Synthesis of Freight Research in Urban Transportation Planning

DETAILS

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AUTHORS

þÿGiuliano, Genevieve; O Brien, Thomas; Dablanc, Laetitia; and Holliday, Kevin

NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

NCFRP REPORT 23

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Genevieve Giuliano
Thomas O'Brien
Laetitia Dablanc
Kevin Holliday
METRANS Transportation Center
Sol Price School of Public Policy
University of Southern California
Los Angeles, CA

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NATIONAL COOPERATIVE FREIGHT RESEARCH PROGRAM

America's freight transportation system makes critical contributions to the nation's economy, security, and quality of life. The freight transportation system in the United States is a complex, decentralized, and dynamic network of private and public entities, involving all modes of transportation—trucking, rail, waterways, air, and pipelines. In recent years, the demand for freight transportation service has been increasing fueled by growth in international trade; however, bottlenecks or congestion points in the system are exposing the inadequacies of current infrastructure and operations to meet the growing demand for freight. Strategic operational and investment decisions by governments at all levels will be necessary to maintain freight system performance, and will in turn require sound technical guidance based on research.

The National Cooperative Freight Research Program (NCFRP) is a cooperative research program sponsored by the Research and Innovative Technology Administration (RITA) under Grant No. DTOS59-06-G-00039 and administered by the Transportation Research Board (TRB). The program was authorized in 2005 with the passage of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). On September 6, 2006, a contract to begin work was executed between RITA and The National Academies. The NCFRP will carry out applied research on problems facing the freight industry that are not being adequately addressed by existing research programs.

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The NCFRP will produce a series of research reports and other products such as guidebooks for practitioners. Primary emphasis will be placed on disseminating NCFRP results to the intended end-users of the research: freight shippers and carriers, service providers, suppliers, and public officials.

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FOREWORD

By Crawford F. Jencks
Deputy Director, Cooperative Research Programs
Transportation Research Board

This report synthesizes information about policies and practices for managing freight activity in metropolitan areas and is based on a comprehensive review of international literature. The primary focus is on "last-mile/first-mile" strategies, but the report also focuses on strategies affecting environmental issues and trading hubs or nodes. The research looked beyond the United States—mostly, but not exclusively, in Europe and the European BESTUFS (Best Urban Freight Solutions) program—for potentially relevant policies and practices that could be used in the United States. The report will be of interest to transportation planners and strategists, particularly those representing the larger urban areas.

Commercial transport for the delivery of goods and services is crucial to the modern urban economy, which relies on frequent deliveries and collections (groceries, parcels, trash), express and urgent deliveries (hospitals, businesses), and a fast-growing home delivery market. Trucks and vans provide the "last mile/first-mile" transport, as well as most medium haul freight transport. In metropolitan areas that serve as trade hubs, trucks are a major part of wholesaling, distribution, logistics, and intermodal operations. Truck traffic also generates significant impacts including congestion, emissions, noise, and traffic incidents. Metropolitan areas throughout the United States, Europe, and the rest of the world are seeking ways to better manage truck traffic. Of particular interest is the BESTUFS program that the European Union has funded to bring together experts, projects, research results, and stakeholders to analyze success factors for urban logistics in European cities.

The objective of the research was to conduct a synthesis of recent urban freight studies in the United States, the European Union, and elsewhere to identify relevant strategies for managing urban freight transport. The results provide useful guidance and information to transportation planners and strategists interested in urban freight issues. The report provides guidance on the types of research and studies that could be undertaken to contribute further to solutions of urban freight transport in terms of economic, environmental, and social/safety issues.

Under NCFRP Project 36(05), "Synthesis of Freight Research on Urban Transportation Planning," METRANS Transportation Center, University of Southern California examined strategies in three general categories: (1) last mile/first mile, (2) environmental, and (3) trade node. Last-mile/first-mile strategies focus on reducing congestion on city streets related to local deliveries and pickups. Environmental strategies focus on reducing emissions and noise from trucks and vans. Trade node strategies deal with the particular problems of metropolitan areas serving as hubs for national and international trade. The report concludes with general observations from the literature review and an assessment of the most promising strategies that could be used to better manage urban freight in the United States.

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Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

SUMMARY

Synthesis of Freight Research in Urban Transportation Planning

The purpose of this research synthesis is to summarize the literature and best practices regarding the management of truck and van transport in urban areas. Truck transport is crucial for the delivery of goods and services within metropolitan areas. Trucks and vans provide the "last-mile/first-mile" transport, as well as most medium haul freight transport. In metropolitan areas that serve as trade hubs, trucks are a major part of wholesaling, distribution, logistics, and intermodal operations. Truck traffic generates significant externalities in metropolitan areas, including congestion, emissions, noise, and traffic incidents. Metropolitan areas throughout the United States, Europe, and the world are seeking ways to better manage truck traffic.

This synthesis is based on an in-depth review of the literature, including academic journals and books, professional reports, and unpublished materials associated with ongoing projects. The review is international in scope, with particular emphasis on Europe, where many urban freight management strategies are being developed and tested. The research team also surveyed public agencies to gather information on projects for which there was no published information.

Organization of the Research and the Report

This research included four tasks and the report includes, in addition to a research summary, four sections that each report on one of the four tasks. Task 1 (Section 1) was to describe the current state of the knowledge of urban freight flows and their impacts. Task 2 (Section 2) was to discuss strategies for managing urban freight problems, focusing on strategies that are either under consideration for implementation or that have been implemented either in the United States or abroad; Task 3 (Section 3) was to present a discussion of the U.S. policy context and how it may impact the feasibility and effectiveness of alternative management strategies; and Task 4 (Section 4) was to consider the effectiveness of alternative strategies and their implementation feasibility and offer some recommendations including areas for further research.

Summary of Tasks 1 through 3

This section summarizes the main findings of the first three tasks.

Task 1: Current State of Knowledge on Urban Freight Flows

Until the recession of 2008, truck vehicle miles traveled (VMT) in the United States had been steadily increasing as a result of economic growth, more international trade, and more intercity trade. In contrast to Europe, where more focused surveys are taken, the data on truck travel within U.S. metropolitan areas are extremely limited. U.S. sources indicate that the main bottlenecks on the Interstate system are in metropolitan areas, particularly those that serve as national or international hubs, but more detailed data on truck traffic *within* metropolitan areas is difficult to find. Most cities have no idea of the number of commercial vehicles (be they heavy trucks, light trucks, vans, cars, or even bikes) traveling on their streets. What little data are available are typically collected by state departments of transportation and focus on heavy trucks as they traverse urban freeways or roads designated as state highways. A few cities have conducted their own surveys. For example, as part of a study of off-hours deliveries in New York City, the research team found some of the only city-level data for trucks' share of "peak period VMT": 8 percent (Cambridge Systematics, 2007, pp. 3–14).

Freight flows are the outcome of demand and supply and their respective spatial distributions. There are two main trends in logistics facility siting: decentralization and consolidation. The review of the research herein shows that while all businesses are moving away from the central city, logistics facilities are moving further than their customers. Exurban locations offer inexpensive land and larger parcels, and this allows logistics firms to build ever larger facilities and consolidate disparate centers. The effect of these two trends on truck VMT is indeterminate; although some studies have suggested that the net effect is greater VMT.

The research team surveyed the literature on congestion, parking, and circulation problems. Truck parking appears to be a perennial problem in urban areas, with the most densely populated cities (e.g., New York and San Francisco) experiencing the worst problems. New York has conducted a demonstration project of off-hours deliveries; the demonstration showed fuel savings and significant reductions in congestion (Holguín-Veras, 2010, 2011; Holguín-Veras et al. 2006). However, the demonstration also revealed that there are substantial costs for receivers, making it difficult to implement such programs on a permanent basis. San Francisco is experimenting with demand-based parking pricing to encourage turnover in commercial loading zones and hopes to reduce circling and double parking.

Other externalities associated with urban truck traffic include crashes, air pollution, and greenhouse gas (GHG) emissions. The number of truck collisions is small relative to truck VMT; however, when trucks crash, injuries are typically worse. Trucks are also a large source of air pollution in cities. Concentrated truck activity in areas that surround freight centers (e.g., ports) or freight-heavy corridors (e.g., freeways such as I-710 in Los Angeles) creates negative health effects in surrounding neighborhoods; the problem is especially serious for children. Finally, trucks are a major contributor of GHG emissions: freight sources (trucks, ships, trains, airplanes, and pipelines) account for 29 percent of the total GHG emissions attributable to transportation in the United States, and trucks account for two-thirds of this total (Cambridge Systematics, 2010, pp. 2–4).

Task 2: Strategies for Addressing Urban Freight Problems

Task 2 was to look at strategies to address three general categories of urban freight management problems: local last-mile delivery/first-mile pick-up, environmental impacts, and trade node problems. (In this report, both first-mile and last-mile trips will be referred to collectively as the "last mile.") Last-mile strategies address local deliveries to and pick-ups from urban businesses or residences. Strategies that reduce environmental impacts focus on reducing emissions and noise through regulation or by offering incentives for use of vehicles that pollute less. Finally, strategies related to trade nodes (i.e., cities that are hubs for national and international trade) focus on locations where there are the largest flows to and from ports, airports, or intermodal facilities. These three kinds of urban freight management problems are distinct, but there is also some overlap among them. Most efforts to manage truck traffic are intended to reduce environmental impacts in some way, along with reducing congestion and achieving other objectives. For example, an increase in truck loading zones (classified in this review as a last-mile strategy), intended to reduce delays caused by trucks parking illegally, may also reduce idling emissions. The Clean Truck Program at the Los Angeles and Long Beach ports is classified as a trade node strategy, even though the program's primary purpose is emissions reduction, because it is a program operated by the ports and applies only to vehicles serving the ports.

The research team conducted an in-depth, international literature review to survey the many strategies proposed, considered, and (in many cases) implemented to solve urban freight problems. Below, each of the three categories is discussed, and all 17 strategies are described.

Last-Mile Strategies

With respect to last-mile issues, the research showed that experimentation with various local freight management strategies is far more extensive outside the United States than inside. The researchers surmise that cities outside the United States have more serious problems than U.S. cities due to higher density city cores, older building stock (and hence limited parking and loading facilities), and less road capacity. Also, cities outside the United States have more legal ability to regulate trucks. The researchers classified six strategies for addressing last-mile deliveries. A brief description of each follows:

- **Labeling or other certification schemes.** These schemes are generally voluntary and involve creating a list of qualifications/minimum specifications for commercial vehicles. Ultra-clean vehicles might get a green sticker, for example. Some governments may use incentives to get firms to participate, such as allowing ultra-quiet vehicles to deliver at night.
- **Traffic and parking regulations.** Regulations are frequently used by municipalities to manage urban freight because these tools are clearly within local authority. However, regulating urban freight has a mixed record of success. Local freight demand must be accommodated; hence, strategies that *manage* rather than *restrict* freight deliveries tend to be more effective.
- **Land use planning and zoning.** Local jurisdictions can use their land use planning and zoning authority to set policies and guidelines for incorporating freight deliveries into new developments; for example, local jurisdictions could set requirements for the presence or design of loading docks and for parking and off-street loading zones.
- **City logistics and consolidation schemes.** These schemes seek to reduce truck traffic by finding ways to combine the pick-ups and deliveries of different shippers or different receivers. These schemes often focus on changing the supply chain, rather than on the final (or initial) step of the chain. Some are successful, such as instituting drop-off/pick-up boxes for online purchases to avoid home deliveries. The more ambitious "urban consolidation centers" typically require heavy subsidies and are not popular with firms.
- **Off-hours deliveries.** This strategy seeks to shift truck activity out of the peak traffic periods and hence reduce congestion and emissions. This is an obvious way to reduce truck-related congestion; yet, few examples of off-hours delivery programs exist. Change (in the hours of operation) is required for both the freight providers and (even more importantly) the receivers; therefore, coordination is difficult.
- **Intelligent transport systems (ITS).** These systems include technologies for providing real-time traffic (and parking) information, automated enforcement of parking or traffic regulations, toll collection, or automated access control. Real-time traffic information is available in the largest U.S. metropolitan areas. Overseas, license plate readers are part of road pricing systems or limited access zones.

Environmental Strategies

Almost all urban freight management efforts include environmental mitigation as an objective. There are several strategies, however, that have environmental mitigation as a primary objective. As with last-mile strategies, the state of practice of strategies to reduce environmental impact appears more advanced in Europe and Asia than in the United States. The five environmental strategies are as follows:

- **Truck fuel efficiency and emissions standards.** These are among the most effective tools for reducing emissions. The recent changes in light truck corporate average fuel economy (CAFE) standards will have a significant impact on the light truck portion of the freight vehicle fleet.
- **Alternative fuels and vehicles.** This strategy is typically limited to public fleets (e.g., transit buses) and utility firms, as well as the operations of large players such as UPS and FedEx in central business districts. Smaller entities making many local deliveries in urban areas face challenges in turning to alternative fuels. Niche markets may exist in the most densely populated city centers for electrically powered "cargocycles."
- **Low emission zones (LEZs).** These are zones in which a minimum standard for environmental performance is set. Those vehicles that do not meet the standard are excluded from the zone. LEZs are now common in European cities.
- **Alternative modes.** Some cities have experimented with shifting local freight from trucks to alternative modes such as rail or even boats. These shifts typically increase costs and require heavy subsidies.
- **Environmental justice.** Issues of environmental justice arise during the environmental review process. Recent research on the relationship between emissions and health has created an imperative for industry to find solutions to problems that might otherwise prevent expansion. Southern California's Clean Truck Program is an example.

Trade Node Strategies

Trade hubs and gateways are places with a significant concentration of ports and airports, intermodal transfer points, and border crossings. The United States is a leader in developing trade-node-related strategies; most significantly, the programs in place at the Los Angeles/Long Beach ports are among the most innovative in the world. The U.S. environmental impact process creates opportunities for nearby communities to demand mitigations any time logistics operations expand. That process may be the root cause of U.S. leadership in trade node strategies. The following six strategies are specific to trade nodes:

- **Appointments and pricing strategies at ports.** These strategies represent changes to gate access policies. Appointments have been successfully incorporated into port and terminal operations where they have been mandated. However, the research indicates that appointments have little to no influence on turn times. The PierPASS program in Southern California is the sole example of a pricing strategy. It shifted a significant amount of eligible cargo to the evening (approximately 40 percent).
- **Road pricing to manage hub-related truck traffic.** Using road pricing to manage hub-related truck traffic has been frequently studied. However, there are few examples to point to in analyzing the effectiveness of this strategy. Additionally, while separated (and priced) truck-only facilities have been proposed, very few exist.
- **Accelerated truck emissions programs.** These programs seek to lower the average age of a truck visiting a location (e.g., a port). One method to achieve this goal would be to ban older vehicles from accessing a port. Such programs might use financial incentives to encourage trucking companies to accelerate the replacement of older, high-polluting vehicles with newer, cleaner trucks.

- **Equipment management.** This strategy aims to change the ownership, storage, and positioning of chassis and containers to make their use more efficient.
- **Rail strategies.** These strategies improve the flow of freight using grade-separation programs like the Chicago Region Environmental and Transportation Efficiency program (CREATE) and the Alameda Corridor.
- **Border crossings.** Strategies to improve freight flow at border crossings have generally centered on using ITS. The Freight Action Strategy (FAST) project in the Pacific Northwest is an example of a comprehensive approach to cross-border freight management.

Task 3: The U.S. Policy Context

Metropolitan areas outside the United States offer many promising examples of how urban freight—particularly truck and van traffic—might be better managed. Task 3 addresses the question of transferability and discusses the U.S. policy context in which these strategies would be implemented. In the United States, authority for setting freight transportation policy is widely distributed across levels of government; additionally, that authority is becoming more widely distributed to even lower levels of government and fragmented among different agencies. This fragmentation of authority is particularly challenging in the case of freight policy, because freight famously "has no borders." The global dynamics that drive freight flows are largely beyond the control of any one government. The fragmentation of authority governing freight policy means that collaboration and consensus building are critical for actions that affect more than a single jurisdiction.

Of particular interest to this study are (1) the fragmentation of regulatory authority across different levels of government, (2) differences in governance structures across modes, (3) the absence of any federal entity that has full jurisdiction across modes, and (4) the potential of local governments to participate in all four of the major public agency functions (see Table 11 in Section 3.1). Local governments can have significant influence on freight activity. They can invest directly in new freight facilities, in roads to provide better access, or in favorable zoning practices to attract industry investment. On the other hand, local governments can discourage industry investment through their management of the environmental review process and control of land use decisions.

There are three policy trends in the United States that are especially relevant to urban freight. First, there is a growing disparity in federal surface transportation funding supply and demand that is likely to continue into the future. Second, the United States lacks a national freight policy or program; the freight-related programs in SAFETEA-LU were collections of earmarked projects. The recently passed MAP-21 legislation includes a provision for the development of a national policy for freight infrastructure, but no funds are attached. Third, the devolution of authority in surface transportation to lower levels of government continues. Devolution leads to parochial decision-making and hinders the formation of an efficient national freight system.

How do these policy trends affect efforts to solve urban freight problems? First, local decision-makers have no motivation for solving national system bottleneck problems, except as they affect the local community, and they also have little authority to do so. Second, freight transportation problems are typically very visible: ports, rail yards, warehouses, and intermodal facilities are very large and significant elements of the urban landscape. Therefore, they attract public attention and often generate conflicting views on how such problems should be solved. Third, fragmentation affects the ability of government to address major problems. One of the most telling examples of how fragmentation constrains governing ability is the current state of air quality regulation, where broad authority does not exist. One consequence of the fragmentation of governing authority is the growth of voluntary programs achieved via negotiation. Voluntary programs, often-termed voluntary regulation, are a good fit for the U.S. governance context.

Overall Summary of Report Findings

This section summarizes the overall findings of this study in three parts. The first part includes three general observations to be drawn from the literature review. The second part presents the research team's assessment of the most promising strategies for better managing urban freight in the United States, and the third part presents recommendations.

General Observations

Urban Freight Contributes Disproportionately to Externalities

Commercial vehicles contribute a significant share of nitrogen oxides, particulate matters, and carbon dioxide emissions in cities and contribute disproportionately to congestion, noise, and road accident fatalities. Freight terminals (e.g., ports) and corridors (e.g., freeways with many trucks) generate pollution "hot spots." Outside the United States, there is evidence that the average age of urban delivery trucks is older, and that it is common practice to use trucks at the end of their service life for short-distance drayage. There is no information on the average age of delivery fleets in the United States. However, aside from the issue of the age of delivery trucks and vans, the nature of local delivery is short trips and frequent stops, which implies lower fuel efficiency and more emissions. There is evidence that the U.S. port drayage sector operates older (and dirtier) trucks. Thus, the need for better urban freight management strategies is clear.

Available Data Are Lacking

The data on commercial vehicle traffic in urban areas are extremely limited because there is no common source. The federal government aggregates data on key areas of concern including intercity truck flows and truck crashes. State departments of transportation collect the data that do exist on freeways and state highways that run through urban areas. Metropolitan planning organizations have begun to collect urban freight data, particularly with regard to truck movements, but this is more often the case for large trade node metropolitan areas such as Atlanta, Chicago, or Los Angeles. Some data from urban intersections exist, but this is more often the case for locations designated as state highways. For the most part, these data are also primarily collected only for the largest of trucks. The research team did not find any data indicating the number of non-truck commercial vehicle trips, i.e., those undertaken in vans, pick-ups, cars, or bikes. This is a critical information gap—data from Europe show that about half of urban deliveries are made by vans. Understanding the characteristics of urban freight flows requires basic data on commercial vehicles and what they carry.

Spatial Distribution of Freight Supply and Demand Needs Better Understanding

There is a need to better understand the factors that drive intra-metropolitan freight flows. The research team identified two main trends on the supply side: decentralization and consolidation. Rising land values provide the economic incentive for land-intensive activities (manufacturing, warehousing, distribution) to *decentralize* to suburban or exurban locations. Larger parcels in these areas allow for the development of larger, *consolidated* facilities.

On the demand side, new activities in revitalized cores generate additional freight demand, but freight facilities are incompatible with rising land values, limited road capacity, and residential communities. Pick-ups and deliveries to serve these new activities still need to be made, but parking and loading facilities are often inadequate. Just-in-time logistics practices increase the importance of reliability and may result in more frequent shipments. More home-based shopping means more home deliveries and less efficient routing (due to the dispersion of deliveries and risk of non-delivery). Nodal cities have the same set of last-mile issues (parking, noise, and emissions) as other regions, but they also have to handle pass-through freight movements bound for locations outside of their region.

Assessment of Strategies for Managing Urban Freight

Table 1 lists 17 strategies for tackling the urban freight problem. The strategies are split into the three overlapping general categories that were previously introduced: local last-mile delivery/first-mile pick-up, environmental impacts, and trade node problems. The section number in this report in which each strategy is discussed is also given. Table 1 also presents the research team's rating of each strategy's effectiveness and applicability to the U.S. context (possible ratings are high, medium, and low). Each of the strategies is described previously in the Task 2 summary.

It is advantageous to the United States that most of the 17 strategies listed are being tried and tested overseas. Domestic policy-makers will be able to assess the results of using these strategies abroad as they consider what strategies will work best in a U.S. context.

Among the last-mile strategies, labeling and certification programs, land use planning (in the longer term), and off-hours deliveries are the most effective strategies. However, off-hours delivery programs are less transferable due to the many changes they require

Table 1. Summary of strategies and their effectiveness and applicability to the United States.

	Section Number	Strategy	Effectiveness	Applicability to United States
Last-mile	4.2.1.1	Labeling or other certification programs	High	High
	4.2.1.2	Traffic and parking regulations	Medium	High
	4.2.1.3	Land use planning policies	High	High
	4.2.1.4	City logistics and consolidation schemes	Low	Low
	4.2.1.5	Off-hours deliveries	High	Medium
	4.2.1.6	Intelligent transport systems	Medium	Medium
Environment	4.2.2.1	Truck fuel efficiency and emissions standards	High	High
	4.2.2.2	Alternative fuels and vehicles	Low	Medium
	4.2.2.3	Low emission zones	High	Low
	4.2.2.4	Alternative modes	Low	Low
	4.2.2.5	Environmental justice	Medium	High
Trade node	4.2.3.1	Appointments and pricing strategies at ports	Medium	High
	4.2.3.2	Road pricing and dedicated truck lanes to manage hub-related truck traffic	High	Low
	4.2.3.3	Accelerated truck emissions reduction programs	High	Medium
	4.2.3.4	Equipment management	Medium	Medium
	4.2.3.5	Rail strategies	Medium	Medium
	4.2.3.6	Border crossings	Medium	High

across the supply chain. Traffic and parking regulations are less effective, because they do not have an impact on the underlying demand for freight moves. Although the research team gave city logistics and consolidation schemes low marks, there are some interesting demonstration projects, such as neighborhood small parcel pick-up centers, that might be highly effective in the United States. The research team rated ITS strategies “medium” due to their limited implementation feasibility and the need for more development of some of the most potentially beneficial applications, such as truck parking and loading information systems.

Within the category of environmental strategies, global (e.g., national) fuel efficiency and emissions regulations have proven their effectiveness over several decades. LEZs are the most effective to address local hot spots, but do not appear to be feasible under current national and state policy in the United States. Alternative fuel vehicles may prove to be very effective long term, but the technology and market penetration are not sufficient to achieve significant reductions in emissions or energy consumption. Environmental justice efforts are more advanced in the United States than in other countries; however, environmental justice problems are challenging to solve.

Among the trade node strategies, pricing and accelerated emissions programs are among the most effective strategies. Despite the effectiveness of pricing, the research team rated it “low” on applicability because of the continuing and strong political opposition from various stakeholder groups. Accelerated emission-reduction programs based on negotiation and voluntary targets have proven to be effective and are a better fit in the U.S. context. Rail strategies can be effective, but they involve high costs for which there are no obvious funding sources.

Recommendations

Without further research quantifying the effectiveness of the solutions presented in Table 1, the research team recommends focusing in the short term on those items that are both effective and easily introduced into the U.S. context. The research team found three strategies that fit that definition: (1) labeling or other certification schemes, (2) land use planning and zoning, and (3) truck fuel efficiency and emissions standards. Certification programs can take a number of forms and have been an effective way to devise incentives that introduce performance goals and incrementally move firms to the desired behavior. The authority of local governments to develop and implement planning and building guidelines is clearly established; even in slow economic times, tenants move out and new tenants move in, creating opportunities for redevelopment/improvement and new code enforcement. The United States has a long history of regulating vehicles for fuel efficiency and emissions reductions, and national fleet standards are among the most effective tools for reducing emissions.

Lack of data is a crippling problem in the emerging field of urban freight. Most cities cannot answer the following questions: How many vehicles are engaged in commercial activity? How many deliveries and pick-ups occur in a day or a week? Data on delivery characteristics that are accessible to planners and researchers are almost non-existent. More data collection is needed. The role of ITS in data collection is also an issue.

Many metropolitan areas are watching their logistics industries move further into the suburbs and exurbs, i.e., logistics industries are decentralizing. These same areas are also seeing fewer and larger facilities, i.e., consolidation. Studying the simultaneous decentralization and consolidation is critical to giving policy-makers the information they need to decide whether to discourage or encourage these practices. A good topic to begin studying would be the effect on VMT of decentralization and consolidation. Are large, dense freight centers worse for the environment than multiple smaller, dispersed facilities?

Socioeconomic factors such as rising income, aging of populations, and changing consumer preferences (i.e., the rise in online purchases) are also important drivers of freight demand. However, our understanding of how these forces affect urban freight flows and how these flows may be better managed remains very limited.

Research is necessary to understand the various market segments of local deliveries and their environmental impacts. For example, large corporations such as FedEx or UPS have modern fleets and use very sophisticated routing practices to operate as efficiently as possible. Local independent operators likely do not have the scale or profits to operate as efficiently.

Finally, there is a need for careful and systematic evaluation of existing policies and experiments (including the strategies listed above). There is a lack of analysis of the impacts of certification schemes, truck access restrictions, and requirements for alternative fuel trucks.

SECTION 1

Current State of Knowledge of Urban Freight Flows and Their Impacts

1.1 Introduction

This section summarizes data on truck and van traffic and its impacts on metropolitan areas. First, a brief review of land use trends relevant to freight supply and demand in metropolitan areas provides some context. Second, the limited data on urban truck traffic is presented. Third, impacts are considered, including congestion, parking, and other circulation problems; crashes and safety; and air pollution and other environmental impacts. Finally, a brief overview of the European urban freight issues is presented as well as a summary of Task 1.

Congestion results in enormous costs to shippers, carriers, and the economy. According to the Texas A&M Transportation Institute (TTI), the total cost of truck congestion amounted to approximately $23 billion in 2010 for 439 U.S. urban areas (TTI, 2011, p. 1). Freight bottlenecks on highways throughout the United States cause more than 243 million hours of delay to truckers annually (FHWA, 2008). At a delay cost of $26.70 per hour, the conservative value used by FHWA's Highway Economic Requirements System model for estimating national highway costs and benefits, these bottlenecks cost truckers about $6.5 billion per year (FHWA, 2008).

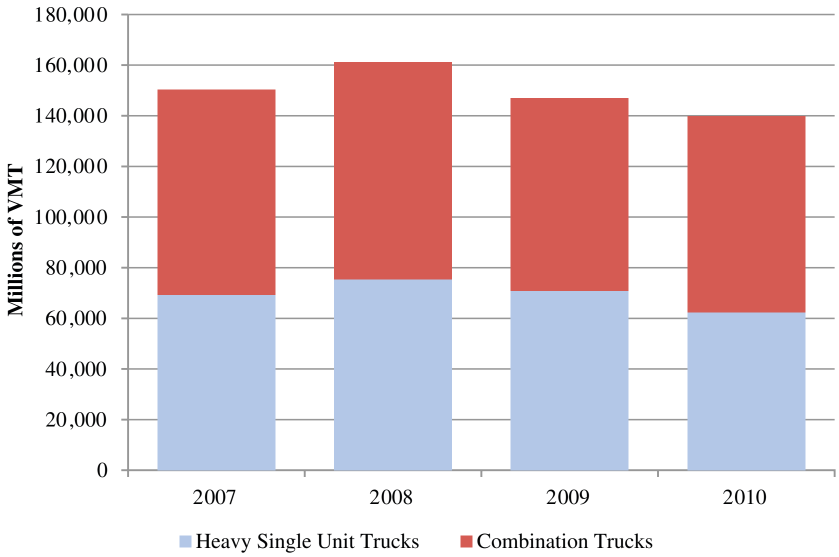
Over the past 25 years, freight transportation costs have declined, contributing significantly to enhanced productivity and economic growth. With ever-lower transportation costs, supply chains have become more complex and dispersed as firms along the chain substitute transport for lower cost inputs and higher product velocity. Prior to 2008, as economic activity was expanding, truck VMT was also on the rise. The recession has taken its toll on the growth rate of VMT. Figure 1 shows annual urban truck VMT from 2007 through 2010, defined as the sum of urban Interstate and other urban VMT by FHWA. VMT peaked in 2008 at 161 billion. By 2010, that figure dropped to less than 140 billion, a 13 percent drop. (2011 figures were not yet available when this study was undertaken.)

Despite the drop in VMT, congestion and bottlenecks continue to be a problem (see Section 1.3.3, Cambridge Systematics Bottleneck Studies). Much of the congestion problem is located in metropolitan areas, where trucks compete with passenger traffic in last-mile pick-up and delivery, freight trains compete with passenger rail (and all vehicular traffic at at-grade crossings), and where most major intermodal nodes are located.

1.2 Land Use Trends

Land use trends are contributing to urban freight problems. There are two main trends: decentralization and consolidation. Logistics activities are decentralizing (i.e., moving away from the central city), in part due to rising land values as metropolitan areas grow. Freight facilities are also consolidating, in part due to increasing scale economies that require ever larger warehouse and distribution facilities. For example, consider a logistics firm that once had three small warehouses in the central city. The firm now has one large facility in a distant suburb. The move from the central city to the suburb represents the *decentralization* of the firm. The reduction from three smaller facilities to one large warehouse represents the *consolidation.*

As logistics nodes both decentralize and consolidate activity, the effect on VMT is indeterminate. Decentralization may mean that pick-ups and deliveries require more truck VMT because the origin is further from most destinations. However, consolidation may lead to more efficient deliveries, reducing VMT. The VMT analysis is made more complex by the increase in just-in-time logistics. Just-in-time operations increase VMT because deliveries become smaller and thus more frequent. Some studies from France suggest that the net effect of decentralization and consolidation is greater VMT (Dablanc and Rakotonarivo, 2010; Dablanc and Andriankaja, 2011). While these trends may have a varying effect on VMT, we can say that logistics concentrations become hot spots of truck traffic and emissions (McKinnon, 1998).



Note: FHWA changed its methodology in 2007; VMT estimates from prior years are not directly comparable and so were excluded.
Source: FHWA (2010, 2008, 2007).

Figure 1. Annual urban truck VMT—2007 to 2010.

An example of the impacts of economic growth and demand for land on the location of logistics activity can be seen in Atlanta, Georgia. Key freight corridors with access to the Interstate and major arterials are becoming prime space for high-density office and residential or mixed-use developments. These uses bid up prices. As a result, more and more logistics firms are moving their facilities to remote sites just outside of the metropolitan area where land prices are lower.

Logistics decentralization is happening all over the United States. Cidell (2010) shows that at the county level in 47 of the 50 largest U.S. metropolitan areas, a decentralization of freight activity occurred between 1986 and 2005, as measured via Gini coefficients. Looking at the zip code level, Dablanc and Ross (2012) have found that in Atlanta between 1998 and 2008, warehouses moved an average of 2.8 miles further away from their geographic centroid. During the same period, all business facilities for all types of activities in Atlanta moved an average of 1.3 miles, i.e., less than half the distance for logistics facilities. A similar trend has been observed in France in the Paris region. Dablanc and Rakotonarivo (2010) calculated that in Paris parcel and express transport companies, on average, locate their terminals 6.8 miles farther away from their geographic centroid today than in 1975, while businesses and shops have only moved 1.8 miles away during the same period. If routing or load economies (from consolidation or other factors) do not offset the increased distance between terminals and destinations, deliveries would require more truck miles traveled.

A study conducted by Shin and Kawamura (2006) revealed that the majority of national retail chains operate under the same type of supply chain system. Under this type of supply chain system, the company's distribution centers are usually quite large, so they must be located far outside city limits where there is ample space to accommodate the buildings (Kawamura and Lu, 2007, p. 34). Delivery trucks must drive many miles to get packages from the distribution center to various parts of the city. Having one main distribution center that is located far from the city center also puts a large number of delivery trucks on the road network in urban areas (Kawamura and Lu, 2007, p. 34).

1.3 Urban Truck Traffic

The data on commercial vehicle traffic in urban areas are extremely limited. State departments of transportation are the primary collectors of the existing data on freeways that run through urban areas. State departments of transportation also collect data on the amount of truck traffic on urban arterials that are part of the state highway system. The research team was unable to find any data indicating the number of non-truck commercial vehicle trips, i.e., those undertaken in vans, pick-up trucks, or cars or on bicycles.

This subsection outlines the data found for trucks on urban freeways followed by a sampling of data found on urban streets designated as state routes. The subsection also discusses some truck bottleneck studies.

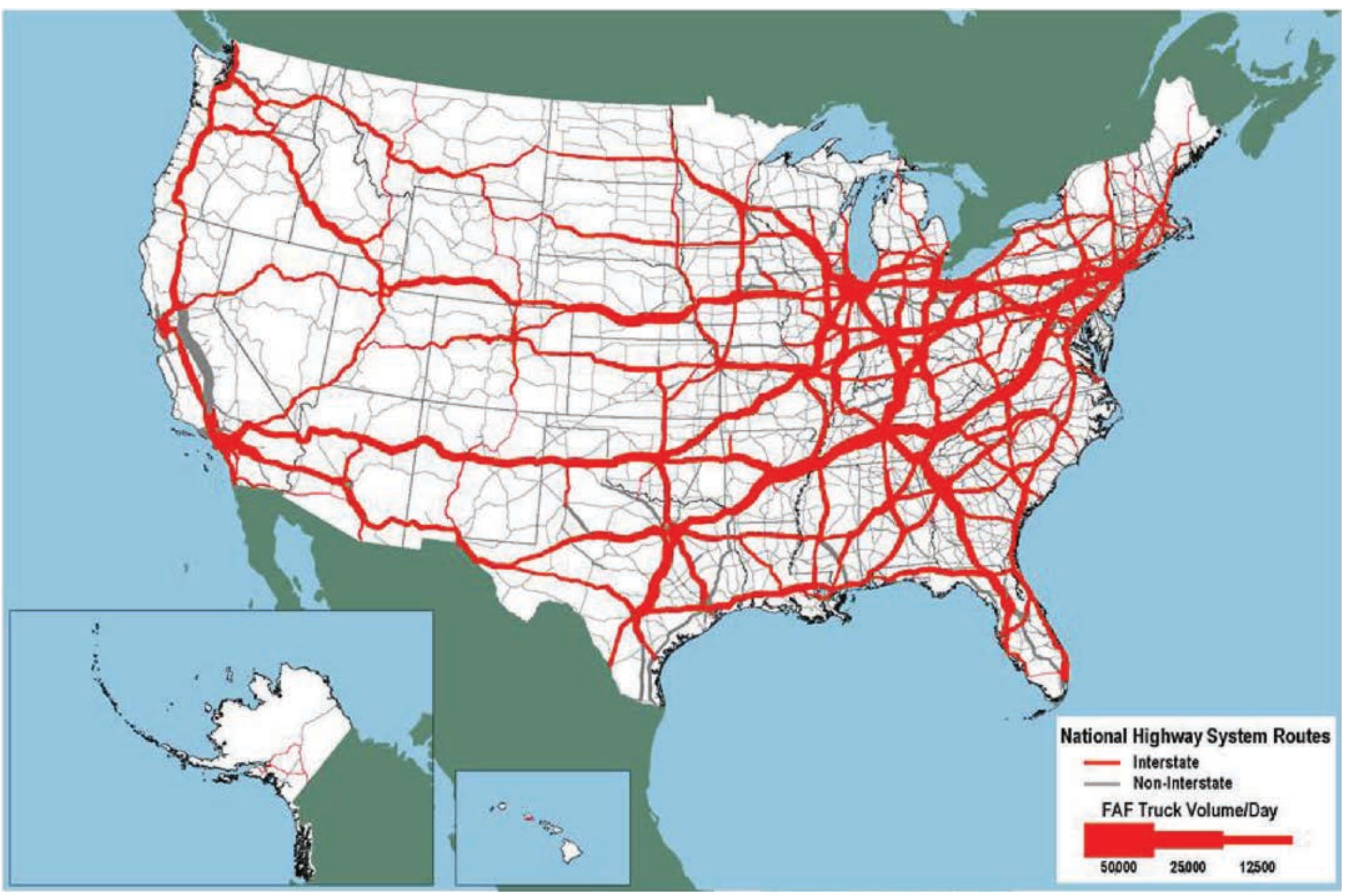
1.3.1 National Highway System Data

Truck traffic makes up about 10 percent of the VMT on urban Interstates and 7 percent of VMT on other urban roadways (FHWA, 2011, Table VM-1). In Europe (where cities do have better truck and van urban traffic data), freight makes up 10 to 15 percent of vehicular traffic in cities, with higher shares observed in the denser core, where automobiles constitute a smaller share of passenger traffic (BESTUFS, 2006). In both the U.S. and Europe, freight transport's share in city core vehicular traffic is growing for several reasons. First, the urban economy requires more freight movement as inventory holding has declined, the number and variety of goods sold has increased, and express transport services have become a key feature of the way urban businesses operate. Second, large cities tend to attract logistics facilities. Modern supply chains require close proximity to consumer markets and trans-shipment facilities in which shipments can be reorganized and goods moved from one truck to another. These requirements are more easily met in large metropolitan areas than in medium-sized cities and rural areas. Third, as noted above, warehouses and distribution centers are decentralizing to the periphery of metropolitan areas, which in turn adds to truck VMT.

The only source for nationwide truck data in the United States is FHWA's Highway Statistics Series. This resource provides annual data on truck traffic on the urban portions of the National Highway System (both Interstate and non-Interstate). The research team could find no source that broke out any counts or volumes that focused on commercial vans nationwide. In FHWA parlance, vans are lumped into the light-duty truck category that would include both commercial and personal vehicles.

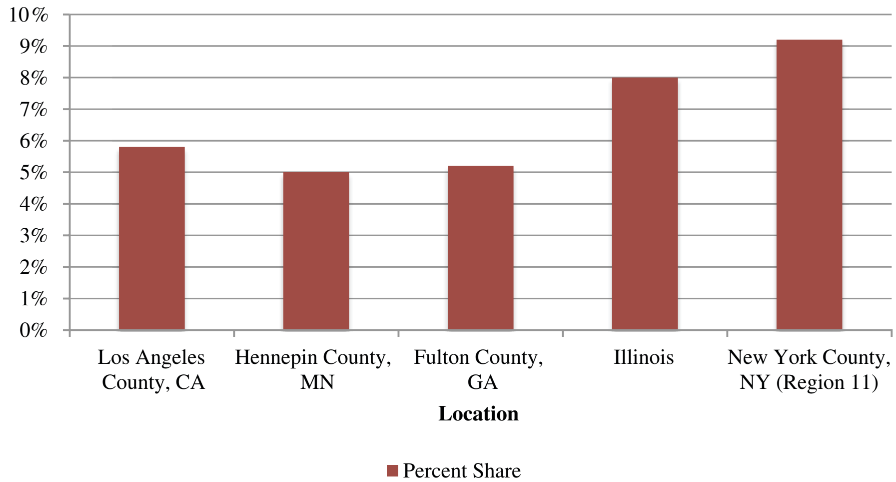
One way to see the concentration of truck traffic in U.S. metropolitan areas is to show total long-haul truck volumes on the federal system. In 2007, approximately 39 percent of the miles within the urban segments of the National Highway System Interstate network carried more than 10,000 trucks per day; 40 percent of the network miles carried between 5,000 and 10,000 trucks per day (USDOT, 2011, Table 5-4). The long-haul truck volumes shown in Figure 2 show large areas of concentration in major cities as trucks originate, terminate, or pass through metropolitan areas.

