REVIEW OF URBAN GOODS MOVEMENT STUDIES

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The majority of studies of goods movement in urban areas has been limited to those related to trucks because truck surveys have generally been included in urban studies. Origin and destination surveys have usually gathered data on truck movements, and some studies have included information on the commodity hauled. Commodities are difficult to inventory and hard to track, and experience is lacking on the methods of utilizing the data obtained. However, in some areas studies have been made that emphasized cargo movements.

The information concerning the flow of commodities into, within, and through the urban area is essential to total transportation planning. Very little data are presently available that will permit the planner to quantify the impact of goods movement on the transportation network, particularly the highway segment of that network. As industry and commercial interests decentralize in the urban area, the network of roads connecting the producer to the supplier and the supplier to the user will become increasingly important. Specific data on such items as generation of commodity trips, technological changes, transfer point characteristics, and characteristics of the commodity carriers will certainly aid the planner in his task of developing an efficient integrated transportation network. Some of the studies already have recommended organization of pickup and delivery service and more efficient terminal operation in transferring shipments between companies and modes to reduce congestion and save shipping costs.

This paper consists of a summary of research done on commodity flow by studies in the larger urban areas in the nation. The reports reviewed were those on file in the Office of Highway Planning of the Federal Highway Administration. The first section of the report draws on facts from studies reviewed to present a general picture of the current situation in goods movement. The second part summarizes the work of studies in the largest urban areas plus Connecticut. Supplemental information was also drawn from the data bank compiled by the Office of Highway Planning and from other sources of national statistics.

URBAN GOODS MOVEMENT: A PROFILE

Growth and Cost of Goods Movement

The American economy is partly structured on the principle of regional economic specialization; that is, specific areas are primarily involved in the production of certain raw or manufactured materials. Thus, Appalachia is a center of mining and steel manufacturing, while the midwestern and plains states serve as the breadbasket of the nation. The arteries by which products are transferred from one area to the consumptive points of other areas, as well as distribution within localities, constitute the nation's goods movement network. The 1968 National Highway Needs Report (3) submitted to Congress notes the influence on goods movement of the metropolitan form of urban development that allows "industries and businessmen a wider freedom of location choice, to exploit the advantage of changing merchandising, manufacturing, and distribution techniques." The importance of goods movement to the nation is reflected in the growth of freight movement and the increasing expenditures for this service.

The national figure of 1,838 billion ton-miles of goods in 1968 is 40 percent more than it was in 1960 and 70 percent more than it was in 1944, the peak war year. Government and industry forecast 3,000 billion ton-miles by 1980, an expected increase of 62 percent. In the New York Tri-State region freight traffic has grown twice as fast as the population since 1945, and the trend is expected to continue between 1965 and 1985. Figure 1 shows this growth of freight movement nationally by mode of transportation (1).

The cost of moving goods accounts for approximately 9 percent of the GNP or $350 annually to move 54 tons per person. In Chicago, 86 tons of goods are moved per resident per year. For every dollar spent on transportation services, 45 cents (1967) is spent on moving goods as compared to 55 cents on moving people. Table 1 gives the estimated national freight transportation expenditures for 1968 by mode (2).

Pipeline and Water Transportation

Figure 2 shows that pipelines transport about 21 percent of the nation's freight, while waterways transport about 16 percent (3). Pipelines are substantially increasing their share of ton-miles of goods hauled. Figure 3 shows that waterways handle relatively long hauls (4).

In the Detroit area, crude oil carried by pipeline increased 42 percent from 1960 to 1965. Likewise, natural gas shipment increased by 190 percent in 10 years.

Of waterborne freight, 85 percent of the total port of Detroit tonnage consists of raw materials. In the New York region, waterborne commodities are listed as petroleum and petroleum products, 60.9 percent; sand, gravel, and crushed rock, 13.4 percent; coal and coke, 10.1 percent; and miscellaneous, 15.6 percent. In Detroit, despite the opening of the St. Lawrence Seaway, only 3 percent of waterborne tonnage consists of overseas shipments. Figure 4 shows that this is true for all of the major Great Lakes ports, as well as Detroit, and also shows the growth of waterborne commerce in this important harbor region (5).

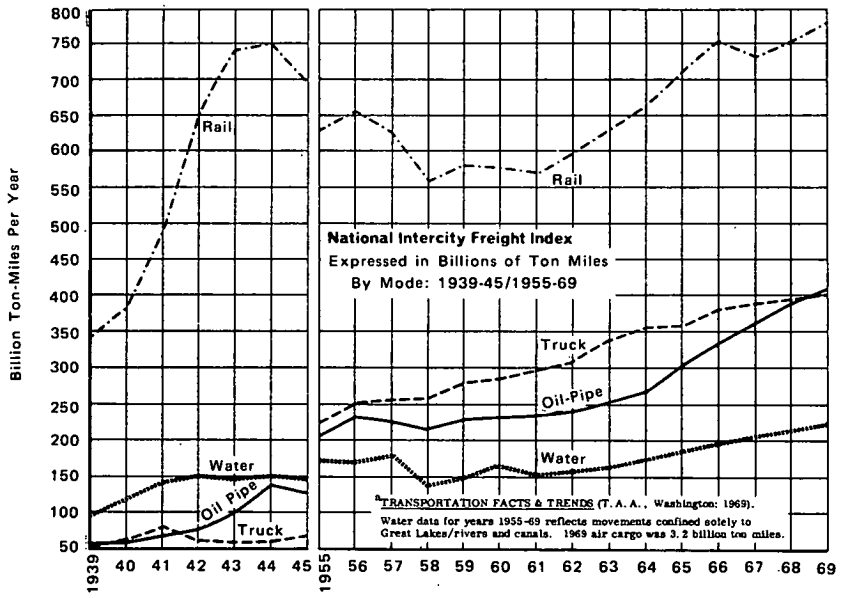

Figure 1. National intercity freight index.

TABLE 1

ESTIMATED NATIONAL FREIGHT TRANSPORTATION EXPENDITURES FOR 1968

Mode	Millions of Dollars	Mode	Millions of Dollars
Highway		Air	
Intercity truck		Domestic	593
ICC-regulated	12,400[a]	International	512[a]
Non-ICC-regulated	16,987[a]		1,105[a]
Local truck	27,146		
Bus	97	Other carriers[b]	
	56,630[a]	Forwarders and REA Express	643[a]
Rail	10,640[a]	Other shipper costs	
Water		Loading and unloading freight cars	1,081
International	3,607	Operation of traffic departments	337
Coastal and intercoastal	683[a]		1,418
Inland waterways	439[a]		
Great Lakes	210[a]	Total	76,953[a]
Locks and channels	373		
	5,312[a]		
Oil pipeline			
ICC-regulated	1,023		
Non-ICC-regulated	182[a]		
	1,205[a]		

Note: Includes mail and express.

[a]Revised.

[b]Domestic ICC-regulated carriers; amounts are operating revenues remaining after payments for other carriers' services.

Railroads

Figure 3 shows that a major portion of the ton-miles of goods in the nation are carried by railroads. Railroads are second only to air transport in average length of haul, with an average haul of slightly more than 500 miles. However, the railroads' share of intercity freight transport has decreased from approximately 56 percent in 1950 to 43 percent in 1965. In this time span, total U.S. rail freight tonnage leveled off after 1958. Moderate increases began in 1968 because of changes in the rate policy, equipment innovations, and redesigned distribution systems.

