REFERENCES

1. S. Eilon, C.D.T. Watson-Gandy, and N. Christofides. Distribution Management: Mathematical Modelling and Practical Analysis. Hafner Publishing Company, New York, 1971.
2. T.L. Magnanti. Combinatorial Optimization and Vehicle Fleet Planning: Perspectives and Prospects. Networks, Vol. 11, 1981, pp. 179-213.
3. W.C. Turner, P.M. Ghare, and L.R. Fourds. Transportation Routing Problem--A Survey. AIIE Transactions, Vol. 6, 1974, pp. 288-301.
4. G.B. Dantzig and J.H. Ramser. The Truck Dispatching Problem. Management Science, Vol. 6, 1959, pp. 80-91.
5. S.A. Cook. The Complexity of Theorem-Proving Procedures. Proc., 3rd Annual ACM Symposium on Theory of Computing, Association for Computing Machinery, New York, 1971, pp. 151-158.
6. R.M. Karp. Reducibility Among Combinatorial Problems. In Complexity of Computer Computations (R.E. Miller and J.W. Thatcher, eds.), Plenum, New York, 1971, pp. 85-103.
7. J.L. Lenstra and A.H.J. Rinnoy Kan. Complexity of Vehicle Routing and Scheduling Problems. Networks, Vol. 11, 1981, pp. 221-227.
8. G. Clarke and J.W. Wright. Scheduling of Vehicles from a Central Depot to a Number of Delivery Points. Operations Research, Vol. 12, 1964, pp. 568-581.
9. B. Golden, L. Bodin, T. Doyle, and W. Stewart, Jr. Approximate Traveling Salesman Algorithms. Operations Research, Vol. 28, 1980, pp. 694-711.
10. R.M. Karp. A Patching Algorithm for the Nonsymmetric Traveling-Salesman Problem. SIAM Journal of Computing, Vol. 8, 1979, pp. 561-573.
11. D.J. Rosenkrantz, R.E. Stearns, and P.M. Lewis II. An Analysis of Several Heuristics for the Traveling Salesman Problem. SIAM Journal of Computing, Vol. 6, 1977, pp. 563-581.
12. J.J. Bearwood, H. Halton, and J.M. Hammersley. The Shortest Path Through Many Points. Proc., Cambridge Philosophical Society, Vol. 55, 1959, pp. 299-327.
13. C.F. Daganzo. The Distance Traveled to Visit N Points with C Stops per Vehicle: An Analytic Model and Application. Submitted to Transportation Science.

Publication of this paper sponsored by Committee on Motor Vehicle Size and Weight.

Urban Freight Practice—An Evaluation of Selected Examples

PHILIP A. HABIB

ABSTRACT

A diverse group of urban goods movement projects and actions taken by municipalities are documented and the principal lesson or lessons derived from each project are highlighted. The research used the literature, field visits, interviews, and independent research to formulate the presentation of the selected examples. The paper contains eight examples of municipalities that have implemented projects in curb space management, off-street facility planning, and zoning. Six examples are drawn from U.S. cities and two from Canada. An evaluation follows each example to highlight the positive and negative results of each as they might affect application elsewhere. This paper is drawn from research sponsored by the UMTA University Research Program and was conducted by the author while at the Polytechnic Institute of New York.

This paper provides a detailed review of a selected number of actions taken by various municipalities to address urban freight transportation. The documentation for several of these actions included field trips and interviews. The literature, plus the author's personal knowledge or involvement, provided the documentation on the other actions.

The urban transportation planner's or the engineer's justifiable preoccupation with the need to optimize the transportation infrastructure to move people has, to date, left a wide gap in professional skills necessary to foster successful urban freight project development and evaluation. The ability to draw on the work and experiences of similar projects has not only markedly facilitated people-transportation project development but has also provided

knowledge of feasible actions to the nonspecialist. The objective of this paper is to begin the construction of a practices-sharing effort in freight, focused primarily on the more typical needs of municipalities.

Difficulties in freight transportation in the vast majority of cities first arise from high densities of pickup and delivery activities concentrated to form a few problem locations, usually in the central business district. Some of these problems can be addressed using "quick-fix" actions; others may require intermediate-term project development; and still others may only be addressed in long-term master planning.

The research effort (1) from which this paper is drawn focused on the vehicle movement of urban freight and discounted the urban movements by rail, pipeline, or helicopter. This paper consists of sections dealing with existing projects and practices in curb space management, off-street freight facilities, and zoning for off-street requirements. These practices are derived from U.S. and Canadian cities. The first part of each section deals with project descriptions and the remainder of each section evaluates each project and addresses the conditions most suited for application.

CURB SPACE MANAGEMENT

Curb space is the primary facility for loading and unloading freight in central areas. This curb space is also the primary facility for bus stops, taxi stands, metered parking, passenger loading and unloading, bus lanes, and other traffic and transportation uses. In the central business district the multidimensional demand characteristics for curb space often exceed the supply during the work day period resulting in a deterioration of the curb space regulatory structure and a reversion to a first-come first-served structure (e.g., trucks parking in bus stops, automobiles double parking, trucks double parking).

The rationing of curb space among its competing users can be organized into three regimes: time, space, and time and space. The most commonly stated objective of a rationalized system for a curb space when the overall demand is greater than the overall supply is to "equitably" allocate space to satisfy the peaks of the various demand patterns (traffic or bus lane in the rush hour, freight pickup and delivery in midmorning, shopper parking in late morning and early afternoon, and the like). Two examples of freight planning and curb space management are described in this section. The cities from which the examples are drawn are San Francisco and Dallas.

San Francisco Reserved Zone

The principal arterials in the San Francisco central business district (CBD) experience heavy surges of peak-hour traffic after which arterial demand for vehicle movement is quite low and the curb space can revert to nontraffic uses. San Francisco has a strong commercial core that attracts a high shopper demand for short-term parking. To service these commercial establishments, large and small, freight pickup and delivery activity is also intense at most locations in the CBD.

On several of the one-way arterials in the CBD, the curb space is controlled by parking meters and parking signs. Except for bus stops, driveways, hydrant zones, and other restricted areas, parking meters are installed along the curb face. Curbside standing is not permitted in the morning peak period on inbound arterials nor in the evening peak period on outbound arterials, and signing on the sidewalk and on the meter heads so indicates. However, when parking is permitted, portions of the curb space are reserved for pickup and delivery vehicles for selected time periods. These reserved metered spaces, which when combined form a loading zone, have special striped marking and a plaque on the post supporting the meter that identifies the space as a truck loading space (the local name is a zebra zone). Typically, these spaces are only allocated to truck loading and unloading until 11 a.m. when the demand peaks for delivery to small retail establishments. These freight vehicles do not have to deposit coins in the meters (Figure 1).

All spaces become available for short-term metered parking on a first-come first-served basis after the reserved period has expired. Freight vehicles rarely will find available metered curb space under this first-come first-served management scheme and typically stop in a hydrant zone or a bus stop or double park.