The FHWA data are limited in three ways. First, only heavy-duty trucks are included, while smaller trucks and vans make up most of the truck traffic in metropolitan areas. Second, the



Note: Long-haul freight trucks typically serve locations at least 50 miles apart, excluding trucks that are used in movements by multiple modes and mail.
Source: USDOT (2010).

Figure 2. Average daily long-haul freight truck traffic on the National Highway System—2007.



Source: Caltrans (2010), pp. 12-13; MDOT (2010), rows 9535-12505, columns AB-AC; GDOT (2010), pp. 6-7; IDOT (2010), p. 34; NYDOT (2011), p. 1.

Figure 3. Annual average daily truck traffic volume as a percentage of total annual average daily traffic volume for five locales—2010.

data do not include truck traffic on local streets and roads. Third, the data are limited to long-haul trips (i.e., 50+ miles) and exclude intra-city trips.

1.3.2 Municipal Reports

Reports on annual average daily traffic volume by state provide data on traffic volume by county. There are few reports on average daily traffic volume by city. Moreover, it is difficult to find reports that categorize traffic volume data by both vehicle classification and road type. One report stated that in Manhattan (NY), "[t]ruck and commercial traffic in turn accounts for 8% of peak period VMT" (Cambridge Systematics, 2007, p. 3-14).

FHWA does request truck share (vehicle classification) data[1] to be submitted to its Highway Performance Monitoring System (HPMS), but states and cities do not collect these data. In practice, these data are submitted for state highways only and are updated irregularly.

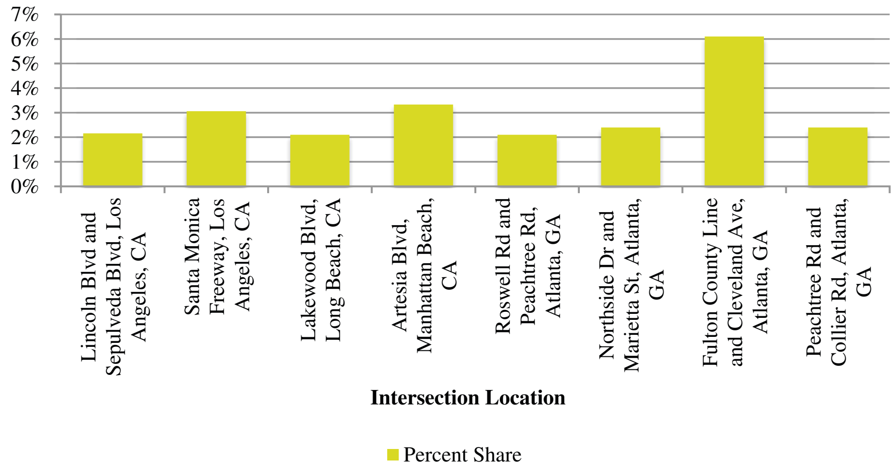
Figure 3 shows the percent share of truck traffic on urban roads and highways for four selected counties and one state. (The State of Illinois did not have data available at the county level for truck traffic volume.) In order to show consistent data across all states and counties in Figure 3, the percentages for Los Angeles County, Hennepin County, Fulton County, and New York County were calculated by averaging the percentage of total truck traffic volume for all types of roads in urban areas. The research team chose these counties because they correspond with major metropolitan cities that have regular freight traffic, and the data were readily available. These percentages reflect an average of traffic volume on both local roads and highways in urban areas and, hence, are only a rough proxy for urban truck traffic. Annual average daily truck traffic volume ranged from about 5 percent to about 10 percent of the total annual average daily traffic volume in 2010 for each of the counties.

Figure 4 highlights some urban intersection data from two state reports: California's and Georgia's. There is no particular significance to the intersections presented other than (1) the data were available and (2) the research team was able to confirm that the intersections were in urban areas using Google Maps. Annual average daily truck traffic volume as a percentage of annual average daily total traffic volume at these urban intersections ranged from a low of about 2 percent to a high of 6 percent.

1.3.3 Cambridge Systematics Bottleneck Studies

Highway interchange bottlenecks affecting trucking are widely distributed across the United States along Interstate freight corridors of national significance. The urban interchange bottlenecks create sticky nodes that slow intraregional freight (as well as long-distance truck moves) on urban roadways. According to a 2005 study of freight bottlenecks prepared for the FHWA (Cambridge Systematics, 2005), 11 of the top 25 highway interchange bottlenecks (measured in hours of delay) are either in greater Los Angeles, the location of the nation's largest maritime port, or Chicago, the nation's largest intermodal center.

[1] Item 81: % Single Unit Trucks in Peak Period; Item 82: % Single Unit Trucks in Average Daily Traffic Flow; Item 83: % Combination Trucks in Peak Period; and Item 84: % Combination Trucks in Average Daily Traffic Flow.



Source: Caltrans (2010); GDOT (2010).

Figure 4. Annual average daily truck traffic volume as a percentage of annual average daily total traffic volume for eight intersections—2010.

An earlier study of the worst physical bottlenecks in the United States (American Highway Users Alliance, 2004) found that 10 of the top 25 bottlenecks were in Los Angeles, Chicago, or Houston—the principal gateway to the Gulf of Mexico. The study did not include metropolitan New York City because of its unique geographic nature (bridges and tunnels) and tolling structure for both passenger and freight traffic.

Freight congestion problems are most apparent at bottlenecks on highways: specific physical locations on highways that routinely experience congestion and traffic backups because traffic volumes exceed highway capacity. Bottlenecks on highways that serve high volumes of trucks are "freight bottlenecks" (Cambridge Systematics, 2005, p. 1-1). They are found on highways serving major international gateways like the Ports of Los Angeles and Long Beach, at major domestic freight hubs like Chicago, and in major urban areas where transcontinental freight lanes intersect congested urban freight routes.

Freight bottlenecks are a problem today because they delay large numbers of truck freight shipments. These bottlenecks will become increasingly problematic in the future as the U.S. economy grows and generates more demand for truck freight shipments. If the U.S. economy grows at an annual rate of 2.5 to 3 percent over the next 20 years and the relationship between economic growth and freight remains constant, domestic freight tonnage will almost double and the volume of freight moving through the largest international gateways may triple or quadruple (Cambridge Systematics, 2005, p. 1-1). Without new strategies to increase capacity, congestion at freight bottlenecks on highways may impose an unacceptably high cost on the nation's economy and productivity.

1.4 Congestion, Parking, and Circulation

1.4.1 Truck Parking and Loading/Unloading Zones or Lack Thereof

One of the many problems faced by truck drivers making last-mile deliveries is the lack of parking and proper zones for trucks to drop off goods at businesses. The research team found information for two U.S. cities, New York City and San Francisco, related to truck parking. Both metropolitan areas have heavy traffic congestion. At some critical periods of the day, some of this congestion can be attributed to traffic caused by trucks making last-mile deliveries to businesses and residences in the city.

A case study report on the Midtown area of New York City showed that much of the traffic congestion during peak hours was due to multiple trucks illegally parking in the curbside lane of traffic in order to make deliveries. "The limited number of loading/unloading zones available, in addition to the number of vehicles using the spaces for long-term parking, has forced many trucks and other large vehicles to double-park, thereby reducing the capacity of the affected street by one lane of traffic" (Bomar, Becker, and Stollof, 2009a, p. 5). Difficulty in locating available parking space for loading and unloading causes trucks to circle the area several times, which in turn causes increased congestion, air pollution, noise, and fuel consumption (Bomar, Becker, and Stollof, 2009a, p. 9).

San Francisco also has commercial vehicle parking problems. Congested loading zones cause commercial drivers to circle looking for a vacant spot or to double park. The San Francisco Municipal Transportation Agency (SFMTA) has developed the SF*park* program to increase turnover at curbside parking spaces including "yellow zones," i.e., those reserved for commercial loading (Transportation Alternatives, 2008, p. 4; SFMTA, 2012). In an attempt to ensure an availability rate of 15 percent of the spaces on a block, San Francisco will vary the price charged for parking. Popular blocks will be priced higher, and blocks with lower demand will be cheaper. If San Francisco is able to hit its availability targets, delivery trucks and vans should have an easier time finding a vacant loading zone.

Parking violations and the fees that accrue in attempting to challenge the violations are a major source of revenue loss for most shipping and delivery companies. Parking ticket costs are high for many companies because there are not enough loading zones for trucks delivering goods throughout the city (Holguín-Veras et al., 2005, p. 44).

1.4.2 Off-Peak Deliveries

Freight delivery in New York City's metropolitan areas causes significant traffic congestion, especially during the day, when delivery vehicles are competing with passenger vehicles (Holguín-Veras et al., 2005, p. 44). Many stakeholders (i.e., shipping, trucking, and warehousing companies) objected to off-peak deliveries because these companies are constrained by customers who mostly prefer to receive their deliveries during normal business hours. Another challenge for off-peak deliveries is that many businesses cannot afford the staff required to accept deliveries at night. All of those interviewed agreed that receivers were the key to initiating off-peak deliveries because delivery companies cater to the needs of the receivers (Holguín-Veras et al., 2005).

While Holguín-Veras et al. (2005) examined stakeholders' perceptions of the idea of utilizing off-peak delivery, Cambridge Systematics modeled the impacts (2007). Cambridge Systematics studied the effects of variable tolls, tax incentives (for receivers staying open at night), shipping cost reductions, and an outright ban on daytime deliveries (Cambridge Systematics, 2007, p. 3-17). The highest peak toll ($7 per axle) combined with the largest tax deduction ($10,000) resulted in a 14 percent shift from daytime to off-peak. Looking at tolls only, Cambridge Systematics predicted that a $2 per-axle toll would lead to a 1.4 percent shift and a $7 per-axle toll would yield a 4.2 percent shift. When modeling tax deductions alone, the smallest deduction ($2,000) leads to a 2.1 percent shift, while the largest ($10,000) yields an 8.3 percent change. Results from this work suggest that high tolls and rather substantial tax deductions have only modest effects. However, another study from Holguín-Veras et al. (2006) shows a higher potential impact of policies on the switch to off-peak hours (see Section 2.1.4.2).

Cambridge Systematics also modeled the effects of shipping cost reductions (Cambridge Systematics, 2007, p. 3-17). A 20 percent reduction in shipping cost led to a 3 percent shift to off-peak delivery. As the shipping cost reduction increased so did the shift to off-peak deliveries. If shipping costs were entirely eliminated, the model predicted a 13 percent shift to off-peak delivery. In other words, *even if shipping costs were zero* for receivers, fewer than one in six would shift to off-peak delivery. Excluding the ban, the highest shift modeled was 19 percent; that scenario included the implausible $7 per-axle toll, coupled with 100 percent reduction in shipping costs (Cambridge Systematics, 2007, p. 3-17). Off-peak deliveries are further discussed in Section 2.1.4.2.

1.4.3 Crashes and Safety

Few studies have been done recently on crashes involving freight vehicles in urban areas. From 2009 to 2010, there was an 8.7 percent increase in the number of people killed in crashes involving large trucks nationwide (NHTSA, 2011, p. 3). However, this figure does not specify the number of fatalities in urban areas caused by crashes involving large trucks.

A study by Retting from 1993 examined fatal crashes involving pedestrians and large trucks in Chicago, Los Angeles, New York, and Philadelphia for a 5-year period from 1986 to 1990. Retting (1993) found that in these cities 51 percent of large truck involvement occurred at intersections or were intersection related. Non-intersection locations accounted for 44 percent of crash involvement for large trucks; pedestrian fatalities involving large trucks were almost twice as likely to occur at traffic signals than were crashes involving other vehicle types (49 percent at traffic signals for trucks versus 26 percent for other vehicles) (Retting, 1993, p. 196). Pedestrian fatalities involving large trucks were more than twice as likely to occur between the hours of 9 a.m. and 6 p.m. as those involving other vehicles (74 percent between 9 a.m. and 6 p.m. for trucks versus 36 percent for other vehicles) (Retting, 1993, p. 196). Only 13 percent of large truck crash involvement occurred during hours of darkness, compared with 52 percent for other vehicle types (Retting, 1993, p. 196). Two crash types involving trucks proceeding forward (Crash Types 1 and 2) account for nearly half of all the crashes (Retting, 1993, p. 198). Other crash types include pedestrians struck in the middle of the block, where—according to many of the police reports—the truck was emerging from between two parked cars (Retting, 1993, p. 198). Trucks turning at intersections and backing up to pull into a delivery loading zone also caused many pedestrian-involved crashes (Retting, 1993, p. 198). Data on the location of crashes by crash type are provided in Table 2.

More recent data on safety incidents involving commercial vehicles and pedestrians are not as specific as the research done by Retting (1993). Loukaitou-Sideris, Liggett, and Sung looked at pedestrian injuries in Los Angeles, but did not break out data by vehicle type, i.e., commercial versus personal (2007). They did find that more pedestrian crashes occur in

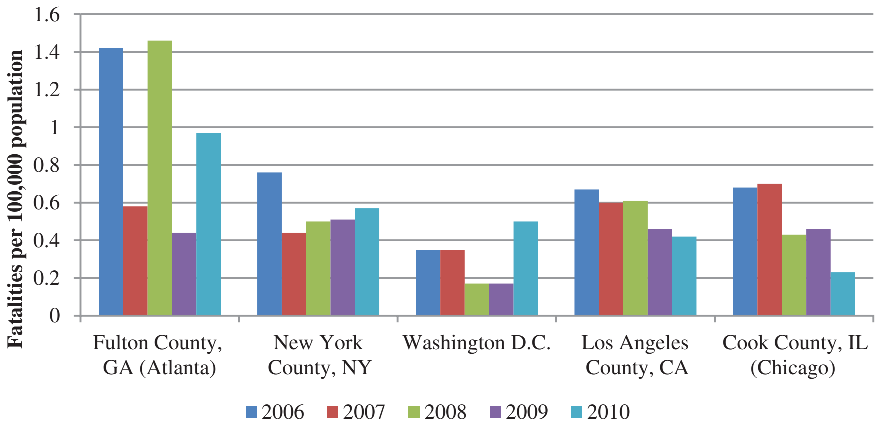
Table 2. Fatal truck/pedestrian crashes by type and location.

Crash Type	Intersection	Non-intersection	Alley	Driveway	Not in a Roadway	Freeway	Total
Truck proceeding forward, pedestrian at intersection (Crash Type 1)	59	0	0	0	0	0	59
Truck proceeding forward, pedestrian not at intersection (Crash Type 2)	0	32	1	0	0	4	37
Truck turning right, pedestrian struck by rear wheels or trailer (Crash Type 4)	11	2	1	2	0	0	16
Truck turning left, pedestrian struck by front of truck (Crash Type 5)	15	0	0	0	0	0	15
Truck turning right, pedestrian struck by front of truck (Crash Type 3)	13	0	0	0	0	0	13
Truck backing, pedestrian struck (Crash Type 7)	6	3	1	1	2	0	13
Pedestrian walked into side of truck or trailer (Crash Type 9)	2	7	0	1	0	0	10
Truck backing, worker struck (Crash Type 8)	0	5	0	0	2	0	7
Truck turning left, pedestrian struck by rear wheels or trailer (Crash Type 6)	6	0	0	0	0	0	6
Other/Unknown	9	13	3	0	1	0	26
Total	**121**	**62**	**6**	**4**	**5**	**4**	**202**

Note: totals corrected from the original.
Source: Retting (1993), p. 201.

locations with high concentrations of commercial land uses (Loukaitou-Sideris, Liggett, and Sung, 2007, p. 343); this could imply a correlation between pedestrian fatalities and a larger number of commercial vehicles serving the businesses. However, Loukaitou-Sideris, Liggett, and Sung also found that the number of pedestrian fatalities was lower in areas near industrial areas (2007, p. 343). That could simply be a function of fewer people walking near industrial land uses. Clifton, Burnier, and Akar looked at 4 years (2000–2004) of pedestrian–vehicle crash data in the City of Baltimore (2009). They found that "vans, trucks, and buses" were slightly less likely than automobiles to be involved in crashes involving the *injury* of a pedestrian, 46 percent versus 50 percent for cars; however, vans, trucks, and buses were nearly twice as likely to cause death, 2.4 percent versus 1.3 percent for cars (Clifton, Burnier, and Akar, 2009, p. 430).

The data presented in Figure 5 from the Fatality Analysis Reporting System (FARS) shows statistics on fatal crashes involving large trucks by county. Each of these counties was highlighted because they contain cities that serve as major hubs for freight transportation and are densely populated urban areas. The number of fatalities is represented as a rate per 100,000 population. Both Cook and Los Angeles counties show a downward trend in the rate; rates for the other counties are more mixed. Fulton had the highest rate, although Los Angeles was highest in absolute numbers.



Source: FARS (2012).

Figure 5. Crash fatalities in which large trucks were involved.

Table 3. Fatal crashes involving large trucks by roadway function class—2009.

Rural			Urban		
Roadway Function Class	**Number**	**Percent**	**Roadway Function Class**	**Number**	**Percent**
Interstate	426	14.3%	Interstate	345	11.6%
Other Principal Arterial	656	22.0%	Freeway/Expressway	110	3.7%
Minor Arterial	358	12.0%	Other Principal Arterial	276	9.2%
Major Collector	298	10.0%	Minor Arterial	153	5.1%
Minor Collector	51	1.7%	Collector	64	2.1%
Local Road	129	4.3%	Local Road	98	3.3%
Unknown	4	0.1%	Unknown	3	0.1%
Total Rural	**1,922**	**64.3%**	**Total Urban**	**1,049**	**35.1%**
Unknown Rural or Urban	16	0.5%	**Total Fatal Crashes**	**2,987**	**100.0%**

Note: A large truck is defined as a truck with a gross vehicle weight rating (GVWR) greater than 10,000 pounds.
Source: FMCSA (2011), Table 37.

Nationally, large trucks accounted for 5 percent (286,000) of all police-reported motor vehicle traffic crashes in 2009. Of all the motor vehicle traffic fatalities reported, 9.6 percent (2,987) involved large trucks (gross vehicle weight rating [GVWR] greater than 10,000 pounds). Of these fatal crashes in 2009, over one-third took place in urban areas (see Table 3). Fatal crashes are twice as likely in rural areas; most urban fatal crashes happen on freeways and principal arterials because that is where trucks travel.

1.5 Environmental Impacts

Recent research has shown that fine particulates are associated with increased incidence of morbidity and mortality from asthma, lung cancer, and other respiratory diseases (Peters, 2004). Heavy-duty diesel trucks are a major source of particulate emissions (Giuliano, Dessouky, and Moore, 2008, p. 182).

While there are many sources of emissions in urban areas, freight movement is a major source of nitrogen oxides (NO_x) and particulate matter (PM)[2]. When looking at goods movement, the emission inventory will vary both in total size and mode split from region to region. For example, a port city like Houston has more emissions from ships than Detroit even though the two cities' total emissions are comparable. Tables 4 and 5 show the contributions of NO_x and PM_{10}[3] emissions by mode of freight transport for six metropolitan regions. Note that the tables only include freight transport sources; the contribution of freight to total emissions depends on the characteristics of each region. Within each of the six

[2] NO_x are gases and one of the six common air pollutants monitored by the EPA. Nitrogen dioxide (NO_2) is the worst NO_x. It "[contributes] to the formation of ground-level ozone, and fine particle pollution, [and] NO_2 is linked with a number of adverse effects on the respiratory system" (EPA 2012a). Particulate matter "is a complex mixture of extremely small particles and liquid droplets. Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles" (EPA 2012b).

[3] PM_{10} designates particulate matter of 10 micrometers or less in diameter. $PM_{2.5}$ designates particulate matter of 2.5 micrometers or less in diameter.

Table 4. Contribution of NO_x emissions by mode of freight transport.

Region	Trucking		Freight Rail		Marine Freight		Air Freight		Freight Total	
	NO_x (tons)	%	NO_x (tons)	%	NO_x (tons)	%	NO_x (tons)	%	NO_x (tons)	%
Baltimore	29,081	83%	2,655	8%	3,315	9%	26	0.1%	35,078	100%
Chicago	96,291	79%	23,212	19%	2,199	2%	462	0.4%	122,164	100%
Dallas-Ft. Worth	53,718	93%	4,157	7%	0	0%	155	0.3%	58,030	100%
Detroit	98,195	97%	2,106	2%	468	0%	40	0.0%	100,809	100%
Houston	64,590	77%	5,163	6%	14,351	17%	85	0.1%	84,189	100%
Los Angeles	130,341	78%	12,744	8%	22,610	14%	870	0.5%	166,564	100%

Source: FHWA (2005), Table ES-2.

Table 5. Contribution of PM_{10} emissions by mode of freight transport.

Region	Trucking		Freight Rail		Marine Freight		Air Freight		Freight Total	
	PM_{10} (tons)	%	PM_{10} (tons)	%	PM_{10} (tons)	%	PM_{10} (tons)	%	PM_{10} (tons)	%
Baltimore	734	74%	71	7%	190	19%	1	0.1%	996	100%
Chicago	2,641	73%	792	22%	173	5%	10	0.3%	3,616	100%
Dallas -Ft. Worth	884	88%	113	11%	0	0%	4	0.4%	1,002	100%
Detroit	2,382	96%	58	2%	27	1%	2	0.1%	2,469	100%
Houston	1,256	54%	141	6%	915	40%	2	0.1%	2,314	100%
Los Angeles	2,210	54%	346	8%	1,521	37%	14	0.3%	4,091	100%

Source: FHWA (2005), Table ES-3.

metropolitan areas, trucks were reported to emit the largest amounts of NO_x and PM_{10} emissions. In comparison to other modes of freight transport, trucks are the number one source of pollutants in metropolitan areas that are the most harmful to people.

The concentration of freight traffic around intermodal terminals or warehouse/distribution centers generates significant external costs in the form of truck emissions, truck and rail traffic, and noise. These external costs negatively affect residential land values. Thus, the neighborhoods surrounding such facilities tend to house low-income and/or minority residents, leading to major environmental justice problems. Well-known examples of such neighborhoods include Hunts Point in New York (Lena et al., 2002), Chicago's South Side, and the I-710 corridor in Los Angeles (SCAQMD, 2000; Ritz et al., 2006; Peters, 2004).

1.5.1 Los Angeles Region

The Los Angeles region is well known for its air pollution problems. Environmental justice problems in the Los Angeles region are particularly well documented as a result of multi-year studies of the impacts of air pollution on children and on the general population (Ritz et al., 2006). Higher rates of asthma and other lung diseases are linked with higher concentrations of particulates (mainly from diesel fuel) and oxides of sulfur (mainly from ocean vessels).

South Coast Air Quality Management District (AQMD) described its *Multiple Air Toxics Exposure Study in the South Coast Air Basin* (MATES II) as "the most comprehensive study of urban toxic air pollution ever undertaken" (SCAQMD, 2000). MATES II covered the parts of Los Angeles, Riverside, and San Bernardino counties on the ocean side of the mountains and all of Orange County. The study showed that mobile sources (including passenger and commercial vehicles) generate 90 percent of the cancer-causing air pollutants in Southern California. The good news was that additional cancer risk attributable to pollution declined 75 percent from the prior decade as Southern California's air improved. Nonetheless, there was still an average of 1,400 additional cases of cancer per 1 million people as a result of air pollution.

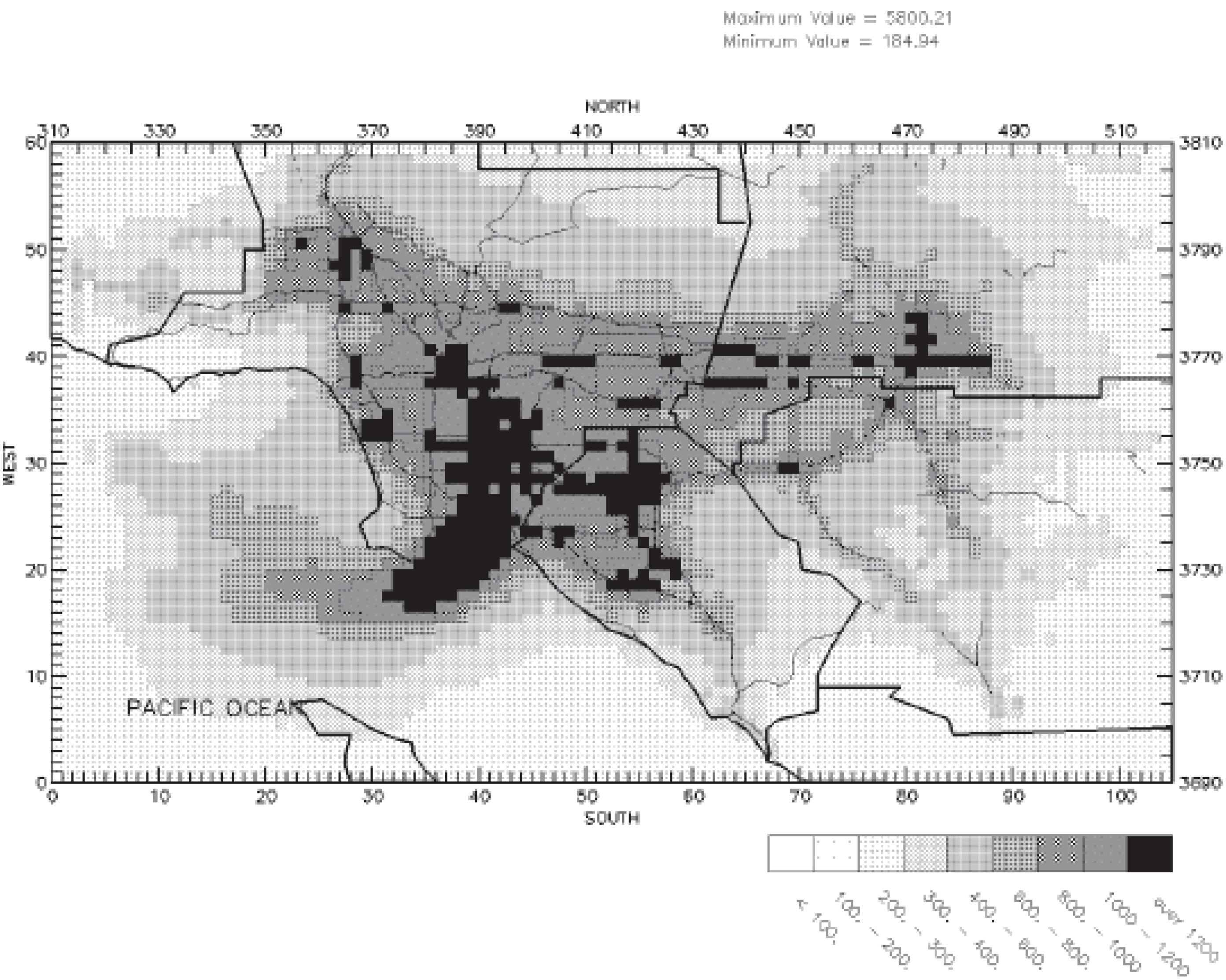
That average masks the disparate figures in different areas. MATES II specifically looked at residents' exposure to PM generated by burning diesel—much of it from commercial vehicles:

> AQMD calculated the cancer risk of diesel particulate based upon a method for estimating diesel particulate in air samples outlined by the State of California and a cancer potency factor determined by the state. Diesel particulate is emitted by diesel-fueled trucks, buses, trains, ships, tugboats, construction equipment, power generators and stationary engines used throughout the region for tasks such as pumping water (SCAQMD, 2000).

AQMD found the PM from diesel exhaust "accounted for 71% of the cancer risk" (SCAQMD, 2000). AQMD concluded that the primary toxic air pollutant was diesel particulate, and this conclusion led to rules for diesel buses and trucks to clean up their exhaust.

Perhaps the most provocative graphic to come out of MATES II, was the so-called "diesel death zone death map" (see Figure 6). This graphic sparked a debate about the effects of urban freight movement in the Los Angeles area. The large banana-shaped dark black section is a corridor that runs from the twin ports of Los Angeles/Long Beach to downtown. The other areas are mostly freeway corridors laden with commercial vehicles. The darker the color, the higher probability of increased cancer risk. The black sections represent areas where the expected excess cancer risk is 1,200 additional cases per 1 million people.

The Children's Health Study is an initiative of the Air Resources Board that began in 1992 and was completed in 2004 by researchers at the University of Southern California. The study is a comprehensive and long-term examination of the effects of chronic air pollution exposures on the health of children living in Southern California. Children were chosen as subjects for the study because the effects of air pollution may be more apparent since their lungs and their bodies are still developing. They are also exposed to more air pollution than adults since they breathe faster and spend more time outdoors in strenuous activities. Data were gathered annually from a sample of 6,000 students until they graduated from high school in order to monitor their health, exposures to air pollution, and factors that affected their responses to air pollution. Four pollutants were accounted for in the



Note: Number in a million, all sources
Source: SCAQMD (2000), c. 5 p. 10, Figure 5-3a.

Figure 6. South Coast AQMD's geographic risk distribution.

study: ozone, nitrogen dioxide, acid vapor, and PM (Peters, 2004, p. 12).

Results from the Children's Health Study indicated that children's lung function growth was adversely affected by air pollution, and new cases of asthma and asthma exacerbations were associated with ambient air pollution levels. Researchers for the study concluded that current levels of ambient air pollution in Southern California are associated with clinically important chronic health effects that have substantial health and economic impacts (Peters, 2004, p. 271).

1.5.2 New York Region

Researchers at Columbia and Harvard Universities conducted a study similar to the Children's Health Study in 1999 to assess the effects of air pollution on a group of 46 high school students living in the West Harlem area of New York City. Harlem is at the center of the metropolitan New York region that in recent years has been out of compliance with the National Ambient Air Quality Standards for PM_{10}. Ambient air toxic levels in northern Manhattan and the South Bronx result from region-wide emissions as well as from local sources such as diesel bus depots, waste incinerators, industrial operations at the New York Port, and the network of commuter highways, commercial truck routes, and bus routes going through and around these communities. The data for this study were collected from each student in the sample two times over the course of a year. The results from the study in New York demonstrate that young people attending school in inner city New York are exposed to a wide variety of air pollutants. Although exposures to some air toxics are clearly driven by indoor sources, exposures to many other pollutants appear to relate more to ambient sources. Urban motor vehicle emissions can be identified as a primary source of harmful air pollution in the area (Kinney et al., 2002, p. 539).

1.5.3 Hot Spots

The U.S. government outlines its requirements for studying the potential for new hot spots in Rule 40 CFR 93.123(b)(1). Generally speaking, if a project would increase the number of diesel trucks, it will need to undergo a hot spot analysis. The City and County of San Francisco looked at the issue of hot spots with respect to land use planning (San Francisco, 2007). While San Francisco did not specifically look at commercial vehicle traffic as a cause of hot spot creation (for the most part the city lumps cars and trucks together), it did cite a California Air Resources Board recommendation to "avoid siting [residential] land uses within 1,000 feet of a distribution center handling more than 100 trucks per day" (San Francisco, 2007, p. 13).

Hot spots do not just affect people in the surrounding neighborhoods; hot spots also affect truck drivers and warehouse facility workers. Smith et al. (2006) found that drivers who made last-mile deliveries and long-distance deliveries had an elemental carbon/total carbon level that was higher than background levels; this elevated level was also found in dockworkers and hostlers working at each terminal. Truck drivers making last-mile deliveries and pick-ups had a small but significantly higher elemental carbon level than other drivers.

1.5.4 Greenhouse Gas and Carbon Dioxide Emissions

Although there is little documentation of the specific effects of freight movement on climate change, a fair amount of research has been done on freight transportation and how much greenhouse gas (GHG) emissions the sector contributes. Carbon dioxide (CO_2) is the most commonly known GHG and accounts for approximately 95 percent of total transportation-related GHG emissions (Cambridge Systematics, 2010, p. 2-3). The amount of CO_2 released per ton-mile is directly related to the energy consumption of the mode providing that service (Forkenbrock, 1999, p. 516). One gallon of diesel fuel releases 22.8 pounds of CO_2 (FHWA, 1997, p. I-5, as quoted in Forkenbrock, 1999, p. 516).

Freight movement (trucks, ships, trains, airplanes, and pipelines) accounts for 29 percent of the total GHG emissions coming from transportation-related sources; trucks were responsible for emitting 68 percent of GHG coming from these freight sources (Cambridge Systematics, 2010, p. 2-4). Idling is a common occurrence at ports and intermodal stations and on inner city streets due to traffic congestion. Nationally, idling trucks are estimated to consume 20 million barrels of diesel fuel and generate 10 million tons of CO_2 annually (Cambridge Systematics, 2010, p. 3-9).

For most vehicles, fuel consumption and the rate of CO_2 per mile traveled decreases as vehicle operating speed increases, up to an optimal speed. As vehicle speed increases above the optimal speed, fuel consumption and the rate of CO_2 per mile traveled begin to increase again. Because of the relationship between vehicle speed and the rate of CO_2 per mile traveled, traffic congestion has a great impact on CO_2 vehicle emissions and fuel efficiency. In real driving conditions, there is a rapid non-linear growth in emissions and fuel consumption as travel speeds fall below 30 mph (Figliozzi, 2010, p. 4). CO_2 emissions double on a per mile basis when speed drops from 30 mph to 12.5 mph or when speed drops from 12.5 mph to 5 mph. Frequent changes in speed, i.e., stop-and-go traffic conditions, increase emission rates because fuel consumption is a function not only of speed but also of acceleration rates (Figliozzi, 2010, p. 4).

Emissions from freight sources accounted for 9 percent of overall U.S. GHG emissions in 2006, which is the equivalent of 608 million metric tons of CO_2. Second only to air freight, trucking emits 313 grams of CO_2 equivalent per ton-mile. This relatively high emissions rate, combined with the fact that trucks are second only to rail in ton-miles of freight moved, explains why trucks are responsible for most freight GHG emissions (Cambridge Systematics, 2010, pp. 2-3, 2-4).

1.6 Noise

A significant amount of noise pollution in metropolitan areas is generated by truck traffic. Albergel et al. (2006) calculated that in one French city during the morning peak hours, goods vehicles traffic added 5 dB(A) to the noise emissions coming exclusively from private automobiles. One of the many obstacles to implementing off-peak deliveries in many U.S. cities is the amount of noise that would be produced during evening hours (Holguín-Veras et al., 2005, p. 42).

Forkenbrock (1999) notes that the composition of the traffic is the most important factor in determining the volume of noise. He cites FHWA's calculation that one combination truck produces as much noise at 55 mph as 28 automobiles (Forkenbrock, 1999, p. 516). A combination truck heard from 50 feet away produces a noise level of 90 dB(A). This level of noise is approximately four times the level emitted by a pickup truck (Forkenbrock, 1999, p. 517). Forkenbrock uses the FHWA's noise emission model for heavy trucks to illustrate how the model can be applied to show the effect of significant traffic noise on housing development and value (1999, p. 518).

Ross et al. find strong correlations between noise and traffic, particularly at night and for medium- and high-frequency noise (2011, pp. 1054–1055). The relationship between noise and pollution was less consistent, although gaseous pollutants were also more strongly correlated with medium- and high-frequency noise, especially at night. These results support the importance of capturing temporally resolved, frequency-specific noise data to better understand community exposures and health impacts of noise (Ross et al., 2011, pp. 1054–1055).

Currently, there are very few studies on the environmental costs of noise pollution caused by freight traffic. In the studies that do exist, the environmental costs of noise are most commonly estimated as the depreciation in the value of residential units alongside the highways. While there are other factors that can cause depreciation in housing values, Berechman specifies that close proximity to a loud highway or *city intersection* is most often the defining characteristic of the environmental cost of noise (Berechman, 2009, p. 391).

Nguyen and Khoo looked at noise near the Los Angeles–Long Beach port complex (2011). They found that trucks were the largest cause of noise at the port and cargo-handling equipment was the second largest. Other equipment, e.g., rail vehicles, contributed insignificantly to noise at the port. The noise coming from the port was under the regulatory limits associated with each vehicle type (Nguyen and Khoo, 2011, p. 50).

There are limited statistical data and little scholarship on noise pollution and its relationship to freight truck traffic in U.S. urban areas (Forkenbrock, 1999; Ross et al., 2011). The most extensive scholarship and research on noise pollution has been conducted in Europe. There, freight transport operations in cities represent 10 to 15 percent of road traffic, but account for 40 percent of air pollution and noise emissions (BESTUFS, 2006). This is a common problem for all European cities even though they have differing geographical, historical, and cultural circumstances.

Table 6 provides noise levels associated with the most common urban freight activities, as calculated by the Dutch government (Goevaers, 2011).

Table 6. Freight-related noise levels.

Noise	Peak level at 7.5 m [dB(A)]
Slamming door	74
Driving up/away	67-83
Load hatch	65-92
Containers over load floor	74-85
Refrigeration kicking in	70-78
Removing on-board forklift	77-82
Shopping trolleys	53-77

Source: Goevaers (2011).

1.7 European Focus

This subsection looks briefly at urban freight issues in Europe. Surveys conducted in the past decade in several European cities have provided specific urban freight data (BESTUFS, 2006). The Lyon-based Laboratoire d'Economie des Transports (LET) has calculated that, on average, there is one delivery or pick-up per week per job in larger French cities. In European cities, urban freight transport tends to be more polluting than long-distance freight transport, because of a higher average age of the vehicles and a large number of short trips and stops. Freight transport generates between 20 and 60 percent (depending on the pollutants considered) of local transport-based pollution. As in the United States, NO_x and PM are pollutants for which urban freight transport has a particularly important responsibility (Albergel et al., 2006). Urban freight vehicles also tend to be quite old. In Dublin in 2004, a fourth of all vehicles were at least 10 years old. Only 15 percent of the vehicles were new (1 year or less).

In the Milan region, 40 percent of trucks circulating are more than 10 years old (quoted in Dablanc, 2009). Urban freight vehicles tend to be old because many transport companies operating in urban areas are very small, competition among operators is acute, and profit margins are low. Operators save money by buying used trucks or vans and using them as long as possible. GHG emissions and noise pollution are also among the most severe environmental impacts of freight in cities. Freight represents about one-fourth of transport-based CO_2 emissions in European cities. There is little information on the congestion impacts of freight in European cities.

Another important issue is road safety. Trucks are involved in a small share of the accidents in cities, but the accidents involving them are serious. In 2005, in London, goods vehicles accounted for 15 percent of VMT, "but represented only 7 percent of the total [motorized] vehicles involved in collisions that resulted in personal injuries" (Transport for London, 2008a, p. 15). However, goods vehicles accounted for 11.6 percent of total casualties in 2005.

The conciliation of truck traffic with bicycle use has been a growing policy target in many European cities following fatal collisions that received a lot of media attention. Trucks have been overwhelmingly (43 percent) involved in bicyclists' deaths on Greater London roads between 1992 and 2006 (Morgan et al., 2010).