About 45 percent of rail tonnage lost by New England railroads between 1950 and 1957 consisted of mine products, namely coal, because consumer markets shifted to petroleum and gas, which are more readily shipped via pipeline and water. Less-than-

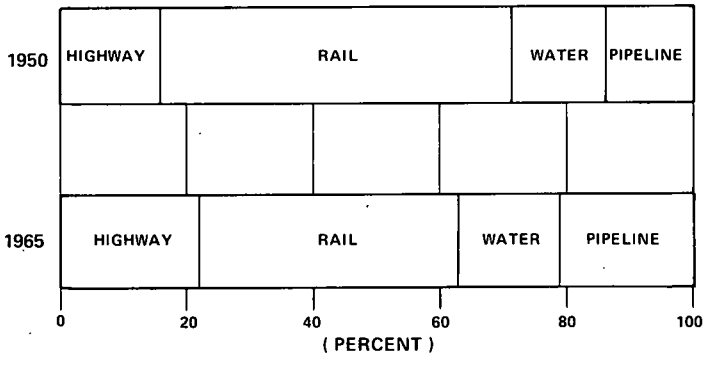

Figure 2. Ton-miles of intercity freight transport by mode.

carload shipments decreased by 60 percent as trucks took over these smaller shipments. Manufacturing and miscellaneous products are reported to constitute over 60 percent of total New England rail revenues.

Air Cargo

Air is the most rapid mode of transportation and carries less than two-tenths of one percent of goods tonnage in the United States. However, air cargo is the fastest growing major segment of commercial aviation. According to FAA statistics, scheduled air carriers handled 1.3 million tons at airports in 22 large metropolitan areas in 1965. Air cargo activity is expected to increase to 19.7 million tons by 1980, an increase of 1,377 percent. In the Tri-State region, increases of this magnitude have required large growth in sophisticated industrial items or changes in rate structures.

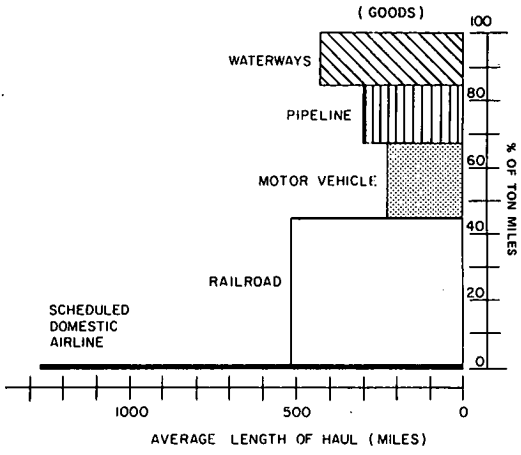

Figure 3. Intercity goods movement in the United States by mode in 1964.

Between 1960 and 1965 air cargo activity in the Baltimore-Washington area increased by 122 percent, while passenger activity increased by 78 percent. At Friendship International Airport the increase reached 171 percent compared to 140 percent in passenger activity. By 1985 air cargo in the Baltimore area is expected to grow to 328,000 tons.

A Detroit study reports that machinery parts and equipment lead in the commodities shipped by air nationally, while over 50 percent of the cargo at Detroit's airport consists of automobile parts and accessories.

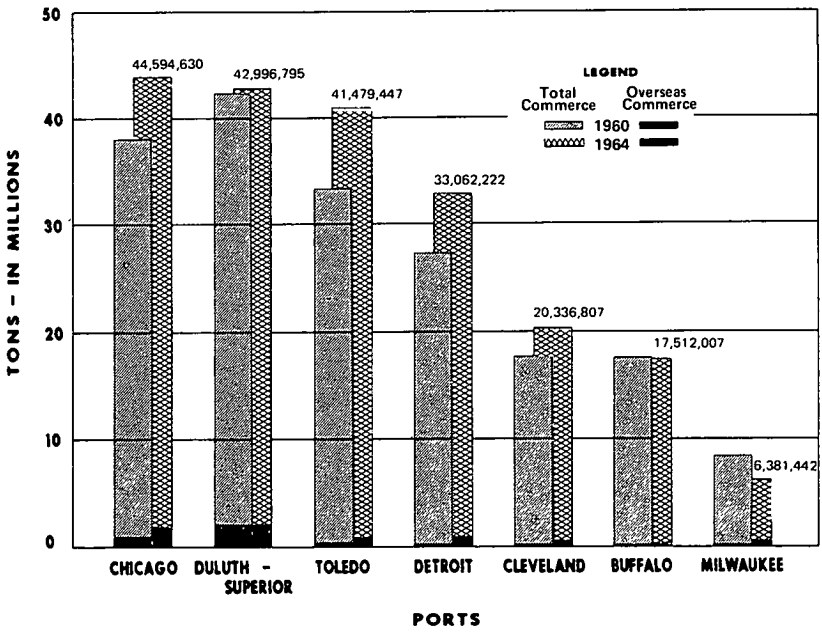

Figure 4. Waterborne commerce of major Great Lakes ports.

Trucking

Growth of Trucking Industry—Ton-miles of truck freight increased by 450 percent intercity and 150 percent locally in the New York region between 1945 and 1968 and by 60 percent intercity in Kansas City between 1953 and 1963. The city has projected a 97.4 percent increase in freight hauled by truck (1966 to 1990), requiring 39 new terminals on 468 acres.

In Milwaukee (1950 to 1965), there has been a 28 percent increase in trucks available and an 87 percent increase in automobiles available. A further 36 percent increase in truck registration is expected in the area by 1990. In Pittsburgh (1958 to 1980), truck registrations are projected to increase by 47 percent compared to an increase in automobile registrations of 66 percent. According to a Chicago study, truck registration will have to increase slightly faster than population in order to move the goods and provide the services required by the increased spending of the average family.

The same Chicago study showed that truck trips projected from the base of person trips were 67 percent more than the 1956 total, 3 percent greater than the growth rate of truck registrations. The 1960 study suggested that increased productivity in the trucking industry—through improved management and terminal operations, more efficient routing, and larger trucks—may well double the average output per trucking worker by 1980. A Baltimore study estimated that, of a 55 percent increase in truck trips by 1980, 58 percent will consist of panel, 2-axle, light-truck trips, and 25 percent will consist of heavy-truck trips.

Truck Size and Capacity—A light truck (panel or pickup) is equivalent to a passenger car in street occupancy, while a tractor trailer combination may equal as many as 4 cars in street space. Less than 5 percent of the New York region's trucks are tractor semitrailers, but they move nearly one-third of all truck tonnage. In Chicago, there is a growing proportion of semitrailers and a lessening proportion of panel trucks; large trucks have become a more important element of the truck fleet in the past few decades.

The capacity of semitrailer vans, which are important in general freight, ranges from 1,800 to 2,400 ft^3, while semitrailer units of all types combined have an average capacity of 2,150 ft^3. The mean load of trucks in the Chicago metropolitan region is estimated at 11.6 tons. In intercity traffic in the New York area, common carriers haul an average load of 10.5 tons and an average shipment of 1.3 tons, while contract and special carriers have an average load of 11.4 tons and an average shipment of 6.0 tons. The New York study notes that common carriers are most efficient for intercity travel because they can secure backhauls (as opposed to private carriage), they make relatively few stops, and they carry fairly heavy loads. However, common carriers require local counterparts to handle pickup and delivery.

Truck Cargo—In the New York region, the bulk of internal truck freight consists of construction materials, fuels, and foods; 46 percent of the tons transferred on a given day are consumer oriented. Figure 5 shows the distribution of freight moved by truck (6). In Detroit, 80 percent of the loaded trucks carry manufacturing products; 42 percent of moving trucks are empty. A Milwaukee study shows that 65.7 percent of the business and industry trucks are in use; that is, on an average weekday 1 truck in 3 does not make a trip. The Tri-State Transportation Commission also reports that one-third of the truck fleet is idle on a given day and that nearly one-half of those trucks that move do not carry freight. However, it should be noted that a number of these trucks may be old and inoperable, or specialized equipment, such as snowplows. These figures suggest a need for better coordination to obtain more efficient use of the existing truck fleet.

