FREIGHT TRANSPORT IN URBAN AREAS: ISSUES FOR RESEARCH AND ACTION

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During 1967, the Summer Program in Urban Transportation was conducted by the Rand Corporation under the joint sponsorship of the U. S. Department of Housing and Urban Development, the U. S. Department of Transportation, and the Rand Corporation. The program brought together persons of diverse professional endeavors—administrators, planners, architects, physical scientists, and policy analysts—to consider selected, outstanding topics in urban transportation in a series of working seminars. The primary intent was to identify those issues requiring near-term government attention (by all levels of government) and those deserving the attention of the research community.

One seminar considered freight transport in urban areas. It began with a problem paper to focus the discussion and continued during the 2½ days with discussion that probed various facets of the topic. This paper summarizes, structures, and synthesizes the ideas developed in those discussions. It is meant to provide a thorough list, in context, of issues requiring government and research attention for freight transport in urban areas. Accordingly, it poses the issues only in skeletal form: No priorities are assigned and no step-wise research programs are presented.

Admittedly, this paper is a "period piece": It lists issues for research and action, but vintage 1967. However, most of the issues raised in 1967 are still relevant and pressing today. (Some have been partially or totally ameliorated; e.g., there is now a special office in the U. S. Department of Transportation that deals with the freight data base issue, and containerization has progressed.) Thus, it should be fruitful to begin a 1970 study of urban commodity flow problems by examining a 1967 study of such problems to gain perspective and to see which ones still obtain.

In the United States, freight transport accounts for about 9 percent of the total annual expenditures for goods and services, very nearly as much as passenger transport. And yet while the problems of passenger transport have become subjects of great concern, those of freight transport have received relatively scant attention from either government or the research community. They should receive more. It is not logical to concentrate nearly all research attention on the passenger transportation subsystem when freight and passenger transportation together compose the transportation system for the nation and for individual urban areas. Complementary studies of both kinds of transportation and their interrelations are necessary if we are to better appreciate the economic and social consequences of transportation and transportation investments.

Moreover, with the expansion of urban areas and the decentralization of population and manufacturing to the suburbs, there has been a growing mismatch between the existing systems for freight transport and the developing patterns of freight demand. The ultimate effect may be to lower the efficiency of freight transport, to raise its social and economic costs, and to aggravate the already critical traffic problem within cities. Already freight transport manifests the following range of symptoms.

1. The transfer of freight among modes and among carriers is inefficient; e.g., the time spent handling freight in terminals often exceeds that spent hauling it between cities.
2. There is interference between freight and passenger vehicles; e.g., trucks engaging in curbside loading and unloading frequently impede the flow of passenger vehicles.

3. Valuable land is used inefficiently by freight terminals; e.g., railroad marshalling yards currently sprawl over large areas of some central cities, while many of their shippers and consignees are located in outlying areas.
4. Some freight operations produce noise and air pollution.

In the following discussion of these and related problems, primary emphasis will be on problems of intraurban freight transport, but interurban and international transport are also considered insofar as they interface with intraurban operations. The discussion will focus on 4 major problem areas: (a) movement of urban freight, (b) interaction of freight and passenger traffic, (c) urban form and quality, and (d) roles for government in urban freight transport.

In the discussion of these subject areas, the goal has been to identify the principal problems of urban freight transport and to suggest issues that require either near-term attention by government or freight-transport operators or long-term attention by the research community. It is hoped that investigation of these issues will afford new insights into the present and future problems of urban freight transport—their possible causes, consequences, and cures.

MOVEMENT OF URBAN FREIGHT

Although urban freight movement occurs continuously, it is nevertheless virtually impossible to describe adequately or to predict for the future. Available data on the subject are sparse, known relationships are tenuous, and existing research studies are fragmentary. Therefore, we must more fully understand the characteristics of freight movement and the factors influencing demands for it before we can properly assess the need for and the importance of improved freight-handling technology or management techniques, or many of the other issues raised in this paper.

Description of Freight Movement

To understand freight transportation, we must first identify and then quantify its significant variables. What do we know about freight movements in cities that differ in size, topography, and spatial pattern? An analysis should determine as fully as possible how these movements can be characterized by factors such as the following:

1. Demand generators (What volume of freight movement is generated within an urban area by factories, by residences, by retail and wholesale establishments, by service industries, and by transportation facilities, particularly seaports, airports, and rail hubs?);
2. Characteristics of freight (What are the significant characteristics—volume, density, value, origin and destination, shipment size such as number and weight of pieces, perishability, volatility, or fragility—of the freight moved? How do they vary with the different demand generators, particularly for freight in the commodity classes of high bulk, high value, general manufacturing, and merchandise?);
3. Kinds of movements (What part of the freight is to be transformed within factories in the urban area? What part is to be consumed within the urban area, shipped within the urban area, or shipped to other urban areas?);
4. Characteristics of flow (What are the types, performance, and mix of freight vehicles? What volumes will be carried by different vehicles at different times on different days in different parts of an urban area? What will be the duration and frequency of stops? What are the changes of carriers and of carrier modes?);
5. Length of movement (What part of the freight movements are intraurban, domestic interurban, or international? How does the length of movement correlate with other factors, such as the demand generators and freight characteristics?); and
6. Freight carriers (What part of the freight enters, leaves, or moves within the urban area by air, by truck, by train, by ship, or by pipeline? How do the factors listed here influence the selection of type and mode of freight carrier?).