1.8 Conclusion

Large truck VMT in urban areas dropped 13 percent from its peak in 2008 (the research team could find no data on smaller truck or vans so cannot say whether the total VMT for commercial vehicles is up or down). The dip in large truck VMT is most likely a result of the economic recession. As the economy improves, it is expected that VMT will again increase.

There are two main trends in logistical facility siting—decentralization and consolidation. The effect of these two trends on truck VMT is indeterminate; although some studies have suggested that the net effect is greater VMT. More research is needed.

Limited data are available on urban freight vehicles. The research team was able to locate only a few scattered reports as well as some data from urban intersections that happen to be designated as state highways. The team did not find any data counting trips in non-truck commercial vehicles (e.g., vans). This is a critical information gap; understanding the characteristics of urban freight flows requires basic data on commercial vehicles and what they carry.

Parking for commercial vehicles is difficult in dense urban areas. The research team highlighted two cities with innovative programs: New York and San Francisco. New York's night-time delivery program is discussed further in Section 2. San Francisco uses variable pricing to encourage turnover and availability in commercial loading zones.

Trucks are in relatively few crashes as a percentage of VMT. However, when they are involved in a collision, they often cause greater injury.

Trucks are mobile sources of pollution that travel through urban areas. In areas and locations where trucks are concentrated (e.g., freight corridors, ports, warehouses, etc.), pollution is pronounced and associated with public health problems.

Noise and carbon emissions are also associated with freight movement. Both issues are more closely researched in Europe than in the United States. In general, there is more research on urban freight movement and policy interventions in Europe; the latter will be discussed in Section 2. Also in Section 2 we discuss some of the solutions urban areas are employing to address the issues outlined in Section 1.

SECTION 2

Urban Freight Problems and Strategies

This section is organized around strategies for managing three general issues in urban freight transportation: local last-mile delivery/first-mile pick-up, environmental impacts, and trade node problems. Last-mile/first-mile strategies address local deliveries and pick-ups to or from businesses or residences. Strategies that reduce environmental impacts include reducing emissions by regulation or offering incentives to use vehicles that pollute less. Strategies related to trade nodes (i.e., cities that are hubs for national and international trade) address locations with the largest flows to and from ports, airports, or intermodal facilities. Although these three issues are distinct, there is overlap among them. Most efforts to manage truck traffic are intended to reduce environmental impacts in some way, along with reducing congestion and other objectives. For example, an increase in truck loading zones intended to reduce delays from trucks parking illegally (classified herein as a last-mile strategy) may also reduce idling emissions. The Clean Truck Program at the Los Angeles and Long Beach ports is classified as trade node strategy, even though the program's primary purpose is emissions reduction, because the program is operated by the ports and applies only to vehicles serving the ports.

2.1 The Local Last-Mile Problem

2.1.1 Introduction

The last mile (or miles) represents the final haul of a shipment to its end receiver, be it a shop, a business, a facility, or a home (in the case of home deliveries). Cities also experience first mile(s), as one-third of urban truck traffic is goods pickups. (In this report, both first-mile and last-mile trips will be referred to collectively as the "last mile.") Serving local businesses and homes in cities is inefficient for several reasons. First, products are often delivered from a vendor to an establishment, so a given establishment (say a department store) may receive multiple deliveries each day. Small deliveries to many destinations generate complex routing problems. If deliveries could be consolidated across vendors, more efficient routing and fewer trips would be possible (OECD, 2003). Second, deliveries may be restricted to certain routes or time periods, adding additional constraints on routing and scheduling. Restrictions on night deliveries, or the reluctance of urban business owners to use night delivery, force more trips to take place during peak hours, adding to congestion. Third, home delivery is inefficient due to the small size of the products, the spatial dispersion of residences, competition within the local delivery industry, and the frequency of failed deliveries (Xing et al., 2010).

North American cities do not face as many delivery inefficiencies as their European counterparts. The greater urban freight efficiency in North American cities stems from (1) a more recent history, (2) the lower densities and more open spatial form of North American cities, and (3) the smaller share of small and independent businesses. Kawamura and Lu (2007) note that the U.S. distribution system is rational from an industry perspective although not necessarily optimal from a system perspective. They note that densely populated cities in the United States, particularly in the Northeast, share similar concerns with Europe regarding inefficient urban freight operations and the need for consolidation. FHWA's Office of Freight Management and Operations developed *Urban Freight Case Studies* as a way to document notable practices in urban goods movement. These case studies provide information on freight-related initiatives that mitigate congestion and improve the safety and efficiency of commercial vehicle travel in Washington, D.C., Los Angeles, Orlando, and New York City (Bomar, Becker, and Stollof, 2009a, 2009b, 2009c, 2009d).

Faced with more acute last-mile challenges than most U.S. cities, European cities have developed more urban freight policy initiatives; therefore, most of the examples provided in this section are European (and Japanese). Nonetheless, these examples can shed light on U.S. urban freight transport policy. Panero, Shin, and Polo Lopez (2011), looking at European last-mile delivery strategies, note that European local governments and citizens are "more likely to accept interventions to solve environmental externalities," while "policy interventions in the United States [are more] likely to be motivated by the need to address traffic congestion or inefficiencies such as the lack of space for loading/unloading and/or for parking" (p. 24). Rhodes et al. (2012) suggest that local policies in the United States "that will make a difference" in the efficiency of urban freight transport include the following: design standards, land use and zoning, urban truck regulations, parking and loading zones, delivery windows/time of day restrictions, and truck size and weight regulations. The following subsections discuss the many strategies and approaches that have been considered and, in many cases, implemented to improve local and last-mile delivery practices.

2.1.2 Initiatives and Strategies: What Has Proved Efficient?

The research team has identified areas where local communities and private stakeholders have been active and rather successful in last-mile issues. In this context, "successful" means implementing policies that have had an impact on the city's economy and/or the environment at a reasonable cost for the stakeholders and that have become permanent or at least have lasted a significant amount of time. These policies include the following:

- **Consultation processes and certification schemes.** Formalized partnership initiatives in cities have raised awareness among freight transport companies and helped policies targeted at freight transport meet their goals. Awarding specific labels to sustainable delivery companies (companies using clean vehicles for example) has proved useful in some cities.
- **Traffic, access, and parking regulations and delivery windows.** These measures can be quite basic, yet have significant positive environmental impacts, provided that enforcement is sufficient. Measures such as congestion charges or low emission zones have appeared recently. Low emission zones and other strategies clearly targeted at environmental mitigation, such as delivery noise reduction, are examined in Section 2.2.[4]
- **Intelligent transport systems.** These systems are not yet widely used for the management of freight transport in cities (although many carriers are already using various kinds of routing software based on GPS locations and current traffic), but some identified practices have proved efficient. ITS use to better manage goods transport may develop in the future, as costs decrease, and may prove crucial in data collection and real-time information on urban conditions for truck drivers.
- **Planning strategies.** Integrating freight into city planning documents and building codes can have both short- and long-term effects.
- **Consolidation schemes and measures that target urban supply chains.** Setting up urban consolidation centers and urban logistics spaces may help to reduce truck VMT.

2.1.3 Consultation Processes and Labeling Schemes

Formalized consultation processes with the freight industry, often called "Freight Forums," constitute one of the most successful strategies to deal with last-mile delivery issues. The urban distribution of goods is organized by private stakeholders (producers, carriers, retailers, and final consumers) operating in an environment, the urban space, which is under close scrutiny from public authorities. Therefore, partnerships among stakeholders can lead to a better understanding of the constraints of each party and allow the development of concerted actions. Consultation processes in urban freight provide unique collaborative opportunities for private companies that otherwise would not be willing to work together.

Participants in consultation processes are commonly local governments' representatives, freight business organizations, shippers' organizations, and trade groups. Some stakeholders are not always well represented. Small operators usually do not have a representative organization. Large transport and logistics companies or their representative organizations are not willing to participate in local consultations in cities other than major or capital cities because of a lack of interest, insufficient staff, or lack of perceived last-mile problems (in smaller cities). Local shopkeepers' organizations tend not to be interested in freight groups mostly because many retailers are not directly involved in the way deliveries are organized or are satisfied with their deliveries and not willing to experience a change such as off-hour delivery times or less frequent deliveries (Holguín-Veras, 2008).

Consultation processes can lead directly to initiatives such as certification or labeling schemes in which freight operators that demonstrate environmentally responsible behavior are recognized. Certification is an incentive offered by local governments to promote greener deliveries. These schemes are often organized following a negotiation between the municipality and representatives of the freight industry. Certification confers privileges, such as extended delivery hours or the use of designated loading/unloading facilities. It may also provide operators with a competitive advantage

[4] In order to reduce the risk of overlaps and repetitions, the research team chose to categorize best practices based on their primary objective (i.e., strategies aiming primarily at better air quality are examined in Section 2.2 (Emissions and Other Environmental Problems and Strategies) rather than 2.1 (The Local Last-Mile Problem).

when bidding for contracts, as clients are increasingly committed to selecting bidders that offer the best environmental guarantees. Labeling can also target cities, vehicles, equipment or even processes. Labels can indicate that a city or company has achieved a specific level of sustainability and efficiency in urban freight operation. Labeling has become a common way of promoting urban freight strategies. Cities that are members of specific networks such as CIVITAS (www.civitas-initiative.org) or SUGAR (www.sugarlogistics.eu) (SUGAR, 2011) in Europe are labeled urban freight cities. Vehicles or handling equipment receiving the PIEK label in the Netherlands (see Section 2.1.3.2) and in a growing number of European cities can deliver at night.

2.1.3.1 Examples of Formalized Freight Forums

The United Kingdom has a long-established history of collaboration with the transport industry, and major policies are developed with broad participation of stakeholders. It took 3 years of consultation with freight organizations in order to produce a mutually acceptable London Freight Plan of 2007 (Transport for London, 2007). Two years of discussion were necessary to agree on the fee for commercial vehicles that was applied within the congestion pricing scheme implemented in 2003 in central London. Before setting up a LEZ (see Section 2.2) in London, a 3-year period of discussion was required, first among the different local governments, then with the private stakeholders and the general public. A campaign targeted at more than 800 organizations was launched, and general information was disseminated through the media. More generally, U.K. cities—and London in particular—have established Freight Quality Partnerships (FQPs) (SUGAR, 2011).

In June 2006, the city of Paris and the most important carriers' and shippers' associations signed an urban freight transport "charter," in which they committed to several points on the environment, drivers' working conditions, and the productivity of urban delivery activities. In fall 2009, the partners conducted an assessment of the urban freight charter and concluded the following (Dablanc, Diziain, and Levifve, 2011):

- Dialogue is important; it defuses conflicts before they break out.
- Public authorities and the private sector do not function on the same time scale; the private sector is accustomed to setting plans into motion rapidly and finds public decision-making processes very slow.
- Private companies demand better enforcement of truck and delivery regulations, as this is the only way to distinguish complying transport companies from less scrupulous ones.
- The municipality must take measures regarding logistics land scarcity, in Paris as well as in the inner suburbs.
- Large professional federations and large carriers are over-represented relative to small businesses.
- The relevant territory for policies or experimentation is larger than the city of Paris.

Some of these conclusions constitute, today, the basis of the current reformulation of the Paris freight consultation process, which is now included in a region-wide collaboration effort (Dablanc, Diziain, and Levifve, 2011). This reformulation led to the identification of new freight projects outside of the boundaries of the city of Paris using former freight rail yards to develop urban logistics terminals. These projects are not yet implemented.

The city of Toulouse in southern France also signed a "delivery charter" setting the rules of good practices for last-mile deliveries. The objectives were to improve sharing of the urban road network among all users, to decrease vehicular traffic, and to reorganize urban deliveries. One tool was the implementation of more efficient and better-located delivery spaces. The delivery charter was signed by 50 different stakeholders.

2.1.3.2 Examples of Labeling Schemes and Incentive-Based Initiatives

Labels can be given to freight companies. The Freight Operator Recognition Scheme (FORS) in London provides a performance benchmark for the trucking industry by certifying operators that comply with a list of efficiency, safety, and environmental impact criteria (such as drivers and driver management, vehicle maintenance and fleet management, transport operations, and performance management) at bronze, silver, and gold levels. FORS is free, voluntary, and open to any company operating vans or trucks in London. Labels are awarded after a formal company assessment carried out by an independent FORS assessor (a private contractor). As of July 2011, more than 300 companies, representing more than 40 percent of the freight vehicle fleet in London, have a bronze label; about 50 have the silver label; and none have yet achieved the gold label.[5] A FORS label provides companies with access to data, benchmark information, and training programs for their drivers. One of the main benefits is access to a program of benchmarking in which truck companies can compare their performance in accidents, fuel consumption, traffic penalties, and CO_2 emissions to the average performance of the trucking industry. Companies also benefit from

[5] See SUGAR (2011) as well as the lists of current members on www.tfl.gov.uk/microsites/fors/downloads/bronze-fors-members-list.pdf.

a reduced tariff for road assistance, free training seminars for their drivers, as well as more technical services such as driver license checks and driver profiling.[6] Certified companies can advertise their FORS status to the general public (by placing the official FORS logo on their vehicles), as well as to their clients or potential clients (such as a shipper or another trucking company). Silver and gold levels provide the same direct benefits, but a higher level of public recognition.

Another labeling program is PIEK, in the Netherlands. The program identifies vehicles and equipment that are allowed to be used for night deliveries. Certified trucks and handling equipment are used by companies willing to reduce noise emissions while delivering and happy to advertise these efforts directly on the vehicles they use (with a PIEK logo painted on their trucks).

Another type of incentive-based policy involves a public administration providing a direct service for organizations that increase the efficiency of their urban deliveries. This type of strategy has been implemented successfully in London in the Delivery and Servicing Plans (DSP) program, an optimizing process for any organization willing to reduce the number of its deliveries. Participants can be a company, a hospital, or an administration. Through the DSP program, Transport for London actually offers a direct (and free) logistics consulting service to committed organizations. Transport for London initiated a DSP for its own building in Southwark in southeast London in 2009–2010. This reduced the number of deliveries by 20 percent. Other outcomes of DSP plans have been the following (Dack, 2010):

- Use of low- or no-emission vehicles (electric and hybrid vehicles used by James McNaughton, a paper group).
- Wider use of legal loading/unloading bays (Pret a Manger, a catering chain).
- Reduction in the frequency of deliveries and trash collection (London Borough of Hackney).
- Increased deliveries outside of peak or normal working hours (Almo, an office supplies and stationery company).

Experiments with DSPs are now discussed in the Trailblazer European network (www.trailblazer.eu).

2.1.4 Traffic, Access, and Parking Regulations and Delivery Windows

Cities are in charge of local traffic and parking regulations, including all regulations that relate to delivery vehicles. Because they belong to the common expertise of municipal administrations, these are the easiest measures any local government can take on last-mile deliveries. Enforcement is very effective, but can represent a significant financial burden for a municipality.

Local public policies regarding freight are quite modest. Historically, most traffic and parking regulations have been aimed at solving local problems at the level of a street or a neighborhood. Rules are generally very parochial and can be conflicting. In the Lyon metropolitan area (France), as many as 30 different rules on trucks' access regulations exist (based on weight and size), forcing truck drivers to decide which rules they will comply with and which ones they will disregard. However, some recent innovative policies on freight traffic and parking provide solutions.

2.1.4.1 Truck Access Regulation

Truck access restrictions have been used for many years, generating various degrees of inefficiency (e.g., reduction in access for large trucks has multiplied the number of small commercial vehicles in city streets). Also, truck restrictions tend to be heterogeneous, differing from one locality to another within the same metropolitan area, creating a patchwork of rules that truck drivers find difficult to understand.

Truck access restrictions can apply to routes (some trucks are limited to certain routes) or whole areas (such as a city center). The restrictions are based on various criteria (used alone or in combination) such as time windows; weight (total or per axle); size (length, height, surface); and, more recently, noise emission, air pollution, loading factor, and type of goods (hazardous or voluminous). Restrictions can be permanent (24/7) or limited to certain hours of the day, or days of the week. For example, the London Lorry Ban, in place since 1975, prohibits heavy goods vehicles weighing more than 18 tons from traveling at night and weekends on a delimited network. In contrast, Paris bans large trucks (larger than 29 square meters) during daytime hours. In Tokyo, trucks over 3 tons are prohibited in many neighborhoods. In Seoul, trucks have been banned from central areas during working hours since 1979 (Castro and Kuse, 2005). In Sao Paulo, to alleviate congestion, access is based on the plate number, with 2 days per week allowed per vehicle, including freight vehicles.

Truck access rules based on weight or size tend to promote use of small-capacity vehicles (vans, light trucks), increasing total congestion and reducing the efficiency of freight transport (although there is a lack of specific studies that assess the degree of negative impacts).

One recent and interesting trend in access restrictions is LEZs (introducing environmental standards that apply to trucks operating in specific urban areas). This trend is described in Section 2.2.

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[6] Driver profiling is an online application that produces specific data on individual drivers by monitoring driving skills and behavior and measuring and analyzing maneuvers that affect safe driving, fuel efficiency, and emissions (http://www.tfl.gov.uk/microsites/fors/53.aspx accessed on December 28, 2011).

2.1.4.2 Off-Peak Deliveries

The promotion of off-peak deliveries in cities is a promising strategy for offsetting the traffic impacts of urban freight. Trial studies were performed in the United Kingdom to test off-peak delivery methods and showed positive results in relation to decreasing vehicle miles and CO_2 emissions (Palmer and Piecyk, 2010). A 3-month night-time delivery trial undertaken at Sainsbury's supermarket in Wandsworth, England, in cooperation with the Freight Transport Association and the Noise Abatement Society, resulted in reduced trip times (60 minutes per trip), delivery costs (£16,000 per year) and CO_2 emissions (68 tons per year) while no noise-related complaints were reported (FTA, 2009). As reported in Palmer and Piecyk (2010), Fisher, McKinnon, and Palmer (2010) estimate that in the United Kingdom a 1 percent increase in out-of-hours deliveries would generate £18 million savings per year in external costs associated with congestion, accidents, and noise.

According to *National Policy and Strategies Can Help Improve Freight Mobility,* off-hour deliveries "[have] the potential to reduce peak hour congestion by giving delivery drivers a wider delivery window and avoiding traffic delays" (GAO, 2008). Palmer and Piecyk (2010) mention, however, that operating trucks during off-peak hours, especially at night, may result in higher driving speeds, with adverse effects on environmental performance: "When vehicle speeds increase above a certain level (i.e., around 75 km per hour for a 44 tonne lorry), fuel efficiency and environmental performance deteriorate rapidly" (p. 8).

In Manhattan, a detailed research experiment was conducted in 2009–2010 by the Renssaeler Polytechnic Institute and New York City's Office of Freight Mobility (with funding from U.S. DOT) to examine the conditions under which carriers and receivers are susceptible to switching to off-peak delivery hours. Twenty Manhattan retailers agreed to shift their delivery windows to between 7 p.m. and 6 a.m. Assessment studies found that

> fewer deliveries during normal business hours allowed [receivers] to focus more on their customers and that their staff was more productive because they waited around less for deliveries that were tied up in traffic. Carriers found that their trucks could make more deliveries in the same amount of time; they saved money on fuel costs and could use a smaller fleet by balancing daytime and night-time deliveries, and that legal parking was more readily available. Their drivers reported feeling safer and less stressed (NYCDOT c.2011).

The monthly reduction in parking tickets for participating truck companies exceeded $1,000 per truck. Delivery routes were completed 48 minutes faster on average. Holguín-Veras (2010, 2011) concludes that off-hour deliveries in Manhattan are more efficient. They require fewer vehicle miles and, on the whole, are cheaper than deliveries during the day, as the benefit of better traffic conditions offsets the disadvantage of higher salaries for night truck drivers. A second conclusion is that promoting night deliveries requires that receivers accept off-hour deliveries. A third conclusion relates to policy: the provision of financial incentives to receivers is recommended in order to achieve a change in the receivers' behaviors. Previous studies (Holguín-Veras et al., 2006) have shown, for example, that a $10,000 tax deduction to restaurants accepting off-hour deliveries would lead to 20 percent of them switching to off-hour deliveries. Following further studies (Holguín-Veras, 2010, 2011), the total cost to taxpayers was estimated: "according to the Census Bureau there are approximately 6,500 restaurants and drinking places in Manhattan; each of them receiving between 6 to 8 deliveries per day. Assuming that each truck is able to serve two restaurants in the same stop, this translates into a total truck traffic reduction in the day hours of 1.3 million trucks/year in the New York City network at a total cost to taxpayers of $13 million/year" (Holguín-Veras, 2010, p. 6376). According to Holguín-Veras (2010, 2011), such subsidies to receivers could be financed via an urban freight road-pricing scheme.

New York City today (2012) keeps promoting off-hour deliveries by asking additional carriers and receivers potentially interested, and advertising this opportunity on the city's website. The city has created an advisory group and provided truck companies organizations and other business groups with outreach material to send to their members promoting the program and asking them to contact the project team for more information (information provided by Stacey Hodge, Director of the Office of Freight Mobility). No data are available on the shift to off-hour deliveries.

2.1.4.3 Efficient Loading/Unloading Areas, Curbside Management

Loading/unloading spaces, also called delivery bays, are a common local policy to organize last-mile delivery operations. These dedicated areas are much needed in dense city cores where a huge variety of street users compete for very limited space, and where patterns were not designed for today's trucks. Insufficient delivery spaces shift delivery operations to traffic lanes or sidewalks and lead to congestion and potentially hazardous situations for other street users. Additionally, the design and location of loading/unloading areas in many cities are often inadequate. Many bays are unable to accommodate trucks with their handling equipment, and sometimes bays are sited in a piecemeal approach, following the demand of a local shopkeeper, for example, without large-scale planning.

Recent initiatives have generated more efficient approaches. In Paris, before 2004, the 10,000 existing delivery bays were more often used for car parking than for delivery operations.

In 2004, the city of Paris took a series of measures to improve the use of delivery bays:

- **Improvement of delivery bay supply and location.** A method was set up to quantify the number of delivery bays needed (depending on the type and quantity of shops). A technical guide was written by the city's technical services in charge of street design. The guide imposed a minimum of one delivery space every 100 meters in the city streets. Delivery areas must be at least 10 meters long, in order to facilitate trucks' maneuvers and the accommodation of platform lifts.
- **Limitation of the stopping time for delivery to a maximum of 30 minutes.** The time limit is controlled using a time disc on which delivery drivers must indicate their arrival time.
- **Sharing of delivery spaces with parking.** In September 2010, 80 percent of the delivery bays were opened to general parking during the night (from 8:00 p.m. to 7:00 a.m.). The remaining 20 percent have been identified as spaces commonly used by delivery trucks early in the morning (before 7:00 a.m.).

A 2008 survey showed that the new policies had a positive impact on supply and maximum stopping times. Delivery spaces are more available during the day, as car parking has decreased. As calculated by the municipality, enforcement has increased considerably, with 13 percent of illegal stops fined in 2008 versus only 1 percent in 2004. This has not yet transferred into an increased use of delivery bays by delivery truck drivers, but it has laid the necessary conditions for a more efficient use of the Paris delivery bays.

Similarly, New York City's Commercial Vehicle Parking Plan recommended providing additional curbside spaces for commercial vehicles, reducing the amount of time these spaces are occupied, and increasing enforcement: "By improving the management of loading/unloading zones in the Midtown area, NYCDOT decreased the number of double-parked vehicles, which resulted in a reduction in congestion" (Bomar, Becker, and Stollof, 2009a, p. 6). A detailed description of commercial vehicle parking rules is provided online by New York City's Office of Freight Mobility (NYCDOT, 2012). As an example, a diagram shows how trucks can park along bicycle lanes. Conditions for double parking or parking at an angle to the curb are also described.

Alternative designs exist, such as loading bays positioned at an angle to the curb. Attention is always paid to removing obstacles around the loading bay, such as humps and posts, which prevent drivers from operating on-board handling equipment. In Paris, some bus lanes are shared with delivery vehicles. Other layouts exist in other cities including dedicating entire sections of a parking lane to deliveries during certain time windows (Toulouse, France).

Roadway time sharing has been implemented successfully in Barcelona, Spain. The municipality introduced an innovative time-sharing scheme on some of its main boulevards by devoting the two lateral lanes to traffic during peak hours, deliveries during off-peak hours, and residential parking during the night. Also, Barcelona formed a dedicated mobility motor squad consisting of 300 officers circulating on motorbikes to control all on-street parking activities including loading/unloading zones. The crackdown prevents illegal, long-term parking and has made these zones much more available to delivery truck drivers.

In downtown Los Angeles, "Tiger Teams," which are traffic control officers supplemented with tow trucks, have been deployed on designated corridors with a high level of loading/unloading activities during peak hours. This enforcement effort, paired with the addition and reorganization of on-street loading areas, has had good results for downtown deliveries and general traffic conditions (Bomar, Becker, and Stollof, 2009b). The program is not a major financial burden as there are only 15 new traffic control officers (and 10 new tow trucks), but the benefits of the new policy were immediate.

The 2008 Chicago Downtown Freight Study made 60 recommendations, focusing on one immediate priority related to curbside management: to create a loading zone plan and inventory supported by a parking violation fine program during peak times and an enforcement campaign to prevent alley obstruction. The study also proposed providing floor area ratio bonuses for additional dock facilities and adding loading zone information to a geographic information system database. One of the main partners for the municipality was the Building Owners and Managers Association.

2.1.5 Intelligent Transport Systems

In the near future, ITS will be a crucial element of an urban freight strategy. Today, use of ITS applications at the municipal traffic-management level or for interfacing with local truck drivers is still rather uncommon.

There are different categories of ITS applications for transport supervision in an urban environment. The most common applications are automatic road enforcement (plate-reading cameras); real-time information provided by variable message signs; traffic-light management; and electronic toll collection.[7] Many other types of applications exist but are not widely used yet, such as car-to-car or car-to-infrastructure communications.

Application of ITS to urban freight movement seems to have a lot of potential, but, so far, very few ITS applications

[7] There are other ITS applications in use or in development for intercity freight (e.g., passes for compliant vehicles to bypass checkpoints and virtual weigh stations). These are beyond the scope of this report.

are specific to (dedicated to) urban freight. Several highly anticipated solutions include real-time, detailed traffic information customized to meet truck drivers' needs (with more detailed incident reporting than is currently available on navigation systems); online reservation of loading/unloading areas; and systems for consolidation of urban deliveries.

Previous attempts at providing online reservations for truck delivery spaces (such as in Barcelona 2000–2004) failed due to the cost and complexity of the systems as well as their perceived rigidity. Truck drivers were reluctant to use the online reservation system because they were not certain they could arrive at the dedicated spot in the reserved timeframe. Other innovative ITS technologies specifically for urban freight applications were tested in the past, but were abandoned. In Barcelona, an automated enforcement of loading/unloading parking provisions by cameras was also attempted, but it proved too costly. The city of Rouen, in France, had an ambitious strategy for developing real-time information on traffic conditions for truck drivers. The project was never implemented because of legal issues and also because there did not appear to be much truck driver demand for the dedicated information.

A consortium of cities cooperating in the European SMARTFREIGHT project (finished in June 2011[8]) has explored different categories of urban freight ITS. The main objectives of the project were "to develop new traffic-management measures towards individual freight vehicles through open ICT [Information and Communication Technology] services, on-board equipment and integrated wireless communication infrastructure"; to "improve the interoperability between traffic management and freight distribution systems"; and (very ambitiously) to "coordinate all freight distribution operations within a city by means of open ICT services, on-board equipment, wireless communication infrastructure and CALM[9] MAIL implementation in on-board and on-cargo units, for all freight vehicles" (www.smartfreight.com). Among the partner cities, Trondheim (Norway) was the main test site,[10] while Winchester (United Kingdom) and Bologna (Italy) performed simulations, and Dublin (Ireland) carried out desktop studies. In Winchester, studies focused on retail waste and returns management strategies. Other efforts included identification of suitable waiting areas to hold vehicles before they enter the city center and shared freight-bus lanes. Bologna used a satellite positioning system to improve the efficiency of its projected urban freight consolidation scheme (Stoffel, 2008). In Dublin, a user needs assessment was made regarding ITS and urban freight. Although the project per se is finished, some SMARTFREIGHT experiments are still ongoing.

In another European project, Cooperative Vehicle-Infrastructure Systems[11] (finished in June 2010), some work was dedicated to urban freight transport. One sub-project looked at commercial parking, loading zone booking, and vehicle access control to sensitive areas, as well as the management of the transport of hazardous goods.[12]

More common are technologies that are used by municipalities *in support* of policies on urban freight. In European and Asian cities, new enforcement technologies have increased the efficiency of truck access restriction policies. Automatic control systems such as automatic number plate recognition cameras, mobile enforcement, vehicle positioning, and on-board equipment have been introduced. The enforcement of access rules through license plate recognition cameras is the best example of an efficient support provided by an ITS technology. This type of automatic control is used in congestion pricing zones or LEZs in many European cities (especially in the United Kingdom, Spain, and Italy). This technology comes at a cost; for example, in London, installation and monitoring of cameras costs £30,000 per traffic-enforcement camera. Although license-plate-reading cameras are expensive, they provide an efficient enforcement system. Truck license plates are registered with the city. License-plate-reading cameras then distinguish between complying and non-complying vehicles. The latter are fined when trying to access a restricted zone. In contrast, in 2007, the city of Paris implemented an environmental regulation (for afternoon deliveries only), but because enforcement agents lack training regarding delivery regulations, the rule is not enforced. Too many small independent carriers, with very old trucks, continue circulating in the city streets. In London, the LEZ (see Section 2.2) could not have been effective without a system of automated control by cameras.

Providing information to truck drivers represents another potentially important use of ITS in cities. A freight website organized by Transport for London (www.tfl.gov.uk/microsites/freight/) provides information to truck drivers such as the location of incidents and works; maps; and advice on safe driving, abnormal loads, and regulations (truck ban, etc.). The portal is connected to other websites of interest such as the congestion pricing scheme (to pay online for example). In other cities, so far, freight transport operators have not been targeted as specific users of information on traffic conditions. Truck routes are mostly identified by traditional signing. Variable message signs do not yet provide much specific information on freight issues; although there are some exceptions,

[8] See final report http://trg1.civil.soton.ac.uk/sf/D1.2%20-%20SMART FREIGHT%20Final%20?Report?.pdf.

[9] Communications Access for Land Mobiles - ISO 15628:2007

[10] In Trondheim, the "Wireless Trondheim Network Lab" already offered a city-wide, high-capacity communication network, helping to test transport services connected to the CALM standard.

[11] www.cvisproject.org (European Commission, Information Society and Media).

[12] See test site results on www.cvisproject.org/download/Deliverables/DEL_CVIS_5.2_Test%20Site%20Results_V1.0.pdf.

such as the variable message signs that display real-time access regulations on the multiuse lanes in Barcelona.

Few of the currently marketed software programs designed for the freight industry (i.e., tour or delivery route planning) are connected to municipal sources that provide information on traffic conditions or access and parking regulations. Even quite widespread systems of logistics network optimization are not as common as one would expect in urban areas. Freight operators using some kind of ITS for pick-up and delivery services in cities are still a minority, and there is little investment in new technologies. This situation could change quite rapidly as the cost of these technologies decreases.

GPS is now used routinely in private and commercial vehicles for route guidance, but it is not yet a very efficient tool for densely built urban areas because the precision of identification is not yet perfect (a higher precision requires expensive technologies). There is extensive use of GPS for vehicle tracking among large delivery services such as FedEx or UPS, but not for any form of system management beyond individual fleets.

Information and communication technologies are very important for some rapidly developing sectors of the urban freight industry, such as B2C (business-to-consumer trade) and C2C (consumer-to-consumer) deliveries. The increase of e-commerce requires new logistics arrangements in city centers, such as space for reception boxes, terminals concentrated on providing logistics operations tailored to the needs of e-commerce, and new traffic arrangements and information services. The examples of Packstation in Germany and Kiala in France and Belgium (discussed in Section 2.1.7.2) show the development of pick-up points as a means of avoiding direct deliveries to customer homes. These new organizations are based on information technologies.

ITS should become an increasingly important part of an urban freight policy. In one way or another, most current local traffic measures already include new technologies. The research team foresees that these technologies will become better tailored to meet the different needs of urban activities and that ITS applications will become an important component of managing the transport of freight in urban areas. ITS applications are also important for urban freight policies in that these applications could prove interesting for data collection. Despite processing challenges and privacy issues, GPS provides a potentially powerful method to enrich commercial vehicle data collection (Greaves and Figliozzi, 2008).

2.1.6 Zoning and Building Requirements for Off-Street Deliveries

Policies and regulations using zoning and building ordinances with a direct impact on freight and deliveries are a potentially powerful way to decrease the number of on-street deliveries, therefore reducing congestion in central neighborhoods.

The compulsory building of off-street delivery areas within companies' premises is a common urban planning policy that can prevent truck parking on sidewalk areas or double parking. These measures apply to new buildings or buildings subjected to important transformations or new activities. Many economic sectors can be included in the regulations: offices, small businesses, industry, hotels, warehouses, cinemas, etc. City planning ordinances and building codes requiring off-street delivery bays for large buildings represent a very effective strategy for limiting the congestion of roads due to on-street deliveries in dense urban areas, provided they are sufficiently enforced. In Europe, many cities that have imposed the implementation of off-street delivery bays have failed to inspect the effectiveness of these bays after the new buildings began operations. This follows a rather common European pattern of poor enforcement of municipal regulations because of a lack of funding for additional enforcement staff or insufficient training of enforcement agents. Consequently, delivery bays are easily transformed into car parking areas, trash collection zones, or storage areas; when this happens, truck drivers cannot use them anymore for deliveries.

The Tokyo off-street parking ordinance of 2002 is rather standard for many cities around the world. It compels all department stores, offices, or warehouses to provide for loading/unloading facilities when they have a floor area of more than 2,000 square meters. European cities' regulations are generally stricter, as buildings of 400 to 1,000 square meters are subjected to the off-street loading zone regulations. This stricter limit is more in line with the objective of freeing street space from delivery operations, as it targets many more buildings.

The Zoning Resolution of the City of New York includes detailed rules for off-street deliveries. It imposes loading berths for most commercial, manufacturing, and storage uses. These requirements vary according to the district, the size of the establishment, and the type of use. For most retail uses, for example, a loading berth is required for facilities with over 8,000 square feet of floor area, and additional berths are required for each additional 15,000 or 20,000 square feet (NYC, 2011). In addition, the size, design, and location of the berths are regulated. The objective is to "provide needed space off public streets for loading and unloading activities, to restrict the use of the streets for such activities, to help relieve traffic congestion in commercial areas within the City, and thus to promote and protect public health, safety and general welfare."

In Paris, the measures requiring loading and unloading areas in private buildings (commercial, industrial, and office buildings) rely on tools imposed by national legislation. Interestingly, the 2006 Paris Local Land Use Plan defines several global orientations for the transportation of goods:

(1) implementing logistic spaces in some urban areas, (2) giving priority to the setting up of logistic activities in areas with a rail or waterway connection, and (3) requiring the main generators of freight (supermarkets, warehouses, hotels, large office areas, etc.) to integrate delivery areas within their premises proportional to the freight volume they generate. However, in this regard, the building prescriptions are vague, obliging only the "accommodation of adequate zones required to ensure common loading or unloading tasks" (article UG12-2 of the Paris Local Land Use Plan, version of October 4, 2012).

Barcelona implemented a local measure on its own initiative. A municipal ordinance of February 1999, Ordenança Municipal de Previsió d'espais per a càrrega i descàrrega als edificis (municipal ordinance for off-street loading/unloading spaces), lists the compulsory provisions for loading/unloading spaces in new buildings, as well as other measures for freight and deliveries. The regulations are precise, imposing a number of loading bays according to the number of square meters of built floor area. There are also two uncommon but rather clever requirements:

- All new bars and restaurants must accommodate storage areas for bottles and drinks. Storage must have a minimal size of 5 square meters within the premises. The rationale behind this rule is that restaurants will not need a daily supply of beverages if they store a sufficient volume, thereby reducing the need for frequent deliveries. This measure has proven to be very effective in reducing the number of daily deliveries to these businesses (interview with Luis Cerda, freight project manager for the city of Barcelona).
- Under certain conditions, collective delivery bays (shared delivery bays) can be arranged by several businesses. Delivery bays can be built in adjacent buildings and do not have to be built in each individual building.

2.1.7 Consolidation Schemes, "City Logistics"

Some cities (mostly in Europe) believe that they need to go further than just regulating truck traffic or establishing a freight forum. Their strategy is oriented towards "city logistics," which aims to organize urban goods movements in a manner that promotes economic and environmental standards and is adequate to the demand for new logistics services. City logistics includes physical operations such as order preparation, shipments consolidation, transport (including home deliveries), short- or medium-term storage of goods, management of drop-off/pick-up boxes for parcels, and return of pallets and empty packages.

Different levels of initiatives coexist, involving various stakeholders—large transport operators and logistics providers, real estate developers, major retailers, and many start-up companies. Initiatives include urban logistics spaces and urban consolidation centers (UCCs). UCCs are a kind of city logistics that provides a specific service of bundled and coordinated deliveries, often requiring public subsidies. Such consolidation schemes aim at reducing the number of delivery vehicles and the distances they travel and increasing each vehicle's load factor. While these initiatives have garnered a lot of media and academic attention, these schemes have had mixed results. Many initiatives have proven too costly or ill-adapted to urban delivery operations. Many have been abandoned, but in some cases an adequate business model was found.

2.1.7.1 Urban Logistics Spaces

Some cities promote the development of urban logistics spaces, such as small terminals located in dense urban areas providing logistics services to neighborhood businesses and residents. These strategies can be costly, but they represent a very efficient way of promoting innovative delivery schemes.

These logistics spaces (of about 5,000 to 20,000 square feet) can be provided directly by public authorities on public properties, such as underground parking lots. The municipality of Paris organizes requests for proposals so that freight operators demonstrating best practices with regard to environmental, social, and economic objectives can use the facilities at low rental cost (see the example of Chronopost in the following paragraphs). Underground parking lots in city centers are often used for this purpose because they are well located in relation to zones of high commercial density and they often belong to municipalities and are managed by private companies that try to make the space profitable with added-value activities. The reduction of car traffic in city centers (effective in many cities around the world) has opened new opportunities for logistics activities within underground parking. An additional advantage of underground consolidation centers in cities is that they are secured, so truck drivers feel safe for their loading/unloading operations.

In Paris, the Chronopost Concorde facility located in the Concorde underground parking lot, below the Place de la Concorde (an upscale area), is a good example of an urban logistics space. Before 2004, the space was used to collect coins from on-street parking meters. In September 2004, Chronopost (an express parcel transport company dominant in the French market) won the bid organized by the city of Paris and developed a new protocol for delivering parcels in the seventh and eighth boroughs of Paris, the busiest neighborhoods of Paris in terms of offices, shops, and administration. The protocol involves a main transport haul from a hub outside of Paris to the Concorde terminal and short hauls from the Concorde terminal, using a fleet of 16 electric vehicles, for final deliveries to clients. All Chronopost parcels destined for (or originating from) the seventh and eight boroughs are included in the new organization. The municipality paid for the renovation of the underground facility and the investments that were needed to conform to safety standards and accommodate the use of electric vehicles. Chronopost pays a subsidized rent for the use of the facility, but has to buy and maintain the electric vehicles used for the final deliveries.