The commodities hauled tend to affect the distance hauled. In the New York region, the average length of haul per ton for higher unit value freight is longer than that of lower unit value freight such as petroleum, sand and gravel, and coal.

Characteristics of Truck Trips—A Chicago investigation showed a very low rate of truck registration per 1,000 population; similar findings have resulted in New York and Pittsburgh area studies. A District of Columbia report showed few truck trips per person in larger areas; the range is about 200 to 300 truck trips per 1,000 population.

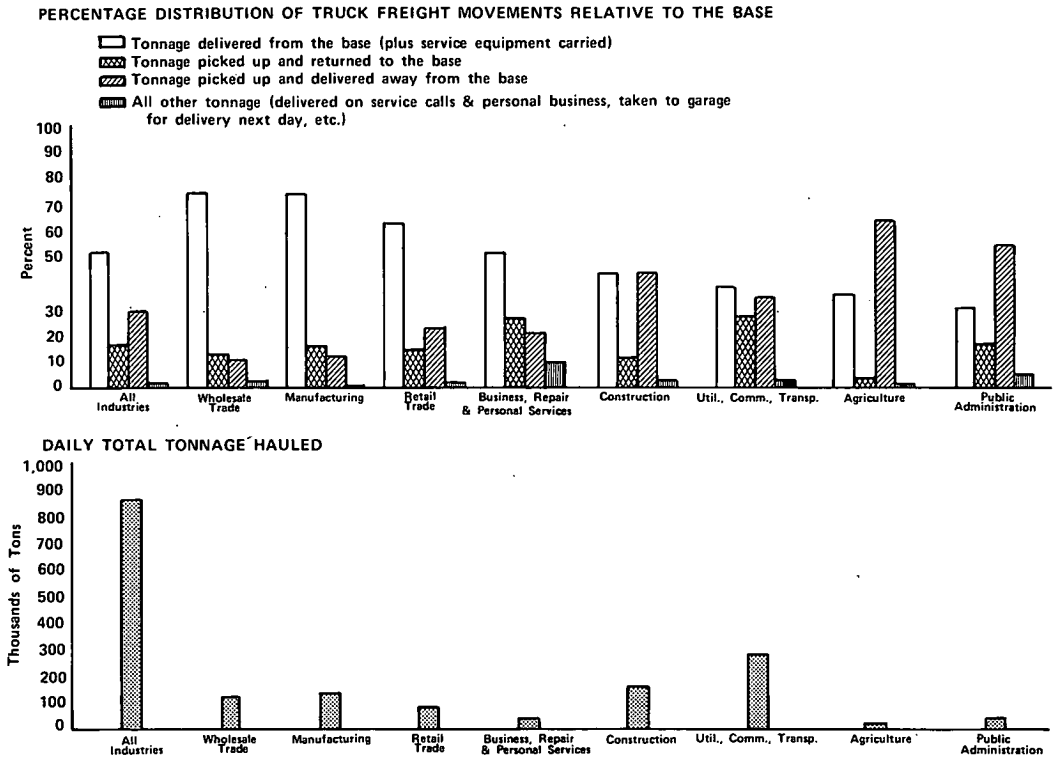

Figure 5. Truck freight movements in the New York City region.

In the District of Columbia report, it was concluded that 16 percent of all vehicle trips made in urban areas on typical weekdays are truck trips, but only 11 percent of all vehicle trips made during peak hours (4 to 5 p.m.) are truck trips. Figure 6 shows the internal truck trip distribution in Milwaukee (7); Figure 7, in Pittsburgh (8); and Figure 8, in the Tri-State region (9).

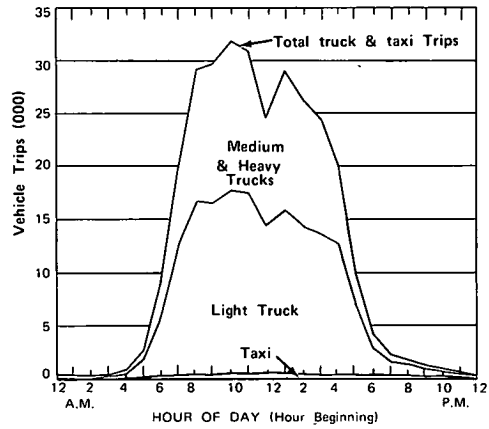

Figure 6. Hourly variation of unweighted truck and taxi trips by vehicle type in 1963 in Milwaukee.

Most truck trips occur during regular working hours. Although the 85 percent of all vehicle trips that are made by passenger cars is the dominant element, trucks are more important as units in the traffic stream than these figures suggest. For example, a Chicago area transportation study reported that in 1956 there were 854,000 truck trips made daily within the study area. Measured in units equivalent to automobiles, this figure was expanded to 1,476,000 automobile-equivalent trips. Weighted in this fashion, truck trips comprised 21.9 percent of all weighted vehicle trips made on the average weekday.

There were 8 average trips per truck per weekday for business and industry in Milwaukee. The average motor truck in an urban area, according to the District of

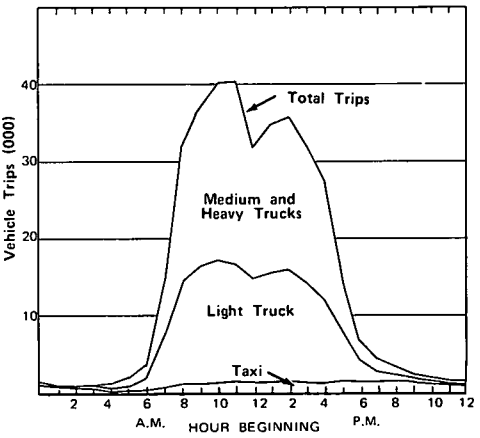

Figure 7. Hourly distribution of internal truck and taxi trips (weighted) by vehicle type in Pittsburgh.

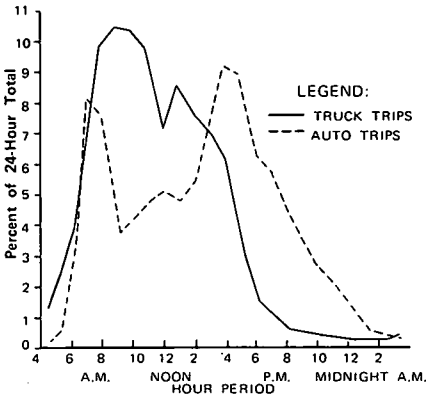

Figure 8. Peak traveling hours of trucks versus automobiles by time of trip origin in the Tri-State region.

Columbia report, makes 6 trips per day. Of the internal truck trips in Milwaukee, 57.7 percent were made by light trucks, 37.8 percent by medium trucks, and 4.4 percent by heavy trucks. The average trip length for light trucks is about 7 minutes per trip, with a large percentage of 3 to 5 minute trips indicating mostly intrazonal movement. The average trip length for heavier trucks is 13½ minutes with no sharp peaking in the 3 to 5 minute range. Figure 9 shows the percentage of internal and external automobile and truck trips (unweighted) by trip length in the Pittsburgh area (8); internal truck trips peak at about one mile in length, while external truck trips are more evenly distributed by length. In New York, the average length of an intercity haul is 167 miles inbound and 136 miles outbound. Internal truck trip length for business and industry in Milwaukee is 4.9 miles. The New York Tri-State region lists the average trip length for single units as 2.22 miles and tractor semitrailers as 9.56 miles. Only about 20 percent of trucks travel more than 200 miles from base. The great majority of truck trips, 70 percent, are local (within urban areas or to and from adjacent counties). Only 30 percent of truck trips are intercity. Thus, trucks are used for comparatively short distances where they have a distinct time advantage over other modes of goods transportation.