The creation of a freight taxonomy does not in itself adequately describe freight movement. The analysis should also assess whether our present tools can adequately measure such factors and their influence on freight demand. If not, then further analysis must be done to develop adequate tools that will enable us to characterize freight movement in terms of variables for which data can be gathered, leading to quantitative descriptions.

It would remain for later studies to quantify these variables for different urban areas, for different places within an area, and for different days, seasons, and times of day. A series of studies having specific goals and moderate scope would probably be more informative than a few big studies. However, if such information is to be of real utility, the urban areas considered should be representative of a range of urban forms and sizes. The studies of freight movement in these selected cities would be somewhat analogous to the origin-destination studies that have been done for passenger movement in various cities. Their results should help to indicate the relations among variables and provide meaningful background for planning.

Prediction of Freight Movement

We are concerned with predicting future patterns of urban freight demand so that we can plan and prepare for them. Future demands will depend on various social, economic, and technological trends for the major classes of urban freight (e.g., retail delivery and bulk industrial). For example, the currently predicted increase in the proportion of service industries in our economy could shift the composition of freight demand. The continuing decentralization of population could result in the further growth of suburban shopping centers and the decline of central-city retail freight demands. The predicted shift from fossil to fissile fuels could greatly reduce demands for coal and petroleum movements. Improved performance from new transportation methods and materials-handling techniques could markedly change the proportions of freight carried by rail, by road, by pipeline, and by air.

Future Trends—Before future demand trends can be predicted, we must determine what is known about the relationship between urban freight-transportation demand and trends in the following factors: level and composition of economic activity, manufacturing locations, technology, and transportation methods. An analysis is needed to identify the major trends in these factors and to assess their potential impact on urban freight demand in the longer term. For example, what would the 1990 demand for crude oil movement be after an earlier switch from fossil to fissile fuels? The analysis might profitably apply the Delphi method (1, 2) or similar techniques for the systematic use of expert judgment in addition to surveying relevant sources. It is also important to identify what additional information is required to better assess such trends and their potential effects.

Freight-Demand Model—A freight-demand model should be developed that explicitly identifies and relates the major variables that characterize freight, its movement demands, and its transport systems. (A question for early resolution would be the proper scope—urban area, urban region, or entire nation—for such a model.) The model would incorporate the factors that influence a shipper's choice of mode and carrier, including capacity, price, freight characteristics (e.g., high value or fragility), and level of service. Although such a freight-demand model would be highly aggregated, at least in its initial form, it would nevertheless serve as a useful tool for predicting the short-term impact on freight demand of proposed measures; it could indicate how a change in one mode's prices might alter the overall demand. Moreover, the very attempt to develop a freight-demand model would be useful in that it could make evident the weaknesses in our data and knowledge about relations among different demand variables.

Forecasting techniques presently applied in passenger transportation and in other fields may be useful in constructing this model. Specific consideration should be given to time-series analysis, computer simulation, and other mathematical-modeling techniques. The proper time horizons for freight planning should also be analyzed; that is, how frequently should freight-demand estimates or the data on which they are based be updated?

Performance Functions—In parallel with work on a demand model, research is also needed to develop supply-performance functions for freight-transportation systems in the present and near term. These functions should indicate how travel time, the level of service to the shipper, or some other performance measure would change with movement volume and with the mix and characteristics of freight vehicles on the links of the freight system. The aim would be to develop a tool capable of predicting, for example, how the performance of a particular mode might vary with different vehicle mixes, or how the introduction of an improved-performance vehicle might change operational costs (and for whom). The research should attempt to identify selected case studies of value. For example, what happened to the level of service when White Plains, New York, excluded truck traffic during certain peak hours?

Costing Methods—The development and distribution of good costing methods (relating transport performance and operating costs to design and operational factors controllable by transport managers) should be undertaken to improve freight-management and planning capabilities. Better methods for making parametric trade-off comparisons of costs and benefits for alternative investments could materially improve the transport operator's ability to perform investment-return evaluations; it has been asserted, for example, that the primary reason railroads took so long to accept the diesel locomotive was that they were unable to cost it properly. Better methods for description and analysis of costs could help management improve efficiency and determine appropriate rates; for example, the inability to differentiate between the costs for freight and passenger movement when an aircraft carries both is a major problem of airline management personnel. Better cost data would aid in the setting of equitable rates and tariffs.

Data Base—What information about present freight movement and demand is necessary to make projections into the future and to make proper management decisions? Research is needed on the desirable composition and format of freight data (prices, costs, volumes, and movements) for all modes and carriers. Voids in the data should also be identified. Moveover, the data are often too highly aggregated to be useful for management or planning; sometimes different pieces of data are not comparable, and sometimes there are problems of data confidentiality. Research should be done on possibilities of a common freight-data reporting system that would emphasize collection and distribution of richer and better data for time-series analysis and other freight forecasting. Methods of data collection must be evaluated. Should the system gather its data in real time or by periodic updates? If by periodic updates, how often should they occur? In view of the competitive nature of freight transportation, it will be necessary to decide what limitations on data access might have to be imposed on carriers and shippers. There is also the question of who would manage such a system. Should the ICC, some other government instrumentality, or a private consortium?