Commentary

A combination of events maximizes the effectiveness of this management scheme. First, the reserved spaces are positioned to be attractive to most freight vehicles; second, the delivery demand is already decreasing by 11 a.m.; third, although many delivery vehicles do double park after the reserved period has expired, the arterial traffic flow is sufficiently low that any adverse effect is usually negligible; and fourth, the businesses are served as their freight and patronage needs are both accommodated.

During several days of observations by the author

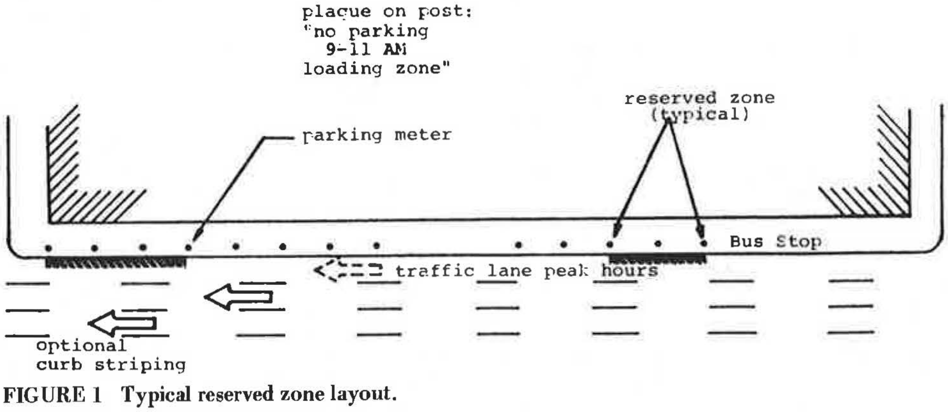

FIGURE 1 Typical reserved zone layout.

in San Francisco, the approach just described was found to work well without explicit enforcement. The use of curb paint to further reinforce the temporary loading zone is also beneficial. The minimum length of a zone was two parking stalls, or about 40 ft. (Almost every freight vehicle was a straight truck or smaller.) An installation should not be considered where, from the demand viewpoint, it is unwarranted. The freight demand necessary to justify the reserved-zone concept should typically exceed four pickup and delivery (PUD) vehicles per hour for each 30 ft of curb space already available for loading and unloading on the block face. This available space can include hydrant zones and inactive driveways. The placement of the reserved zone should be based on field observations and distribution of demand and located, if possible, adjacent to hydrant zones, driveways, and bus stops to facilitate access and egress. According to research (2) on truck and traffic impacts, the highest benefit to traffic is derived from placing such zones near the ends of the block face because interference with traffic flow at these critical points causes maximum delays on arterials.


FIGURE 2 Truck meter installation.

Dallas Metered Loading Zone Project

In the fall of 1981, the city of Dallas instituted what is believed to be the first metered truck loading zones in the United States. Two such zones were placed on arterials in the Dallas CBD, one on Commerce Street and the other on Main Street. The purpose of the installations was to increase the curb space capacity of existing truck loading zones. Both installations were of a pilot nature, with a subsequent evaluation to determine their effectiveness.

Each truck meter is set for 20 min and then must be reset. The meters on Commerce Street were free meters and the meters on Main Street cost 5¢. The objective was to determine whether timing of the PUD activity would increase turnover and reduce the number of non-PUD users in the loading zones. Using the meter system as a mechanism for enforcement of the city's loading zone time limit (also 20 min) was also considered a positive element of the installations. The Commerce Street zone typically services office PUD trips whereas the Main Street zone is on a block dominated by small retail establishments.

Figure 2 shows a typical installation. The meters were set approximately 30 ft apart, one meter per pole. Except for the periods between 7 and 9 a.m. and 4 and 6 p.m. when the curb lane becomes a traffic lane, the metered loading zones are exclusively for vehicles loading and unloading freight.

Commentary

A before-and-after study was conducted at each of the two installations to determine their effectiveness in achieving the project objectives. Two full weekdays of data were collected at each location. Table 1 gives the resultant vehicle type distributions.

In general, the after data show a slight reduction in total vehicles compared to the before. It cannot be concluded that this is an effect of the meter program both because of statistical confidence considerations and because the before data were collected in late October and the after data were collected in December and January, slower goods movement periods, especially on Main Street. Therefore the vehicle populations served by the meters were essentially unaffected by the installations. Because the number of passenger cars (typically non-PUD vehicles) using the loading zones did not decrease, one of the main objectives of the meters was not accomplished.

Table 2 gives the effect of the 20-min meter on average dwell time.

The installation on Commerce Street (typically office PUD activity) showed a reduction in the relatively long average dwell times as might have been expected. However, totally unexpected is the increase in dwell time shown for the Main Street (typically retail PUD activity) installation. Most of the after data were collected between December 16 and 22, a principal shopping period in the retail areas. This may have had an impact on the characteristics of the Main Street installation. Fortunately this hypothesis can be checked because, in addition to the before-and-after data collection at the installation sites, before-and-after data were also collected on a nonmetered loading zone on Ervay Street (also in the retail district). Table 3 gives the average dwell times at this "control" loading zone during the periods when before-and-after data were being collected for the installation sites.

It appears that, during the after analysis in the retail section of the Dallas CBD, increases in dwell time compared to the before period was a base characteristic, which probably overshadowed the impact of placing the meters in the Main Street loading zone. Therefore no conclusion can be drawn about the effectiveness of the Main Street installation.

Observations indicate that at the Commerce Street installation (office-related PUD activity) the meter spacing of 30 ft 0 in. was larger than necessary and, as a result, irregular parking patterns (not organized about the meters) ensued (Figure 3). This irregular pattern was no different than what might have been expected had no meters been installed in that loading zone. Observations at the Main Street installation showed a more regular parking pattern; however, the demand for that loading zone was substantially less than at Commerce Street and the zone was greatly underused in the afternoon.

To address the difficulty of accommodating various sized PUD vehicles in a regular pattern, it is suggested that, for any new installations of this type, the single-headed meter spacing of 30 ft 0 in. should be replaced with double-headed meters spaced 45 ft 0 in. on center in an office PUD environment and 50 ft 0 in. on center in a retail PUD environment (Figure 4). "Doubling up" provides a more efficient accommodation of the various sized vehicles and keeps them organized about the meters.

TABLE 1 Distribution of Vehicle Types

	Commerce St.				Main St.			
	Before		After		Before		After	
	No.	Percentage	No.	Percentage	No.	Percentage	No.	Percentage
Passenger cars	95	49	98	53	39	59	32	64
Light trucks[a]	88	45	70	38	16	24	12	24
Straight trucks	11	6	17	9	11	17	6	12
Tractor trailers	0	0	0	0	0	0	0	0
Total	194	100	185	100	66	100	50	100

[a]Vans and panel and pickup trucks generally 20 ft 0 in. or less in length.