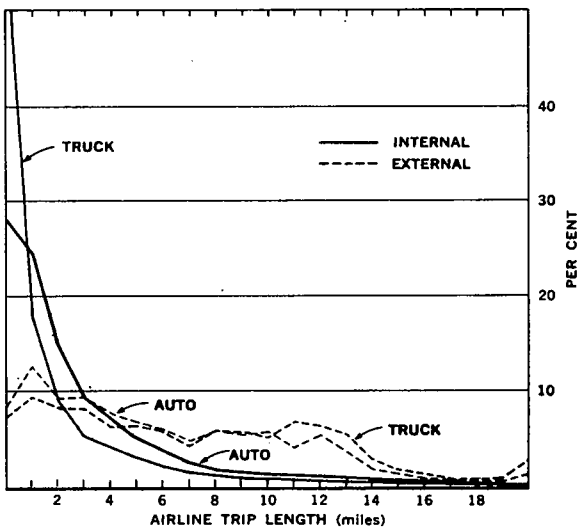

Figure 9. Percentage of internal and external automobile and truck trips (unweighted) by trip length.

Truck Trips and Land Use—A summary of the spatial distribution of truck terminals and trip destinations by land use, as found by a Milwaukee study, is given in Tables 2 and 3. Approximately 293,000 trips were made on an average weekday by trucks garaged within the study region.

A Chicago study showed that truck trips are closely related to

TABLE 2

LAND USE AT GARAGING ADDRESS OF TRUCKS IN MILWAUKEE

Land Use	Percent of Trucks
Commercial	41
Industrial	12
Transfer and pickup, including truck terminals and transfer warehouses	14
Governmental and institutional	9
Other, including residential, recreational, and agricultural	24

TABLE 3

LAND USE AT TRUCK TRIP DESTINATIONS IN MILWAUKEE

Land Use	Percent of Trucks
Commercial	36
Residential	29
Industrial	13
Transportation, utility, and communication	10
Governmental and institutional	6
Other, including recreational and agricultural	6

person trips at each land use type in a stable way. Detroit studies concluded that internal truck trips are very similar to the pattern of internal passenger cars, because light-truck trips are dominant in urban areas (estimated at 75 percent in a District of Columbia report) and have patterns similar to automobile trips. According to the Chicago findings, residences, public buildings, and public space require a fairly small amount of goods or truck-borne services. The estimates for these land uses were 370 weighted truck trips per 1,000 person trips in 1956, which are expected to remain constant to 1980. Manufacturing and commercial activities, where goods are fabricated and sold, have more truck trips, about 499 weighted trips per 1,000 person trips in 1966 and forecast to be 518 per 1,000 person trips in 1980. Transportation and wholesale land uses, primarily goods-handling activities, show the highest peak of truck trips, 575 weighted truck trips per 1,000 person trips in 1956 and 607 per 1,000 person trips by 1980.

The same study concludes that, as more person trips are made to any area in the future, comparatively more truck trips will be made. For example, if more people travel to industrial, transportation, and commercial land, probably more goods will be produced, transferred, and sold, and proportionately greater truck movements can be expected. Likewise, more person trips to homes, schools, and parks will require more delivery and maintenance vehicle trips.

A Pittsburgh analysis, however, carefully points out that the converse may not always hold. With the declining density of industrial employment, the number of person trips to a particular site may decline, while production and the number of truck trips required remains relatively constant. In Pittsburgh, truck trips to commercial land are expected to increase 63 percent (1958 to 1980), and trips to industrial and residential land are expected to increase 53 percent. It is estimated that these 3 land uses combined account for about 95 percent of the total gain in trips, as they represent the flow of raw materials and finished goods from the source to plants, to stores, and ultimately to homes. Trips to transportation land use, public buildings, and public open spaces will account for a small portion of trip gains, it is concluded, as they more often represent infrequent service calls rather than daily distribution of consumer goods.

Truck Activity in the CBD—Trucking activities cause a considerable portion of the CBD congestion. Improvements are needed that will benefit freight movement as well as increase CBD accessibility. According to a District of Columbia report, only 1.5 percent of trucks parked in the CBD of the cities studied were double-parked, but the problem is

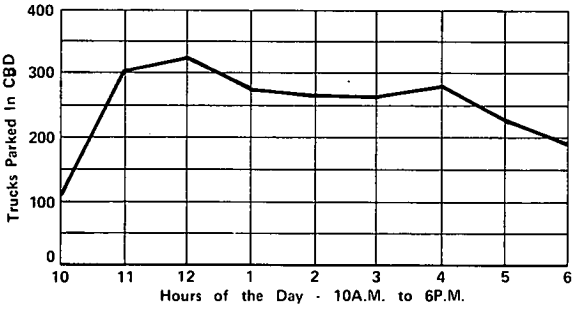

Figure 10. Accumulation of parked trucks in the Central Business District of New Orleans.

TABLE 4

TRUCKS PARKED BETWEEN 10:00 A.M. AND 6:00 P.M. IN NEW ORLEANS BY FACILITY TYPE

Facility Type	Number of Trucks	Percent
Loading zone	365	16.7
Other legal curb	472	21.6
Illegal curb	1,032	47.3
Off-street	313	14.4
Total	2,182	100.0

TABLE 5

TRUCKS PARKED IN LOADING ZONE BETWEEN 10:00 A.M. AND 6:00 P.M. IN NEW ORLEANS BY TRIP PURPOSE

Trip Purpose	Number of Trucks	Percent of Zone Users
Shopping	8	2.2
Business	56	15.3
Work	63	17.3
Sales and service	62	17.0
Loading and unloading	165	45.2
Other	11	3.0
Total	365	100.0

more serious than this figure suggests because a single double-parked truck may block a whole lane of traffic. Of the trucks parked in the CBD, about one-fourth were in loading spaces, and slightly less than 6 percent of the total curb space was used by trucks. The heaviest amount of truck parking is between 11 a.m. and 4 p.m.

The parking of trucks in the New Orleans CBD is shown in Figure 10 by hour of day and given in Tables 4 and 5 by parking facility and trip purpose. More than 47 percent of the trucks parked were parked illegally; the difference between this figure and that of the Washington, D.C., report could be caused by less enforcement of parking regulations; less space available for truck parking, perhaps due to fewer alleys; and more truck traffic. The data given in Table 5 show a poor utilization of loading space in New Orleans.

In a Dallas report, trucks are included in future plans for the CBD. Trucking activity in the CBD varies seasonally. For example, the volume of goods handled in the last 12 weeks of the year is double the year's daily average. Smaller stores in the CBD often cause more congestion than department stores because they require curb space (department stores have receiving docks), require contact with the shop owner (department stores have receiving clerks), and have smaller stock space and, therefore, require more frequent replenishing.

In Chicago one loading space is required for every 100,000 sq ft of office, hotel, apartment, institutional, and hospital buildings, and one for every 42,000 sq ft of other land uses.

The Dallas report offers several suggestions for improving freight distribution in the CBD: Place time limits on use of curb space; restrict hours of truck loading operation; coordinate freight distribution (possibly by limiting the number of carriers licensed to deliver in the CBD); and pass zoning ordinances requiring off-street truck parking in new or rebuilt structures.

STUDIES OF URBAN GOODS MOVEMENT

Tri-State Region Including New York, New Jersey, and Connecticut

The Tri-State Transportation Commission has done extensive research into freight traffic of the region. Data gathered from 15,000 interviews showed the bulk of commodities carried were construction materials, fuel, and food (6). The Tri-State region has about 1 truck for every 41 inhabitants; nationwide, there is 1 truck for every 14 persons. The regional truck fleet is comprised of 430,000 vehicles, makes 3 million daily trips, and carries 206 million tons annually (9). Reports published by the Commission relate to survey findings and projections of freight movements at terminals and transfer facilities (15, 16) and by truck (11, 12), by rail (11, 13, 18, 20), by water (11, 14), and by air (19). Trends and projections of freight movements in the region are based on the 1965 traffic as shown in Figure 11 (17).

