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Trucks, Traffic, and Timely Transport: A Regional Freight Logistics Profile

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16. Abstract

This report justifies and designs a comprehensive tool for describing intraurban trucking, which is the bulk of truck movement in an urban area but typically is unexamined in regional transportation planning.

We begin by reviewing literature describing the characteristics and policy issues bearing on freight. We extract from that literature a structure for describing those policy issues, and then go on to design a series of map displays and quantitative measures that provide a linkage between the characteristics of local delivery trucking and the public policy issues that stem from and influence these characteristics. The Regional Freight Logistics Profile (RFLP) emerges as an easy-to-understand yet comprehensive description of urban trucking that stimulates a more constructive dialog among government transportation leaders, shippers, truckers, and the general public. The design balances coverage of the variety of public and business concerns relative to freight against the costs and other practicalities of collecting data. To overcome reluctance on the part of private companies to reveal performance information, we have designed an institutional approach to gathering truck fleet performance data that does not compromise confidential performance data from competing carriers and shippers.

We recommend that metropolitan planning organizations, as well as state and federal freight mobility offices with responsibility for technical assistance to MPOs, review the RFLP design for potential adaptation and adoption.

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The report integrates data from many sources and made numerous critical interpretations, and any opinions and conclusions expressed are solely those of the author.

We also wish to thank the MTI staff, including Research Director Trixie Johnson, Research and Publications Assistant Sonya Cardenas, Student Editorial Associate Kemberly Gong, Graphic Artists Tseggai Debretsion, Shun Nelson, and Emily Kruger, and Editorial Associates Irene Rush and Catherine Frazier.

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EXECUTIVE SUMMARY

Regional transportation plans in the United States are required, by federal law, to cover the transportation of freight as well as the transportation of people. In reviewing examples of such plans, we found that freight transport in trucks—the way most freight moves in an urban area—is not usually described comprehensively at even a gross level of detail. Basic metrics, such as the fraction of trucks in daily traffic streams and simple descriptions of where and how familiar trucks, like those in the fleets of FedEx and Safeway, move during the day, are not available. The proportion of blocking accidents on major highways that can be attributed to trucks is not measured and reported, nor are the results of monitoring air pollution from the diesel engines that characterize large trucks. Furthermore, all the significant impediments to freight mobility are seldom acknowledged. Specifying these and other elements in a simple yet comprehensive description of urban trucking would foster a more constructive dialog among interested parties:

- Government transportation leaders who decide on infrastructure investments
- Shippers and truckers who are directly concerned with performance levels of freight movement
- The general public, who perceive trucks more as an environmental impact than as support for economic sustenance and the quality of life in their community

We took on the task of designing a comprehensive description, which we call the Regional Freight Logistics Profile (RFLP). Our focus is intraurban trucking, the bulk of truck movement in an urban area. We reviewed literature describing the characteristics and policy issues bearing on freight and designed a series of quantitative measurements that provide a linkage between the characteristics of local delivery trucking and the public policy issues that stem from and influence these characteristics.

We found the design work challenging because of our intent to balance coverage of the variety of public and business concerns relative to freight against the costs and other practicalities of collecting data. Because the RFLP is data intensive, we recommend a concept of iterative incrementalism—expanding over time in successive annual cycles beyond a necessarily limited breadth and depth of geographic and topical coverage at the initial implementation. A major feature is building expansion potential into the RFLP to anticipate and accommodate the data streams potentially available in the next few years from private telematics and Intelligent Transportation Systems (ITS) equipment installed on fleet trucks.

We reached the conclusion that priority action by government to relieve the increased travel times and lack of reliability in hitting delivery windows can be guided by measuring truck volumes and congestion levels on key road segments. We found reluctance on the part of private companies to reveal performance information, so we have designed an institutional approach to gathering truck fleet performance data that does not compromise confidential performance data from competing carriers and shippers. Metropolitan planning organizations (MPOs) should review the RFLP and decide if devoting resources to using it would contribute to a better understanding of urban freight. State and federal freight mobility offices with responsibility for technical assistance to MPOs would also benefit from examining the RFLP for potential adaptation and adoption.

OVERVIEW

The vast majority of daily traffic volume on the roads of any North American metropolis comprises vehicles with the primary purpose of transporting *people* from one place to another: cars, vans, SUVs, personal pickup trucks, and buses, all providing personal mobility.

In addition to the many vehicles that are moving people, other vehicles—trucks—are on the road to move *things*. In commercial service, trucks are becoming relatively more important in America's vehicle mix. Table 1 shows the number of U.S. trucks in several major categories of use over the 10-year period 1987 to 1997. The growth rate in the number of trucks has exceeded the growth rate in both population and number of cars, in each case by a multiple of two or more.[1]

Table 1: Growth of Commercial Trucks in Service, 1987-97

Trucks by Major Use	1987 (1000s)	1992 (1000s)	1997 (1000s)	Percent Change 1987-97
Wholesale trade	969.5	1,136.1	1,264.6	30.4
Retail trade	1,537.1	1,950.9	2,243.8	44.9
Services	1,980.8	3,123.3	4,233.5	113.7
Daily rental	147.6	307.6	508.0	244.2
Passenger cars and small trucks	*172,589*	*183,672*	*199,973*	*15.9*
U.S. population	*242,231*	*255,039*	*267,636*	*10.5*
Source: U.S. Bureau of the Census; Federal Highway Administration				

However, truck traffic is still a small fraction of total traffic in most circumstances. Trucks moving freight typically represent between 5 and 10 percent of vehicles over the course of a day in a U.S. metropolitan region. In the San Francisco Bay Area, trucks are reported to represent 5.5 percent of traffic (Bole 1997). In the central Puget Sound region, heavy and medium trucks generated approximately 6.2 percent of the vehicle hours in 1998 (Outwater 2001). The percentage is smaller during peak commuting hours and larger during off-peak periods, especially late at night when most people are asleep and the roads are more reliably clear of congestion.

Compared to railroads, trucks are dominant. In California, trucking dominates shipments more than in the rest of the nation, capturing over 60 percent in ton-miles of California's shipments, compared to less than 40 percent for the nation as a whole. Trucks also capture the higher-value shipments, such as electronics. In California, trucks carry more than 67 percent of the value of all shipments (Deakin, et al. 2001).

Truck movements support the economic vitality of a region. Freight—including goods, cargo, packages, construction materials, bulk commodities, and outgoing waste material—encompasses the things that factories, offices, warehouses, stores, and households make or in some way prepare for shipment elsewhere. Freight also encompasses the things that factories, offices, warehouses, stores, and households need to receive and use. Because cities grow in parallel with an ongoing increase in the specialization of labor, many needed things are produced elsewhere. Human life in advanced economies depends on the food, clothing, construction materials to build shelter, fuel, medical supplies, tools, and other essentials that move as freight. Economic prosperity, our way of life, and many of the pleasures of living beyond the bare essentials are also supported by freight movement. Human survival, sustainability, and progress as most people understand these concepts require that freight transportation exist and work well.

Federal law requires U.S. regional transportation planning organizations to focus on the movement of freight as well as people. In response to that mandate, regional transportation planning for freight in the United States has put most of its emphasis on increasing the efficiency of *intermodal freight in support of trade between regions*, that is, the regional contribution to the movement of goods between cities, nations, and continents. The central contribution of long-haul shipping to trade and economic prosperity and the availability of data on interstate and international commerce are the cause of this focus. For urban planning, this emphasis means examining and improving how freight moves *into and out of urban areas* and *between modes within an urban area* as part of a long-distance journey. This leads to the visible emphasis on freight movement across the northern and southern boundaries of the continental United States and into and out of marine ports.

As the economy becomes more global, products increasingly move between nations and continents, as well as between cities within the nation. All modes of transport are involved. Ships and barges, railroads, trucks, pipelines, and airplanes are important means of freight movement. Focusing on trade-related freight leads one to study the movement of freight in and out of marine docks, airports, and rail yards, as well as the passage of large trucks along the interstate highways connecting cities. A map of the United States illustrating the flow of freight movements by truck between metropolitan areas is shown in Figure 1. The thickest lines, of course, follow the Interstate Highway System.[2]

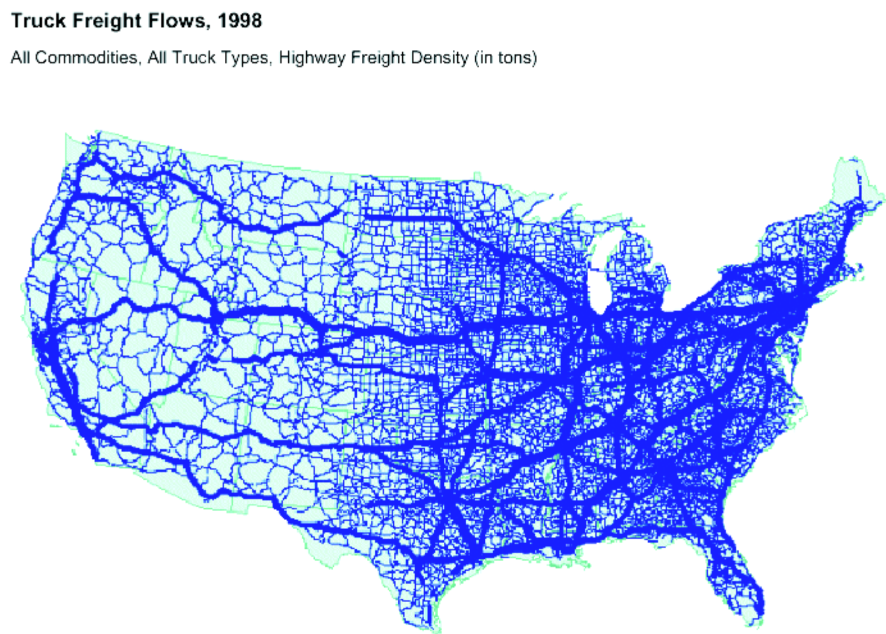

Figure 1: Nationwide Truck Freight Flows

Source: Ohio DOT at http://www.dot.state.oh.us/planning/Studies/Freight/freight_default.htm

Similar maps exist for railroad freight and for the portion of freight that moves through seaports for transport by ship. Less examined by transportation planners, typically, is the process of *moving freight within the confines of urban areas*. Here, trucks are dominant, with some exceptions. One exception is certain liquid and gaseous products—water, natural gas, sewage, some industrial wastes, and liquid petroleum products— that move in pipes. Short-line railroads move some material within cities, and conveyer belts move some coal and gravel. When modes other than trucks are part of freight movement to destinations within a region, there usually are intermodal transfer points where freight is transferred to or from trucks.[3] Examples where trucks are part of intermodal transfers include gasoline delivered to retail filling stations from pipeline terminals, air-express packages moved to and from airports, new automobiles delivered to car dealers from marine and rail terminals, and standard shipping containers moved to and from warehouses from both marine container ports and intermodal rail terminals.

An illustrative map of truck flows within one urban region of the United States, Seattle-Tacoma, is shown in Figure 2.

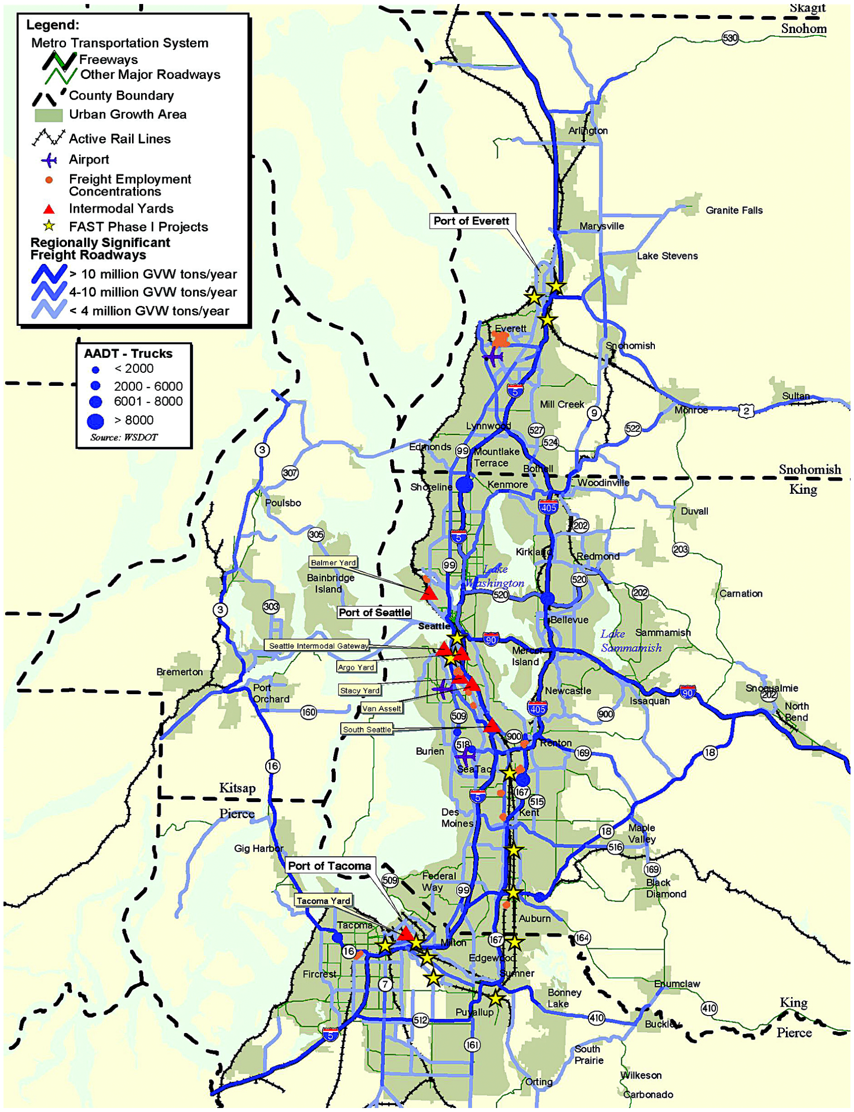

Figure 2: Puget Sound Regional Truck Volumes

Source: FASTRucks Study, Washington State Department of Transportation

The *Mobility 2001* report[4] describes several specific benefits to an urban region that come from freight mobility:

- Manufacturers and distributors obtain raw materials, parts, subassemblies, and complete products from distant sources.
- Firms consolidate production and goods distribution services to achieve economies of scale and sell to a larger market.

- Individuals obtain food, energy, construction materials, and other goods reliably at costs of time and money that do not discourage development and growth.
- Producers and individuals send and receive packages and other shipments of different sizes without excessive cost or time.
- Metropolitan areas grow larger because economies in freight delivery support scale and density in public services, production, housing, and other economic sectors.
- Metropolitan areas can have lower density through easy transport of goods within the region.

These benefits are thought by those associated with the trucking industry to be under-appreciated in public deliberations about transportation investment. In Washington State, those professionals focused on maintaining freight mobility are fond of saying, “freight doesn’t vote.” A civic leader in Oakland, California lamented to a journalist, “I don't think anybody in the position of decision making or anybody in the position of power has spent any time thinking about how goods are moved. They think goods get to Kmart in a taxicab.”[5]

This study is a reaction to the lack of public appreciation of freight issues.

INTRODUCTION TO URBAN FREIGHT MOVEMENT

This project seeks to characterize freight in ways that support planning and policy improvements that maintain and improve intraurban freight movement. Our intent is to elucidate some key characteristics of urban freight movement, for example, growth in vehicle volumes, the expanding number and dispersion of urban origins and destinations, changes in vehicle size, variations in vehicle loading, and the requirements of timing for deliveries and pick up. We will show the design of a planning tool that displays the key characteristics of intraurban freight movement and thus points to public policy changes that reduce the social cost of urban freight movement.

Professor Kenneth W. Ogden of Australia has written a comprehensive book on urban freight, *Urban Goods Movement: A Guide to Policy and Planning* (Ogden, 1992). We will draw from, build upon, and extend Ogden's work to provide some initial structure to urban freight issues.

In this chapter, we first describe basic supply and demand factors in urban freight, then discuss logistics, identify the supply factors in freight movement, look at the interaction of supply and demand in truck movement, and end with a discussion of the scope of the proposed regional freight logistics profile.

DEMAND FACTORS IN FREIGHT MOVEMENT

There are three demand factors in freight movement: what is moved; the places between which goods are moved; and business processes governing movement, including the timing of movement.

Goods

The first element of demand in freight movement is the type of goods that are moved, that is, what the trucks are carrying. We are interested in finding enough detail about the cargo moved within cities to understand what influences the movement of trucks.

Standard, comprehensive categories of what trucks carry are provided by the Census Bureau's Standard Transportation Commodity Classification code (STCC) from the Commodity Flow Survey and Principal Products Carried classification from the Truck Inventory and Use Survey (TIUS), as shown in Table 2.

