip may not be usable because it is impossible to make another trip on the same day. In another situation, time savings may be of little use if the commodity is simply being transferred to another site for storage; it is of no benefit to be able to store the commodity at the destination for a slightly longer period. In the extreme case, a reduction in travel time may mean that a storage facility must be provided which was formerly not required.

For reasons such as these, an investigation of the relevant physical distribution system would be necessary before a value could be put on time savings to commercial vehicles. Only then could commercial vehicle time savings, or losses, be traded off against passenger vehicle time savings, or losses.

Thus, because of the complexity of identifying commercial vehicle time savings and other benefits to commercial vehicles from TSM schemes, it is extremely difficult to perform a formal quantified evaluation of such TSM schemes. However, this does not remove the need to investigate and evaluate a proposed scheme, so a less formal means must be adopted.

In essence, the evaluation process then comes down to recognizing all of the negative and positive effects of any particular TSM strategy and identifying the trade-offs involved. In its initial stages, the scheme might involve little more than a "balance sheet" or checklist showing the impacts of any particular strategy. In time, and as a result of relevant research, the process could be adapted to a more formal and numerical approach.

In proceeding towards this more formal approach, however, the scale of many TSM projects should be kept in mind. In many situations, the costs and benefits associated with TSM projects are relatively small. Whilst one would like to develop evaluation procedures which are as broad, wide and deep (see Fig 1) as possible, it should be remembered that the complexity of the evaluation procedure should be commensurate with the scale of the project involved. The cost of the evaluation process is a cost which should be attributed to the TSM project in question.

Bearing this qualification in mind, it should be stressed that before any major TSM schemes explicitly oriented towards trucks are embarked upon, an evaluation process, even if only of the balance sheet type initially, should be conducted. Obviously, in many cases, minor improvements can be carried out which benefit all vehicles, including commercial vehicles, and disbenefit no-one. In such circumstances, no rigorous evaluation process is necessary. However, in most cases, benefits gained by one class of vehicle are at the expense of another class of vehicle. In such situations, a comprehensive evaluation process is necessary.

## 6. CONCLUSION

Urban goods movement has been shown to be a significant part of the total urban transport task. Recent changes in economic and social conditions have meant that the movement of goods is no longer provided for as a direct consequence of the provision of sufficient peak hour capacity for passenger transportation. Specific provisions must be made for the movement of goods.

Also, as a consequence of attempting to utilize fully existing capacity for passenger transportation by means of TSM schemes, the movement of goods has sometimes been adversely affected.

This paper has described how some TSM schemes have impacted commercial vehicle operations. It then showed the potential of using TSM to benefit commercial vehicle flows, or to reduce the environmental impacts of such vehicles.

The major problem in the evaluation of TSM schemes is the difficulty of trading off passenger vehicle benefits against commercial vehicle benefits. The identification of commercial vehicle benefits is also seen to be a problem which can only be studied in the context of the complete physical distribution system.

Finally, it is argued that before any major commercial vehicle oriented TSM schemes are initiated, an evaluation process, commensurate with the scale of TSM project costs and benefits, should be conducted.

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