Los Angeles

In the Los Angeles area, 2 truck origin-destination and commodity surveys were conducted in 1960 (21). The survey of commercial or proprietary trucks, systemati-

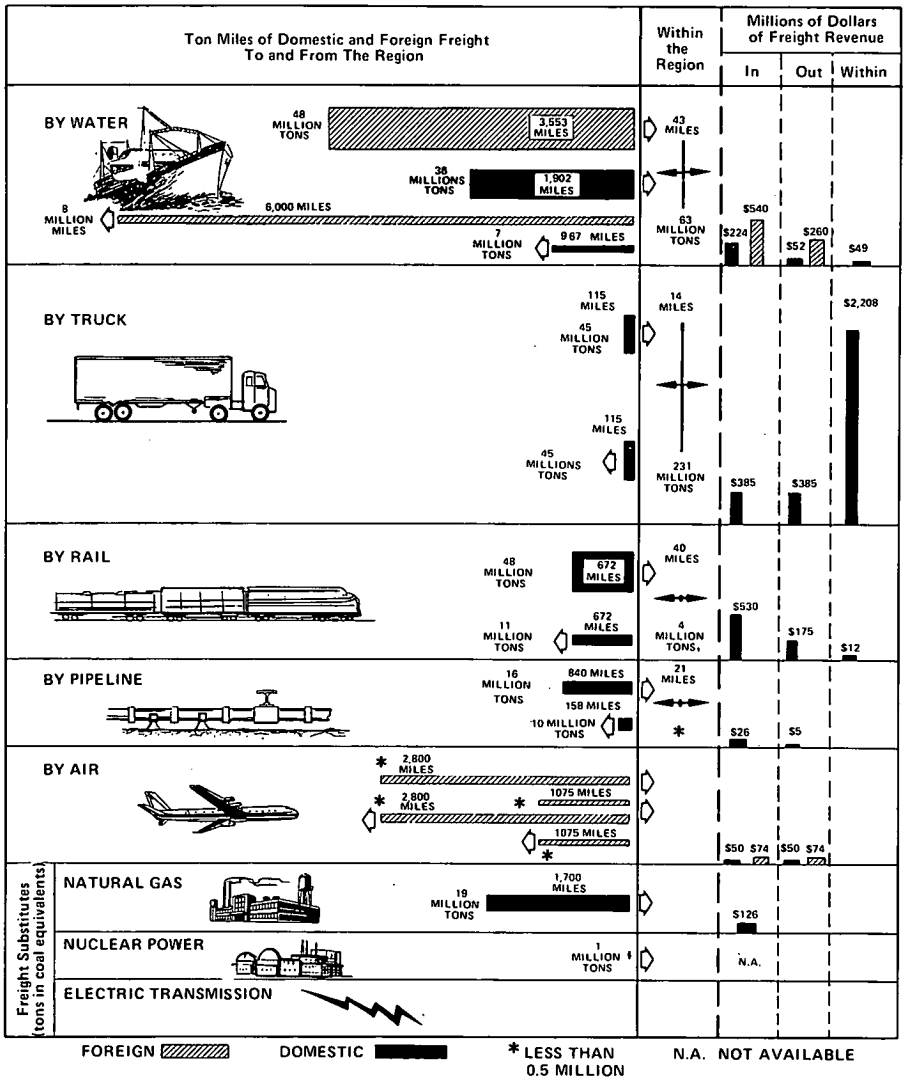

Figure 11. Freight traffic of the Tri-State region in 1965 by mode of carriage.

cally sampled from registration records, consisted primarily of mailed questionnaires. Direct interviews were conducted only with firms having 10 or more trucks. Owners of for-hire trucks, sampled from the Board of Equalization registration, were directly interviewed. An external cordon survey was also conducted. Based on 1960 truck data and 1980 automobile projections, the total number of 1980 trucks in use was estimated. Truck trips for 1980 were projected by using 1980 total trips and obtaining the weekday trips per truck in 1960.

Chicago

The regional freight study in the Chicago area is composed of a short-range and a long-range program (1). Estimates from these programs will be used to guide future freight facility investments. Interviews and mailed questionnaires were used to obtain the following for each mode of freight: current facilities; estimated volume of goods

movement into, out of, through, and within the region; future estimated demands (1969 to 1975); and new or retired facilities planned. The result of the short-range study is an interim plan consisting of a listing and forecast of freight facility development for 1975 and an atlas of freight facilities (5 modes). The following information is being gathered for the long-range study: types of commodities; types of vehicles; volume of goods; origin-destination of commodity and vehicle for trips generated by land use, planning zones, major terminal complexes, employment, population, and other activities; time of travel; trip frequency; and trip length. Internal, external, and through trips will be distinguished.

The second part of a 3-part study is concerned with estimating the amount, kind, and location of travel likely to take place within the Chicago area in the year 1980 (22). The estimates are based primarily on data from the inventories of the metropolitan region taken in 1956.

Detroit

In the Detroit area, because each mode seems to be better suited for transport of particular commodities, competition among modes is reduced. Comparatively little truck traffic is susceptible to diversion to other modes, and forecasting of future truck traffic can be seen as a function of economic growth indicators.

An inventory of modes and terminals (5) revealed that in Detroit, automobile parts and accessories composed 50 percent of the commodities shipped by air. Relatively little information resulted on harbors, railroads, and pipelines. Truck terminals in the area were located, sized, and appraised as to rail accessibility. Data on truck traffic obtained from the state indicated a larger increase in truck traffic than in automobile traffic. About 79 percent of the truck trips had origins and destinations in Michigan and Ohio, where trucks have a distinct economic advantage over other modes for shorter distances. Manufactured goods were carried in 80 percent of the loaded trucks; 42 percent of the trucks were empty.

Although trucks comprise only 15 percent of the traffic, their special characteristics cause them to have a greater effect on the traffic stream. These characteristics vary greatly from a panel truck to a tractor-trailer combination. The dominance of light trucks produces internal truck trip patterns similar to those of automobiles.

Boston

In a report devoted to goods movement by rail (23), data from the Interstate Commerce Commission were cited to show a decline, particularly acute in the eastern district and especially the northeast, in the volume of freight carried by rail. It was noted, however, that railroads carry more than twice the ton-miles of any competing mode of transport, reflecting the longer hauls of railroads. The report analyzed data from a 1959 survey of the New England freight market to point out specific factors that help explain this decline. The greater emphasis on speed and dependability for today's markets that maintain smaller inventories, coupled with the deterioration of railroad service (excessive delay in classification yards, poor switching service, uncoordinated freight schedules, and holding for tonnage), makes rail an impractical mode of transport for many goods. Small shipments tend to minimize the bulk rate advantage of railroads because the cost of loading from rail sidings is expensive for small tonnages. The report concluded that the high cost of freight traffic was due to overcapacity and, consequently, a poor utilization of railroad locomotive power and fixed facilities.

Washington, D.C.

In 1969, a truck origin-destination survey was conducted by using a 4 percent sample, approximately 4,000 vehicles (24). Data were collected for coding and tabulation on trips, vehicle types, vehicle capacity, vehicle ownership, and vehicle usage. Although the information is not yet available, it will be analyzed to obtain an accurate description of the truck fleet, measure the truck component of total vehicular trip activity, and measure the amount and nature of commidities moved by truck. Data from earlier

studies on trucks and goods movement in the District of Columbia were analyzed to obtain information on truck trips, cargo movements, land use and truck movements, truck parking, and truck-highway relationships or the cost of operation related to speed. The report (28) identified the following benefits to be realized by trucks operating on improved highway facilities: reduced vehicle operating costs, reduced labor costs, and reduced vehicle ownership costs. It noted that public and private costs for goods and services movements have constantly increased and warned that future growth and increased density of population will intensify the supply problem. Attention to the following 3 areas of goods and services movement was recommended: planning of terminal and transfer facilities; routing of truck movement on selected highway facilities; and design, allocation, and regulation of parking and loading spaces. The report emphasized the need for greater attention to the relationship of goods and services movements to all aspects of transportation systems.