Table 2: U.S. Census Bureau Comprehensive Category Lists for Truck Contents

STCC		1992 TIUS – Principal Product Carried	
1	Farm Products	1	Fresh Farm Products
		2	Live Animals
8	Forest Products		-
9	Fresh Fish and Other Marine Products		
10	Metallic Ores	4	Mining Products
11	Coal	4	Mining Products
13	Crude Petroleum, Natural Gas	10	Petroleum and Petroleum Products
14	Nonmetallic Minerals, excluding Fuels	5	Building Materials (sand, gravel, concrete, flat-glass, etc.)
19	Ordnance and Accessories		-
20	Food and Kindred Products	3	Processed Food
21	Tobacco Products		-
22	Textile Mill Products	17	Textile, Apparel, Leather Products
23	Apparel	17	Textile, Apparel, Leather Products
24	Lumber and Wood	6	Logs and Forest Products
		7	Lumber and Fabricated Wood Products (except furniture)
25	Furniture and Fixtures	16	Furniture or Hardware
26	Pulp and Paper	8	Paper Products
27	Printed Matter	8	Paper Products
28	Chemicals	9	Chemicals/Drugs
29	Petroleum and Coal Products	10	Petroleum and Petroleum Products
30	Rubber and Plastics	11	Plastics and Rubber Products
31	Leather	17	Textile, Apparel, Leather Products
32	Stone, Clay, Glass & Concrete	5	Building Materials (sand, gravel, concrete, flat-glass, etc.)
		26	Glass Products
33	Primary Metal Products	12	Primary Metal Products
34	Fabricated Metal Products	13	Fabricated Metal Products
35	Machinery, excluding Electrical	14	Machinery
36	Electrical Machinery	14	Machinery
37	Transportation Equipment	15	Transportation Equipment
38	Instruments		-
39	Miscellaneous Manufacturing	27	Miscellaneous Manufacturing Products
40	Waste and Scrap	21	Scrap, Refuse, Garbage
41	Miscellaneous Mixed Shipments	20	Mixed Cargo
42	Empty Containers		-
48	Hazardous Waste	29	Hazardous Waste (EPA)

Source: Jack Faucett Associates, 1999

Merging everyday experience with the comprehensive lists in the table above, a preliminary simplified categorization of the most significant types of freight found in intraurban transport follows:

- Packages and mail for offices and households
- Food and beverages for grocery stores, restaurants, and other meal service facilities
- Appliances and furniture for households and offices, both deliveries of new furniture and moving of existing items
- Office supplies
- Automobiles and other motor vehicles
- Construction materials
- Other stock bound for retail stores and other walk-in supply and service facilities
- Fuels, including gasoline, diesel fuel, and home heating oil
- Other factory output (finished goods)
- Factory input (raw materials, parts, subassemblies, and packaging materials)
- Trash, refuse, garbage, recycling
- Full and empty cargo containers moving between points of unloading/loading/intermodal movement, known as drayage

The Regional Freight Logistics Profile developed and described later in this report provides a place to indicate categories of freight as part of fleet descriptions.

The economy of metropolitan areas provides an increasing variety in the goods that consumers and businesses demand. While volume of food per household per day may not be changing much, the variety of food items is expanding. For example, the number of different items in an average grocery store grew from 10,000 in 1980 to more than 30,000 in the mid-1990s (McKenna, 1995).

While an office complex may require an ongoing volume of pens, pencils, paper, and other office supplies, the variety of pens, papers, and other office supplies demanded and used in offices has increased, and the rise of the office supply superstore has occurred. Because of the variety that the market can and does produce in parallel with demand, and the ability of computers and electronic data flows to keep track of a larger number of separate items, there are more kinds of distinctly different goods (each separate kind is known in retail as a different stock-keeping unit or SKU) that make up freight flows.

Ogden (1992) claims that the volume proportion of most categories within the total freight mix has not changed much over time as the economy and freight volumes have grown. However, a few specific categories, such as packages for express delivery, are increasing relative to the others.

Land Use

The second element of demand is land use, meaning the homes, offices, stores, factories, and warehouses, both where goods originate and where they are delivered. Complicated business processes such as production systems and supply chains are embedded in land use, but we will seek simplifications as much as possible.

A preliminary categorization of land uses in a metropolitan area includes the following:

- Housing units, including single-family and multiunit
- Retail stores and service facilities, including restaurants, hotels, and hospitals
- Office buildings, including government and schools
- Factories and processing facilities, including laundries and printers
- Wholesale distribution centers and other short-term warehouses where goods arrive and leave actively, including post offices
- Long-term warehouses and storage facilities, where goods are stored for weeks or months
- Truck depots (sometimes adjacent to warehouses) where trucks are stored and dispatched
- Sports arenas, fairgrounds, convention centers, and other temporary exhibition venues
- Refuse transfer stations, recycling centers, landfills, waste treatment plants
- Construction sites
- Intermodal terminals (airports, seaports, rail terminals, pipeline terminals)

This categorization is a starting point for the design of the RFLP later in this report.

Figure 3 illustrates how commercial trips are distributed across land uses in an unnamed metropolitan area that was studied. Home base refers to a distribution center, motor pool, or other garage from which trucks are dispatched each workday.

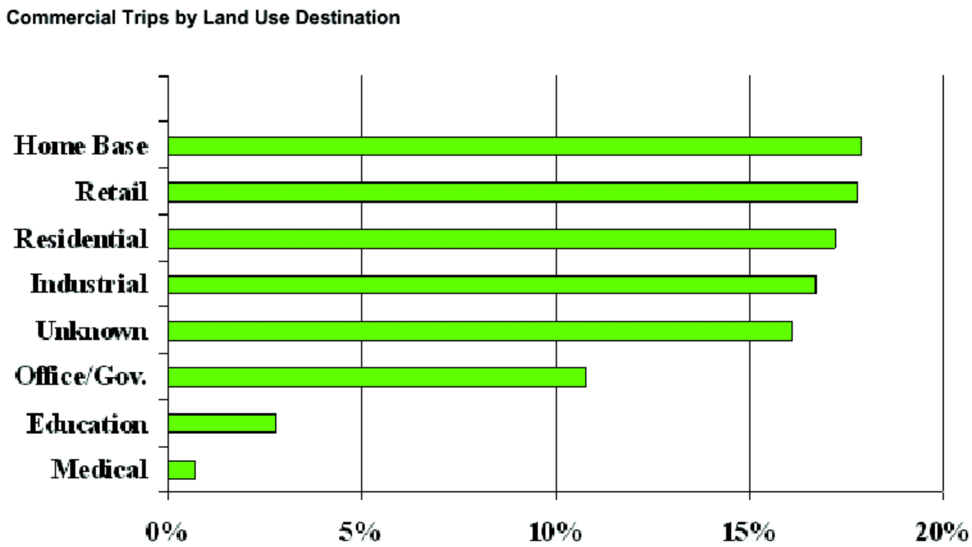

Figure 3: Typical Commercial Truck Trips by Land Use Destination

Source: Michael Meyer, http://www.fhwa.dot.gov/freightplanning/meyer.htm

According to Ogden, based on data from a decade ago, the proportion of trips that is generated by each different land use appears to be fairly stable. This generalization needs to be verified in the present day in regions of interest. He also noted that more suburban locations for the origins and destinations of freight resulted in truck trips increasing in length over time.

Another land use distribution issue is the growing volume of package delivery to private housing units as online shopping grows. This is the result of more online and mail-order catalog shopping by consumers, telecommuters working at home, and business owners.

Business Processes

A demand factor not delineated by Ogden is the effect of business processes, the methods by which businesses carry out their work. Business processes influence the timing, quantity, and packaging characteristics of freight movement, such as day of week, time of day, frequency of delivery, speed of delivery, and package sizes. For example, one restaurant may keep food delivered on Monday in refrigerated storage so that it is still fresh on Wednesday. Another restaurant may want fresh food delivered every day. One office may assign a person to help a delivery truck driver unload an arriving shipment. Another office may have no such person and may be situated in a building with a small elevator that allows only handcarts of a certain size, so that multiple trips in the elevator are required by the delivery driver.

LOGISTICS

A general term for an important category of business process that impacts the demand for freight is *logistics*, defined overall as "the process of planning, implementing, and controlling the efficient flow and storage of raw materials, in-process inventory, finished goods, services, and related information from point of origin to point of consumption (including inbound, outbound, internal, and external movements) for the purpose of conforming to customer requirements."[6] *Supply chain management* is a nearly synonymous term. *Transportation management* is the subcategory of activity within logistics and supply chain management that is of interest in this study.

Traditionally, logistics is inventory-based, following a "push" model, in which factories or distribution centers push goods out to fill inventories further downstream toward customers. If factories are fast and flexible, and if communications and transportation can operate faster and in coordination, the model can shift gradually to one in which customers order what they want directly from factories and distribution centers. Goods are then made specifically on demand, or "pulled" from stock, to fulfill customer orders and shipped directly to them. Rather than having goods pushed on them by overstocked stores and supply systems holding sales and offering bargains, retail customers pull what they want for replenishment of their needs when they want.

According to a study commissioned by FHWA[7] "inventory-based logistics prototypes still dominate among most large-scale manufacturing and distribution firms. Inventory-based logistics also represents the primary model for 'E-tailing' (Internet-based retailing): national or regional warehouses supplying home and business delivery with airfreight and package delivery services." The FHWA study continues: "The manufacturers and retailers we interviewed believed that replenishment-based logistics systems offered efficiency versus traditional inventory-based models, but were reluctant to risk the increased stockouts perceived to accompany replenishment models. We found little evidence of pure pull systems in high-volume logistics applications. The companies interviewed did not anticipate a major shift over the next decade, but rather a gradual expansion of pull systems in response to increasing pressure to improve customer service and still reduce inventories."

Note that a single supply chain of goods can encompass both push and pull elements. In other words, a large central warehouse in a metropolitan area may pull inventory for the retail store chain it serves in a replenishment mode of operation, then push the inventory it acquires out to the stores as rapidly as possible. The opposite configuration also can exist. Various manufacturers could push inventory to a wholesale company with a large warehouse, but the warehouse serves a variety of stores with rapid delivery of what the store managers order and pull out. This is analogous to the differences between household members who buy groceries as needed on the way home and those that have large storage cabinets of food bought in response to the availability of bargains at grocery stores.

Logistics is a business process that evolves over time under the influence of many nontransportation factors but also is influenced by transportation public policies that impact the access to each physical location of the firm. Such public policy influences the availability and quality of road infrastructure, the cost of shipping as impacted by the level of road-related taxation, and the timeliness of deliveries influenced by the level of road congestion.

Features of Modern Logistics

Many reviews of the transportation implications of logistics describe the following features that influence the movement of freight in the gradual evolution from push to pull logistics.

Centralized warehousing: Businesses are finding that they improve efficiency by reducing the number of warehouses for storing and distributing products. This lowers the inventory levels but also increases the lengths of delivery trips leaving from warehouses (Cambridge Systematics 1995).

Warehouses have become more active as sorting and distribution centers, with trucks coming and going with more frequency. Large multiacre locations where goods can be moved from dock to dock quickly and trucks can get in and out without facing frequent congestion become a much-sought resource. Such facilities are more compatible with low-density suburban areas than with high-density central cities.

Crossdocking: A growing trend in warehousing is crossdocking, a flow of freight through a warehouse characterized by goods arriving on one loading dock by truck, quickly sorted, and within hours directed to another dock where a second truck waits to take them away.

Warehouses on wheels: The flow of goods from factories to point of consumption can be managed tightly by telecom and computers, to the point that inventories can be managed even while in motion aboard airplanes and trucks.

Harry Caldwell, chief of the Freight Policy Team at Federal Highway Administration, says, "Using the transportation system as a form of rolling warehouse allows the private sector to reallocate its resources away from warehouse maintenance and leasing to basic and applied R&D, equipment development, and worker training and retraining. . . . But as levels of congestion increase on our nation's transportation system, higher levels of unreliability and unpredictability are created, and that causes true problems for U.S. companies that have to rely on the system as a dependable asset."[8]

Just in time: In manufacturing, more delivery activity and smaller inventories is called just-in-time (JIT) supply. In retailing, this pattern is called *quick response*.

As reported by Cambridge Systematics in its 1995 review for the NCHRP, “JIT systems focus on keeping inventories at minimum levels through a coordination of input deliveries with production schedules. Adopting a JIT system usually results in increasing the frequency with which inbound shipments are scheduled, decreasing the lead times for these shipments and their size, and increasing the importance of receiving these shipments on time. Firms adopting JIT systems frequently reduce the number of suppliers and transport companies with which they deal, and they require suppliers that are close enough to be able to deliver shipments reliably within the constraints of short lead times.”

In retail quick response (QR), the stock in a store is minimized. Replenishment of stock may be triggered by the supplier keeping track of sales of each item. Express package delivery is used by some retailers to obtain needed items.

The effect of JIT and QR in reducing the relative importance of inventory cost in logistics is seen in the shrinking share of GDP the inventory costs represent in the U.S. economy. This is shown in Figure 4 where the blue line has dropped lower since the early 1980s.

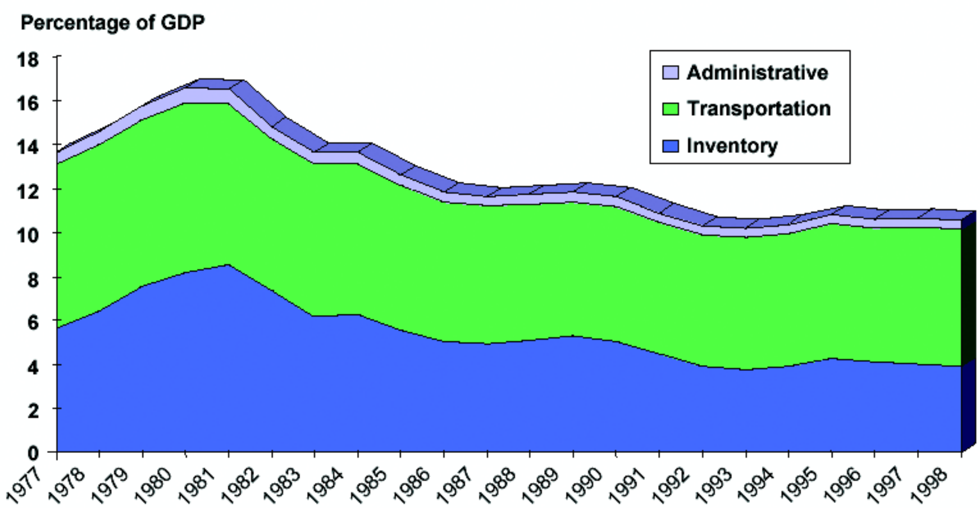

Figure 4: Logistics Expenditures in Relationship to Gross Domestic Product

Source: Prologia and Cass Information, Inc., *12th Annual State of Logistics Report*, June 4, 2001.

Customer use of service options: The package delivery industry—including Federal Express, Airborne Express, the U.S. Postal Service, and United Parcel Service—now offers several grades of guaranteed delivery speed. Service grades include first day morning, first day afternoon, second day, and three day, a gradation that leads to more and more truck delivery runs by these competitors throughout the business day and even on weekends.

The emphasis on fast, guaranteed delivery times leads to the dispatch of more trucks carrying only partial loads, instead of waiting for enough cargo to fill a truck up. When common carriers are involved, Internet applications have been designed to facilitate the creation of transportation capacity brokerages that buy and sell available capacity on trucks that would otherwise move out with only partial loads.

Electronic commerce: The use of electronic messages in maintaining relationships and fulfilling transactions is increasingly a feature of logistics and other business processes. E-commerce is a growing feature of consumer relationships with business, but is even more a feature of business-to-business transactions. The World Wide Web and electronic mail make out-of-town sources of supply more visible and accessible to customers in homes, businesses, and institutions of all kinds. More online and telephone ordering by households and businesses feeds and facilitates the growth in package shipments over long distances, reducing intermediate local stockpiles of goods (Browne, 2001).

SUPPLY FACTORS IN FREIGHT MOVEMENT

Returning to Ogden's analysis, we can identify three supply factors in freight movement: road networks, truck characteristics, and nonroad networks. We reclassify Ogden's "truck movement" supply factor as the result of interacting demand and supply factors.

Road Networks

The first supply factor, the road network over which freight travels, makes up the paths that freight follows as it moves. As with passenger vehicles, truckers gravitate wherever possible to the use of limited-access highways and arterials, in order to move faster. Because deliveries by truck are made at least occasionally to every developed location, urban freight travels on almost all roads at least some of the time. Exceptions can be found. Some metropolitan areas have parkways with truck restrictions because of lane width or height impediments. Many locations have particular road segments where certain types of trucks are banned by regulation because of noise, height, width, length, weight, or type of cargo. Limitations of bridges and tunnels are a common cause of restriction. Some regions and jurisdictions designate a subset of major roads and highways as truck routes for which special accommodations may have been made, such as traffic-light timing that recognizes the acceleration and braking characteristics of heavy trucks.

Truck Characteristics

The second supply factor is the trucks themselves. Our emphasis in this report is on trucks used commercially for moving goods, not the growing volume of smaller trucks used primarily for personal travel with the cargo area used for personal belongings. Personal travel, the bulk of urban movement, is already covered by MPOs with existing modeling and planning tools. Therefore, trucks used for personal travel, including the movement of employees on business such as repair or inspection, are outside our scope. This exclusion also encompasses trucks, vans, and SUVs that individuals use to bring home goods such as groceries, furniture, or construction supplies for their own household consumption.

The modern economy and its resulting lifestyles have produced a set of new consumer services directed at the home that did not exist previously in their present scope and volume. A house is becoming technically more complex, and the busy working people who live in houses cannot always maintain the features and systems themselves. Such services include home security; telephone, cable TV, and satellite antenna installation; landscape services; housecleaning; food delivery; used goods pickup; and package delivery. Businesses rely on services that are even more extensive and specialized, including equipment maintenance services. Although service delivery is an important component of traffic volumes, our focus here is on the services that incorporate the movement of material (including waste) that requires the use of trucks that are larger than cars and thus are distinctly truck-like.

Therefore, a Sears appliance repair van is not within our scope, but a Sears truck delivering and installing an appliance is within it. A post office or FedEx delivery truck or van is of interest here, but the van of a plumber or electrician is not. Within any category of delivered goods, we will classify the vehicle in or out of our scope based on the dominant vehicle type. For example, most pizzas are delivered in cars; therefore, we will not focus on the relatively small number of pizza delivery trucks that flow in a city. Landscape and tree service trucks would be counted in our scope of concern because of the vehicles' size.

In general, we consider trucks with more than two axles or more than four tires to be carrying freight, whereas many (but not all) smaller trucks are for personal or business-related human mobility. We exclude rental trucks of any size employed by individuals for short-term moving but include leased trucks of any size used by stores and other businesses for deliveries.