Freight Management

Meeting the future demands for urban areas will require more than the development of improved vehicles or freight-handling technology. Existing problems, such as inefficiencies in central business district freight distribution and difficulties in tracing freight shipments, must also be overcome. The solutions to these problems, and to others that were raised, will require managerial as well as technological approaches.

Many problems and inefficiencies occur at interfaces between different freight-transport modes, different carriers, and different vehicles and at interfaces between intraurban and interurban freight. Each truckline that services an urban area normally picks up and delivers all the freight it carries, which results in duplication of routes and in partially loaded vehicles. Accordingly, it has often been suggested that effectiveness of freight transportation would be enhanced by greater consolidation of shipments, by greater coordination among routes and carriers in an urban area, and by better coordination between transport modes (interurban and intraurban). These enhancements can be achieved by the use of freight-transfer facilities such as union terminals and intermediate distribution centers. For different sections of an urban area, these facilities would handle both incoming and outgoing freight; shipments would be sorted and consolidated, then transferred to the appropriate vehicles.

Freight Terminals and Interfaces—The following issues pertaining to freight terminals and interfaces deserve special attention:

1. What are the present and prospective magnitudes of the problems of friction and inefficiency at interfaces between modes and between interurban and intraurban carriers? How can these problems be reduced?
2. What should be the characteristics of union terminals and intermediate distribution centers? Where should they be located? In what manner should zones of service be matched to sections of the urban area?
3. How can coordination and cooperation among transportation companies be encouraged? To what extent and in what ways should such coordination be encouraged by government action? Specifically, what are the trade-offs between coordination and competition? How can billing be handled for the load-swaps between carriers that may occur through such coordination? What labor problems could arise under these circumstances?
4. Should terminal facilities be publicly or privately owned? Will they better serve the public interest if they are profit-making or nonprofit?

These issues would best be explored through case studies of existing terminals and other analytic research; specific hypotheses or design concepts could be explored with demonstration projects.

Automation of Sorting and Routing of Freight—The plans of the U. S. Post Office for the automatic classification, labeling, sorting, forwarding, and delivery of assorted sizes and types of mail might well be paralleled for handling small-article freight. Research should be undertaken to examine various approaches to the automatic sorting and routing of freight to determine their practicality and potentiality for reducing present inefficiencies. Such questions as the following might be addressed: How would freight be given machine-readable labels showing origin, destination, fragility and perishability, methods of carriage, and so forth? To what extent might automatic routing be allowed to override a customer's preferences as to carrier or method of carriage, in the interests of efficiency? What compensatory payments might be required? What limitations on freight size or character would describe the items suitable for automatic sorting and routing?

Intermodal, Intercontinental Transportation Companies—Substantial problems and inefficiencies occur on the interfaces between different modes and carriers, and between interurban and intraurban freight, as well as in routing and tracing. In exploring ways to reduce these problems, it might be useful to investigate the potential service improvements that could result from allowing intermodal, intercontinental transportation companies to be established, in which the shipper would specify the level of service required and the company would choose the best method for achieving this level for the quoted price. Such investigation could reveal what barriers exist to the formation of such a company, why the barriers are there (e.g., to help maintain competition among modes and individual carriers), and whether they should be removed. (The growing role of "freight forwarders" should also be considered.)

Freight Technology

There have been many new developments in the technology of freight vehicles, warehousing, and materials handling, some of which require further investigation in order that their potential applications and problems be better understood. Also, because research or governmental encouragement can in many ways speed or direct development of some new technology toward a particular problem area, a number of freight-technology issues appear to merit attention. There are 2 general areas for research: (a) determination of what ways and to what extent new technology might reduce the interface problems between modes, between carriers, and, particularly, between interurban and intraurban freight movements, and identification of what, if any, desirable items are not yet under development; and (b) determination of what ways and to what extent new materials-handling and freight-movement technology might alter the present balance among the amounts and kinds of freight carried by rail, road, sea, pipeline, and air.

In addition to these issues, several others, more specific ones also deserve investigation.

Although the containerized movement of freight is widespread, it still presents problems needing research or government action. For example, a container-loading site requires expensive overhead cranes or special van lifts, and, because containers move between different carriers, different modes, and even different nations, problems of compatibility and standardization arise that can strongly affect the transfer of freight in and for urban areas.

Containerization—Studies of containerization should address the following questions:

1. Should there be global standards, national standards, or no standards at all for freight containers, for their modules (from small to very large), for their international designation, and for a uniform marking code?
2. Is it possible that development of more flexible materials-handling devices in conjunction with the establishment of maximum and minimum size restrictions on containers could make rigid standardization unnecessary?
3. If standards are desirable, how do the preferences and needs of shippers, carriers, and consignees differ and how can they be reconciled? (In particular, the needs of the shipper and consignee deserve special attention because they may have physically unusual cargoes, require special pallet sizes, or have limited-size loading docks.)
4. If standards are adopted, what steps should the government take to accelerate conversion? Should there be accelerated write-offs of nonstandard equipment? Should there be replacement subsidies? Would legislation preempting state laws and setting uniform highway trailer regulations be needed?