TABLE 2 Average Dwell Times at Installation Sites (min)

	Commerce St.		Main St.	
	Before	After	Before	After
Passenger cars	17.9	14.5	14.31	22.5
Light trucks	25.0	16.7	16.3	27.7
Straight trucks	28.9	25.3	26.4	44.2
Tractor trailers				

TABLE 3 Average Dwell Times (min) at Control Site

	Evray Street	
	Before	After
Passenger cars	16.8	32.2
Light trucks	20.5	26.3
Straight trucks	16.2	39.6
Tractor trailers	80[a]	200[a]

[a]Small number of samples.

FIGURE 3 Typical irregular parking pattern.

Overall, as a pilot program, the installations in Dallas have provided partial evidence of the behavior of PUD vehicles under metering in the loading zone. What made the Commerce Street installation successful in terms of reduced dwell times was that almost all PUD drivers in the zone were servicing office buildings and out of close contact with their vehicles. On Main Street, however, with the storefront retail activity and the relatively low PUD demand at the installation, little or no efficiency would be expected. At neither installation did PUD drivers avoid using the zones because of the metered installations. Also, the meters did not appear to prevent unauthorized use of the loading zones by non-PUD vehicles.

Summary

The management of curb space requires recognition of the patterns (primarily temporal) of the competing users. The shared-zone concept in San Francisco is an excellent example of accommodating the traffic, freight, and shopper activity of a typical downtown arterial (Figure 5). The concept of the traditional all-day loading zone within retail sections of the CBD is difficult to justify, especially because the PUD demand falls off rapidly after 12 noon. In Dallas, where one loading zone was quite active, the installation of meters proved an effective management tool. However, where a loading zone is used actively only during a portion of the day, the most effective management tool would be to free the space to all users on a demand-response basis. Therefore installing truck meters in such a loading zone is not recommended.

CENTRAL AREA FREIGHT FACILITIES

The most practical long-term planning approach to minimize freight loading conflicts with traffic on the arterial system is to physically separate these operations where possible. Because most central area generators tend to be quite small, an aggressive planning approach to provide off-street loading docks in new buildings will only partly address the issue. Three examples of physical separation for loading and unloading of freight, which have been implemented and which may have wider applications, are presented. These are in Dallas; Rochester; and New York and Brooklyn, New York.

Thanksgiving Square Truck Terminal--Dallas, Texas

Dallas' 1969 Master Plan calls for, among other things, underground truck traffic connected to strategically located terminal facilities that, in turn, are connected to various buildings. One of the components of the plan is the Thanksgiving Square Truck Terminal (also known as the Bullington Truck Terminal) that was constructed and opened for operation in May 1977 (Figure 6). The land for the facility was donated by a private foundation and the surface level has a park, a chapel, and elaborate pedestrian facilities. The underground truck terminal serves a projected 5 million square feet of office buildings surrounding it with "finger" passageways leading

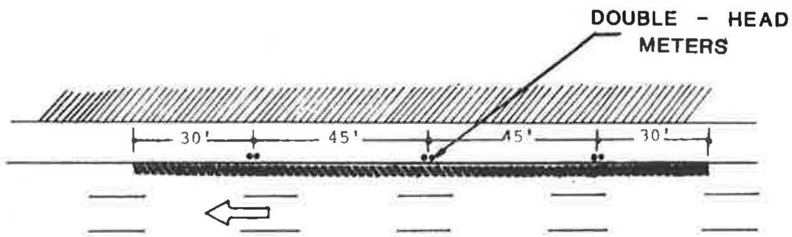

FIGURE 4 Recommended layout for loading zone metering.

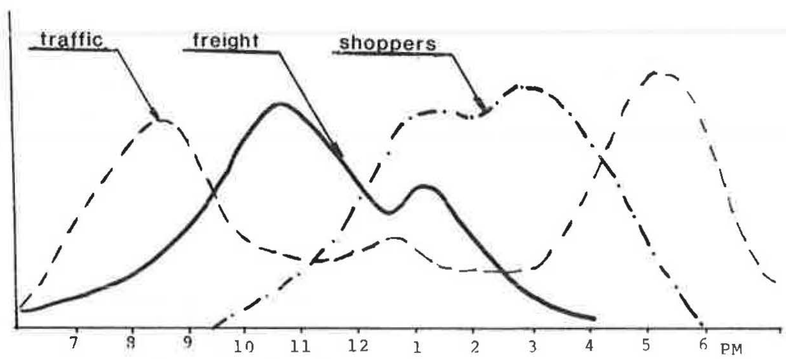

FIGURE 5 Typical peaking of curb space use.