An assessment study performed by Grant Thornton in 2008 (information provided courtesy of the city of Paris, also quoted in TURBLOG, 2011) provided the following results. From a strictly operational point of view, the Concorde urban logistics space gives Chronopost the advantage of being very close to its clients. This means higher productivity (70 addresses per route instead of 56 addresses when the route started from a hub outside of the city limits). Delivery times were not affected by the new organization. The total cost per parcel delivered has not changed significantly. Annual CO_2 emissions have decreased by about 60 percent (see Figure 7, which shows the 6-month decrease from 27.9 tons to 11.42 tons). Two-thirds of the reduction is due to the use of an electric fleet for final deliveries; one-third is due to the new logistics organization (there is only one consolidated shuttle a day between the urban terminal and the external hub instead of five or six small trucks before).

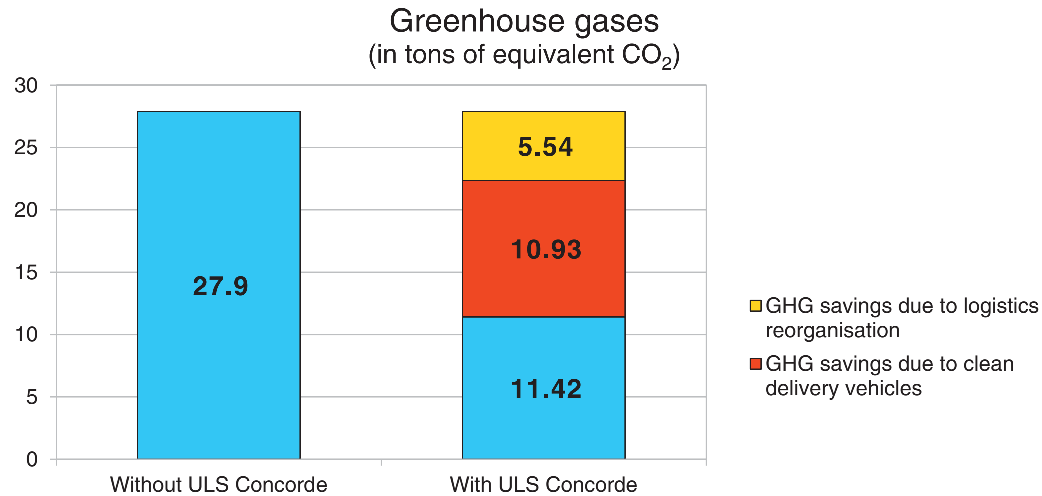
The total distance traveled by traditional vans decreased by 75 percent. Local emissions of NO_x decreased (compared to the previous year) from 192 to 48 kilograms, and PM_{10} emissions decreased from 12 to 3 kilograms. Employees working for the urban logistics space now reach their workplace by public transport, which was not possible before. The use of electric vehicles replaced noisy vehicles with silent ones. The implementation of the terminal has located 19 new jobs within Paris (mainly low-skilled jobs). The impact assessment study showed that employees who relocated to the Paris premises were quite satisfied to work in the Concorde logistics terminal. Employees provided the following reasons for their satisfaction during interviews: less time spent in congestion; driving electric vehicles is more comfortable; and the starting hour for the delivery runs is later than previously, when employees started their work in the suburban terminal.

2.1.7.2 Pick-Up Points

On a smaller scale, urban logistics spaces also include pick-up points. In recent years, the number of these local depots in urban and suburban areas has grown rapidly (Augereau and Dablanc, 2008). The first experiments with pick-up points took place in the 1990s and were quite unsuccessful. However, since 2003 and the rapid increase in e-commerce, the development of pick-up points, drop boxes, and relay points has been remarkable.

Pick-up points are local collection and distribution depots, or boxes, from which consumers can pick up goods that they have ordered via mail order or on the Internet. Pick-up points provide an innovative and technology-intensive alternative to home deliveries and generate considerable savings for delivery companies. Pick-up points eliminate failed delivery attempts to residential addresses and consolidate many stops in a neighborhood to a few.

Some of the most developed networks of pick-up points in Europe today are in the United Kingdom, Germany, Belgium, Holland, Luxembourg, and France. In Germany, Hermes Group has an extended relay-point network. The Kiala network in France and Benelux and the Packstation network in Germany are well known. These two systems differ in many ways: Packstations are automated locker banks designed for



Source: data courtesy of the City of Paris

Figure 7. Inventory of CO_2 emissions before and after the new Chronopost Concorde organization (assessment made for a 6-month study).

the needs of one transport operator (Deutsche Post/DHL), whereas Kiala provides a network of pick-up services in local businesses to many different transport operators. Kiala points are managed by local businesses (flower shops, grocery shops, etc.) as an additional service provided to customers. They handle products from all retailing companies that have a partnership with Kiala.

Although the establishment of pick-up points has been rather successful, it has been expensive: in addition to requiring investments in ITS and in safety equipment, there have been costs related to pick-up point location. In Germany, the success of Packstation is linked to two factors: the partnership with the Deutsche Post/DHL, which provides freight volume, and the ability to set up lockers in public places and on the street. In some countries, for safety or aesthetic reasons, such implementations are forbidden.

2.1.7.3 Urban Consolidation Centers

UCCs are one of the most popular urban logistics concepts among municipal decision-makers. UCCs provide bundled and coordinated deliveries. A UCC is a logistics facility located in close proximity to the city center (or any kind of dense commercial area), from which consolidated (across multiple and competing vendors) deliveries are carried out and in which a range of other value-added logistics and retail services can be provided (BESTUFS, 2007). The objective is to serve a city with fewer vehicles that are better loaded and make less frequent deliveries to each recipient, reducing the overall vehicle miles needed for last-mile deliveries. Often, vehicles used in a UCC run on natural gas or electricity in order to further increase the environmental benefits of the new system. UCCs usually (but not necessarily) require financial support from public authorities to operate.

Many such terminals (up to 150) existed in European cities over a decade ago, but due to operating costs, most of them closed down when municipalities could no longer subsidize them. Today, a few UCCs are operating, mostly in medium-sized cities: Bristol in the United Kingdom, many Italian cities, La Rochelle in France, and Motomachi in Japan. Some UCCs are dedicated to specific economic sectors, such as commercial streets' retail (Bristol UCC, Cityporto in Padua and Vicenza), airport retail (Heathrow), or building sites (London and Stockholm). Panero, Shin, and Polo Lopez (2011) provide details on several UCCs in Europe and Japan.

The London Construction Consolidation Center (LCCC) was implemented in 2006 with funds from Transport for London and private investors, with the aim of consolidating and organizing all deliveries of construction materials to major construction sites in the city. Transport for London reported a 68 percent reduction in the number of vehicles delivering to or picking up material at the building sites served by the LCCC, an average reduction in delivery time of 2 hours (including loading/unloading) for building supplies, a 75 percent reduction in CO_2 emissions, a 15 percent reduction in wasted material, and a 30-minute increase in workforce productivity per day (SUGAR, 2011). Despite these achievements, the LCCC was closed after 3 years of operation due to financial problems. Although the LCCC reduced collective costs, the allocation of investment and operating expenses of the terminal could not be settled. Transport for London was expecting that the LCCC would eventually operate at a profit, which did not happen.

This is a common case of positive net social benefits (the reduction of truck traffic on and around construction sites) without the savings being passed on to the parties incurring the costs. The LCCC experience, however, benefitted the management of the London 2012 Olympics Games' construction sites (interview with Ian Wainwright, Transport for London).

About six urban consolidation terminals are currently in existence in Italy. All share the purpose of protecting historic centers with rich architectural heritage. Also, Italy is characterized by many self-supplied shop owners and small truck companies ("padroncini") who do a small number of truck trips per week or haul less than truckload on poorly organized routes. This explains why Italian local officials attempt to impose more efficient freight transport strategies in city centers. In Parma, only accredited carriers can deliver within the historic center; others have to use the services of Ecologistics, the municipal UCC. To receive accreditation, vehicles must meet the Euro III standard, they must be fully loaded (at least to 70 percent of capacity in volume or weight), and they must possess a geo-positioning system that allows tracking.

Motomachi is an upscale retail area of Yokohama in Japan. In 2004, a consolidated delivery scheme was implemented and has proved successful since then (SUGAR, 2011). It is managed by a shopkeepers' association and serves most of the stores in the area. Retailers' associations have been key players in the implementation of the scheme. A consolidation terminal of 330 square meters is located a few hundred meters away from the retailing area. On an average day, 22 truck companies use the facility. Sagawa, one of the most important Japanese parcel and B2C transport companies, represents 60 percent of all UCC activity. The UCC and its 14 employees process about 350,000 parcels per year. Three low-emission, compressed natural gas (CNG) trucks make delivery rounds from the consolidation center to the shops. The scheme has managed to break even financially. The operating budget is ¥55 million (about €412,000), 95 percent of which comes from the revenue generated by the fees (¥150 or about €1.25 per parcel delivered) paid by the freight carriers using the UCC. A subsidy from the shopkeepers' association covers the remaining operational deficit.

UCCs have been popular because they generate important savings in vehicle-kilometers and CO_2 and local pollutant emissions, as many local impact assessment studies have demonstrated. However, because of their central locations, UCCs often require significant real estate expenditures. They often require electric or gas vehicles, which are much more expensive than regular vehicles and can have maintenance or depreciation problems. The allocation of a UCC's operating costs is often complex, generating governance issues. Past UCCs have run up against difficulties related to municipalities' hesitancy to continue subsidizing experiments.

UCCs can also lead to legal complications and risks for municipalities and the UCC operators. To ensure a UCC's effectiveness, many municipalities implement strict vehicle access rules for the zone covered by the UCC and provide regulatory or financial benefits to UCC operators (for example, in La Rochelle, only UCC electric vehicles can use the city's bus lanes). The question then emerges as to how far authorities can carry regulations before they risk legal challenges. In Vicenza, Italy, a local regulation favoring a municipal UCC led to litigation by an association of freight transport carriers. Court rulings were needed in 2006 and 2009 to allow the city to go forward with its regulation (Ville, Gonzalez-Feliu, and Dablanc, 2012). Many other cities, observing these difficulties, are now reluctant to promote similar concepts. Some UCCs were established by private initiatives because of an expected increase in the difficulties of serving city centers. However, in many European cities, this has not proven true, as stricter control of private car traffic has actually made access to the center easier for commercial vehicles. This was the case in Basel, Switzerland, where the UCC had to close down after a few years of operation due to better traffic conditions in the city center (Dablanc, 1998). Panero, Shin, and Polo Lopez (2011) report the same issue for the oldest UCC worldwide, that of Fukuoka in Japan, which was established in 1978. The municipality's recent policy of adding underground parking spaces in the city center has actually reduced the natural advantages of the UCC for trucks bound for inner city destinations.

Among the recently established UCCs, Motomachi, Bristol, Lucca, and Padua have engaged in practices that have contributed to (limited) success:

- Local authorities elaborated a specific regulation giving priority city center access to the carriers using the UCC (but there have been legal issues).
- The operation of the final deliveries (from the consolidation center to the shopkeepers) was not given to a competitor but to a logistics provider not previously involved in local trucking activities, which made it more acceptable to the UCC users.
- The definition of the consolidation scheme has been based on a profitable business plan that allows the municipality to decrease its subsidies in proportion with the consolidation center's development.
- Most of the consolidation center experiments were undertaken through public–private partnerships. The feasibility studies were often financed by the government (particularly in France) and impact assessments were carried out by consultants and financed partially by the government.

However, in most cases, local subsidies remain necessary.

There are no UCCs in the United States today. In comparison with Asian and European countries, "the United States has been slow to adopt truck demand management strategies" (Kawamura and Lu, 2007, p. 34). Panero, Shin, and Polo Lopez (2011) examine the potential transferability of the UCC concept to the New York City case. According to these authors, the probability of New York City adopting such a scheme is rather low. The authors agree that there is a need for more efficient urban freight operations in the United States: "consolidation and economies of scale are harder to obtain at the 'last mile' of the journey, mostly because urban distribution tackles small orders. Hence, opportunities for further freight consolidation still exist at the city freight level" (Panero, Shin, and Polo Lopez, 2011, p. 23). Nonetheless, UCCs may not be the most appropriate tools for U.S. cities, due to two main factors: (1) the physical layout of American cities (few U.S. cities have a historical street grid that requires specific protection from trucks) and (2) the reluctance of most American municipalities to provide regulatory or financial support to UCC schemes. Kawamura and Lu (2007) also show that to offset the costs of an urban terminal (mostly land costs), a UCC needs to operate in very dense areas. Compared with European and Asian cities, American cities lack the denser urban situations and stricter limits on the use of large trucks that would make the cost of consolidation schemes attractive to U.S. industry. Kawamura and Lu (2007) conclude, however, that U.S. cities do have the legal power, if not the political opportunity, to pursue such policies. If they do so, they should do that by favoring private initiatives or at least very active participation from private stakeholders.

2.1.8 Conclusion

Strategies for handling last-mile deliveries are diverse, from routine policies related to truck access restrictions and delivery time windows, to more sophisticated consolidation schemes and city logistics initiatives. Sophisticated strategies have not always been the most successful, and the cities that have succeeded in implementing effective policies have focused on traditional measures while also modernizing them: for instance, basing truck restrictions on the age of the vehicle instead of its weight and size; ensuring that there are a sufficient number of on-street loading spaces and that they are big enough to accommodate trucks with handling equipment; instituting innovative traffic management in lanes accommodating traffic, parking, and deliveries at different times of the day; implementing enforcement tools that use ITS; and providing specific training to enforcement agents. Off-hour deliveries have showed large gains in speed and reliability as well as decreases in vehicle miles when receivers of goods (e.g., retailers and restaurants) agreed to reorganize their deliveries.

What makes a city implement an urban freight strategy? Why are some cities more willing to engage in these kinds of policies than others? First, large, congested cities with dense urban cores must deal with truck traffic and deliveries, and this is increasingly the case as traffic is—in relative as well as absolute terms—growing. London, Paris, New York, and Tokyo are quite naturally advanced in designing and implementing urban freight strategies. Historic cities with an architectural heritage have also been very active. Spanish and Italian cities are at the forefront in designing innovative urban freight schemes, sometimes in rather radical ways, such as in Vicenza where all parcel and express transport companies have been banned from the city center, or in Barcelona where the municipal zoning ordinance obliges restaurants and cafes to build storage areas within their premises. Other types of cities stand out because their transport policy's priority is sustainability and the reduction of environmental impacts. This is the case for northern European cities (Gothenburg, Copenhagen, and Stockholm) and, in a very different way, for the megacities (such as Mexico City, Shanghai, or Manila) of more recently industrialized countries that are faced with overwhelming challenges in managing emissions and congestion (Dablanc, 2009).

At a finer level of analysis, the best strategies that the research team has identified also reveal the crucial role of a project leader. The project leader can be an elected official or a technician or (as was the case in Paris and London from 2000 to 2005) a combination of both. The appointments of a freight team in London and, more modestly, a "Mr. Freight" in Paris were critical to the completion of the many urban freight initiatives that followed. A freight project leader has a key role in the success of urban freight projects; a change in project leadership can result in abandonment of a project (or significant delays). In some cases where there has been no designated project leader, private stakeholders have been crucial in raising awareness and promoting innovative strategies, but this role could also be played by a freight industry leader, representatives of a chamber of commerce, or a retailers' local group. What is then needed is an adequate response from the local government, and this is often secured through the establishment of a freight forum. Conversely, the active and highly visible involvement of a public body such as a municipality can deter transport operators from participating, and, in this case, a careful dialogue among all stakeholders is crucial.

Some other conditions must be met for a successful implementation of a last-mile strategy (SUGAR, 2011). It is important to conduct an analysis before the implementation of the project (ex-ante analysis) and to implement a follow-up with regular assessment surveys using relevant indicators in order to be able to draw comparisons between the ex-ante and ex-post situations. When designing a local solution to an urban freight problem, the whole supply chain involved must be taken into account, not just the segment that is being reorganized. It is also important to recognize that the preparatory phase of an urban freight strategy is often longer than planned and that legal analyses at different steps of the project implementation, sometimes leading to useful modifications, must often be undertaken. One of the critical success factors is achieving a transition phase from the feasibility study to the actual implementation, and then to the perpetuation of the measure.

2.2 Emissions and Other Environmental Problems and Strategies

Trucks are a significant source of air pollution in metropolitan areas. "There is a need to significantly reduce freight transportation emissions in major [U.S.] metropolitan areas" (Ang-Olson and Ostria, 2005). In European cities, a large share of transportation-related PM, NO_x, and ozone come from freight traffic (see Section 1). Trucks operating in urban areas tend to be older and hence more polluting than those operating in the long-haul sector. Urban congestion adds to the problem due to idling, stops, and starts. Of particular concern are particulate emissions. The particulate emissions problem is especially severe in major trade centers.

While truck emissions are the most visible externality in most U.S. cities, many very dense cities experience serious noise problems from truck activity. To address delivery noise problems, innovative European programs combining the development of silent equipment, regulations favoring silent operations, and training programs have been implemented. Other important environmental externalities include the impacts of major truck traffic generators (e.g., warehousing/distribution) on local neighborhoods, truck parking in residential areas, the impacts of rail traffic on local traffic circulation and residential neighborhoods, and so forth.

Finally, urban freight may generate environmental justice and livability issues. Residential neighborhoods located near intermodal or distribution facilities or near major

Table 7. Jurisdictional authority related to goods movement air quality impacts in Southern California.

Level of Government	Agency	Type of Authority	Function of Regulation
Federal	U.S. Environmental Protection Agency (EPA)	Emission Standards (causes of pollution)	Sets maximum levels of emissions for pollutants coming from new engines.
	U.S. EPA	Ambient Air Quality Standards (levels of pollution)	Sets health-based standards for air quality and requires a plan for achieving the standards
State of California	Air Resources Board (ARB)	Emission Standards	Sets maximum levels of emissions for pollutants coming from existing trucks and off-road equipment
	ARB	Truck Idling Regulations	Limits idling of trucks to 5 minutes
Region	South Coast Air Quality Management District (SCAQMD)	Develops Air Quality Management Plan to meet federal and state standards.	Sets rules for emissions sources
City or County	Planning Department (or equivalent)	Land use guidelines, Zoning code, Design standards	Restricts location and design of new land uses
	Planning Department (or equivalent)	City/County Code	Sets limits on truck idling

Source: MIG, ICF International, and UltraSystems (2009), p. 1-10, Table 1-1.

transport corridors tend to be low income and include disproportionate numbers of minority populations. Efforts to develop higher density, walkable neighborhoods may pose challenges for the associated freight activities. This section will include a review of strategies to address environmental and livability issues.

2.2.1 Reducing Truck Emissions

The major strategies for reducing truck emissions in urban areas include (1) accelerated achievement of existing standards or increasing the stringency of emissions standards, (2) mandating alternative fuels and electric delivery vehicles, (3) restricting idling or other detrimental operational activities, and (4) creating truck-free zones, LEZs, or other spatial restrictions. The following explores strategies for reducing truck emissions, assessing the effectiveness of these strategies, costs and benefits, and feasibility.

All levels of government can take actions that decrease the urban air quality impacts of trucking activities, from setting limits on truck idling to influencing the location and design of new facilities for goods movement to voluntary agreements with vehicle owners to reduce emissions. As an example, Table 7, from MIG, ICF International, and UltraSystems (2009), provides a useful overview of jurisdictional authorities involved in urban truck movements and air quality in Southern California.

2.2.1.1 Accelerated Achievement of Existing Standards or Increasing the Stringency of Emissions Standards

Local Pollutants' Emissions. For the past 20 to 30 years in the United States and other regions such as the European Union, emissions standards have been used to reduce vehicle emissions. NO_x and PM are among the pollutants commonly targeted. $PM_{2.5}$ has been a more recent addition to targeted pollutants. NO_x and PM are closely related to diesel vehicles and are specifically detrimental to human health (see Section 1). Emissions standards have only partially offset the increase in the number of vehicles and vehicle miles traveled in urban areas, as the concentration of NO_x and PM in the air have tended to decrease much more slowly than other pollutants, remain stable, or even increase (see below).

Emissions standards for vehicle construction in the European Union follow designated "Euro standards." For trucks, the current standard is Euro V[13] (trucks manufactured after October 2009) with the more stringent Euro VI standard due at the end of 2013. In the United States, the current standards started applying in 2007 and 2010.[14]

[13] By convention, the Euro name is followed by Arabic numerals when it applies to light-duty vehicles and Roman numerals when it applies to heavy-duty vehicles.
[14] For 2010, medium- and heavy-duty engines must emit no more than 0.01 g/bhp-hr (grams per brake horsepower per hour) of PM and no more than 0.20 g/bhp-hr of NO_x (the PM standard took effect in 2007).

Table 8. Fuel consumption reduction standards for semi-trailer trucks.

	EPA Emissions Standards ($g\ CO_2$/ton-mile)			NHTSA Fuel Consumption Standards (gal/1,000 ton-mile)		
	Low Roof	Mid Roof	High Roof	Low Roof	Mid Roof	High Roof
Day Cab Class 7	104	115	120	10.2	11.3	11.8
Day Cab Class 8	80	86	89	7.8	8.4	8.7
Sleeper Cab Class 8	66	73	72	6.5	7.2	7.1

Source: EPA (2011), p.5

In addition to the federal standards for new trucks, some states have reinforced rules for existing trucks. California is the only state that is permitted to set stricter standards, because it is the only state that had a regulatory agency before the passage of the federal Clean Air Act. The authority to regulate California's emissions comes from the California Health and Safety Codes, which provide authority to the California Air Resources Board (CARB) to find feasible and cost-effective strategies to reduce emissions from all mobile source categories. CARB's regulation applies to in-use trucks and requires owners to upgrade their vehicles and equipment. Other states are permitted to follow CARB standards, but not set their own. Consequently, California has the most stringent truck emissions regulations in the United States. Comparably, in Europe, the European Union sets vehicle emissions standards and deadlines of application, and member nations can impose additional retrofit systems to circulating trucks.

In California, new emissions-reducing regulations went into effect on January 1, 2012. They target heavy trucks and buses, which are defined as those with a GVWR over 26,000 pounds. Engines must be retrofitted with a diesel PM filter. Owners can also opt for a flexible phase-in option that requires any 30 percent of vehicles in the fleet to have a PM filter. Owners of small fleets (one to three trucks) can postpone the compliance requirement until 2014, but must report their fleet information to CARB in order to receive the extension. Lighter diesel trucks with a GVWR of 14,001 to 26,000 pounds have no compliance requirements until 2015.

CO_2 Emissions and Climate Change. The regulation of trucks' CO_2 emissions is a rather recent idea, and governments are more reluctant to impose it.[15] The European Parliament and Council have recently decided to postpone until 2017 the implementation of the standard of 175 grams per kilometer of CO_2 for new vans sold within the European Union. The objective for 2020 has been set at 147 grams per kilometer, instead of 135 as previously proposed. Heavy-duty trucks (defined as commercial vehicles weighing more than 3,500 kilograms) are not subject to CO_2 regulations yet. In the United States, in May 2010, President Obama ordered the EPA and the U.S. DOT to develop GHG standards for medium and heavy trucks (combination tractors, heavy-duty pick-up trucks and vans, and vocational vehicles including refuse or utility trucks) for model years 2014 to 2018. The move followed the release of a study by the National Research Council that found that despite some progress on the part of manufacturers, trucks could still be made 50 percent more fuel-efficient over the next 10 years (TRB, 2002). The State of California and major automobile and truck manufacturers expressed support for a national heavy-duty GHG and fuel efficiency program as well as further light-duty GHG and corporate average fuel economy (CAFE) standards. A final agreement was signed in August 2011 for heavy trucks (see Table 8 for standards applying to semi-trailers. For other trucks, standards are more variable. The standards represent an average of 15 percent reduction of fuel consumption for diesel vehicles). Regarding light-duty trucks, an agreement was announced in July 2011 among EPA, NHTSA, automakers, and the State of California on GHG and fuel economy standards for model years 2017 to 2025. According to the EPA, standards could achieve, on an average industry fleet-wide basis, 163 grams per mile (101 grams per kilometer) of CO_2 in model year 2025.

California is actively involved in developing the new measures. This follows the state's actions related to climate change. In 2006, AB 32, the Global Warming Solutions Act, set 2020 GHG emissions reduction goals into law. It directed CARB to develop early actions to reduce GHGs while also preparing a plan for the 2020 limit (http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm). The Sustainable Communities and Climate Protection Act of 2008, SB 375, required CARB to develop regional emissions-reduction targets. In February 2011, CARB published its automobile and light

[15] This is not to say that GHG reduction strategies do not exist at the local level. Lutsey and Sperling (2008) record 684 cities that have taken GHG emissions-reduction target initiatives in the United States, together with multiple regional or state initiatives. Lutsey and Sperling actually view the local level as the most effective level for climate change initiatives in the United States. However, they note that the most common targets of these GHG initiatives are light-duty vehicles and renewable electricity; freight traffic is rarely targeted (2008).

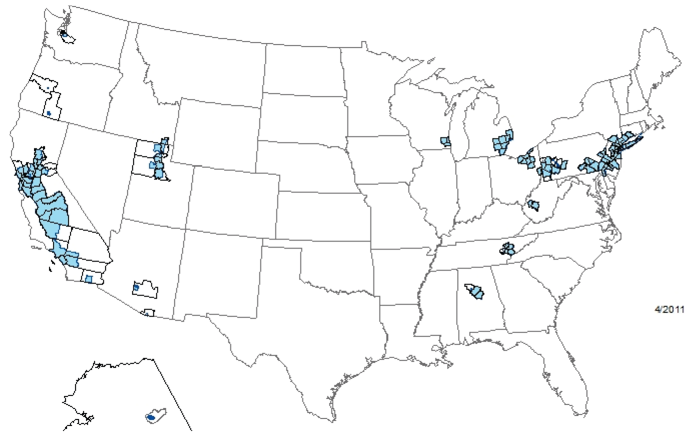
truck emissions targets for 2020 and 2035 for each of the state's 18 metropolitan planning organizations (MPOs).[16]

Wygonik and Goodchild (2011) considered strategies to reduce truck CO_2 emissions and their potentially negative impacts on the cost of urban freight deliveries. These researchers concluded that reducing CO_2 emissions is complementary with increasing the cost-effectiveness of urban delivery operations.

Air Quality Attainment Areas. The EPA as well as the European Commission set standards for cities' ambient air quality. The standards cover various pollutants coming from diesel engines and other pollutants. Different limits can be set, such as compulsory values or informative values and alert thresholds.[17] The EPA has set National Ambient Air Quality Standards for six principal pollutants, which are called "criteria" pollutants. Regulations require that areas in violation of standards improve air quality and reach the standards by specific dates. Member states in Europe "shall take the necessary measures to ensure compliance with the limit values," including a strict regulation on motor traffic (Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on Ambient Air Quality and Cleaner Air for Europe). In the United States, areas of the country where air pollution levels persistently exceed the National Ambient Air Quality Standards are designated "nonattainment" (see Figure 8 for $PM_{2.5}$-related nonattainment areas) and must design and implement a plan to reach the standards.

At the regional or metropolitan level, many agencies have jurisdiction over air quality issues, which can be overlapping. In Southern California, primary jurisdiction belongs to the South Coast AQMD, which works with CARB to implement air quality regulations and incentives. Additionally, the South Coast AQMD is responsible for bringing the Southern California region into compliance with federal and state clean air standards (O'Brien and Giuliano, 2012).

Despite vans' and trucks' significant share in urban emissions, local and regional strategies to reach attainment status rarely include specific actions on freight movements (Dablanc, 2008). An exception in Europe is the Netherlands, where standards on air quality (notably the limit values for particulates) have prompted the Dutch Supreme Court to make decisions leading to a freeze on infrastructure projects in cities where limit values were not respected. Conversely, in December 2011, the Paris administrative tribunal turned down a request from environmental organizations accusing the administration of a lack of action on traffic limitation to reduce PM and NO_x concentration. The regional Atmospheric Protection Plan for the Paris region is now obsolete (it ran until 2010), and the new plan is not due for several years. The tribunal ruled, however, that the plaintiffs were not specific enough in establishing how actions on traffic would contribute to attainment. In the United States, freight traffic related to port activities is often a primary target for litigation and for cleaner air actions (O'Brien and Giuliano, 2012). The example of the Ports of Los Angeles and Long Beach Clean Truck Program is provided in Section 2.3.



Source: EPA Green Book (http://epa.gov/oaqps001/greenbk/mappm25_2006.html)

Figure 8. $PM_{2.5}$ nonattainment areas (2006 standard) in the United States as of April 2011.

2.2.1.2 Alternative Fuels

A variety of alternative fuels can be used in freight vehicles and equipment. Some, such as emulsified diesel or biodiesel, require little or no modification to the engine while others, such as natural gas, require engine conversion or replacement (Ang-Olson and Ostria, 2005). Environmental advocates, policy-makers, and the trucking industry have great expectations for use of hybrid and electric commercial vehicles in specifically urban applications. Urban freight, because of its "stop-and-go" patterns, has been viewed as a natural market for electric vehicle operations. The distance range of today's batteries (up to 100 miles) is not an obstacle for most urban delivery routes.

[16] As an example, the SANDAG (San Diego Association of Governments) region has to reduce its per capita greenhouse emissions relative to 2005 by 7 percent in 2020 and 13 percent in 2035. All 18 MPOs' targets can be found at http://www.arb.ca.gov/cc/sb375/final_targets.pdf (last accessed on January 10, 2012). In November 2011, SANDAG's Sustainable Communities Strategy was formally approved by CARB, which found it able to achieve ("if implemented") the 2020 and 2035 emissions reduction targets.

[17] The EU regulations include limit values, target values, and alert thresholds. A limit value is a level fixed with the aim of avoiding, preventing, or reducing harmful effects on human health and/or the environment as a whole, to be attained within a given period and not to be exceeded once attained. A target value is a level fixed with the aim of avoiding more long-term harmful effects on human health and/or the environment as a whole, to be attained where possible over a given period. An alert threshold is a level beyond which there is a risk to human health from brief exposure and at which immediate steps shall be taken. European Council Directive 2008/50/CE, in particular, targets the pollutants NO_2, NO_x, PM_{10}, and $PM_{2.5}$, which are closely linked to transportation activities.

Because of these improvements, and despite many drawbacks (see below), various incentives to use alternative fuel vehicles have been implemented, such as access privileges in urban areas (e.g., extended time windows and lower tolls) or subsidies to buy vehicles. In London, alternative fuel vehicles do not pay the congestion charging fee that is applied in central London. Clean Cities is a U.S. network of nearly 100 city coalitions sponsored by the U.S. Department of Energy that promotes alternative and renewable fuels in transportation. A guidebook for heavy-duty and commercial fleet managers (from municipalities to freight operators) was published in 2010 (USDOE, 2010). A National Clean Fleets Partnership was established with the Clean Cities network to work with companies operating large fleets to reduce petroleum use. The program provides technical expertise and some financial support. Some of the program's main initiatives related to delivery vehicles are presented in Table 9.

Despite the promotion of alternative fuel vehicles, so far their overall use remains extremely limited, especially use of natural gas and electric delivery vehicles. Today, the vast majority of trucks and vans operating in urban areas are fueled by diesel or gasoline. The main reasons for the very slow introduction of natural gas and electric vehicles are their initial cost (an electric truck is two to three times more expensive than a diesel equivalent), higher operating costs, a lack of available expertise in maintenance of these vehicles, a lack of refueling stations, and difficulty in setting the vehicle's depreciation value and value for the second-hand market (Dablanc, 2008). Another reason is the negative impact on fleet routing and logistics of the limited driving range before recharging (although progress has been made in recent years). In London, as of June 2010, despite strong financial incentives (electric vehicles receive a 100 percent discount on the congestion charge), only 1,700 vehicles were registered as electric vehicles, of which 50 percent were trucks and vans (information provided by Ian Wainright, Transport for London).

Electric delivery vehicles are used in niche markets, especially in the city centers of large cities, because they contribute

Table 9. Alternative delivery vehicle experiments from the National Clean Fleets Partnership.

Location (Company and City) of Experiment	Alternative Technology Used	Results from Evaluation Studies
FedEx Express Los Angeles and Sacramento, CA	20 gasoline hybrid electric delivery trucks	Compared with diesel hybrid trucks: • Considerable difference in tailpipe emissions • No difference in fuel cost or maintenance cost per mile[a]
UPS Phoenix, AZ	Six Class 4 hybrid electric delivery vans (diesel)	Compared with traditional diesel vans: • 29% higher fuel economy • Less reliability (because of prototype components) • 8% lower maintenance costs[b]
Staples Nationwide, partnership with Massachusetts Clean Cities	Introduction of 53 all-electric trucks in high-density urban delivery areas Electronic speed control device on medium-duty diesel delivery trucks to limit speed to 60 miles per hour Limit of truck idling to 3 minutes	Speed limit saves 1 million gallons of fuel per year (equivalent to about 10,000 tons of CO_2)
Coca-Cola Bottling New Orleans, LA	Eight hybrid electric delivery trucks	Detailed study not available
Golden Eagle Distributors[c] Tucson, AZ	Entire Tucson heavy-duty fleet converted to CNG First vehicle (from Ryder) received in Sept 2011, remaining 22 trucks being converted	Detailed study not available

[a] Barnitt (2011).
[b] http://www.afdc.energy.gov/afdc/pdfs/47327.pdf and Lammert (2009)
[c] Golden Eagle Distributors is a carrier of alcoholic beverages.
Source: Alternative Fuels Data Center Case Studies (http://www.afdc.energy.gov/afdc/fleets/delivery_experiences.html)

Photographed by L. Dablanc

Figure 9. Electric van from Geodis-Distripolis program in Paris, France.

Photographed by L. Dablanc

Figure 10. Electrically assisted cargocycle, La Petite Reine, in a Paris street.

strongly to the "green" image of trucking companies operating in urban areas. In Europe and the United States, electric delivery vehicles are being tested by prominent companies such as DHL whose GoGreen worldwide program includes the use of electric vehicles. In March 2011, 30 electric vehicles and 60 hybrid vehicles were introduced in Manhattan. The company is also testing electric vehicles for deliveries in the Paris region. France's largest freight carrier, Geodis, uses electric vehicles for deliveries in city centers for its program called "Distripolis" (see photo in Figure 9). FedEx operates the largest fleet of hybrid commercial vehicles in North America and has introduced all-electric delivery vehicles in large cities (see Table 9). As of January 2012, the company operates 365 hybrid electric trucks and 43 all-electric trucks in Chicago, Los Angeles, Memphis, and New York City, as well as in London and Paris (information from www.fedex.com).

Some start-up delivery companies have made a name for themselves because of their use of innovative delivery vehicles such as cargocycles. The French delivery operator and delivery tricycle manufacturer, La Petite Reine, has contributed to the creation of a niche market of electrically assisted cargocycles running in large cities in France and the United Kingdom (see Figure 10). These vehicles are being operated for major companies such as Office Depot in London's Regent Street (see Figure 11) or DHL in Paris.

In 2010, the French government grouped all electric commercial vehicle requirements from all governmental administrations and public agencies (including the national postal service) so that manufacturers might be interested in responding to a bid involving more than 50,000 electric vehicles, of which one-third was commercial. In October 2011, different lots were allocated to different automakers. The largest lot was won by Renault for 15,000 Kangoo Z.E. vans (pictured in Figure 12).

Photographed by L. Dablanc

Figure 11. Cargocycle for Office Depot, Regent Street terminal.

Source: © Renault, used with permission.

Figure 12. A Kangoo Z.E. van from Renault.

Low-Carbon Fuels. A low-carbon fuel standard (LCFS) was enacted in California in 2007 with the objective of a reduction of at least 10 percent in the carbon intensity of California's transportation fuels by 2020. The full cycle of production and distribution of the fuel is to be integrated in the evaluation of carbon intensity. A ranking of fuels according to their carbon intensity was proposed by CARB.[18] This was controversial and gave rise to lawsuits. In December 2011, a federal judge ruled that the low-carbon fuel regulations discriminated against crude oil and biofuel producers located outside California (Cart, 2011). The state will appeal the ruling.

2.2.1.3 Idling, Speed or Other Operational Restrictions

Ang-Olson and Ostria (2005) estimate that "reducing all overnight idling by 50 percent would reduce NO_x emissions by 156 tons per year in the Dallas–Fort Worth area and 524 tons per year in the Houston area [representing] 0.3 and 0.8 percent of the on-road heavy-duty vehicle emission inventories in these regions, respectively." According to the American Trucking Associations, using EPA studies, options available to fleets to minimize discretionary idling have the potential to reduce CO_2 emissions "by an estimated 61.1 million tons over the next ten years" (ATA, 2013).

One important step toward the reduction of idling is truck-stop electrification. Truck-stop owners are installing equipment that allows truck drivers to get power for truck heating, air conditioning, and appliances without keeping the engine running. The Alternative Fuels and Advanced Vehicles Data Center provides a list of truck electrified parking spaces in the United States by state and city.[19] There are about 60, a tiny share of the total truck parking locations in the country. Some companies such as Shorepower Technologies and IdleAir (see Figure 13) are developing the equipment of truck stops with charging stations throughout the country. Some trucks can use truck-stop electrification through a simple extension cord. Installing an additional adapter can provide better ventilation and air conditioning services.

Government can promote reduced idling through regulation. The CARB implemented a 5-minute limitation on diesel truck idling in January 2005, which applies to commercial vehicles over 10,000 pounds. Since 2008, even sleeper berth trucks must comply with the law, which provides for exemptions only in cases of emergency. A violation of the provision can lead to a fine of at least $100. In New Jersey, idling has also been outlawed after 3 minutes, but drivers of trucks manufactured after 2007, or correctly retrofitted, can use an extended time of idling for cooling or heating before sleeping in their trucks in non-residential areas. Since February 2009, a municipal law in New York City has reduced the amount of time the engine of a motor vehicle is permitted to idle from 3 minutes to 1 minute when adjacent to a school. The impact of these regulations on idling is unknown; the research team has found no studies of the effectiveness of these regulations on reducing emissions.

Source: © IdleAir, used with permission

Figure 13. IdleAir charging station for trucks.

The reduction of speed is an efficient way of reducing fuel consumption of trucks. Freight operators will generally go as fast as speed limits allow. While this may make sense from a time perspective, fuel economy and GHG emissions generally worsen at high speeds (Cambridge Systematics, 2010). Fuel efficiency can be improved and GHGs reduced by increasing the time that trucks operate at the most fuel-efficient speeds. Gas mileage usually decreases rapidly at speeds above

[18] A table is presented at http://en.wikipedia.org/wiki/Low-carbon_fuel_standard showing values of midwest ethanol at 105 grams of CO_2 equivalent per megajoule of energy produced, to compressed natural gas coming from landfills at 11 grams. This table is made from various CARB sources.

[19] http://www.afdc.energy.gov/afdc/progs/tse_listings.php (last accessed January 6, 2012).

60 miles per hour. A recent DOE evaluation estimated that a 55 mile-per-hour speed limit implemented at the national level could result in a fuel consumption savings of between 175,000 and 275,000 barrels of oil per day, or about 27 to 43 million metric tons of CO_2 equivalent per year. This amount is equal to approximately 1.6 to 2.4 percent of on-road vehicle fuel consumption and emissions (Cambridge Systematics, 2010). Many trucking companies have adopted a maximum speed policy for their drivers as a way to limit fuel expenses. Staples found that by imposing an electronic speed control device on all its medium-duty diesel delivery trucks to limit speed to 60 miles per hour, it saved 1 million gallons of fuel, equivalent to about 10,000 tons of CO_2 per year (see Table 9). However, other companies value speed over fuel savings because longer travel times add costs for both the shipper and the cargo owner. Express transport companies have had a hard time complying with the 2007 French law (based on safety issues, not on environmental consideration) reducing the maximum speed from 100 to 90 kilometers/hour on highways for vehicles between 3.5 and 12 tons of GVWR because it disturbed their whole organization. Chronopost, a major parcel and express carrier in France, estimated that by reducing average speed and conflicting with working hour rules, the new regulation increased their haul times by an average of 22 percent.