Palletization—An analysis should consider remedies for the interrelated problems of pallet return, accountability, and compatibility. For example, the efficiencies materials-handling techniques offered by pallets or forklifts are frequently reduced or lost entirely because of incompatibility between the size of shipper pallets and the requirements of carrier or consignee. As another example, the pallet owner often will not let pallets pass out of his control because of poor accountability and return procedures; in most such instances this means that freight must be transferred by hand from pallet to floor to pallet, or from pallet to pallet.

A study should be undertaken to survey the potential applications of continuous-movement systems and to assess their feasibility and desirability. In particular, an analysis should be made of the Swedish experience with pulverizing solid wastes at their residential and commercial sources and then transporting them by vacuum tubes to outlying plants for processing into mulch and land-fill. New methods of adapting freight to continuous movement should also be considered; for example, new techniques of sterilization and irradiation can extend the life of perishables such as milk sufficiently to make their movement by pipeline practical.

Lighter-Than-Air Vehicles—Lighter-than-air vehicles (LTAV's) have recently been employed in rough-country logging and transmission line tower installation and have proved to be cheaper than helicopters for those applications. Recent advances in flexible structures, power plants, controls, and helium technology ensure that a modern LTAV could be designed that would be as far advanced over the venerable blimp as the C-5A is over the DC-3. It appears that a modern LTAV could be useful in freight transportation, particularly for the movement of very bulky or heavy items (e.g., transformers) from their point of manufacture and assembly to their point of use. Accordingly, an LTAV of modern design for very low-cost, low-speed (less than 100 mph) delivery should be investigated. Present and prospective uses of V/STOL vehicles for interurban and intraurban movement of freight (and people) should be reexamined to determine whether any are better suited to a 1970 style of LTAV. The economies of nonlifting propulsion should be reevaluated in the light of latest knowledge, and the traditional problems of how to load, moor, and hangar an LTAV should also be restudied in the light of present technology.

Transfer of Technology—Existing technology (particularly in military applications) that might profitably be applied to freight-transportation problems should be evaluated. Military cargo technology, in particular, is highly advanced. Specialized V/STOL techniques have been developed that permit quick, spot deliveries of palletized loads, often without any vehicle touchdown. Sophisticated tracing techniques are used for high-value parts, and a 3-ton, long-range electric truck has been successfully demonstrated.

Freight-Transport Engineering Information Center—Attention should also be given to the possibility of establishing a freight-transport engineering information center, somewhat analogous to the technology utilization program of the National Aeronautics and Space Administration, that would continuously examine military and civilian technology for developments applicable to civilian freight technology. The uses of such a center (Should it do developmental research?), its institutional form, and appropriate sources of financial support should be investigated.

Several other freight-technology issues exist that merit attention. However, these will be considered later in the more appropriate contexts of reducing the problems of urban congestion and of urban pollution and noise.

THE INTERACTIONS OF FREIGHT AND PASSENGER TRAFFIC

The preceding section was concerned with the interactions of different components of the freight-transportation system with each other and with the demands for freight movement. Here the discussion considers interactions between freight and passenger traffic, emphasizing the impact that freight traffic will have on passenger traffic in the near future. Although there are and will be some beneficial interactions (mentioned briefly later), primary concern is with determining the manner and extent to which freight traffic may interfere with passenger traffic and with finding potential solution approaches to reducing this interference.

Interference of Freight and Passenger Vehicles

Freight and passenger vehicles may interfere with each other on any guideway or in any terminal they share. At the present time, however, nearly all interference occurs on streets and highways where trucks compete with automobiles and buses for space and priority. Here freight vehicles may interfere with passenger vehicles in 2 principal ways. First, the presence of freight vehicles (which are often much larger than automobiles) effectively reduces the capacity of the streets and highways for moving passenger traffic. Second, trucks generally accelerate more slowly than passenger vehicles and frequently engage in curbside loading and unloading, which may either retard the flow of passenger vehicles or block it entirely.

The extent of capacity reduction and flow impedance may differ markedly among cities, depending on a multitude of factors characterizing the urban area, its transportation system, and its temporal and geographic patterns of freight and passenger movement. These factors include the following: size and performance of freight vehicles; purpose of journey (retail delivery, wholesale delivery, nondelivery business use, mail and parcel delivery, and services and maintenance); duration and frequency of stops for each type of journey; size of city; layout and width of streets; and character and utilization of public transit.

Description of Freight-Passenger Interference—Research is needed to develop methods to describe interference, determine its causes, and assess its severity and its economic and social costs. As a first step, specific attention is directed to the following questions:

1. What are reasonable indexes of capacity reduction and flow impedance, such as the time for a passenger's journey in the presence of freight traffic versus the time for the same journey in its absence? What are the social and economic costs of the interference?
2. What information do we need to evaluate these quantities? What information is available? What is known about the duration of curbside loading and unloading for different types of vehicles making different types of calls? How can we measure capacity reduction and flow impedance? Are traditional types of cordon-line surveys adequate? Can we really separate out the freight contribution to total congestion?