Because there are gray areas between car use and truck use in service delivery that also includes goods, the final determination of what counts in or out of the RFLP is a subject for future refinement.

Classification by Size

The *Quick Response Freight Manual* (Cambridge Systematics 1996) provides the following basic, three-way classification of trucks by size:

- Light Trucks: Four-tire commercial vehicles, including delivery and service vehicles. Pickups and vans fall into this category.
- Medium Trucks: Single-unit trucks with six or more tires.

- Heavy Trucks: Combination trucks consisting of a power unit (truck or tractor) and one or more trailing units.

Ogden (1995) reports a growing preponderance of heavier (larger) trucks in urban freight movement, although other fragmentary evidence (U.S. DOT 1995) suggests the opposite. There is logic on both sides.

A rising proportion of smaller trucks would be suggested by just-in-time logistics delivering smaller quantities more often and the need for vehicle maneuverability in growing traffic congestion. Larger trucks are suggested by driver shortages, the goal of increasing driver productivity through economies of larger vehicles, the goal of improving energy efficiency, the influence of third-party logistics services with multiple clients, and the growth of high-volume, lightweight packaging techniques. Actual measurement proposed later will show which trends predominate.

On the last point, a technological trend in packaging is the increasing use of high-volume, lightweight plastics such as styrofoam and bubble wrap (Cambridge Systematics 1995). Reportedly, this has caused shipments of manufactured goods to have a lower average density and thus to require bigger trucks to carry the same weight of products.

Classification by Shipment Size and Truck Ownership

Truck owners include individuals and organizations. Owners of trucks who carry freight for a fee fall into four segments: truckload (TL), less-than-truckload (LTL), package express, and logistics (National Research Council, 1999).

- TL carriers move shipments weighing over 10,000 pounds and averaging 27,000 pounds from one location to another, with each load occupying the cargo area exclusively.
- LTL carriers move shipments weighing between 150 and 10,000 pounds, with multiple shipments occupying the cargo space. They try to consolidate loads and coordinate deliveries.
- Package express refers to carriers like FedEx and UPS who move shipments weighing less than 150 pounds, often in conjunction with overnight air shipment between cities.
- Logistics, or “third-party logistics” (3PL), is a new category of firms that appeared in the past decade. 3PLs provide a comprehensive suite of freight-moving services, using different vehicle sizes and modes as needed to provide the most efficient service. The previous three categories of firms are increasingly offering logistics services. For example, package express carrier UPS provides logistics service to Ford Motor Company and is responsible for moving all its new cars from the factory to the showrooms (Mitchell 2001, pp. 21-28).

In addition to firms that carry freight for a fee as a business, there are private carriers that are part of the operations of a firm that generates a freight movement requirement. Firms such as Frito-Lay, Safeway, and Boeing own the trucks that carry the firm's goods as part of a business process that includes distribution of product to customers and transfer of goods between the firm's different locations. According to the trade association National Private Truck Council (NPTC), corporate or "private" truck fleets are operated by manufacturers, distributors, processors, and retailers to meet their inbound and outbound transportation needs. Such fleets include food, retail, wholesale, construction, and service companies. NPTC reports that the two million vehicles in the private motor carrier fleets account for approximately 82 percent of the medium- and heavy-duty trucks registered in the United States and generate approximately 53 percent of all the U.S. miles traveled for medium- and heavy-duty trucks. In other words, private fleets make up the largest segment of the trucking industry.[9]

Nonroad Network

A third distinct supply factor in the analysis of freight is the nonroad transport network, meaning infrastructure and associated vehicles for transporting goods on nontruck modes, such as the pipelines, railroads, shipping lanes, and airways between cities. From the urban freight point of view, the main interest in the nonroad modes and networks lies in the necessarily limited number of intermodal terminals providing the points of freight transfer between the nonroad modes and trucks. Such terminals are marine ports, airports, intermodal railroad yards, and access points to pipelines.

INTERACTION OF SUPPLY AND DEMAND: TRUCK MOVEMENT

The ease of trucks' movement over the road network is the freight issue of most interest for regional transportation planning organizations and the citizens and businesses that reside in a region. Therefore, we are interested in characterizing the efficiency of truck movement for planning and policy purposes.

Most freight traffic in the United States is local and regional, as opposed to interstate and intercity. As reported in the *Quick Response Manual,*[10] the coding for "range of operation" in the Bureau of Census' Truck Inventory and Use Survey reveals that "about 36 percent of the vehicle miles traveled by trucks occur on trips of less than 50 miles, and an additional 30 percent fall into the category of 50 to 200 miles. Moreover, 95 percent of all trips are less than 200 miles in length, with 81 percent less than 50 miles. Thus, the majority of all truck trips are local, and most vehicle miles can be considered local."

As noted earlier, the best data exist for intercity trucking because of data collection supporting interstate commerce regulations and truck weight monitoring. The trend of growing freight movement generally is indicated by the measurement of ton-miles of freight per capita moving in intercity trucks, as shown in Figure 5.

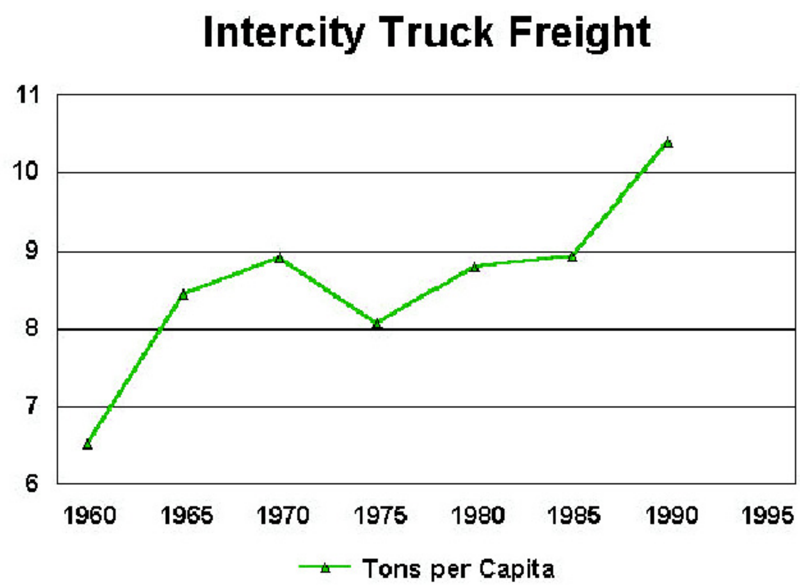

Figure 5: U.S. Intercity Truck Freight Volumes

Source: U.S. Census Bureau

Intercity truck freight, as illustrated above, is around 10 tons per capita, with a growth trend as of 1990. The magnitude of intracity freight in the 1990s was larger, estimated as 21 tons per capita in 1993 and 24 tons in 1997, using the Commodity Flow Survey data of the Census Bureau for shipments less than 50 miles on all modes, which for this short distance overwhelmingly means trucks.

Urban trucks tend to move during the normal business day with an hourly pattern that indicates an attempt by commercial firms to avoid peak commuting hours. An example of a pattern detected by Michael Meyer in an unnamed region is shown in Figure 6.

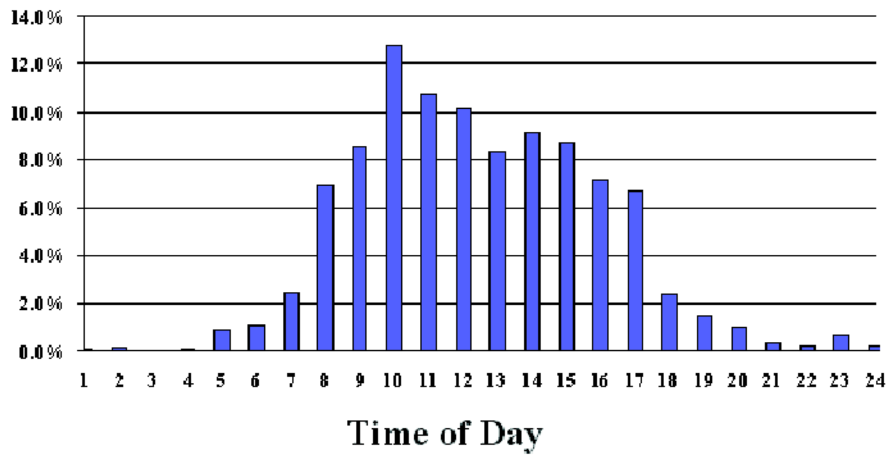

Figure 6: Typical Truck Trip Distribution by Time of Day

Source: Michael Meyer at http://www.fhwa.dot.gov/freightplanning/meyer.htm

Truck Movement Categories

Truck traffic in a metropolitan region can be logically divided into four categories:

Through trucks: Trucks entering and leaving the region within a few hours or so (transitting), without a transaction related to the cargo. (However, there may be a stop for driver rest/relief or vehicle fueling.) For example, a truck traveling from Vancouver, Washington, to Vancouver, British Columbia, along interstate highways.

Interregion shuttle traffic: Trucks that travel between a single destination in the region and points exterior to the region. For example, picking up containers at the Port of Seattle and taking them to Wenatchee or truck traffic in the opposite direction.

Intraregion shuttle traffic: Trucks that travel back and forth between two major facilities, such as intermodal facilities and distribution centers. For example, picking up containers at the Port of Tacoma and shuttling them to distribution centers located in Kent, a city north of Tacoma with many such facilities. Shuttle traffic is also called drayage.

Generally in-region, multiple-stop, urban pick-up/delivery: This pattern represents what can be called urban delivery tours, of which there is a main case where trucks remain within the region of interest and four variations where trucks work outside the region as well as within.

1. *Urban delivery tours, main case*: Trucks that begin every workday at an in-region fleet depot, office, or driver's home, conduct multiple transactions within the region, then return to the starting point at the end of the work period, typically one day.
2. *Urban delivery tours, variation one*: Some of the stops may be outside the region, although the daily tour returns back to the starting point in the region. For example, a UPS fleet in a metropolitan area that provides some delivery services beyond the boundaries of the metro area.
3. *Urban delivery tours, variation two*: Trucks enter the region and travel to multiple transactions, and then leave the region. Trucks in such a pattern could be based at nearby depots outside the region or might arrive sporadically from far away. For example, a truck from Wenatchee, Washington, an agricultural center, delivers fruit to multiple warehouses, then returns to Wenatchee.
4. *Urban delivery tours, variation three*: Trucks that begin the work cycle in the region, conduct transactions at one or more regional locations, then leave the region to return one or more days later. For example, a common carrier truck starts from a depot, picks up freight at three locations around Seattle-Tacoma, then proceeds to Portland, Oregon.
5. *Urban delivery tours, variation four*: Trucks that enter the region near the end of a work cycle, conduct one or more transactions, then are parked for a period before beginning the next work cycle, which will involve more in-region transactions, then leaves the region. For example, a common carrier truck arrives from Spokane, delivers its cargo to four locations, then parks at its owner's depot in Seattle, awaiting the next assignment.

Ogden reports that the distance traveled by truck in a day has increased along with truck trip length, but he notes that total daily trips per truck do not appear to have changed much. This indicates that the distance between stops on a daily tour has become longer.

Each particular type of truck cargo has a distinct and often multitrip movement pattern within the urban area. The combination of goods and land use generates the freight that needs to be transported, with variation between goods and firms transporting goods that result in a variety of movement patterns. For example, gasoline may enter an urban area via a pipeline and be transported by tanker trucks between pipeline terminals and retail filling stations. Heating oil is transported between storage depots and homes. Groceries, clothing, and hardware may arrive from outside the region to a distribution warehouse, then be transported to retail outlets. Construction materials are transported between supply yards and building sites. Trash trucks pick up at homes and take their contents to transfer stations. Larger trucks move trash between transfer stations and a landfill, incinerator, or a railroad yard. When trucks lack a back load of returned merchandise or some other cargo, they travel empty.

Origins and Destinations

More generally, truck movements can be characterized by origins and destinations that fall across land use types, as described earlier. The land use types also have a relationship with sectors of an urban economy. A representation of these sectors, with an indication of the geographic positioning of the sectors vis-a-vis an urban region, are shown in Figure 7. Each symbol represents a land use type and corresponding freight origin and destination type within a region, except for the symbol at the upper left, which represents freight origins/destinations outside the region of interest. The regional land use types represented are factories; warehouses/distribution centers; retail and service locations; residential (homes); and intermodal terminals.

Factories (F): Includes the major institutions of the manufacturing sector, including materials processing and food processing. The distinguishing characteristic is a high volume of inbound and outbound goods that are distinctly different.

Warehouses (W): Includes warehouses, distribution centers, package and mail sorting centers, break bulk facilities where goods inside shipping containers are removed, and the like. The distinguishing characteristic is a high volume of inbound and outbound goods that are largely the same goods, although the packaging and load sizes may differ.

Retail and Service (R): Includes stores, professional supply houses, restaurants, hotels, commercial and government offices, medical and educational facilities, and other facilities where individual customers go to purchase goods or where goods are consumed by workers. The distinguishing characteristic is a large supply of inbound goods that are purchased and taken away by customers in personal vehicles or used on the premises. A further breakdown of this category may emerge later in the study. Currently, sports arenas and exhibition centers are included in this category.

Residential homes (H): All houses and housing units are in this category.

Intermodal terminals (I): Places where truck cargo is loaded for shipment on other modes of transportation, such as railroad cars, marine ports, and airports.

Origin-Destination Flow Types

The arrows in Figure 7 represent freight flows between land use types by truck. Thicker arrow lines represent higher-volume flows. The arrowheads indicate the predominant directions of flow, although the flow is bidirectional in all cases. We can identify 11 different freight flows, as depicted in the diagram.

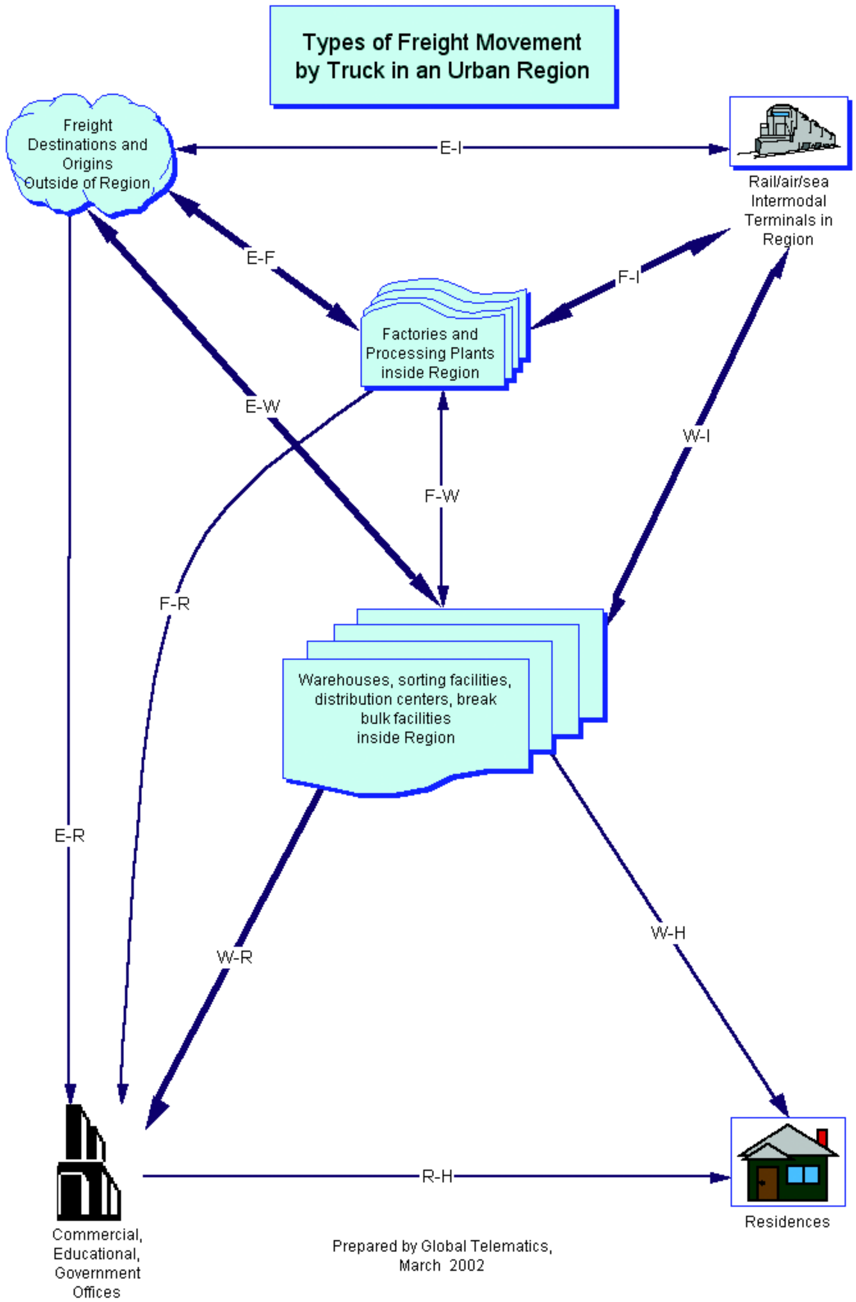

Figure 7: Types of Freight Movement by Trucks in an Urban Region

External—Factories (E—F): Raw materials, parts, and subassemblies flow from sources external to the region direct to factories. The output of factories, including processed materials, parts, subassemblies, and finished goods, flows from factories to destinations outside the region.

External—Intermodal (E—I): Since intermodal terminals such as seaports and airports typically serve a larger area than the immediate urban region, trucks flow to and from the terminals from outside the region.

External—Warehouses (E—W): In many circumstances, distribution centers send or receive goods beyond the urban region in which they are situated.

External—Retail & Service (E—R): Retail stores and offices may have deliveries from trucks coming in from external to the region, for example, if a wholesaler is located in a different city.