Pittsburgh

According to the findings of a Pittsburgh study (25), the percentage increase in truck registration will not be as great as the increase in automobile ownership. Therefore, the truck proportion of vehicle travel may decrease. However, the decrease may be small because there will be a more rapid gain in the number of larger trucks (increasing weighted travel) and more efficient utilization of all trucks (increasing travel per vehicle). The expected distribution of truck trips, like that of automobile trips, reflects the decentralized pattern of future person trips. Much of the information from this study has been presented earlier in this report.

Cleveland

In an origin and destination survey in 1963 in Cleveland (26), data were obtained on owner of truck, type of business, principal commodity hauled, garage address, and type of truck. The external survey was made by standard roadside interview. Later, a screenline check disclosed panel trucks well reported but combination and other trucks underreported.

St. Louis

In St. Louis, interviews were conducted with owners of 6,890 trucks that made 42,592 trips to obtain the following data: type of truck, gross vehicle weight, industry and business of owner, day's total mileage, origin and destination of each trip, time of trip, land use at origin and destination, on- or off-street parking, and commodity hauled. Analysis of the data revealed that most truck trips occurred between the rush hours and that the majority were service-delivery or freight-handling trips (27). Figure 12 shows the distribution of truck trips between zones versus off-peak driving time be-

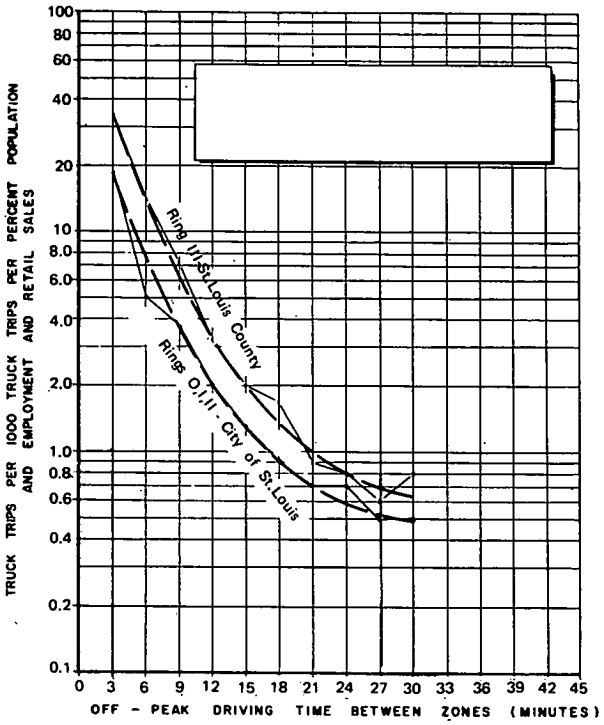

Figure 12. Distribution of truck trips between zones in St. Louis in 1957.

tween zones. Estimates were made of 1970 and 1980 intrazonal and interzonal truck trips.

Baltimore

In a Baltimore study, data from secondary sources were examined for usefulness in supplying the necessary information for analysis and proposing of solutions (4). Analysis of the data revealed certain broad characteristics of goods movement that should be useful in planning for future needs in transportation.

The first characteristic of goods movement named in the study is that it is more rational and susceptible to analysis by economic theory. Length of haul, frequency of dispatch, travel time, and cost of service are all taken into account by the shipper in determining the mode of transport. The study concluded that national issues more radically affect the movement of goods than of persons. Changes in goods produced—which are more varied, more valuable, less bulky and heavy per unit, and less durable—and changes in production—including larger units of production, better quality control, tighter scheduling, and more responsiveness to market demands—are factors affecting goods movement. Changes in the regional economies, which appear to be more self-sustaining, are reducing the amount of long-haul service needed. In addition, the locational preferences of industrial plants have shifted from the inner city.

In view of these factors, the study concluded that the system of goods movement has become more complex and interrelated and is no longer so capable of shaping the future demands of its services as it has been in the past, during the westward push of the railroads in the last century, for example. The study emphasized the requirement of increased coordination of services and cooperation among suppliers.

A portion of an airport study was devoted to air cargo, which was named the fastest growing major segment of commercial aviation. The study made no recommendations for planning for this projected increase in goods movement by air (28).

Milwaukee

An origin-destination survey was conducted in Milwaukee (7) to obtain information on trips, garaging address, vehicle type, business and industry of owner, and principal commodity. Plots were drawn of the spatial distribution of truck garaging locations and destinations (Tables 2 and 3). The majority of the trips occurred during working hours. The study also listed trip generation as a function of land use.

From analysis and projection of observed trends in registration of each truck type, changes in population levels, and changes in commercial and industrial development, this study forecast truck registration for 1990 as an increase of 36 percent over 1965 (29). Future truck trip generation was estimated by utilizing the relation between trip-making and land use. The Fratar expansion method distributed the truck trips. External trips at the time of the 1965 survey accounted for 15 percent of the truck traffic and will constitute 12 percent in 1990.

Dallas-Fort Worth

A study for the Dallas CBD forecast future freight needs based on anticipated employment and floor space and on present truck-stop characteristics (30). Figure 13 shows the future demand for truck loading spaces in the CBD. To accommodate future freight activity, the study suggested a plan that would include a truck tunnel under the inner core of the CBD and that would free surface streets in the area of truck traffic, free some valuable street grade areas for other uses, and be less restrictive on pickup and delivery services (Figs. 14 and 15).

Officials of several large trucking companies were interviewed in the course of another study (31) in order to obtain their opinions and suggestions in regard to the adequacy of terminals and routes. Generally, there was great satisfaction with the Interstate and local highway and street systems, except for only one quadrant of Fort Worth. From the truckers' point of view, loading and unloading sites were considered adequate. However, it was indicated that this point of view might change if the legal

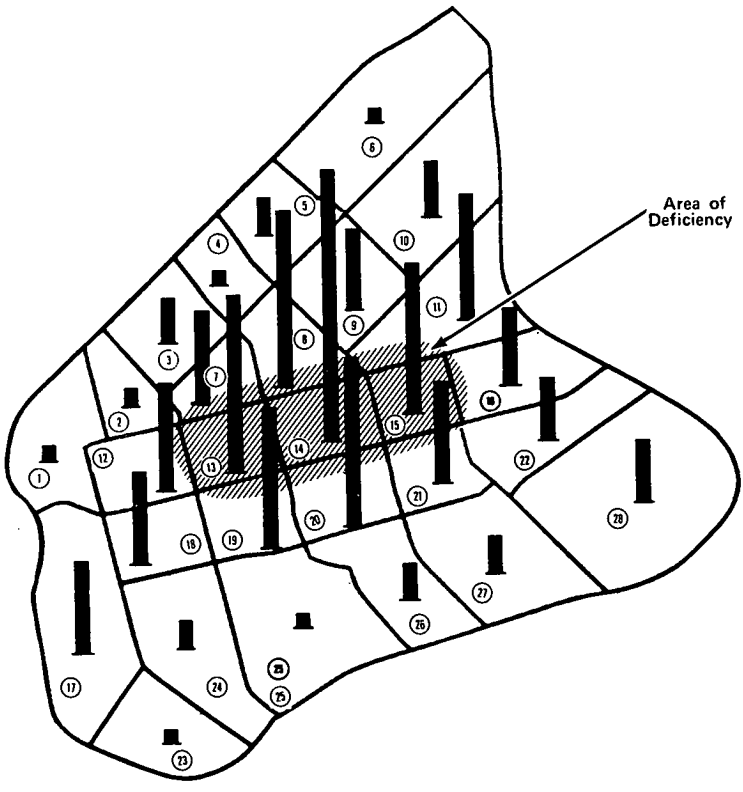

Figure 13. Future demand for truck loading spaces in the Dallas CBD.