Interference Case Studies—The methods developed should be used to determine the relative magnitudes of capacity reduction and flow impedance for both intraurban and interurban traffic for several different cities, including New York, which is an extreme case. We must also find out how these magnitudes depend on factors such as time of day (particularly the peak hour), various city characteristics, section of the city, and presence of ports, airports, rail hubs, or other facilities serving as internal generators of traffic.

In the future, several trends in commerical growth and urban development seem likely to alter the magnitude of interference between freight- and passenger-vehicle traffic. For example, the growth of public transit could reduce automobile traffic in the CBD and thus reduce conflicts. For individual cities, and for cities in general, an analysis should be made to determine which trends seem likely to affect freight-passenger interactions and what impact the different trends might have.

Solution Approaches to Interference

There appear to be 4 potential solution approaches for reducing the interference between freight and passenger traffic: (a) consolidation of freight routes and shipments, (b) separation of freight and passenger traffic, (c) diversion of freight journeys from times and routes of high congestion, and (d) minimization of curbside loading and unloading. For each approach, specific attention is suggested.

Consolidation of Freight Routes and Shipments—Specific measures for consolidation and their relative effectiveness should be analyzed. Freight terminals, containerization, automated routing of freight vehicles, and other measures previously suggested to improve the efficiency of freight movement should also be examined to determine their collateral benefits in reducing interference and to find ways in which to make them more effective.

Separation of Freight and Passenger Traffic—The specific measures for separation of freight and passenger traffic and their relative effectiveness should be analyzed. Such separation might be achieved by the construction of separate and exclusive freightways, by banning freight vehicles from certain roadways, or by shifting a significant fraction of either freight or passenger movement to modes that move in exclusive rights-of-way or to nonsurface modes so as to lessen competition. An analysis should search for ways to exploit nonsurface modes for freight movement.

Of particular interest is underground transport in the central city. With rising surface-land costs, underground freightways, terminals, and loading docks could become practical (perhaps even for existing trucks) if tunneling costs were reduced. Reductions in interference plus aesthetic and social advantages would result from moving a substantial fraction of central-city freight through underground tunnels, either by special vehicles or by the pipelines discussed earlier. But would such advantages be worth their costs? (Tunnel movement of coal was tried in Chicago early in the century and was then discontinued as uneconomic.) An analysis should be conducted to assess the costs and problems of underground freight transport and to determine what items would be most suitable for underground movement and what means would be used to move them. Moreover, the development of long-distance, high-speed rock-tunneling machines could be encouraged and accelerated. Such machines would, of course, have applications to future passenger-movement systems and to other construction.

Diversion of Freight-Vehicle Journeys From Times and Routes of High Congestion—The specific measures for diversion of freight vehicles to times and routes of low congestion and their relative effectiveness should be analyzed. Such diversion might be accomplished by making alternative routes more attractive (e.g., by providing effective circumferential highways in urban areas). Potentially more effective in the near term would be the use of direct road pricing to make freight journeys more expensive on congested routes or to influence the time of day at which freight traffic operates. Permits, either issued free or purchased, could also be used to restrict access to congested routes or to divert freight traffic from peak-hour operation. Considerable research is needed on prices and permits. The basic questions are as follows: How expensive must prices or permits be to influence behavior? How might they be implemented? What broader social benefits or disbenefits are implied?

Movement Hours—The issue of traffic diversion raises questions concerning movement hours. Must urban freight travel during peak commuter hours? For some items, are these times merely the most attractive? To what extent might the following (and other) factors make the diversion of freight movement to nonpeak or nondaytime hours impractical: the necessity for immediate delivery (e.g., for perishables), the insistence on synchronization between business hours and delivery hours, and the willingness of drivers or shipping clerks to work nondaytime or shifted hours?

After-Hour Freight Drops—Shifting freight deliveries to nighttime or after-business hours might be made more practical if a freight-drop system were developed or exploited. Specially sealed freight modules could be left in delivery bins or put through freight slots (analogous to residential mail slots). This would permit freight deliveries to be made to a business even when none of its employees was present. After-hour deliveries could also produce earlier arrivals in some cases; e.g., air freight that arrived during the night might be delivered before a business opened for the day. As suggested later, it might even help minimize the curbside unloading time for some deliveries during peak hours. In view of the apparent utility of after-hour, freight-drop systems, research should be conducted to develop and evaluate alternative design concepts for such systems.

Minimization of Curbside Loading and Unloading—The specific measures for minimization of curbside loading and unloading and their relative effectiveness should be analyzed. Curbside operations could be minimized either by speeding up the process or by shifting it off the street. Incentives could come from the enforcement of sanctions against curbside loading and unloading or from use of a pricing mechanism to regulate the duration of curbside pauses. Both of these measures, of course, would involve investigating issues of implementation and enforcement.

Building Ordinances and Freight Facilities—The congestion caused by freight vehicles on the streets could be alleviated through building and zoning ordinances requiring in-building accommodations for trucks, trailers, vans, freight docks, and elevators. (These might be analogous to a current Los Angeles ordinance requiring one automobile parking space for every 500 sq ft of floor space.) Research should be undertaken to (a) examine the potential character and content of such ordinances, i.e., the requirement and enforcement issues, and (b) identify the necessary and desirable characteristics of in-building freight vehicle docks, turnarounds, and slot spaces. The basic need, however, is for a cost-benefit analysis to see under what conditions the benefits of in-building freight facilities would outweigh their costs. Such an analysis should explicitly consider the social and economic costs for retrofitting and revamping buildings in older central cities as well as those for new construction.