Some state and local agencies have considered highway speed reductions as a way to reduce emissions. As reported by Ang-Olson and Ostria (2005), the Tennessee Department of Transportation reduced the truck speed limit in Shelby County to 55 miles per hour as a way to help the region attain ozone standards.

In general, measures related to drivers' training can lead to substantial fuel savings, especially in urban areas (BESTUFS, 2007). The FORS in London (see Section 2.1) includes truck drivers' training as one of its main targets.

2.2.1.4 Truck-Free Zones or Other Spatial Restrictions

Europe's LEZs. Europe has seen a surge in specifically designated urban areas with stricter access rules for trucks, preventing access for trucks that pollute most. These LEZs apply truck restrictions based on environmental criteria—only recent trucks[20] are permitted to enter the city center. In a few cases (Copenhagen), access is allowed for clean as well as "fully loaded trucks," that is, only trucks with most of their destinations in the restricted zone that meet a minimum load factor (60 percent of authorized tonnage in the case of Copenhagen) can access the zone. The regulation is enforced through regular reporting from the truck companies to the municipality (Geroliminis and Daganzo, 2005).

London has the most stringent and largest LEZ in Europe. Since 2008, trucks older than the Euro III standard (trucks manufactured after 2001) and, since January 2012, trucks older than the Euro IV standard (trucks manufactured after 2006) are prohibited from the Greater London area, i.e., the area surrounded by the M25 highway, which totals 1,580 square kilometers. Also, since January 2012, large vans (weighing more than 1.205 tons GVWR) must follow the Euro 3 standard (newer than 2002) to get into the zone. From 2008 to 2011, the number of Euro II, I and 0 trucks (when they are not retrofitted) went from 20 percent of all trucks before implementation of the LEZ to nearly zero today. Transport for London, the Greater London DOT, calculated that the scheme has directly produced a yearly reduction of 28 tons of PM_{10}, 26 tons of $PM_{2.5}$, and 529 tons of NO_x (Transport for London, 2008b), representing a 3.6 percent reduction in road traffic exhaust emissions for PM_{10}, a 3.7 percent reduction in $PM_{2.5}$, and a 2 percent reduction in NO_x (Transport for London, 2008b). According to Transport for London, "the latest measurements suggest that London is likely to comply successfully with the limit value for PM_{10} by 2011, and LEZ will have played an important part in making this possible" (2008b). Interestingly, NO_2 concentrations have failed to decrease; average concentrations in 2009 in London are similar to average concentrations in 2004. According to Transport for London, this could reflect the increased emission of "primary NO_2" from newer diesel-engine vehicles and abatement equipment designed to reduce emissions of PM_{10}.

Replacing old trucks and vans with newer types of vehicles benefits the environment because old trucks and vans emit a large amount of current air pollutants (NO_x and particulates). See the example of Gothenburg, Sweden, in Table 10.

An LEZ can be combined with road pricing, as is the case for the London congestion charge (the perimeter of which is much smaller than the LEZ). Most urban tolls apply to all vehicles, while many LEZs apply only to commercial vehicles. In London's congestion charge perimeter, green vehicles (defined as emitting 100 grams per kilometer or less of CO_2

Table 10. Effects of truck environmental regulations in Gothenburg, Sweden (trucks more than 7 years old prohibited).

Trucks	PM_{10} (kg/year)
< 16 tons with regulation	187
< 16 tons without regulation	566
> 16 tons with regulation	3312
> 16 tons without regulation	4531

Data from City of Gothenburg, May 2006, after 4 years of implementation.

[20] Defined by age or by their Euro standard. Most regulations apply an age limit of 8 to 9 years or the equivalent Euro III standard (Euro IV becoming more common 2011–2012).

and meeting the Euro V standard) do not pay the £10 charge that other vehicles pay to enter.

In Milan, Italy, an urban toll with fees varying according to vehicles' Euro standards was implemented in 2008. The scheme was called Ecopass until a new scheme was introduced on January 16, 2012, called Area C. Ecopass had a complex range of fees. For freight vehicles, all Euro IV vehicles had a full exemption from the fee; for Euro III, the fee was €5 per day; and for older trucks, it was €10 per day. According to Rotaris et al. (2009), the results of Ecopass were rather substantial. The number of freight vehicles daily in the Ecopass zone was 13,174 before the introduction of the scheme, and 10,500 after. This means that the goods supply of Milan's businesses and residents was provided with nearly 20 percent fewer freight vehicles. Rotaris et al. calculated the financial costs and benefits of Ecopass over 1 year of operation. They estimated that the financial value of emissions reduction was a gain of €1.8 million for NO_x and PM_{10} reduction and €0.6 million for CO_2. Freight vehicles saved an estimated €2.2 million in reduced trip time and increased travel reliability, but at a cost of €5.2 million in toll fees or investments in new vehicles. Overall, Rotaris et al. consider that freight operators were the biggest "losers" in the scheme, while the municipality gained the most, primarily because of the new revenues (especially through violation notices and fines rather than through the toll revenues). No financial aid was provided to the trucking companies to cope with the new rules.

Starting in January 2012, Ecopass was replaced with Area C, a simplified scheme. Vans and trucks that are not at least Euro IV cannot access the zone anymore. Eligible vehicles pay €5 a day to enter the zone, except electric vehicles. Until December 2012, hybrid and natural gas vehicles also have an exemption.

Many other European cities, especially the largest ones, have established LEZs. Amsterdam (the Netherlands), Copenhagen (Denmark), and Swedish cities initiated these types of ordinances in the early 2000s. All major European cities now have similar rules, including cities in Spain, Italy, and Germany. Energy consumption and the related CO_2 emissions could well be targets of LEZ or toll differentiation policies for the future, i.e., only trucks reaching a specified level of fuel efficiency or CO_2 emissions would be allowed to enter a city center or other specified zone. This was mentioned for the city of Gothenburg, but has not yet been implemented (SUGAR, 2011).

In the United States, no LEZ (with the exception of the San Pedro ports discussed below) or urban cordon pricing scheme exists. New York City proposed a congestion pricing plan for the Manhattan area (south of 60th Street) that would have established a high daily fee for trucks ($21) and a lower fee ($8) for private cars. The fee was to be reduced for clean trucks. Announced in 2007 as part of the Mayor's Greener Greater New York initiative, the plan was never implemented due to political opposition (despite support expressed by New Yorkers in polls). In 2008, the state assembly did not vote in favor of the plan, which was then abandoned with a subsequent loss of federal grants.

New types of truck access regulations such as the San Pedro ports' Clean Trucks Program or the European LEZs and urban tolls have a positive additional outcome to cleaner air. As old trucks cannot access a city anymore, small truck operators need to adapt their fleet. One way to do so is to grow bigger: very small companies are therefore replaced by medium-sized truck companies. Because they can bundle shipments and organize routes better, medium-sized trucking companies have been associated with increased operational efficiency. They have more ability to secure funding for investing in newer vehicles and modern equipment than owner-drivers or very small truck companies. This can contribute to the restructuring of the urban freight market (Dablanc, 2007).

Nonetheless, these schemes for truck access regulation have been criticized. After reviewing several assessment studies, Maes, Vanelslander, and Sys (2011) estimate that LEZ benefits are not high enough. An LEZ would need to target all traffic to significantly reduce emissions. According to Browne et al. (2010), who are looking at both LEZ and congestion charging schemes, restricted areas often fail to have a significant effect on congestion and pollution because light goods vehicles (LGVs) are not targeted. These schemes fail in promoting a more efficient use of LGVs or a switch to larger and more fully loaded vehicles. As Brown et al. (2010) note,

> In principle, [congestion] charging could discourage frequent, small-sized deliveries by LGVs. However charges would have to be set sufficiently high to have such an effect and would need to reflect the number of vehicle movements. Experience with congestion charging in London does not indicate a switch in use from LGVs to HGVs [heavy goods vehicles], but given the current charges in force and the fact that a single payment allows the vehicle to enter and leave the charging zone as many times as desired in a day this is not unexpected.

Also, it can be argued that companies operating both within and outside of a restricted area can relocate all their old vehicles to the non-restricted area, resulting in additional emissions in the non-restricted area, which can offset the benefits to the central area.

Other Truck Restrictions, Designated Truck Routes. Perhaps the most common regulation of urban truck traffic is route and parking restrictions. European cities have used this kind of regulation since the Roman Empire.[21] In recent

[21] Julius Caesar initiated a series of municipal ordinances known as the Law of Caesar on Municipalities (44 B.C.), of which Number 14 restricts the hours when a wagon can be driven through Rome and its residential suburbs. See Allan Chester Johnson, Paul Robinson Coleman-Norton, Frank Card Bourne, *Ancient Roman Statutes*, Clyde Pharr (general editor), University of Texas Press, 1961.

history, the most famous truck ban in Europe is the London Lorry Ban, in place since 1975. Heavy goods vehicles weighting more than 18 tons cannot circulate at night and on weekends within a delimited area. Paris has banned trucks (over 29 square meters) during the day time. All trucks in Seoul have been banned from the central areas during working hours. This ban has been in place since 1979. In Sao Paulo, to alleviate congestion, access is based on the plate number, with 2 days allowed per vehicle (including freight vehicles). In Mexico City, since 2008, the following rules apply: (1) trucks over 3.5 tons are forbidden between 7 a.m. and 10 p.m. in the historical center, and (2) trucks over 3.5 tons or over 7.5 meters in length are forbidden on one segment of the city's main boulevard (Eje Central between Churubusco and Consulado) from 6 a.m. to 11 p.m. In both cases, there are exceptions for trucks delivering mail, construction material, and perishable and frozen products.

Heavy-duty vehicles can be restricted to designated routes by local jurisdictions based on their size and weight. Most cities have truck routes made up of major arterials, with trucks allowed to deviate from these routes only for pick-up and delivery stops. The justification for limiting heavy-duty vehicles to certain routes is based on roadway wear, lane width and clearances, adequacy of intersections for turning movements, and noise impacts in residential areas.

Large, dense cities tend to have the most serious problems because of competition for scarce road space. Older cities have a local physical geography that was never designed for large trucks. New York City provides an example. The city has identified a truck route system of about 1,000 miles: 172 miles in the Bronx, 298 miles in Brooklyn, 243 miles in Queens, 130 miles in Manhattan, and 194 in Staten Island (Hodge, 2009), distinguishing between local routes and through routes. In its most recent update, the truck route network is available online (http://www.nyc.gov/html/dot/downloads/pdf/2011_truck_route_map.pdf), and the map can also be sent to trucking companies on demand.

A 2008 U.S. Government Accountability Office (GAO) publication (GAO, 2008, p. 27) notes the following:

> Recognizing that New York City is heavily dependent on trucks for goods movement, the New York City Department of Transportation initiated the Truck Route Management and Community Impact Reduction Study. This study revealed several negative effects of truck traffic on local communities, including traffic congestion, damage to residences and roads, and safety concerns for pedestrians and passenger traffic. In response to these findings, the New York City Department of Transportation has started to implement a number of solutions to mitigate these negative effects. For example, in some areas of the city, routing changes were implemented that improved access into the area by taking truck traffic off of some residential streets and putting it onto wider streets.

Truck route restrictions have both positive and negative impacts on emissions. Route restrictions reduce the network on which trucks may travel and may generate more truck VMT than use of all routes. On the other hand, route restrictions may reduce the overall level of congestion, leading to reduced emissions. To the research team's knowledge, no study has made a global assessment of the effects of truck routes.

2.2.2 Reducing Noise from Deliveries

While truck emissions represent the most recognized impacts of urban freight operations, many dense cities experience noise problems from truck activity. As seen in Section 1, noise is often mentioned by local communities as the number one perceived environmental nuisance. Freight traffic has a large share of responsibility for noise, especially close to freight corridors or freight facilities (logistics parks and warehousing districts) or in dense city centers where residential neighborhoods are also commercial and retail areas (see Table 6 in Section 1 for common delivery noise levels). Truck parking in residential areas and rail traffic in local areas also have important impacts on residential neighborhoods.

Governments implement different strategies to address delivery noise problems. In *Healthy Economies and Healthy Communities: A Toolkit for Goods Movement,* MIG, ICF International, and UltraSystems (2009) report that the city of South Gate, in Southern California, has installed rubberized asphalt material on some city streets, leading to "noticeable decreases in noise impacts." European programs have been implemented combining the development of silent equipment, regulations favoring silent operations, and training plans (see below for more discussion). In the United States, federal standards set the maximum level of noise that can be caused by transportation projects when federal funds are used. In California, Caltrans (the state DOT) sets similar standards at the state level for freeways and other state highways. For land and building projects, criteria have been set to evaluate the severity of noise impacts. Local city and county governments can set noise limits for specific activities (Los Angeles County's Health Code prohibits loading and unloading operations at night). Local governments can also establish criteria to judge the severity of noise impacts on various land uses and encourage noise barriers or buffers on new local development projects.

The reduction of noise generated by deliveries is especially crucial when night (or early morning/late evening) deliveries are promoted. Night deliveries represent a new target of urban freight policies (see Section 2.1.4). Some cities combine the promotion of silent equipment and noise regulations. An interesting initiative from the Netherlands is the PIEK program. In 1998, legislation on "Retail Trade Environmental Protection" came into effect regulating noise emission levels.

Noise emissions generated when loading and unloading goods at night must comply with strict peak noise standards. Maximum noise levels for a night delivery operation were set: directly above a building (7.5 meters), the limit is 65 decibels from 7 p.m. until 11 p.m. and 60 decibels from 11 p.m. until 7 a.m. A PIEK certification is given to operations respecting these standards. The certification applies to the vehicle, machines, and all the equipment and processes such as slamming a door, starting up, using forklifts, unloading, and using refrigerating units (these operations typically emit from 70 to 92 decibels, as seen in Table 6). A research and development program was set up to develop silent delivery vehicles and handling equipment. Four areas of development were implemented: low-noise truck bodies, low-noise engines, low-noise handling equipment, and staff training (Goevaers, 2011). In 25 pilot cities, the national government provided financial help for operators investing in PIEK vehicles and handling equipment to be used for night deliveries at supermarkets. As an example, Albert Heijn, a major retailer, purchased 1,000 PIEK-certified trucks. Assessment surveys were carried out by the company involving 10 shops in 9 cities, totaling 1,000 evening deliveries (Goevaers, 2008). The surveys were carried out for 3 months. Deliveries were made between 5 a.m. and 7 a.m. or between 7 p.m. and 2 a.m. the following day. For the same distances and the same type of vehicle, the benefits of the scheme were (for one vehicle doing one delivery round): 1 hour time savings for each delivery round, 10 liters of fuel saved, and a total reduction in labor costs of €12,600. This represents a savings of 30 percent in delivery costs and 25 percent in diesel consumption (SUGAR, 2011; Goevaers, 2011). On a 1-year basis, environmental benefits were reductions of 57 tons in CO_2 emissions, 147 kilograms in NO_x emissions, and 3 kilograms in PM_{10} emissions.

Interestingly, an agency is in charge of the development of PIEK standards domestically as well as the coordination of initiatives in Europe, where other national agencies are introducing the PIEK standard. Experiments have been conducted in cities such as Barcelona, Dublin, and Paris. The delivery company LR Services, a supplier of McDonald's restaurants in Paris, uses PIEK-certified equipment. In Barcelona, Spain, the retailer Mercadona replaced seven daytime trucks with two PIEK-certified night trucks. The benefits were estimated to be €6,000 a month, which balanced out the initial investment in 2 to 3 years. Noise measures were made and compared to ambient noise levels on nights without deliveries. No major difference in noise levels was recorded (NICHES, 2010).

2.2.3 Environmental Justice, Land Use Issues

As seen in Section 1, the concentration of freight terminals in urban residential neighborhoods generates significant impacts on local communities. Cities have engaged in various strategies to minimize these negative consequences.

In *Healthy Economies and Healthy Communities: A Toolkit for Goods Movement,* MIG, ICF International, and UltraSystems (2009) give the example of the Mira Loma community in Riverside County in Southern California. The area experienced significant impacts from goods movement facilities. Community members and activists participated in quantifying the health impacts from situating sensitive land uses, particularly schools and residential areas, near freight facilities. With regard to this community activity, MIG, ICF International, and UltraSystems (2009, p. A-15) note,

> Specifically, they have identified significant health disparities related to air quality from the railyard and supporting truck operations including premature deaths, reduced lung development and capacity, and cancer rates. Additionally, community members and activists have worked to gain more influence over land use decision-making in their community, which they believe is central to creating a safer and healthier community for residents.

MIG, ICF International, and UltraSystems (2009, p. 3-8) also note,

> Local communities can reduce exposure to truck emissions through land use policies and development regulations. Such policies move residents away from sources of truck pollution, protect residents from nearby emissions, and discourage new development near truck routes. Land use siting policies typically focus on the location of community services, such as schools and day care centers. The State of California recommends that schools be set back 500 feet from major roadways, to reduce exposure to exhaust. Local governments may be able to re-route truck traffic from sensitive areas by designating truck routes.

The County of Riverside Truck Routing and Parking Study (Meyer, Mohaddes Associates, 2005) was undertaken as a way to identify truck intrusions (including parking and idling) and impacts on neighborhoods. A toolbox of potential solutions was developed to alleviate identified problems. One of the main recommendations was to coordinate the different truck routes (usually defined at city levels) at the scale of the county, so that truck drivers find the network easier to understand and to comply with. Another recommendation was for the county to start discussions with the main local maps provider (Thomas Brothers[22]) to introduce truck route and restrictions information.

Since 2003, the New York City Department of Transportation has been engaged in a Truck Route Management and Community Impact Reduction Study (Edwards and Kelcey, 2007). With this initiative, the city "seeks to coordinate engineering, education, information and enforcement efforts to mitigate the negative impacts relating to truck traffic, as well

[22] Today, the targets would also include car navigation system providers.

as improve the overall truck management framework that exists in the City of New York."

2.2.3.1 Protecting Logistics Land Uses in Cities, Buffering Logistics Facilities

Logistics decentralization is the location of freight terminals and warehouses in increasingly suburban locations (see Section 1). For some cities, this movement has generated additional vehicle miles in urban areas (Dablanc and Rakotonarivo, 2010). Some cities have therefore considered providing incentives to retain freight and logistics activities within the urban core, while protecting the adjacent areas from freight activity impacts. In Baltimore, a "maritime industrial zone overlay district" (MIZOD) has helped port activities, especially private marine terminals, to remain in the urban area. Several actions have been taken, as described at www.mdot.maryland.gov. The underlying zoning of the area is "Heavy Industrial," preventing activities such as restaurants, hotels, and commercial uses to be implemented in the zone, unless as an accessory use. The MIZOD is to be in effect until 2024.

Weisbrod et al. (2002) look at the European concept of freight villages[23] to explore its relevancy for congested U.S. urban areas. Freight villages are master-planned clusters of freight and logistics facilities with collective amenities and support services such as security, catering, and truck maintenance. Weisbrod et al. argue that implementing such a concept in the United States could lead to substantial environmental and economic benefits. It would also require available land adequate for logistics activities. One way to find that kind of land is to redevelop brownfield spaces and implement freight-dedicated planned unit developments, which Weisbrod et al. define as planned clusters of modern warehouses and freight facilities with value-added logistics activities such as picking and order preparation and conditioning and packaging of goods.

2.2.3.2 Metropolitan Level Freight Planning and the Role of MPOs

There are many challenges to metropolitan-level freight planning. First, the transportation models used in forecasting are based on passenger flows and take freight into account only in rudimentary ways. Second, reliable models for forecasting freight flows at the sub-metropolitan level have yet to be developed. Third, intercity freight flows make up a much larger share of traffic than is the case for passenger flows, and freight flows are largely out of the control of metropolitan decision-makers. Fourth, rail infrastructure is private, and hence outside the domain of public planning. Finally, with a few exceptions (e.g., Portland, OR), MPOs do not have authority over land use decisions, which limits their ability to plan for future demand (Rhodes et al., 2012).

Six publications from the Transportation Research Board demonstrate an increasing consideration given to freight planning and land use issues. The first publication was released in 1996 and the most recent one released in April 2012. These publications are the following:

- *NCHRP Synthesis of Highway Practice 230: Freight Transportation Planning Practices in the Public Sector* (Coogan, 1996).
- *NCHRP Synthesis of Highway Practice 320: Integrating Freight Facilities and Operations with Community Goals* (Strauss-Wieder, 2003).
- *NCHRP Report 594: Guidebook for Integrating Freight into Transportation Planning and Project Selection Processes* (Cambridge Systematics et al., 2007b).
- *NCHRP Report 570: Guidebook for Freight Policy, Planning, and Programming in Small- and Medium-Sized Metropolitan Areas* (Cambridge Systematics et al., 2007a).
- *NCFRP Report 13: Freight Facility Location Selection: A Guide for Public Officials* (Steele et al., 2011).
- *NCFRP Report 14: Guidebook for Understanding Urban Goods Movement* (Rhodes et al., 2012).

Presented as an extended outreach to local practitioners and experts, *NCFRP Report 13: Freight Facility Location Selection: A Guide for Public Officials* (Steele et al., 2011) provides a comprehensive set of recommendations to local governments regarding the integration of freight facilities. The overall purpose of the guidelines is "to provide insight on location decisions for freight facilities and suggest best practices for transportation, land use, economic development, and regional partnerships to public sector agencies and officials considering and responding to freight facility development and location decisions."

Interestingly, what the guidebook insists on is the support that public agencies can and should provide in order to retain and develop logistics activities. De Lara (2011) discusses this orientation, arguing that "many regional development forces created a discourse of development that posits the logistics industry as a viable replacement for disappearing manufacturing jobs. As a result, billions of public and private funds have been invested in expanding a national distribution

[23] Freight villages are rather popular in Europe, where governments have been promoting them through public projects or public–private initiatives. Many freight villages provide access to rail or waterway services. They are not directly related to urban freight, although part of their traffic is for the urban markets adjacent to where they are located. The most developed freight village concepts are the *interporti* in Italy, the *Güterverkehrszentrums* in Germany, and the *plates-formes logistiques* in France. See, for example, the website of the German association of freight villages: http://www.gvz-org.de.

infrastructure." According to De Lara, while the freight industry offers some access to good job opportunities, it is also "a source of low wages and economic insecurity for a growing legion of contingent logistics workers."

How do recommendations on freight guidelines translate into actual metropolitan-level freight planning? In Orlando, the *Freight, Goods, and Services Mobility Strategy Plan* serves as the foundation for transportation planning and the development of long-range strategies to guide future infrastructure decisions that balance goods movement with passenger travel. Two elements of the plan are (1) freight villages (see definition in Section 2.2.3.1) and (2) truck treatment in the Development of Regional Impact (DRI) review process (Bomar, Becker, and Stollof, 2009c). Not surprisingly, MPOs in areas with major trade nodes are more likely to include freight elements in the regional transportation planning process. Examples include the Los Angeles, New York, Chicago, Seattle, and Atlanta metropolitan areas. However, even in these regions, freight issues do not always translate into strategies. A recent study (Dablanc and Ross, 2012) looked at five MPO transportation plans[24] from the Piedmont Atlantic region, an urban corridor extending from Birmingham, Alabama, to Raleigh, North Carolina. In the Charlotte area, the Mecklenburg–Union MPO's long-range transportation plan of 2010 includes 12 pages on freight, covering all modes of transport from air cargo to road and rail. Freight is recognized as an element of growth: "Freight handling and transit capacity has become an important platform for regional economic growth." However, the document is very descriptive and few propositions for actual policies are made, with the exception of the implementation of a regional freight forum. In the Birmingham area (under the Regional Planning Commission of Greater Birmingham), a recently formed Freight Advisory Committee is responsible for a freight-planning program that aims at collecting data, identifying specific freight needs, developing related planning solutions, and reaching a regional consensus on ranking freight projects. The 2035 long-range transportation plan of Raleigh's MPO (i.e., the Capital Area Metropolitan Planning Organization) mentions (p. 67) that a commercial vehicle survey is under way, which will include the location of distribution centers throughout the region. Raleigh's MPO and the Durham–Chapel Hill–Carrboro Metropolitan Planning Organization have included a freight plan in their unified planning work program. The Charleston MPO (i.e., the Berkeley–Charleston–Dorchester Council of Governments) takes a wider view on freight: because of the port, "the region serves as a major intermodal link between the southeastern U.S. and the world" (Chapter 8.1). Freight is recognized as a major economic asset for the region. The plan then establishes a list of freight issues, described as relatively minor, such as the differences in South Carolina, Georgia, and Florida regarding truck weight restrictions. A metropolitan area quite involved in freight is Atlanta. A freight advisory task force was established in 2003 by the Atlanta Regional Commission and two freight studies have been conducted in the last 4 years. A Freight Improvement Program of more than $75 million has been set aside for the 2014 to 2017 period with 80 percent of the funds coming from federal programs.

[24] MPO plans are the following:
- Mecklenburg–Union Metropolitan Planning Organization, 2035 Long Range Transportation Plan, adopted March 24, 2010.
- Capital Area Metropolitan Planning Organization and Durham–Chapel Hill–Carrboro Metropolitan Planning Organization, 2035 Long Range Transportation Plans, adopted March 20, 2009.
- Berkeley–Charleston–Dorchester Council of Governments Long Range Transportation Plan, April 2005.
- Atlanta Regional Commission, Atlanta Regional Freight Mobility Plan Final Report, February 2008.
- Atlanta Regional Commission, ASTROMAP: Atlanta Strategic Truck Route Master Plan, 2010.

2.2.4 Alternative Modes

Urban freight is carried almost exclusively by trucks and vans. In the past, trains and barges were common features in goods' supply in the heart of cities. Rail and waterborne transportation made a valid combination in New York harbor with floating bridges active until the 1960s (Dablanc, 2009). Barge transport remains in cities with waterways, such as Paris, Amsterdam, and Brussels. For example, barge accounts for about 7 percent of the tonnage arriving in or departing from the city of Paris.

Rail is not competitive with trucks for short hauls; however, rail is an important mode for regional import/export traffic associated with ports. In many European cities, land use pressures, passenger rail demand, and local opposition to rail freight have contributed to eliminating rail as a mode for freight transport.

Recent years have seen some new projects. They fall into three categories: (1) reuse of traditional rail freight terminals, such as in Rome, Munich, and Paris (one example, the Monoprix experiment, is described below); (2) use of underground rail facilities for freight (e.g., projected within the renovation of Les Halles commercial center in Paris, a "flower train" project in Amsterdam/Schiphol, and a mail train in London), although no project yet has been implemented; and (3) cargo-tram services, using existing tramway infrastructure. In Dresden, Germany, a cargo-tram that supplies parts to a Volkswagen plant has been in operation since 2000. Cargo-tram services are used in Zurich, Switzerland, for voluminous refuse. A major project, called Amsterdam City-Cargo project, went bankrupt in early 2009.

The Monoprix train experiment in Paris has been in operation since November 2007. Monoprix is a chain of supermarkets with 90 stores located in and around Paris. These stores receive nonfood products and nonalcoholic beverages by rail. A 20-car train arrives in Paris Bercy station (in the eastern part of Paris) every evening. Pallets are then transferred to CNG-operated trucks, which deliver to the stores early in the morning. The train, which is assembled at a terminal 30 kilometers south of Paris, uses regional and urban passenger train tracks to reach the Bercy terminal. This project distributes 210,000 pallets per year this way, with a yearly savings of 10,000 diesel trucks, 280 tons of CO_2, and 19 tons of NO_x. The city of Paris has invested €11 million in the project, mainly to renovate the inner city freight terminal. The Monoprix rail project is technically satisfactory, but its operation is quite expensive. Monoprix covers the additional cost of 26 percent per pallet carried compared to the former all-road solution.

2.2.5 Conclusion

Trucks are a very significant source of air pollution and also contribute to CO_2 emissions, noise, congestion, and traffic accidents. Different strategies to reduce the environmental impacts of freight have been identified and implemented at various levels of government. The research team has examined the key role of higher levels of government such as the federal level in the United States and the European Union level in Europe in setting standards for new vehicles' emissions of targeted pollutants. California has a special mandate and can define standards for existing vehicles (other states can adopt Californian standards or remain under federal ones). In California, new regulations went into effect in 2012 for trucks over 26,000 pounds. Engines must be retrofitted with a diesel PM filter. Owners of small fleets (one to three trucks) have until 2014 to comply; lighter trucks have until 2015.

Despite vans' and trucks' significant share in urban emissions, local and regional strategies to reduce traffic-related emissions rarely include specific actions on freight movements, with one significant exception: the new LEZs in several European cities. Only recent trucks are permitted to access an LEZ. London has the most stringent and largest LEZ in Europe. Trucks manufactured after 2006 (and large vans manufactured after 2002) are prohibited from the Greater London area. In 2008, the ban led to a reduction of 2 to 4 percent of total traffic-based PM_{10}, $PM_{2.5}$ and NO_x, contributing to London's efforts to become an attainment area for European Union air quality standards. The only comparable experience in the United States is the Clean Truck Program in the Ports of Long Beach and Los Angeles (see Section 2.3). While the ports are legally considered private entities, U.S. municipalities could have interstate commerce issues if they attempted to implement an LEZ modeled after those of London, Milan, and other cities in Europe.

Many cities promote the use of alternative delivery vehicles (hybrid, electric, or natural gas). However, the vast majority of trucks and vans operating in urban areas remain diesel or gasoline because of initial cost (an electric truck is between two to three times more expensive than a diesel equivalent), higher operating costs, lack of expertise in maintenance, lack of refueling stations, and difficulty in setting the vehicle's depreciation value. The limited driving range before recharging can also be a problem although progress has been made in recent years, with better batteries and a higher number of recharging stations.

While truck emissions represent the most recognized impacts of urban freight operations, many cities experience noise problems from truck activity. As night deliveries represent a new target of urban freight policies (to decrease congestion), recent strategies have included the promotion of silent vehicles and loading/unloading equipment. The research team has examined the Dutch program PIEK, a leader in research and development in this area, as well as a promoter of municipal regulations requiring the use of silent delivery equipment.

Urban and regional goods movements also raise environmental justice issues. The number of warehouses and distribution centers has increased dramatically in many large metropolitan areas of the United States and other parts of the world, following the rise in global trade and imports of manufactured goods. In many cities today, industrial land uses are essentially oriented towards logistics activities. This generates jobs and revenues for local communities, but today's mega-distribution centers concentrate truck traffic and subsequent environmental impacts on neighboring communities. Strategies to mitigate these impacts range from buffer zones to strict architectural and landscaping requirements to better access to a transportation network. A very important first (and permanent) step is to establish a freight group at a metropolitan level where different local governments, the MPO(s), and business and freight groups can meet, exchange information, and discuss the role of freight in planning and investments.

Finally, the research team has examined the use of non-road modes of transport to carry urban freight. While some experiments have been tested and remain in operation today, such as a train in Paris supplying the retailer Monoprix and a cargo-tram in Dresden supplying a Volkswagen factory, very few non-road urban freight operations exist today in cities in Europe and the United States, due to the costs and organizational complexity.

2.3 Trade Nodes: Problems and Strategies

This section assesses the unique problems related to truck, van, and rail traffic engaged in interregional trade. The focus is on trade hubs and gateways (places with significant ports and airports, intermodal transfer points, and border crossings) as well as the ancillary facilities that serve logistics and intermodal operations and that also generate trade-related traffic. These include distribution and warehousing.

Trade hubs share the same "last-mile" issues addressed in previous sections such as truck and van delivery and access issues, evening and weekend vehicle movements, and incompatible land uses. However, trade hubs are further defined by the scale and scope of operations that take place within them, particularly in the port, warehousing, and distribution sectors. A combination of rising trade volumes, demand for larger facilities, and the cost of land has pushed distribution centers and warehouses to the periphery of metropolitan areas. These facilities generate freight-related activity that may pass through the urban core on its way from ports and airports to markets outside the region.

Addressing trade-related externalities at this level can prove problematic for a number of reasons. While local communities and their elected officials welcome the economic benefit of the activity that comes from the presence of a hub or gateway, they recognize that the benefits of pass-through freight are widespread while the negative impacts are much more localized. This can often result in policies and strategies designed to internalize those costs through strategies like cargo fees and congestion pricing.

However, the discretionary cargo that does not stay in the region is much more sensitive to fees and other changes in pricing. The challenge is to mitigate the impacts while minimizing the potential for cargo diversion to avoid job losses and other negative economic consequences for the region as a whole. This is made more difficult by the number of jurisdictional authorities involved at the regional level as well as the diversity of services that operate as part of a complex and sometimes fragmented supply chain.

The section begins by defining the trade node problem, i.e., identifying the issues that result from the presence of trade hubs and what this means for local communities in and around the hub, the region as a whole, and across regions. The literature is then reviewed for the strategies that have been developed and tested to respond to the unique problems of interregional trade. These include mobility-related strategies like peak pricing and tolling. The discussion also reviews the experience of the Southern California region with off-peak truck access at the ports.

Like urban goods movement, interregional trade also has significant environmental impacts. Solutions designed for local trade activity however will differ from those that address pass-through traffic. The research team considers how both industry and decision-makers have attempted to mitigate hub-related trade activity and reviews strategies that respond to the problems of trade that cross regional and, in some cases, international boundaries.

This literature review includes North America, Europe, and Asia. Particular attention is paid to the lessons learned in Southern California that have influenced policy and program development in other places. Reducing the impact of freight in metropolitan areas often requires substantial infrastructure investment. As a result, the section concludes with four cases of infrastructure projects intended to reduce congestion and pollution impacts.

2.3.1 Defining the Problem

Improved transport contributes to more efficient supply chains. As transportation becomes more efficient, its cost—relative to the total cost of a finished good—is reduced. Lower transport costs allow major transporters and retailers to take advantage of more affordable labor in overseas production centers. This increases the distances over which trade occurs.

Global trade is also made possible by technology-based services that help to coordinate and process the increased flow of goods, particularly when the transactions involve various stakeholders in numerous countries. These services include finance, insurance, research and development, and international maritime law.

2.3.1.1 Growth in International Trade and Global Services

Trade in both manufactured goods and services has increased since the post-World War II period (World Trade Organization, 2011b). The volume of world exports has outpaced growth in gross domestic product (GDP) in every decade since the 1950s. Despite negative growth in 2009, the volume of world exports increased 14.5 percent in 2010, the single largest annual increase since the data were first tracked in 1950. The World Trade Organization projected positive growth would continue in 2011, with export growth figures estimated to be 6.5 percent versus approximately 4 percent for world GDP growth (World Trade Organization, 2011a).

Trade-related services are also increasing as a percentage of GDP in places like the United States, the world's largest exporter of commercial services, as well as in developing countries, with India being the prime example (James, 2009; De, 2006). In the United States, the value of trade-related services rivals cargo trade and helps improve the balance of trade with other nations (US Department of Commerce, Bureau of

Economic Analysis, 2008). Between 2005 and 2006, the surplus of cross-border trade in private services in the United States increased 12 percent, to nearly $97 billion (Koncz and Flatness, 2007).

The United States has also benefitted from the emergence of Asia, China in particular, as a low(er) cost center of production and manufacturing. The Southern California gateway—with its proximity to Asia's production centers; well-developed network of (air)ports, roads, and railways; and large local market—has accommodated a large share of this growth in trade. In 2010, two-way trade through the Los Angeles County Customs District—the nation's largest—totaled $346.9 billion. This was a 22.6 percent increase over 2009 figures (Los Angeles Economic Development Corporation, 2011).

The increase in global trade has created a demand for a variety of transport services including those, like ocean transport, that provide the supply chain with a low-cost, high-volume option for moving bulky, heavy, or large items. Ocean transport is also appropriate for items with a value that does not merit transport via higher cost options, such as air freight.

2.3.1.2 Scale Economies in International Freight Transport and the Emergence of Trade Hubs

Shipping containers are measured in 20-feet equivalent units (TEUs), and today the largest ships carry upwards of 12,000 TEUs. New 18,000-TEU vessels, dubbed the Triple E class (for economy of scale, energy efficiency, and environmental design), will come on line in 2014. Larger ships are part of the current economics of ocean shipping, which is driven by the desire to gain economies of scale on trade lanes throughout the world. The result has been a vertical concentration in liner service. A relatively small number of ocean carriers now control significant goods flows on major routes (Heaver, Meersman, and Van de Voorde, 2001). Furthermore, as container ships grow in size, the number of port complexes that can accommodate the largest ships decreases. Many of these ports are located in countries that are also home to the major ocean carriers, reinforcing the shift in the geography of the supply chain to places like Asia (United Nations Conference on Trade and Development, 2008).

Many of the larger vessels in service today (not to mention the new Triple E class of ships) are post-Panamax vessels—i.e., vessels too large to pass through the Panama Canal. [25] Instead, these larger ships depend upon a vast network of roads, railways, warehouses, distribution centers, and transfer facilities to move goods across entire continents. Mega-ships encourage the growth of mega-ports, which not only receive goods for local markets, but serve as global gateways and transshipment centers for goods destined for markets all over the world.

These gateways are often at the heart of major urban centers that have developed at the interface of transportation networks and systems of global commerce. Their populations are large, diverse, and often densely located in proximity to trade-related activity at ports, airports, manufacturing centers, distribution centers, rail yards, and border crossings. These gateways serve extensive inland/hinterland regions while at the same time connecting the community and the region with the broader global system. They contain a wide array of transportation systems and are major points of trans-shipment for both goods and people. Global gateways have an international orientation that contributes to a diverse economy that involves not only trade but important trade-related services—legal, financial, and insurance, for example. They are also marked by jurisdictional and regulatory complexity, reflecting the scale and sheer volume of activity that passes through them (Woudsma, Hall, and O'Brien, 2009).

Transport costs, organization of the supply chain, the transactional environment (including accelerated information flows), and the physical environment all have an impact on the amount of trade and goods flowing through a gateway region and are interdependent in a way that blurs the distinction between physical distribution and other aspects of the supply chain (Hesse and Rodrigue, 2004). This interdependence facilitates interregional trade with responsibility for the distribution function shared by manufacturers, wholesalers, and retailers, all in different locations. These partners depend upon a regionally and nationally (if not globally) designed network in order to secure cost reductions through economies of scale. The hub provides access to both consumer markets and, in Hesse's and Rodrigue's terminology, "the interfaces of trade."

2.3.1.3 Dynamic Nature of Supply Chains and Impacts on Regional Freight Flows

Hesse and Rodrigue (2004) call the multidimensional nature of integrated freight transport demand the logistical friction. It is one of the reasons why both mapping trade flows within regions and assessing their impacts is problematic.

Cidell (2010) argues that the changing geography of trade interfaces benefits suburbs/hinterlands as well as core counties. While ports and airports tend to be located near urban centers, in recent decades the warehousing and distribution

[25] The Panama Canal is being expanded to accommodate the largest vessels; it is scheduled to open in 2015.

activity that supports the gateway activity has become more decentralized. This is true in both North America (Cidell, 2010; Bowen, 2008; Husing, 2012) and Europe (Dablanc and Rakotonarivo, 2010). The ability to develop large warehouses with a large number of truck bays that are flexible enough to accommodate a wide range of products stacked to maximum height necessitates lower cost land outside of urban cores. Ideally, these facilities also have good access to highways and rail networks.

The decentralization of freight-related activity is likely to continue as long as lower suburban and exurban land costs can help reduce the total logistics cost. The total cost of logistics includes inventory, transportation, warehousing and materials handling, and facility networks (Bowersox, Closs, and Cooper, 2010). The freight rate is a function of a number of variables, including the location and cost of distribution services (Li, Hensher, and Rose, 2011).