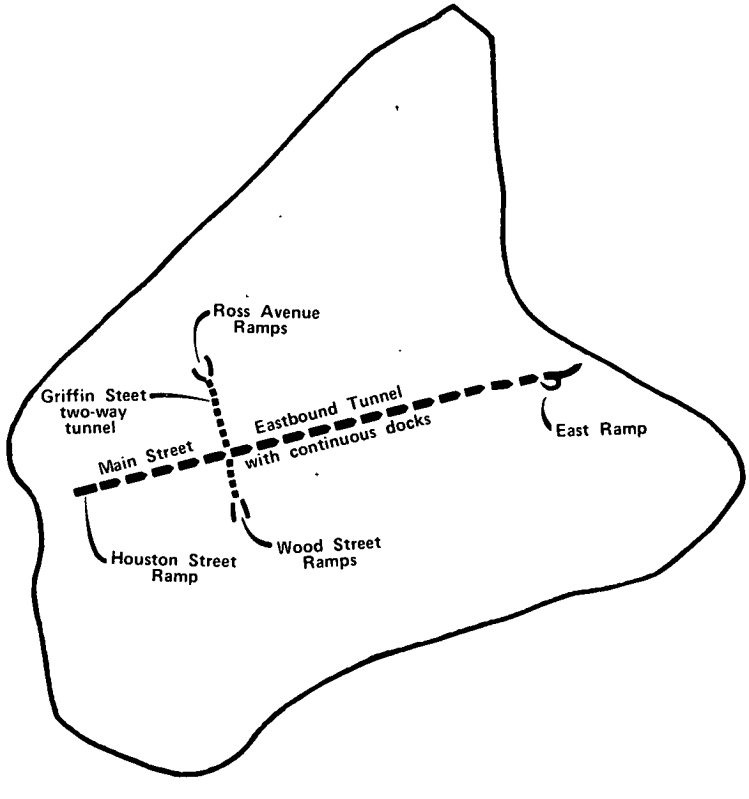

Figure 14. Proposed tunnel under Dallas CBD.

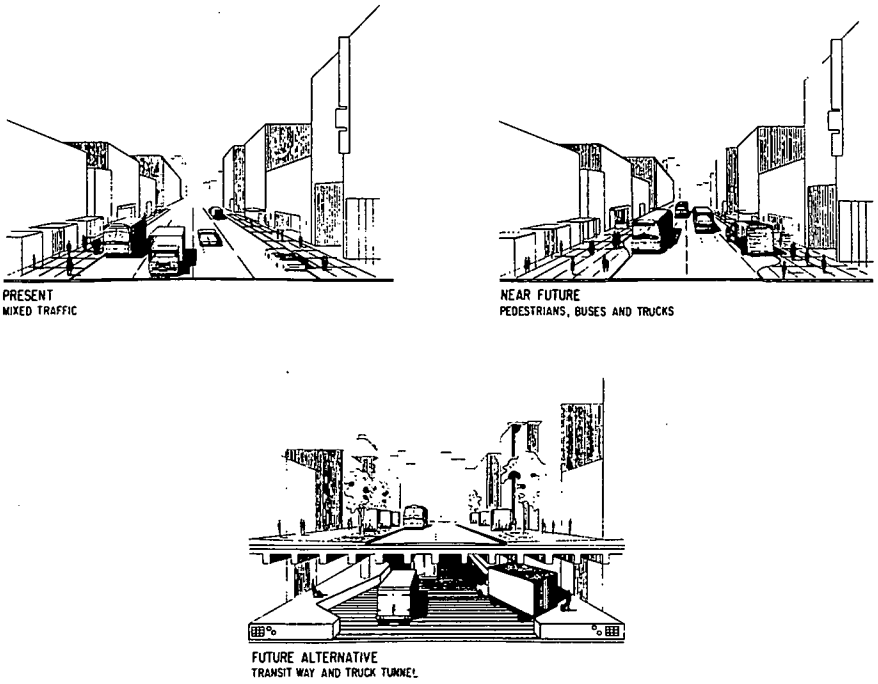

Figure 15. Short- and long-range proposed improvements for traffic in Dallas CBD.

use of sites were enforced. Loading and unloading problems were said to have been prevented by delivery arrangements with the traffic sections in both cities, but it was noted that major traffic problems will exist as long as on-street, across-the-sidewalk loading and unloading is the only means of servicing adjacent properties.

Kansas City

1990 projections for Kansas City indicate a 97.4 percent increase in freight hauled, requiring construction of 39 new terminals (468 acres). The report (32) recommends that (a) a large tract of several hundred acres on the fringe of the urban area and near a freeway be designated for locating many individual terminals and (b) consolidated pickup and delivery service be provided within the CBD. According to the report, these steps would improve efficiency of interline transfers and reduce the volume of pickup and delivery traffic in the CBD.

Denver

The truck portion of a 1962 Denver study (33) included an external and internal survey. Data collected in the external survey were type of truck and amount of load (by fraction of volume). In the internal survey, the following information was gathered: owner's name and address, registered weight of truck, origin and destination of trip, purpose of trip, and time at midpoint of trip.

Connecticut

The following data were collected by interview in a survey in Connecticut (34): vehicle type and body, industry, business, origin and destination of trip, land use at origin and destination of trip, trip purpose, and arrival and departure time. Truck travel patterns were established by obtaining data for the previous day's travel. Some

TABLE 6
GROWTH IN AUTOMOBILE AND TRUCK TRIPS IN 13 CITIES

City	Study Year	Target Year	Projected Increase in Internal Truck Trips (percent)	Projected Increase in Internal Automobile Trips (percent)	Projected Annual Increase Based on Study Year Truck Trips (percent)	Projected Annual Increase Based on Study Year Automobile Trips (percent)
Los Angeles	1960	1980	112	111	5.6	5.6
Denver	1959	1980	104	72	5.0	3.4
Washington, D.C.	1955	1975	56	59	2.8	3.0
Chicago	1956	1980	69	89	2.9	3.7
New Orleans	1960	1980	54	85	2.7	4.2
Baltimore	1962	1980	56	78	3.1	4.3
Minneapolis-St. Paul	1958	1985	125	167	4.6	6.2
Kansas City	1957	1980	62	72	2.7	3.1
Buffalo	1962	1985	78	95	3.4	4.1
New York	1963	1985	48	60	2.2	2.7
Houston	1960	1980	296	297	14.8	14.8
Seattle	1961	1985	92	90	3.8	3.8
Milwaukee	1963	1990	55	82	2.0	3.0

interviews were repeated each day for 5 days to estimate more accurately commodity movement. Railroad data, collected during a 4-month study, were type of commodity, origin and destination, number of cars, and weight of each inbound, outbound, and local shipment. Data collected at 8 key locations furnished information on the movement of goods into and out of Connecticut.

Data obtained in these surveys were analyzed with additional data from the U. S. Bureau of the Census, the state labor department, and the Tri-State Transportation Commission. Trip length distribution curves were plotted for various commodity groups. From the 1960 data, projections were made of internal truck goods movement, external truck goods movement, and goods shipment by railroad (35). Total rail shipments were assigned by using the Univac assignment package.