Underslung-Payload Vehicles and Straddle Carriers—Special vehicles will almost certainly be necessary if the process of curbside loading and unloading is to be speeded up. Particularly promising are concepts of underslung-payload vehicles and straddle carriers. Before urban freight vehicles can be developed by using these concepts, however, existing regulations on vehicle design and configuration must be liberalized so as to allow innovations in the rapid extraction and insertion of goods, and, particularly, in vertical dropoff and pickup. (Certain design regulations conceived for standard vehicle types impose implicit restrictions on new vehicle types or innovations, for example, the requirements that vehicles be able to withstand certain axial compression forces and the restrictions on the maximum turning circle.) Moreover, ordinances prohibiting street use of straddle carriers need to be revised to encourage the design of freight vehicles with fast pickup and drop-off capabilities. After these revisions, special straddle carriers and underslung-payload vehicles could be designed for use where curbside (or other) turnaround time is to be minimized. The potential of such vehicles for use in conjunction with the after-hour, freight-drop systems discussed earlier should also be exploited.

Truck Parking Sanctions and Fees—It has been asserted that many of the problems caused by curbside loading and unloading of trucks could be eliminated by proper use of police powers. The desirable character of sanctions against curbside pauses or the use of fees to regulate the duration of such pauses should be investigated. We must ask, How stringent should such measures be? How should they be implemented? What amount of enforcement might be needed to institute new loading, unloading, and waiting restrictions?

Probable Future Interference

Except on the streets and highways, there is little interference between freight and passenger vehicles at the present time because other guideways carry one or the other predominantly. But what of the future? An analysis, probably in the context of the investigation of future trends raised earlier, should consider whether significant interference will be likely to occur anywhere besides the streets and highways in the foreseeable future (in the airspace, for example) and what steps might forestall this.

Beneficial Interactions

Not only interference but also beneficial and complementary interactions can occur between freight and passenger transportation, provided that we plan and prepare for them. Vehicles and terminals both offer opportunities that should be investigated.

Possibilities exist for combining freight- and passenger-movement systems; that is, vehicle systems designed primarily for carrying passengers could also be employed for hauling freight. The Chicago rapid-transit trains, as an example, are again being considered for use as mail carriers, a service they performed several decades ago. As another example, subways may have potential for the slack-hour distribution of newspaper bundles or smaller freight. Freight-passenger vehicle combinations such as these could help offset the costs of a public transportation system by increasing its utilization. They could also help reduce congestion by consolidating some freight movements into passenger-vehicle movements that are going to occur regardless.

Freight-Passenger Vehicle Combination—An analysis is suggested to determine the desirability and practicality of combination freight-passenger vehicles for urban freight transport. (Such vehicles could either be integrated vehicles that can carry freight and passengers simultaneously or convertible vehicles that can quickly change from freight to passenger configurations.) A survey should first be made of the costs and benefits that have been experienced with such systems, particularly those for the European "articulated bus," essentially a tractor that pulls either a freight or a passenger trailer. Next, the potential of various new vehicles (e.g., the skycrane with changeable freight and passenger pods) should be evaluated. The relative advantages of convertible and integrated vehicles should also be analyzed, along with the major problems of implementation, past and prospective. For example, will unions be opposed to passenger transport employees being directly involved in moving or handling freight, or will there be other labor problems? How will costs be divided between passenger- and freight-movement customers (particularly on a publicly owned system)?

Freight-Passenger Terminal Combination—Possibilities for combining freight and passenger transportation also exist in terminals. (Some combining has already been done at airports.) Such combination might produce economies of scale, increase utilization, and help defray public investments and operating expenditures. Therefore, the following multifaceted study is suggested: (a) An analysis should determine the desirability of freight-passenger terminal combination and would include identifying the modes and circumstances for which combination terminals would be attractive and which freight and passenger modes should be mixed (e.g., V/STOL and truck); (b) in this context, it should be noted that such combinations could provide new options for moving baggage (an air traveler, for example, might take the usual amount of baggage with him and have the excess follow on a special baggage plane or high-speed baggage train) and, thus, an analysis should also consider the practicality and potentiality of such options; and (c) problems of possible freight-passenger conflict must be considered, and an analysis should treat questions such as, What will happen if both passengers and freight are to be loaded from the same subway platform? How should the financing, support, and responsibility for combination terminals or transportation centers be apportioned among their many users (freight carriers, public and private passenger carriers, individual users, and political jurisdictions)?

URBAN FORM AND QUALITY

Thus far, the discussion has dealt primarily with the efficiency of freight transport and its impact on the movement of passenger vehicles. The program discussions also considered the broader impacts of freight transportation—social, economic, and developmental—and the ways in which these effects may be used in urban planning to achieve desirable urban form and quality. The issues suggested for consideration fall roughly into 3 broad areas: freight transport as a component of urban society, freight transport as a user of urban land, and freight transport as a tool for urban development. Each area will be considered in turn.

Freight Transport as a Component of Urban Society

Freight transport is an important integral component of urban society whose influence can profoundly affect the urban social environment. On the negative side, railroad yards can bring unsightly blight to central cities, and trucks can generate unpleasant noise and pollution. Although investigations of the social role of passenger transportation have been undertaken (and others have been suggested elsewhere in this paper), no comparable investigations of freight exist. Yet freight and passenger transportation together constitute the transportation system for an urban area; thus, complementary studies of both kinds of transportation are necessary if we are to appreciate the social consequences of transportation and transportation investments.

Social Costs and Benefits of Freight Transportation—An analysis is needed to identify and develop measures for the social costs and benefits of freight transportation and to find a means to relate freight transportation explicitly to urban form and quality. Such understanding is a major prerequisite if freight systems are to be considered in analyses of the social consequences of transportation and in cost-benefit evaluations of alternative transportation investments.

In this context, analysis should specifically assess the detrimental effects of freight transportation: How does it contribute to urban noise, pollution, and blight? Are these detrimental effects necessary by-products of technically efficient freight movement? If not, how can they be reduced?

Several concepts might be considered as means of reducing these detrimental effects, e.g., pipelines, underground freight movement, and electric vehicles. At present, considerable research is under way on electric passenger cars, all-electric buses, and electrified roads; but there is no comparable effort under way in the United States to develop electric power for freight movement.

Electric Freight Movement—Analysis is needed to investigate the desirability and practicality of developing electric trucks, electric vans, and other electric systems for the movement of urban freight in U. S. cities. It might be profitable to begin by reexamining the systems that have been proposed or experimentally developed for passenger movement and then discarded (e.g., high-speed overhead conveyors presented excessive boarding problems).

Social Costs of Business Location—A location in or near the CBD reduces costs for many businesses, while the congestion induced by the freight vehicles raises the social and economic costs of freight and passenger transportation for others. If information concerning the total social and economic costs of CBD location for various commercial and industrial firms were available through analysis, policy-makers could use this information in planning and zoning.

Interstate Highways—The contribution of freight transport to the cost-benefit evaluation of Interstate highways in urban areas has been incomplete. An analysis should remedy this by indicating how freight movement can be included explicitly in the highway location and design-decision framework, and how, if freight impact is included in highway design, the needs and contributions of freight movements might be better reflected, e.g., by the inclusion of priority ramps or special freight lanes.

Freight Transport as a User of Urban Land

Because freight transport is one of our largest industries, the use of substantial quantities of urban land by freight transport—as highways, railways, airports, and railroad yards—is accepted without question as to the wisdom or efficiency of this use. Does freight transport need all this land? Can we not find better uses for some of it (particularly in central cities)? Does freight transport use the land it occupies efficiently, or could it do as well or better with somewhat different holdings? Research is needed to explore these issues and others that pertain to the most efficient use of urban land for freight transport. One topic of particular importance is the relocation of freight facilities to improve their efficiency or to reclaim valuable land for redevelopment. In this connection, research should establish what government investments (local and federal) would be appropriate to achieve more efficient freight-facility location and what investments should be used to help offset relocation costs for freight-distribution facilities as an aid to urban renewal and redevelopment. These explorations should be extended by also investigating the following topics.

Railroad Marshalling Yards—These yards currently occupy large areas in major cities. An analysis should be made of their operation, technology, and design. Findings could help establish whether they should be made much smaller and could also furnish data required when relocation to extraurban areas is examined. A particular focus would be on investigating the use of the third dimension, i.e., vertical stacking, as a basis for making more efficient use of land areas.

Freight-Terminal Location—As a second basis for the possible relocation of freight facilities, an analysis should be conducted to determine the optimum location of railroad freight terminals under present conditions of customer demand, routes, and traffic levels. The analysis should include an examination of the need for large marshalling yards in the core of urban areas and of the possible uses of presorted trains for distribution of goods within a city.

Land-Redevelopment Incentives—Railroads might be motivated to examine development opportunities for their current landholding in several ways. For example, they might be encouraged to improve the quality of their present facilities, develop their air rights (as a couple of railroads are doing), or relocate the facilities to other sites. What innovations in taxation are needed to motivate railroads to modify their present patterns or manner of land use? In addition to negative incentives such as taxation and social pressure, positive measures such as relocation allowances, tax write-offs, and other subsidies might provide land redevelopment incentives. These also should be investigated.

Abandoned Railways—An analysis should be made of the potential use of abandoned railways in urban areas. These linear areas might be suitable locations for schools, parks, greenbelts, industrial sites, or housing. Analysis should focus on how such development can be obtained. Can zoning or other measures encourage the railroads to develop these lands for industrial purposes? Should these lands revert to the government for development?

Freight Transport as a Tool in Urban Development

There is no question that freight transport has potential as a tool for urban development. Because freight transport feeds the population and industries of an urban area and carts away their wastes, it must therefore exert some leverage on the area's development. We need to assess the amount of leverage on development and the ways of employing it.