As discussed in Section 1, this decentralization of activity (or logistics sprawl) poses significant problems for metropolitan regions. A portion of the goods that are sorted, transloaded, or cross-docked at inland or hinterland sites travels to the urbanized core for final delivery. Regional truck trips also involve different metropolitan regions. The economics of logistics management dictates that rail is only feasible for trips of more than 500 miles. For the United States, only around 5 percent of intermodal rail traffic covers distances of less than 750 miles (Rodrigue, Comtois, and Slack, 2009). As a result, large distribution centers in one region may serve markets in another. Distribution centers in northeast Atlanta, for example, commonly serve Florida's markets (Dablanc and Ross, 2012). These intercity trips impose significant costs including accidents, emissions, and noise as well as unrecovered costs associated with the provision, operation, and maintenance of facilities. Forkenbrock (1999) determined that these external social costs are more than 13 percent of private costs.

2.3.2 Trade Nodes: Balancing Local Economic Benefits and Costs

The large trade volumes that confer a special status upon trade nodes also carry heavy social costs that include vehicle operations, congestion, increased accidents, environmental costs (including air and noise pollution), and increased infrastructure development and maintenance costs (Berechman, 2007).

As has been discussed in previous sections, however, jurisdictional complexity and the structure of the goods movement industry pose a problem for the regulatory agencies that are charged with controlling the more negative impacts of trade. Governmental agencies at the regional and local level have a combination of policymaking and fiscal authority that can influence certain aspects of freight movement. This authority can include the ability of counties to generate revenue for transportation projects, including infrastructure development, through sales taxes. Municipal authorities maintain local zoning and land use controls that regulate truck access and parking and hours of operation for trade-related services like warehousing and distribution. Through the environmental review process, local governments, as well as other stakeholders, have the option of using the courts to influence trade-related operations.

At the regional level, however, there may be conflicts between different local governments that hinder the development of region-wide solutions to trade-related problems. The sheer number of stakeholders adds another layer of complexity. This does not negate the need for solutions, and, in the absence of mitigation plans that cover the gateway region as a whole, a combination of efforts by government and industry has filled the gap. The remainder of this section reviews those efforts.

2.3.2.1 Gateway Strategies: Ports and Airports

Congestion at trade hubs, including ports and airports, means congestion for the road and rail networks that carry goods to transfer points and to the store shelf. Truck activity at ports is concentrated at peak period hours when roads are also congested with passenger vehicles. Attempts to eliminate bottlenecks at marine terminals have included both the use of appointment windows and road pricing strategies. There have also been efforts to mitigate the environmental impacts of truck and rail traffic at trade hubs by overhauling the fleet of vehicles granted access to port facilities. Many of these efforts have started in California, the location of North America's two largest container ports (in Los Angeles and Long Beach) and LAX, the fifth largest air cargo airport in the United States (Airports Council International, 2011).

Appointments and Pricing Strategies at Ports. In Southern California, recent attempts to increase operating time (and thus minimize truck queuing and delays) at the Ports of Los Angeles and Long Beach came about in response to the threat of legislative action. California Assembly Bill (AB) 2650 (the Lowenthal Bill) was passed in August of 2002 by a 75-2 vote and signed by Governor Gray Davis. The bill encouraged off-peak operations. It imposed a penalty of $250 on terminal operators for each truck delayed more than 30 minutes waiting to enter a terminal gate at the ports of Los Angeles, Long Beach, and Oakland. Terminals that operated gates 70 hours per week or offered trucks an appointment system to pick-up or deliver cargo were exempt. Both options were, however, voluntary; consequently, the means of implementation differed greatly. According to Giuliano and O'Brien (2008a) the legislation had limited impact. No terminal at either port extended its hours of operation because of AB 2650. Appointments to enter the terminal gate are not appointments for cargo loading and unloading on the docks, and no terminal used appointment information to set aside containers for a trucker in advance. Once inside the terminal, all drivers must wait for a container to be removed from the stacks before being loaded onto a chassis. As such, where appointment systems have been implemented, there is as of yet no record of improved terminal operating efficiency.

An extended hours of operation program known as PierPASS began at the Ports of Los Angeles and Long Beach in July 2005. Terminal operators at both ports jointly developed the program in response to the threat of legislation introduced by Assembly member Alan Lowenthal in 2004 to mandate off-peak hours at the Ports of Los Angeles and Long Beach. Lowenthal agreed to withdraw the legislation in response to the terminal operators' proposal (Giuliano and O'Brien, 2008b).

PierPASS assesses a Traffic Mitigation Fee (TMF) on certain containers moved in and out of the San Pedro Bay ports between 8 a.m. and 5 p.m. The program is run by the terminal operators, and the fees are intended to defray the costs of extended operations at the ports. Under PierPASS, terminals initially agreed to offer complete off-peak services; that is, duplicating the daytime truck handling capacity of the terminals at night and during weekends. However, the reduction in cargo volumes brought about by the global recession has resulted in a reduction in the number of off-peak gates offered by marine terminals.

In March 2009, terminals eliminated either one night or one weekend gate. To date, the PierPASS program has shifted almost 30 percent of truck traffic to evenings and weekends, an increase from 10 percent in 2005 to almost 40 percent of the total port truck traffic in 2007 according to figures reported at the PierPASS website (pierpass.org). PierPASS has been successful in reducing the number of truck trips made during peak hours and in relieving rush hour cargo congestion along urban commercial corridors. It has shifted freight traffic to off-peak hours, but has not reduced the aggregate number of truck trips. As a result, the program has not entirely eliminated the environmental and social impacts associated with these truck trips (Le-Griffin and Moore, 2007; Giuliano and O'Brien, 2008b).

Steimetz et al. (2007) used PierPASS as a model for investigating the feasibility of a uniform congestion fee levied on all truck trips made during peak gate hours at the Ports of Los Angeles and Long Beach. The authors argued that because gate delays are only a small part of peak period congestion costs and because all truck trips generate externalities, a fee of $18.25 assessed on each TEU (as opposed to the $50 PierPASS fee charged for a select number of transactions at the ports) over a wider class of trucks, loaded or empty, and balanced across peak and off-peak would be optimal.

There are few other examples of extended gate operations in the United States. Marine terminals do not typically accommodate cargo pick-up and delivery outside of weekday hours because of longshore labor costs (Giuliano and O'Brien, 2008b). Section 2 of the Pacific Coast longshore labor contract provides for differential shift pay, overtime pay, minimum hour guarantees, and minimum size of labor work units (Pacific Maritime Association, 2009). The International Longshoremen's Association contract, which covers ports on the East and Gulf Coasts of the United States, has similar provisions (International Longshoremen's Association, 2004). Terminal operators seek to maximize longshore labor productivity and, therefore, restrict cargo pick-up/delivery activities to a single day shift. Evening and weekend operating hours are typically limited to a special arrangement with an ocean carrier or preferred customers moving large numbers of containers.

Another reason for the absence of extended gate hours is resistance from truck drivers and customers, as discussed in Section 1. For drayage truck drivers, off-peak work means either an extended work day or a shift in schedule to a less family-friendly night shift. For owner-operators, neither comes with a guaranteed pay increase. Warehouses, distribution centers, manufacturers, and other entities must also be available to process cargo during off-peak hours. This may involve additional labor shifts. In some areas, local zoning prohibits night or weekend deliveries.

Research on off-peak operations at ports from other parts of the world is limited. Davies (2009) included the Port of Long Beach as part of a study of appointment (reservation) systems that also included Sydney, Australia; Vancouver, British Columbia; and Southampton in the United Kingdom. Davies found that appointments had no influence on turn times—which is what is needed to incentivize drivers to participate—and that appointments and peak period pricing appear to be competing solutions. In addition, Lam (2007) has argued that accurate measurements of truck queuing and flow times both outside and inside terminal gates are needed to assess the impacts of appointment systems and peak period strategies.

Shibasaki and Watanabe (2010) conducted a cross-sectional traffic volume survey of semi-trailers with international maritime containers at the port districts and hinterland areas in Japan and South Korea. They estimated the ratio of expressway use of semi-trailers, investigated the breakdown according to container sizes and transport patterns, and considered daily traffic flow patterns on the basis of time period distributions according to distance from city centers and according to district. Due to various contributing factors, the container terminal gate open time at most ports in Japan, including the five major ports, is between 8:30 a.m. and 6:30 p.m. (with a 1-hour lunch break). The authors argue, based on survey responses, that there is a lack of demand for evening gates because the basic flow patterns for the transport of cargo in Japan include one round trip per day. Drivers responded that if they were going to drive overnight, they would prefer to load the cargo in the late afternoon so that they could drive all night to make an early morning delivery.

The gate at the Port of Busan in Korea is open 24 hours. There is heavy utilization at night (6:00 p.m. to midnight) despite the fact that the port imposes a 50-percent surcharge to pick up cargo between 6:00 p.m. and 7:00 a.m. Evening pick-ups allow drivers more flexibility, particularly for the half-day trip between Busan and Seoul. Shibasaki and Watanabe (2010) argue that in Japan, where container terminal gates are located in the urban core, better use of evening and weekend gates could help reduce congestion.

Appointments have also been the subject of simulation studies. Jula, Dessouky, and Ioannou (2006) developed a terminal simulator, referred to as TermSim, to study the potential effects of a time window appointment system on various terminal operations. Based on data collected on truck arrivals, several simulation scenarios were created that compared current practices to use of an appointment system. The simulations indicated that when an appointment system is used, the queues at the inbound and outbound gates become smaller, and the import and export yards are serviced more efficiently.

Road Pricing and Related Strategies to Manage Hub-Generated Truck Traffic. Palmer and Piecyk (2010) examined the opportunities that companies have to mitigate the adverse effects of congestion on their road freight transport operations by rescheduling more of their traffic to off-peak times. Based on 56 sample journeys in the United Kingdom, Palmer and Piecyk demonstrated that significant time, cost, and CO_2 savings can be achieved by increasing the percentage of vehicles operating at off-peak times. For journeys up to 100 kilometers, early morning (around 5:00 a.m.) start times are best. For journeys between 100 and 200 kilometers, the best start times are either early in the morning or around midnight, and, for distances over 200 kilometers, night-time operation is most time-effective. Morning and evening peak times are the worst start times for trips up to 250 kilometers and late afternoon start times are the worst for journeys that involve a greater distance. Since the average distance traveled by trucks in the United Kingdom is currently 87 kilometers, Palmer and Piecyk argue that their research suggests that companies would experience minimum transit times and increased reliability of deliveries by scheduling more road freight traffic for early morning hours.

There is also little research on congestion pricing in trade hubs. As seen in more detail in Section 1, a study on the potential for off-peak freight deliveries in the Manhattan and Brooklyn areas considered how operational changes would impact costs for shippers and receivers (Holguín-Veras et al., 2005; Holguín-Veras, 2010).

Quak and van Duin (2010) examined, based on in-depth interviews with carriers, the expected effect of a proposed Dutch road pricing scheme (abandoned following the 2011 general elections) on logistics decisions to supply stores in urban areas. The goal of the program was to have road users pay for using the road infrastructure instead of paying a fee for owning a car. The price per kilometer would have varied by the time of the day and location. The government would charge more for crowded locations and peak hours. The authors derived the expected impact of the scheme for urban goods transport. The expected reactions differed for for-hire carriers, shippers, and private carriers. In the short term, carriers were expected to try to limit logistics charges by passing on extra costs.

Roorda et al. (2007) investigated the potential for highway lanes specifically designed for trucks in Canada. The research was intended in part to develop a microscopic traffic simulation model of alternative truckway configurations for conducting detailed operational analysis and measuring congestion and other identified performance indicators. The work did not focus on road pricing strategies, but underscored the limited number of truck-only lanes in operation in North America. The authors identified case studies in Boston (the 1.5-mile South Boston Haul Road for commercial vehicles), the I-5 truck bypass lanes in Los Angeles, and the Clarence Henry Truckway providing truck-only access to Mississippi River terminals in New Orleans. They also included the New Jersey Turnpike, which provides an automobile-only inner road and a general-purpose outer road. The research identified a greater number of cases of proposed truck-only lanes under study, but not actually implemented. These include the I-710 and SR-60 projects in Southern California, I-81 in Virginia, the TransTexas Corridor, the I-4 Crosstown in Tampa, and proposed truck lanes in metropolitan Atlanta and Dallas.

Outside of pricing mechanisms, much of the literature on improving mobility is focused on strategies to optimize trucking operations. These include strategies using simulation to attempt to minimize departure times for outgoing trucks in a cross-dock operation (Wang, Regan, and Tsai, 2007). The strategies also include the use of statistical models (Liu and Kaiser, 2006) to forecast the truck VMT growth of four facility categories at the county and state levels. These models incorporate both socioeconomic and transportation system supply variables. The model results show that local socioeconomic variables alone explain a considerable amount of truck VMT variance, particularly for urban Interstate and non-Interstate facilities. A number of simulation studies have shown that tolls can be used to optimize the truck arrival pattern at terminals (Zhou, List, and Li, 2007; Chen, Zhou, and List, 2011).

Ruan, Lin, and Kawamura (2009) used data from the Texas commercial vehicle survey to study the efficiency of commercial vehicle daily tours in different chain patterns. They identified a loop-like pattern for vehicles running one round trip and a star-like pattern for vehicles making multiple round trips as part of a daily tour.

Other studies on vehicle routing optimization include one by Xu, Yan, and Li (2011) that focuses on minimizing travel cost and maximizing customer satisfaction; another by Quattrone and Vitetta (2011), who tested a route choice model for freight transport on a test road network in Italy; and another by Escudero et al. (2010), who developed a dynamic optimization model that uses real-time knowledge of a fleet's position, enabling the route planner to reallocate tasks as conditions change. Using Osaka, Japan, as a test bed, Nakamura et al. (2010) found that the performance of vehicle routing and scheduling in delivery simulations is influenced by characteristics of travel time information. Nemoto, Hayashi, and Hashimoto (2010), in a case study on Japanese automobile manufacturers in Thailand, demonstrated that by introducing milk-run logistics—even under heavily congested traffic conditions—manufacturers can have full control of the procurement process, resulting in a reduction of the number of trucks dispatched and improvements in traffic conditions to some extent in urban areas. Milk runs are an example of a delivery method accommodating mixed loads from different suppliers. Instead of each of several suppliers sending a vehicle every week to meet the demands of a customer, one vehicle visits each supplier on a daily basis and picks up deliveries for that customer. Similar research has also been conducted by Qureshi, Taniguchi, and Yamada (2010) and Sungur, Ordonez, and Dessouky (2008).

The Clean Air Action Plan and Other Clean Truck Programs. In the fall of 2006, the Ports of Los Angeles and Long Beach jointly adopted the Clean Air Action Plan (CAAP). The CAAP was an attempt by the ports to get ahead of state-mandated environmental mitigation. The CAAP consolidated many of the existing measures that the two ports had previously adopted individually, including vessel speed reduction programs. The Clean Trucks Program (CTP), a component of the CAAP, progressively bans older vehicles with engines that have not been appropriately retrofitted from accessing the port complex. As part of this program, grants and financial incentives were created to encourage trucking companies to accelerate the replacement of older, high-polluting vehicles with newer, cleaner trucks. Subsidies also encourage the use of alternative fuels. The CTP is modeled on a much smaller 2002 truck replacement program that was jointly sponsored by the ports and the Gateway Cities Council of Governments, a coalition of 27 cities in the vicinity of the ports.

The CTP banned all pre-2007 model trucks as of January 1, 2012. The ports expected that the CTP would reduce air pollution from harbor trucks by nearly 80 percent as of January 1, 2010 (Wilson and White, 2007). More than 9,000 compliant trucks entered port service between the fall of 2008 and the summer of 2011. These trucks reduced emissions by more than 80 percent in 3 years, 2 years ahead of schedule (Mongelluzzo, 2011a). Approximately one-third of these vehicles were financed in part through the support of the ports or the CARB (Mongelluzzo, 2011b).

The CAAP includes a Technology Advancement Program that initially identified $15 million over a 5-year period to be spent on accelerating the verification and commercial availability of new, clean technologies in four main areas: control measurements, green container transport, emissions inventories, and emerging technology demonstrations. Recent technology investments have supported the conversion of rubber tire gantry cranes to run on electricity at a container terminal and the development and testing of the world's first hybrid tugboat (Cocker III et al., 2011). In the summer of 2009, the ports jointly released a Request for Qualifications to develop and demonstrate a zero-emissions container mover system. This is being done in conjunction with the Alameda Corridor Transportation Authority, the joint powers authority that runs the 20-mile grade-separated rail link between the ports and rail yards around downtown Los Angeles.

There are a number of other U.S. ports in various stages of implementing a clean trucks plan. In the spring of 2010, the Port Authority of New York and New Jersey announced a clean trucks program that borrows somewhat from the plans adopted by the San Pedro Bay ports. The centerpiece is a truck replacement program, with pre-1994 trucks banned as part of the first phase of a multiyear program. The Ports of New York and New Jersey also require registration and use of 1994 model year or newer trucks, with all pre-2007 trucks to be phased out by 2017 (compared to 2012 in Los Angeles and Long Beach).

No other East Coast port has undertaken a similar approach although there are examples from the West Coast. The Seattle truck program requires registration and use of 1994 model year trucks or newer. However, neither Seattle nor New York has a clean truck fee like the one in Southern California. Los Angeles and Long Beach are in a better position to impose fees without diverting cargo to other ports because of the large local market of consumers. Trade through a discretionary port like Seattle is much more sensitive to changes in port-related fees.

Vancouver has a truck program similar to the CAAP's but with more stringent driver employment restrictions as a result of a previous strike settlement (Woudsma, Hall, and O'Brien, 2009). The Vancouver Truck Licensing System (TLS) has its origins in disputes involving owner-operator port truckers in 1999 and 2005. While compensation was a central focus of those disputes, supporters argued that a wider regulatory apparatus would help to stabilize the industry. As part of the resolution of those disputes, port authorities were required to establish a TLS and dispute resolution program.

The TLS has provided a mechanism whereby the port is able to impose stricter emission requirements on trucks that enter port land. Currently, the TLS requires that 1993 model year trucks and older be prohibited from entering the port, and trucks that are 10 years or older must pass an opacity test. By 2017, only 2010 model year trucks or newer will be allowed on port land.

Vancouver has also developed other environmental programs that target truck and rail operations, particularly those tied to the port. These include enviroTruck, an incentive-based program designed to reduce truck emissions. Qualifying tractor-trailers must meet or exceed 2007 model year emissions standards, travel at reduced speeds, and be fitted with a series of emissions-reducing, add-on devices. Operators may choose from a list of approved add-on devices, with incentives linked to estimated emissions reductions. The program is run by Green Fleets BC, a partnership-based program led by the Fraser Basin Council and funded by the British Columbia Ministry of Environment as part of its Air Protection program. enviroTruck itself is a partnership between Green Fleets and the BC Trucking Association.

The Vancouver efforts are part of the Northwest Ports Clean Air Strategy of 2007, which aims to reduce maritime, port-related emissions that affect air quality and climate change in the Pacific Northwest. The strategy is an international joint effort among the ports of Vancouver, Seattle, and Tacoma; Environment Canada; the EPA; and the Puget Sound Clean Air Agency. The Vancouver Chamber of Shipping was a partner designing elements of the strategy, including a Harbour Dues Program that provides incentives for ships to reduce their in-port emissions.

Equipment Management Problems and Strategies. Because of the U.S. trade imbalance with Asia, around half of all containers imported to the United States are returned to Asia empty. This requires the repositioning of empty containers from import drop-off areas (distribution centers, warehouses, railyards, etc.) back to marine terminals and container depots once the imported goods have been unloaded. This occurs on surface roads, which can exacerbate already serious congestion and pollution problems.

Inefficient use of the container can also mean inefficient use of the chassis on which the container rests. In the U.S. context, where ocean carriers own both the container and the chassis, these problems are exacerbated by equipment management practices that require truckers to make additional trips between distribution centers and ports to reposition the carrier-owned equipment (Le-Griffin and Murphy, 2006). Carrier-owned chassis are a legacy of containerization. By controlling the chassis, ocean carriers had access to other portions of the U.S. domestic market. As containerization spread into Europe and Asia however, trucking companies or shippers provided the container chassis (Prince, 2006). Thus the practice of shipping lines owning the chassis is unique to the United States (Le, 2003).

Once containers are drayed to intermodal facilities, most bare chassis need to be brought back (i.e., repositioned) to the marine terminal, mostly due to a lack of demand for reuse by local exporters (Le, 2003). In addition, dozens of acres of land at terminals and rail yards are currently used to store thousands of bare chassis needed for the operations of different steamship lines within a terminal. If a truck arrives at a terminal with a loaded export container carried on a chassis that does not belong to that terminal and intends to pick-up an import container at the same terminal, then the driver will be required to return the chassis to its owner first.

Operational changes that are designed to address these problems include the use of "virtual" container yards or VCYs (Chang et al., 2006; Davies, 2006). VCYs allow truckers to locate an empty container close to the site where they have an import drop-off, thereby eliminating a non-revenue trip to a terminal where empties are typically stored. The equipment ownership structure outlined above has proved an impediment to virtual container yards (Theofanis and Boile, 2007).

Chassis pools are another strategy for better equipment management. A chassis pool is simply a group of chassis that two or more shipping lines agree to share when moving their containers. The operation of chassis pools can be set up in different ways. One common method is to have different carriers contribute their own chassis to the pool on slow days for "pool credit" and then use this credit to pay for the times when they need to borrow extra chassis from the pool on busy days (Brennan, 1997). If carriers do not want to contribute any of their chassis to the fleet, they also have the option of simply paying a fee for using a chassis from the pool (Brennan, 1997). Another option is to use all "neutral chassis" in which a leasing company—considered the "neutral" third party—provides all of the chassis in the chassis pool.

O'Brien and Le-Griffin (2011) find that current chassis management practices at Southern California ports, which do not provide for a cooperative chassis pool, have a negative impact on overall container terminal performance in terms of effective capacity, system operation times, and air emissions. Their research indicates that effective and sensible mitigation policies should focus on emissions generated by container handling equipment inside the terminal gate in addition to the emissions created by trucks outside the terminal gates. Failing to do so works to diminish the effectiveness of policies designed to make overall port operations more "green" and efficient. Accordingly, measuring and improving performance both within a terminal and beyond the terminal gate should be included in efforts to measure the effectiveness of mitigation policies.

2.3.2.2 Rail Strategies

Freight rail impacts metropolitan areas in a number of ways. Rail cargo leaving trade gateways is destined for places outside the region. On its way, it intersects with routes traveled by passenger vehicles and may delay passenger rail traffic by using its right-of-way. There are environmental concerns related to diesel emissions and noise- and safety-related concerns at grade crossings.

While decision-makers have focused their efforts on truck or ocean-going vessel emissions, 2012 will see the introduction of cleaner Tier 3 locomotives as railroads introduce them into their fleets in response to federal or state regulations. In California, Burlington Northern Santa Fe (BNSF) and Union Pacific (UP) signed a memorandum of understanding with the CARB to phase in new locomotives on an expedited schedule. Lawsuits could bring about more aggressive changes at rail yards. In the fall of 2011, the Natural Resources Defense Council (NRDC) sued the two Class I railroads in order to force them to implement new technologies like electric gantry cranes, alternative fuel yard equipment, and pollution reduction measures for switcher engines at 12 existing rail facilities. BNSF and UP are already planning to implement the new technologies at two intermodal facilities being planned in Southern California.

The literature on strategies to improve interregional rail traffic is largely drawn from the engineering disciplines and focuses on optimization of rail scheduling. Mu and Dessouky (2011) address the limited capacity of freight rail through an optimization approach for scheduling trains assuming track segments. There is also a developing literature on dynamic scheduling and routing that is a response to the need to optimize complex systems not only within fleets but across fleets as well. Mu and Dessouky (2011) developed algorithms for static and dynamic scheduling of freight trains for small and large networks. This dynamic algorithm is able to reduce delay by at least 40 percent compared to existing algorithms on representative rail scenarios. Dessouky et al. (2010) developed a model designed to accept, defer, or reject shipments on a railroad, with decisions based on an accurate representation of the delays the shipments cause and the possibility of real-time rerouting of trains to alternative tracks.

While there appears to be tremendous interest in shifting truck traffic to rail as a means of mitigating the impacts of freight operations, there are few examples of this occurring and, as a result, not much in the literature that addresses the topic. As previously stated, shifting freight from truck to rail is difficult because rail is competitive only for long-distance trips (500 miles or more).

Agarwal, Giuliano, and Redfearn (2004) assessed the Alameda Corridor, a 20-mile-long rail cargo expressway linking the Ports of Long Beach and Los Angeles to the transcontinental rail lines near downtown Los Angeles. The Alameda Corridor is a series of bridges, underpasses, overpasses, and street improvements that separate freight trains from street traffic and passenger trains. The project's centerpiece is the Mid-Corridor Trench which carries freight trains in an open trench that is 10 miles long, 33 feet deep and 50 feet wide. The purpose of the Alameda Corridor was to consolidate train traffic and eliminate grade crossings, not to shift truck traffic to rail.

You et al. (2010) used microscopic simulation to capture emissions resulting from stop-and-go traffic on the freeways leading into and out of the Ports of Los Angeles and Long Beach. They determined that emissions of both NO_x and $PM_{2.5}$ can be significantly reduced by switching container moves from truck to train, despite the increased train emissions along the Alameda Corridor. From a policy perspective, the authors argued that a modal shift should be encouraged, particularly if there is unused train capacity, but they recognized that a shift might conflict with shippers' interests.

Maes and Vanelslander (2009) assessed a program designed to test the feasibility of incorporating the regional rail (RER) system in metropolitan Paris into local freight deliveries. Lu et al. (2007) investigated the possible use of BART subway cars in the San Francisco Bay Area to deliver FedEx freight packages. The proposed system would use modified cars and flatcars. Costs and institutional issues keep these programs largely conceptual.

Other strategies include the diversion of truck freight to rail or barge, also known as short sea shipping or marine highways. Research indicates that while these kinds of freight diversion programs are feasible, they are not competitive with trucking because of the high cost of cargo handling at ports. Sustained short sea shipping efforts would depend upon more and better cooperation among ports, increased congestion at gateway ports to drive traffic elsewhere, and regulations that encourage use of barges (Le-Griffin and Moore, 2006, 2007; Banister and Berechman, 1999). Researchers warn, however, that from an environmental perspective, the use of vessels on rivers and along coasts may only shift emissions from trucks to ships and not reduce them.

2.3.2.3 Border Crossings

Border crossing regions are a unique subset of trade nodes. Like port regions, border crossings generate truck traffic destined for local distribution or transfer facilities as well as markets beyond the immediate metropolitan area. This means "last-mile" impacts as well as the pass-through impacts previously discussed. Border crossings provide a unique challenge with regard to managing regional freight capacity, however, because of the international context. Both assessing and mitigating the negative impact of freight flows can be problematic and data collection can be difficult. The literature on cross-border freight management is decidedly underdeveloped [the Washington State Fast Action Strategy (FAST) for the Everett–Seattle–Tacoma Corridor is an exception and the subject of a case study in Section 2.3.3]. The focus instead is on delays at the border crossing itself and the use of technology to eliminate border crossing bottlenecks.

The U.S.–Canadian border has provided a useful test bed for researchers investigating both the institutional and technological framework for freight flows across borders. The literature includes attempts to profile freight flows. Goodchild, Albrecht, and Leung (2009a) used five data sources, including a probe vehicle border crossing time data set, a border operations survey data set, and loop detector volume counts to describe commercial vehicle delay, transportation patterns, and commodity flows across the British Columbia–Washington State border. The same authors (2010, 2009b) used commercial vehicle crossing time data from the British Columbia Ministry of Transportation as well as GPS technology to investigate the relationship between border crossing time and arrival volume. Their findings indicate that border delays can be attributed to a number of factors in addition to delay at the inspection booth. These factors include a lack of driver preparedness and the need for trusted traveler programs.

The same British Columbia–Washington State crossing has been used to study the economic impacts of trade across the U.S.–Canadian border. Goodchild, Globerman, and Albrecht (2009) conducted interviews with regional carriers as part of an investigation of service time variability at the border and its impacts on regional supply chains. They determined that increased buffer times reduce carrier productivity, but with negligible impacts because of the current nature of the market. Taylor (2010) researched increased border-related costs (like those tied to security) since 2001 and reports that declines in both truck and passenger vehicle traffic exceed what would be expected from broader economic changes such as changes in GDP and industrial production. Miller (2011a) supports the notion that fleets seek more uniformity of inspections in shipments crossing the U.S.–Canadian border.

There appears to be less research on other U.S.–Canadian border crossings, including Detroit–Windsor even though Detroit is the largest land freight gateway (measured in value) in the United States. One reason may be the smaller percentage—relative to Washington State—of freight-related employment in the region. Belzer and Howlett (2009), in examining the potential for increased goods handling in Michigan, show that location quotients for freight-related industries and occupations in greater Detroit are less than the national average. They conclude that freight volumes in Michigan have not translated into a concentrated goods movement industry.

U.S.–Mexican border crossings, in many ways, operate in a more complex and uncertain environment. The North American Free Trade Agreement (NAFTA) and other institutional and regulatory reforms have been designed to improve cross-border freight flows for the United States, Canada, and Mexico. A recent agreement between Washington and Ottawa has further harmonized regulations and will allow customs clearance in Canada at locations other than crossing stations as a way to relieve congestion (Edmonson, 2011).

The U.S.–Mexican border is not as open as the U.S.–Canadian border. The United States has limited the number of Mexican trucks that can access this country (apart from a narrow border region) through a cross-border trucking pilot program. As a result, the Mexican government has implemented retaliatory tariffs on U.S. goods (Miller, 2011b).

The lack of a truly open border, therefore, results in further delays at crossings as goods are unloaded and reloaded onto different vehicles on opposite sides of the gate. This has created a demand for technology-based solutions. Rajbhandari and Villa (2010) conducted interviews with stakeholders from the freight and government sectors in the El Paso–Ciudad Juarez region and found an urgent need for ITS deployment at the border to measure, relay, and archive crossing times for both commercial and passenger vehicles. State and federal agencies have in fact begun to implement a series of ITS deployment projects that measure border delay and crossing times (Villa and Solari-Terra, 2008) including radio frequency identification (RFID; Rajbhandari and Villa, 2011) at Mexican border crossings.

As major gateways, and therefore potential bottlenecks, border crossings are also potential locations for congestion pricing strategies. The El Paso region is the subject of a research case study on the potential implementation of pricing based on freight value, but researchers (Baker, Ungemah, and Boyd, 2008) have acknowledged the obstacles to such a strategy in the form of limited infrastructure, rigid staffing practices, antiquated technology, competing information technology systems, and lack of coordinated planning between U.S. and Mexican officials.

A study in the U.S.–Canadian context (Springer, 2010) looked at the potential costs and benefits of a congestion pricing strategy on the southbound Pacific Highway crossing. The focus of the study was on excess capacity on Washington

State's FAST lane corridors, opening them up to trucks that do not initially qualify for FAST access. The study determined that the approach has the potential to reduce overall waiting times at the border.

2.3.3 Case Studies

Reducing the impact of freight in metropolitan areas often requires substantial infrastructure investment. Impacts in gateway cities are particularly significant. In Sections 2.3.3.1 through 2.3.3.4, four cases of infrastructure projects intended to reduce congestion and pollution impacts are presented. In Section 2.3.3.1, the Chicago Region Environmental and Transportation Efficiency program (CREATE) is discussed. This program seeks to reduce the time trucks and trains spend in traffic. Section 2.3.3.2 discusses proposed truck lanes in Atlanta. Section 2.3.3.3 reviews the under-construction tunnel connecting the Port of Miami to I-395 and I-95. Finally, in Section 2.3.3.4, the FAST Corridor program in Seattle is considered. Each of these brief case studies explains the urban freight problem, the way the city or region tackled the problem, and any evaluation or future prospects for the project or program.

2.3.3.1 Chicago—CREATE

Problem. More than one-quarter of all domestic rail freight by weight originates, terminates, or passes through Chicago, Illinois. Congestion is estimated to cost the region $11 billion per year in travel delays, air pollution, safety impacts, and interference with passenger trains. Freight transport is a significant contributor to the delays and bottlenecks that characterize the region and is estimated to cause approximately 17 percent of all commuter delays (DiJohn and Tenebrini, 2010, pp. 1–2). Trucks move $572 billion in goods each year through Chicago, a figure that is projected to nearly double over the next 25 years, accounting for two-thirds of the overall increase in traffic in the region. By contrast, trains move $350 billion over the same time period (Chicago Metropolis 2020, 2004, p. 8).

Suburban truck traffic is of particular concern in Chicago because of an inefficient and uncoordinated network of suburban truck routes, with gaps as large as 12 miles between the routes. Trucks traveling on the Illinois Tollway, for example, are often forced to travel miles out of their way on surface streets due to mismatches between designated routes and interchanges (Chicago Metropolis 2020, 2004, p. 11).

Solution. The State of Illinois, City of Chicago, all six Class I North American railroads serving Chicago, Amtrak, Metra Commuter Rail, and the U.S. DOT formed a public–private partnership to create, fund, and execute a freight traffic improvement program with the goal of eliminating bottlenecks and reducing travel delays by investing in transportation infrastructure. Specifically, the partnership plans to improve rail/highway at-grade crossings, viaducts, and transportation infrastructure throughout the region. The partnership issued its formal plan of action, titled the Chicago Region Environmental and Transportation Efficiency program, or CREATE, in 2003 (DiJohn and Tenebrini, 2010, p. 5).

Projects are to be funded by both the public and private sectors. The legislature of the State of Illinois approved an investment of $332 million (Conkey and Roth, 2009, p. A8), private rail contributed a total of $100 million, and the U.S. DOT committed $233 million in funding (FRA, 2012, p. 1). The original plan detailed 78 projects to be completed, including 35 rail projects and 25 grade-separation projects (FRA, 2012). The partnership subsequently divided these projects into three phases. Phase I was to run from 2007 to 2009, with 32 projects identified for completion. At year-end 2010, 11 were complete, 14 were in progress, and 17 were in the environmental impact report stage (Stagl, 2010, p. 1). The 11 completed projects include improved rail connections, installation of computerized signal systems and automated interlocking, and remote tower control (DiJohn and Tenebrini, 2010, p. 7).

Evaluation. The project, so far, does not appear to have made a significant impact on regional congestion. Although 25 (one-third) of the proposed projects were grade-separation projects, only 1 of the 11 completed projects was in this group, and none have addressed the gaps in truck routes. The remaining 10 completed projects were rail corridor improvements, designed to increase average train speed and enhance safety, rather than directly affect truck congestion (CREATE, 2012).

The program has sound intentions, but progress has continued to be delayed by funding setbacks. Phase I projects are expected to continue through construction. Phase II has yet to be finalized, and future funding for CREATE is uncertain (Stagl, 2010, p. 1).

2.3.3.2 Atlanta—Statewide Truck Lanes

Problem. Atlanta ranks twelfth in the nation in overall congestion and fourth in overall freight activity (INRIX, 2012). From 2005 to 2035, freight tonnage transported to Georgia is projected to increase at a rate of 3 percent per year to a total of 1.7 billion tons per year (Cambridge Systematics, 2006, p. 2). Trucks are a particular concern because they carry approximately 93 percent of the freight traveling through Atlanta (Parsons Brinckerhoff, 2005, p. vi), 86 percent of all freight transported in Georgia, and 97 percent of intrastate freight (HNTB, 2008, p. ES-2). Trucks also account for over 12 percent of VMT on Georgia state highways. Three-quarters of freight tonnage travels less than 500 miles from the state borders, making rail travel inefficient for most of the state's freight movement demands (Cambridge Systematics, 2006, p. 2). Truck traffic is not only increasing, but at a rate 50 percent faster than general traffic (GDOT, 2012). Despite the fact that 60 percent of metro Atlanta truck travel occurs outside of peak-travel periods, trucks have a significant negative impact on Georgia's roadways, much more than that of passenger automobiles. Each truck traveling in Georgia is estimated to cause the operational impact of 2.5 cars and the wear of 10,000 cars (HNTB, 2008, p. ES-3).

Solution. Georgia's State Road and Transportation Authority commissioned a study of the potential for implementation of truck-only toll roads (TOTs) in Atlanta and received the results in 2005 (Parsons Brinckerhoff, 2005). The study concluded that TOTs provided significant benefits to both the trucking industry and the general public in terms of improved mobility (Meyer, 2006, p. 5). In 2006, Bechtel and a team consisting of Goldman Sachs, McGuire Woods, and PBSJ submitted public–private partnership proposals to the Georgia Department of Transportation to develop 15-mile truck-only toll lanes (TOTLs) along several Atlanta highways and freeways (eTrucker, 2007, p. 1; TollroadsNews, 2006, p. 1).

At the same time, the Georgia Department of Transportation commissioned a study to investigate the feasibility of TOTLs statewide and published the final results in 2008 (HNTB, 2008). The study concluded that 60 percent of the truck market would choose the TOTLs, freeing up some capacity. However, much of this capacity would be consumed by motorists changing routes and availing themselves of the newly created space. Assuming the TOTLs were built and despite this modal shift, volumes in the general-purpose lanes were expected to decrease 5 percent overall. Although the proposed TOTLs would mainly benefit the trucking community, the study concluded that transportation user benefits would exceed project costs overall by a factor of two or more (HNTB, 2008, p. ES-7).

Despite awarding initial contracts, as a result of economic conditions and government budget limitations, the proposed TOTLs were cut from the Atlanta Regional Commission's long-range plans in late 2011.

2.3.3.3 Miami—The Tunnel of Miami

Problem. The Port of Miami is recognized as both the cruise capital of the world and cargo gateway of the Americas, and both functions contribute to congestion in and around Miami. The port handled over 7 million tons or almost 150,000 TEUs of cargo in Fiscal Year 2009/2010, amounts that are projected to increase by more than 50 percent over the next 5 years. The Port of Miami ranks first in trade value of Florida's 13 ports, with a 2010 total of $21 billion, relatively evenly distributed between imports and exports. The Port of Miami also ranks first in the state in seaport container movements, with almost 850,000 movements in Fiscal Year 2009/2010. This number is projected to increase to 1.3 million in the next 5 years (FSTAEDC, 2011, pp. 24–30).

An estimated 16,000 vehicles travel to and from the port through downtown Miami streets, and trucks account for 28 percent of this traffic. Downtown congestion restricts port growth, increases port user costs, and causes safety concerns (POMT, 2011). There are plans to rebuild a connecting rail line (Chardy, 2011, p. 1), but with only 11 percent of the cargo leaving South Florida, most port-related freight is not a candidate for rail transport. Even with completion of this rail line, 95 percent of port-generated, overall roadway traffic and 98 percent of port-generated downtown traffic will remain (Fagenson, 2011, p. 1; Tompkins, 2007, p. 1).

Solution. The Florida Metropolitan Planning Organization established a task force in 1981 to find a solution to port-generated roadway traffic. After consideration of several alternatives, in 1984, its proposed Port of Miami Transportation Improvement Plan was approved by both the city and county. The Plan centers on construction of a four-lane, toll-free, underwater tunnel connecting the port to adjacent freeways 395 and 95, bypassing downtown Miami surface streets. Over the next two decades, the port, the city, the county, the state and FHWA, as well as industry and citizen groups, considered specific specifications for the design, financing, and operation of the tunnel. In late 2005, the Florida Department of Transportation (FDOT) hosted an industry forum to present public–private partnership opportunities for the tunnel and issued a Request for Qualifications in early 2006 for proposers to design, build, finance, operate and maintain (DBFOM) the tunnel project. A private firm was selected for this purpose in mid-2007. Construction began in May of 2010, and the tunnel is expected to open to the public in 2014 at an estimated capital cost of $607 million. Half of the capital costs and all of the operation and maintenance costs will be paid for by the state of Florida. The remaining capital costs will be covered by the city and county (POMT, 2011).