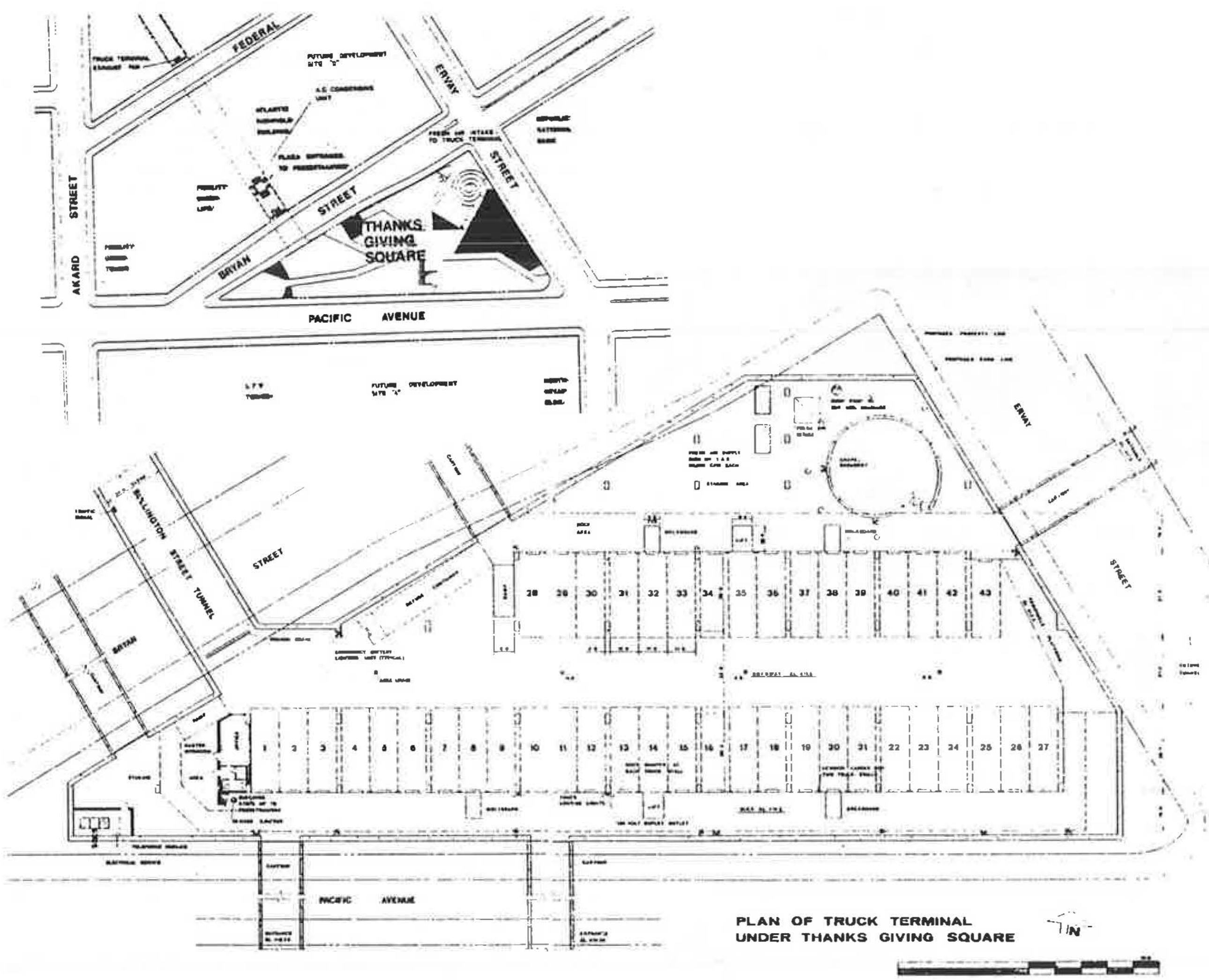

FIGURE 6 Thanksgiving Square terminal *(3)*.

from the facility. Selected characteristics of the facility are

- Forty-three truck bays;
- Operates 6 a.m. to 6 p.m., weekdays;
- Capacity of 800 deliveries per day;
- Annual operating cost in 1980 of $96,000; and
- Street access via a two-way, 24-ft ramp.

Each arriving vehicle is assigned to a position number by a dispatcher as the vehicle enters. The dispatcher keeps track (via a display board) of position occupancy and typically assigns a truck to a position as close to the destination building as possible.

Commentary

There is little doubt that the truck demand (700 to 800 truck trips per day) associated with 5 million square feet in different buildings would cause significant disruption to surface traffic and pedestrians in this concentrated area of downtown Dallas. For an estimated average service time of 30 min per delivery, the facility accommodates 350 to 400 truck space hours per day. The absolute benefit of the project for surface traffic operations is difficult to measure because there is no "before" condition. If it is assumed that, with a capacity of 800 operations per day for 250 days annually, the facility has an operating cost of approximately 50 cents per operation, which is borne entirely by the buildings being served. Furthermore, the buildings connected to the facility now have an area at least the size of the truck terminal (47,000 ft^2) available for rental because they are not required to have their own off-street facility, which translates conservatively into a minimum of $1.0 million of additional annual rental revenues for these buildings, or ten times the operating cost of the facility. As such, the road-user benefits accrued by the project--and they are substantial--are being achieved at no incremental cost, a remarkable achievement.

The principal lesson of the facility is that a shared off-street facility for large office buildings is feasible. The facility has physical connections to each existing and future building site and all connections run under the adjacent street system. The facility could just as well have been in the basement of a new building (instead of the "basement" of a park) and would have operated in a similar manner (except for the structural configuration and size of the internal columns). The point here is that new large buildings, many of them public, are routinely constructed in the central area and the opportunity to provide much needed off-street truck spaces is not seized.

New shared facilities do not have to be of the scale of Thanksgiving Square. However, many buildings adjacent to a redevelopment site that do not have adequate off-street parking facilities and adjacent buildings on principal arteries are the essential signals that should trigger consideration of opportunities for shared off-street loading facilities.

Underground Truck Road in Rochester

The Underground Truck Road is a subgrade truck tunnel serving the central core of downtown Rochester, New York. It consists of five segments built at different times (4). Excavation for the Underground Truck Road began in 1959 and the midtown section was opened in 1961. The tunnel was constructed originally to serve Midtown Plaza, America's first and largest downtown shopping center and office-hotel building development under one roof (a 7 1/2 acre site, more than a million square feet of retail space).

The total length of the existing truck tunnel is approximately 1,440 ft. The width of the tunnel varies from 24 to 30 ft. Two T-intersections at the subgrade Cortland Street limit the use of the truck tunnel for the largest semitrailers. There are two signals controlling traffic in the tunnel. There is only one street level access to the tunnel, with divided up and down ramps.

There are more than 30 truck loading docks of different types and heights in the different sections along the road and there are only three designated parking places for service vehicles. Many of the loading areas are behind closed overhead garage doors that enclose either the entire area or just the end of the dock.

The downtown truck tunnel serves two major functions: freight pickup and delivery and vehicular access to underground parking facilities. The tunnel provides freight service to more than 40 businesses including two major department stores, a hotel, and a restaurant. More than 700 vehicles were counted entering and leaving the tunnel between 6:30 a.m. and 8:45 p.m. one day in July 1981. Of that number, 375 were automobiles. The following table gives the breakdown:

Vehicle Type	Vehicles in/ out of Tunnel
Automobiles	375
Light trucks	194
Medium trucks	128
Tractor trailers	19

Commentary

The Underground Truck Road is a valuable asset to downtown Rochester and a vital link in its pickup and delivery transportation system of alleys, ground-level off-street loading docks, and underground loading docks. With approximately 400 PUD vehicles (trucks and automobiles) using the facility in the typically slow goods movement month of July, this is one of the most heavily used central area facilities in the United States. Unlike Dallas, Rochester does not appear to have an official master plan that supports the underground truck distribution concept. However, at each opportunity, the tunnel is extended. With its current length of just over 1/4 mi, significant reductions in surface traffic vehicle-miles of travel are accruing to the arterial system, thereby benefiting traffic flow as well as pedestrians.

The security benefits of this system are also identified as a principal attribute. A major bank as well as consumer freight movements are involved in this PUD process. Several receivers use shutters to close themselves off from the tunnel, sometime with a truck at the dock. Rochester also has harsh winter months and a major underground PUD component provides measurable benefits in time and convenience of goods transfer.

Livingston-Bond Garage and Remote Dock

Whereas the previously discussed facilities are for shared use, the facility discussed in this section is for a single user. A large department store in downtown Brooklyn needed to expand its off-street facilities significantly and to free large numbers

of vehicles queued on-street at the present off-street docks (5). Simultaneously, a new municipal parking garage was being constructed on the other side of the street (Livingston Street, an arterial). The New York City Department of City Planning and representatives of the department store concluded an arrangement whereby the city of New York would build a remote off-street loading facility in a portion of the garage and then lease that portion to the user on a long-term basis. Figure 7 shows the facility.

The freight component of the garage has seven berths of varied dimensions. Delivered freight is unloaded at the dock and transferred to a tow-line dolly system (continuous cable in the floor) that moves down a ramp (about 10 percent grade) under the garage (Figure 7), under Livingston Street, and into the basement of the receiving facility where it is loaded into a freight elevator. The empty dolly then returns on the tow-line directly to the dock of the remote facility.