Locational Pressures of Freight Transport—Analysis is needed to answer the following questions: What are the locational pressures of freight-transport capability on manufacturing, on commercial facilities, and on residences? How do these locational pressures depend on transport modes, types of industry, and kind of housing? How strong are these pressures with respect to other locational forces (e.g., taxes, cost and availability of land, cost and availability of labor, and external economies)? The purpose of this research would be not to develop highly sophisticated locational-choice models, but rather to determine how such pressures can be used as tools of urban development. The basic question is, How can we integrate the planning of freight-facility locations and technology with urban planning and zoning?

Groupings of Industries—Freight movement among industries and its impact on the urban environment can be modified by location. As a basis for urban planning and zoning, it is suggested that the possible groupings of industries and the impact of alternative group arrangements on freight movements be studied. If the impact of groupings and locational factors were known, local governments could take appropriate zoning action.

ROLES FOR GOVERNMENT IN URBAN FREIGHT TRANSPORT

Government, at all levels, could play a wide variety of roles in urban freight transport. It might support the development of electric freight vehicles with research funds, or it might accelerate the retirement of obsolescent equipment by providing for tax write-offs. It might set standards for containerization or for other freight-transport components to help ensure their compatibility among different carriers and modes. It might regulate unsafe practices or seek to limit rates to an equitable level.

The basic problem, then, is to assess which roles government should play and to what extent. Which current roles should grow or continue? Which current roles should be discontinued? Which other roles should government consider? Some possible studies for investigation or action that could lead to a reasonable assessment of these roles are suggested in the following.

Application of New Technology

If freight transport operations—and, indeed, the nation—are to grow and prosper, proper advantage must be taken of opportunities afforded by new technology to improve efficiency or accomplish new tasks. Without government encouragement, excessive delays may occur in implementing new freight technologies. These delays can be reduced, however, by governmental encouragement of the innovation and implementation of new freight technology.

Analysis is needed to identify and evaluate the various instruments available to government at different levels for encouraging and accelerating innovation in freight (and related) technology. Suggested potential instruments are funds for research and development on vehicle propulsion systems and other appropriate areas; subsidies for equipment modernization; accelerated tax write-offs for obsolescent equipment; other tax breaks for modernization investments; altered regulatory structures that either favor or penalize technologically backward carriers; and legislated specifications or performance standards (e.g., container standardization might be quickly implemented if uniform highway trailer regulations were established for the entire nation). In evaluating such instruments, a specific attempt should be made to determine the particular situation or area of technology where each instrument was most applicable. As an example, legislated standards to encourage a particular innovation would produce thoroughly compatible modernization among carriers, whereas accelerated tax write-offs could produce highly individual innovations. The analysis should also consider criteria by which to identify technology deserving high priority for encouragement. This question might profitably be addressed in the earlier context of predicting key trends that will affect future freight demand.

Regulation

Although the government encourages some innovations in freight transport, it discourages others that it regards as undesirable—unsafe practices and inequitable prices, for example—through regulation. Questions arise as to the manner and degree of regulation appropriate for different carriers and modes in the freight system. Excessive regulation may restrict competition unduly, whereas insufficient regulation may allow undesirable practices to continue unabated. A question of major importance is that of determining the proper balance between the interests of the public and the interests of the freight transport industry, between freight transport "coordination" and competition. It is appropriate, in fact necessary, to periodically reconsider the effects of regulation on competition, service, and prices in the freight-transport industry. Within this broad area, several specific issues are suggested for initial investigation.

Tariff Simplification—Over the years a freight tariff structure has evolved that is so complex that literally millions of man-hours per year go into determining the rates for freight movements. At the federal level, for example, 8 different motor-carrier regions exist for the ICC-regulated carriers alone, with 8 different tariff structures set by 8 different bodies on the basis of 8 different tariff histories. At the state level, there are 50 bodies making their own intrastate tariffs. Thus, the heterogeneous tariff structure that exists has come about through gradual evolution, and it seems appropriate, therefore, to question whether it is adequately matched to today's needs. An analysis should be made of the possibilities for tariff simplification. The basic question for research and subsequent government action is this: If no freight tariffs existed, what simplified tariff structure would be most desirable and what administrative bodies in what institutional form should have the responsibility for it? Then, how might these tariff desiderata be adapted for the real world? Specifically, how should existing tariff structures be simplified to bring desirable changes in freight-transport competition, service, and prices? What is "desirable"?

Intraurban Freight Regulation—An analysis should be conducted to determine if any justification exists for the explicit economic (price-setting) regulation of intraurban freight transport. (Such regulation sometimes occurs where an urban area is made up of several municipalities.) This study would examine the historical basis and effectiveness of freight regulations in other, broader contexts to determine their relevance to this limited context. Specific attention would be directed to the following issues: Is regulation necessary to protect customer interests and transport-operator interests? Could service improvements be obtained? Can such regulations encourage the cooperation of different transport operators? Approaches other than government regulation should be considered as alternative solutions to problems for which intraurban freight regulation is proposed.

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REFERENCES

1. Helmer, O., and Gordon, T. Report on a Long-Range Forecasting Study. Rand Corp., Santa Monica, Calif., P-2982, Sept. 1964.
2. Helmer, O. Social Technology. Basic Books, New York, 1966.