New Orleans

As an important part of an overall transportation study, a parking survey of the central business district was performed in compliance with procedures recommended by the Federal Highway Administration. A report of the survey (10) includes existing and projected future parking demands and needs and immediate and long-range parking programs for the central business district. Information on truck parking in the CBD has been presented earlier in this paper.

Other Cities

A report of a Cincinnati study (36) briefly mentioned that trucks were in the survey but contained no recommendations or major findings on goods movement. Reports on file from 10 other large cities were examined, but very little information was found that could be summarized and included in this report.

National

The information in the data bank of the Office of Highway Planning has been compiled from urban planning data of urban transportation studies requested by the office in 1964 and 1966 and submitted by the state transportation and highway departments. Only those urban areas for which substantial amounts of data were submitted are included. The data show that out of 25 cities researched for this report 22 had made internal truck traffic counts and 13 had projected internal truck trips. The average annual growth rate of internal truck trips projected for the 13 cities combined is 3.6 percent based on the various study years. For automobiles, the average is greater at 4.3 percent. Table 6 gives the individual projections for each of the 13 cities.

In a report by the Federal Aviation Administration (37), aviation activities at 173 airports within the large hubs and open to the public were reviewed, analyzed, and projected through 1980. The purpose of this effort was to develop forecasts for use in planning physical airport facilities and finances required to meet the needs of 1980 and to develop long-range metropolitan airport master plans. Air cargo (domestic and international) and cargo facilities (number of gate positions, square yards of apron areas, square feet of cargo building, number of spaces, and square yards of vehicular loading and unloading area) were listed for each of 22 metropolitan areas classified as large hubs (communities that generate 1 percent or more of the nation's scheduled air carrier domestic enplaned passengers).

SUMMARY

1. In 1968, 1,838 billion ton-miles of intercity freight movement took place in the United States. Government and industry forecast 3,000 billion ton-miles by 1980, a 62 percent increase.

2. The cost of moving goods accounts for approximately 9 percent of the GNP, or $350 annually to move 54 tons per person.

3. Pipelines transport about 21 percent of the nation's freight, while waterways, which carry mainly raw materials, transport 16 percent.

4. Railroads transport about 40 to 45 percent of the nation's freight in ton-miles, and rail freight has leveled off since 1960, after a previous decline. Poor utilization of equipment and overcapacity have contributed to the higher cost of freight traffic by rail.

5. Air cargo is the fastest growing major segment of commercial aviation, but it transports less than two-tenths of one percent of the goods tonnage in the United States.

6. Truck freight in the New York region has increased 450 percent intercity and 150 percent locally from 1945 to 1968.

7. Truck registration will have to increase slightly faster than the population in order to move the goods and provide the services required by the increased spending of the average family.

8. Less than 5 percent of the New York region's trucks are tractor semitrailers, but they move nearly one-third of all truck tonnage, and the proportion of larger trucks is growing.

9. On a given day in New York, nearly one-half of those trucks that move carry no freight.

10. Trucks account for about 15 percent of all unweighted vehicle trips in urban areas on typical weekdays.

11. Trucks are used for comparatively short distances (only 30 percent of truck trips are intercity) where they have a distinct time advantage over other modes of transportation and where they are necessary to complete the final segment of long hauls by air, ship, rail, and pipeline.

12. Most truck trips occur during working hours, and few are made during peak hours (4 to 5 p.m.).

13. Light trucks (panel or pickup), which have trip patterns similar to those of automobiles, account for as much as 75 percent of urban truck trips.

14. Truck activities appear to cause a considerable proportion of the congestion in the CBD, and improvements, such as enforced regulation of loading zones, coordination of freight distribution, and ordinances requiring off-street truck parking in new or rebuilt structures, are needed.

15. Public and private costs for movements of goods and services have constantly increased, and future growth and increased density of population will intensify the supply problem.

REFERENCES

1. Planning for Freight Facilities. Chicago Area Transportation Study and the Lake-Porter County Regional Transportation and Planning Commission, Ill., June 1970.
2. Transportation Facts and Trends, 7th ed. Transportation Assn. of America, Washington, D.C., Quarterly Supplement, Oct. 1970.

3. 1968 National Highway Needs Report. Federal Highway Administration.
4. Issues Affecting the Transport of Goods in the Baltimore Region. Aug. 1968.
5. Inventory of Airports, Harbors, Railroads, Pipelines, and Truck Terminals. Detroit, 1967.
6. Characteristics of Internal Truck Freight. Tri-State Transportation Commission, New York, Interim Tech. Repts. 4042-3512, 1966.
7. Inventory of Findings. Southeastern Wisconsin Regional Planning Commission, Vol. 1, 1963.
8. Pittsburgh Area Transportation Study, Vol. 1.
9. Truck Transportation: Regional Profile. Tri-State Transportation Commission, New York, 1968.
10. Parking Demands and Needs—New Orleans. Wilbur Smith and Associates, Vol. 1, 1960.
11. Measuring Urban Freight in the Tri-State Region. Tri-State Transportation Commission, New York, 1970.
12. Truck Freight in the Tri-State Region. Tri-State Transportation Commission, New York, Vol. 1, Oct. 1969.
13. Rail Freight of the Tri-State Region. Tri-State Transportation Commission, New York, Vols. 1 and 2, 1967.
14. Waterborne Freight of the Tri-State Region. Tri-State Transportation Commission, New York, Vol. 2, 1967.
15. Truck Freight Activity at Selected Terminal Areas in the Tri-State Region. Tri-State Transportation Commission, New York, Interim Tech. Repts. 4102-6591, 1968.
16. Regional Profile—Direct Freight Transfer. Tri-State Transportation Commission, New York, Vol. 1, No. 5, 1967.
17. Freight Traffic of the Tri-State Region—The Trend and the Projection. Tri-State Transportation Commission, New York, Interim Tech. Rept., 1968.
18. Railroad Freight Trends: Tri-State Region Versus U.S. Total and Other Areas. Tri-State Transportation Commission, New York, 1966.
19. Wood, R. T. Air Cargo in the Region and the World: A Quick Overview. Tri-State Transportation Commission, New York, 1966.
20. Railroad Investment Policy, Technical Progress and Efficiency, 1917-1966. Tri-State Transportation Commission, New York.
21. Los Angeles Regional Transportation Study: 1980 Progress Report. Transportation Assn. of Southern California.
22. Data Projections. Chicago Area Transportation Study, Vol. 2 of final report, July 1960.
23. Railroads: Boston Regional Survey. 1962.
24. Truck Characteristics in Urban Areas. National Capital Regional Transportation Planning Board, Washington, D.C., Information Rept. 26.
25. Pittsburgh Area Transportation Study, Vol. 2, 1963.
26. Accuracy Checks of Adjustments on the 1963 Origin-Destination Survey. Cleveland.
27. A Highway Planning Study for the St. Louis Metropolitan Area. Wilbur Smith and Associates, 1959.
28. Regional Airport System: A Reconnaissance. Baltimore.
29. Forecasts and Alternate Plans, 1990. Southeastern Wisconsin Regional Planning Commission.
30. Long-Range Transportation Plan for the Central Business District of Dallas. De Leuw, Cather and Company, 1965.
31. 1967 Plan. Dallas-Fort Worth Regional Transportation Study, Vol. 2.
32. Johnson-Wyandotte County Truck Terminal Report. Kansas City, 1967.
33. Origin-Destination Report. Denver, 1962.
34. Goods Movement Data Collection Procedures. Connecticut Interregional Planning Program.
35. Goods Movement Projection and Distribution Model. Connecticut Interregional Planning Program.

36. Existing Travel Patterns and Origin-Destination Surveys. Ohio, Kentucky, and Indiana Regional Transportation and Development Plan, Cincinnati, 1969.
37. Aviation Demand and Airport Facility Requirement Forecasts for Large Air Transportation Hubs Through 1980. Federal Aviation Administration, Aug. 1967.