COMMENTARY

The remote facility is unique in character and operationally sound. The facility has expanded the receiving capacity of the department store to a desirable (actually excessive) level. The tow-line has the capacity to move more than 100,000 lb of freight per hour, or about that generated by continuous unloading operation at a 12-berth facility. Because the tow-line is on ramps for a portion of its length, the dollies cannot handle extremely heavy items. One option might have been to use a freight elevator at dockside to transfer the loaded dolly to the basement level and then to use the tow-line to transfer the dollies to the destination.

The implementation and successful use of a remote loading facility open applications for future consideration. The concept is to provide off-street loading space in a new facility in order to reduce or eliminate curbside freight activity on the ar-

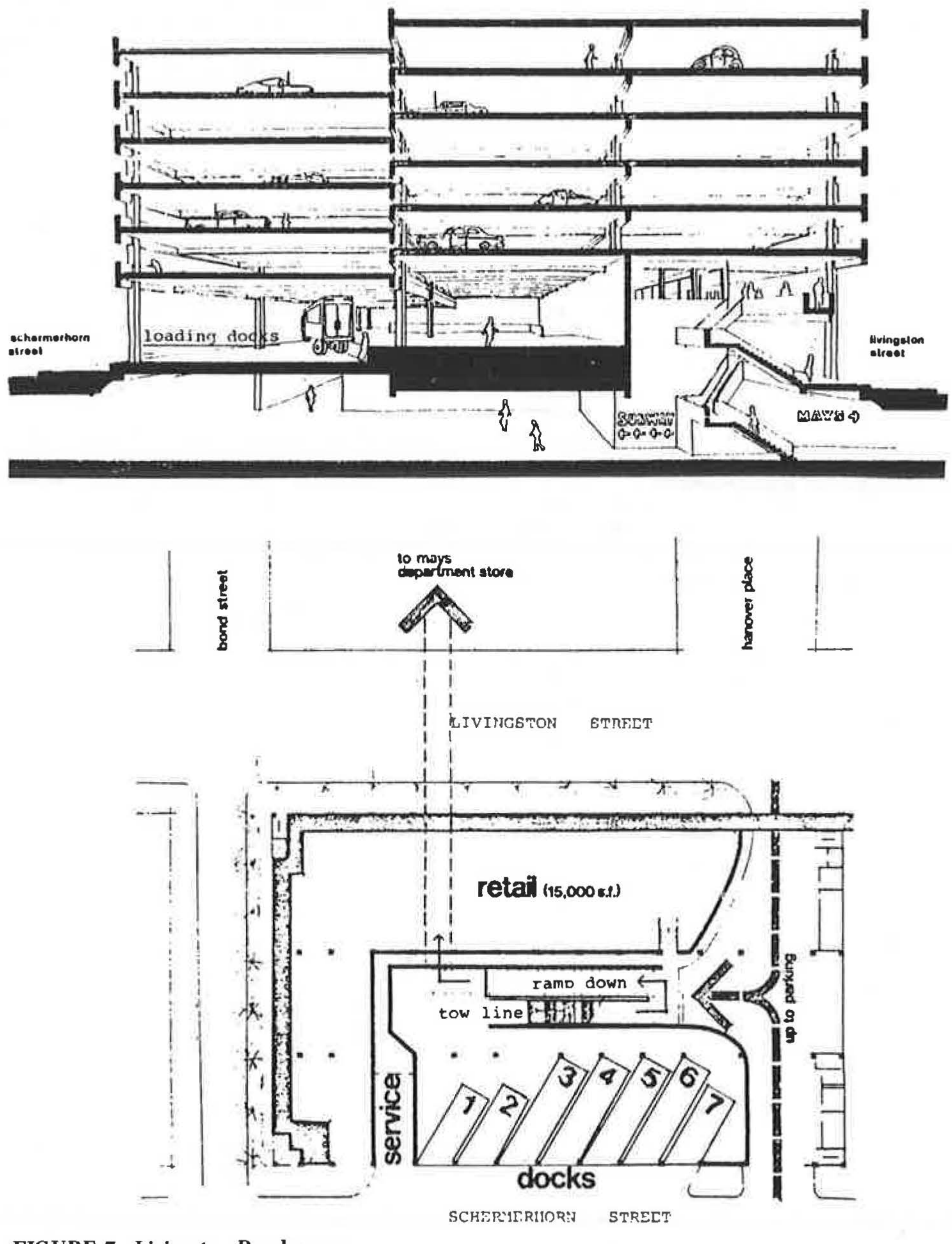

FIGURE 7 Livingston-Bond garage.

terial system at a problem location. The application of the concept to a central area department store appears to be the most reasonable one. Central area department stores are strong traffic generators, are generally fairly old, have antiquated handling facilities and therefore use curbside loading for much of their freight, and are usually located on the arterial system.

Parking garages are constructed to supplement automobile parking at the curbside. Spatial separation of trucks from the curbside appears to be a logical extension of this principle. The reuse of a portion of an existing parking facility for freight distribution is one of a battery of measures available to transportation engineers as this example exhibits.

TABLE 4 Loading Deficiencies in Peak Hour (7)

Block No.		Description	Peak Hour Stops		
			Supply	Demand	Deficiency
63E	(1)	Federal building	21	47	30
75	(2)	LTV-Dresser building	26	32	6
76 & 76½	(3)	Kirby building	67	72	5
223½	(4)	Dallas Times Herald garage	11	12	1
232	(5)	Sanger-Harris	46	67	23
107	(6)	Joske's block	46	71	25
243	(7)	Crow building	44	49	5
247	(8)	2001 Bryan	40	47	7
257/258	(9)	Plaza of the Americas	18	73	55
478	(10)	Dallas Centre	15	26	11

OFF-STREET ZONING AND LOADING REQUIREMENTS

The implementation of off-street loading facilities in new buildings typically follows the requirements set forth in a municipality's zoning ordinance. The zoning stipulates how many berths are required in a new building as a function of building size and use. Zoning will usually also stipulate the required dimensions of the off-street area; however, it will not stipulate how the area should be managed after construction. Most ordinances do not require that the spaces be at a dock, but only that they be off-street (in the building's parking lot or garage) and on the building's premises.

Zoning requirements for off-street loading facilities are not new. Most cities have such requirements. However, findings from previous research efforts show that these requirements have evolved from secondary source material not from independent investigations by the municipalities. The examples in this section focus on office buildings and the cases presented come from Dallas, Calgary, and Ottawa. The Dallas example presents new concepts in ordinance development; the Calgary example treats different components of PUD operations in a unique manner. The Ottawa example, although not directly related to zoning, was a case study of implementing central receiving and shipping in an existing office building.

Dallas Zoning Ordinance

Off-street zoning revisions began in 1974 with a review (6) of off-street ordinances from other cities in the United States that showed, as suspected, that Dallas had one of the lowest off-street loading requirements in its central area (7). The acknowledged problems with the ordinance were somewhat reduced because most developers exceeded the ordinance requirements in providing off-street facilities. The unacceptable likelihood of trucks loading and unloading in front of their buildings, it is understood, motivated developers to increase facilities.

Several years passed before additional work was conducted to actually revise the ordinance. In 1979 loading and unloading counts at critical locations were taken to verify demand estimates for various land uses and to quantify the deficiencies in existing buildings. Table 4 gives these deficiencies between the maximum number of PUD operations in the critical hour and the capacity of the existing off-street loading facilities. The deficiencies varied considerably among large buildings.

The concept of the new ordinance is the provision of loading space necessary to fully accommodate peak-hour demand at a site. The draft ordinance was reviewed by a city council-appointed advisory committee, as well as by the major downtown developers. Several severe objections were recorded by the developers because of the increases in the new ordinance. Face-to-face meetings and discussions followed in which both sides adjusted their positions. As an example, the demand estimate used for office buildings was found to be about 15 percent too high, and the requirement for accommodating 100 percent of peak-hour demand in off-street facilities was modified to include a provision that curbside loading zones, where available, could substitute for a portion of the off-street requirement.

Figure 8 graphically shows the new ordinance requirements in terms of number of off-street loading spaces and Tables 5 and 6 give the size distribution and location of these spaces. It is to be noted that, in Table 5, emphasis is placed on maximizing space available to developers by tailoring the size of the spaces to the inventoried vehicle-type characteristics loading at each land use. The data in Table 6 indicate that where curb space is available for a conveniently placed loading zone, up to 40 percent of the ordinance requirements can be placed on-street for the largest generators.

Commentary

The ordinance developed in Dallas addresses the concept of accommodating peak PUD operations (over a 60-min period) at the generator. For the vast majority of these generators, this accommodation is off-street. The use of the on-street complement (if available) for the largest generators to satisfy the ordinance is unique among U.S. cities. The combined off-street and on-street loading requirements address the differences between buildings in the center of the core (presumably there would be little or no side-street curb space available) versus buildings at the fringes (or outside) of the core where curb space is more readily available for loading zone use.

The ordinance significantly downgrades the importance of the tractor trailer (55 ft 0 in. vehicle) in off-street loading. Most studies typically show 2 to 3 percent tractor trailers in downtown PUD operations, with department stores having the highest percentages (5 to 6 percent). The ability to eliminate off-street loading facilities for vehicles longer than 35 ft 0 in. makes it possible to justify (to developers) the increase in the total number of off-street spaces with little or no change in square footage allocation to the loading and unloading function. It would appear, however, that the explicit write-off of tractor trailer facilities in the commercial and industrial land use category would be inappropriate for non-CBD facilities and potential users of the Dallas model should adjust the requirements to accommodate some large vehicles.

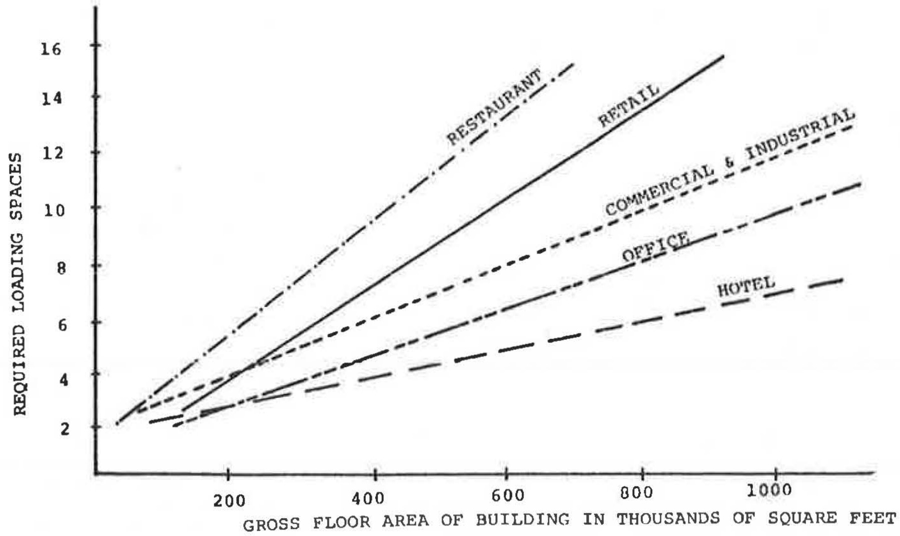

FIGURE 8 Dallas ordinance requirements.

TABLE 5 Loading Space Size Distribution for Various Land Uses

	Percentage of Space Sizes		
Land Use Category	55 ft	35 ft	20 to 25 ft
Office	–	40	Balance
Retail and personal services	–		Balance
Retail, if over 60,000 ft^2	25	25	Balance
Commercial industrial	–	40	Balance
Hotel or motel	1 space	75	Balance
Food and beverage services	–	40	Balance

TABLE 6 Options to Satisfy Off-Street Loading Space Requirements

No. of Required Spaces	Minimum Off-Street	Maximum On-Street
6	6	0
7	6	1
8	6	2
9	6	3
10 or more	60 percent	40 percent

Calgary CBD Office Building Requirements

This project developed a detailed statistical background on PUD operations at office buildings, with a special focus on the emergence of courier services in the CBD. The output of this project was the development of loading requirements for Calgary office buildings and the incorporation of these requirements into the city's by-laws (H. Ho and J. Morrall, Freight Facilities for Central Business District Office Buildings, internal paper provided by Transport Canada, 1981).

As in Dallas, a detailed inventory of PUD operations was undertaken at selected CBD office buildings in 1978 and 1979. The inventory included vehicle arrivals, type, service times, a survey of building managers, and a building loading facilities inventory. A major difference in this Calgary project was that the then by-law requirements were perceived to be too severe by developers, and few if any office buildings met the requirements (Figure 9). For example, 1-million-square-feet office buildings would require about 23 loading spaces (compared to 10 in the new Dallas ordinance).

The project calibrated detailed arrival time and service time statistical distributions for office buildings for the 9 a.m. to 12 noon period. This represented the period when PUD operations were highest and during which the developed by-law revision would be applicable.

The calibrated exponential service-time distributions are unique for each type of operation:

Trucks and Delivery Vehicles

$P(g \geq s) = e^{-0.03635}$, $n = 1.207$, $\mu = 27.6$ min

Courier Vehicles

$P(g \geq s) = e^{-0.10205}$, $n = 3{,}065$, $\mu = 9.8$ min

Service Vehicles

$P(g \geq s) = e^{-0.02075}$, $n = 118$, $\mu = 48.31$ min

where $P(g \geq s)$ is probability of a service time greater than or equal to s, n is number of observations, and μ is the mean service time.

The loading standards derived from the analytical representation of demand (9 a.m. to 12 noon) and service are based on full accommodation (zero queue) for the average 180-min demand of each vehicle type. The demand from 9 a.m. to 12 noon is somewhat less than the peak-hour demand and, as such, the standards, as implemented, imply some queues in the peak hour. Table 7 gives these off-street standards. It is noted in Table 7 that the recommendation is to also accommodate courier and service vehicles with off-street parking spaces.

Commentary

Under the new guidelines, a new 800,000-ft^2 office building in Calgary would be required to have 10 PUD loading spaces versus 8 in Dallas. It would appear that there are some discrepancies because the Dallas standard is designed for full accommodation in the peak hour and the Calgary standard for accommodating an average arrival rate over a 3-hr period. An independent study by the author that determined off-street loading requirements on the basis of minimal

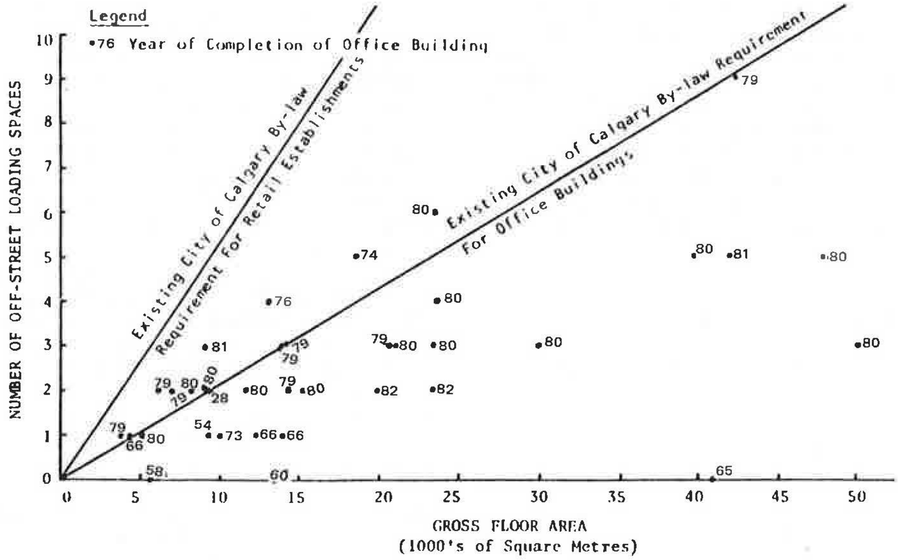

FIGURE 9 Existing loading spaces in Calgary CBD major office buildings.

TABLE 7 Recommended Freight Requirements for CBD Office Buildings in Calgary

Range of Total Gross Floor Area (m^2)	Minimum No. of Loading Spaces Required for Trucks and Delivery Vehicles	Minimum No. of Parking Spaces Required for Courier Vehicles	Minimum No. of Parking Spaces Required for Service Vehicles
10 000 - 14 999	4	2	1
15 000 - 19 999	5	3	2
20 000 - 27 999	6	4	3
28 000 - 39 999	7	5	4
40 000 - 49 999	8	6	4
50 000 - 64 999	9	7	5
65 000 - 79 999	10	7	5
80 000 - 94 999	11	8	5
95 000 - 109 999	12	9	6
110 000 or more	Additional one for every 15 000 m^2 or fraction thereof	Additional one for every 17 000 m^2 or fraction thereof	Additional one for every 47 000 m^2 or fraction thereof

Note: 1 m^2 = approximately 10.8 $ft.^2$

peak-period queuing found that seven berths would be appropriate. It therefore appears that the Calgary requirements may still be somewhat excessive. It is noted here that the previous by-laws in Calgary would require about 16 PUD spaces and thus the recommended changes do more accurately represent facility needs.

The concept of accommodating couriers and service vehicles is novel; this appears to be the first instance in which inclusion of nonloading vehicles is recommended for by-law revision. The provision of separate courier space must be considered on a city-by-city basis. As an example, in San Francisco a substantial portion of courier traffic at office buildings moves by bicycle. In New York bicycles, transit, and walking account for much of the courier traffic.

The provision of separate space for service vehicles has been supported by most researchers involved in freight and services transportation. It is difficult for service vehicles to find parking in the CBD. Most loading time restrictions are shorter than the average dwell time of a service vehicle and most vans and light trucks, commonly used for service, cannot be accommodated in garages due to headroom restrictions and insurance limitations. However, as in the case of courier vehicles, individual cities have different needs for service vehicle accommodation. In the densest cities, such as New York, Chicago, San Francisco, Philadelphia, and Dallas, many service trips can be provided by walking between destinations where electrical, telephone, or light maintenance functions are being performed. In cities with spread-out central areas, such as Phoenix, Los Angeles, and to some degree Seattle and Washington, D.C., transportation by vehicle between destinations is essential. In reviewing the criteria developed for service vehicle accommodation in Calgary, potential users should consider these ideal needs and tailor the necessary accommodating facilities on the basis of city characteristics, current and future use of curb space, expected developer cost, and other location and project characteristics.

Ottawa Receiver Consolidation Demonstration

This third example, from Ottawa, Canada, in 1977-1978, was designed as a demonstration project to evaluate the effectiveness of implementing central receiving in a multitenant office building (8). The objective was to reduce the temporal aspects of the pickup or delivery thereby improving curb space use, reducing carrier costs, reducing local traffic congestion, and improving air quality.

The demonstration project was conducted during a period of 6 months and involved having a desk and space in the lobby, two persons working 10 hr per day each, two telephone lines, and a secure storage room to hold freight overnight. The selected office building had multitenant occupancy and was just over 100,000 ft^2 in size. The project involved substantial amounts of data collection needed for before-and-after analysis of PUD dwell time, curb space use, traffic flow speed, and engine idling. In addition, attitudinal surveys of tenants and carriers were conducted after the experiment. It should be noted that the use of consolidated receiving in the demonstration building was completely voluntary on the part of the tenants and several chose not to participate.

In general, the experiment proved its point by reducing somewhat dwell times for shipments going through central receiving. The number of samples collected was limited in the after data and there-

fore statistical significance cannot be proven at the 95 percent confidence level. Table 8 gives a summary of the dwell time analysis. Of particular note here is the uncharacteristically short "before" dwell times for PUD operation at this building. This is partly explained by the small size of the building, which may prove to have been too small a building for which to achieve appreciable benefits. Another contribution to short dwell time may be an inordinate number of courier vehicles (typical of office buildings).

TABLE 8 Dwell Time Effects of Receiver Consolidation

	Front of Building			Upstreet/Downstreet		
	Before	After Using	After Not Using	Before	After Using	After Not Using
Passenger cars						
Observations	79	8	63	18	5	18
Mean	6.4	5.3	5.9	4.4	4.8	6.4
Standard deviation	5.3	4.9	3.6	2.0	4.7	3.6
Light trucks, vans						
Observations	72	13	38	25	7	47
Mean	8.4	7.3	7.6	7.6	7.7	8.2
Standard deviation	7.0	3.9	5.5	3.7	4.0	6.4
Heavy trucks						
Observations	37	10	21	12	2	14
Mean	8.1	8.9	7.6	8.8	5.5	8.5
Standard deviation	6.5	7.1	5.3	7.7	0.7	3.8

The study notes that where internal time benefits were achieved, drivers tended to use up this savings in inefficiencies external to the building. As a result of the relatively minor impacts on dwell time, the parking benefits were not definable. The total accumulation of PUD vehicles at any one time was slightly reduced, but even this benefit was not statistically validated. Further, the results of the before-and-after traffic speed analysis also show no statistical change attributable to the demonstration. The before-and-after analysis of the PUD vehicles that were left with their engines running for all or a portion of the time showed a significant decrease. However, the before study was conducted in November and the after study in June, and this is expected to be the explaining factor for this phenomenon.

Several interesting findings were generated from the attitudinal survey, especially of carriers and tenants. Detailed survey findings are available elsewhere (7). Carriers viewed the system positively; however, they have no influence in a system in which the tenant decides whether or not to participate. The tenants do not appear enthusiastic about the concept nor are developers. When cost was asked about, no group volunteered resources although the most popular response related to developer financing of any centralized operation.

Commentary

Overall, the experiment to provide a small office building with consolidated receiving and shipping cannot be viewed as a success in achieving the stated objectives. That only a minor number of tenants volunteered to be in the program was an indicator of the relative disinterest. It might have been interesting if the attitudinal survey had solicited responses about reasons for volunteering or not volunteering to be part of the system. It can only be assumed that the tenants who did not volunteer considered the system to be an erosion of the quality (increased time) of good access.

The preliminary nature of the results of the after study shows that, although hypothesized dwell time benefits are generally achievable, they are not realized because of average increases in external driver inefficiencies. If the building selected for the experiment had had loading docks, it could be hypothesized that the efficiencies gained with consolidated receiving would have resulted in sizable overall decreases in dwell time because drivers would have stayed at the dock and would usually have been monitored.

Only limited practical application is seen by this author for consolidated freight transfer in multitenant office buildings. Some characteristics of the ideal building for instituting centralized receiving are minimum size of 500,000 ft^2, poor elevator service (passenger and freight), problems with freight security, overused loading docks, and location in a street environment with little or no available curb space. The system cost would be borne by the building owner and the facility staffed by building personnel. Even under these ideal conditions, the final effectiveness of such a system would not be guaranteed.

Summary

This section has provided an overview of office building freight characteristics, problems, and possible solutions. As central areas of cities become increasingly service oriented, the rapid movement of small packages will increase in dominance. Two scenarios can be constructed for the future of this trend. The first scenario is the ever-increasingly large numbers of courier vehicles moving about the central area with small packages and documents. The second scenario is the emergence of technology in telecommunications that would be adapted to the "movement" of much of the currently transferred freight at office buildings. Characteristically, these scenarios are diametrically opposite and cannot easily be planned for simultaneously.

As municipalities try to come to grips with central area movement of freight, the recognition of the growth in service vehicles must be translated into the planning process. Offices (and other land uses for that matter) will continue to have more equipment (communications, computers, and so forth) that require specialized servicing. A casual walk through the central areas of larger cities will point out the significant presence of service vehicles at curb side and parked in off-street loading areas where permitted.

SUMMARY

In this paper an outline of examples of actions taken by municipalities to plan for and better manage freight transportation as a component of overall urban transportation has been presented. The number of actions available for presentation was limited by the real lack of overall consideration of freight transportation by most municipalities. New ideas were difficult to come by. Of particular note is the lack of any action in the traffic engineering and arterial management area, which presumably has the most impact on urban transportation. In the area of land use planning, certain municipalities, Chicago as the prime example, have taken actions to improve truck terminal access as well as terminal location planning. The only example of sidewalk management was found in the New York garment center where signposts are being eliminated to facilitate freight movement and building transfer. No municipality was found to have any program to supervise off-street

loading facilities to ensure that these facilities are being used for their intended purpose. This has been a problem for some time.

The role of urban goods movement, already accounting for one-half of the nation's truck transportation bill, is expected to increase in the decades ahead. The concept of centralized manufacturing has been eroding as small automated plants located near the consuming market are proving to be a more cost-effective alternative to ever-increasing over-the-road transportation and distribution costs. In addition, the concept of zero inventory ("just-in-time") is expected to also increase in popularity in small establishments (manufacturing and retail alike) thereby placing more importance on the movement of decreasing shipment sizes.

The eight examples presented in this paper serve to identify some ideas and options for municipal goods movement project development. Because new goods movement projects are few, evidence of successful and unsuccessful techniques is needed and serves to improve the effectiveness of new projects. It is hoped that this paper satisfies a portion of these information-sharing needs.

REFERENCES

1. P.A. Habib. Practices in Urban Freight. Report UMTA-NY-11-0023-F. UMTA, U.S. Department of Transportation, May 1983.
2. P.A. Habib. Curbside Pickup and Delivery Operations and Arterial Traffic Impacts. Report FHWA/RD-80/020. FHWA, U.S. Department of Transportation, Feb. 1981.
3. Datum Structures Engineering, Inc. Thanksgiving Square Feasibility Report. Department of Public Works, Dallas, Tex., Feb. 1972.
4. A. Ketter. Underground Truck Road--Rochester. Internal Report. Genessee Transportation Council, Rochester, N.Y., 1981.
5. Livingston-Bond Garage. Mayor's Office of Downtown Brooklyn Development, Brooklyn, N.Y., Sept. 1972.
6. Dallas CBD Goods Distribution Project--1979 Update. Internal Report. Office of Transportation Programs, City of Dallas, Tex., July 1979.
7. C.A. Walters. CBD Dallas: A Case Study in Development of Urban Goods Movement Regulations. Proc., Engineering Foundation Conference--Goods Transportation in Urban Areas IV, Easton, Md., June 1981.
8. TEE Consulting Services, Inc. Consolidated Building Receiver Demonstration. Urban Transportation Research Branch, Transport Canada, Jan. 1979.

Publication of this paper sponsored by Committee on Urban Goods Movement.

Directions for Urban Freight Transport Research in Australia

K. W. OGDEN and D. P. BOWYER

ABSTRACT

Some results are reported of a project undertaken to (a) assess the need for further research in freight in Australia, (b) formulate research project statements and identify costs and benefits of such projects, and (c) develop recommendations for further research. The procedures used, which were found to be an effective way of identifying research needs and formulating research priorities and project statements, are documented. The findings of the study are also summarized.

Research in urban freight in Australia has been sustained at a relatively low level in recent years (1). In this sense, it mirrors the situation in North America (2) and Europe (3).

The value of undertaking urban freight research has sometimes been questioned in Australia, as it has in the United States (4). It is sometimes argued that there is little that can be done to influence freight activities, that there is no political or public pressure to tackle freight issues, and that there are few international precedents indicating "successful" freight research. The essential point that these arguments reflect is that there is uncertainty about the value of further freight research.

In the recognition that such uncertainty exists, the Australian Road Research Board (ARRB), together with the Transport Group in the Department of Civil Engineering at Monash University, recently conducted a study with the broad aim of assessing the desirability of further road freight transport system research and the likely payoffs from such research. The specific aims of this study were to