Evaluation. The public–private partnership transferred DBFOM responsibility to the private sector, allowing the public agencies to direct their efforts toward generating the necessary start-up and ongoing capital for the project. Eighty percent of passenger car traffic and all but hazardous-freight-carrying truck traffic is projected to use the tunnel to access the port. The project is on schedule for completion as planned, and the tunnel will be returned to the FDOT at the end of the DBFOM contract in late 2014.

Not only is the tunnel projected to successfully alleviate most of the local impacts of port-related traffic, but the process was heralded by FDOT as merging the strengths of the public and private partners. The public sector brings the legal authority to acquire and commission, and the private sector brings efficiency and optimal technology and therefore better value for taxpayer money (Martinez, 2005, p. 20).

2.3.3.4 Seattle—FAST Corridor

Problem. The Seattle metropolitan area, or Puget Sound region, is home to three seaports: Seattle, Tacoma, and Everett. These three ports combine to form the third largest container port complex in the United States—the Seattle–Tacoma Ports. The complex peaked in freight volume at 4 million TEUs in 2005, a doubling from 1990. Despite moderate recession-related decreases, projections point to another doubling in freight volume by the year 2020 (Giuliano, 2011b, p. 10).

The Puget Sound region is congested. The 135,000 average daily truck trips in the region make up 3 to 9 percent of vehicle volume on Seattle freeways. These trucks are not only a concern due to their numbers. The size, relative weight, and slower speeds of these trucks (with average speeds up to 12 miles per hour slower than cars) make them a significant contributor to regional congestion (PSRC, 2011, p. 27).

In 1994, the Seattle metropolitan planning organization, the Economic Development Council of Seattle and King Counties, and Seattle-area private industry freight stakeholders formed a public–private partnership known as the Freight Mobility Roundtable. The Roundtable, designed to address this expected growth, wanted to ensure that the Puget Sound area remained competitive with Los Angeles. The Ports of Los Angeles and Long Beach were of particular concern to Seattle in light of Los Angeles' Alameda Corridor project, which was expected to reduce congestion and more efficiently carry freight to and from these ports (PSRC, 2012).

Solution. In 1998, in an effort to facilitate freight and passenger traffic mobility and mitigate the environmental impacts of the expected growth in freight transport, the partnership proposed the FAST for the Everett–Seattle–Tacoma Corridor (FAST Corridor). The FAST Corridor was designed and supported by the U.S. DOT, the state of Washington, the Puget Sound Regional Council, the 3 ports, 3 private freight carriers, 12 local cities, and 3 counties (Giuliano, 2011b, p. 11; PSRC, 2012)

The FAST Corridor members identified highway/rail crossings as the most pressing concern and proposed a first phase of 15 projects: 12 grade separations and 3 truck access projects totaling $470 million (Giuliano, 2011b, p. 12). Funding sources for this initial phase included $119 million from federal, state, and local funds and $58 million from the ports and railroads. A good portion of the state funding comes from tax revenue, including state fuel and weight taxes (Giuliano, 2011b, p. 14).

Evaluation. To date, the partners have generated $568 million in public and private funding, including voter-approved taxes, a good indication of public support. Sixteen projects have been completed, and five are funded, in design, and/or under construction (PSRC, 2012).

2.3.4 Conclusion

Gateway regions and trade nodes provide unique challenges for the urban areas in which they are located. The new geography of international trade and global services, together with scale economies, concentrate trade-related activity in a fewer number of larger gateways. These gateways, many of which are home to mega-ports, also offer a wide range of value-added services that include distribution and warehousing as well as rail and road connections to markets outside of the region. As a result, the gateway experiences both "last-mile" impacts as well as impacts tied to pass-through traffic.

Mitigating the negative impacts of trade activity resulting from operations at ports, distribution centers, and rail yards is difficult because of the scale and scope of operations and the institutional complexity that comes with multiple stakeholders who often have poorly defined areas of responsibility.

Appointments, reservation systems, and peak period pricing at terminal gates were implemented at ports in Southern California and in Vancouver, where a combination of trade volumes and regulatory pressures forced terminal operators to act. In the Southern California context, terminal operators were able to identify an economic benefit from off-peak gates, particularly when compared with a government-driven alternative.

The inability of stakeholders to identify similar benefits has limited the number of pricing-based strategies in other regions. The New York example of road pricing to manage the flow of goods through a hub region is one unique case, but it is largely focused on last-mile impacts. Expanding the scope of this kind of program throughout the gateway region requires the cooperation and approval of a much greater number of stakeholders, including carriers and jurisdictional authorities.

The lack of economic incentive has also prevented more widespread use of equipment management practices that could result in more efficient regional trade flows and in the diversion of cargo from truck to rail and/or barge. The latter has the potential to improve air quality and reduce noise and truck trips, but adds cost in diverting cargo from trucks (particularly when those trips will still end up on a truck for last-mile delivery) and, therefore, has limited application in real-world settings. More efficient operations are needed at border crossings, but institutional impediments have prevented all but tests of technology to reduce or eliminate delays at the check-in gate.

Technology plays a key role in many gateway-level strategies. For example, use of RFID and GPS has the potential to solve some of the data collection issues that prevent the adoption of pricing programs in large metropolitan areas. There are examples from the literature that demonstrate the effectiveness of technology-based scheduling algorithms and route optimization, but there are fewer examples where this research has been translated into practice.

The case studies presented suggest the conditions that are needed for more widespread solutions to work. Financing availability is first and foremost. This includes the ability of stakeholders to recognize the benefits of participation. A smaller number of more targeted solutions benefitted the FAST Corridor, while the number of proposed solutions, their cost, and the number of stakeholders involved have limited the impact of the CREATE project in Chicago. Similarly, while both Miami and Atlanta focused on a single mode (i.e., trucking), only Miami's tunnel was implemented. The Atlanta effort, which covered a much wider geographic area, was unable to overcome the obstacles of poor economic conditions and budget constraints.

SECTION 3

The U.S. Policy Context

The purpose of Task 3 was to provide context for the assessment of policies and strategies for managing truck transport in U.S. urban areas. In Task 2, we identified a broad array of strategies implemented in Europe and other parts of the world, as well as several best practices that have been implemented in the United States. To what extent are these policies and strategies transferable? Are the innovations we have seen in a few U.S. metro areas the result of unique circumstances, or might they be more broadly replicated?

This section begins with an overview of the complex governance arrangements in which freight policy takes place. Next, policy trends are discussed, including shifts in policy emphasis and the devolution of freight policy to lower levels of government. The third section discusses the impacts of these trends: what motivates policy decisions and what challenges are faced by the public sector in making effective policy decisions. The last section discusses recent trends and considers how these may influence decision-making in freight transport planning and management.

3.1 The Public Sector Role in Urban Freight[26]

Although the U.S. freight transport industry is privately owned and operated, the public sector plays an important role in ensuring safety, monitoring competition, regulating for environmental protection, imposing taxes and fees, and, in some cases, providing infrastructure and various services. Government at all levels is involved. Federal agencies engage in system planning, collect taxes and fees, and invest in infrastructure, as well as regulate safety, economic competition, and environmental impacts. Special authorities own and operate ports and intermodal facilities. Local governments invest in infrastructure, manage traffic, and regulate the location and operation of freight facilities. As freight transport has evolved, so has the role of the public sector—for example, from active economic regulator of air, rail, and trucking from the 1930s through the 1970s, to providing minimal oversight of freight markets since the 1980s, but with increasing emphasis on environmental and safety externalities.

A paper by Robin and Strauss-Wieder (2006) summarizes the roles of public agencies in the freight sector; Table 11 is a modified version of their Figure 2. It includes the major federal agencies, as well as several categories of state, regional, and local agencies that play a significant role. Note that this is not an exhaustive list of agencies that have a role in the freight system.

The rows in Table 11 are grouped by level of government—federal, state, and regional/local. The table columns are grouped by function (system planning; infrastructure development, operation, and maintenance; funding and taxing; and regulation and oversight), and within each group there is a column for each mode (rail, truck, air, and waterborne). The pattern of filled cells indicates the prevalence of public agency roles and makes it obvious that regulation and oversight are the most common activities of government. The table also indicates that regional and local governments often play an active role in freight.

3.1.1 Federal Agencies

The FHWA has—in addition to its role in facilitating the development, operation, and maintenance of the federal highway system—some specific freight-related responsibilities through its Office of Freight Operations. These include the following:

- Certification of vehicle size and weight standards,
- Freight research,
- Advanced technology operational tests,

[26] This section is adapted from Giuliano (2011a), with permission from the Eno Foundation for Transportation, Washington DC.

Table 11. Public agency roles.

Agency	System Planning				Infrastructure Development, Operation, and Maintenance				Funding and Taxing				Regulation and Oversight			
	R	T	A	W	R	T	A	W	R	T	A	W	R	T	A	W
Federal																
Treasury/Customs											Y	Y	Y	Y	Y	Y
FHWA		Y				Y			S	Y						
FAA			Y				Y				Y				Y	
FRA													Y			
U.S Maritime Administration				Y				Y								Y
FMCSA														Y		
TSA					S	S	S	S					Y	Y	Y	Y
EPA													Y	Y	Y	Y
Corps of Engineers				Y				Y								Y
Surface Transportation Board													Y			
State																
State Departments of Transportation	S	Y	S	S		Y				Y						
State Environmental Protection Agencies														Y	Y	S
Regional/Local																
Port Authorities	S		Y	Y	S		Y	Y			Y	Y			Y	Y
MPOs	Y	Y	Y	Y					S	S	S	S				
Local Government	S	S	S	S	S	S	S	S		S	S	S	Y	Y	S	S

R = Rail, T = Truck, A = Air, W = Waterborne; Y = Yes, S = Sometimes, Blank = No

Source: Adapted from Robins and Strauss-Wieder (2006), p. 3

- Funding of freight infrastructure, and
- Freight-related professional training and development.

The FAA is the safety regulator for the air transport industry and the operator of the air traffic control system. FRA is the safety regulator for the railroad industry. FMCSA is the safety regulator for the trucking industry; it develops, maintains, and enforces safety regulations for drivers, carriers, vehicles, and equipment. It also regulates hazardous materials transport.

The EPA has a major impact on the freight system through environmental regulation. The Clean Air Act of 1970 and its amendments set emission standards for heavy-duty diesel truck, locomotive, marine vessel, and aircraft engines. The EPA also sets water quality standards and discharge limits for water bodies that are enforced by the Coast Guard and the U. S. Army Corps of Engineers. The EPA is also charged with oversight of wetlands and of endangered species and habitats that are prone to impact by construction and operation of freight infrastructure projects. Freight activities are also subject to noise standards and environmental review of major projects through the National Environmental Policy Act (NEPA). Standards for hazardous material transport are issued by the Pipeline and Hazardous Materials Safety Administration (PHMSA) and are enforced by each modal agency.

3.1.2 Other Agencies

State departments of transportation are also important actors in the freight system. They operate and maintain the state highway system, conduct short- and long-term multimodal planning, and construct major facilities. The states also have the authority to regulate speed limits. Truck size and weight limits are established by the federal government, but states have some latitude in allowing longer combination vehicles (tractor-trailer combinations with two or more trailers, known as LCVs) and higher weight limits.[27] State police and highway patrols enforce state and federal safety standards. States with major freight nodes or high volumes of freight activity (such as California, Illinois, Georgia, New York, and Kansas) tend to have higher levels of engagement in

[27] Truck size and weight limits are complicated. The first laws limiting size and weight were enacted in 1956; since then, size and weight limits have changed many times. State limits have been grandfathered at various times to allow previously established state-level standards to remain in force.

freight-related planning and investment. States may develop statewide freight plans, collaborate with neighboring states to facilitate commerce flows, or directly invest in freight infrastructure.

Far more numerous and diverse are the many local and regional public institutions. As with state departments of transportation, MPOs in regions with heavy freight flows are more likely to include freight in the formal planning and forecasting processes. Ports and airports in the United States are typically owned and operated by public authorities, which are special-purpose governmental units authorized by the state. Port and airport authorities are managed by governing boards that include representatives of industry, local jurisdictions, and other levels of government. Local governments have authority to regulate truck traffic on streets and roads, regulate the location of freight facilities (distribution centers and warehouses) and the hours of operation, and determine parking zones and standards.

Local governments can have significant influence on freight activity. They can invest directly in new freight facilities, in roads to provide better access, or in favorable zoning practices to attract industry investment. On the other hand, through their management of the environmental review process and control of land use decisions, they can discourage industry investment. The ability of local governments and interest groups to influence ports, airports, and other intermodal activity is a major theme of the next subsection.

Waterborne commerce is particularly complicated due to its international component. International shipping is governed primarily by the International Maritime Organization (IMO), an agency of the United Nations established in 1948. The IMO is a voluntary organization; member states agree to abide by IMO guidelines on safety, pollution, and documentation. Ocean-going vessels are governed by the rules of the country in which they are registered. They are entitled to the protection of the "flag country" while at sea, and they are subject to all safety, commercial, and operating regulations of that country. The ocean shipping industry consists almost exclusively of non–U.S. flagged vessels. However, water shipping within the United States (including coastwise shipping) is governed by the Jones Act (Merchant Marine Act of 1920), which limits transport of goods or passengers within the United States to ships built in the United States, operated by U.S. owners, and operating under the U.S. flag.

International waterborne commerce is monitored by the Federal Maritime Commission (FMC). It is charged with administering the regulatory provisions of shipping laws that apply to U.S. foreign commerce. As with other parts of the freight industry, shipping has undergone substantial deregulation. The FMC's main purpose is to maintain "just and reasonable practices" in U.S. foreign trade by administering the provisions of the Shipping Act of 1984 and the Ocean Shipping Reform Act of 1998 (i.e., to maintain an adequate competitive environment). Other functions include monitoring foreign government activities as they affect U.S. shipping and enforcing regulatory requirements on ocean common carriers.

This brief overview illustrates the enormous complexity of freight-related governance. Of particular interest to this study are (1) the fragmentation of regulatory authority across different levels of government, (2) differences in governance structures across modes, (3) the absence of any federal entity that has full jurisdiction across modes, and (4) the potential of local governments to participate in all four of the major public agency functions.

3.2 Policy Trends

There are three policy trends in the United States that are especially relevant to urban freight: (1) a growing disparity in federal surface transportation funding supply and demand, (2) the lack of a national freight policy or program, and (3) devolution of authority in surface transport to lower levels of government.

3.2.1 Federal Surface Transportation Funding

The problems of federal surface transportation funding are well known. Two different national commissions have documented the growing gap between revenues and system needs and have recommended a long list of strategies to address the shortfall (National Surface Transportation Policy and Revenue Commission, 2008; National Surface Transportation Infrastructure Finance Commission, 2009) Given population and employment growth, it is expected that transport demand will increase. At the same time, greatly increased fuel efficiency will further erode the revenue-generating capacity of the fuel tax. As this report is written, there is no political consensus on how to address the federal funding shortfall.

The federal funding shortfall is relevant to urban freight for two reasons. First, as discussed in Section 1, the major freight bottlenecks are located in large metropolitan areas, particularly those that serve as gateways or intermodal nodes for the nation's commerce. These bottleneck problems are perceived as "national," in that they are related to interstate commerce and economic productivity, and they are seen as being a federal responsibility. In an environment of funding scarcity, freight bottleneck problems are just one of many problems competing for funds. Freight is a relative newcomer to the surface transportation program, and, even as recently as the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), only a little over $5 billion was allocated for freight-related capital programs, a tiny fraction of the $244 billion bill.[28] It is unlikely that freight project funding will grow in the current environment. Without a long-established program, freight funding could disappear as core programs take up all the available revenues.

The absence of federal funding options is relevant to urban freight also because this creates an incentive for states and local governments to develop their own options for dealing with freight problems. Because of this, there is great variation in the types of solutions being proposed and in the funding mechanisms used to pay for them. There is also variation in the effectiveness of metropolitan areas in solving freight problems. For example, the Alameda Corridor was built on time and within budget, making it a national success story, while the CREATE project in Chicago has encountered many difficulties. From the perspective of a national freight system, reliance on local governments to solve bottleneck problems means that the efficiency of the national system is critically dependent on the actions of local and state governments.

It bears noting that several TRB policy studies have addressed freight infrastructure needs, and a major topic is the extent to which federal funding is merited and the conditions under which it is justified (TRB, 2009, 1998, 2003, 2004, 2006). Various forms of pricing (e.g., road pricing and container fees) can both increase system efficiency and generate needed revenues. While many proposals for freight-related tolls and fees have been made, few have been implemented to date.

3.2.2 National Policy

The 1991 ISTEA included provisions for freight planning, and the increased funding flexibility made freight projects eligible in various aid programs, but the first allocation of funds exclusively to freight came with the 1998 Transportation Equity Act for the 21st Century (TEA-21), which included $1.1 billion for border crossings and trade corridors. Both programs were established as discretionary grant programs, but ended up as fully earmarked programs. SAFETEA-LU expanded both the border crossing and national corridor programs and added a new program for Projects of National and Regional Significance (PNRS). PNRS was widely viewed as a program for funding major freight projects. The border crossing program was restructured as a formula distribution, while the national corridor program and PNRS ended up as earmark programs. As noted above, several credit programs relevant to freight and intermodal infrastructure were also expanded in SAFETEA-LU.

Taken together, these programs do not make what could be interpreted as a national policy for freight. There is no statement of federal responsibility or overall national system goals (beyond the general discussion of goals in the U.S. DOT Strategic Plan). The prevalence of earmarking in the SAFETEA-LU freight-related programs suggests a funding allocation process based on political power rather than transportation system priorities (Giuliano, 2010). There are therefore not only no guidelines for state and local governments seeking to solve their freight problems, but instead a strong incentive to use earmarks to promote local agendas. Thus while the absence of federal leadership has allowed for rich and varied experimentation in addressing urban freight problems, it has also precluded the consideration of national priorities or a consistent national public policy.

The recent passage of MAP-21 may signal a change in federal policy, as it calls for the development of a national freight infrastructure policy, but no funds are attached. The PNRS is continued, but with funding at $500 million, it will provide limited federal leverage to implement a national policy.

3.2.3 Devolution

Over the past few decades major shifts in the role of government have taken place. Experts identify a different model of public service provision: one that is collaborative rather than authoritative, horizontal rather than hierarchical, and jointly provided by public and private entities. These shifts in the role of government also imply a different public decision-making process—one that is highly localized and fragmented, based on single-issue alliances, and incremental in nature (Kettl, 2002, p. xi). Governance scholars identify three trends that have led to this structural change: devolution, fragmentation, and privatization.

Devolution typically refers to the shift of responsibilities from higher to lower levels of government. Devolution has a long history in transportation; the original legislation for the surface transportation program established a decentralized model, with the federal government providing policy guidance and core funding and the states doing the implementation (construction, maintenance, and system management). As noted above, constraints on federal funding are providing an additional incentive for devolving responsibilities to state and local governments. Fragmentation refers to both the proliferation of governmental units and the dispersion of authority over public funds among them. Fragmentation in government is demonstrated by the growth in the number of local government units, particularly special-purpose governments over the past few decades (U.S. Census Bureau, 2002). Fragmentation

[28] SAFETEA-LU included other provisions to expand funding for freight, including expansion of the TIFIA program, establishment of Private Activity Bonds (PABs) for private freight investments, and an increase in the Railroad Rehabilitation and Improvement Financing (RRIF) program. Until the bank credit freeze in 2009, none of these programs had been widely used. Assessing the extent to which credit programs may address urban freight bottleneck problems is beyond the scope of this report.

is visible in the transport sector with the increase in special authorities and single-purpose agencies, such as toll authorities or county-level transportation commissions.

Trends in privatization take many forms—deregulation of industry, increased participation of the private sector in service provision, and a devolution of ownership of and authority over traditionally public services to the private sector. Efforts to reduce the role of government in the transport sector began in the 1980s with deregulation of railroads, air transport, and trucking in the United States. Privatization efforts in the transport sector include proposals for private highways and the use of private capital in public infrastructure. These trends have had a significant impact on public decision-making. Fragmentation disperses power and authority over many governmental units, complicating the decision process. There are some special challenges for transportation (Giuliano, 2007). These include the following:

- Network aspects of transport systems may not be managed effectively, because local decision-makers do not have an incentive to preserve network benefits if local costs are perceived to outweigh them.
- Inefficient decisions are more likely because those with veto power must be accommodated, and achieving agreement among multiple jurisdictions and decision-makers is a more time-consuming and complex process.
- Social costs and benefits tend to be perceived in the context of geography, so the smaller the decision units, the smaller the scale at which social costs and benefits are considered.
- A highly localized and fragmented decision process raises the standard for impact mitigation because only local benefits are considered. Transportation infrastructure tends to have narrowly focused costs and broad benefits, hence highly localized decision-making is particularly challenging.
- Fragmentation divides and obscures responsibility and authority.

3.3 Impacts on Solving Urban Freight Problems

How do these policy trends affect efforts to solve urban freight problems? Following is a general discussion, followed by a discussion focused on local decision-making.

3.3.1 Impacts of Policy Trends on Decision-Making

First, local decision-makers have no motivation for solving national system bottleneck problems, except as they affect the local community, and they also have little authority to do so. Railroads and trucking are protected by interstate commerce laws; local governments thus have limited ability to influence these industries. A common problem is at-grade rail crossings. The local community suffers delays at train crossings, but has no authority to restrict rail traffic or require the railroad to correct the problem. A frequently proposed solution is for the public sector to pay for a new below- or above-grade crossing. Local decision-makers argue that funds should come from higher levels of government—federal or state—because the problem is being generated by interstate commerce and the benefits of an efficient freight system are national. In a constrained funding environment, such mitigation projects are difficult to accomplish. An illustrative example is the Alameda Corridor East (ACE) in Southern California. In contrast to the original Alameda Corridor, ACE is primarily a set of grade-crossing projects. The project is stalled due to limited public funding.

Second, freight transportation problems are typically very visible: ports, rail yards and intermodal facilities are very large and significant elements of the urban landscape. Trucks are perceived as a major cause of congestion and accidents. Solutions to freight problems often involve major infrastructure investments (truck lanes on freeways, consolidation and reconfiguration of rail facilities). Thus, transportation decision-making tends to be very visible and highly politicized (Altshuler, Womach, and Pucher, 1979; Dunn, 1998; Altshuler and Luberoff, 2003). Devolution changes the nature of the politics by increasing the number of participants in the decision-making process and empowering local governments and communities (Giuliano, 2011b). The combination of multiple stakeholders, large and costly projects, and significant local impacts results in a highly contentious decision-making process. Often there is insufficient consensus; a process of lawsuits and revised plans may go on for years or even decades. If consensus is reached, it may require substantial payoffs to various interest groups, adding to project costs and sometimes reducing the effectiveness of the project. An extreme example is the I-710 expansion project in Los Angeles, which has been in the planning process for well over a decade. The current set of alternatives includes tolled "clean truck" lanes, which are envisioned to be available only to zero-emission, heavy-duty trucks.

Third, fragmentation affects the ability of government to address major problems. One of the most telling examples of fragmentation is that of air quality regulation. Freight-related emissions come from a variety of sources: trains, trucks, ocean vessels, off-road vehicles and equipment, and harbor craft, with trucks of all sizes as major contributors (see Section 1). All levels of government have some role in air quality regulation. Using Los Angeles as an example, authority over emissions is shared among the EPA, CARB, and South Coast AQMD as follows:

- On-road light-, medium-, and heavy-duty trucks: CARB, with approved waiver from the EPA.

- Off-road vehicles and harbor craft: CARB and South Coast AQMD jointly, with fuel standards that exceed EPA standards with EPA approval.
- Railroad locomotives: EPA.
- Ocean-going vessels: Subject to national standards by flag of origin. The international container fleet is primarily foreign flagged and hence is under the International Convention for the Prevention of Pollution from Ships (MARPOL), created by the IMO. In the United States, the authority for enforcing MARPOL standards is vested in the EPA, so the EPA has authority over local emissions and fuel standards for ships. An area of uncertainty is authority in coastal waters and the extent to which national and state governments have authority to regulate foreign carriers within their waters.

The South Coast AQMD, which has authority over stationary sources and mobile sources not covered by the EPA or CARB, has responsibility for the region's air quality plan and its compliance with the Clean Air Act. However, a significant portion of air pollution comes from sources over which the South Coast AQMD does not have formal control. This lack of authority, together with growing public pressure to solve air pollution problems, has resulted in a number of actions: (1) The South Coast AQMD attempted to preempt state and federal authorities with its own regulations; (2) state legislation was used to regulate or threaten to regulate the ports and port operations; and (3) ultimately the Los Angeles and Long Beach ports established their own mitigation plan, the CAAP.

3.3.2 The Local Environment

Governance within U.S. metropolitan areas is highly fragmented. Cities, counties, special districts, and authorities all play a role. Cities have jurisdiction over land use and the local road system and thus can greatly influence where freight activities take place, what facilities and policies guide local pick-up and delivery, where trucks may travel, and the degree to which local policies are enforced. Counties have jurisdiction over the county road system and, in the case of "self help" counties, also raise funds for capital investments and thus influence the regional transport system. Special-purpose governments operate public transport systems, bridges, toll roads, and other facilities; build major facilities; regulate air and water quality; and conduct regional transportation planning. Large metropolitan areas have large numbers of local government entities.

Multiple local governments generate a complex regulatory environment for shippers and their clients. Design and capacity requirements for loading bays, parking limits, or truck route designations may differ from one city to another, creating challenges for trucking companies and others whose operations span multiple jurisdictions. Also, local freight is embedded within the dynamics of the larger supply chain. Delivery restrictions, for example, affect the routing and scheduling of an entire shipment system. Local regulatory actions have impacts throughout the supply chain, so the net impacts of efforts to reduce traffic congestion or emissions locally could be increased congestion or emissions elsewhere.

Multiple local governments also create the possibility of competition between cities to attract activities perceived to be beneficial (e.g., white-collar jobs) and resist activities that impose costs (e.g., distribution centers). More affluent cities have more resources to resist unwanted activities, shifting them to less affluent locations and often generating significant social justice problems. Activities that generate negative externalities also influence surrounding land values; as land values decline, these areas are more likely to be populated by low-income and minority people, reinforcing the social justice problem.

As noted above, fragmentation makes metropolitan-level decision-making difficult. With few exceptions, there is no regional governing body with authority to make land use decisions (hence the repeated calls for regional governance by urban planners and others). Thus the locations of activities that generate freight supply and demand (shopping centers and warehousing districts) are influenced by individual cities based on unique and highly localized considerations. Such location decisions may impose costs on neighbors in the form of truck VMT and emissions. The situation is somewhat different in the case of major transportation infrastructure due to the key role of MPOs in creating regional transportation plans. MPO boards are made up of local elected officials and hence ultimately depend on some level of regional consensus.

Fragmentation is additionally challenging in the case of freight policy because freight famously "has no borders." The global dynamics that drive freight flows are largely beyond the control of any one government. The lack of authority over these flows, combined with the external costs they impose, create especially serious problems for local governments, whose citizens are incurring the external costs.

Finally, fragmentation requires collaboration and consensus building among jurisdictions in order for action to be taken. Examples include mitigating impacts of freight through traffic, truck, or rail emissions reductions, as well as consolidated delivery efforts. The review of best practices in Section 2 shows that innovative efforts are typically the result of collaborations across stakeholder groups and utilize mechanisms outside the traditional regulatory process. The next section elaborates on this point.

3.4 New Directions

Faced with multiple and diverse local government partners and limited jurisdictional authority, metropolitan areas have turned to collaboration, consensus building, and engagement with industry to solve urban freight problems. Why has industry in so many cases complied and accelerated fleet turnover, adjusted delivery practices, or employed new technology such as particulate traps, without formal regulation?

3.4.1 Voluntary Regulation[29]

Urban freight problems are at their core externality problems. Moving freight generates noise, air pollution, and congestion costs that are imposed on the surrounding community (and the global population in the case of GHGs) and for which those who incur the costs are not compensated. Typically externalities require government intervention to implement some form of regulatory strategy. However, when jurisdictional authority does not exist, or scientific evidence is insufficient to justify formal regulation, or the problem is considered too urgent to await the establishment of formal regulation, or when political opposition to regulation is particularly strong, governments may choose various forms of voluntary regulation (Linder, 2010).

Voluntary regulation can take a variety of forms, but in all forms the targeted industry participates by choice. A public voluntary program is initiated by government. The public agency sets goals and provides technical assistance and/or positive publicity to firms seeking to meet the goals. The European "green certification" programs are examples. Another form is a bilateral agreement, in which the public agency offers some benefit (technical assistance, relief from certain regulatory requirements, or an operating permit) in exchange for the firm meeting specific pollution reduction goals (Lyon and Maxwell, 2001; Alberini and Segerson, 2002). The voluntary speed reduction (VSR) program at the Ports of Los Angeles and Long Beach and the Dutch PIEK delivery program provide examples. Negotiated agreements are similar to bilateral agreements, but they are achieved through collaboration with the targeted industry. The New York City off-hours delivery demonstration program is one of the most visible examples of negotiated voluntary regulations. Finally, there is self-regulation—an individual firm or industry commits to a course of action, such as Wal-Mart's commitment to "greening" its supply chain, or FedEx's experimental use of electric delivery vehicles in urban areas.

[29] This section is adapted from Giuliano and Linder (2012).

There are several possible explanations as to why industries or firms would engage in voluntary regulation or self-regulation. The first is social legitimacy. Firms must operate within "institutionalized norms of acceptability" or according to social norms and expectations (Bansal and Roth, 2000, p. 202). If a firm does not fulfill social expectations, it risks losing customers, business, and profits. Thus, as social norms change, so does firm behavior. With growing public attention to sustainability, it is not surprising that consumer-oriented firms are "going green." The second and related explanation is social pressure placed on firms by clients, stockholders, or citizen groups. Pressure can be applied through lawsuits or local activism, imposing high costs on firms and affecting their reputations (Linder, 2010).

A third explanation is the threat of regulation. Companies may choose to go beyond what is legally required by government regulation in order to preempt stricter regulation (Lyon and Maxwell, 2001; May, 2005) or to gain competitive advantage (Desimone and Popoff, 1997; Schot and Fisher, 1993). Preemptive moves can be taken for several reasons: to avoid stricter regulations, to weaken pending regulation, or to disadvantage competitors (Lyon and Maxwell, 2001). Operating beyond compliance can also be a strategy to obtain recognition from government and communities, an improved working relationship with regulators, access to technical assistance and resources, and lower regulatory transaction costs (Fiorino, 2006). Voluntary behavior may also help to set future standards, providing a form of first mover advantage.

The fourth explanation is the business case or eco-efficiencies. More efficient operations can lead to cost savings (as in the case of reduced packaging) as well as environmental benefits (less waste). Eco-efficiencies may lead to development of new markets and customers (reduced packaging attracts environmentally conscious consumers) and contribute to social legitimacy (Clifford and Dixon, 2006). Eco-efficiencies are debated in the literature: eco-efficiencies may require large up-front investments that are not fully offset, and, in a competitive industry, it is unlikely that opportunities for efficiencies would not be exploited (King and Lenox, 2001).

Whatever the motivation, it is apparent that voluntary regulation is an important tool in managing urban freight problems. The policy and governance environment make negotiation and offering of incentives often the most feasible and effective means for achieving mitigation objectives.

SECTION 4

Conclusions and Recommendations

4.1 Main Findings

This synthesis of urban freight literature reveals a growing interest in the topic, but also underscores the need for future studies, particularly those that generate data on freight movements within the urban area. This section summarizes the key findings of this synthesis and lessons learned from this investigation of experiments with various policy measures in places like Southern California, New York, and Paris. Whether these experiments are transferable and may be identified as best practices is also considered in this section. The section closes with some recommendations and suggestions for future research.

4.1.1 Urban Freight Contributes Disproportionately to Externalities

The first finding of this research effort is that urban freight is associated with many externalities that affect the quality and livability of metropolitan areas. Commercial vehicles contribute a significant share of NO_x, PM, and CO_2 emissions in cities and contribute disproportionately to congestion, noise, and road accident fatalities. The various studies examined in this research indicate that in areas and locations where trucks are concentrated (e.g., freight corridors, ports, warehouses, etc.), pollution is pronounced and associated with public health problems.

Outside the United States, there is evidence that the average age of urban delivery trucks is older; a common practice is to use trucks at the end of their service life for short-distance drayage. The research team found no information on the average age of delivery fleets in the United States. Whether or not delivery trucks and vans are older, the nature of local delivery is short trips and frequent stops, which in turn implies lower fuel efficiency and more emissions. There is evidence that the U.S. port drayage sector operates older (and dirtier) trucks because of the structure of this industry segment: owner-operators who earn very low wages. Only a few studies have attempted to quantify the impact of delivery trucks and vans on emissions. Research is necessary to understand the various market segments of local deliveries and their environmental impacts. For example, large corporations, such as FedEx or UPS, have modern fleets and use very sophisticated routing practices to operate as efficiently as possible. Local independent operators likely do not have the scale or profits to operate as efficiently. As noted above, there is a lack of information on the characteristics of local delivery fleets or their travel patterns.

Noise is also associated with freight movement, but studies that isolate the noise-related impacts of freight are underdeveloped. Environmental impacts, in general, and the policy measures to mitigate those impacts are more extensively researched in Europe than in the United States.

Finally, trucks and vans contribute to urban congestion not only because they compete with passenger traffic for scarce road space, but also because adequate parking and loading facilities are not always available (causing truck queuing and double parking) and most pick-ups and deliveries take place during hours of high passenger traffic demand. The magnitude of these impacts is rarely quantified due to a lack of data on truck movements.

4.1.2 Available Data Are Lacking

Another important finding of this research is that the data on commercial vehicle traffic in urban areas are extremely limited. The more general problem of national freight data availability is well known and has been the topic of several studies (TRB, 1998, 2003, 2004, 2006, 2009). The availability of freight data at the urban level is even more limited because there is no common source for sub-metropolitan data. The federal government is a source of valuable information for aggregate data on key areas of concern including intercity truck flows and truck crashes. State departments of transportation are primarily responsible for collecting the data that do exist on freeways and state highways that run through urban areas. There are also some data, again collected by state departments of transportation, that measure truck traffic on urban arterials that happen to be part of the state highway system.

MPOs have begun to collect urban freight data, particularly with regard to truck movements, as part of the regional transportation planning process, but this is more often the case in trade node metropolitan areas such as Atlanta, Chicago, or Los Angeles. Moreover, truck flow data are difficult to collect: surveys do not always capture the complexity of freight transfers, including (de)consolidation within regions or intermediate stops made before the final delivery destination. Data from urban intersections and bottlenecks exist, but these data are more often available for locations designated as state highways. These data are also typically collected only for the largest of trucks. The research team did not find any data on the number of non-truck commercial vehicle trips, i.e., those undertaken in vans, pick-ups, cars, or bikes. This is a critical information gap as data from Europe show that about half of urban deliveries are made by vans. Understanding the characteristics of urban freight flows requires basic data on commercial vehicles and what they carry.

The lack of data on commercial truck traffic also affects the ability to estimate truck emissions. New modeling tools have made emissions calculations easier, but without reliable data on the commercial vehicle mix, emissions model results have a great deal of uncertainty. In metropolitan areas that do not meet air quality standards, emissions models are used to estimate future emissions and determine mitigation measures to be included in regional transportation plans. Better commercial vehicle data would allow more effective and targeted mitigation plans.

4.1.3 Spatial Distribution of Freight Supply and Demand Needs Better Understanding

There is a need to better understand the factors that drive intra-metropolitan freight flows and result in changing patterns for both local deliveries and pass-through freight. Shippers may change where and in what form they move goods (e.g., rail/truck intermodal versus all truck). Just-in-time logistics practices increase the importance of reliability and may result in more frequent shipments. More home-based shopping means more home deliveries and less efficient routing (due to the dispersion of deliveries and risk of non-delivery). Socioeconomic factors, such as rising income, aging of populations, and changing consumer preferences are also important drivers. These factors have made urban economies more dependent on transportation systems, with more frequent and customized deliveries. Understanding of how these forces affect urban freight flows and how these flows may be better managed remains very limited.

The larger dynamics of urban change and economic development also affect freight flows. Efforts to revitalize urban cores are widespread, and such efforts typically involve more residential and commercial development. These new activities generate additional freight demand, but freight facilities are incompatible with rising land values, limited road capacity, and residential communities. Pick-ups and deliveries still need to be made, but parking and loading facilities are often inadequate.

Rising land values provide the economic incentive for land-intensive activities (manufacturing, warehousing, and distribution) to decentralize to suburban or exurban locations. Larger parcels in these areas allow for the development of larger facilities that can take advantage of scale economies, a trend called “consolidation” in this report. This is particularly the case in trade nodes that have benefitted from shipper decisions to move more goods in higher volumes through a fewer number of gateways. Nodal cities have the same set of last-mile issues (parking, noise, and emissions) as other regions, but they also have pass-through freight movements bound for locations outside of their region. How these location shifts affect metropolitan areas and how public policy may influence these shifts are not well understood.

4.2 Best Practices and Policy Initiatives

In response to growing urban freight problems, cities around the world have engaged in extensive experimentation to manage urban freight. In the case of last-mile problems, the challenge is to facilitate freight flows that are necessary to sustain urban life while also reducing truck and van volumes, eliminating conflicts with other modes, and minimizing public costs. In trade node cities, the challenge is how to manage flows that are essential to the regional economy yet impose substantial costs on local communities. In this section, the research team summarizes findings from our review, discusses effectiveness and impacts on freight stakeholders, and considers transferability to widespread implementation in the United States. Three general categories are used to discuss strategies: last mile, environmental mitigation, and trade node strategies. These categories in practice overlap; almost all strategies have an environmental objective, for example.

4.2.1 Last-Mile Strategies

The majority of last-mile experiments have come from overseas—Europe, in particular—where local municipalities have more apparent regulatory control over truck access and roads (including non-local roads) than municipalities in the United States. In the United States, the few domestic policy experiments that do exist (like clean truck programs and off-peak deliveries) come from one or the other of the two largest trade node cities: New York and Los Angeles. Other North American cities' freight initiatives tend to center on new or improved infrastructure (such as grade separations, added highway capacity, or logistics parks) rather than operational changes. In the absence of a clearly defined authority to regulate trade, local governments must resort to enforcement through zoning and land use controls as opposed to new policy initiatives that might have more widespread impacts on regional freight flows. This situation means that frustration with last-mile freight deliveries translates into harder-to-secure building permits for new construction, new parking restrictions, weight restrictions, regulated hours of operation, and/or mandates for off-street loading zones.

The main types of last-mile strategies and some examples of each are presented in Table 12. Table 12 clearly illustrates the preponderance of examples coming from outside the United States.

4.2.1.1 Labeling or Other Certification Programs

Certification and labeling programs are examples of voluntary regulation. The public sector negotiates with private industry to develop a set of *voluntary* targets or operating rules that confer either recognition or special benefits. These include the various "green" certification programs that promote use of cleaner vehicles, cleaner fuels, or operations during less congested periods of the day (see Table 12 for examples).

The effectiveness of certification/labeling programs depends on how much agreements change behavior, which depends in

Table 12. Last-mile strategies.