Factories—Intermodal (F—I): Some factories ship their output, or receive their input, directly by truck via an airport, seaport, or railhead.

Factories—Warehouses (F—W): Most factories receive some or all of their raw materials, parts, or subassemblies from local warehouses and/or ship to local warehouses, in addition to receiving or making shipments external to the region.

Factories—Retail & Service (F—R): Some factories ship directly to retail and service locations within the region, for example, bakeries and fish processors shipping directly to grocery stores in some regions.

Warehouses—Intermodal (W—I): Some warehouses pack standard containers for shipment, which are then trucked to railheads and marine terminals in the region.

Warehouses—Retail & Service (W—R): Wholesale warehouses shipping to retail outlets are a major category of urban freight. Office supplies and packages arrive at office complexes from warehouses and sorting facilities.

Warehouses—Homes (W—H): Mail and overnight packages arriving at residential locations originate from warehouses and sorting centers.

Retail & Service—Homes (R—H): Appliance stores and pizza shops are examples of businesses that move goods direct to residential locations.

Not shown, but implicit in the diagram, are flows from one location in a category to a different location in the same category. For example, output goods at one factory can be loaded up and taken to another factory (F—F), or there can be a shipment of retail goods from one central warehouse to a distribution center at another location (W—W).

Shipping containers can flow from seaport to railhead (I—I). A library or bookstore or company with multiple locations can ship books or other materials from one branch to another (R—R); a moving company can move furniture between two end-user locations (H—H) or (R—R).

Materials for building construction can fit into any of these patterns. Refuse removal fits into the scheme with some reverse flows if landfills and incinerators are considered to be factories.

Sports arenas, conventions centers, hotels, and motels can be considered a special case of retail venue.

SCOPE OF THE REGIONAL FREIGHT LOGISTICS PROFILE

Our intent in the design of the RFLP is to create a tool that makes urban freight comprehensible to public sector transportation planners and policy makers. We want the RFLP to provide an overview of how truck traffic interacts with the more prevalent passenger traffic in cars and other personal vehicles. We want it to show MPOs how to measure and monitor trucks interacting with congestion—avoiding it, dealing with it, and causing it. To be useful, the RFLP must also provide some focus and direction on solving problems that are identified.

The RFLP will identify and account separately for trucks that are passing through the region as opposed to those that are conducting business by making stops for loading or unloading within the region. Those making stops can be divided into interurban and intraurban truck movements. Because of the relatively high number of intraurban truck trips compared to interurban, we will focus on the intraurban and treat the other types as context. Examples of the kind of trucks in which we are most interested are package services such as FedEx and UPS and retail delivery trucks such as Safeway, Frito-Lay, and beer distributors.

This project aims to create a tool that makes urban freight easier to understand. Ken Ogden claims, "To a greater degree than in urban passenger transport, the urban freight task is enormously complex and heterogeneous." (Ogden 1992, p. 4) Ogden's characterization may be overstated, since trucks originate in a more limited number of locations than automobiles and operate largely in a planned and controlled manner based upon economic rationality. Despite the variations across enterprise operations, the rationality inherent in truck movements may make them easier to portray and understand than personal vehicles that move about according to the daily scheduled and unscheduled activity demands of consumers.

What the RFLP Will Measure

The starting point for the RFLP is to provide documentation to MPOs, political leaders, and citizens on changes in operating patterns for delivery trucks on urban streets—how many trucks, what kind, where they go, and when.

Because of our focus on urban impacts, we will develop an approach that describes and quantifies truck vehicle flows between representative origins and destinations within a metropolitan area, rather than using commodity data. Commodity flow data are now collected every five years by the

Census Bureau, and these data establish the weight, economic value, and shipping distance of what is being moved by trucks down to the geographic level of metropolitan regions. For example, the 1997 Commodity Flow Survey establishes that 83 percent of the 100 million tons of goods shipped by truck from establishments in the San Francisco Bay Area was sent to destinations less than 50 miles away, a finding that again highlights the predominantly local nature of trucking (U.S. Census Bureau 2000). Commodity flow data can be analyzed to reveal the intercity and interstate patterns shown in Figure 1 on page 5, but the data are not sufficiently disaggregated to reveal any detail on truck movements between origins and destinations within a metropolitan region.

Whatever the value and weight of the load, the economic contribution of a truck is influenced by how congestion reduces delivery speeds and creates variation in arrival times. Rather than make the subjective determination of what is or might be sufficiently fast and reliable delivery of goods and services to dispersed locations in a congested travel environment, we will strive to measure the more objective and fundamental fact of the growth in the volume of urban trucks and where and when they make their delivery stops.

Taking the Seattle region as an example, the *Seattle Times* reports that the movement of freight between the separate industrial locations of Boeing is significantly impacted by traffic congestion.[11] An increasingly congested metropolitan area is building up over time among Boeing's operations dispersed within the central Puget Sound metropolitan area. The RFLP will be a tool that places Boeing's freight mobility problem in perspective. Year by year, how many trucks does Boeing dispatch, where do they go, when do they move? A Boeing freight manager revealed to the Puget Sound Freight Mobility Roundtable in January 2003 that the annual trip count for one kind of delivery truck used for interplant freight movement is down 24 percent from 1995 to 2001. On-time performance for these trip types is measured to be 96 percent. However, there is no ongoing context for measuring the performance and regional impact of Boeing's fleet or any other. By setting up a process to track the changes in the movement of key regional truck fleets, the RFLP tool contributes to the ability of decision-makers to ferret out whether deterioration in freight flows is such a significant problem that it can be considered a contributor to plant relocation decisions.

The choices that a truck-using firm has are industry- and enterprise-specific. The RFLP's method to measure and understand these is to track the visible impact of these changes by describing truck operating patterns, including time of day, routes, origins, and destinations, in a way that can be monitored for year-to-year shifts.

If FedEx wants to make package pickups in a central business district during the late afternoon peak period, they will have to deal with congestion, and so will a manufacturer putting trucks onto crowded road segments during the morning peak. We want the RFLP to fully recognize and measure the options that businesses have in dealing with increasing delays and variability. For example, manufacturers and other truck-dependent enterprises have the option of relocating their facilities. Service industries dependent on afternoon FedEx shipments that have increasingly earlier pickup deadlines have the option of moving closer to the FedEx terminal. Frito-Lay, Coca-Cola, and other food and beverage companies dispatching delivery trucks to retail outlets throughout the region have a choice on where to locate the dispatch point.

The RFLP will also be designed to reveal data that illustrate the phenomenon of firms relocating because of congestion, if the phenomenon exists. The rise of new firms on the metropolitan periphery will also be measured to illustrate the private sector response to the traffic congestion that makes locations in more central areas less efficient.

These companies have other choices that do not include moving facilities but rather making operational changes—using more trucks and drivers, changing hours, or forcing customers to change their expectations. We intend the RFLP to reveal these choices as well. The RFLP also needs to go beyond the economic effects of congestion on travel times and arrival variability. The story of freight from a comprehensive public policy perspective combines economic contribution and environmental externalities. The RFLP must consider all significant public policy issues, economic or environmental. For example, deterioration in air quality from diesel emissions is emerging as a public health problem in Seattle and other metropolitan areas.[12]

Any changes in truck operations, whether by private initiative or new government regulation to improve enterprise economic efficiency, may also change the level of environmental impacts. Examples include trucks making noise at an earlier hour, the volume of trucks increasing on particular streets, and changes at a delivery or dispatch point expanding its impacts on parking or local congestion in a neighborhood.

In addition to characterizing fleets and their movements, we see detailed descriptions of a representative sample of trucking activity nodes such as shopping centers (leading goods destination) and warehouse/distribution center clusters (leading goods origin and destination) as an important component of the RFLP. Learning how the number and location of these nodes change from year to year would be illuminating.

Regional entrances, start-ups, moves, and closings of truck-dependent businesses at the selected centers should be monitored in the RFLP, which becomes a starting point and prelude to in-depth investigations on the relationship of these business changes to congestion.

In focusing on specific locations, the RFLP should generate data that describe how trucking operations cause congestion around what might be considered inappropriate locations for a facility and its related truck operations.

PROBLEMS, ISSUES, AND OPPORTUNITIES

Our broad goal in creating the Regional Freight Logistics Profile is to support public policy design and implementation that improves the overall social cost-benefit ratio of urban freight [Ogden 1992]. This goal has two components: improving the economic performance that is the result of freight movement, and managing the environmental and other external costs of trucking in a socially beneficial way. Freight goals can also be examined by comparing the views of businesses using trucks with those of government agencies. After we examine these four components, we present a framework for analyzing freight and a preliminary design of RFLP coverage.

IMPROVING ECONOMIC PERFORMANCE

Reducing the costs of regional freight movement relative to other regions provides two economic benefits. First, a region gains a competitive advantage in shipping performance over other regions, which shows up in better business performance—lower prices or better service to customers, for example—resulting in enterprise growth and thus economic growth for the region. Second, enhanced shipping efficiency contributes on the margin to a higher regional standard of living, as resources formerly devoted to freight are freed up and reallocated to other demands.

With respect to regional competitive advantage, growing traffic congestion that slows the movement of freight or adds uncertainty to delivery times is a cost generator that takes regional freight performance in a negative direction. For example, rising urban traffic congestion can cause an afternoon deadline time for pickup by an overnight package delivery firm such as FedEx to be moved earlier so that trucks can reach the airport on schedule. If the FedEx office in a particular city needs to move up its package pickup deadline from 5 P.M. to 4:30 P.M., then the increasingly congested city becomes economically disadvantaged relative to other cities where congestion is not changing the deadline.

In regard to the effect on standards of living, if the cost of truck deliveries to retail stores for a particular region is unusually expensive, the costs of goods and services in those stores will tend to be higher. This means that the standard of living would be lower than in another region where trucking costs are lower.

MANAGING ENVIRONMENTAL AND SOCIAL COSTS

In moving freight and achieving the benefits that come from timely and efficient delivery of goods, trucks affect the environment surrounding their operations in ways that society judges as harmful for various reasons. For example, trucks cause pollution from their power train and brake lining emissions and generate noise and vibration beyond that generated by smaller vehicles; some people think they cause aesthetic blight.

Noise and vibration are exacerbated and objectionable to the degree that trucks operate at night and in residential areas. The need for operational efficiency and guaranteed delivery times will create more pressure for evening and late-night deliveries, when personal automobile traffic is less of a constraint on urban truck movement. On the other hand, increasing nighttime truck traffic in some North American jurisdictions has caused a political call for regulations that restrict night operations so that people who live near places where trucks deliver and move about do not have their sleep interrupted by truck noise.

Traffic Congestion

One obvious impact of truck movement is its contribution to traffic congestion on roads and highways, especially in peak periods. Trucks mixing with personal vehicle traffic contribute to congestion for all traffic. In stop-and-go traffic, large trucks disrupt the flow by acceleration and stopping characteristics that are markedly different from autos and small personal trucks. Large trucks also take up more road space than passenger vehicles.

Congestion results not only from trucks being on the road in peak periods, but also from the disproportionate number of accidents caused by heavy trucks. Truck accidents generate social and economic environmental impacts in the form of deaths, injuries, and property damage. Accidents can be significant because of the weight of the truck or as a result of a flammable or toxic load.

The public cost of providing and maintaining the road infrastructure that supports trucks can also be considered an environmental impact. Although most of the road use on most segments is personal vehicles, some characteristics of roads are the result of accommodating trucks. Examples of these characteristics include pavement that supports heavier vehicle weight and the special road geometry that accommodates the heights, acceleration, stopping distances, and turning radii of trucks.

Trucks can and do add to congestion on urban arterial streets because of inadequate facilities for loading and unloading at delivery points. Depending on the configuration of the facilities at a delivery stop, trucks may have to load, unload, arrive, or depart in ways that interfere with the movement of other vehicles on the public right of way. Poor facilities cause impediments to the flow of vehicles on public roads from intrusions of stopped trucks or from backups of waiting trucks, for example, loading zones along the curb can be inadequate, and there may be insufficient private truck parking for loading and unloading. Private passenger vehicles may illegally take up space meant for trucks in commercial loading zones if regulations are not enforced. In urban environments, trucks often are stopped for a delivery in a traffic lane.

Land Use

The last environmental impact from trucking that we will note derives from the linkage between truck transportation and land use. Trucking generates some characteristic land uses—fleet maintenance bases, large distribution centers, intermodal terminals, for example—that have large land footprints, environmental impacts, and a spatial orientation to widespread metropolitan area destinations that make suburban locations preferable to center city locations. The requirement of stores and office complexes to take truck deliveries at frequent intervals also creates land use configuration requirements for truck access at all metropolitan locations where commercial activity is sited. Many aspects of land use, such as allowable uses, size of facilities, and traffic mitigation actions, are subject to state or local government regulation in the form of building and zoning codes.

BUSINESS POINT OF VIEW ON FREIGHT GOALS

Business organizations and the trade associations that represent them see freight movement as one of many functional components that bear on serving customers well and profitably. Stores need to stock their shelves, wholesalers need to ship the products that customers order, and factories need to receive parts and ship final goods. Trucks carrying freight do this. Enterprises work to improve freight and logistics within a competitive market environment to meet business goals—typically growth in sales, market share, and profits—while seeking lower costs and greater efficiency.

Enterprises generally seek efficiency (or productivity) of freight transport operations, including dealing with traffic congestion and loading and unloading delays, in order to reduce costs. Costs are generated in the delivery itself and in coordination with other operations. Enterprises that move freight to commercial facilities such as factories, stores, and warehouses usually need to operate in coordination with operations and resource availability at receiving locations. The production line needs parts to keep assembly going; an unloading crew finishes with one truck and is ready for the following one. Generally, urban delivery trucks across many sectors must aim to arrive at stops for loading and unloading during scheduled time windows that are 15 minutes to 2 hours in length. Arriving too early and arriving too late may be equally undesired. Deliveries to homes are somewhat less sensitive to arrival times than commercial deliveries, but good customer service requires schedule discipline for residential deliveries as well.

Reacting to Congestion

On the multiple stops of a delivery tour, congestion can both affect the average driving time between points and add to variability in the time to drive, thus creating uncertainty in the time of arrival. These are two distinct issues. A predictable level of congestion can be handled by allowing more time in the schedule, as can a variable but predictable level of congestion, for example, a delivery environment where congestion is known to be bad on Fridays or when there is rain. If the variability is high and unpredictable, the rational response in scheduling resources is more difficult because it depends on the costs of being unpredictably late versus unpredictably early at a delivery point, and how often each occurs.

Traffic congestion causing delay and uncertainty in the timing of deliveries and pickups is an ongoing private sector challenge that adds complexity and cost to operations. All other things being equal, deteriorating delivery performance following on-time dispatching often signals a rise in traffic congestion that is adding to delay and uncertainty in travel times. Logistics managers must deal with congestion in practical, short-term, self-help ways, since relief from public sector action to reduce congestion—building new roads or retiming traffic signals—is typically slow in arriving.

Time-of-day operating patterns are one parameter that business managers can change, if the workforce is willing. Trucks can be dispatched at earlier or later times that are more likely to keep them off the road during morning and afternoon peak periods. The order of stops may be flexible. Arrival time windows for deliveries can sometimes be enlarged, or loading docks expanded, in recognition of the uncertainty in arrival times that cause too many trucks to arrive simultaneously. Changes in truck arrival times may require changes in the operating hours of shipping and receiving departments that trucks serve.

Drivers can be provided with technology that alerts them to traffic congestion and then allows them to alter their delivery route patterns to minimize time spent in traffic. This technology can involve data displays of traffic conditions or the sharing of traffic information among drivers via voice radio or cellular telephones.

Reengineering

Operational patterns can be reengineered in response to congestion. Changing origins and destinations is one possibility. Facilities can perhaps be expanded at or relocated to locations where traffic congestion has a lower effect on truck movement. A retail chain that sells merchandise from multiple vendors may need to establish a receiving point on the periphery of a metropolitan area at which loads from multiple suppliers can be consolidated for delivery by a smaller number of trucks to stores in congested central areas.

Another kind of reengineering would be to reduce the dwell times for deliveries, to provide extra time on the road in response to congestion. If there is sufficient space, a delivery might involve dropping off a loaded trailer and picking up an empty one from the last delivery. Goods could be packed to yield faster loading and unloading times.

Another form of reengineering that might be used is to change freight transportation modes from trucks to railroads, barges, a pipeline, or a conveyer belt, for example. This can be done partially to move freight in and out of a congested region. A new rail line to the waterfront docks at a container terminal might reduce road traffic from trucks going to those docks.

Business Site Location Decisions

Businesses seek to have deliveries at some standard of efficiency for the company and reliability for customers, but performance along these dimensions trades off against important cost variables including labor, equipment, and facilities, plus the cost of implementing changes. A firm may not have the flexibility to change the geographic location of a facility. A retail chain that decides to serve a congested urban market must cope with the delivery challenges.

Road transportation conditions, including traffic congestion, is just one of many considerations that managers take into account when choosing the locations of facilities. Factors that once made a site suitable can change and prompt a relocation of the facility. An area of a metropolitan region, such as a waterfront industrial zone, may evolve over time to have more commercial or residential characteristics, thus making a trucking-intensive operation that was once appropriate become ill-advised. A parts supplier to a major manufacturer who starts out with operations in a distant part of town may be asked by a major customer to move closer, thus reducing shipping distances. In the Puget Sound region, grocery store chain Safeway is relocating its distribution center from a crowded location in suburban Bellevue to one in the Kent area where many other distribution centers are located.

If traffic congestion cannot be avoided and delays slow down operations, more trucks and drivers may deploy, with each truck making fewer stops to achieve the same amount of freight movement. If too many firms react this way in a region, a death-spiral dynamic can be created. When more congestion motivates a business to add more trucks to the delivery fleets, more congestion is created for existing trucks. The downward cycle continues with more trucks added to compensate for increasing congestion and delay, yielding more congestion, and so on.

Still, for any given enterprise, there may not be a budget for more trucks and drivers. A firm may choose to live with deteriorating freight mobility for a period of time until the public sector can make investments that will improve the situation.

Managers and owners of business firms that have freight delivery as part of their operations also have a range of opinions about the environmental externalities of trucking as they bear on the interests of their own enterprise. The relationship of business enterprises to environmental regulation is complex, but in most cases, environmental externalities are not a primary focus in most of the private sector, unlike in the public sector.

While the business requirement for freight movement is the main force behind trucking and all the environmental impacts it creates, businesses are not necessarily insensitive to public reaction and government regulation of these impacts. It is a commonplace to say that they want clear, fair rules that, if applied to them, also apply to their competitors.

As a general rule, any business associated with trucking wants roads to be safe and adequate to the job of getting trucks to where they need to go. They want traffic operations and other trucking-related service to be applied in locations that meet business requirements.

For a firm deciding between two or more metropolitan areas in which to establish a trucking-intensive facility, such as a distribution center or manufacturing facility, transportation infrastructure and road congestion around potential sites are typically just two of many considerations in the eventual decision. Bad traffic in a particular region may be mitigated by lower labor or energy costs in that region, or even management preferences on where they want to live. If all factors were exactly equal except transportation, the transportation issues might be deciding, but rarely is a site location decision this easy.

The land use characteristics generated by truck-based operations are certainly more tolerated by the enterprises that need these patterns than by the public at large.

FREIGHT GOALS FROM THE VIEWPOINT OF THE PUBLIC SECTOR

Unlike the narrow focus that enterprise managers take on serving owners and customers, government managers are charged with serving the public more generally and thus must adopt a broader focus that recognizes the externalities that affect the lives of all citizens, in addition to support for a healthy economy.

Government has a responsibility to provide the publicly owned physical facilities and services that provide freight transport operations, especially constructing and operating the roads and bridges over which trucks must pass. To keep their geographic jurisdiction functioning efficiently, governments have an interest in zoning and building code regulations that specify the permissible locations and configurations of facilities for loading and unloading commercial trucks. On a multijurisdictional regional basis, metropolitan planning organizations conduct planning processes that provide some direction to municipalities and counties on which infrastructure should be built next.

In addition to planning and implementing transportation infrastructure, local governments and regional planning organizations often have a mission of supporting regional economic development, which means planning and taking action across a broad front to support job creation by the private sector. This means influencing private enterprises to expand and relocate in target areas and to retain existing firms. This influence sometimes includes working with transportation authorities to make sure that trucks can move efficiently throughout the region. Government economic development activities attempting to influence the path of the economy typically are coordinated with other government interests.

In the public sector's oversight of land use, authorities might try to persuade trucking-intensive firms that want to move a facility in or out of an urban district to be aware of market trends and the intent of land regulation activities as described by master plans. Firms might reasonably want to relocate away from an urban district because the congestion makes logistics difficult. For example, the City of San Francisco has evolved its waterfront away from marine cargo activity toward more commercial and tourist-oriented activities.

The government management of externalities is a balancing act between support for economic development and the other public interests that are affected by trucking. The noise, vibration, emissions, additional traffic congestion, and occasional accidents caused by trucks are seen as a price for the benefits of economic activity that trucks support, but government usually attempts to put some limits on these impacts. An example of achieving balance is land use zoning to put business facilities that involve trucking activity into geographic areas where residential areas will not be disturbed.

On the other hand, all governments seek to improve the accident record of trucking. Safety is a goal accepted by businesses as well, subject perhaps to economic conditions that sometimes cause too little investment in maintenance and driver training, raising the probability of accidents.

The public sector also is responsible for the performance of society in emergencies. When natural disasters, terrorist attacks, and other emergency conditions strike, people assume that government will ensure that basic human needs for food and medical supplies are met through freight delivery, even if roads are disrupted. In Washington State, the occasional seasonal experience of simultaneous blockage of Highway I-5 leading into Seattle from the south and I-90 into Seattle from the east because of flooding and snow respectively has illustrated that shortages in retail grocery store stocks occur within three days.[13]

FRAMEWORK FOR ANALYZING FREIGHT

As discussed in Chapter , there are three demand factors in freight movement:

- D1: Goods, cargo, what is moved
- D2: Land use, or origins and destinations
- D3: Business processes governing freight, determined by enterprise

There are four supply factors in freight movement:

- S1: road networks
- S2: trucks
- S3: truck movement
- S4: nonroad networks

The following are all the interactions of the basic factors in supply and demand:

- D1 with D2: Land use interacts with cargo: Freight generation
- D1 with D3: Cargo interacts with business process: Enterprise design
- D1&D3 with S1&S4: Cargo and business process interacts with networks: Freight flows by mode
- D1&D3 with S2: Cargo and business process interacts with vehicle: Vehicle design
- D1&D3 with S3: Cargo and business process interacts with vehicle movement: Vehicle loading
- D2 with D3&S1&S4: Land use interacts with business process and networks: Site location decisions
- D2 with S2: Land use interacts with vehicle: Building site design for freight loading/unloading
- D2 with S3: Land use interacts with vehicle movement: Trip generation
- S1 with S4: Road interacts with nonroad: Intermodal transfers
- S2 with S1&S4: Vehicles interact with networks: Roadway and other transport infrastructure design
- S2 with S4: Vehicles interact with vehicle movement: Freight industry structure
- S3 with S1&S4: Vehicle movement interacts with networks: Freight flows on roads and nonroads

Ordering of Freight Components by Amount of Public Policy Influence

We can assign the various freight interactions from the previous section into categories that reflect the amount of public policy influence.

High Influence: Transportation Infrastructure Investments

Public policy heavily influences road investments, which are required because vehicles interact with transportation networks (S2 with S1&S4). Road infrastructure design to support trucking must permit truck movement without unreasonable restrictions. The design of roads is influenced by the turning radius, weight, and dimensions of trucks. Features that must respond to these characteristics of trucks include overhead clearances on bridges and other underpasses, pavement thickness, strength of bridges, design of railroad crossings, truck lanes on uphill grades, transit design, and the location of public facilities such as sports stadiums in relationship to high truck activity areas.

The following infrastructure design issues are related to causing delays for trucks:

- Lack of direct routes to truck terminals
- Lack of locations for new truck terminals
- Lack of capacity on roads, bridges, and tunnels most heavily used by trucks
- Lack of or inadequate truck layover facilities that let drivers wait for terminal openings
- Grade-level railroad crossings
- Drawbridges
- Traffic signal timing that does not reflect truck acceleration characteristics
- Lack of nonhighway alternatives such as railroads, pipelines, and barge facilities
- Truck restrictions for certain routes and hours
- Inadequate access to public and private facilities, the result of poor codes
- Inadequate enforcement of truck loading-zone regulations

High Influence: Traffic Operations Management

Governments also have a strong position in traffic operations management, affecting Factor S3-S1&S4, yielding traffic flow on roads and nonroads. In the twenty-first century, governments nationwide are focusing more on traffic operations management techniques, including traffic information services, signal synchronization on arterials, freeway ramp metering, electronic signage to signal drivers to change speeds and divert away from blocked segments, rapid incident clearance, time-of-day restrictions on trucks, and other techniques that leverage Intelligent Transportation System (ITS) investments.

Some Influence: Land Use Shaping

Three factors here are subject to a combination of private sector planning and investment and government influence through regulation and incentives. Factors S1-S4 (intermodal transfer facilities), D2-D3&S1&S4 (site location decisions), and D2-S2 (building site design) are different aspects of land use shaping that bear on trucking.

Some Influence: Vehicle Regulation

Local and regional governments have minor influence over Factors D1&D3-S2 (vehicle design) and D1&D3-S3 (vehicle loading). Restrictions on overly large vehicles and on certain hazardous loads are applicable here.

Lowest Influence: Results of Business Decisions

The following areas of business decision-making and economic functioning are primarily the result of business decisions, operating within a framework of regulation that is not always directly related to trucking regulation: Factors S2-S4 (freight industry structure); D1-D3 (enterprise design); D1-D2 (freight generation); D2-S3 (trip generation); and D1&D3-S1&S4 (freight flows by mode).

PRELIMINARY DESIGN OF RFLP COVERAGE

We have ranked the public policy areas that the RFLP can inform in their likely order of importance.

1. Transportation investments by government, including infrastructure and traffic operations management. RFLP might show:
   - Truck volumes relative to other vehicle flows on major highways, roads, and bridges to provide a sense of the parts of the transportation infrastructure where truck usage is most important
   - Points on the infrastructure where there is consistent traffic congestion with truck involvement
   - High accident locations for trucks
   - Places where the road design constrains truck movement
   - Segments with posted truck restrictions—time of day, type of cargo, height or weight restrictions
2. Land use shaping. RFLP might show:
   - Locations of intermodal freight transfer facilities
   - Locations of truck fleet bases; points of origination for truck tours
   - Problem spots in local truck access to loading docks and other private facilities where unnecessary impedance in routine operations cause backups of waiting vehicles or other obstructions of the public right of way

    - Location of high-volume origins and destinations for trucks—commercial and industrial property

3. Vehicle regulation. RFLP might show:
    - Inventory of all trucks operating in the region, classified by size and cargo type
4. Characteristics that are largely the result of business decisions and that set the context for public policy involvement in trucking. RFLP might show:
    - Descriptions of significant local truck fleets measured by count, by industry, by function

Crosscutting Issue: Traffic Congestion

Congestion is invariably stated as a leading urban transportation issue. Traffic congestion is affected by all government policy areas that concern trucking.

Congestion afffecting trucks is a topic of public interest frequently covered by media and academic studies. The observations of truck fleet operators, political leaders, economic development advocates, and regional planners are taken into account. Some examples follow.

Golob and Regan (2000), in a survey of approximately 1,200 managers of trucking companies operating in California, found that more than 80 percent consider traffic congestion on freeways and surface streets to be either a “somewhat serious” or “critically serious” problem for their business. These researchers broke down congestion into five distinct problem areas: slow average speeds, unreliable travel times, increased driver frustration and morale, higher fuel and maintenance costs, and higher costs of accidents and insurance.

A survey of managers of companies in the Portland, Oregon, metropolitan area that ship freight or provide trucking services revealed that most felt congestion was becoming “noticeably worse in the region and they were having to take significant actions to manage around the congestion. . . . Most individuals interviewed expressed hope that there would be efforts to maintain mobility for freight movement in the region.” (Loudon, et al. 2000)

A study of freight movement in Central Florida found that “the number of large trucks delivering goods and services to tourist-based businesses has increased, adding congestion to already crowded roadways.” Dennis Hooker, the study project manager reports, “Delivery trucks are getting bigger and the time of deliveries more frequent. If we don’t find a solution, this will continue to equate to more traffic congestion.”[14]

In Seattle, a package express shipping company executive is quoted, “Poor roads level a direct economic hit on Airborne Express every day. Time is money, and our company loses both when employees wait in traffic as they try to make deliveries.”[15]

Trucks are slowed by recurrent congestion caused by the volume of all vehicles exceeding road capacity and by nonrecurrent congestion caused by breakdowns, accidents, railroad crossings blocked by trains, and raised drawbridges. Trucks are also slowed by conditions that then require waiting or maneuvering at loading and unloading points that then spill over into blockages on the public right of way.

In covering traffic congestion, the RFLP could show these factors:

- Map of traffic congestion illustrating
- Ratio of trucks to cars in peak and off peak
- Passenger car equivalent of trucks in peak and off peak
- High-traffic or high-congestion locations where trucks are delayed on public roads

CONCLUSION

Congestion and the other issues mentioned relate to changes over time in the volume of trucks, the proportion of trucks in the road traffic mix, the size, speed, and performance of such trucks, and the location and time of day of their movement, within the context of the level of general vehicle traffic. The RFLP will be designed to provide an overview that is relevant to policy analysis and development.

The degree of importance for fast and reliable delivery is illustrated implicitly by changes in the behavior of urban trucks—how many, where they originate, where and when they make their delivery stops. The private sector is constantly coping with traffic congestion by changing what they do. These changes are what policymakers need to understand.

One important point for the RFLP is to stimulate the consideration of public policy responses to revealed problems that raise the social cost of trucking. Potential public policy responses to congestion include the following issues:

- Expanding regional road capacity for freight movement.
- Prioritizing street improvements based on the amount of truck traffic. The Puget Sound Freight Mobility Roundtable has focused on fixing roadway bottlenecks that are particularly onerous to truckers, primarily at-grade railroad crossings.
- Influencing the locations of new freight/truck facilities through land use regulations that coordinate placement with public infrastructure plans.
- Using building code regulation to shape the configurations of freight/truck facilities for quicker access. In particular, there are loading zone sizing and placement and other zoning/

design issues, especially in the newer urban forms such as transit-oriented development and urban villages where commercial truck access may not have been sufficiently considered.

- Enforcing parking regulations and other operations issues related to truck parking for deliveries and pick up.
- Promoting residential land use policies that bear on truck access, for example, restricting truck deliveries per day.
- Implementing new or expanded public utilities and services supporting freight logistics that the marketplace would not otherwise provide, such as ITS incentives or new, shared facilities.
- Installing ITS truck overspeed detection on curves to prevent rollovers and subsequent delays.
- Promoting off-peak freight movement through incentives, promotions, and regulations.
- Providing financial incentives and new institutions or systems for the private sector to coordinate shipments more completely, reducing the number of trucks on the road. Government could establish, or subsidize, a coordination mechanism. While the private sector is willing to absorb congestion-related costs within its economic structure, more trucks driving under business orders into congested peak periods generates public costs. There might be a net public benefit in spending on incentives and public systems for trucks to stay out of peak period traffic flows. Public policy already tries to reduce single-occupant use of private automobiles in order to reduce vehicle traffic. An equivalent public interest in impacting the load factors in trucks to reduce truck traffic is called "city logistics," a development in freight planning arising in the 1990s largely outside the United States. City logistics means studying and optimizing the logistics and transport activities of private companies in urban areas while considering the social, environmental, economic, financial, and energy impacts of urban freight movement.[16]
- Establishing local public policies that change the economics of remote sensing applications in order to reduce truck movement. Remote sensing is beginning to be applied to some industries that dispatch trucks for servicing dispersed locations. For example, remote sensing of the status of the content level of soft drink vending machines is one application of monitoring equipment. This technology enables industry to wait to service vending machines until they need refilling. In wide application, this technique might significantly reduce the number of trucks on the road devoted to refilling such machines. This could be a relatively cheap way for the public sector to remove trucks from the road, but the economics of doing this are not yet favorable for the soft drink industry, especially for low-volume machines. If this were the case, providing incentives for machine operators to install such remote sensing technology on more vending machines might be a reasonable incentive for governments to fund in a trasnportation demand management program aimed at reducing the number of trucks on the road.

- Helping to support the expansion of other modes, such as railroads or underground conveyer belts serving downtown package delivery.
- Removing cars from the road to leave more room for freight by implementing public transit or other actions.

The RFLP will be designed to provide a framework for measurement that can be expanded in order to create, explore, elaborate, test, and validate or reject for implementation and to provide a means of measuring freight movement performance and impacts over time or in comparison to other metropolitan areas. Regions A and B might be compared in an attempt to seek insight into differences and similarities in conditions and policies that suggest policy innovations in region A based on what was seen in region B.

DESIGN FOR THE RFLP AND RECOMMENDATIONS FOR USE

Up to this point, we have provided a broad overview of urban freight trucking and the public policy issues that bear on it.

In this final chapter, we will offer a simple yet comprehensive method of describing urban trucking in a metropolitan region such as the central Puget Sound region of Washington State or the San Francisco Bay Area of California. This method yields a Regional Freight Logistics Profile. The RFLP is a living document that at any stage of development is a tool to foster a more constructive dialog between the government transportation leaders who decide on infrastructure investments, shippers and truckers who are directly focused on performance levels of freight movement, and the general public who perceive trucks more as an environmental impact than as support for economic sustenance and the quality of life in their community.

We begin by describing how metropolitan planning organizations (MPOs) treat freight, since the RFLP is, in part, a response to current MPO practices. Then, based on the analysis of Chapter , we describe an RFLP tool that measures urban freight trucking in the context of regional surface transportation.

MPO PLANNING FOR TRUCKING

The leading method by which MPOs address freight issues is the establishment of discussion forums that bring together private sector trucking interests and government planning interests to interact and educate each other about freight and trucking issues.[17] Through discussions with personnel who are familiar with infrastructure conditions, MPO staff can identify and advocate for funding truck-related transportation improvement projects, such as railroad grade crossing improvements and upgrading roads in industrial districts where there is high truck traffic.

Long before these forums were established, the mainstream long-range transportation planning processes of MPOs centered around responding to the implications of quantitative forecasts of traffic volumes reaching several decades into the future. The forecasting tool, called four-step modeling, informs a main outcome of planning, namely recommendations for public investments primarily for roads, transit, and other infrastructure. Recommendations also emerge for improvements in traffic operations management and regulations. These investment decisions are aimed at maintaining and improving the speed of the movement of people, especially daily commuting between home and work during the two daily peak periods that most severely challenge the capacity of the highway infrastructure.The main emphasis of MPO modeling is cars and transit vehicles. The mathematical techniques generally treat truck movement as a vehicle volume increment in addition to the vehicles that are moving people.

There are several mathematical techniques for estimating truck trip volume increments (Cambridge Systematics 1996; Fischer and Han 2001). One is to derive the number of trucks from data on the amount of goods, or commodities, that are produced in each geographic subarea of the region. Economic input-output statistics that measure how much steel or paper has been produced or consumed in an industrial or commercial zone can be translated into a volume of trucks.

Another method is to correlate the number of trucks serving a location with the kind of freight that is shipped or received and a quantitative activity measure such as the number of employees working there. A printing plant that employs 100 people receives and sends out more trucks than a similar plant that employs 50. There appears to be a paucity of survey data available to cover the diverse and changing firms that make up each metropolitan region. Furthermore, neither commodity input-output tables nor employment-based freight trip generation works well to characterize the variety of goods, load levels, and vehicle movements that yield the trip-chained truckloads of urban delivery. Still, numbers can and are derived through these techniques. The car trips, along with a relatively few truck trips, are then assigned to road segments for the metropolitan traffic forecast.

There is rarely, if ever, a separate characterization of truck volumes in MPO regional planning documents. The truck numbers are too approximate to make that step reasonable, so relatively uncertain truck numbers derived through commodity or employment statistics are added to more robust estimates representing automobile volumes to represent vehicles in general.

A potential exception to this generalization is the truck modeling work of Kuppam and Outwater in the central Puget Sound region. A truck forecasting model for 2020, calibrated against base year 1998, was developed to evaluate the benefits of capital investments that help freight movement. The model uses the Vehicle Inventory and Use Survey of the Census Bureau, average truck capacities, and commodity flow data to estimate truck movements into and out of the region. To estimate the much larger number of truck trips that stay inside the region, trip generation tables based on employee counts and number of households are derived from the *Quick Response Freight Manual* (Cambridge Systematics, 1996). This work appears to be a one-time forecasting study rather than an ongoing monitoring effort to detect and assess changing conditions.

MPOs and others have occasionally commissioned one-time studies of freight that provide overviews and detailed insights into specific aspects of urban trucking. Some of these special studies are based on surveys of shippers and/or trucking companies; others are based on more rigorous quantification of truck volumes. These studies are not usually structured or carried out to provide a basis for the measurement of changes over time. Examples of these studies include *Learning from Truckers* (Pivo, et al. 1997) that describes conditions at loading zones; a Portland Oregon metro area survey of how truckers and shippers respond to congestion, sponsored by Oregon DOT and the Portland MPO (Loudon, et al. 2000); and a study of Southern California freight flows (Gordon and Pan 2001).

Internet searching did not reveal any examples of regional-level, top-down, ongoing descriptions of intraurban trucking broken out separately from descriptions of general vehicle traffic. We have not found any MPO regional transportation plan that monitors, over time, any of the following information about trucking in the covered region:

- The number or proportion of vehicles registered in the region or moving on major roads that are trucks
- What has been or will be the growth in the number or proportion of trucks on metropolitan roads
- The different functions, sizes, or trip types of trucks

We also have never seen a quantification of truck volumes that is focused to show an interaction effect with automobile flow. For example, observers of the freight industry believe that as a generalization, most truck drivers and their dispatchers try, if possible, to keep their trucks from having to move through peak hour commuting traffic (Parks 2001). The net result is that trucks are increasingly reported to be in motion earlier in the morning. We could find no examples from MPOs where this effect has been measured on even a single road segment.

To reinforce and illustrate these general impressions, we examined in detail the latest regional transportation plans of the MPOs for the Seattle-Tacoma region and the San Francisco Bay region. Neither of these plans distinguishs truck volumes or provide detail on truck movement generally. The Puget Sound regional growth plan, Destination 2030, lists projects that are expected to remove points of truck delay. These are based on the deliberations of the Freight Mobility Roundtable discussion forum. The Bay Area plan provides quantitative estimates of travel time on key major highway segments observed to be well used by trucks and lists planned improvements that are associated with major highways, such as faster response to blocking accidents and truck parking areas.

We are struck by the paucity of data in MPO planning documents that would provide a more quantitative, holistic grasp of trucking across a metropolitan region. There seems to us to be a large gap between the outputs of four-step modeling that obscure the movement of trucks within the estimates of general vehicle traffic and a relatively few obligatory, earnest paragraphs about the importance of freight mobility and the need to make public investments that keep it rolling. We thus see an opportunity in regional transportation plans for introducing measurements that will illustrate the impact and role of trucking more fundamentally and descriptively.

GOALS FOR THE RFLP

The contemplated RFLP is to be a reference document that comprehensively characterizes the urban delivery phenomenon found in a modern metropolitan region. It provides a common starting point for policy discussions among government officials, business interests, and citizens. It isolates and describes the biggest part of urban freight, intraurban delivery, which comprises approximately 80 percent of all truck traffic in a region.

The RFLP that we envision could provide an overview picture of the basic structure of urban freight. It can describe where trucks go—which starting points, which roads, which destinations. Individual enterprise destinations are to some degree clustered into shopping centers, office parks, and other business districts. Many delivery trucks begin their movement cycles at a truck depot or distribution center from which they venture out in the morning on delivery tours. Other trucks enter the region on main highways and arterial roads at points we can call regional gateways. Over time, vehicle counts can be taken periodically to provide a sense of the relative importance of the various origins, destinations, connecting road segments, and regional gateways.

Vehicle counts can be classified by the size of truck and the time of day, perhaps even measuring over enough days to pick out day-of-week patterns or seasonal patterns.

By focusing on individual enterprises having large fleets, or groupings of similar enterprises that collectively have a large fleet, the RFLP can begin to describe the business processes that drive truck movement and how the business processes and the truck movement are interrelated. For example, the logistics supply lines that feed grocery stores may be similar between competing chains, and thus a description of one serves as a description of all.

The RFLP can describe the public problem areas that government policy and action can address. Examples include points of frequent congestion with significant truck involvement, road segments with repeated truck accidents, and regions of significant air pollution that can be attributed to trucks.

We have designed the following seven principles into the RFLP:

- The RFLP informs public policy improvement.

  It should stimulate and suggest public policy response to changing conditions, so it is designed with policy analysis and prescription in mind. The RFLP supports scanning for changes—for example, in accident rates or congestion that involve trucks—that reveal opportunities for public sector investment that can cause positive change.

- The RFLP enhances general public awareness and understanding of freight trucking.

  By its introduction as a tool in MPO planning, the RFLP offers a picture that explains how roads serve the economic purpose of moving cargo as well as people. It begins to describe how and what urban delivery contributes to the wellbeing of the community, and thus educates the public on the reality of the economy's operation. This general awareness must be ongoing and dynamic, supporting the identification of new issues.

The regional community as a whole would benefit from accurate civic and political leadership awareness of how urban freight and logistics work to make an urban area survive and thrive, beyond the increasing recognition that some goods are only passing through the region on highways and through intermodal facilities in support of interstate and international trade.

- The RFLP motivates cooperation with the public sector by shippers and truckers.

  We want to gain business cooperation in revealing their operating patterns and issues that public policy can address. We want to stimulate private actions in the public interest. As we will describe later, we need to attract cooperation from private sector data-keepers. We want to use the RFLP as motivation for truckers and shippers to come forward with new information that improves interaction between the public and private sectors.

- The RFLP provides a way of measuring change in an understandable framework.

  The RFLP can provide a baseline reference framework against which freight interests can make requests for government action. It needs to illustrate critical issues, such as the impacts and causes of traffic congestion where trucks are involved. The RFLP must be designed to appeal to nontechnical leadership audiences. It must communicate with nonspecialists while providing a picture that specialists will respect for its technical integrity.

- The RFLP builds upon and expands an understanding that begins with simple observations and anecdotes about trucking.

  We design the RFLP to present numbers that provide more generalization and quantification of typical points made through anecdotes. For example, we read that trucks are stuck in congestion. How much are trucks stuck in congestion? We read that big trucks cause accidents. To what degree is this really true? There is a gap between mainstream technical work in the measurement of trucking and the rhetorical characterizations made by civic leaders, journalists, and everyone else. We want to use the RFLP to extend and sharpen common, observable experience. We want to refute conventional wisdom, if warranted, as well as confirm it.

- The RFLP provides measurements that are affordable and add value.

  In the design of the RFLP, we seek to implement simple measures that provide high value across a wide range of public policy issues. Because of the lower priority of focus on trucking in most transportation planning to date, we judge that the RFLP emphasis should be on breadth rather than depth in the coverage of the issues. Depth in specific areas can be added when more data are needed to address a problem that rises to significance in the broad coverage.

We choose to work with physical observations and counting to the greatest degree possible. Where counting is not initially possible, we will advocate providing estimates of the results of direct counts along with a range of uncertainty that can be narrowed and filled in later with actual counts as time and resources permit.

As a criterion for value, we seek to focus on measuring characteristics of and influences on trucking that public policy can affect. For example, although a variety of different management decisions about business processes can affect the timely arrival of freight shipments, we want to focus the RFLP on the influence of road congestion, since this a phenomenon that government can address through its resources and charter.

- The RFLP implements an iterative measurement process that begins simply, provides value initially, and improves measurement and understanding over time.

  We think that the RFLP should be embedded in a process that allows a practical, feasible beginning that may be incomplete in the short term but that is subject to incremental improvement over time. At the same time, we suggest that even initial, incomplete results of measurement can be illustrative and suggestive of fruitful directions to pursue in public policy improvement.

BUILDING THE RFLP

We have built the RFLP from our awareness of the basic public policy points of influence listed in Chapter as follows, with the coding of Supply (S) and Demand (D) factors retained:

- High Public Policy Influence: Investing in infrastructure

  S2-S1&S4: Vehicles interact with networks: Roadway and other transport infrastructure design

- Some Public Policy Influence: Managing traffic operations

  S3-S1&S4: Vehicle movement interacts with networks: Traffic flow on roads and nonroads (traffic management; time-of-day restrictions; ITS investments; dealing with security vulnerabilities and safety hazards)

- Some Public Policy Influence: Shaping land use

  S1-S4: Road interacts with nonroad: Intermodal transfers

  D2-D3&S1&S4: Land use interacts with business process and networks: Site location decisions

  D2-S2: Land use interacts with vehicle: Building site design

- Some Public Policy Influence: Regulating vehicles
  D1&D3-S2: Cargo and business process interacts with vehicle: Vehicle design
  D1&D3-S3: Cargo and business process interacts with vehicle movement: Vehicle loading

- Lowest Public Policy Influence: Regulating or stimulating business decisions
  S2-S4: Vehicles interact with vehicle movement: Freight industry structure
  D1-D3: Cargo interacts with business process: Enterprise design
  D1-D2: Land use interacts with cargo: Freight generation
  D2-S3: Land use interacts with vehicle movement: Trip generation
  D1&D3-S1&S4: Cargo and business process interacts with networks: Flows by mode

KEY ISSUE: MEASURING OR INFERRING TRAVEL TIME RELIABILITY

Traffic congestion arises repeatedly as a major crosscutting concern in urban freight policy. (Kilcarr 2002). We want to be clear on how we deal with the issue of traffic congestion in the RFLP.

Traffic congestion at times and places where trucks are on the road causes longer and more variable trip times for those trucks. Longer trip times come from the recurrent congestion caused by such things as insufficient road capacity or a poorly timed traffic signal at a busy intersection. Variable travel times for trucks arise from the nonrecurrent congestion that is primarily caused by random accidents and incidents coming at different times and different places every day, road maintenance and other varying conditions that block the right of way; or volume surges that come from special events and circumstances. Truckers seek both faster average speed and reliability of arrival time. Faster average speed means shorter average travel times and more production—more pickups and deliveries—from trucks during the workday. Variable trip times potentially lead to variable arrival times at a pick up or delivery.

Arriving early or late for a pickup or delivery can have negative consequences. Late is more understandable as a negative: Arriving late to a delivery window may mean that the available space on the loading dock has been taken by trucks that arrived on schedule for their time slot. Arriving early may mean that the space on the loading dock or a loading/unloading crew is not yet available, and the arriving truck has to wait unproductively. Still, it is probably better to arrive early than to arrive late because of penalty charges imposed by the shipper. Both logic and preliminary observation indicate that truckers try to arrive on time to scheduled pickups and deliveries through a combination of driving performance and use of holding patterns while in motion (slowing down, for example) or at waiting points near destinations (for example, stopping for coffee).

The exact dynamics and economics of hitting scheduled arrival times are complex and not determinable without extensive survey research. The ability to compensate for traffic congestion combined with penalties for being behind schedule have caused truckers to learn how to arrive on time for pickups and deliveries most of the time (Parks 2001).

Shippers and truckers may react to congestion by changes in their operations. Potential means of reacting include shifting operations to less congested times of day, moving the locations of facilities, scheduling a lower number of stops per day, and adding more trucks to their fleet (Mercer Management Consulting 2000). The reactions contribute to a new traffic and congestion pattern on the roads of the region. Their reactions, and the dynamic reaction of the traffic stream to their reactions collectively, are complex.

Ongoing direct measurement of truck performance in hitting delivery windows is too difficult to contemplate even if private industry were willing to let it be measured for public consumption, which it is not. Furthermore, arrival performance is subject to influence by factors that governments do not control or even influence.

Our conclusion from analyzing these dynamics is that the focus of the attention for the RFLP should be on the factors influencing longer or more variable truck travel times over which governments have some influence through infrastructure investments, traffic operations initiatives, or other public policy. This focus is illustrated in Figure 8.

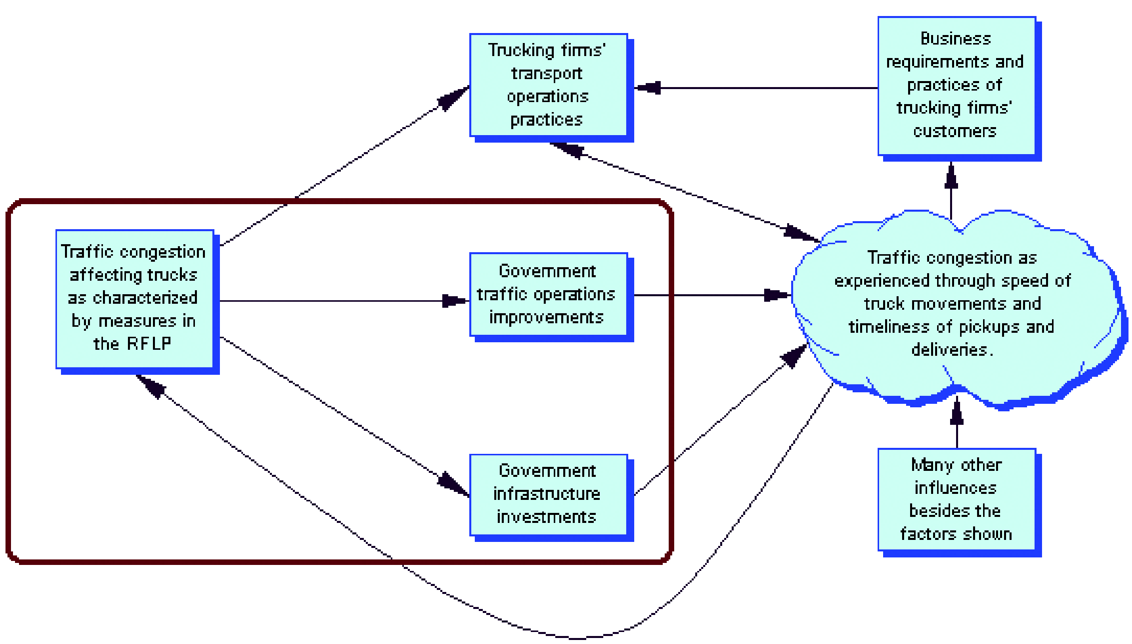

Figure 8: Analysis of Government Influence on Travel Time Variability
Source: Global Telematics, 2002

The elements in the figure are explained below.

The cloud shape on the right represents traffic congestion as experienced through the speed of truck movements and timeliness of pickups and deliveries. This congestion affects the daily experience of truckers, dispatchers, and loading dock personnel doing their work, as trucks arrive at times influenced by congestion.

Above the cloud is a box representing business requirements and practices of trucking firms' customers—shippers and receivers. How trucks perform in congestion is one of many influences on these requirements and practices. The expectations for truckers adhering to arrival schedules, transit times for cargo movements, and good locations to conduct business are influenced by how trucking performs in congested urban environments.

Moving to the left, we follow the arrow that signifies that customers' demand for services influences trucking firms' transport operations practices. For example, how many trucks they deploy and the number of stops scheduled in a daily delivery tour depend in part on what their customers demand or are willing to accept in on-time performance and price for service. The other part of the story for them is the direct influence of traffic congestion. The two-way arrow between transport operations and traffic congestion signifies the two-way influence.

The three elements described so far—trucking performance, customer demands, and the business practice of truckers—form a tight circle that operates within the relatively static environment of public sector facilities and services (such as roads, traffic signals, and traveler information systems). The infrastructure and services from the public sector change little from day to day.

However, the public sector can make investments that eventually will improve the capacity of highways and thus reduce delay and uncertainty. Infrastructure and traffic operations management (shown in two separate boxes within the square frame), are two policy areas in which the public sector can influence traffic congestion. The view of traffic congestion provided by the measurements in the RFLP, also within the frame, is a tool for helping governments decide where to make such investments and improvements if freight mobility improvements are the intended result.

Traffic congestion affecting trucks, as characterized by measures in the RFLP, is an important information input for decision-making on infrastructure investments, such as new roads and railroad grade separation projects, and traffic operations improvements, such as faster clearance of freeway blockages following accidents and incidents.

In other words, the private sector can act to reduce the impacts of congestion on their trucking operations. However, rising traffic congestion is a force for both extending the average travel times for trucks and increasing the variability of their arrival times during their delivery tours.

Therefore, measuring traffic congestion on truck routes (that is, those streets and highways with the greatest truck volume) is an important focus to design into the RFLP. Traffic congestion on truck routes is a phenomenon that government has the tools to address. Measuring congestion delays on the roads most used by trucks is a first step in allocating resources for infrastructure investment (railroad crossing grade separation) and traffic operations improvements (signal retiming) that would tend to reduce congestion delays.

By measuring time-of-day truck volumes, we can observe over the course of months and years if peak truck volumes are occurring earlier in the day on congested segments. This gives an indication of the private sector responsive action of shifting operations to earlier in the workday.

GENERIC REGIONAL FREIGHT LOGISTICS PROFILE

Below, we take all the above into account and present an RFLP outline for a generic metropolitan area. We provide a few examples of data elements from the Seattle-Tacoma, San Francisco/ Oakland/San Jose, and Los Angeles metropolitan areas.

We propose that an RFLP have the following sections:

- Regional infrastructure supporting trucks
- Number and proportion of trucks
- Major truck origins and destinations
- Truck operations
- Safety-related information
- Environmental impacts
- Public policy issues

The contents of each section are described below.

Regional Infrastructure Supporting Trucks

This section provides a picture of the roads and highways that support regional trucking, including the management of operations on this infrastructure. The seven proposed elements are discussed below.

1. Map of officially designated truck routes in the region.
2. Table showing travel time averages and variance over time on major truck route road segments. An example of a measure of travel time variance on major segments of Los Angeles

freeways is shown in Figure 9. The measure of variance here is the buffer index, defined as the amount of extra buffer time needed to be on time 95 percent of the time (late one day per month).

3. Summary table listing and map showing road segment and intersection locations with frequent/consistent recurrent traffic congestion with truck involvement.

4. Summary table listing and maps of locations where the road design constrains truck movement or causes an unusual number of accidents with resulting congestion.

5. Measures requiring special studies on nonrecurrent congestion:
   - Display of truck involvement in nonrecurrent congestion caused by road work.
   - Display of truck involvement in nonrecurrent congestion caused by incidents or accidents.
   - Display of truck involvement in nonrecurrent congestion caused by special events that cause surges in traffic volume, such as sporting events and festivals.

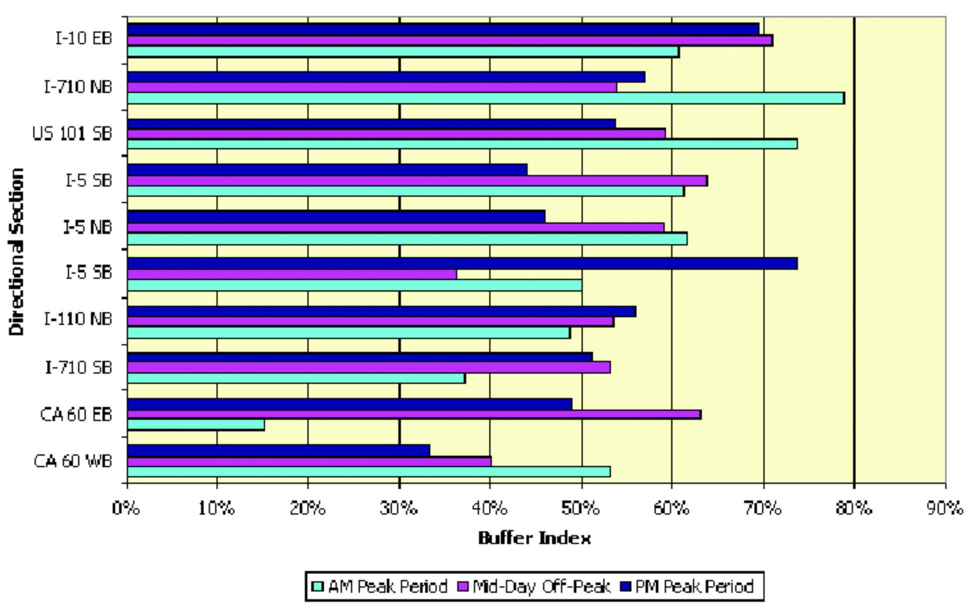

Figure 9: Travel Time Variability on Major Freeway Segments in Southern California

Source: Texas Transportation Institute

6. Summary table and map showing road segments with posted truck restrictions. These restrictions might cover time of day, day of week, special events, type of cargo, and height or weight restrictions.

7. Summary table and map showing planned infrastructure additions and improvements supporting truck movement, with status and timeline indicated.

The Number and Proportion of Trucks

This section shows the extent to which trucks use the regional infrastructure of roads and highways. The three proposed elements are discussed below.

1. Table showing the universe of urban truck trips.

   An important presentation here is an indication of how intraurban trucks contrast with those entering and leaving and with those passing through the region going elsewhere.

   There have been relatively few studies of all freight movements in a major urban area. Two West Coast studies, although highly aggregate in nature, shed light on the relative volumes of freight movements within, into/out of, and through the region. They allow some general conclusions to be reached on the relative volumes for each of the freight mobility patterns we have defined for the RFLP.

   A consultant study for the Puget Sound Regional Council estimated the number of daily truck trips in the Puget Sound region for each of the categories indicated in Table 3. Total individual (unlinked) trips were calculated on the basis of the average number of stops provided by fleet operators. Trips were not differentiated by size of truck.

Table 3: Freight Movements by Trip Category in the Puget Sound Region

Truck trip category	Number of daily individual trips	Percent of total
Intraregional	130,515	51
Public services (refuse removal, mail delivery, etc)	73,615	31
Interregional	21,324	9
Through	9,740	4
TOTAL	235,194	100

Source: Puget Sound Regional Council. *Analysis of Freight Movements in the Puget Sound Region*, Report of study by Science Applications International Corporation and Harvey Consultants, Inc., September 1997.

A 1991 study found that most truck trips in the San Francisco Bay Area were local or in-region. Surveys conducted at five highway weighstations and four toll bridge crossings determined that

98 percent of the truck trips (8,700 total) had either origin or destination in one of the nine Bay Area counties (Table 4).

Table 4: Freight Movements by Trip Category in San Francisco Bay Area

Truck trip category	Number of daily individual trips	Percent of total
Internal-Internal	228,903	85
Internal-External	38,007	14
External-External	1,510	1
TOTAL	268,420	100

Source: Schlappi, M. L., R. G. Marshall, and I. T. Itamura. "Truck Travel in the San Francisco Bay Area." In *Transportation Research Record 1383*, Washington. D.C., Transportation Research Board, National Research Council, 1993: 85-94.

The Puget Sound example indicates that intraregional shuttle traffic is the largest general category of freight movement, accounting for about half of all trips. Intraregion pick up and delivery, which includes public services such as mail delivery and refuse collection, is the next largest category, accounting for almost one-third of truck trips in the Puget Sound region.

A large majority of truck traffic in a major U.S. metropolitan region appears to have an origin and/or destination within that region. When the Puget Sound region's intraregional and public service trips are combined, the total percentage (81 percent) is quite close to that for internal-internal trips in the San Francisco Bay area (85 percent).

Interregion shuttle trips were a small fraction of all trips: 9 percent for Puget Sound and 14 percent for San Francisco. Yet these trips may have a high symbolic value since they often involve shipments that reflect the interdependence of the economies of adjacent regions.

Less than 5 percent of all truck freight movement in an urban region is in transit through the region. However, freight patterns are not static. The North American Free Trade Agreement (NAFTA) has resulted in increased freight shipments on several major north-south corridors connecting Canada, the United States, and Mexico. Some U.S. urban regions on these routes, including those on the West Coast, have seen increasing levels of through truck traffic.

2. Truck trip types classified by truck size across average workday.

- Table showing the number of all truck types operating in the region classified by size and cargo type. This data could be approximated by vehicle registration data.
- Table showing a range for the number of trucks on a nominal workday classified by size and by trip type as passing through, headed outbound, headed inbound, container drayage (shuttling, inbound, outbound), and local delivery tours.
- For a sample of prominent and indicative road segments, an indication of how truck traffic varies by time of day. This would be a weekday hour-by-hour profile with a count of vehicles classified as cars, buses, or trucks by size (small, medium, and large).

The basic idea is to show truck volumes relative to total vehicle flows and in the context of congestion to provide a sense of where truck use of infrastructure is most important.

The RFLP design is to select major truck routes—designated or de facto—with an emphasis on congested segments. To keep costs reasonable, there must be existing vehicle-counting measurements already underway with a vehicle-sensing technology that can be adapted to differentiate trucks from cars.

One method of presentation would be to show maps of monitored street segments with characterizations of truck traffic both in absolute terms and in comparison to personal vehicles and transit traffic. A series of maps of the monitored roads would be needed, with parameters shown for each monitored road.

The parameters we seek to show for a series of typical date/time periods that represent the broad circumstances are a combination of the following factors:

- Level of congestion as measured by nominal truck travel time
- Per hour volume of trucks
- Proportion of trucks in the flow

This could be done either by showing the ratio of trucks to cars in peak and off-peak periods, or by showing passenger car equivalents of trucks in peak and off-peak.

The University of Washington has developed flow measurement charts that indicate congestion status by colors against time of day and freeway milepost location. Figure 10 shows four levels of flow ranging from green (uncongested) to yellow (restricted) to red (heavily congested) to blue (unstable, stop and go). If a three- or four-way classification of truck volumes were overlaid on these flowcharts as a dense but discernible series of points on the charts, the involvement of trucks in traffic congestion would be illustrated clearly. For example, a mockup of estimated truck volumes as high, medium, or low (H, M, L) is overlaid on the sample traffic flow measurement chart in Figure 10. In this hypothetical case, we show the plausible situation of truck flows being high in the morning before rush hour and in the midday lull between the peaks.

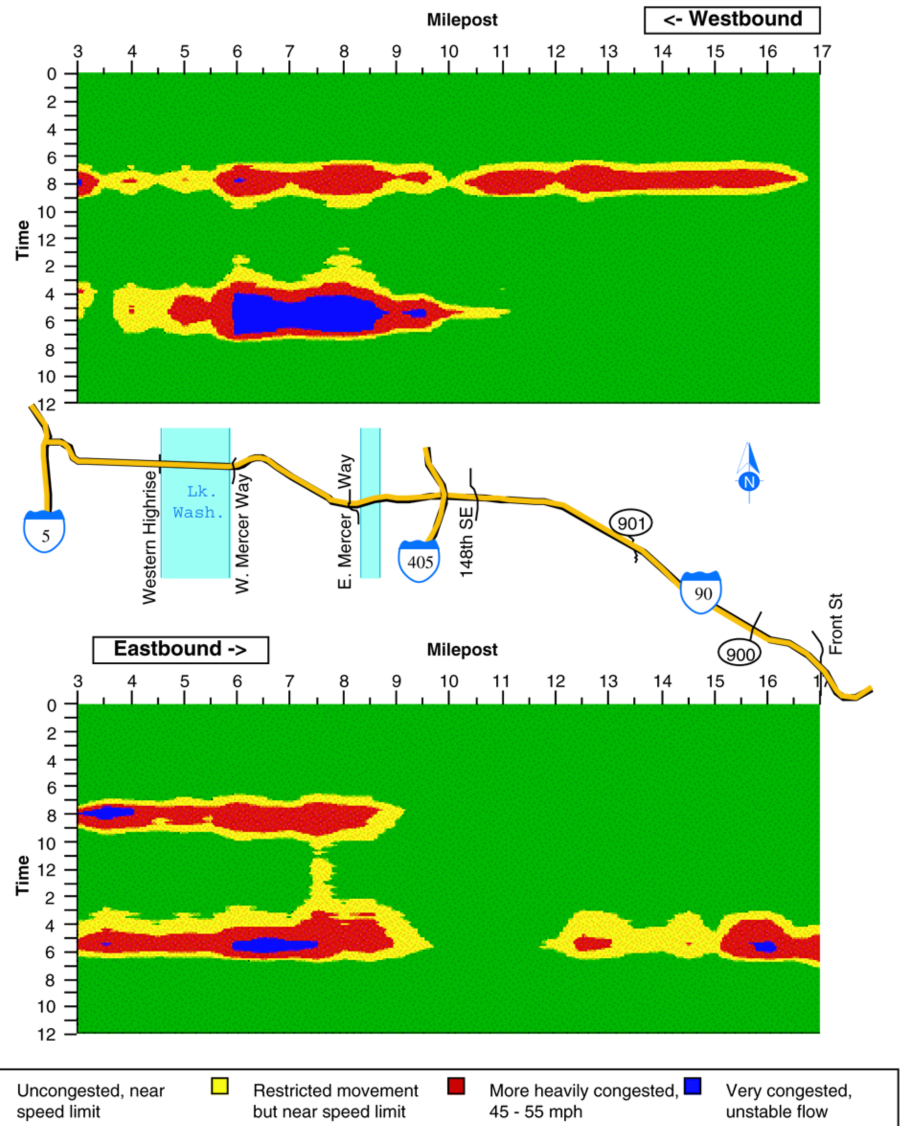

Figure 10: Illustration of Method for Displaying Relative Truck Volume on Space-Time Plot of Freeway Traffic Congestion

Source: University of Washington; modified by John Niles to illustrate a method of displaying Low, Medium, and High truck volumes in the context of traffic congestion

Until charts like the graphic shown in Figure 10 can be developed in a region, illustrations of truck volumes from the existing Highway Performance Monitoring System (HPMS) operated by state and local governments, and that are used to measure the vehicle counts that are sent to the Federal Highway Administration, can be inserted into the RFLP as initial placeholders.[18] Computer-generated, color-coded regional highway maps are available now from the HPMS website. They show the percentage of trucks in traffic streams on major highways in most urban regions. There are coverage gaps, but the display is relatively easy to understand and focuses attention on the roads that are relatively important for freight movement.

3. Regional intraurban fleet census.

This section provides a focus on significant subsets of the region's trucks by showing a table of the 50 largest regional truck fleets. Each row of the table would describe a different fleet, ranking from largest to smallest. The table columns would be as follows:

- Name of owning firm
- Firm's industry or function (for example, assembles airplanes; delivers packages; delivers to Safeway stores from regional distribution center)
- Geographic location of the base (city or section of city)
- Vehicle count, classified by size (for example, 15 semitrailer tractors; 34 large vans)

We also recommend a map showing the regional fleet operating base locations with the number and type of vehicles coded for each base point. These bases represent the points of origination for daily truck tours. A table footnote should indicate the percentage of urban trucks accounted for in these fleets.

Ideally, the table should be supported by an urban truck fleet descriptive database with the following fields:

- Organization served by the fleet
- Operations contact name, address, phone number
- Home garage location
- Description of geographic area served
- Number of vehicles in active fleet
- Measure of fleet vehicle count growth in past five years
- Description of vehicles by size and type
- Purpose of daily activity
- Characterization of time sensitivity

- Description of driver shift activity cycle (qualitative word description; one or several paragraphs)
- Number of driver shifts per day
- Number of hours parked and at work per day
- Description of days worked in month (weekdays, weekends, holidays)
- Miles per day per route—high, low, mean
- Miles per year per truck —high, low, mean
- Description of routes; note whether fixed or variable
- Number of stops per day—high, low, mean
- Classification of uncertainty in the daily movement pattern
    a. Same stops, same ordering of stops, same routes
    b. Some skipping of stops
    c. Some variation in stops, variable routes
    d. Extreme variation in stops
- Maintenance cycle (description of out-of-service time)

Major Truck Origins and Destinations

This section illustrates where trucks originate and go while delivering freight. The three proposed elements are described below.

1. A map or maps, maintained in a geographic information system for easy updating and map production, showing zoning and significant individual facilities graded for daily truck attractions and productions per day. Initial gradation suggested as quartiles: highest, high medium, low medium, and lowest. Early iterations of the RFLP in a region can begin with estimates and be upgraded as data are collected. The map categories are as follows:
    - Residential zones, separating areas of single family from multiunit
    - Commercial zones, including retail stores and service facilities, restaurants, hotels, and hospitals
    - Commercial zones with office buildings, including government and schools
    - Industrial zones with factories and processing facilities, including laundries and printers
    - Wholesale distribution centers and other short-term warehouses where goods arrive and leave actively, including post offices

- Long-term warehouses and storage facilities, where goods are stored for weeks or months
- Truck depots (sometimes adjacent to warehouses) where trucks are stored and dispatched, such as fleet yards, maintenance yards
- Sports arenas, fairgrounds, convention centers, and other temporary exhibition venues
- Refuse transfer stations, recycling centers, landfills, waste treatment plants
- Major construction sites
- Intermodal terminals (airports, seaports, rail terminals, pipeline terminals)

2. Case studies of truck movements at a sample of characteristic pickup and delivery points, such as malls, large office towers, convention centers, large industrial plants, airports. Describe truck arrival and departure patterns around key destinations. Begin where records are available.
3. Map of delivery locations consistently demonstrating truck loading or access practices that contribute to arterial congestion, with keyed descriptions. There are cases of trucks lined up in street rights of way waiting to get into an intermodal loading area or distribution center. In some facilities, trucks consistently need to load and unload while sitting in inappropriate "right-of-way" locations. This would be keyed to a table describing loading/unloading facility improvements needed to correct the problems (Pivo, et al. 1997).

Truck Operations

This section provides an understanding of how trucks, their origins, their destinations, and the connecting infrastructure interact. One element is proposed.

1. Case studies of the operating cycles of leading regional fleets, such as UPS, FedEx, Frito-Lay, Sears, Safeway, and Texaco.

   These would be structured case examples illustrating how the companies have changed their operations as a result of congestion.

   An important design issue in the RFLP is how to reduce the data collection load while providing a useful descriptive tool. To meet this requirement, we recommend an "indicator fleet" concept, meaning the selection and documentation of prominent, large fleets in a region, such as FedEx, UPS, Safeway, Frito-Lay, and McDonalds. Trucks with these labels travel frequently to destinations scattered throughout the region. If an MPO sufficiently documents a limited number of prominent fleet operations meeting standard criteria (numerous trucks, easily comprehended mission, geographically expansive coverage, representative daily duty cycles), the result would provide an informative picture of urban delivery trucking as a whole, evolving over time.

An indicator fleet could be redocumented annually to detect changes. To span and represent the universe of operational variations in a region, these representative fleets would be chosen to touch collectively each of the various categories laid out in Chapter . Ideally, these case examples would be prepared with the cooperation of the companies who run large fleets of trucks in urban areas. Such cooperation would be helpful, but not essential, since indicator fleets probably can be documented sufficiently by direct observation from points on public property. In the course of this project, we have found that company managers are reluctant to provide information that describes their operations even in rudimentary detail.

We suggest a course of iteration and successive and converging approximation: Prepare the first draft from sidewalk observations, but seek confirmation and further input from responsible managers to improve later drafts.

The following are examples of hypothetical but realistic truck flows that represent first approximations of core descriptions illustrating how trucks operate.

- A double tanker truck fills with gasoline of two different grades at a terminal location that is served by a pipeline leading from refineries that are outside the metropolitan region. The truck then proceeds to a retail gasoline station where it discharges its entire load into the twin tanks beneath the ramp. The empty tanker then returns to the fuel terminal to refill its twin tanks and repeat the cycle. The cycle repeats every few hours, 24 hours per day.
- A beer delivery truck begins every workday at a base where it is loaded for the deliveries to be made during that day's tour. Once loaded, the truck proceeds to a series of delivery points, stopping to unload part of its cargo at each one. It may also load some cargo at some of the stops. The truck continues making stops throughout the day and returns to base at the conclusion of the driver's daily duty cycle.
- A food processing company in Mount Vernon, Washington, one hour north of Seattle, makes a weekly delivery to a number of wholesale food companies in the Seattle area. The truck is loaded early on Thursday morning, then makes deliveries at five grocery distribution and restaurant supply companies in the Seattle-Tacoma area, unloading part of the cargo at each stop. After the fifth stop, the truck is empty and returns to Mount Vernon.
- A local household or small-office moving truck begins empty at its base and proceeds to a first moving job. At the move location, the truck is loaded with furniture. After loading, it proceeds to the destination to which the customer is moving, where the truck is unloaded. The moving crew then goes to lunch. Following the meal break, the crew proceeds with the empty truck to the pick-up point of the next moving job. The truck is again loaded and driven to the destination of the move, where the truck is again unloaded. At the end of the afternoon move, the truck returns to base empty.

- An independent truck operator shuttles cargo containers one at a time between the waterfront container marine facility at Port of Seattle and designated distribution centers mostly south of Seattle. The truck occasionally brings an empty container from the distribution center back to the dock area. Between waiting in line for his load and pushing through traffic congestion, the driver is able to complete a half dozen or fewer round trips in a workday.

In the course of our research, our project research associate developed a case example of FSJ Trucking in the Bay Area. (The name has been altered at the request of the company.)

- FSJ Trucking is an LTL common carrier operating in the San Francisco Bay Area with 11 tractor-semi-trailer trucks. The trucks work out of a base in Vallejo, departing empty from 5 A.M. to 7 A.M. in the morning and returning to base empty about eight hours later. The trucks travel to distribution centers and factories throughout the Bay Area, generally making 10 to 15 pickups and deliveries per day. FSJ has many contract customers so the locations and routes followed are familiar to drivers, although there are no regular daily routines. The cargo is usually pallets and individual cartons of packaged consumer goods that are delivered to retail locations and warehouses. Trucks are expected to be at customer loading docks at a set time, and FSJ is charged if they arrive more than one hour late. The drivers know alternative routes if there is traffic congestion, and generally the scheduled pick up and delivery times are met.

Another first approximation was developed for the FedEx terminal in San Jose.

- Standing near the FedEx World Service Center on Dado Street in San Jose, we observed and inferred from the sidewalk on a Friday morning that trucks carrying packages arrived from the airport on nine semi-trailers from 7 to 7:30 A.M., and departed on 91 delivery vans that left in the interval between 8:30 and 9 A.M. We assumed from general knowledge of how FedEx operates (with highly automated, centralized sorting operations in Memphis and elsewhere) that distribution of presorted packages from the larger trucks to the delivery trucks took place between 7:30 and 8:30 A.M., then trucks left to make deliveries. Six delivery vans arrived between 7 and 9 A.M. and one tractor-trailer combo departed, all for reasons that are unclear and undetermined.

Safety-Related Information

This section would cover safety issues stemming from truck accidents, which are rightly perceived as adding danger to the life of the community because commercial trucks, on average, are bigger than cars. Five elements are proposed.

1. Truck accident rates in the region in comparison with accident rates involving only automobiles, and showing trends over time.

2. Map of truck accident hot spots in the region to identify potential infrastructure deficiencies.
3. Description of significant blocking accidents with truck involvement.

   The following are examples of truck incidents that required more than 90 minutes to be cleared from blocking a lane. These examples are from the quarterly performance measures publication of Washington State Department of Transportation.[19]

   - Bellevue vicinity: Interstate 405 at Coal Creek Parkway. Injury collision and rollover blocking the exit ramp that involved two vehicles. Driver of semi reportedly had a heart attack and subsequently ran off the ramp, rolling his tractor/trailer, spilling the load of beer onto the highway. It took 5 hours and 10 minutes to clear the scene.
   - Pierce County: State Route 512/Canyon Rd. Interchange. Hazardous material spill that blocked two lanes. Driver of semi failed to negotiate curve on Canyon Rd. to SR 512, went through the guardrail and over the embankment, and blocked the adjacent on-ramp. Remaining diesel in fuel tanks was pumped. It took 2 hours and 53 minutes to clear the scene.
4. As an indicator of safety, a table reporting representative samples of truck speeds on selected road segments, probably as a special study if roadside monitoring equipment is not permanently installed and available. This measurement cannot be done with a representative fleet concept, since the safety focus requires monitoring of *all* trucks to measure compliance with speed limits as a proxy for measuring the degree to which trucks are operating safely.
5. Results of truck inspections.

Environmental Impacts

This section contains measurements of critical environmental disturbances to which trucks contribute. Four elements are proposed.

1. Table and/or maps reporting on air emissions from diesel trucks.
2. Table of truck noise complaints, if available.
3. Truck breakdown statistics on major roads, if available.
4. Table of compiled statistics on truck noise and vibration complaints.

The issues being measured are estimated to show more impact from large trucks than from small trucks, but the point of the RFLP measurement in the environmental area is to become more precise and compelling in characterizing problems and opportunities.

Public Policy Issues

This section highlights problem areas in urban trucking that might be addressed through public spending or government regulation.

We have in mind several different sources for these problems:

- There may be a trend over time in one of the earlier measures that serves as a warning of a problem. Growing traffic congestion or a rising number of truck accidents on a road segment is a simple example.
- There may be a public outcry that results in a metropolitan leadership decision to focus on a condition that is revealed in a single incident or observation, such as a terrible accident with fatalities or an incident causing extreme environmental damage.
- A leading businessperson whose company is a large generator or receiver of freight speaks out on a transportation-related issue that may or may not have been measured previously.

Whether the source of the public issue is one of those mentioned above or a different source, creating measurement of the issue in the RFLP would be desirable, if the issue is not already covered in the RFLP.

For example, a transportation planner in the Bay Area has pointed out to the authors that inadequate street parking for trucks near the terminals of small, independent truck operators in the East Bay is a critical issue. This situation might be handled by creating a map in the RFLP showing where these operators are and how many trucks each of them owns, along with a periodic street parking survey that compares the number of trucks parked against the supply of curb space available.

MEASUREMENT ISSUES

Our research revealed that there are practical considerations in implementing the RFLP specified above. The design work is challenging because of our intent to balance coverage of the variety of public and business concerns relative to freight against the costs and other practicalities of collecting data.

Because the RFLP seeks to provide broad coverage of the trucking environment, we are led to these implementing recommendations.

- We recommend matching and adapting the phenomena and parameters to be measured to the availability of data and the resources to collect data.

- We recommend giving priority to establishing measures and collecting data that bear on high-priority, trucking-related public concerns in the regional community.
- We urge that data collection be phased in across all the areas we have specified here, to bring to the surface issues that may be damaging local economic health or public safety and which would be the focus of policy action if data were available to highlight the issues.
- Part of the process of building and growing the RFLP will be the management of a backlog of unaddressed measurement targets; resources are insufficient to measure them all. Priorities will need to be set and the most important areas measured first.
- While the measurement efforts should be the subject of continuous expansion and improvement, we recommend that consistent time series with annual data sets be established in order to make comparisons and illustrate trends.
- Because measurements are not yet available for some of the areas specified, we recommend a concept of iterative incrementalism in the execution of the suggested measurement areas within the RFLP. By this we mean beginning within existing resource availability and expanding coverage geographically, in the number of topics, and in the depth of topical measurement in successive months and years.
- We found private companies are reluctant to reveal performance information. Thus, we have spent time designing an institutional approach to gathering truck fleet performance data that does not compromise confidential performance data from competing carriers and shippers. This is discussed further below.

RECOMMENDATIONS

We suggest that the following measurement concepts be explored for their potential to add value to the RFLP.

Automatic Vehicle Location Technology

As part of building expansion potential into the RFLP, we recommend anticipating and taking steps to accommodate the data streams potentially available in the next few years from private telematic and intelligent transportation systems (ITS) equipment installed on fleet trucks. The most important of these technologies is automatic vehicle location (AVL), in which vehicles have devices that are aware of their location, and in real time or, later report that location via wireless telecommunications to a monitoring point. Studies in Florida (PSB&J 2001), Washington State (Washington State DOT 1992), and California (Dowling Associates 1999), plus assessment work by the Federal Government (Federal Highway Administration 1998), have indicated that "probe vehicles" moving along roads with an awareness of location and speed provide a satisfactory means of measuring travel time, and, hence, congestion.

Conceptually, animated time lapse maps of the region, prepared and displayed via computers and showing a representative sample of trucks as dots moving throughout the day, would provide orders of magnitude more information than what is available today in the rhetoric of politicians and planners about businesses suffering from traffic congestion. An effort to create on paper some suggestive data displays for a few fleets that point the way to a dynamic map may serve to motivate a cooperative effort across several fleet operators or one of their national associations to provide a composite picture. Combining data from several fleets would obscure operational trade secrets of individual businesses but provide an illuminating picture of how delivery fleets interact with urban traffic generally. Real-time truck location data merged from various fleets would present a picture of interest without compromising proprietary information.

One or more MPOs could establish a nonprofit organization that focuses on using AVL tracking data from leading fleets to measure and document travel times and road usage. Aggregating data from several fleets would serve to obscure proprietary data from any single fleet. With data from several fleets, the combined set of trucks is a composite “indicator fleet” that can be studied to characterize traffic conditions for trucks in metro areas. We believe that reasonable conditions of participation, potentially including cash side payments, would motivate fleet managers to permit government use of their internal performance monitoring and other vehicle tracking information sufficiently aggregated and sanitized to cover proprietary concerns.

The logic of cash payments to motivate the private sector to cooperate is explained as follows: If it costs government $50 million to wire the arterials of the region to comprehensively monitor traffic congestion as it impacts delivery trucks, governments could spend $30 million instead to create some derived, aggregated, sanitized output from the UPS/FedEx delivery fleet tracking system based on AVL fleet tracking technology that is already in place for business purposes.

Richer Mapping Techniques

A more complicated but illustrative kind of mapping in time and space, developed with computer technology at Ohio State University, might provide a useful format for displaying the aggregate vehicle location data. As illustrated in Figure 11, vehicle tracks on a map have their position in time depicted by a vertical scale that rises upward from the map. This would provide a rich combined display of truck movements with a time dimension present.

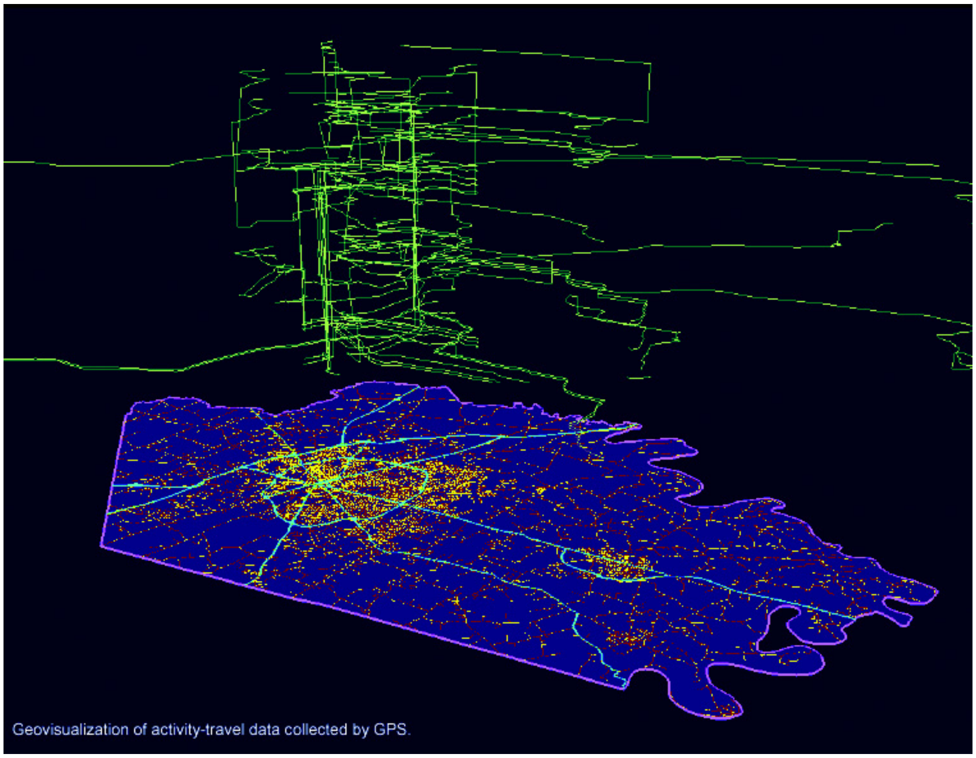

Figure 11: Vehicle Movement Patterns Plotted Against a Vertical Time Axis

Source: Mei-Po Kwan, Department of Geography, Ohio State University

Incorporating RFLP into Transportation Planning of MPOs

We conclude by offering what the project experience suggests for the improvement of transportation planning for intraurban freight by MPOs.

Because intraurban trucking is a majority share of the trucking volume in a metropolitan area, MPOs should make a commitment to specifically measuring intraurban trucking.

MPOs should review the RFLP and decide if devoting resources to using it would contribute to a better understanding of urban freight. State and federal freight mobility offices with responsibility for technical assistance to MPOs would also benefit from examining the RFLP for possible adaptation and adoption.

We have not tested whether the RFLP, as we have designed it, would stimulate a more productive interaction among the parties who are concerned with trucking and freight. This proposition needs to be tested.

We suggest the following test protocol:

1. Exposure of design to MPO freight roundtable and consideration of implementing their suggestions for improvement.
2. Execution of sample measurements.
3. Exposure of refined RFLP design with sample measurements to the MPO freight roundtable.
4. Further refinement.
5. More measurements taken.
6. Exposure and marketing of the RFLP partially filled in with data to a wider civic audience.

CONCLUSION

The Regional Freight Logistics Profile anticipates the public policy issues that plans for urban freight mobility improvement need to address and suggests a comprehensive and largely untried approach to measurement and reporting. As a supplement to existing trends of development in freight measurement carried out by traffic modeling professionals, the approach proposed in this study is designed to create technology-enabled data displays that more directly link to observed conditions and thus inform policy debate and investment decision making. The RFLP is now at a stage where testing and refining the recommended techniques would help to emphasize the critical issues in freight movement in support of the U.S. economy and way of life.

END NOTES

1. The fast-growing category called “services” includes all the common carrier and contract trucking companies that carry freight for customers in shipment sizes ranging from full truck loads (TL) and less-than-truck loads (LTL) to express packages and overnight letters. This category also includes the commercial trucks that carry repair and maintenance personnel with tools, replacement equipment, and parts. Common carrier and contracted trucks serve all sectors of the economy, so trucks classified under “services” is not an accurate measure of the trucking needs of the services sector of the economy, as opposed to manufacturing or resource extraction.
2. A series of state maps illustrating freight flows is available in a comprehensive national data and analysis tool (the Freight Analysis Framework) from the Federal Highway Administration. State profiles are available for download at http://www.ops.fhwa.dot.gov/freight/state_profiles.htm
3. Exceptions include facilities such as marine bulk terminals for grain and coal served by rail cars only; power plants receiving fuel strictly by railroad, barge, or pipeline; and rail-on-dock marine ports where containers move directly between ship and railroad.
4. Massachusetts Institute of Technology and Charles River Associates Incorporated. *Mobility 2001*. Report prepared for Sustainable Mobility Working Group of the World Business Council for Sustainable Development, at http://www.wbcsdmobility.org.
5. Levine, Daniel S. “Congestion also holds up goods, not just commuters,” East Bay Business Times, July 15, 2002. Quote from Marianne Dreisbach, a director of the Industry and Labor Alliance.
6. Noted at http://www.fedex.com/us/services/logistics/faq.html.
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ABBREVIATIONS AND ACRONYMS

3PL	third-party logistics
AVL	automatic vehicle location
DC	distribution center
FedEx	Federal Express
FHWA	Federal Highway Administration
GDP	gross domestic product
HPMS	Highway Performance Monitoring System
ITS	Intelligent Transportation System
JIT	Just In Time—more delivery activity and smaller inventories relating to manufacturing.
LTL	less-than-truckload
METRANS	National Center for Metropolitan Transportation Research
MPO	Metropolitan Planning Organization
NAFTA	North American Free Trade Agreement
NCHRP	National Cooperative Highway Research Program
NPTC	National Private Truck Council
QR	Quick Response – more delivery activity and smaller inventories relating to retailing.
RFLP	Regional Freight Logistics Profile
RTPO	regional transportation planning organization
SKU	stock-keeping unit
STCC	Standard Transportation Commodity Classification code (of the Census Bureau.)
SUV	sport utility vehicle

TIUS	Truck Inventory and Use Survey
TL	truckload
UPS	United Parcel Service

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