Strategy	Location	Description
Consultation processes and certification schemes	London	Freight Quality Partnership
	London	Freight Operator Recognition Scheme
	Paris	Delivery Charter
	Netherlands, 25 cities	PIEK label program
Traffic and parking regulations	Paris	Daytime hours truck ban (over 29 square meters)
	Sao Paulo	Access 2 days/week/vehicle
	New York City	Commercial Vehicle Parking Plan
	Barcelona	Off-peak hours use of roadways for unloading/loading
	Los Angeles downtown	Increased enforcement of use of loading bays
	San Francisco	Demand-dependent parking charges
Intelligent transport systems	Several European and Asian cities	Automatic control systems for truck access regulation
	London	Transport for London Freight Website
	Europe Arlington, VA	DHL Packstation and United States Postal Service Gopost: automated self-service parcel delivery lockers
Planning strategies	Tokyo	Loading/unloading facilities requirements for new commercial buildings of > 2,000 square meters
	New York	Loading/unloading requirements for new commercial buildings of > 8,000 square feet
	Barcelona	Minimum 5 square meters of storage for new bars and restaurants
	Paris	Technical guide to delivery bays for the City of Paris design guide for on-street loading bays
Consolidation schemes and measures targeted toward urban supply chains	Paris	Urban Logistics Spaces: subsidized rental rates for freight storage in municipal parking garages
	Europe	Kiala network: pick-up points for home deliveries
	Bristol (U.K.), Motomachi (Japan), Cityporto (Italy)	Urban Consolidation Centers
	London	Construction Consolidation Center
Off-hours deliveries	New York City	2009–2010 experiment, focus on receivers
	Los Angeles/ Long Beach	PierPASS off-peak program

turn on the costs and benefits of doing so. Certification programs that allow access to loading facilities or extended delivery hours offer a significant benefit to shippers and, therefore, make it easier to justify the purchase of new, compliant vehicles. Most certification programs incorporate environmental goals, typically reduced emissions, and offer last-mile delivery benefits. The certification programs reviewed by the research team were perceived as very successful both by the public sponsors and private participants. One potential problem is the buy-in and participation of all industry segments; for example, the large shippers are more capable of negotiating program conditions with public sponsors and, hence, programs may be designed to advantage the larger shippers.

Certification programs were identified as having additional benefits. First, the process of developing a voluntary program requires engagement of all stakeholders and over a period of time may increase trust and foster more collaborative relationships between industry and government. Second, certification programs raise visibility of both the problem and the solution, especially within the targeted industry. Third, industry (shippers) may enjoy a competitive advantage when bidding for contracts, as more clients place value on doing business with "green" firms. Fourth, certification programs are relatively low cost, with most of the costs in the form of transaction costs—establishing and maintaining public–private relationships. Fifth, contrary to the possible fears of industry, the research team has not observed any cases of voluntary certification programs leading to traditional regulation. Finally, certification programs may evolve: as targets are reached, new targets are negotiated, leading to significant improvements over time.

As noted in the Task 3 discussion, voluntary regulation is a good fit with the U.S. context of decentralized governance and dispersed regulatory authority. In cases where direct regulation is either impossible (due to lack of authority) or infeasible, voluntary regulation may be the best available alternative. Certification programs can take a number of forms and have shown themselves to be an effective way to devise incentives that introduce performance goals and incrementally move firms to the desired behavior. The research team found labeling and other certification schemes to be both highly effective and highly applicable to the United States.

4.2.1.2 Traffic and Parking Regulations

City efforts to manage last-mile problems have focused on local traffic and parking regulations because these tools are clearly within local authority. In theory, traffic and parking regulations are effective as long as they are enforced. However, cities have no control over demand for pick-ups and deliveries, and, consequently, traffic and parking regulations are limited tools for managing last-mile problems. In practice, highly restrictive regulations are costly to enforce and may lead to other problems. Restricting truck parking areas may result in trucks double parking in the roadway or using curb space reserved for other purposes. Prohibiting large trucks from certain streets or neighborhoods may increase truck trips and congestion as goods must be transloaded to smaller vehicles.

When the demand for truck pick-up and delivery greatly exceeds the supply of loading and parking areas, enforcement becomes costly and increasingly difficult. The longer it takes for truckers to locate parking and make the delivery, the higher the cost is of doing so. At some point, the risk of being cited becomes less costly than the delays incurred in waiting for a parking spot. This is observed in dense places like New York and San Francisco.

Traffic and parking regulations have a mixed record of success. Restrictions on truck access, such as the ban of large trucks in the center of Paris and in Seoul, or the limit of truck deliveries to certain days of the week, as in Sao Paulo, tend to shift truck traffic to smaller vehicles (generating a net increase in truck VMT) or to concentrate traffic into shorter time periods (generating more congestion). Large truck bans add to delivery costs and may result in more pollution and congestion. Consistent with expectations, Seoul reports serious enforcement problems as a result of the lack of loading and delivery facilities. Regulations aimed at encouraging the most efficient use of road resources tend to be successful. Barcelona's policy of allowing use of traffic lanes for pick-up and delivery during off-peak hours is an example. San Francisco's recent implementation of dynamic parking charges is another. The lesson drawn from both U.S. and international examples is that local freight demand must be accommodated; hence, strategies that *manage* rather than *restrict* freight deliveries tend to be more effective.

4.2.1.3 Land Use Planning Policies

Local jurisdictions also have land use planning authority and, hence, may set policies and guidelines for incorporating freight deliveries into new developments, for designing loading docks, and for developing parking and loading standards. With increased development in city cores and more frequent deliveries for each business, freight demand has increased; at the same time, the scarcity of road and curb space and ever higher land values have increased the cost of managing demand. New development or redevelopment offers the opportunity to implement planning standards for on-site freight facilities. Examples include Tokyo's and New York's requirements for new commercial developments. Barcelona goes further, adding a requirement for minimum storage areas for new restaurants and bars. On-site facilities decrease the need for on-street loading zones, reducing conflicts with passenger demands. On-site facilities also add to building costs and, hence, may be resisted by the development community.

Cities may also develop freight loading and parking standards for off-site activities (e.g., in a public right-of-way). There are more opportunities in developing areas, where the road infrastructure is still being constructed. However, even in already-developed areas, standards can have an impact over time if they are tied to future development and redevelopment.

Experiences with on-site planning policies have been largely positive. Although such requirements add to development costs, these requirements also add to commercial property value by ensuring that freight deliveries are accommodated. Shippers and truck drivers clearly benefit from having reliably available loading facilities.

These policies are a good fit in the U.S. context for several reasons. First, the authority of local governments to develop and implement planning and building guidelines is clearly established. The ability to negotiate the zoning and approval process allows for flexibility in enforcement and is widely accepted. Second, the problem of loading facilities being used for other purposes (e.g., storage) that has been observed in other countries (France, Spain, and the United Kingdom) is less likely to occur in the United States due to the generally high level of building code enforcement. Third, U.S. metropolitan areas are characterized by a high level of "churning": even in times of slow economic growth, there is constant change in business activity, with new firms emerging and old firms leaving. At the same time, less of the building stock is subject to preservation than is the case in most European metropolitan areas. Thus, the long-term impacts of planning policies can be significant.

4.2.1.4 City Logistics and Consolidation Schemes

Consolidation schemes seek to reduce truck traffic by finding ways to combine pick-ups and deliveries of different shippers or different receivers. These schemes often focus on changing the supply chain, rather than on the final (or initial) step of the chain. Supply chains are highly complex, and the specific make-up of any specific chain is influenced by many different factors. Efforts to change the supply chain are therefore challenging.

The simplest (from a supply chain perspective) consolidation schemes are those that focus on final delivery or pick-up, e.g., on the end of the chain. An example of consolidating final deliveries is the use of common pick-up points for home deliveries, as in the Kiala and the Packstation networks in Europe, and a new locker service being implemented in Arlington, Virginia. These common pick-up points reduce home deliveries (truck trips) but may also increase private vehicle trips. The net impact of common pick-up points on VMT and emissions is unknown. If these facilities are located in or near public transit facilities, the research team would expect that many pick-ups would be made by walking trips. If the facilities are located in shopping centers or parking lots, most trips would likely be made by car.

Another version of consolidation is shared logistics spaces, where multiple shippers use an in-town facility to consolidate loads (typically from different, out-of-town logistics facilities) before final deliveries. The intent is to reduce truck VMT with more efficient routing of final deliveries (or initial pick-ups). The Paris Chronopost facility is a single-shipper facility; deliveries are trucked to the central facilities and then trans-loaded to electric vehicles for last-mile delivery. Studies of the Chronopost operation showed that total delivery costs (for Chronopost) did not change much. The city of Paris subsidizes facility rent and incurred all the up-front capital costs. Due to the use of electric vehicles and more efficient routing, both truck VMT and associated emissions declined.

The most ambitious version of consolidation is the urban consolidation center, where goods from multiple shippers or vendors are combined and delivered by third-party trucking firms. The idea is simple. Rather than have goods delivered from many different firms, combine them so that deliveries can be more efficient. As in shared logistics spaces, consolidation requires an in-town facility and rental payments to use it. Although it would appear that shippers would benefit from the lower costs of consolidated deliveries (more full truck loads), whether these benefits would offset the rental and added labor costs of trans-loading is unclear. In the many European experiments, consolidation centers were not feasible without public subsidies, and many have since closed.

The transferability of consolidation schemes to the U.S. context is limited. Home delivery centers are the most likely to be adopted as consumers accept the concept of picking up their own e-shopping orders at local depots (which can be located in local stores). Information technology makes possible secure lockers for specific customers. It bears noting that there has been experimentation and development in Europe and Asia for over a decade, with some mixed results, some with widespread development (Kiala and Packstation in Europe, deliveries in neighborhood convenience stores in Japan). The project in Arlington, Virginia, is the first in the United States. Home delivery centers require facilities, security, and sophisticated IT, so whether such centers proliferate depends on the savings from fewer home deliveries versus the costs of developing and operating the center.

The other consolidation models are more problematic. The required subsidies to freight operators would be politically difficult, even if local jurisdictions had the funding to provide them. Any effort to force consolidation via regulation (as in several Italian cities) would be very difficult and possibly impossible due to interstate commerce laws.

4.2.1.5 Off-Hours Deliveries

The aim of off-hours deliveries is to shift truck activity out of the peak traffic periods and, hence, reduce congestion and emissions. Like consolidation schemes, off-hours delivery appears to be an obvious way to reduce truck-related congestion; yet, few examples of off-hours delivery programs exist. Again, the reason is the supply chain: off-hours deliveries require off-hours truck drivers and receivers. Constraints on the trucking side include federal hours of service requirements, shift premium pay for unionized drivers, and possible efficiency losses associated with spreading shipments out across more hours of the day. Constraints on receivers include having to open receiving facilities early and to operate loading terminals more hours of the day, shift premium pay for terminal workers, and local zoning codes that prohibit after-hours truck activities in residential neighborhoods. In the New York City test, receiver constraints were found to be the most difficult to overcome.

There is only one permanent off-hours program in the United States, the PierPASS program at the Los Angeles/Long Beach ports. It was implemented due to unique circumstances that do not exist in other U.S. metropolitan areas. The New York City demonstration is the first and only in-city program. It has resulted in reduced congestion, energy consumption, and emissions and thus demonstrates the potential benefits of such programs. However, adoption on a permanent basis has not yet happened. Receivers have no incentive to incur the additional costs, and local residents have no incentive to be subject to truck noise more hours of the day.

Off-hours delivery may have potential as a voluntary regulation. The public sector could offer incentives such as recognition (green certification for receivers) or tax breaks to promote off-hours deliveries in areas where residents would not be affected (e.g., commercial zones). Shippers might be incentivized to purchase and use quieter trucks and handling equipment in exchange for being able to deliver off-hours, as in the PIEK program in the Netherlands.

4.2.1.6 Intelligent Transport Systems

ITS for monitoring or managing urban freight includes technologies for providing real-time traffic (and parking) information, automated enforcement of parking or traffic regulations, automated toll collection, and automated access control. The research team did not address ITS applications that are purely private in nature, such as GPS technology used for tracking fleet vehicles or packages. Real-time traffic information is available in the largest U.S. metropolitan areas, and the extent and quality of information is improving as sensing technology continues to develop. The large private shipping companies (e.g., UPS and FedEx) have extensive internal systems to inform near-real-time routing. Experimentation has begun with parking information, but no successful system has yet been developed due to high costs and complexity. The research team expects that the technical problems will be solved, and parking information systems may soon become a critical element in urban truck movements.

Use of ITS for monitoring truck traffic via license plate readers and other devices is extensive outside the United States (e.g., in the United Kingdom, Spain, and Italy). Automated monitoring systems involve high up-front costs and tend to be used either as part of road pricing systems or limited access zones. Once implemented, automated systems make possible continuous, low-cost enforcement of tolls or access zones and, thus, can be very effective. How transferable are these tools in the U.S. context? Technological expertise is not a problem; the United States has examples of toll roads and bridges with automated fare collection systems, an automated bypass system for compliant trucks on Interstate highways, and RFID systems for limited access facilities (e.g., ports). Transferability depends more on the perceived acceptability of the policies to be implemented. So far, security at limited access facilities has proven to be an acceptable justification for semi-automated monitoring. The use of tolls to manage congestion in metropolitan areas is not yet widely accepted. The New York City congestion pricing proposal is illustrative; it included truck tolls that could be discounted by using clean trucks, and studies indicated that congestion and emissions reductions would be substantial. However, the research team expects that tolls will become more acceptable as congestion increases and funding from traditional sources to support capacity expansion declines. Access zone policies are discussed in the next section.

A second implementation challenge in the United States is the general resistance to automated monitoring by public authorities. An illustrative case is the conflict surrounding cameras used to enforce red light violations at intersections. Monitoring could provide comprehensive data on truck movements, which are greatly needed for better analysis of urban freight problems. However, these data may be perceived as proprietary, and, therefore, monitoring may be resisted by trucking companies and shippers. Use of ITS for truck tolls or automated monitoring outside limited access facilities appears to have limited transferability to the U.S. context.

4.2.2 Strategies to Reduce Environmental Impacts

Strategies to reduce environmental impacts are aimed at reducing truck emissions and energy consumption by improving engine performance, shifting to cleaner (and quieter) conventional diesel trucks or alternative fuel trucks, or shifting freight to more energy-efficient modes. The research team's review yielded these observations: (1) strategies that address the entire commercial fleet have the most impact, even if the impact is small on a per-vehicle basis; (2) strategies that impose substantial costs on private industry will not be adopted unless industry is forced to do so; and (3) strategies that seek to shift freight from trucks to slower modes are not attractive to industry without large subsidies and may have little impact on emissions or energy consumption. Strategies to reduce environmental impacts are summarized in Table 13.

4.2.2.1 Truck Fuel Efficiency and Emissions Standards

The United States has a now long history in regulation of vehicles for fuel efficiency and emissions reductions. National fleet standards are among the most effective tools for reducing emissions. The recent changes in light truck CAFE standards will have a significant impact on the light truck portion of the freight vehicle fleet. The shift to cleaner diesel engines and fuels is having a similar impact on heavy-duty diesel trucks. As discussed in Section 2.2, increasing the stringency of fuel efficiency and emissions standards and accelerating the targets has had significant impact in California. The Los Angeles/Long Beach Ports' Clean Truck Program is by far the most ambitious emissions reduction program in the United States and, in 4 years, led to large reductions in diesel truck emissions. The research team expects fuel efficiency and emissions regulations to continue to be one of the most effective tools for reducing air pollution and CO_2 emissions in metropolitan areas.

4.2.2.2 Alternative Fuels and Vehicles

Alternative fuel vehicles (AFVs) have been widely promoted in the United States, but they have achieved little market penetration due to higher capital and operating costs, the complexities of operating diverse fleets, limited range,

Table 13. Strategies to reduce environmental impacts.

Strategy	Location	Description
Truck fleet emission standards	California	CARB truck, diesel particulate filter standards
	United States	EPA 2011 truck CO_2 emissions and fuel efficiency standards
LEZs	Greater London	LEZ: access restrictions on old trucks and large vans
	Milan	Historic center truck regulations
	Swedish, Dutch, and Danish cities	Regulations based on Euro standards
Alternative fuels, electric delivery vehicles	London, Milan	Congestion charge exemption for alternative fuel vehicles
	U.S. cities	Delivery company use of alternative fuel trucks and vans
	European cities	Electrically assisted cargocycles
	France	Program to group purchases of electric vans for commercial fleets for public administrations
	Los Angeles/Long Beach Ports	Clean Air Action Plan Technology Advancement Program
Promotion of alternative modes, cargo diversion	United States	U.S.DOT (MARAD) Marine Highways/Short Sea Shipping Grant program
	San Francisco Bay Area	FedEx BART pilot program
	Paris	Cargo-Tram, Monoprix rail, and waterways deliveries projects
	Dresden	Cargo-Tram
Restriction on truck idling	California	5-minute limit on diesel truck idling
	United States	Truck-stop electrification
Delivery noise reduction	Netherlands	PIEK research, development, and regulation program
	Atlanta	ASTROMAP
Environmental justice, community mitigation measures	Greater Los Angeles	Southern California Association of Governments (SCAG) Toolkit for Goods Movements
	County of Riverside, CA	Truck Routing and Parking Study
	New York City	Truck Route Management and Community Impact Reduction Study
	Baltimore	Maritime Industrial Zone Overlay District
	Europe	Freight villages
	Atlanta	Regional commission's freight studies
	United States	Environmental Justice Guidelines Publications (*NCHRP Report 320*, *NCFRP Report 13*, and *NCFRP Report 14*)

and lack of fueling infrastructure. AFVs are limited largely to public fleets (transit buses) and utility firms. Efforts such as the National Clean Fleets Partnership are voluntary programs aimed at reducing barriers to adopting AFVs in private industry; these have had limited success. In Europe, even large subsidies (as in London) have not prompted adoption of AFVs on any significant scale. However, the largest private delivery firms—FedEx, DHL, and UPS—are all experimenting with AFVs and have small numbers of electric and hybrid electric trucks operating in various cities. It is possible that these numbers will increase as the technology becomes more competitive with conventional fuels.

For large trucks, AFVs are not yet sufficiently competitive with diesel engines, and the progress being made in reducing diesel emissions may make it more difficult for AFVs to compete. Research is needed on the costs and benefits of AFVs in comparison to cleaner diesel and on which types of AFVs (natural gas, electric, or biodiesel) may be the most effective to pursue and develop. AFVs are a potential long-term solution for GHG emissions and energy consumption.

The research team noted experiments in Europe with smaller AFVs, such as small electric vehicles and "cargocycles" for local deliveries. Because of the small capacity and range of these vehicles, they are a feasible option only for small, concentrated pick-up and delivery points. Niche markets may exist in the most dense U.S. city centers (e.g., New York, Chicago, and Boston), depending on the costs (labor, new vehicles) relative to conventional vans or small trucks. Lack of a potentially large market suggests that these strategies would have little impact on emissions reductions.

4.2.2.3 Low Emission Zones

LEZs have been established in several European cities to limit the types of vehicles that may operate within the zone based on their emissions and energy consumption. The most notable examples are London, where the LEZ is combined with the congestion toll (the LEZ encompasses a much greater area, as all the metropolitan area is covered), and Milan. LEZs have some obvious advantages: to the extent that performance standards are imposed on all trucks, the entire urban fleet is affected, and emissions reductions could be large. It is argued that LEZs generate secondary benefits by forcing the reorganization of the local trucking industry into larger and hence more efficient operations.[30]

Although LEZs are a potentially effective strategy, the transferability of LEZs to the U.S. context is low. The only comparable program is the Los Angeles/Long Beach Clean Truck Program. It was implemented under unique conditions, and parts of the program remain in legal dispute 6 years later. The ports argued that they could impose requirements on those seeking access to their facilities, much as airports regulate taxi and shuttle access. In an LEZ, the local jurisdiction would have to make such an argument, and this would violate current interstate commerce protections. In the absence of jurisdictional authority, an LEZ would have to be established as a voluntary program. Cities might offer off-hours delivery or other benefits, but these could be offered without the structure of an LEZ. Otherwise, cities would have to offer subsidies to purchase and operate cleaner vehicles, which is unlikely given fiscal and political constraints.

4.2.2.4 Alternative Modes

Efforts to shift truck freight to slower but more energy-efficient and cleaner modes have not been successful. The Paris Monoprix experiment of using the regional rail system to ship goods to central Paris for distribution and delivery requires large public subsidies. Studies of using commuter rail for package delivery in both the United States and Europe failed to result in demonstrations or experiments. Efforts to shift freight to water have been similarly unsuccessful, in both the cases of coastal shipping and river transport, with a few exceptions such as parcel and beer distribution in some Dutch cities on inner canals. In fact, waterborne freight continues to lose market share in the United States.

Mode shifting has large impacts on the supply chain. In order to use a slower mode, cargo owners must hold the inventory longer, and these inventory costs tend to exceed the higher costs of using faster modes. In addition, mixing modes adds to the number of times shipments must be handled, further increasing labor and facility costs. The most promising segments for mode shifting are (1) through freight traffic (port or airport imports/exports) in large volumes, as for example increasing on-dock rail facilities to eliminate short drayage trips, or (2) large-volume, longer distance deliveries (say to distant distribution and warehouse centers) where use of rail is close to competitive with use of trucks.

It is important to note that the research team's assessment is based on the lack of mechanisms to offset private costs in order to achieve public benefits. It may well be the case (as was shown for short sea shipping in New York) that the social benefits of reduced pollution and energy consumption have greater value than the added costs to shippers and cargo owners.

4.2.2.5 Environmental Justice

The United States has taken the lead in the incorporation of environmental justice as a performance measure for new freight projects. In part, this is due to the geography of U.S.

[30] The research team notes that whether LEZs generate net benefits is uncertain, as the elimination of small operators would eliminate jobs and small businesses.

cities, where poor and minority populations tend to be concentrated near major freight facilities. The environmental review process provides a venue for environmental justice concerns. More recent research on the relationship between emissions and health has created an imperative for industry to find solutions to problems that might otherwise prevent them from securing the needed support of elected officials and regulatory agencies. Environmental justice considerations are therefore widely institutionalized in the transportation planning process. Examples include the Southern California Association of Governments' (SCAG's) Toolkit for Goods Movement, New York City's truck impact study, and Baltimore's industrial overlay zone study. Some of the most effective, long-lasting, and widespread solutions to environmental justice problems have been industry driven or have involved industry–government partnerships. These include clean truck programs, certification and labeling programs, and off-peak deliveries.

U.S. ports have been particularly proactive in addressing environmental justice concerns. In addition to the extreme case of Southern California, clean truck programs, freight rail investments, and elimination of at-grade rail crossings are part of programs in New York/New Jersey, Seattle, and Oakland, as well as Chicago and Atlanta—two major intermodal hub cities. Environmental justice, however, remains a contentious topic, and solutions to the inequitable incidence of freight transport impacts are often difficult. Research is needed to better understand the effectiveness of alternative mitigation strategies on local communities.

4.2.3 Trade Node Strategies

Unlike the last-mile and environmental strategies outlined above, the majority of trade node strategies have been developed and tested in the U.S. context. The largest trade nodes—in particular, Southern California—have had the greatest influence in the development of strategies to address environmental problems. In the Southern California gateway, which includes the Ports of Los Angeles and Long Beach and Los Angeles International Airport (LAX), the threat of legislative mandates and rising trade volumes created a unique set of conditions that favored an industry-driven response to environmental pressures. The question is whether the same conditions exist in other places in the United States.

Both political pressure and competitive pressures exist in other parts of the world, but it is apparent from the research that the two in combination drive the environmental agenda in trade gateways. Rising trade volumes have increased throughput at major gateways in Europe and Asia as well as in North America, but for ports that serve as major transshipment centers, where cargo moves largely from one vessel to another, the landside pressures are not as great. Many leading Asian ports serve as trans-shipment centers. For trade gateways located in places with strict environmental controls (like those in Europe), the volumes may not be as great, and the principal concern may be with congestion in the urban core. In the United States, however, where good intermodal connections encourage the development of pass-through traffic transited through trans-load centers, the gateway plays a pivotal role in framing the debate surrounding the environmental impacts of trade. Trade node strategies are highlighted in Table 14.

4.2.3.1 Appointments and Pricing Strategies at Ports

Increased congestion at maritime ports encouraged solutions that attempted to spread out the flow of truck traffic passing through terminal gates across more hours of the day. As noted with several strategies discussed above, truck traffic at ports is part of a complex set of movements that make up the supply chain. Thus, the feasibility and effectiveness of different strategies depends on how the supply chain is affected.

Truck appointments or reservation systems were a logical first step in seeking a smoother flow of port truck traffic. Appointments have been implemented at several ports. They have the potential to increase the efficiency of port operations and therefore reduce truck turn times (hence reducing truck idling), but to date there is little evidence that such efficiencies are being realized. Appointments require operational changes by terminal operators, so appointments are likely to be used effectively only when yard congestion makes it worthwhile. Thus, although appointment systems are proposed as a means for reducing truck queuing at gates (and hence reducing emissions), their effectiveness depends on whether they offer efficiency benefits for terminal operators.

The sole example of pricing-based terminal gate operations is the PierPASS program in Southern California. PierPASS was intended to reduce road congestion, and it proved successful at shifting a significant amount of eligible cargo to the evening (approximately 40 percent). It also created a possible model for other ports by facilitating cooperation among competitors through discussion agreements approved by the FMC as well as cooperation between industry and elected officials.

The model has not been transferred elsewhere in the United States, however. No other U.S. metropolitan area has the severity of congestion and air pollution to motivate use of peak fees, and no other port is inclined to take the risk of losing business in response to a fee. Thus, although pricing is clearly an effective way to spread port truck traffic more smoothly across the day, it is not likely to be adopted at other ports. The model also promotes changes along the rest of the supply chain, including at distribution centers and retail

Table 14. Trade node strategies.

Strategy	Location	Description
Congestion pricing: marine terminal gates	Los Angeles/ Long Beach Ports	PierPASS off-peak program
	Vancouver	Off-peak gate program
	Busan, South Korea	Evening gate program
Congestion pricing: road pricing	New York City	Proposed pricing
	Europe	Truck VMT pricing
Truck reservation and appointment system	Los Angeles, Long Beach, and Oakland Ports	Reduction of truck queues at marine terminals under CA state law (Assembly Bill 2650)
	Port of Vancouver	Reservation system
Lane separation/ Truck-only lanes	Georgia	Statewide truck-only lanes (proposed)
	South Boston, Southern CA, Port of New Orleans	Short-distance/truck-only access roads
Elimination of at-grade crossings	Los Angeles	Alameda Corridor
	Greater Los Angeles	Alameda Corridor East
	Chicago	CREATE
	Seattle	FAST program
Border crossing delays	Washington State	FAST Corridor
	U.S./Mexico Border Crossing	Pilot program
Accelerated emissions reduction	Los Angeles/ Long Beach Ports	Clean Air Action Plan Clean Trucks Program
	Port of Vancouver	Truck Licensing Program
	New York and New Jersey, Seattle, Oakland	Voluntary truck emissions programs
Equipment management	New York and New Jersey, Oakland	Virtual Container Yards
	Worldwide	Industry-driven chassis pools

establishments, which presumably also operate on more traditional work schedules. The net benefits at the system level are not yet proven.

4.2.3.2 Road Pricing and Dedicated Truck Lanes to Manage Hub-Related Truck Traffic

Despite the demonstrated effectiveness of congestion pricing in the few places where it has been implemented, pricing strategies continue to be difficult to implement. There is more use of pricing strategies in Europe and Asia than in the United States and at least a few examples of truck pricing—notably, the weight-distance fees in Switzerland, Austria, and Germany and the cordon pricing scheme in London. There are numerous proposals for truck tolls in the United States, including the New York bridge toll plan, and proposed tolled truck lanes in Atlanta and in Los Angeles, but none of them have even reached the stage of being part of an accepted project.

Truck pricing is perhaps more difficult than pricing of passenger cars because of the competition between truck and rail. The trucking industry argues that they already pay their "fair share" for using the roadways, and additional charges would reduce their competitiveness with rail. From an environmental perspective, if trucking generates more emissions per ton of freight carried, this shift would be socially beneficial despite the negative impact on the trucking industry. Despite the promise of pricing strategies for managing congestion, implementation of pricing strategies will require extensive education and political leadership.

A second strategy (often linked with tolls to offer a funding mechanism) is truck-only lanes. They have been proposed in major metropolitan areas (most notably Atlanta) and included in regional transportation plans. Truck-only lanes have failed due to lack of funding and scarcity of land. Truck lanes are costly to build due to pavement and geometry requirements and can rarely be justified on the basis of truck volumes. The truck lanes that currently exist in this country are largely access roads; they include the 1.5-mile South Boston Haul Road for commercial vehicles, the I-5 truck bypass lanes in Los Angeles, and the Clarence Henry Truckway, which provides truck-only access to Mississippi River terminals in New Orleans. Given the fiscal constraints facing the U.S. highway system, truck-only facilities do not appear to be a promising option for dealing with truck traffic.

4.2.3.3 Accelerated Truck Emissions Reduction Programs

Given the success in the United States of national regulation to increase fuel efficiency and decrease emissions of the vehicle fleet, a logical extension of regulation is to accelerate the introduction and use of cleaner vehicles at trade nodes. Several U.S. ports have "clean truck" programs, which are intended to accelerate the use of cleaner diesel and AFVs in drayage trucking. The most aggressive effort is the Clean Truck Program at the Los Angeles/Long Beach ports; Seattle, Oakland, and New York/New Jersey have programs with more flexibility and less aggressive targets. These programs are examples of voluntary regulation: the targets are reached via negotiation and are beyond regulatory requirements. As voluntary, negotiated programs, they are a good fit in the U.S. context. The targets and program structure differ from place to place, reflecting the different circumstances of each metropolitan area.

The Clean Truck Program has been successful in turning over almost an entire drayage trucking fleet. While the Clean Truck Program had many consequences (lawsuits that continue as this report is written, conflicts between port stakeholders, many independent operators driven out of business), it also achieved its goal of large emissions reductions from port-related sources. Similarly, it appears that the other programs are progressing as anticipated. These "beyond compliance" voluntary efforts are successful and have good potential for more widespread adoption.

4.2.3.4 Equipment Management

Another potential strategy for reducing truck VMT is to use port-related freight equipment—chassis and containers—more efficiently. Section 2.3 describes how ownership practices often require the repositioning of containers and chassis, which can result in additional truck trips and increased VMT. If these ownership practices were relaxed, it would become possible to share containers and chassis, reducing VMT associated with picking up or moving containers or chassis. VCY allow truckers to locate and use an empty container close to the site where they have an import drop-off, thereby eliminating a non-revenue trip to a terminal where the empties are typically stored.

Although carrier-owned (steamship line) chassis are still the dominant model in the United States, there are experiments with different models. Maersk, the world's largest shipping line, decided to change its equipment management structure in 2009. Maersk owns some 90,000 chassis in the United States, a significant percentage of the 550,000 chassis in use. Maersk's ChassisLink, launched in August 2009 in the Port of New York and New Jersey, charges truckers a daily fee—initially $11—which allows them to use a Maersk chassis any way they want and make as many trips as they want until it is returned. Since then, three industry approaches have emerged: (1) carriers charge truckers for equipment usage, (2) carriers divest themselves of equipment fleets and require truckers to lease equipment from a third party, or (3) carriers pool their equipment with other ocean carriers. In some cases, carriers adopt some combination of these approaches.

Equipment owners are motivated to experiment with different models due to the growing standardization of equipment characteristics (and therefore the declining value of branding one's own equipment), the cost of owning equipment that is idle much of the time, and the cost of storing equipment at land facilities. Despite such motivations, public sector assistance may be necessary to assist with land assemblage for shared equipment facilities and to sponsor studies that document the savings from such programs.

Shared equipment offers a promising way to reduce truck trips while increasing the efficiency of port-related freight operations. Since it is industry motivated, it is a good fit in the U.S. context. The research team is unaware of studies that quantify the savings from shared equipment programs; this is clearly a topic for future research.

4.2.3.5 Rail Strategies

Efficient rail and intermodal facilities are critical to international trade. However, at-grade rail crossings are vulnerable to conflicts among high-volume rail corridors, surface road traffic, and passenger commuter rail traffic. The main trade node city strategy to address these problems is capital investment to increase rail capacity and to eliminate at-grade rail crossings. The Alameda Corridor is a good example of both increasing rail capacity and reducing at-grade conflicts. CREATE in Chicago is a more ambitious project that seeks to rationalize the maze of rail and highway networks that converge in Chicago. A lesser known example is ReTrac, in Reno, Nevada, which relocated a major rail corridor and reconstructed it below grade to reduce impacts on downtown Reno.

The major challenge to capital investment strategies is the lack of an obvious funding source. Railroads have little incentive to incur costs to solve a problem for road transport and, hence, are typically unwilling to pay for these investments. Local jurisdictions have no authority to force railroads to incur these costs, and local jurisdictions also have little incentive to pay for these investments, as they view rail traffic as a national responsibility. At the national level, there is no specific funding source for such projects. Federal funding has in the past come from earmarks.[31] In concept, capital investments to reduce the impacts of rail on local residents and at the same time to increase rail efficiency are a reasonable and effective strategy. However, absent a federal funding source,

[31] The freight programs in SAFETEA-LU were largely earmarked; see Giuliano (2007) for details.

such investments do not happen, as in the case of Alameda Corridor East.

4.2.3.6 Border Crossings

Border crossing regions are a unique subset of trade nodes. Like port regions, border crossings generate truck traffic destined for local distribution or transfer facilities as well as markets beyond the immediate metropolitan area. This means last-mile impacts as well as the pass-through impacts. Border crossings provide a unique challenge with regard to managing regional freight capacity because of their international context. Both assessing and mitigating the negative impact of freight flows can be problematic and data collection can be difficult.

The results of this research suggest that the literature on cross-border freight management is decidedly underdeveloped. ITS-based projects have been used to mitigate delays at border crossings, but fewer projects (with the exception of the Pacific Northwest FAST project) have taken a more comprehensive approach to cross-border freight management. A more comprehensive approach would factor in issues in addition to delays at the border itself, including a lack of driver preparedness and the need for trusted traveler programs. The unique nature of North American border crossings (including the United States, Canada, and Mexico) demands responses that are tailored to the type of activity at each location.

4.3 Recommendations

4.3.1 Urban Freight Management Strategies

The research team's review and assessment suggests some promising options for improved management of freight in U.S. cities and metropolitan areas. The findings of this research are summarized in Table 15. Each strategy discussed previously is rated based on its effectiveness (meaning the extent to which the intended objectives were achieved) and applicability to the U.S. context. The section number in this report in which each strategy is discussed is also given in Table 15. Among the last-mile strategies, labeling and certification programs, land use planning (in the longer term), and off-hours deliveries are the most effective strategies. However, off-hours delivery programs are less transferable due to the many changes they require across the supply chain. Traffic and parking regulations are less effective, because they do not have an impact on the underlying demand for freight moves. The research team has rated the effectiveness of ITS strategies as medium due to their limited implementation feasibility and the need for more development of some of the most potentially beneficial applications, such as truck parking and loading information systems.

Within the category of environmental strategies, global fuel efficiency and emissions regulations have proven their effectiveness over several decades. LEZs are the most effective at addressing local hot spots, but do not appear to be feasible

Table 15. Summary of strategies and their effectiveness and applicability to the United States.

	Section Number	Strategy	Effectiveness	Applicability to United States
Last-mile	4.2.1.1	Labeling or other certification programs	High	High
	4.2.1.2	Traffic and parking regulations	Medium	High
	4.2.1.3	Land use planning policies	High	High
	4.2.1.4	City logistics and consolidation schemes	Low	Low
	4.2.1.5	Off-hours deliveries	High	Medium
	4.2.1.6	Intelligent transport systems	Medium	Medium
Environment	4.2.2.1	Truck fuel efficiency and emissions standards	High	High
	4.2.2.2	Alternative fuels and vehicles	Low	Medium
	4.2.2.3	Low emission zones	High	Low
	4.2.2.4	Alternative modes	Low	Low
	4.2.2.5	Environmental justice	Medium	High
Trade node	4.2.3.1	Appointments and pricing strategies at ports	Medium	High
	4.2.3.2	Road pricing and dedicated truck lanes to manage hub-related truck traffic	High	Low
	4.2.3.3	Accelerated truck emissions reduction programs	High	Medium
	4.2.3.4	Equipment management	Medium	Medium
	4.2.3.5	Rail strategies	Medium	Medium
	4.2.3.6	Border crossings	Medium	High

under current U.S. national and state policies. AFVs may prove to be very effective in the long term, but the technology and market penetration are not yet sufficient to achieve significant reductions in emissions or energy consumption. Environmental justice efforts are more advanced in the United States than in other countries; however, environmental justice problems are challenging to solve.

Among the trade node strategies, road pricing and accelerated emissions programs are among the most effective strategies. Despite the effectiveness of road pricing, the research team has rated its applicability as low because of the continuing strong political opposition from various stakeholder groups. Accelerated emissions-reduction programs based on negotiation and voluntary targets have proven to be effective and are a better fit in the U.S. context. Rail strategies can be effective, but involve high costs for which funding sources are not obvious.

4.3.2 Future Research Needs

There are many opportunities for further research. First, most cities cannot answer the following questions: How many vehicles (be it a heavy-duty truck, a light-duty truck, a van, a car, or even a bike) are engaged in commercial activity? How many deliveries and pick-ups occur in a day or a week? As an example, the research team found little information on van deliveries and small package services. Data on delivery characteristics that are accessible to planners and researchers are almost non-existent. Without these data, it is hard to confirm or refute conventional wisdom such as the idea that the rise of e-commerce means a net increase in commercial VMT. It may be that as people shift to buying goods online, small parcel delivery trucks are fuller, but do not increase their VMT. It may also be that as consumers buy fewer products in stores, those retailers get fewer deliveries (although as today's urban economy requires more frequent, customized deliveries, this may be unlikely). The basic task of describing the current state of urban freight flows is clearly a research priority.

Additionally, the research team has found that while there is abundant research on system optimization, there is little research on how optimization methods work out in practice. Better data are needed on, for example, real-time route optimization that is based on actual fleet movements. Border crossings are a place where this could be done. Similarly, there is a great need for field tests in the area of technology deployment.

Since many urban areas are watching their logistics industry simultaneously decentralize and consolidate, studying the effect of this phenomenon on VMT is critical. It may be that the efficiency gains of consolidation outweigh the increase in VMT attributable to decentralization. If so, regions may wish to facilitate or even encourage these shifts. Of course, the converse may be true, resulting in its own policy implications.

As centralization-consolidation occurs in the logistics industry, there are winners and losers. Central city neighborhoods may welcome the exodus, but the move is just a shift in the problem. With regard to consolidation, are dense freight centers worse for the environment than multiple smaller, dispersed facilities?

One of the biggest problems associated with urban freight is truck emissions, and this review has shown the many different approaches being taken to address this problem. There seems to be limited information on the relative benefits and costs of truck registry systems, certification systems, or LEZs. Research is needed to better understand the effectiveness of these strategies. For example, in the case of LEZs, (1) what are the associated costs for both the government and logistics firms; (2) what is the impact on the trucking industry; and (3) are LEZs legally possible in the United States and, if so, at what level of government?

Finally, there is a need for careful and systematic evaluation of existing policies and experiments. There is a lack of analysis of the impacts of certification schemes, truck access restrictions, and requirements for alternative fuel trucks. Ongoing experimentation provides a rich resource for discovering whether these efforts have the expected results or have unintended consequences that reduce their benefits.

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Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation