EFFECTIVE DECISION-MAKING METHODS FOR FREIGHT-EFFICIENT LAND USE

FINAL REPORT

Prepared for National Cooperative Highway Research Program (NCHRP)

Transportation Research Board

of

The National Academies of Science, Engineering and Medicine

José Holguín-Veras, Cara Wang, Juvena Ng, Diana Ramírez-Ríos, Jeffrey Wojtowicz, Oriana Calderón, Benjamin Caron, Carlos Rivera-González, Sofía Pérez, Joshua Schmid, Woojung Kim, Abdelrahman Ismael, and Julia Coutinho Amaral
Rensselaer Polytechnic Institute
Troy, NY

Catherine Lawson
State University of New York at Albany
Albany, NY

Daniel Haake
HDR
Indianapolis, IN

March 2020

ACKNOWLEDGMENT OF SPONSORSHIP

This work was sponsored by the National Cooperative Highway Research Program Project 08-111, "Effective Decision-Making Methods for Freight-Efficient Land Use." The team is grateful to the NCHRP program officers, to the members of the panel, and also to the participants of the Peer Exchange Workshop who provided insightful remarks that helped shaped the final version of this research's products.

DISCLAIMER

TABLE OF CONTENTS

Executive Summary 1

1 Introduction 6

2 Summary of Phase 1 Research 9

2.1 Task 1: Kick-Off Meeting 9

2.2 Task 2: Analyze Land-Use Concepts and FELUs 9

2.2.1 Concept of Freight-Efficient Land Uses 9

2.2.2 Identification of Existing and Potential Land-Use Practices 13

2.2.3 Evaluation of Land-Use Practices on Freight Activity 16

2.3 Task 3: Identify Emerging Market and Technological Trends 20

2.4 Task 4: Land-Use Policy and Decision-Making Framework 23

2.5 Task 5: Assessment of Impacts 24

2.5.1 Re-purposing the BMS 25

2.5.2 Baseline simulation of case study 26

2.5.3 Selection of land-use initiatives 27

2.5.4 Final simulation of case study 27

2.5.5 Post-processing of results to obtain social and economic indicators 27

3 Summary of Phase 2 Research 28

3.1 Task 6: Interim Report and Peer Exchange Workshop 28

3.1.1 Agenda Detail 29

3.1.2 Public and Private-Sector Workshop Participants 30

3.2 Task 7: Production of Decision Support Tools and Methods 30

3.3 Task 8: Land-use Policy and Decision-Making for FELUs 31

3.4 Task 9: Final Deliverables 32

3.4.1 A Guide for Effective Freight-Efficient Land Use Planning and Decision-Making 32

3.4.2 Land-Use and Transportation Initiative Selector 33

3.4.3 Behavioral Micro-Simulation for Freight Efficient Land Uses (BMS-FELU) 34

4 Implementation of Research Findings and Products 35

4.1 Putting Research Findings/Products into Practice 35

4.2 Challenges for Implementation and Measuring the Impact of Products 37

5 Conclusions and Recommendations 38
Appendix A: NCHRP 08-111 Kick-off Meeting Minutes 40
Appendix B: List of Webinars 43
Appendix C: NCHRP 08-111 Peer Exchange Workshop Summary 46
Appendix D: Workshop Participants 53
6 References 55

EXECUTIVE SUMMARY

The purpose of this summary is to provide a high-level view of the overall strategy adopted by the NCHRP 08-111 project team to conduct the "Effective Decision-Making Methods for Freight-Efficient Land Use (FELU)" project, including the definition of goals and guiding principles, and the work done.

Urban and metropolitan areas exist because they are efficient markets where goods and services are traded, individuals can find suitable employment opportunities, and companies can find the personnel they need. At the heart of these activities is the production and consumption of physical goods. Without a doubt, the vast majority of human and economic activities—including highly sophisticated service activities—utilize physical goods in one form or another. In this context, the **ultimate goal** of land-use planning, in relation to freight activity, should be to help achieve a seamless integration of freight activity into urban, suburban, and rural areas in ways that foster quality of life and livability, enhance economic competitiveness and efficiency, and reduce congestion and such related externalities as emissions, crashes, and conflicts with other road and sidewalk users. Achieving this goal, however, requires the implementation of land-use initiatives that seek to:

(1) Maximize the beneficial impacts associated with the production and consumption of physical goods, while mitigating or eliminating the externalities produced by the resulting freight traffic; and,

(2) Recognize the dramatic effects of economic and technological trends—particularly, e-commerce and novel freight technologies—that are reshaping, and will continue to reshape, consumer behavior, transportation systems, land use, and the economy.

As implied in consideration (1), it is important to consider the production and consumption of goods separately from the freight traffic that is generated. The reason is that freight generation—both freight production and attraction—is, in most cases, an inherently beneficial activity that increases economic welfare and wellbeing by making it possible for businesses and individuals to access needed supplies. In most cases the places of production are physically separated from the places of consumption, therefore the physical transport of goods to consumption locations is required. The resulting freight traffic—a byproduct of the economic transactions—produces negative externalities. Instead of curtailing freight traffic, which is bound to have negative impacts on the economy, the best approach is to use policies to maximize the benefits of the activities that produce and consume goods, while minimizing the negative externalities produced by the associated freight traffic. Properly accounting for the effects of e-commerce and emergent technologies on consumer behavior, transportation systems, land use, and the economy—as suggested in consideration (2)—is imperative because their interactions determine the amount and nature of the freight activity. It suffices to say that the number of deliveries and shipments in the US, driven by e-commerce, has more than tripled since before e-commerce. Notwithstanding the major changes already produced by e-commerce, all signs indicate that the speed of the transformation and the depth of the impacts produced by e-commerce will increase with the eventual deployment of such emergent vehicular technologies as autonomous freight vehicles, including delivery droids, drones and others. These trends have a direct implication on land use and transportation. The fully or semi-automated freight vehicles, on the one hand, will tend to increase the distance of facilities and decrease the delivery frequency, while promoting long-haul travel. On the other hand, the drones and delivery droids will shift the location of facilities closer and increase the frequency of deliveries.

The term *freight activity* is used here to collectively refer to all manifestations of production and supply chain systems—the flows of freight (the supplies) and freight trips (the vehicles), and the associated pick-ups and deliveries—that materialize at the urban, suburban, and rural levels.

In considering freight activity, it is important to make a distinction between two sets of metrics: (1) *deliveries received* and *shipments sent out*, and (2) the *freight vehicle-trips* that arrive at the establishment (*freight trip attraction*) and the freight vehicle-trips that depart from the establishment to deliver shipments elsewhere (*freight trip production*). While the number of deliveries and shipments are associated with the characteristics of the establishments, the number of freight trips produced depends on the ability of freight carriers to consolidate multiple deliveries and shipments in the same trip. In situations where multiple deliveries are made to locations in close proximity to each other, they could be made as part of the same trip. In contrast, a single delivery to an isolated location requires a freight trip. Fostering consolidation of deliveries destined for nearby areas, whenever possible, could indeed reduce the number of freight trips and the associated externalities, without materially impacting the production and consumption of the supplies. These metrics do not distinguish between types of vehicles, yet the most common types of delivery vehicles are delivery vans and small trucks. These vehicles typically represent between 80 to 90% of the total freight traffic in urban areas (Holguín-Veras et al., 2017a).

Throughout the Guide, to facilitate the exposition, the term *business-to-consumer (B2C)* is used to refer to the freight activity associated with consumer-oriented e-commerce, while *business-to-business (B2B)* represents B2C's counterpart for commercial establishments.

Land-use planning and policymaking is central to how communities manage their economic activity and the social and environmental impacts these activities have. Because of this central role, enhancing land-use practices to better incorporate the needs and impacts of freight activity has strong potential to improve the efficiency of their associated supply chains. Freight activity is integral to the economic activity of every municipality, both large and small. However, in any concept of freight, efficiency is highly dependent on land-use plans and the decisions made by transportation stakeholders.

Freight-Efficient Land Uses (FELUs) are the land-use patterns that minimize the social costs (private plus external costs) associated with both the supply chains and the economic activities that consume and produce goods, at all stages of production and consumption; including reverse and waste logistics.

The main goal of NCHRP Project 08-111 "Effective Decision-Making Methods for Freight-Efficient Land Use" was to develop tools that assist land-use and transportation decision-makers in supporting the efficient movement of freight. A key deliverable to accomplish this task is the Planning Guide (the Guide), a unique document designed to prepare practitioners to make land use decisions that, step by step, lead to freight-efficient land uses (FELUs) by providing them with the tools needed to analyse the freight efficiency of current and future land uses in their jurisdictions, and identify and select initiatives. The Guide attempts to be both rigorous in the treatment of the subject matter, and pragmatic in the formulation of the suggested FELU process. Due to their importance, the Guide places a great deal of emphasis on the economic activities that create supply chains and freight traffic. The reason is simple: solid knowledge of these interconnections will help ensure that land-use planners and policymakers are aware of the broader impacts of their decisions. Emphasis has been placed on the use of the team's state-of-the-art research results. Throughout the Guide, these results are discussed to help the reader understand the role played by supply chains in the economy, the associated externalities, and the ways that land-use planning can play a constructive role in fostering

freight sustainability. As a starting point for integrating FELU concepts into current land-use practices, several key principles were identified. The principles are:

#1: Minimize the private and external costs of supply chains and their stages

#2: Reduce the distance traveled at supply chain stages, up and downstream

#3: Mitigate, or eliminate, the externalities at supply chain nodes and Large Traffic Generators (LTGs)

#4: Recognize and account for local conditions

#5: Proactively engage all stakeholders

The first principle highlights that land-use planning should consider the effects of land-use decisions across all supply chains, as only focusing on the effects at specific locations could lead to significant unintended effects. The second principle provides a pragmatic and robust rule that operationalizes the FELU decision-making process. The gradual implementation of this rule will result in more compact and efficient supply chains. The third principle reflects the social and economic imperative of ensuring that LTGs, such as distribution centers and ports, do not negatively impact the surrounding communities. The fourth principle explicitly states the importance of context appropriate and sensitive FELU initiatives. The fifth Principle recognizes the importance of participatory exercises to ensure that all involved contribute to the development of sound land-use planning and policy.

Developing a set of tools and recommendations that are applicable to a wide variety of agencies and regions is a challenging task. They have to consider the heterogeneity in land-use patterns, economic conditions, and government structures across the United States. To help consider the local context, the project team developed tools and methods to evaluate existing conditions unique to local areas and to understand how these conditions influence freight mobility. The methods rely on publicly available data that allow the tools to be more accessible to practitioners that seek to understand the geographic distribution of freight activity and the separation between key stages of the supply chain.

The term *initiative* is used here to refer to an entire spectrum of mechanisms, including projects, programs, regulations, and policies, that the public and private sectors can use to foster sustainable practices.

A key component of this research effort was to develop a comprehensive list of initiatives that promote freight efficiency. These recommendations are not only limited to those that alter land-uses, but also include complementary transportation initiatives that support freight-efficient operations. To ensure the reader has a holistic treatment of how to address freight issues, the team included—with approval from NCHRP—the urban freight transportation decision-making process and the freight transportation initiatives identified in NCFRP Report 33 (Holguín-Veras et al., 2015). The freight transportation initiatives from NCFRP Report 33 were combined with the ones designed as part of this project to form a comprehensive framework that encompass both land-use and transportation initiatives.

Initiatives were conceived based on literature reviews, expert academic and practitioner knowledge, and discussions with public and private sector stakeholders, all of which sum to over 300 references. Forty-three land-use-related initiatives and sixty-one transportation-related initiatives were categorized into several major groups, listed and described below:

<u>BOTH LAND-USE-RELATED AND TRANSPORTATION-RELATED INITIATIVES:</u>

- **Facilities/Infrastructure Management**: construct or upgrade private or public facilities and infrastructure to enhance freight efficiency

- **Parking/Loading Areas Management**: expand parking and loading areas or optimize the space available for these activities to maximize freight efficiency
- **Pricing, Incentives, and Taxation**: use monetary transactions or voluntary regulations to incentivize and encourage FELUs
- **Stakeholder Engagement**: facilitate stakeholder interactions and provide platforms that allow education, communication and collaboration between stakeholders

LAND-USE-RELATED INITIATIVES:

- **Long-term Planning**: employ planning tools or planning strategies that foster FELUs while acknowledging the local economic and land-use conditions
- **Zoning**: utilize zoning tools (either regulatory controls or discretionary approaches) as ways to enhance freight movements and reduce the negative externalities created by freight activity
- **Site/Building Design**: change the design of sites and buildings to minimize or eliminate the negative effects of freight activity on surrounding communities

TRANSPORTATION-RELATED INITIATIVES:

- **Vehicle-related Strategies**: foster the use of technologies and practices that reduce the negative externalities produced by freight vehicles
- **Traffic Management**: improve traffic conditions using techniques from traffic engineering and control, including vehicle restrictions, time restrictions, and traffic control
- **Logistical Management**: implement intelligent transportation systems and improved last-mile delivery practices to coordinate local freight activity
- **Freight Demand Management**: address the negative externalities generated by freight activity by altering the modes of travel and the timing of deliveries

Each initiative is accompanied by a short description, analysis of the initiative's implementation barriers and potential unintended effects, and examples of best practice implementations.

By design, the Guide allows the user to explore only land-use initiatives, only transportation initiatives, or both. The team expects that by presenting both land-use and transportation initiatives together, transportation and land-use practitioners will be able to familiarize themselves with the tools used by both areas. Achieving a better understanding of each type of initiative's strengths and limitations will facilitate better coordination. This is particularly important because combining land-use and transportation initiatives may have substantial positive results. That is, land-use initiatives can help achieve transportation objectives, while transportation initiatives can help foster FELUs. These synergies must be exploited to the fullest.

Another key deliverable of this project is the Behavioral Micro-Simulation for Freight Efficent Land Uses (BMS-FELU), a software tool that uses data to simulate freight and freight vehicles flowing through a metropolitan area. The BMS-FELU software estimates the routes and aggregated performance measures such as total vehicle miles traveled (VMT) by freight vehicles and transportation costs. The BMS-FELU software also simulates the consequences of alternative land-use policies to assess their effectiveness from the perspective of freight efficiency.

The following document acts as the final report for NCHRP Project 08-111. Chapter 1 provides an overview of the NCHRP 08-111 research project. Chapters 2 and 3 summarize the key findings and processes followed in each task for Phase 1 and 2 respectively. Chapter 4 discusses the main deliverables of the project

and the target audience of each product. Chapter 5 concludes the project and provides recommendations for future works. The last sections contain references and appendices that accompany this report.

1 INTRODUCTION

Land-use planning and zoning are tools used by decision-makers to regulate the use of land by specifying the types of economic activities that can take place in a given area. Land-use planning and zoning can profoundly affect the efficiency of supply chains and freight activities, and not always in a beneficial manner. Quite often, land-use planning and zoning are conducted with only a partial view of the role of supply chains in metropolitan areas. Although it is natural to focus attention on the most visible form of freight infrastructure—airports, marine ports, manufacturing sites, and distribution centers, and the like—the reality is that supply chain and freight activities are not limited to these "Large Traffic Generators" (LTGs). Supply chains are pervasive. At the highest level, global supply chains interconnect large regions of the world through these LTGs. National/regional supply chains serve the needs of population centers and LTGs, connecting global supply chains to metropolitan/urban economies and supply chains. At the local level, there are innumerable supply chains that serve the myriad of establishments at the core of local economies.

Supply chains are the backbone of the economy, yet emerging trends and technologies can transform supply chains, freight transportation systems, and the spatial distribution of economic activities in ways that are not foreseen or fully understood. Trends such as globalization have lifted millions of people in developing countries out of poverty, while large portions of traditional manufacturing activities in developed countries have been wiped out, leading to dramatic changes in land-use patterns and rising concerns about the environmental effects of the resulting freight transportation activity. In contrast to years ago—when local supply chains handled mostly local products with minimal interactions with global supply chains—all levels of supply chains are now tightly interconnected. A store in the Midwest may sell T-shirts made in Bangladesh; a diner at a Seattle restaurant may enjoy Kobe beef or Chilean grapes; a shopper in Memphis may be pondering whether to buy high-end leather boots from Finland or a pair made in Australia.

Emergent technologies are producing, and will continue to produce, major changes in the economy, supply chains, and land-use patterns. Smart City technologies, truck platooning, drones, 3D Printing, delivery crowdsourcing, and others are already making their mark. Truck platooning—where a single driver operates a chain of connected trucks—will provide a new alternative transportation mode with characteristics of both trucking and rail freight. This could lead to the use of platoons of ten or more trucks transporting containers from marine ports to distribution centers, inducing changes in the location of these facilities and freeing up land for other uses. 3D Printing may lead to the decentralization of manufacturing, and to the development of on-demand manufacturing; the space occupied by former manufacturing sites may be freed up for other uses, with an increase in demand for space for small-scale manufacturing throughout metropolitan areas. Drones could play a role in transporting high-priority small shipments, though in so doing, drones would require the provision of suitable land and airspace. Smart City technologies offer a framework that integrates these technologies, providing a measure of public policy on what otherwise could be a process driven solely by private-sector forces. However, this poses challenging questions related to the proper balance between the private-sector interests of technology developers, and broader, societal interests in achieving sustainable and livable cities. These scenarios exemplify what planners may have to contend with in the near future. Although the extent and direction of these impacts are not yet clear, they must be anticipated to take preparatory steps and corrective actions to minimize negative impacts.

The profound diversity in land-use patterns in metropolitan areas, and among jurisdictions within those areas, presents other challenges to fostering freight-efficient land uses. At one end of the spectrum, metropolitan areas like Los Angeles, Chicago, and New York City serve as major freight hubs and global gateways. The local supply chains and freight transportation systems in those areas facilitate global trade while

handling significant demand to sustain their regional/local economies. Midsize areas, such as Memphis and Kansas City are major freight hubs, but their freight activity related to national/regional supply chains is relatively narrow and specific, with less of a localized impact. Finally, the most common medium and small metropolitan areas generally have mixed economies served by supply chains that are largely dependent on regional hubs located in larger cities.

The heterogeneity among metropolitan areas extends as well to their institutional and decision-making environments; each with their own land-use controls, comprehensive plans, and political environments. To complicate things further, each state has its own unique land-use enabling legislation and case law. Governance structures within a metropolitan area can be very diverse as well. Land-use control may be the responsibility of a city, county, village, or township.

There are also differences between metropolitan areas associated with a wide range of geographic densities of the population and economic activities. Most of the large metropolitan areas in the US have an urban core, with a high density of both population and consumer-oriented businesses, as well as relatively old street networks not originally designed to handle the large number of urban deliveries generated there. The challenges to urban freight mobility in these areas are different from those faced by midsize and small metropolitan areas, where the population density and the density of freight activity are typically lower, and the network capacity is typically not as restricted.

The goal of Freight-Efficient Land Uses (FELUs) is to foster land uses that minimize the social costs associated with supply chain activity. The principles (outlined below) provide guidance for the formulation of FELU programs. Far from being prescriptive, the FELU principles should be interpreted as guidance for action, to be adapted to the local conditions. The principles adopted are:

#1: Minimize the private and external costs of supply chains and their stages
#2: Reduce the distance traveled at supply chain stages, up and downstream
#3: Mitigate, or eliminate, the externalities at supply chain nodes and Large Traffic Generators (LTGs)
#4: Recognize and account for local conditions
#5: Proactively engage all stakeholders

NCHRP 08-111's goal is to respond to challenges facing freight transportation and to the need to fight climate change by developing methods of effective decision-making for freight-efficient land-use (FELU). Due to the rise in internet deliveries to households, in the team's view, this goal could only be accomplished if the decision support tools and methods developed account for the freight and service activity generated by both commercial establishments and households. As stated in the project's proposal, the project was centered on the following objectives:

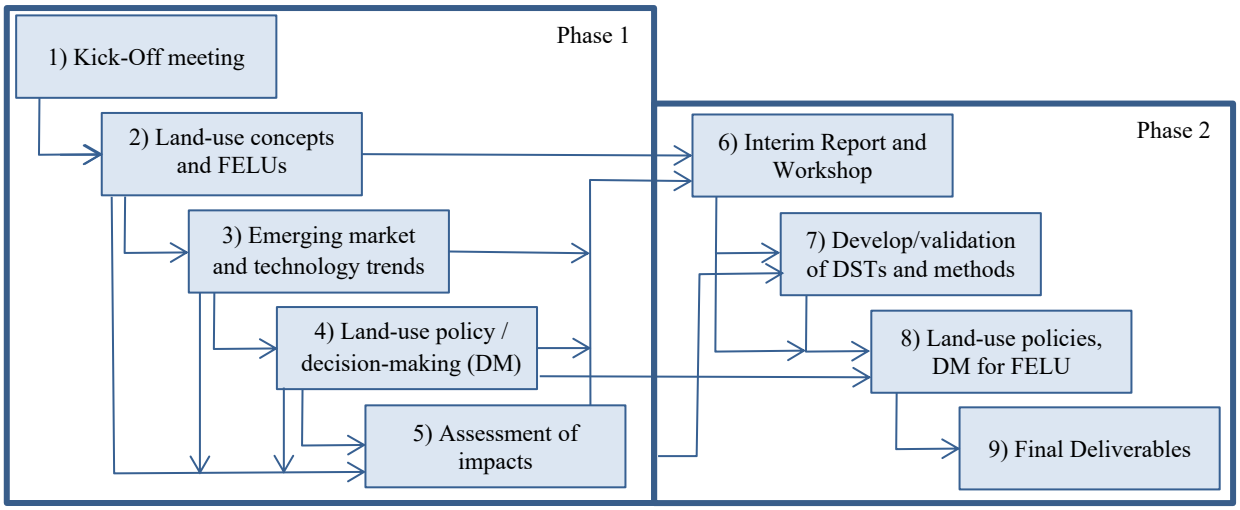
- *Quantify and evaluate the impact of land-use practices and policies to support efficient movement of all modes of freight generated by both commercial establishments and households.*
- *Quantify and evaluate the impact of land-use practices and policies to support efficient movement of the service activity generated by both commercial establishments and households.*
- *Produce quantitative and qualitative land-use assessment tools to assist local, regional, and state land-use and transportation decision makers in supporting efficient movement of freight.*
- *Fully exploit the comprehensive establishment-level and household-level internet-delivery models developed by the team, which together provide a unique foundation to identify FELUs.*
- *Build on the acclaimed DSTs developed by the team for NCFRP 38, which provide a comprehensive*

framework to improve freight systems.

- *Take advantage of the Behavioral Micro-Simulation (BMS) developed with USDOT funding, as it could readily be re-purposed to assess the impacts of land-use decisions.*

To achieve these goals, the research project was separated into a series of tasks, as shown in Figure 1. Phase 1 starts with the Kick-Off meeting and ends with the submission of the Interim Report. During Phase 2, the team developed and refined decision support tools and methods based on feedback from a workshop and finalized the Planning Guide.

Figure 1: Project Work Plan



2 SUMMARY OF PHASE 1 RESEARCH

Phase 1 is very important, as it lays the groundwork for the entire project. The project started with a Kick-Off meeting (Task 1), which was in the form of a webinar, where the team presented the work plan and gathered feedback from the panel. Task 2 focused on developing a thorough conceptual understanding of land-use theory and practices to guide the research work. Task 3 identified the impacts of emerging trends that may influence freight activities and land uses. Task 4 analyzed the land-use decision-making environment to identify its main features, stakeholders, and the best ways to transform practices to foster effective decision-making methods for FELU. In Task 5, the team re-purposed the Behavioral Micro-Simulation, which had been previously used to analyze the impact of off-hour deliveries, to simulate changes in supply chain activity due to altering land-use policies. These efforts allow the estimation of freight VMT, total cost and time spent doing deliveries and pick-ups, and the environmental impacts of freight activity.

2.1 Task 1: Kick-Off Meeting

The NCHRP project panel and the research team were introduced to each other during the kick-off meeting held on April 17, 2017. The goals and objectives of the research were reviewed and the research team sought input on potential case studies and emerging trends, possible efficiency metrics and the overall direction of the research. The minutes of the kick-off meeting can be found in Appendix A.

2.2 Task 2: Analyze Land-Use Concepts and FELUs

The main objective of Task 2 is to develop a thorough conceptual understanding of land-use theory and practice to guide the research work. The work focused on three main areas: definition of FELU concept, identification of existing and potential land-use practices, and evaluation of their impacts on freight activity. A brief description of the work in each area follows.

2.2.1 Concept of Freight-Efficient Land Uses

To foster Freight-Efficient Land Uses (FELUs), it is important to adopt an unambiguous definition of "efficiency" to guide the overall process. In doing so, it should be stressed that the definition of FELUs is *aspirational in nature*, as it represents the goal to be achieved through the application of the principles and tools outlined and developed in this project. Recognizing the need to consider the impacts that freight and supply chain activity have, the following definition is adopted:

> *"Freight-Efficient Land Uses (FELUs) are the land-use patterns that minimize the social costs (private plus external costs) associated with both the supply chains and the economic activities that consume and produce goods, at all stages of production and consumption; including reverse and waste logistics."*

The private costs involve all of the production/logistics/facility costs incurred by the business and infrastructure operators. The external cost is the sum of the externalities produced. An externality is a cost or benefit that affects those who are not directly involved in the economic activity being performed. An example of this is a polluting factory that produces negative health effects on nearby communities, a negative externality. For land-use planning, considering the external costs is important, as not doing so runs the risk of leading to land-use patterns that generate significant externalities that negatively impact local communities.

To demonstrate the importance of considering the externalities caused by land use, a notable example from the New York City (NYC) region provides a compelling lesson. In the early 20th century, the New

York City (NYC) harbor was the biggest and most important port in the United States (Lueck, 1986). NYC's industrial sector grew due to its proximity to the port, and manufacturers crowded near the waterfront so that they could be near shippers (Boyd, 2014). By 1950, after the Port Authority took over the failing Port of Newark, maritime activities started to shift to the Port of Newark, which became the first port that could handle containerized cargo (Port Authority of New York and New Jersey, 2019). Over time, for reasons unrelated to the relocation of the port, the economic nature of NYC dramatically changed as its economic base evolved from manufacturing to a service orientation. This major economic shift did not mean that freight activity diminished. In fact, the opposite is true. At the height of its manufacturing heyday in the early 1960s, the 18.5 million residents and 8 million employees in the NYC metropolitan area generated about 2.8 million freight-trips per day (about 90% by delivery vans and 6-tire trucks) (Wood, 1970). As of 2016, the area's 20.2 million residents and 8 million employees generate about 5 million deliveries per day (Holguín-Veras et al., 2019). This includes about 2.0 million deliveries to commercial establishments, and about 3 million internet deliveries to households. As the bulk of the freight being transported to NYC arrives at locations in Pennsylvania and New Jersey, the supplies must be transported across the Hudson River, causing congestion on the bridges and tunnels, and costing NYC billions of dollars in congestion—over sixty years—to transport the cargo across the Hudson River.

To illustrate the concept of efficiency through land-use planning, consider the case of locating a distribution center in a monocentric linear city, shown in Figure 2. The city has an urban core (on the right edge of the figure) where the receivers are located. The supplier of the goods is located to the left of the figure, which represents the least urbanized area and the farthest location to the urban core. In this model, locating a distribution center is an essentially unidimensional problem since the only decision is the distance from the urban core where the distribution center is to be located. As is typical with many supply chains, it is assumed in this model that large trucks transport goods between the regional supplier and the distribution center, and small trucks carry supplies from the distribution center to the final customers. In this simplified case, the private and external costs associated with the decision of where to locate the distribution center are summarized in Table 2.

Figure 2: Linear Monocentric City

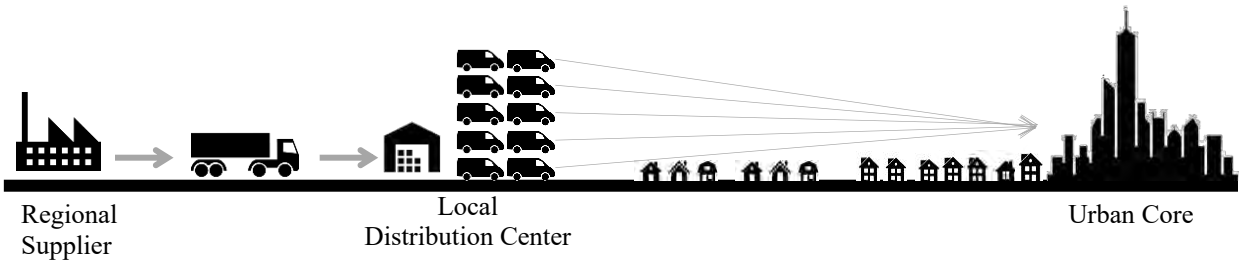


Table 1: Components of Social Costs in the Linear City Example

Private Impacts	External Impacts (Externalities)
Producer / supplier: • Cost of labor, land, buildings, equipment to operate the distribution center Carriers: • Cost of labor, acquisition and operation of freight vehicles	Communities near the distribution center (DC): • Congestion, pollution, noise, accidents, aesthetic degradation etc. … produced by the DC operations Communities along the corridor Producer-DC: • Congestion, pollution, noise, accidents, aesthetic degradation etc. … produced by the traffic of freight vehicles Traffic along the corridor Producer-DC: • Congestion, pollution, noise, accidents, aesthetic degradation etc. … produced by the traffic of freight vehicles Traffic in local streets DC-consumers: • Congestion, pollution, noise, accidents, aesthetic degradation etc. … produced by the traffic of freight vehicles between DC and consumers Communities along the corridor DC-consumers: • Congestion, pollution, noise, accidents, aesthetic degradation etc. … associated with the traffic of freight vehicles

The discussion on the location of distribution centers can begin with the private-sector perspective that only considers the private costs and does not necessarily consider the externalities produced. In reality, firms decide on the location of their facilities based on strategic, economic, technological, and political factors, as well as on the available infrastructure, competence, response time, logistics and facility costs. For simplicity, the analysis assumes that the private sector decision of the location of the distribution center is only based on operational and facility costs. Thus, a distribution center will seek to be located where it maximizes its net revenue, which is the difference between its gross revenue and total logistics and facility costs. Since the cost of using the large truck is lower than the total cost of operating the smaller trucks, it is beneficial for the company to maximize the use of the large truck as much as possible. At the same time, the company must consider the land costs, which generally increases with proximity to the urban core. Getting closer to the urban core makes sense if the savings in transportation costs are larger than the increment in land costs. The optimal location is the point no further improvements are needed and the marginal saving in transportation costs is equal to the marginal increase in the land cost. This optimization is depicted through the thin solid line shown in Figure 3.

If the cost of externalities (dashed line in Figure 3) is considered, a different outcome emerges. This is because a distribution center located far from the urban core will produce large flows of small trucks and delivery vans, which will increase congestion in the network. Moving the distribution center closer to the urban core will reduce the external pollution and congestion costs, as transporting the same amount of cargo with a single large truck produces fewer negative externalities than using multiple delivery vans. The benefit of using larger trucks to replace multiple smaller vehicles is more substantial nearer to the urban core, where transportation systems are often closer to reaching capacity and where there is often more pollution. However, locating distribution centers within the urban core may be counterproductive as large trucks could produce excessive negative externalities if navigating through narrow streets and intersections.

The implication is that land-use policy should facilitate the location of facilities such as distribution centers at the locations that minimize the social costs. They can do this by regulating the locations that the private sector is permitted to operate on, or by encouraging the private sector to internalize the external

costs they produce. If land-use decisions are made based on the social perspective, the potential benefits produced by FELU programs are bound to be substantial.

Figure 3: Location Decision under Private and Social Objectives

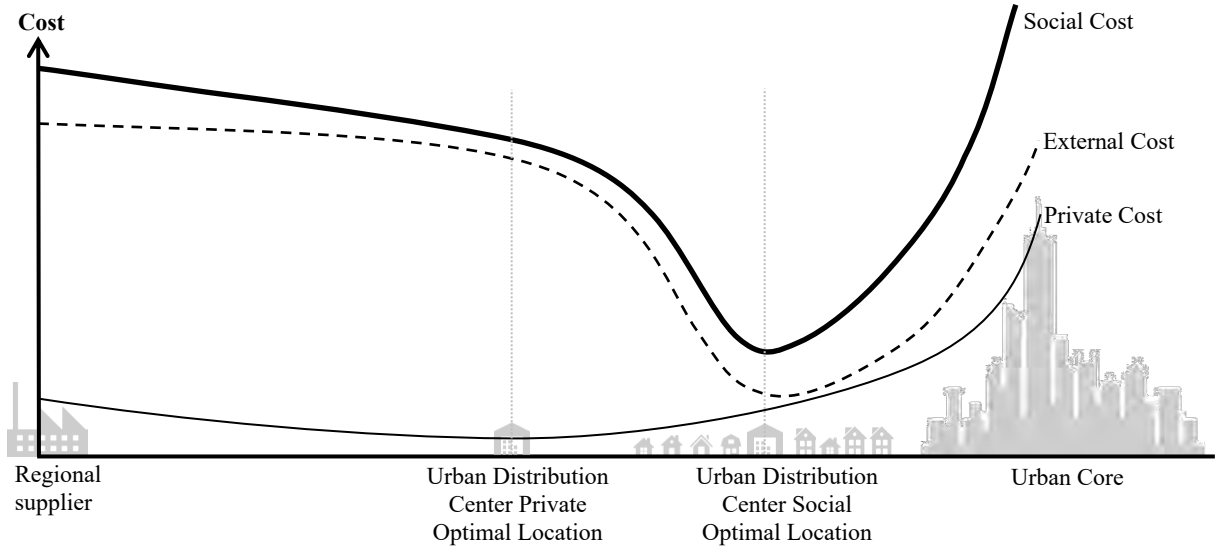
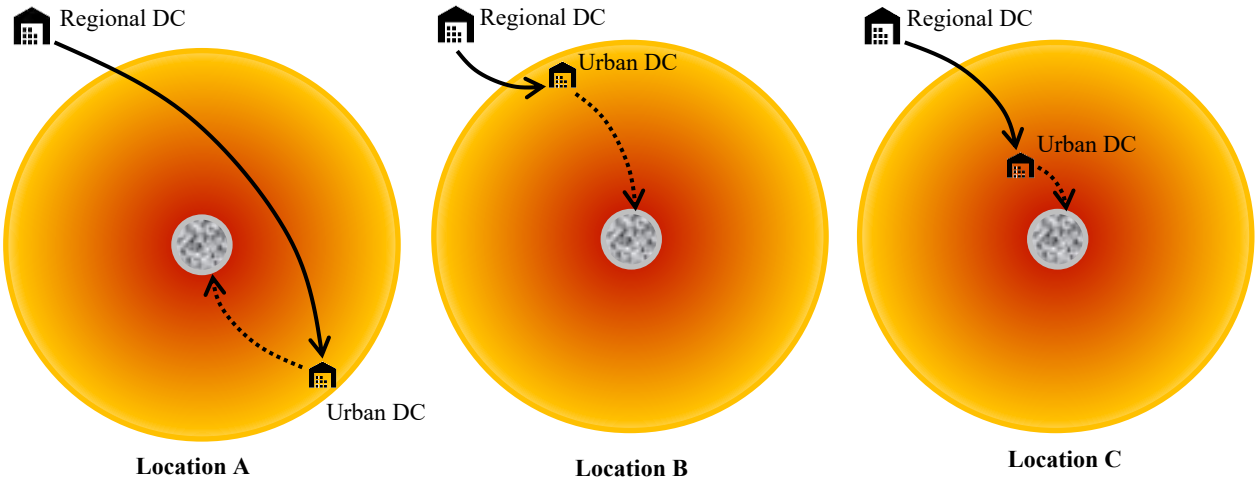


Figure 4 more concisely shows the concept of measuring efficiency through the relative location of distribution centers to the city center. The figure shows a city with a major retail district in its urban core, and supplies demanded by the retail district come from a regional distribution center outside the city. Large trucks transport supplies between the regional distribution center and the urban distribution center, and from the urban distribution center, supplies are delivered to retail locations using ten delivery vans for every large truck that arrives at the urban distribution center. In this figure, there are three alternative locations for the urban distribution center: A, B, and C. To denote the degree of road congestion, a color gradient pattern from bright red in the areas close to the center (indicating high congestion) to light yellow in the outskirts of the city (minimal congestion) has been applied to the figures.

From the *private-sector perspective*, the only consideration is private cost; the externalities produced may not even be considered. Using a similar cost analysis as Figure 3, the best candidate for the urban distribution center is likely to be location A or B, as these locations have relatively low land costs. However, in both A and B, high reliance on delivery vans is bound to produce significant externalities as they travel to deliver supplies to their customers in the urban core. In addition, from the *perspective of the communities near the urban distribution center*, locations A and B are most optimal because the externalities produced by these facilities would be experienced by the fewest residents as these areas have the lowest population density and traffic congestion. From the *social perspective*, location C would minimize the total sum of the cost of externalities associated with traveling between the regional distribution center, the urban distribution center, and the retail district, in addition to the associated cost to the private sector.

Figure 4: Effects of the Location of an Urban Distribution Center (DC)



2.2.2 Identification of Existing and Potential Land-Use Practices

The team conducted an extensive literature review of both land-use and freight practices. The topics covered include, but are not limited to, land-use concepts, land-use practices and tools, freight practices and tools, and freight and land-use planning. The team also reached out to the CoE-SUFS' partners and transportation, retail, and land-use experts to identify innovative FELU practices. Nineteen speakers from the US and abroad have presented at webinars on some of the innovative practices (See Appendix B for a list of webinars). The topics covered include, but are not limited to: innovative freight/land-use planning, state-of-the-art freight operations, and planning retail spaces in the era of major e-commerce disruption.

The research takes advantage of NCFRP Report 33 "Improving the Performance of Metropolitan Freight Systems" (Holguín-Veras et al., 2015), which produced a comprehensive review of all potential initiatives to address freight issues. Land-use initiatives developed as part of this project, together with the NCFRP Report 33's initiatives, were organized in part of a continuum of initiatives that can be used by both land-use and transportation agencies. A schematic of the entire set of initiatives is shown in Figure 5. As shown in the figure, the center pillar of achieving freight-efficiency is based on the process of stakeholder engagement, without which implementing effective FELU initiatives is very difficult. As shown in Figure 5, these initiatives are divided based on their targeted audience. Each group is listed and defined below.

- Land-use initiatives can be used to, among others, facilitate or enact changes in zoning, buildings, sites, and the nature of the activities that could be performed at the site.
- Transportation-related initiatives would mitigate, or eliminate, the negative effects on local communities that could jeopardize the implementation of land-use initiatives to foster FELUs.
- Joint initiatives share the goals of land-use and transportation initiatives, but would benefit from the joint efforts of land-use and transportation agencies.

Figure 5: Land-Use and Transportation Initiatives

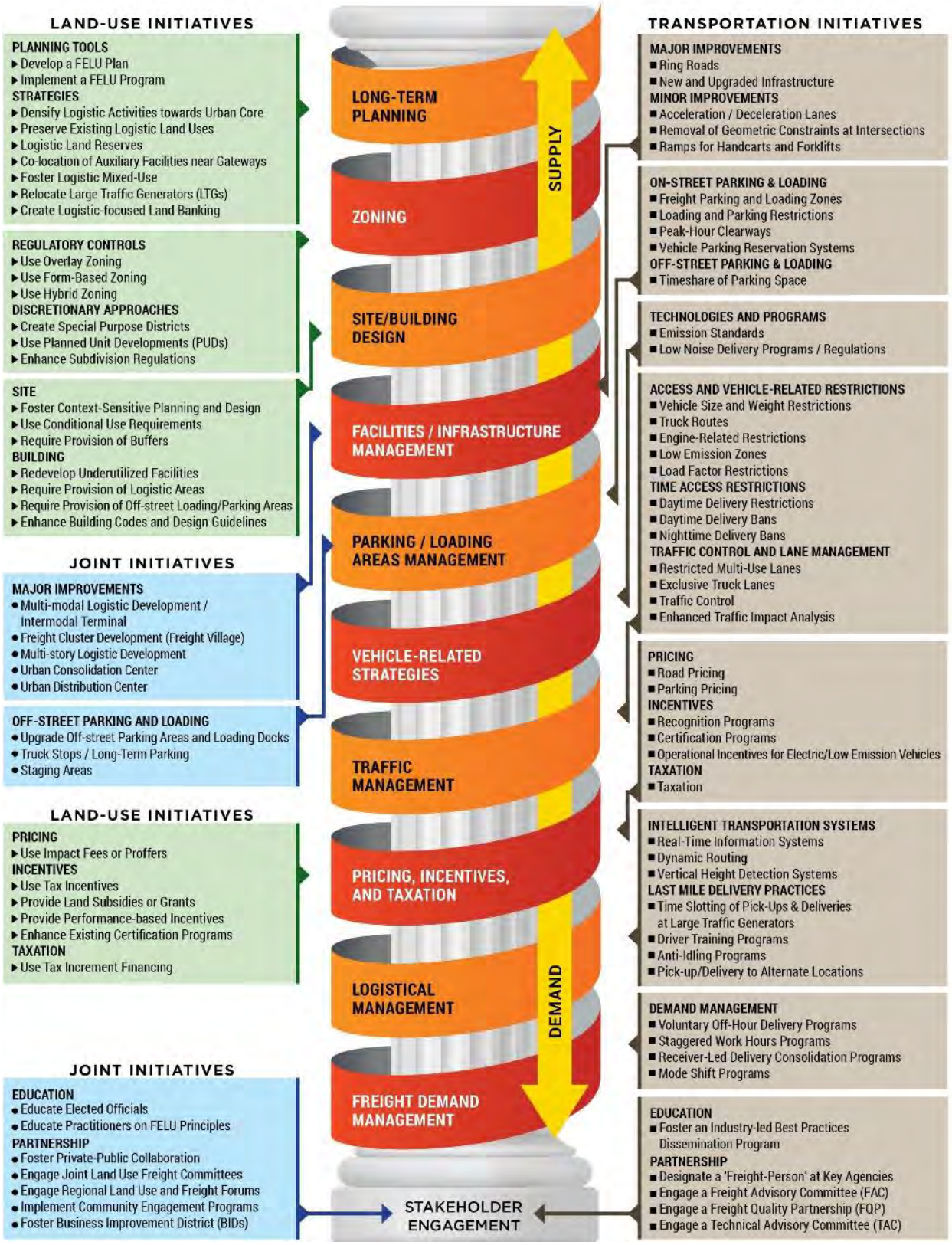


Figure 6 shows only the subset of the initiatives classified as related to land-use. Seven categories of initiatives were identified that are geared toward altering land uses: Long-Term Planning, Zoning, Site and Building Design, Facilities and Infrastructure Management; Parking and Loading Areas Management; Pricing, Incentives, and Taxation; and Stakeholder Engagement. These initiatives are projects, programs, or policies that land-use planners and land-use decision makers can use to foster FELU.

Figure 6: Land-Use Related Initiatives

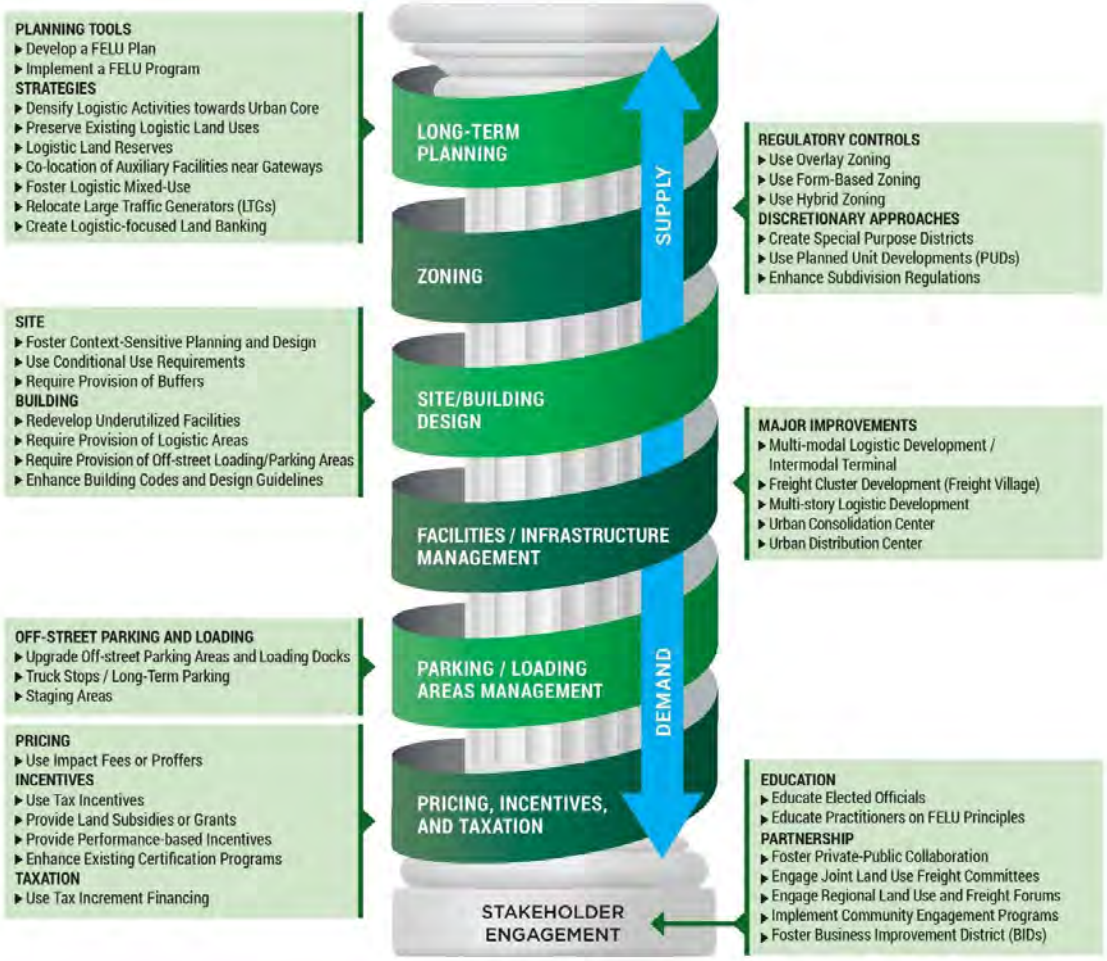
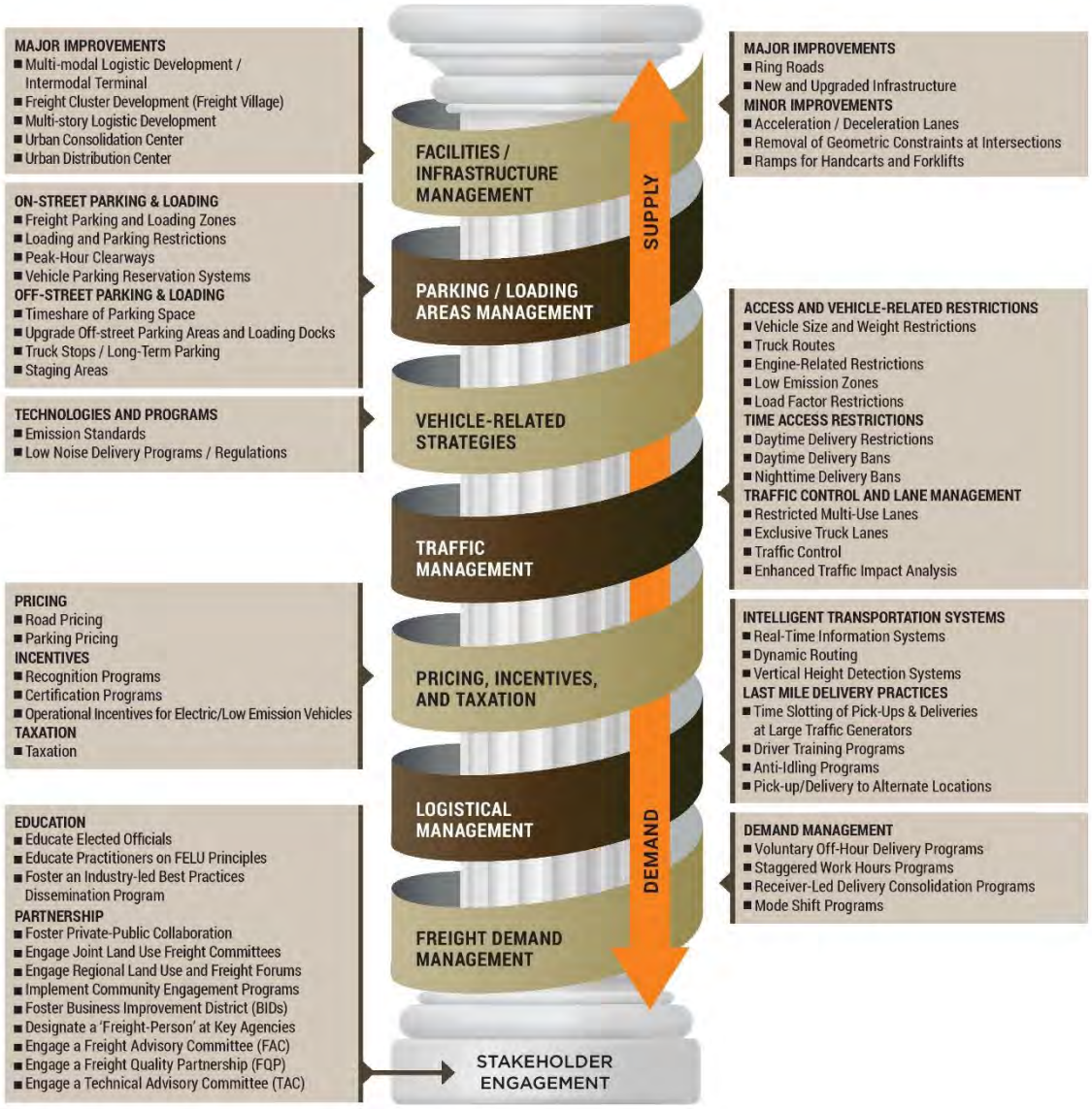


Figure 7 shows only the subset of the initiatives classified as related to transportation. These are divided into eight categories: Facilities and Infrastructure Management; Parking and Loading Areas Management; Vehicle-Related Strategies; Traffic Management; Pricing, Incentives, and Taxation; Logistical Management; Freight Demand Management; and Stakeholder Engagement. These initiatives aim to mitigate, or even eliminate, the negative effects of freight activity on local communities. By doing so, they can complement land-use initiatives to allow them to be more effective at fostering FELUs.

Figure 7: Transportation Related Initiatives



Each initiative was analyzed based on the geographic scope of potential influence, the perceived problem source it resolves, expected cost and level of effort to implement, the stakeholders that should be involved, the estimated timeframe to reap benefits, the advantages and disadvantages, and related land-use initiatives and complementary transportation initiatives. The results of the analysis is captured in one-page summaries so that practitioners can refer to them easily. These one-pagers can be found in the Planning Guide.

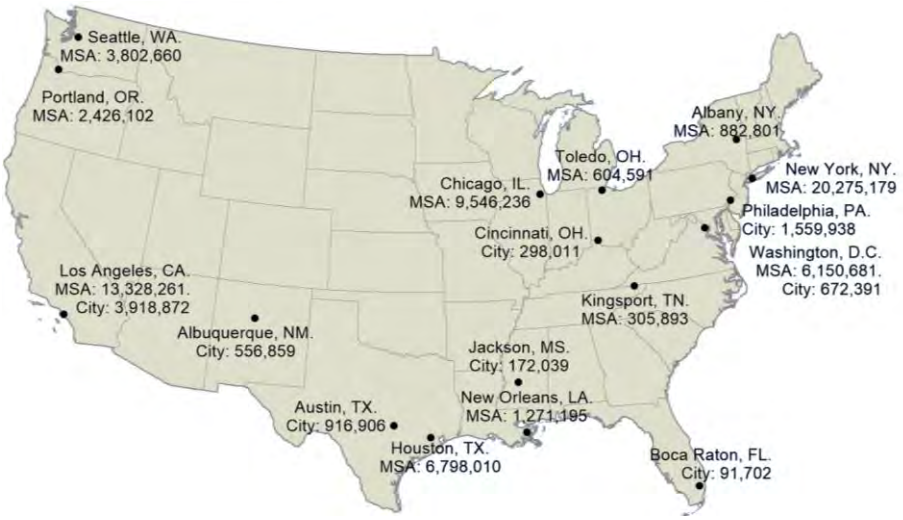
2.2.3 Evaluation of Land-Use Practices on Freight Activity

Cities exist because they are efficient markets where goods and services are traded, individuals can find suitable employment opportunities, and companies can find the personnel they need. At the heart of these activities is the production and consumption of physical goods. Without a doubt, the vast majority of human

and economic activities—including highly sophisticated service activities—utilize physical goods in one form or another.

The team selected several US cities and US metropolitan statistical areas (MSAs) of varying sizes to represent the freight activity across a wide variety of region sizes and geographic areas in the United States. The list of cities and MSAs are presented in Figure 8. These cities and MSAs were analyzed in terms of their population sizes, the composition of their economies, and the spatial distribution of their economies and the impacts on freight activities.

Figure 8: Map of Selected Cities and MSAs with Population



The production and consumption of goods is a physical expression of the economy. In general, freight activities increase with population. Across select areas, the estimated amounts of daily freight vehicle trips ranges from 29,400 (Kingsport MSA) to 2,066,000 (NYC MSA) for deliveries to establishments and 6,700 (Kingsport MSA) to 608,300 (NYC MSA) for deliveries to households. To provide a sense of the economic activity that freight activity generates, establishment and employment indicators were analyzed by industry sector in two major clusters: freight-intensive sectors (FIS), and service-intensive sectors (SIS). The FIS consist of those industry sectors for which the production and consumption of freight is the most essential component of the economic activity, such as the sectors of manufacturers, retailers or restaurants. The SIS are those industry sectors where the provision of services is the main activity, such as healthcare or education facilities. Classification of an establishment as FIS or SIS is based on the North American Industry Classification System (NAICS) as shown in Table 2.

Table 2: Classification of Industry Sectors based on Freight and Service Activity

NAICS	Freight-Intensive Sectors (FIS)	NAICS	Service-Intensive-Sectors (SIS)
11	Agriculture, Forestry, Fishing, Hunting	51	Information
21	Mining, Quarrying, Oil / Gas…	52	Finance and Insurance
22	Utilities	53	Real Estate and Rental and Leasing
23	Construction	54	Professional,Scientific,Tech. Services
31-33	Manufacturing	55	Management of Companies /
42	Wholesale Trade	56	Administrative,Support,Waste Manag.
44-45	Retail Trade	61	Educational Services
48-49	Transportation and Warehousing	62	Health Care and Social Assistance
72	Accommodation and Food Services	71	Arts, Entertainment, and Recreation
		81	Other Services
		92	Public Administration

At the broadest scale, the economy of MSAs can be defined as freight-inclined or service-inclined, depending on whether the majority of the employees work in freight-intensive sectors (FIS) or service-intensive sectors (SIS). In the US, 67% of the MSAs have freight-inclined economies, while 33% of the MSAs have service-inclined economies.

Analyzing the breakdown of freight trips by industry sectors provides insights into the source of freight activity in these areas. Across US MSAs, the FIS represents 45% of the total number of establishments and 49% of total employment. FIS, as opposed to SIS, rely more directly on freight activity. Typically, establishments within FIS generate about 90% of a region's B2B freight trips. Within FIS, the primarily consumer-oriented establishments—such as retail, restaurants, hotels, food stores, and "big-box" retailers—generate the bulk of freight traffic. These consumer-oriented sectors generate 70% or more of all B2B freight trips in the cities analyzed. In addition, the Transportation and Warehousing sector represents less than 13% of the total. The rising popularity for online shopping is increasing the amount of B2C transactions and home deliveries. A significant proportion of freight traffic is generated from these home deliveries, especially in larger cities. In large cities, B2C activity often represents more than 20% of all freight traffic.

By analyzing the selected cities and MSAs, the team produced indicators that can assist practitioners estimate the amount of freight activity in their jurisdiction. The indicators, available in Chapter 5 of the Planning Guide, can be used to estimate freight activity using a region's total employment, number of establishments, or population. More disaggregated indicators are available to estimate the rates of freight trip generation by individual industry sector, which allows, for example, the practitioner to estimate how many freight trips are generated by the warehousing sector. Indicators to estimate B2C are also available.

The analyses of the composition of the economy and freight activity provide insight into the main contributors of freight activity. However, it is equally important to understand how these activities are distributed across the geographic areas under study. In a basic view of land use, the production and consumption of supplies take place in different areas. Various quantitative methods were developed to describe the spatial distribution of freight activity. A key method first identifies the sectors that comprise the key interactions in an economy—for example, the manufacturing to warehouse—and then estimates the geographic separation between these sectors. This analysis is important to freight efficiency, as the spatial separation between the production (supply) and consumption (demand) zones has a direct impact on the distance for deliveries.

The team conducted a comprehensive review of the existing literature to identify potential typologies of metropolitan areas that could be used to gain insight into the various ways in which the wide range of economic activities are organized. However, the team could not find any suitable existing typology that could be used for this project.

The team developed multiple techniques to analyze the spatial urban pattern using publicly available data. Details on these techniques can be found in Chapter 6 of the Planning Guide. These techniques are built on the idea that accounting for the local conditions is critical to making decisions relating to land use.

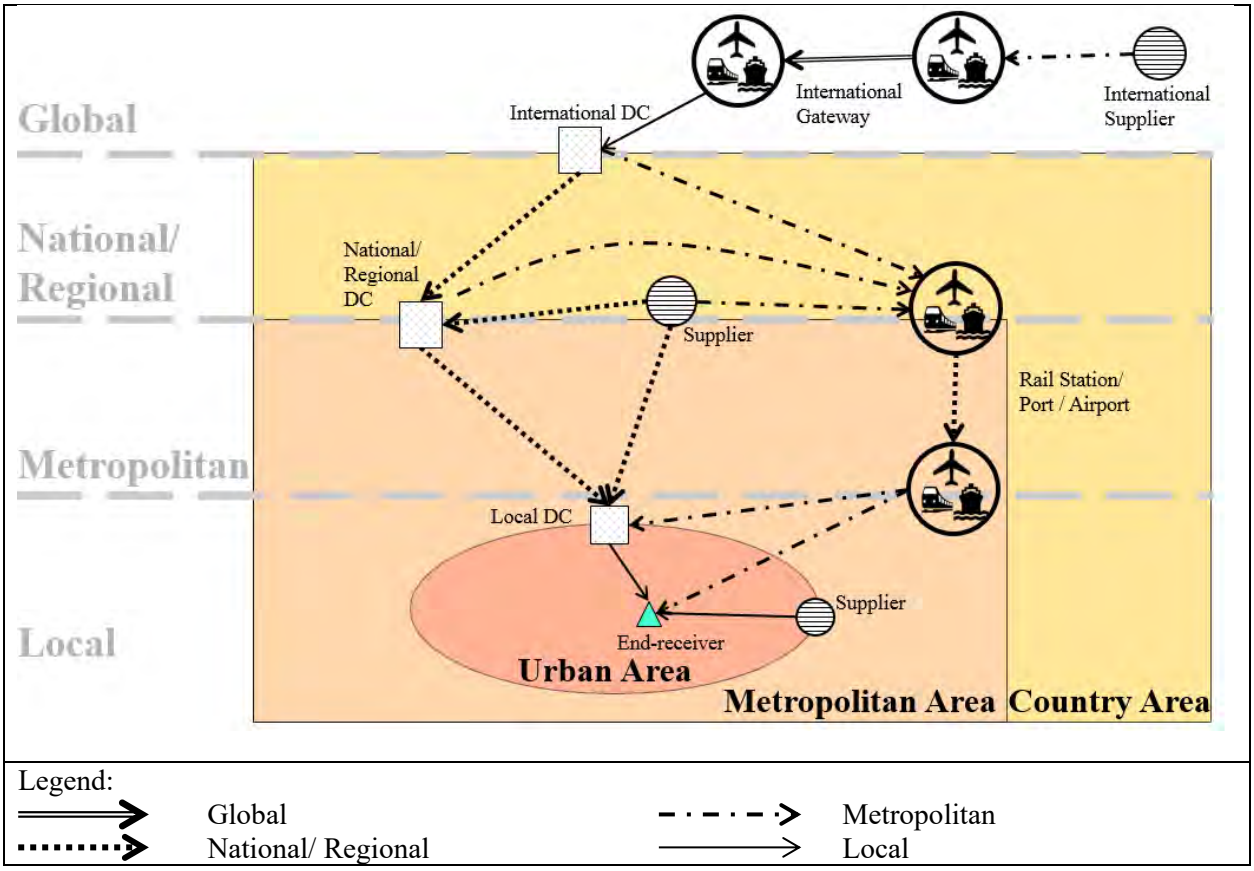
In addition, the team characterized the wide range of supply chains to understand the relationship between the establishments of different sectors, their roles, and their characteristics. These analyses are important because, in order to foster FELUs, one must consider how efficient the supply chains—from points of origin to the points of sale—are. Focusing exclusively on large traffic generators—such as ports and distribution centers—in isolation of the rest ignores the upstream and downstream linkages between these facilities and the rest of the supply chains they are part of. The primary function of supply chain activity is to ensure that all participants in a production system—from manufacturers to consumers—have access to the supplies needed. Due to the flow of goods between participants, each participant typically performs at least one of the following functions: production, distribution, or consumption of goods. For example, an establishment has the function of production when it is shipping out goods from its facility, but at the same time, it consumes goods (consumption) when it receives raw materials from a supplier. Each participant can be classified to be playing one of the following main roles:

- Gateways: Transportation facilities—marine ports, airports, intermodal terminals, highway access points and the like—that provide critical interconnections with supply chains beyond the metropolitan region. In most cases, these gateways interact primarily with suppliers and distributors.
- Suppliers: Commercial establishments that mainly undertake the physical transformation of input supplies into either final or intermediary goods. They could be physically located inside or outside of the metropolitan region. In both cases, they likely ship goods to distributors.
- Distributors: Commercial establishments, mostly warehouses and distribution centers that store, process and distribute supplies from the suppliers to the receivers and, in some cases, get involved in reverse logistics. They represent the middleman in supply chains. Distributors could locate inside or outside of the metropolitan region.
- Receivers: Commercial establishments whose primary function is consumer-oriented, e.g., restaurants and retail stores. These establishments are frequently the terminus of supply chains. They usually receive goods from distributors, but may receive them from suppliers in certain cases. They also contribute to the bulk of freight trips in metropolitan areas. Households will be included as receivers, which is critical in accounting for the surge of internet deliveries.

To untangle the complexity of supply chains and to understand land-use needs from the perspective of freight facilities, thirteen different types of supply chains were analyzed: (1) Gasoline and Petroleum Fuels; (2) Aggregate-based Construction Materials; (3) Pharmaceutical and Biotechnology ; (4) Retail Drug Store; (5) Hospital; (6) Soft Drink Beverage; (7) Urban Wholesale Food; (8)Supermarket; (9) Food Services; (10) Big Box Retailers; (11) Retail Apparel; (12) Waste Management; (13) Parcel Delivery. The first twelve supply chains were adapted from *NCFRP Report 14* (Rhodes et al., 2012), which provides an overview of the urban goods movement. In addition, the Parcel Delivery Service supply chain was incorporated into the analysis due to its growing importance related to the movement of parcels in urban and metropolitan areas.

To this effect, the teams created simplified depictions of the various stages of these supply chains, with emphasis on the metropolitan and urban portions of the supply chains. Starting with the general template shown in Figure 9, various supply chains were characterized. The team analyzed the role of facilities within the supply chain, the relationship between facilities, and the spatial patterns of the facilities in an urban environment. The approach is to examine the roles that various stakeholders play in each of the supply chain stages and the spatial arrangement of the facilities in a metropolitan context. The resulting analysis of the thirteen supply chains is documented in Appendix D of the Planning Guide.

Figure 9: Schematic of Generic Supply Chain



2.3 Task 3: Identify Emerging Market and Technological Trends

The objective of this task was to identify the impacts of emerging trends that may influence freight activities and land use in metropolitan areas. The task has two key parts: (1) identification of emergent trends; and, (2) qualitative assessments of the impacts of these trends on freight and land use.

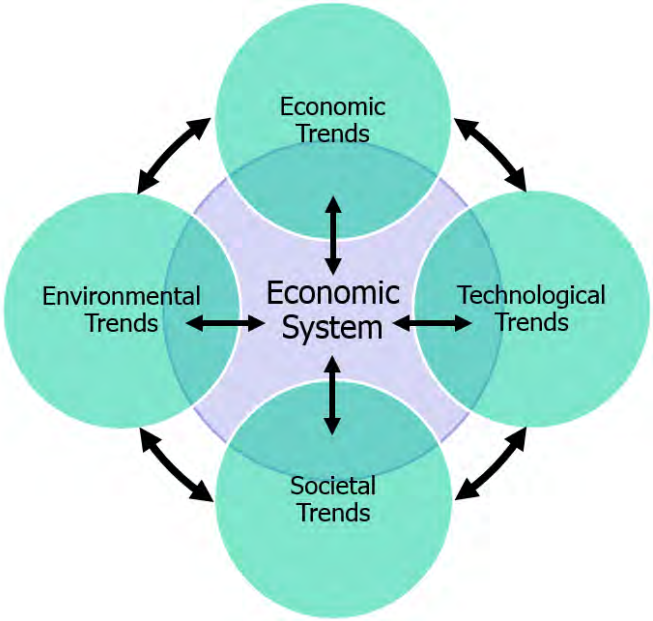
Identification of emergent trends

Trends are forces that continuously transform economies, business practices, and supply chains, and evolve the economic system. Market trends are the physical manifestations of the economy, and internal forces in the economic system. However, there are also external forces that can change the economic system. These trends or external forces can be classified into four distinct categories: economic, technological,

societal, and environmental. Economic trends are those that define the overall direction in which the economy is moving. Technological trends account for developments in software and/or hardware that result in, or influence, economic trends. Societal trends are changes in the ways in which people live, or the characteristics of the population itself, such as the aging population and the increase of urbanization. Environmental trends are related to impacts on living conditions in the planet biomass, the atmosphere and any component that affects living things. Trends within these categories can be market trends within the economic system or external forces that interact with the economic system.

Essentially, all trends exist in the same realm. They can indirectly influence other trends through interaction with the economic system. At the same time, one trend can directly exert external forces on another trend and change the trajectory of its development. Forces exerted by trends can propel, stifle or change the direction of development of other trends. Rising environmental awareness can encourage the acceptance of electrification, or discourage the acceptance of expedited B2C deliveries if the community is aware of their environmental impacts. However, consumers' desire to receive parcels faster and low transportation costs have fueled the demand for expedited B2C deliveries, causing significant impacts due to the prevalence of the trend. At this moment in time, it is unlikely for rising environmental awareness to change the trajectory of expedited B2C deliveries, due to the lack of awareness of their environmental impacts. These trends continuously influence each other, transforming business operations, supply chains, and freight transportation systems to varying degrees.

Figure 10: The Economic System and Emergent Trends



Each trend under these categories has the ability to transform supply chain operations, but the relevant ones are those with the most significant impact on land use, supply chains, and freight transportation systems. The key trends are listed in Table 3. The selected trends were classified into those that have a direct and indirect effect on freight activities and land-use decisions.

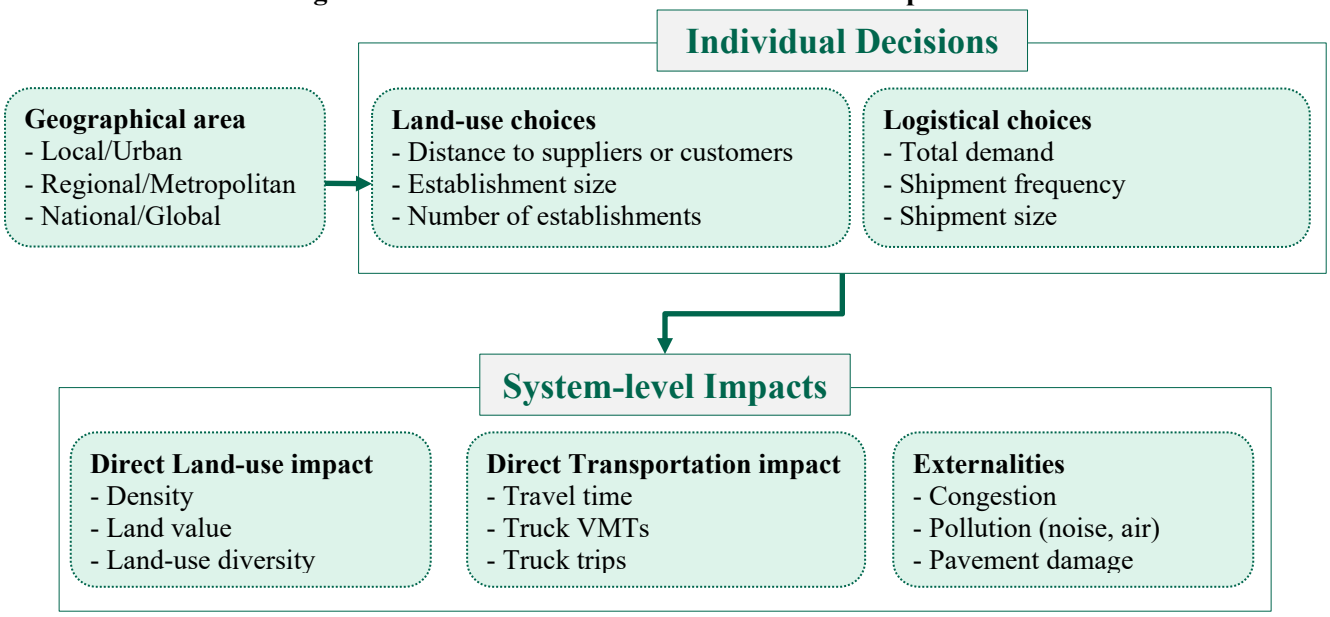
Table 3: List of Selected Emerging Trends

Impact	Trend
Direct	Globalization
	Anti-globalization
	Expedited B2C deliveries
	Regular B2C deliveries
	Sharing economy
	Unmanned autonomous delivery vehicles
	Connected and autonomous trucks
	Urbanization
	Electrification
	Advanced manufacturing
Indirect	Artificial intelligence and big data analytics
	Internet of Things (IoT)
	Rising environmental awareness

Analysis of emergent trends

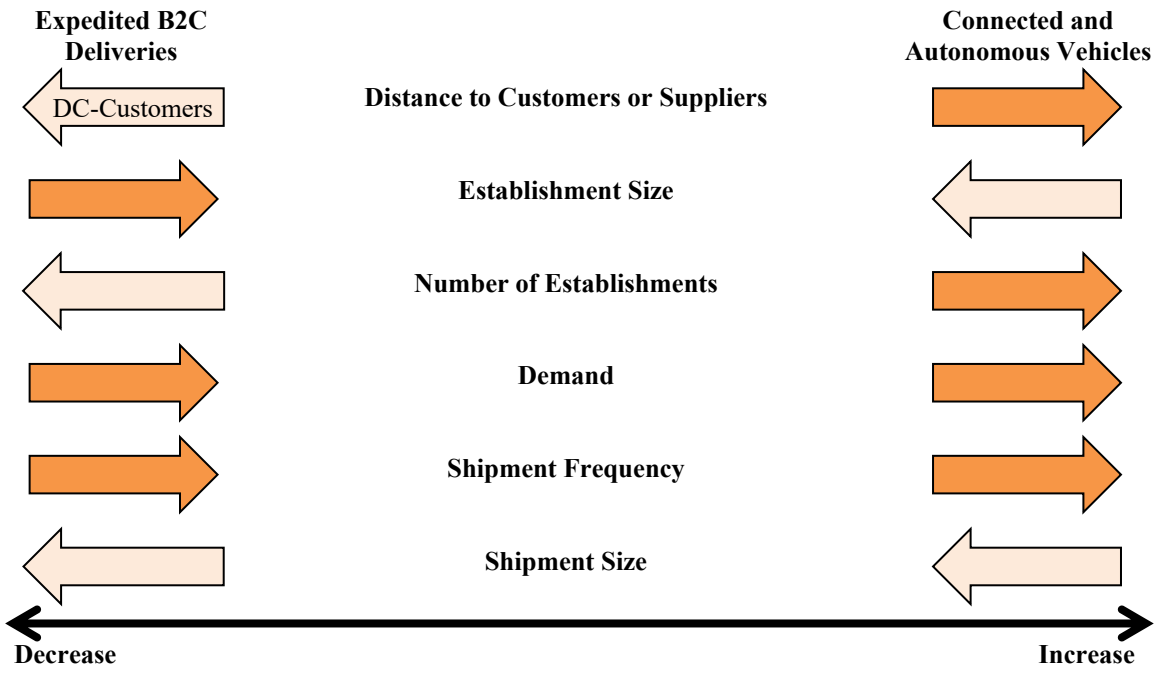
Emerging trends and technologies have the power to alter economic activities and supply chain operations, including changes in the amount of freight produced or consumed, the locations where activities take place, the distances traveled to perform deliveries, the types of vehicles used, as well as their characteristics. To understand the drivers of change in freight activities and land use, it is important to understand how trends impact the decisions of the agents involved in the supply chain. Changes in decisions ultimately result in changes in the land-use pattern, and freight traffic pattern and externalities. Therefore, the impacts of trends are considered at two levels: first, how the trends impact individual decisions, and second, how the individual decisions impact transportation and land-use systems. Figure 11 illustrates these dynamics and interconnections between the levels of impacts of the trends. This chart provides a guideline to analyze the potential impacts that emerging trends can have on the freight activities and land uses, from the supply chain perspective.

Figure 11: Interconnections between Levels of Impacts



This approach can be used to gain insight on the impacts of a single trend at a single geographic area. However, the economy in general, the urban patterns, and the freight activities are shaped by many trends at the same time. Depending on the extent or direction of these trends, the effects of some of the trends may be amplified, while in other cases, may diminish on a system level. Figure 12 illustrates an example of such interaction considering the effect of individual decisions on both expedited B2C deliveries, and the use of connected and autonomous vehicles. These two trends exert competing forces on the demand for land and space, evolving the urban pattern in different directions. Expedited B2C deliveries increase the establishment sizes, but decreases the distance to customers or suppliers, and number of establishments. On the other hand, the connected and autonomous vehicles trend has the opposite effects on individual decisions. When both the trends have similar magnitude of impact, it may be impossible to see a distinct trend on the change in urban pattern. In terms of freight activities, both trends are likely to increase demand and shipment frequency, and decrease in shipment size. Hence, there will be a distinct growth in freight demand and freight trips.

Figure 12: Effects of Expedited B2C Deliveries, and Connected and Autonomous Vehicles



This is an era defined by social, economic and technological transformation. The various trends are currently producing and will continue to produce counterbalancing effects. The net effects will be determined by the net result of these forces. More than ever, transportation and land-use decision-makers must frequently update policy procedures to keep up the changing pace of these dynamics.

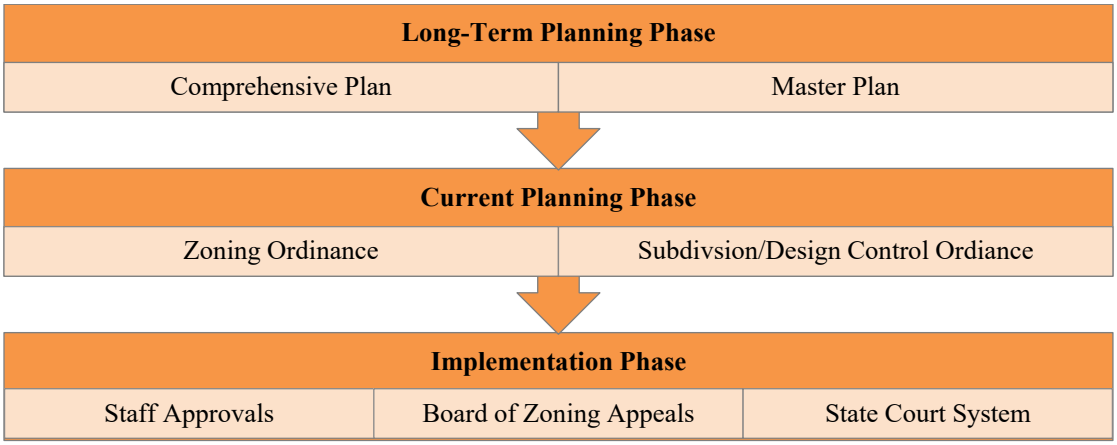
2.4 Task 4: Land-Use Policy and Decision-Making Framework

Task 4's main objective is to understand the typical decision-making environment and institutional setting in the metropolitan areas so that the existing framework can be enhanced to foster FELU. The team began the process by understanding the complexities and differences between the typical transportation and

land-use planning processes. The traditional planning process, described in urban planning textbooks, presents a pragmatic linear process that is deliberate and features a feedback loop to ensure that activities undertaken result in their intended purpose(s). In practice, this is not always the case.

In addition, the planning processes between land use and transportation are very different. The most obvious divergence is that transportation planning is largely a federally driven process and land use is a local process. However, that is only one part of the dichotomy. There are also large temporal differences, complicated even further by community differences, and their respective values and stakeholders. Effectively, every state has a different land-use planning framework and each community has its own culture, personality, and practices. The typical land-use decision-making process (described in Figure 13) consists of three major phases, including: developing a comprehensive plan, zoning ordinance and an implementation phase (approvals and enforcement).

Figure 13: Typical Decision-making Framework



In review of the stakeholders that should be involved in the process of FELU decision-making, it was identified that transportation planning has largely integrated transportation stakeholders (shippers, carriers, receivers, and their representative associations) into its planning process – most notably, the FAST Act advocated state freight advisory committees. However, integrating freight stakeholders with transportation planning is only a part of the process to create freight-efficient land-use decisions. Freight stakeholders must also be part of the land-use planning process. This is because a great deal of freight movement is driven by the geographical location of freight shippers, distribution points, and receivers.

2.5 Task 5: Assessment of Impacts

The main objective of this task is to produce a quantitative assessment of the impacts of various land-use patterns on supply chain activity in metropolitan areas. This important effort is only possible due to the resources brought to bear by the team, specifically the FTG models from NCFRP 25(01), and the Behavioral Micro Simulation (BMS) from the USDOT projects. The task consists of main components: (1) re-purposing the BMS; (2) baseline simulation of case study; (3) selection of land-use initiatives; (4) final simulation of case study; and (5) post-processing of results to obtain social and economic indicators. The work conducted is described next.

2.5.1 Re-purposing the BMS

The first step is to repurpose the BMS into the BMS-FELU. The original BMS was developed to support the design and implementation of the NYC Off-Hour Delivery project. It simulates (using real data) the generation of freight tours, where a carrier makes pick-ups/deliveries. Then, the BMS uses behavioral models to simulate the receivers' reactions to public-sector incentives. Once the receivers' decisions are obtained, the BMS simulates the reaction of the carrier: if the resulting operation leads to cost savings, the carrier agrees to do it; otherwise, the carrier does not. However, for purposes other than modeling off-hour delivery policies, there is no need to model these interactions. Thus, the simulation subroutines that depict these interactions were removed from the BMS, leading to a more compact and efficient software that only focuses on the estimation of the freight tours that match the freight trip generation estimates (the ground conditions).

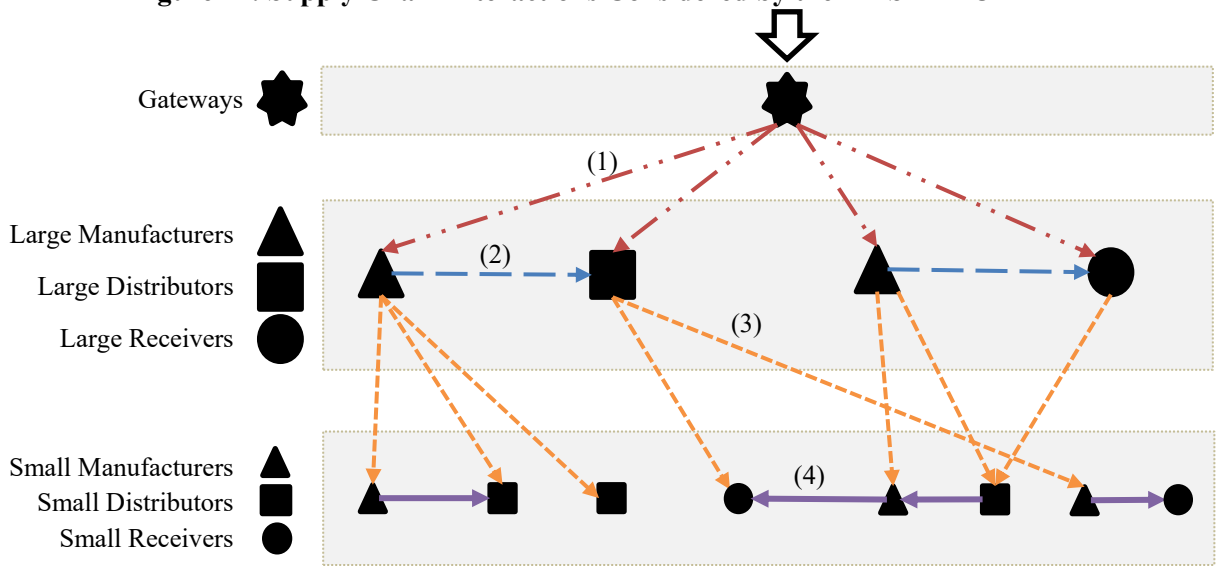
To estimate the impacts of land-use policy on freight activity, one must consider the policy's potential impacts on supply chain operations. Assessing these impacts, however, requires estimating the amount of travel associated with delivering supplies to/from distribution centers, and to/from commercial establishments in the city. This is a major challenge as traditional transportation models cannot conduct such analyses. The main issue is the consideration of the various echelons of the supply chains with the fine level of details required for land-use policy analyses. The combination of a complex depiction of supply chains, and the need for a fine level of detail creates a situation where simulation systems are the only practical choice.

The BMS-FELU was repurposed to consider those additional echelons in the supply chains. Doing so, however, requires careful consideration of the data and computational implications. To start, modern supply chains consist in some cases of dozens, and even hundreds of interactions. These interactions differ from company to company, and from industry sector to industry sector. It is not possible to consider each of them individually. In most cases, the interactions that matter are those that take place in the metropolitan region of interest. The key ones are identified to be

(1) "Gateways to Large": from gateways to large establishments,
(2) "Large to Large": from large establishments to large establishments,
(3) "Large to Small": from large establishments to small establishments, and
(4) "Small to Small": from small establishments to small establishments.

The repurposed BMS-FELU considers the key interactions under a layered structure comprised of seven types of agents: freight gateways, large manufacturers, large distributors, large receivers, small manufacturers, small distributors, and small receivers. Figure 14 depicts the overall logic that the repurposed BMS-FELU follows to incorporate the various echelons of the supply chain.

Figure 14: Supply Chain Interactions Considered by the BMS-FELU



Along with producing the list of delivery tours, an additional consideration for the repurposing of the BMS is to generate statistics from the delivery tours for policy assessment. The statistics generated by the BMS include total miles traveled by freight vehicles, travel costs, and estimated emissions from freight activity. Using these performance metrics, impacts of various FELU policies can be assessed. To compare the estimated effects of multiple land-use policies, each policy can be inputted as a separate case into the BMS-FELU software. It is important to note that the outputs are only estimates and may not replicate real-world outcomes. It is recommended that the assessments of land-use policies rely on the direction of the change rather than the estimated magnitudes of change.

2.5.2 Baseline simulation of case study

This task consists of selecting a metropolitan area for a case study that assesses the impacts of land-use initiatives on the freight activity by using the BMS-FELU. Although the BMS produces a fine level simulation, it is best for analysis at the metropolitan level. The Albany, New York metropolitan area has been selected for a case study due to availability of data, as well as the team's knowledge and familiarity of the area. Data preparation for the case study included the estimates of Freight Trip Generation (FTG) for commercial establishments, classified in the freight intensive industry sectors listed in the North American Industry Classification System (NAICS), and the FTG at the corresponding freight gateways. In addition, the team collected the Use Tables built from the Commodity Flow Survey from the US Census Bureau, and the Input-Output account from the US Bureau of Economic Analysis (Bureau of Economic Analysis, 2009) to infer the supply-demand relationship between industry sectors. The parameters for the individual pick-up and delivery tours were assumed based on previous research (Holguín-Veras et al., 2013), used in conjunction with travel cost functions which model cost as a function of distance (ZIP code level) and travel times. Finally, the major gateways of the area were identified, including ground transportation, waterways, and railways.

The results from the baseline simulation consist of the sequence tours for all levels of the supply chain, and statistics about the tours, including vehicle-miles traveled, total vehicle hours, average tour cost. In addition to the outputs from the BMS, a set of maps helps users visualize the freight trip flows modeled in the Albany case. The visualization will assist in validating the results based on ground knowledge, in this

case, leveraging the team's knowledge from the area.

The baseline simulation of the case study provides the initial data that will serve for comparison of impacts from land-use initiatives. This simulation of the Albany metropolitan area captures the picture of the status of the area before implementing any change in the system.

2.5.3 Selection of land-use initiatives

Through a series of case studies, the BMS software was used to assess the performance of various land-use initiatives in the Albany metropolitan area. As the target area is an entire metropolitan area, the initiatives to be considered must be implemented at a relatively large scale. Multiple scenarios were developed that address common freight efficiency issues. These scenarios could be the result of implementing one initiative while others could be a combination of multiple initiatives. Case studies analyzed the effects of densifying logistics activities towards the urban core, which is expected to reduce freight vehicle miles traveled. This initiative can be implemented by using incentives to attract developers to build their new or relocate their existing urban distribution center to the urban core. Another case study that could potentially be considered is to reduce logistics sprawl, which can be achieved through many land-use initiatives such as preserving land near logistics facilities or relocating large traffic generators or co-locating auxiliary facilities near major gateways.

2.5.4 Final simulation of case study

Once a set of initiatives was defined, the inputs to the BMS software were modified to incorporate each of the initiatives. Each iteration can represent individual initiatives, or it is possible to combine initiatives if the intention is to determine the aggregated effects of multiple initiatives. For example, implementing urban consolidation centers would require assuming additional establishments that generate freight, and are connected with other larger and smaller establishments. Once the new input data have been arranged, the BMS can be run again. The new input would be obtained in the same format of the input for the baseline case. Additional maps could be developed according to the needs that each initiative requires.

2.5.5 Post-processing of results to obtain social and economic indicators

Once the baseline case and the final simulation are performed, the different metrics produced in each simulation can be compared in order to understand the actual impacts of the initiatives on supply chains. These impacts relate directly with transportation and land-use effects, and indirectly with externalities on to the system and the society. After the former impacts have been quantified, further analysis can be carried out to identify the social and economic indicators that are affected by the initiatives. Overall validation of the results from the study cases are obtained from expert knowledge of the local region.

For example, in the case of building a new distribution center, the BMS software was used to estimate the impact of the facility's location on freight efficiency by comparing the freight vehicle miles traveled resulting from different locations of the distribution center. The results show that adding a large distribution center located 35 miles from the urban core of Albany, NY would increase the demand for roadways 6,300 miles more every day than locating the large distribution center only 6 miles from the urban core of Albany. This represents increasing congestion, pollution, and other transportation externalities. More details about the assumptions of these cases and the estimated results can be found in Chapter 10 of the Planning Guide.

3 SUMMARY OF PHASE 2 RESEARCH

The Phase 2 work focused on the production of decision support tools (DSTs) and decision-making methods to support FELUs. Phase 2 began with synthesizing the information and analysis conducted in Phase 1 into an Interim Report, and gathering feedback on the work to be done during the remaining part of Phase 2. The DSTs produced as part of this research includes: (1) A Planning Guide for Effective FELU Planning and Decision-Making; (2) Land-Use and Transportation Initiative Selector; and (3) Behavioral Micro-Simulation for Freight Efficient Land Uses (BMS-FELU). This section describes the objective and limitations of the DSTs.

3.1 Task 6: Interim Report and Peer Exchange Workshop

The objective of this task was to summarize the research completed in Phase 1, outline the research to be completed in Phase 2, and to get feedback on the research to date. The Interim Report summarizes the work done in Tasks 1 thru 5 and also outlines the work to be done in Tasks 7, 8, and 9. The Interim report also includes the plan for the Peer Exchange Workshop that was conducted as part of the task. The team submitted the Interim Report on December 17, 2018. The team organized an online meeting with the panel, in webinar form, to discuss the outcomes of Phase 1 and any potential changes required for Phase 2 and the Peer Exchange Workshop.

As another part of *Task 6,* the team arranged and conducted a one-day workshop with potential guide users, including panel members, and invited public and private-sector participants. The workshop was designed to demonstrate, vet and evaluate the Freight-Efficient Land Use Planning Guide and the Decision Support Tools with its intended audiences, including public and private-sector participants from a variety of metropolitan areas.

The workshop was held at the Keck Center of the National Academies in Washington, DC on June 26, 2019. The project team was responsible for invitations, agenda, electronic presentations, and handout materials during the event.

The workshop agenda included presentations of principles of Freight-Efficient Land Uses; the potential impacts of emerging trends and technologies; tools developed to understand local conditions; public sector initiatives; Initiative Selector and the Behavioral Micro-Simulation for Freight-Efficient Land Use (BMS-FELU); stakeholder engagement and implementation process. Table 4 presents the Workshop Agenda.

Breakout sessions were held to receive comments and feedback from participants on the project's products (e.g., the *Guide*, Initiative Selector, and Freight and Service Activity Generation Software). Participants will discuss the following four questions:

1. How and under what conditions can the Guide, Initiative Selector, Freight and Service Activity Generation Software and other project products be applied to freight mobility issues?
2. Is the information, the manner in which it is presented, and the level of detail provided adequate, useful and useable to the participants and their group?
3. What changes are needed to the Guide?
4. Are any major concepts, topics or issues missing from the study and products?

Table 4: Workshop Agenda

8:00 am – 8:30 am	Registration
8:30 am – 8:45 am	Presentation 1: Welcome and Overview
8:45 am – 9:15 am	Presentation 2: Introduction to Freight-Efficient Land Use
9:15 am – 9:45 am	Presentation 3: Potential Impacts of Emerging Trends and Technologies
9:45 am – 10:00 am	Break
10:00 am – 11:00 am	Presentation 4: Proposed Tools to Understand Local Conditions
11:00 am – 12:00 pm	Small group working session 1
12:00 pm – 12:30 pm	Presentation 5: Potential Initiatives
12:30 pm – 1:30 pm	Lunch
1:30 pm – 2:00 pm	Presentation 6: Proposed Tools to Design and Analyze FELU Programs
2:00 pm – 2:30 pm	Presentation 7: Potential Tools to Influence Land-Use
2:30 pm – 3:00 pm	Presentation 8: Potential Roles of Stakeholders
3:00 pm – 4:00 pm	Small group working session 2
4:00 pm – 5:00 pm	Group report and wrap-up
5:00 pm	Adjourn

A workshop summary (see Appendix C) was produced to capture the chief recommendation and decisions made at the Peer Exchange Workshop. This summary was shared with the participants of the Workshop on September 24, 2019.

3.1.1 Agenda Detail

The workshop included three types of facilitated interactions: 1) presentations and demonstrations; 2) small group working sessions; and 3) discussions and reporting by participants. To accomplish the workshop goals within a single day, each interaction was held to a tight facilitated schedule yet open to comments by participants; given that the understanding of and reactions to the products of the Guide is the primary reason for the workshop. Workshop facilitators included members of the research team. Each presentation focused on specific topics. A PowerPoint handout covering the materials presented was provided to each participant, which provided the background information for the Working Sessions.

***Welcome, Introductions, and Objective*:** During this first workshop segment, the Principal Investigator (PI) welcomed the participants and asked them to introduce themselves, including their role in freight and land use in their metropolitan area. The PI presented a high-level overview of the project and its intended products and outcomes. He explained the purpose of the workshop, provided an overview of the content and explained the role of the participants in helping to evaluate the products.

***Presentation on Freight-Efficient Land Use Planning*:** During the presentations, the team members presented and discussed the approach adopted to define FELU, and the planning approach that could be adopted to encourage consideration of freight-efficient land uses.

***Presentation on Understanding Local Conditions*:** The team presented and discussed in detail how different cities could be characterized and understood from the perspective of freight activities and urban form. This included discussing typologies based on freight activities, urban forms, and types of governance structures. Participants were asked to provide feedback on the approach based on their experience, and suggest possible case studies that they would like to see covered as part of the project.

***Presentation on Emerging Trends and Technologies*:** The team presented and discussed the list of trends and technologies that would likely to affect freight activities and land use. The presentation also included

the approach adopted by the team to assess the impact of these trends and technologies. Participants were asked to provide insights or lessons learned, and their perceptions of the trends and technologies.

***Small Group Working Sessions*:** Following the presentations, the participants were divided into small groups, with a mix of public and private-sector stakeholders at each table. Team members were distributed at as many tables as feasible to help facilitate the discussions. Each table was given one or more strategy groups to discuss, evaluate and make recommendations about. Instructions for the working sessions were provided on each table and explained at the end of the presentations.

***Presentation on Tools Available for FELU Analyses*:** The team members presented the tools that could be available for FELU, such as regulatory controls and policy tools, discussing each strategy type, its objective, expected costs, advantages, and disadvantages. Participants were asked to share their experiences with the tools and their perceptions of how the tools could work for them.

Overview of the Products: The team members presented an overview of the products that will be provided as part of the deliverables. The presentation includes the purpose of the tools, the conceptual appearance of the tools, and how the tool is used in conjunction with the guide.

Group Session Reports and Workshop Wrap-Up: This final workshop segment was opened and led by the facilitator of each session. The main purpose of the segment is to have each group share their comments and have the research team acknowledge a full understanding of those comments.

3.1.2 Public and Private-Sector Workshop Participants

For the workshop, participants came from both private (e.g., shipper and carrier companies, real estate companies) and public sectors (e.g., land-use planning departments, urban economic development partnerships, metropolitan planning organizations, state and city department of transportation officials). Table 5 shows the mix of participants representing a variety of metropolitan areas from throughout the US. The complete list of participants is shown in Appendix D.

Table 5: Summary of Workshop Participants

Stakeholder group	Number of participants
Motor carriers	3
Real Estate / Receivers	1
Metropolitan Planning Organizations	6
State Department of Transportation (DOT) and Port Authorities	8
Land-use Organizations	5
Urban economic development partnerships	1
City DOTs and Metro DOT Districts	4
Total	**28**

3.2 Task 7: Production of Decision Support Tools and Methods

This task involved the production of decision support tools to foster FELUs that are developed based on the knowledge gained from the previous tasks. The intended users of these tools are a variety of land-use and transportation stakeholders and these tools were designed with a broad range of users in mind. The purpose of the decision support tools is primarily to provide qualitative and quantitative assessments to support decision makers in fostering FELUs. The goals of these tools are that they are *effective* in providing

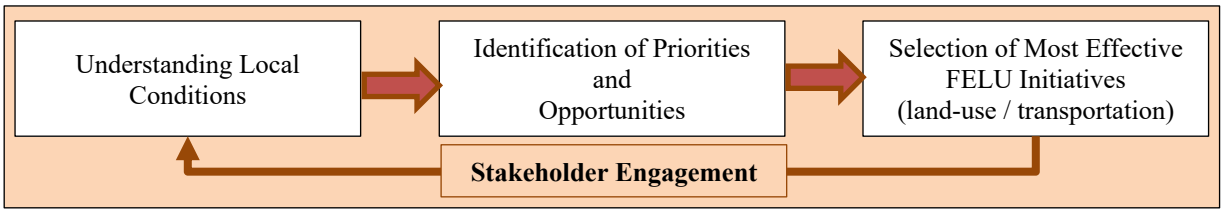
sound results and suggestions, *flexible* to enable their use in a wide variety of decision-making environments, and *trustworthy* so that decision-makers do not doubt their results. These tools act as qualitative and quantitative decision support tools that provide conceptual depictions and ideas about general impacts and implications of land-use initiatives, and some of the numerical estimates needed for engineering and economic analyses. The decision support tools suggested for use include:

- **Freight and Service Trip Generation Software (FASTGS):** This tool estimates the generation of freight and service trips by commercial establishments. This uniquely important tool uses either employment data at the ZIP Code, county, city, MSA and State levels, which are publicly available, or employment data at the establishment-level provided by the user, to estimate the number of deliveries received and shipments sent out by commercial establishments (Holguín-Veras et al., 2017b).
- **Land-Use and Transportation Initiative Selector:** A dynamic webpage that includes both land-use initiatives and the transportation initiatives from NCFRP Report 33 and allows users to specify the problem they face, and obtain suggestions of potential solutions. Clicking on a suggestion produces a one-page summary that provides additional information about the initiative, to aid the user in considering its use (Holguín-Veras et al., 2021).
- **Behavioral Micro-Simulation for Freight Efficient Land Uses (BMS-FELU)**: This stand-alone software enables practitioners to compute aggregate metrics of performance related to the impacts of land use on supply chain activity. The BMS-FELU reads freight trip data files (produced by the FASTGS), the travel times to-from the transportation analysis zones (including the location of distribution centers), the distribution of number stops by industry sectors, and other input files to conduct a simulation of the supply chains operating in the area. The BMS-FELU produces a number of performance metrics that quantify the efficiency of the study area's supply chains.

3.3 Task 8: Land-use Policy and Decision-Making for FELUs

The objective of task 8 was to synthesize the research completed into a FELU decision-making framework. This was completed by reviewing the typical decision-making process identified as part of Task 4, and recommending steps to foster FELUs. As such, the team proposed an approach to develop FELU programs so that all jurisdictions can foster FELU practices. This robust process is outlined in Figure 15.

Figure 15: Steps to Produce a FELU Program



As shown, there are four major steps intended to (1) gain a solid understanding of the chief features of the local economy, freight activity, and supply chain patterns in the area; (2) develop an understanding of the issues to be addressed, and the opportunities that could be exploited; (3) obtain a general idea about how the prevailing economic and technological trends may impact land-use patterns and freight activity; identify the most effective FELU initiatives; and, (4) engage stakeholders to determine the way forward. These regulatory instruments, widely used around the country, provide a legal mechanism to ensure that

the issues identified during the approval processes—those undertaken by land-use and transportation agencies—are fully addressed. As implied in the figure, stakeholder engagement is intended to permeate the entire process of developing the FELU program.

A key step in this process is to understand the local conditions, many of the recommendations and initiatives are only suited for regions with certain characteristics. For example, it is likely that the same set of initiatives that work for dense urban areas such as New York City would not be as effective in rural areas that experience high volumes of through-traffic. Understanding the local conditions helps identify the key issues regarding transportation and land-use, and helps decision-makers identify opportunities to combat these issues. A technical document that describes analytic techniques to account for the local conditions is provided in Chapter 6 of the Guide.

To help accomplish this task, the team has developed the Land-Use and Transportation Initiative Selector and has made it accessible to the public. The Initiative Selector is a publicly available webpage that aids in the selection of potential alternatives for various metropolitan freight and land-use problems and suggests initiatives that fosters freight-efficient land-use practices. In this way, users can input details about their local conditions and the problems they face, and in turn, receive suggestions about potential initiatives that could be implemented to fix a given problem.

3.4 Task 9: Final Deliverables

The final deliveries were produced to translate the findings of this project into reports, guides, and software that are accessible to all audiences. To ensure that these products are of high quality, key deliverables have been reviewed by the panel and revised based on their suggestions. This section will review some of the key deliverables that were produced as part of this project.

3.4.1 A Guide for Effective Freight-Efficient Land Use Planning and Decision-Making

The Planning Guide provides practitioners with a point of entry to FELU policy and planning. It offers practitioners with general guidance and a framework for decision-making. It includes the principles of freight-efficient land use, the approach to developing a freight-efficient land use program and its strategies, the steps to develop a freight-efficient land use plan, and the tools to understand the local condition and assess impacts of land-use policies. A comprehensive list of FELU initiatives was incorporated into the Guide, with discussion on their impacts on freight activity, advantages and disadvantages, and related policies. The Guide also included discussion of the various decision support tools to assist in identifying suitable freight-efficient land-use initiatives, and the user manuals of the various DSTs were appended at the end of the Guide.

The Guide has limitations worth mentioning. It is not a substitute for the due diligence required to properly analyze any particular initiative's potential to address a given urban freight issue. In-depth analyses must always be conducted, including: an adequate diagnosis of the problem, an objective analysis of potential alternatives, careful consideration of associated benefits and costs, assessment and consideration of tradeoffs involved, and identification of potential unintended consequences. The Guide's main objective is to provide guidance regarding the alternatives that could be considered in a variety of common freight system situations/scenarios. The Guide is intended to be general; it would not be possible to discuss the myriad highly specific application environments that characterize land-use practice in the US. The initiatives presented are those that have been adopted into practice, discussed, or are on the verge of being adopted; futuristic ideas are not presented, as there is not enough research on their applicability for freight-

efficient land uses. The Guide is intended to serve as a comprehensive reference for all aspects of an urban area, from the urban core to more suburban and exurban areas (urban fringe), which together encompass the metropolitan area.

3.4.2 Land-Use and Transportation Initiative Selector

A key component of this research effort was to develop a comprehensive list of initiatives that promote freight efficiency. Throughout this Guide, the term "initiative" refers to an entire spectrum of mechanisms, including projects, programs, regulations, and policies, that the public and private sectors can use to foster sustainable practices. These recommendations are not only limited to those that alter land-uses, but also include complementary transportation initiatives that support freight-efficient operations. The land-use initiatives were developed as part of this project and the complementary transportation initiatives consist of an updated set from those found in NCFRP Report 33 (Holguín-Veras et al., 2015). Initiatives were conceived based on literature reviews, expert academic and practitioner knowledge, and discussions with public and private sector stakeholders, all of which sum to over 300 references. Forty-three land-use-related initiatives and sixty-one transportation-related initiatives were categorized into several major groups, listed and described below:

<u>BOTH LAND-USE-RELATED AND TRANSPORTATION-RELATED INITIATIVES:</u>

- **Facilities/Infrastructure Management**: construct or upgrade private or public facilities and infrastructure to enhance freight efficiency
- **Parking/Loading Areas Management**: expand parking and loading areas or optimize the space available for these activities to maximize freight efficiency
- **Pricing, Incentives, and Taxation**: use monetary transactions or voluntary regulations to incentivize and encourage FELUs
- **Stakeholder Engagement**: facilitate stakeholder interactions and provide platforms that allow education, communication and collaboration between stakeholders

<u>LAND-USE-RELATED INITIATIVES:</u>

- **Long-term Planning**: employ planning tools or planning strategies that foster FELUs while acknowledging the local economic and land-use conditions
- **Zoning**: utilize zoning tools (either regulatory controls or discretionary approaches) as ways to enhance freight movements and reduce the negative externalities created by freight activity
- **Site/Building Design**: change the design of sites and buildings to minimize or eliminate the negative effects of freight activity on surrounding communities

<u>TRANSPORTATION-RELATED INITIATIVES:</u>

- **Vehicle-related Strategies**: foster the use of technologies and practices that reduce the negative externalities produced by freight vehicles
- **Traffic Management**: improve traffic conditions using techniques from traffic engineering and control, including vehicle restrictions, time restrictions, and traffic control
- **Logistical Management**: implement intelligent transportation systems and improved last-mile delivery practices to coordinate local freight activity
- **Freight Demand Management**: address the negative externalities generated by freight activity by altering the modes of travel and the timing of deliveries

3.4.3 Behavioral Micro-Simulation for Freight Efficient Land Uses (BMS-FELU)

The Behavioral Micro-Simulation for Freight Efficient Land Use (BMS-FELU) is a stand-alone software that enables practitioners to compute aggregate metrics of performance related to the impacts of land-use pattern on supply chain activity. The BMS-FELU reads the freight trip generation input files (produced by the FASTGS), the travel times to-from the transportation analyses zones (including the location of distribution centers), the distribution of number stops by industry sectors, and other input files to conduct a simulation of the supply chains operating in the area. The BMS-FELU produces a number of performance metrics that allow to study the efficiency of the study area's supply chains.

By modeling a complete representation of supply chains, the BMS-FELU allows to understand freight trip patterns within various levels of the supply chains, differentiating by establishment sizes and industry sectors. It is a flexible tool that allows the user to analyze based on their preferred level of geographical disaggregation (e.g., ZIP Code, or plot level) or focus on the industry sector of their interest. The users are able to insert their own freight generation data and travel cost data. The inputs provide the flexibility to adapt each case to a broad type of information, from general broader areas, to specific more detailed zones. The BMS-FELU focuses on the tours and the optimization of the tours within the metro area and it can also be used to model trips along a corridor or regional area with small changes of the input. The calibration process can be relatively easy in case of available data.

However, the BMS-FELU remains as a tool that simulates tours at an aggregate level, without performing traffic assignment. Finer level of analysis, such as street analysis, or any other analysis that requires a network input, would be out of the scope of the BMS-FELU. Also, the logic of the BMS-FELU assumes that key types of interactions and key agents remain fixed. If the user requires to consider more interactions or agents, it must be targeted from modifying the input files (maybe give an example to give more context). Finally, the tool uses several inputs, from which a few are difficult to obtain or estimate, and other are based on experience.

4 IMPLEMENTATION OF RESEARCH FINDINGS AND PRODUCTS

The main research findings and products were comprehensively documented in the Planning Guide, and the tools were validated with the best data available. Equally important is to ensure that these products are in the reach of potential users. The products include:

- **PowerPoint Presentation.** Slides describing the research conducted and the results as included in the Guide that can be tailored to various groups.
- **Executive Summary.** A stand-alone executive summary of the research project.
- **A Guide for Effective FELU Planning and Decision-Making.** This document explains in detail how practitioners could use the decision-making process and the DSTs and methods developed by the project. This guide also helps practitioners identify and weigh critical factors involved in the selection, design, and implementation of the selected FELU initiatives (strategies, programs, and projects).
- **Final Report.** A document summarizing the work undertaken and completed in the project. This document also presents recommendations on needs and priorities for additional research.
- **FELU Initiative Selector.** A dynamic HTML webpage that, for a given set of inputs, provides practitioners with suggestions about potential initiatives to address land-use issues.
- **Behavioral Micro-Simulation for Freight Efficient Land Uses (BMS-FELU).** This software enables practitioners to compute aggregate metrics of performance related to the impacts of land use on supply chain activity.

4.1 Putting Research Findings/Products into Practice

Since NCHRP 08-111's main goal is to foster adoption of FELU initiatives, the main thrust of the implementation plan is the dissemination of research products that will make it easier for practitioners to use the DSTs and methods developed to support FELU planning, design, and implementation. This is essential to enhance the skills and technical competence of land-use decision-makers and analysts, and to help bring about a new generation of professionals with a deeper understanding of freight matters and more insight into how best to influence freight systems for the better by means of land-use policy. To foster successful implementations, an effective outreach process must be undertaken to ensure widespread dissemination of research findings and the DSTs and methods developed. To this effect, the team has:

- **Identified target audiences and the most appropriate outreach mechanisms.** The team has reviewed the typical land-use planning process and has geared various products towards stakeholders in every stage, ranging from planners at Metropolitan Planning Organizations (MPOs) to elected officials at local Planning Commissions. In addition to preparing products for policymakers and planners, the team is also engaging with other urban freight researchers to expand the impact of this research.

- **Shared research findings at conferences and through webinars.** The team has shared their research findings with policymakers and researchers at conferences and through webinars. As the team sees great potential to encourage altering land-use practices for the better by sharing their findings, the team will continue to spread our findings after the completion of this project. The experience with NCFRP 38, a previous, yet similar, project, taught the team the value of speaking at conferences and participat-

ing in interactive workshops, as these efforts enabled the team to reach out to professionals that otherwise would not have been aware of our findings. After the end of the NCFRP 38 project, team members gave presentations at the New York MPO Conference, Talking Freight Webinar, Mid-America Freight Coalition, and APA National Conference. The latter presentation was extremely well attended, which led APA to request team members to contribute an article for its magazine.

To date, the team has shared research findings from NCHRP 08-111 at multiple conferences.

- Lawson, C. T., "Linking Land Use and Freight Performance Measurement: Lessons from New York State", presented at the Transportation Research Board (TRB) Meeting, January 12-16, 2020, in Washington, D. C.
- Holguin-Veras, J., Ramirez-Rios, D., Kalahasthi, L., Coutinho Amaral, J., "Freight and Service Activity Patterns in U.S. Cities", poster presentation at the Transportation Research Board (TRB) Meeting, January 12-16, 2020, in Washington, D. C.
- Holguin-Veras, J., Rivera-Gonzalez, C., Schmid, J., Calderon, O., Caron, B., Kim, W., "Centrality and Measures of Spread to Characterize Metropolitan Statistical Areas", poster presentation at the Transportation Research Board (TRB) Meeting, January 12-16, 2020, in Washington, D. C.
- Ramirez-Rios, D., "On-Street Parking Requirements for Freight and Service Activity," US DOT Talking Freight Webinar in November 2019.
- Ng, J., Holguin-Veras, J., Rivera-Gonzalez, C., Schmid, J. "Characterization of Spatial Patterns in Metropolitan Statistical Areas," presented at the International Urban Freight Conference, October 16-18, 2019, in Long Beach, California.
- Rivera-Gonzalez, C., Holguin-Veras, J., Calderon, O., "Spatial Patterns of Freight-Intensive Sectors," presented at the International Urban Freight Conference, October 16-18, 2019, in Long Beach, California.
- Lawson, C. T., "NCHRP 08-111: Effective Decision-Making Methods for Freight-Efficient Land Use" presented at the TRB Applications Conference, June 2-5, 2019, in Portland, Oregon.
- Lawson, C. T. and J. Wojtowicz, "Potential Impacts of Emergent Technologies on Freight-Related Land Uses in Urban Area" presented at the Urbanism Next Conference, May 7-8, 2019, in Portland. Oregon.
- Lawson, C. T., "What Should Land Use Agencies Do?", presented at the Transportation Research Board (TRB) Meeting, January 13-17, 2019, in Washington, D. C.
- Holguin-Veras, J. "Impacts of New Technological and Economic Trends in Transportation and Land Use Activity," Plenary session of Freight Day, Part 2. Transportation Research Board (TRB) Meeting, January 13-17, 2019, in Washington, D. C.
- Ng, J., Holguin-Veras, J., Ramirez-Rios, D., "Urban Economies and Freight Activity," presented at the VREF Conference on Urban Freight, October 17-19, 2018, Gothenburg, Sweden.
- Perez-Guzman, S., Wang, C., Ng, J., Ramirez-Rios, D., Calderon, O., "Emerging Market and Technological Trends Impacting Freight Landscape," presented at the VREF Conference on Urban Freight, October 17-19, 2018, Gothenburg, Sweden.
- Lawson, C. T. and D. Ramirez-Rios, "Land Use/Freight and Service Generation Modeling", presented at the Volvo Research and Educational Foundation Advanced Studies Institute on

Sustainable Urban Freight Systems (VASI-SUFS), August 6, 2018, in Troy, New York.
- Lawson, C. T., "Freight Efficient Land Use: Tools of the Trade", presented at the Urbanism Next Conference, March 3-5, 2018, in Portland, OR.

- **Engaged with targeted users during product development.** Throughout the project, the team has shared research findings and the decision support tools with organizations such as the Capital District Transportation Council (CDTC), who generally see value in the products we are developing. In addition, at the NCHRP 08-111 workshop in June 2019, the team discussed their products with workshop participants and determined the most desired features of both land-use and transportation stakeholders. By engaging with the targeted users of NCHRP 08-111's products, the team has received feedback that allowed us to enhance the usefulness of our products.

4.2 Challenges for Implementation and Measuring the Impact of Products

As the goal of NCHRP 08-111 is to foster change in current land-use practices for the better, there are numerous challenges to overcome. To start, there are barriers related to prevailing limitations in technical knowledge, models (DSTs), and data. The team hopes to overcome these challenges by means of an aggressive program of dissemination (to address the knowledge limitation), the development of appropriate and sound DSTs and methods that use minimal data and that could function with publicly available data (to address the limitations related to models and data).

Institutional and professional inertia could also be impediments. In an era when public sector practitioners are over-stretched, after decades of highly constrained budgets, it is very difficult to change decision-making procedures if doing so leads to additional efforts and expenses. The team expects that dissemination efforts, and the creation of effective and freely available DSTs and methods will provide the incentive needed for prompt adoption of project products.

The ultimate accomplishment of any research idea is to bring about transformation for the benefit of society. Yet, the transition from research to practice often takes a long time. As the research focuses on developing the Guide and DSTs that would be applied soon after its publication and release, the team assumes that NCHRP is interested in conducting short-term assessments. For that reason, after the project is completed, the team will use a set of metrics that will examine the impact of our products. The metrics include:

- The number of practitioners and researchers involved in outreach and dissemination activities such as webinars and presentations to professional organizations;
- The number of practitioners and researchers who use project products (measured by number of downloads), especially for the Guide and the decision support tools;
- The number of citations received by the journal papers produced and project products created.

5 CONCLUSIONS AND RECOMMENDATIONS

This project identified approaches and developed tools that assist decision-makers in fostering freight-efficient land uses. The Guide first offers methods for the initial steps in developing freight-efficient policies: understanding existing conditions and identifying existing concerns and potential opportunities. It then identifies a wide range of initiatives that help decision-makers consider potential alternatives on both the supply and demand sides of freight transportation. There are ten major groups of initiatives that are classified as land-use initiatives, transportation initiatives, or joint initiatives, where the collaboration of both land-use and transportation agencies may be needed or advised. Each initiative is paired with a short description and an analysis of the initiative's implementation barriers and potential unintended effects. The initiatives differ in scope, with some covering large areas or long time horizons while others offer short-term or local solutions.

The chief impacts of each initiative are identified based on evidence reported in the literature and are reported considering six performance criteria: geographic scope of the initiative, investment required, time required for implementation, perceived problem source, anticipated major impacts, and potential for unintended consequences. A qualitative assessment of the performance of each initiative is provided in Chapter 7 and Chapter 9 of the Guide. A tool was developed by Rensselaer Polytechnic Institute (RPI) entitled *Initiative Selector for Fostering Freight System Performance, Energy Efficiency, and Freight-Efficient Land Use* (Holguín-Veras et al., 2021). This tool facilitates the identification of potential initiatives that could be used to address a freight-related issue by electronically searching for initiatives that may solve a given set of inputs provided by the user. This "Initiative Selector" allows users to specify the type of problem they need to solve and outputs initiatives that could be effective in addressing the specified issue. Selecting a given initiative leads the user to a one-page summary, complete with examples, references, and links to related initiatives.

The Initiative Selector is not designed to be a substitute for good engineering or detailed planning studies: it can only offer general guidance on best-practice alternatives. Detailed studies are required for a fully informed selection of the most appropriate solution to a particular freight-related issue. Such complex analyses can only be achieved by competent professionals who explicitly take into account the specific local conditions surrounding the issue.

Chief recommendations

The research conducted suggests that to maximize the potential transformative impacts of the initiatives discussed in the Planning Guide, a number of preparatory steps must be undertaken. These actions will lay the groundwork for land-use and transportation agencies to move forward with innovative and effective initiatives to help achieve goals such as reducing congestion, improving productivity, increasing sustainability, and enhancing livability in urban areas. The following actions are recommended:

1) Integrate freight into land-use planning. Public agencies should consider how they could have a role in supporting freight activity through comprehensive land-use planning. Agencies can consider the extent to which their current land-use plan harms or helps the efficiency and sustainability of supply chains that are integral to the economic activity in their regions. Successfully doing this would minimize the externalities produced by freight traffic and maximize the efficiency of freight activity. Specific recommendations to improve the integration of freight activity into land-use planning are as follows: the creation of a Freight-Efficient Land Use Plan; and the creation of joint land-use and transportation committees.

2) Consider local conditions in the process of planning and designing freight initiatives. For effective land-use planning and policy design, it is important to recognize the heterogeneity in land-use patterns, economic conditions, and government structures between regions. Studying the existing features of local economies and their associated supply chains will help to identify any strengths and weaknesses. The resulting knowledge will assist policymakers in identifying suitable policies to ensure that freight activities take place in the most sustainable manner. For example, an understanding of the extent of freight activity in the region can be gained from reviewing the geographical distribution of economic activity and the number of freight trips. In addition, engaging the private sector is key to gaining qualitative knowledge about supply chain activity and the challenges that local supply chain stakeholders face.

3) Educate practitioners on FELU practices. It is essential for practitioners to understand the implications of land-use decisions on freight activities and to be equipped with the knowledge and skills to foster freight-efficient land-uses. Key findings and training programs can be used to equip policy and technical staff at transportation agencies and land-use agencies with the technical expertise needed to play a competent and effective role in planning, design, implementation, and follow-up of FELU initiatives. The potential organizations to undertake dissemination or training programs include American Planning Association, Association of Collegiate Schools of Planning, Urban Land Institute, US Department of Transportation, Federal Highway Administration, and Transportation Research Board.

4) Educate decision-makers on FELU goals. Inform public and private sector decision-makers on the importance of freight so that they do not put in place policies and/or projects that will negatively affect freight operations. In addition, decision-makers may benefit from knowledge on developing a FELU program, using decision support tools to gain insight into local conditions, and understanding a wide range of land-use and transportation initiatives. Specific recommendations include the following: the creation of technical workshops and webinars; the education of elected officials in freight-related matters; and the education of members of the community in freight-related matters.

5) Communicate and collaborate with multiple stakeholders across disciplines. Freight-Efficient Land Uses require a multi-disciplinary approach to enhancing the sustainability of economic activity. Gathering feedback from stakeholders, or those involved in freight activity, can help identify potential opportunities and can lead to improved outcomes. Stakeholders could provide critical information on how best to achieve particular urban freight goals. Specific recommendations include the following: the designation of a “Freight-Person” at key agencies; the creation of a joint land-use and freight committees that also includes the participation of the private sector; and the implementation of Community Engagement Programs.

6) Conduct ex-post evaluations on the performance of implemented initiatives. Complete an assessment of the overall performance of the implemented initiative by gauging the effectiveness of an initiative at addressing a particular freight issue and reviewing any negative consequences that resulted from the initiative. These evaluations will help future decision-makers (either within the agency or within other agencies) understand the effects, both good and bad, of freight initiatives that have been implemented in real life settings.

APPENDIX A: NCHRP 08-111 KICK-OFF MEETING MINUTES

Date: April 17, 2017
Time: 1:00 PM
Venue: Conference Call

Attendees:

NCHRP Panel:

TRB Staff Representative
- William (Bill) Rogers (BR)

Chairman
- Gabe Sherman (GS)

Members
- Steve Bowman (SB)
- David Lee (DL)
- Jose Marquez-Chavez (JMC)
- Peter Martin (PM)
- Scott Marco (SM)
- Spencer Stevens (SS)

Research Team:

Rensselaer Polytechnic Institute (RPI):
- Jose Holguin-Veras (JHV)
- Cara Wang (CW)
- Jeff Wojtowicz (JW)
- Juvena Ng (JN)
- Carlos Rivera (CRG)
- Diana Ramirez-Rios (DR)
- Trilce Encarnacion (TE)

SRF Consulting (SRF):
- Dan Haake (DH)

University at Albany (SUNY):
- Catherine Lawson (CL)

ATRI:
- Dan Murray (DM)
- Jessica Huffman (JH)

	Discussion	**Action**
1.	Introduction	
	JHV gave an overview of the project. • Goals and objectives • Research approach • Team members and their responsibilities • Project timeline • Deliverables	
2.	Current work status	
	RPI has scheduled webinars with key international researchers to learn about their experience with land-use related freight initiatives. Their experience can be relevant to us as we share similar problems with urban freight. These webinars have been recorded and will be shared with the Panel. RPI will continue to organize webinars as part of the data collection and the Panel will also be invited to future webinars.	RPI
3.	Efficiency Metrics	
	JHV asked the Panel to discuss on the efficiency metrics which are most relevant for practi-tioners when assessing freight-efficient land use initiatives.	

	Discussion	Action
	PM stated that the traffic engineering community (e.g., modeling LOS of links) treats all trucks alike, however they are obviously not alike (e.g., small trucks vs big trucks). Differentiating trucks of different sizes will be useful. BR enquired about the approach to differentiate vehicles. JHV suggested using RPI's FTG models and vehicle breakdown data extracted from cameras at key areas of NYC could help bridge the gap for classified vehicle data. DM acknowledged the potential of using the state truck data. However, he also highlighted that the key data required is freight truck data such Amazon and UPS freight truck data, and mentioned that ATRI has access to some of the freight truck data. He also added that there is another traffic data provider which can provide freight truck data. But their data also includes mostly utility trucks and school buses. It is a terrible surrogate data for freight activity and will be challenging to process. BR highlighted that it is important to profile the vehicles to understand the efficiency of each vehicle type. An initiative, such as replacing 2 or 3 small trucks with 1 large truck, will require understanding of vehicle type efficiency. GS suggested that different efficiency metrics will appeal to different user groups. For example, local authorities may be more concern with the dwell time while on the state level, users may be more concern with greenhouse gases and truck miles travelled. Products of the research project should be presented in way which appeal to different levels of practitioners. SB enquired on the approach to integrate land-use and efficiency metrics. JHV proposed using the freight models in NCHRP 25 which can determine the freight traffic volume based on economic classes. The team plans to convert NCHRP 25 models to be based on land-use class, whereby the team will map economic classes to land-use classes in a seamless manner. For example, if a city decided to develop a street of restaurants, the model will be able to determine the number of freight trips generated.	
4.	Case Studies	
	As the project can only cover limited number of case studies, JHV asked for suggestions on the type of cases which the Panel consider to be the most important. PM suggested that the greatest ignorance on the research topic is at the local level of the city (neighborhood level) rather than the MPO or state level. It may have the greatest payoff if the project highlights the pros and cons for zoning regulation on the district level. JMC suggested Gateway City, located beside Port of Long Beach, as they have similar issues which preliminarily related to freight. GS suggested that to consider different size of municipalities. Big cities have more resources to conduct more comprehensive planning compared to mid-size cities, which may not have sufficient resources to complete an entire freight land-use plan.	

	Discussion	Action
	SB enquired if it is imperative to plan for case studies at this point or to select as the work progress. JHV agreed that it is too early to make final decision on the case studies now, but it will be beneficial for the team to be guided by Panel's perspective while researching on case studies.	
5.	Emerging Trends	
	JHV noted that the market forces are drastically changing manufacturing, retail, transportation and others. Some trends are having impact now (e.g., e-commerce) while some may have impact in the future (e.g., truck platooning). JHV enquired on the approach to balance selection of trends. BR asked for the duration to research on trends and highlighted that the answer is likely the change over time. One of the Panel members mentioned that many people do not have a good grasp of the details and implications of trends. He suggested getting insights from various stakeholders (e.g., transportation professional, shippers) to gather the common understanding among various parties on a trend. BR suggested some of the information are already available in literatures. JHV agreed and presented New York Times article on "Zombie Malls".	
6.	Other Suggestions	
	One of the Panel members suggested to consider the freight land-use decisions based on immediate term (e.g., what they can do now?) to long term (e.g., what they can do to consider the trends?). DL highlighted that the products delivered by this project should be practical and generalizable could be applied to other regions. Tennessee DOT can offer cooperation and provide data for case studies, if available. JHV shared experience of the team which products of previous projects are validated with local data to ensure applicability. JHV highlighted that the team are aware of the need to develop tools which are applicable to wide range of conditions and are committed to that.	
7.	Any Other Business	
	BR shared that there will be a webinar on freight on Wednesday (April 19) organized by FHWA. One of the Panel members asked if they could be updated regularly rather than on official meetings such as kick-off and interim meeting. BR mentioned that the team are supposed to submit quarterly report to update the Panel. The meeting adjourned at 2pm.	

APPENDIX B: LIST OF WEBINARS

3/9/17 Mike Browne – General Discussion of Freight-Efficient Land Use

In this webinar, Prof. Mike Browne, from University of Gothenburg, explored with the team possible international case studies that the project could look into, and potential definition of freight-efficient land use.

3/28/17 Laetitia Dablanc – Logistics Hotel

In this webinar, Prof. Laetitia Dablanc, from IFSTTAR, University of Paris-Est, spoke to the team about Logistics Hotel. The objective of a Logistics Hotel is to address logistics sprawl issues by accommodating logistics buildings in the center of the Paris Metropolitan Area. One of the intentions of the facility is to consolidate freight transport to Paris and transfer to cleaner modes of transport. Logistics Hotel is also a mixed development that contains activities such as logistics activities, leisure, office spaces and housing.

4/10/17 Russell Thompson – Deliveries to Towers

In this webinar, Prof. Russell, from University of Melbourne, shared the Australian experience in handling freight trips for LTGs, which involves the use of a slot booking system to stagger delivery trips.

4/11/17 Jardar Andersen – Common Logistics Function for Shopping Centers

Shopping centers often represent challenges for logistics service providers, as individual retailers may be located far from the freight receipt area, and the norm is that truck drivers have to bring all items to the shop. In Norway, shopping centers represent around 30% of retail trade. Steen & Strøm AS is a Nordic branch of the Klépierre group, which is planning a new shopping centre at Økern in Oslo with the goal of establishing common functions for inbound and outbound freight flows. The implementation will facilitate identification of consolidation opportunities for logistics service providers as well as off-hour deliveries, as the transport leg and the in-house transport leg in the shopping center may be decoupled. To read more, please visit http://www.citylab-project.eu/Oslo.php.

4/19/17 Sonke Behrends – DenCity

DenCity develops innovative solutions for sustainable passenger and freight mobility in dense neighborhoods, with high standards of attractiveness, accessibility and sustainability. DenCity stands for radically new thinking and innovative processes for sustainable densification. To read more about DenCity, please visit http://closer.lindholmen.se/en/projects-closer/dencity

4/21/17 Sara Verlinde – Brussel's experience especially on the innovative solutions to make deliveries to small independent stores

Brussels has around 900 independent small grocery stores and average store is replenishing stock twice per week, mostly by the store owner buying goods from a wholesaler and in some cases by van delivery through a distributor. Dr. Verlinde will share with us a solution whose main concept is to introduce a new online sales channel and to use spare van capacity from existing service providers to reach these stores. The goal is to replace inefficient store owner collections and increase the vehicle load factors of the service providers. To read more, please visit http://www.citylab-project.eu/Brussels.php

5/11/17 Hans Quak – The Future of City Logistics: Trends and Development Leading Towards a Smart and Zero Emission System

City logistics system faces serious challenges in the near future: zero-emission transport in cities and decarbonization to meet the climate agreements. Dr. Quak will discuss the main trends and developments influencing city logistics that enable, through new opportunities and expected policies, zero emission city logistics initiatives in the near future.

5/22/17 Eiichi Taniguchi – Tokyo SkyTree Town

Tokyo SkyTree is the tallest structure in Japan in 2010. It is a major large traffic generator (LTG) as has a broadcasting tower, exhibition hall (observatory), aquarium, Dome Theater, Offices, Halls, Academic Institutes, and over 300 shops. Prof Eiichi will share with us the strategies adopted by SkyTree Town to handle the chaos created by the large number of freight trips it attracts.

6/1/17 Gordon Feller – Emerging Trends and Technologies

Gordon Fellers, co-founder of Meeting of the Minds, provided the team with an overview of emerging trends which may impact freight and land use. He discussed in detail the impact of Internet of Things, such as connected vehicles and smart devices, have on logistics.

6/19/17 Julian Allen – Logistics Land Availability in London

Dr. Julian Allen is a Senior Research Fellow from University of Westminster. He shared with the team the challenges London faced in providing land for logistics purposes and their proposed solutions. He also discussed proposals work and do not work in London.

8/3/17 Kazuya Kawamura – Effects of land-use policies on local conditions for truck deliveries

Kazuya Kawamura is a Professor at the Department of Urban Planning and Policy at the University of Illinois at Chicago. He presented the findings from a study that examined the relationship between local land-use policies such as zoning code, tax increment financing district (TIF), and planned manufacturing districts, and the built environment factors that are important for urban freight deliveries using data from Chicago. The presentation also introduced a tool called "Truck Scores", which measures local conditions for ease of making urban freight deliveries.

8/4/17 Anne Strauss-Wieder – NJTPA's perspective on freight planning

Ms. Anne Strauss-Wieder is the Director of Freight Planning in NJTPA. She shared her perspective on freight planning based on her experience in NJTPA.

8/29/17 Sergio Jara-Diaz – A Parametric Description of Cities for Strategic Transport Planning

Sergio Jara-Diaz is a Professor at the University of Chile. He shared his approach for defining a typology of cities and its uses for strategic transport planning.

11/16/17 Ian MacMillan – Facility-Based Mobile Source Measures

Ian MacMillan is the Planning and Rules Manager at South Coast Air Quality Management District. He shared the strategy that the South Coast Air Quality Management is pursuing to go from having the worst air quality in the nation to meeting federal air quality standards in the next few years. The strategy focuses on reducing emissions from mobile sources (cars, trucks, ships, etc), which are the primary contributor to local smog. Facility-based Mobile Source Measures are one of many measures that are proposed to reduce emissions from mobile sources visiting facilities like warehouses, ports, etc. In order to better understand truck activity and to assist in quantifying mobile source emissions, SCAQMD funded a study to evaluate truck trip generation in southern California warehouses. This study and an overview of some of the challenges in reducing mobile source emissions was discussed in the presentation.

11/21/17 Tom O'Brien – Land-Use Needs for Port Development

Tom O'Brien is the Executive Director of the Center for International Trade and Transportation (CITT) at California State University, Long Beach and the Associate Director of Long Beach Programs for the METRANS Transportation Center. He shared with the team some of the challenges faced by port operators / users and the land-use related solutions that were proposed.

11/23/17 Seckin Ozkul – Land-Use Analysis to Enhance Successful Logistics Activity Center (LAC) Development

Seckin Ozkul is a Research Associate Faculty at Center for Urban Transportation Research/ University of South Florida. He shared with us an approach to determine potential locations for a Logistics Activity Center (LAC).

1/3/18 Jean-Paul Rodrigue – Comparative City Logistics: Land Use and Home Deliveries

Jean-Paul Rodrigue is a Professor from the Department of Global Studies and Geography in Hofstra University. He spoke about the different types of freight landscapes and the impacts of home deliveries.

3/19/18 David Greensfelder – Planning for Retail in an On-line World

Mr. David Greensfelder is the Founder and Managing Principal at Greensfelder Commercial Real Estate. He shared with the team on the planning of retail spaces in light of growing ecommerce sales.

4/03/18 Larisa Ortiz – Retail and Land-Use Patterns

The rise in e-commerce has made retail planning even more complex, with significant implications for those who design public policy, make capital investment decisions, and develop the regulatory and zoning frameworks that inform land use and urban design. What we do know is that these changes have caught the retail industry, as well as those in the public sectors by storm. This presentation offered a set of solutions to help mitigate impact and take advantage of opportunities during this time of transition.

APPENDIX C: NCHRP 08-111 PEER EXCHANGE WORKSHOP SUMMARY

Date: June 26, 2019
Venue: Keck Center, Washington, DC

Q1. Key land-use and freight issues suggested by participants during the Workshop

Land-use or space-related

- Lack of loading zones
- Lack of space for truck parking, including parking for long-range trucks/overnight
    - In Atlanta, large DCs do not have space for trucks to park after making their delivery on site. These DCs generate a lot of traffic, but force the drivers to park/ rest illegally somewhere else.
    - Even with space available for truck parking facility, operating it may be a challenge.
    - Example: One of the State DOT in the southern region owned 60 acres of land and allocated it for a truck parking project. The private sector would lease the land, but it is proving to be challenging.
- Lack of availability to set transfer points to make micro deliveries (final deliveries into the city)
- Lack of suitable land available for freight activities
    - lack of large parcels of land for industrial use
    - lack of parcels within the urban area and close to customers
    - incompatible adjacent land uses or regulations (e.g., noise concerns)
- Competition of road space with other users, such as complete streets requirements, or cycling lane, transit, traffic calming facilities, etc.
- Competition of prime land for freight activities with other land uses
    - Developers compete for land and develop facilities/uses that give the highest return on investments (ROI). This results in (1) Change of land use tends to go from freight to non-freight; and (2) land prices are too high for freight use (freight activity has lower ROI compared to other uses), which reduces the ability for freight to compete with other land uses.
    - Where congestion is not a significant issue and there is sufficient road infrastructure, the freight community tends to buy cheaper land that is farther away and drive additional miles.
- Many land-use planners do not understand the economics of land use, not even the price per square foot. When they do planning, they do not consider the economic implications of their plans.
- Lack of buffer between truck routes and residential building (e.g., residential buildings are constructed up to the sidewalk along truck routes in Baltimore)

- Logistics sprawl, with industries moving away from the city center and the general spread of industries away from each other

Mode, Vehicle Type, and Infrastructure

- Infrastructure has limited ability to handle different truck types (e.g., parking facility, docking facility, road curbs, etc.). They are typically designed for a limited range of trucks
- Infrastructure cannot adapt as fast as society/ behaviors changes. There should be a balance between adapting infrastructure to freight traffic and vice versa
- Complete streets design can be incompatible with truck traffic
- Roadway geometry needs to appropriately accommodate trucks, especially when complete streets and other new solutions are made
    - Cities need to protect freight corridors and not allow other groups to change how it is used
- Larger trains may cause more delays at grade crossings

Equity

- Equity issues: the freight facilities are not evenly distributed (e.g., 1-hour delivery service may be offered for the privileged, not for all due to how facilities are concentrated in certain areas)
- Environmental justice issues: freight land uses tend to locate themselves in lower land value areas which are closer to the lower-income communities, causing more issues to them (safety, congestion, emissions, health, etc.)

Operation

- Lack of delivery management such as off-hour delivery, or joint-delivery programs
    - It can be difficult to implement programs such as Off-hours deliveries due to prohibitions of making deliveries in that time window, such as limited building access at night.

Externalities

- Congestion
- Noise produced by trains using railways
- Vibrations
- Safety

Education and Outreach

- People are not educated or aware of freight issues

Others

- Drivers shortages cause higher costs and more delays
- Additional truck trips produced by consumer consumption behavior
- Low tax benefits in freight programs do not adequately incentivize efficient behavior

Q2. Does your planning agency proactively collaborate with local jurisdictions to solve freight issues that involve land-use issues?

Many of the MPOs are not usually involved in land-use issues since it is not their role; sometimes they collaborate with other agencies to resolve freight issues, but they just fill the gaps instead of taking on a more comprehensive role. Nobody is facilitating the conversation between land use and transportation.

The challenge with land use and freight is that land use is more regional in scale but the cities are not talking to each other and understanding the impacts on other communities. There is a need to have a regional look at freight and land-use decisions.

Different agencies are competing with each other on the funding and resources, so they do not collaborate with other agencies. In addition, the funding sources for transportation projects and land-use projects are different. Transportation projects receive their money from the federal government, but land-use projects are funded from private companies. This also makes collaboration difficult. Overall, there is a disconnect between regional and local agencies.

Although collaboration may not be common, below are some cases where collaboration is exhibited.

Examples:

- Chicago Metropolitan Agency for Planning (CMAP) does quite a lot of work with local-level offices, especially in the area of freight land-use planning, such as collaboration with Will County. This collaboration may result from the fact that Chicago is a major freight hub.
- In Texas, the DOT works with local planners on matters related to access but not land use. The DOT tends to find out about land-use considerations at a much later stage, such as the construction stage. However, they would consider land use when looking at corridor studies.
- Maryland Port engages with land use because of encroachment issues. A good case is MIZOD - Maritime Industrial Zoning Overlay District. MIZOD not only protects and preserves land for maritime industry (such as secure access to deep-water areas for port activities), but also allowed investors to have greater access to credit for projects in this area.
- In Philadelphia, most jurisdictions try to collaborate, using appropriate Memorandum of Understanding. Traffic impact studies are required at times.

Q3. What are the key technological, economic, or social trend(s) that you think will have the most significant impact on freight land use and worry you?

- E-commerce
  - High volume of B2C movement: Amazon moves about 2.5 billion/year through parcel, out of which 3 million are Amazon's products
  - Relying on a single company (AMAZON) for so much is not a good thing
  - Increase in CO2 impact resulted from B2C movement
  - The consumer consumption behavior will increase the freight volume and the impact on freight land use
  - Impacts of cost of B2C shipping not considering social equity (contributing to a higher cost of being poor)
- Expedited deliveries
  - particularly additional externalities from a higher number of trips, such as CO2 impacts
- Connected and Autonomous Vehicles (CAVs)
  - Safety issues
  - Human may not have full control over driverless vehicles
- Automation
  - Implies that jobs will be lost BUT the economy and investments are justified based on employment, not the type of jobs; old job types will be lost and new types of jobs will be created
- Uberization
  - Its impact on private car ownership and parking is unclear. Is street parking no longer required for passengers other than pickup and drop off? What about garages? Will passenger car demand drop and could garage be used for deliveries?
  - Uber for Freight, which is harder to regulate publicly because most of the drivers are not driving traditional large trucks, as well as the impacts it may have on deliveries and truck parking
- Crowdsourcing
  - How can the impact of crowdsourcing be captured?
- Electrification of transportation
- Big box retail converted into loading docks
- Changes in the delivery pattern/ behavior of last-mile deliveries
  - Changes to freight activities when retail employees also serve as delivery personnel (e.g., Walmart using their employees to drop stuff off to customers)
  - Amazon flex uses personal vehicles to make final deliveries
- Community-friendly freight
- Competition between transportation planning agencies
- Competition for use of public space
- Geographical disparities of freight services
  - Unequal impacts of freight on more/less dense areas

Q4. In what ways can the tool used to analyze trends and technology be improved?

- Connected and Autonomous Vehicles (CAVs)
    - In the US, the rear platooning vehicles are not driverless. Currently Tennessee states would not see multiple driverless vehicles connecting. It is important to distinguish the various levels of automation and defined what is used in the analysis.
- It is not clear what establishment means, and
    - 'Establishment size' = overall company size even though spread across many locations
- Safety could be added to the matrix that relates individual decisions to system-level impacts
    - Policymakers may be made more aware of the impact of freight activities, if it is explained in safety terms
    - VMT might not accurately reflect safety
- To make it easier for land-use planners to understand the impacts, "human" issues such as environment, economic and human considerations should come up more clearly on the system level impact
- The link between how businesses make a decision and how the tool can help the public sector make informed decisions can be made clearer. Public policy is based on business plans/decision but the return on investment (ROI) is not clear in the trends. Public policies are more reactive than proactive. Although there are exceptions like in the Bay Area, where businesses are responding to public sector initiatives.

Q5. Are there any other land-use initiatives that should be included?

- State-level initiatives
- Tax credits and other incentives
- Initiatives related to mode such as rail, in-land waterways, and air
- Reserve parking through cell-phone
- Use of spaces such as Convention Center Parking for trucks with fees to use it
- Use of parcel lockers
- Demand Management initiatives
- Facilitation of Off Hour Delivery (OHD) programs
- Curb management
- Common distribution spaces
- Change building codes to consider: (1) Commercial vehicle; (2) Loading docks; (3) Overnight deliveries facilities; (4) Common distribution space; (5)Winter cleaning
- Having neighborhoods to distribute deliveries
- Create incentives to certify receivers, similar to clean energy program
- Foreign trade zones (to focus transportation effort on these lower tax zones)
- Amend complete streets to better include freight
- Land banking, allows public sector to manage an inventory of surplus land through the establishment of quasi-governmental country or municipal authorities (land banks), so that

the underutilized, abandoned, or empty land could be repurposed or revitalized. The land could be used for freight-related activities.
    - Land banks acquire properties through tax foreclosure intergovernmental transfers, non-profit transfers, and open market purchases. Tax foreclosures are the most common method of acquisition.
    - Benefits of land banks:
        - Vacant lots cannot be develop due to irregular shape or small size can be aggregated by land banks when they put together adjoining parcels to create a larger, more marketable property
        - Land banks can hold property for future development, enabling local government to curb negative effects from trends such as gentrification
        - Developers can save on holding cost by acquiring property directly from land bank
    - US Department of Housing and Urban Development Board Best Practice Award is given to Fulton County/City of Atlanta Land Bank Authority for revitalizing blight neighborhoods in the city of Atlanta through the use of land banking schemes.
- Use of alleys for logistics or parking when available
- Shared facilities
    - Chicago: Talk with hotels to get them to share parking
    - NYC: World Trade Center (WTC) shared underground truck inspection and deliveries. The World Trade Center Vehicle Security Center in NYC supplies safe and efficient deliveries to WTC tenants while minimizing adverse impacts on street-level pedestrian and vehicular activities.
- Stakeholder engagement
    - Reach out to trade organizations, lobbying arms
    - A more active role for all stakeholders

<u>Potential Case Studies:</u>

- Philadelphia: Tax Abatement (10 year) in consideration of potential benefits to land owners that offer FELU. Real estate developers are given a 10-year abatement on property taxes for new development/construction in the city.
- Minneapolis: Proactive loading zones. Currently, curbside loading zones are established based on business request and they pay annually. Would be interested in studying where there is mismatch in loading zones/need, and pilot a few proactive loading zones sponsored by the city, which could charge for use.

Q8. In general, what ways can the suggested tools be improved?

- Tools must allow a corridor-level analysis, not just city or regional
- Easy to visualize the data
- GIS feature in Freight and Service Trip Generation Software
- Link tools to quantify emissions
- Make sure tools are available and are known

- Pilot/case study using these tools in an actual freight plan or corridor study

Q9. Are there any other approaches/tools that can help implement FELU?

It can be helpful to implement FELU if we focus on benefits to receivers and shippers. Additionally, policymakers may be more aware of the impact of freight activities if it is explained in terms of safety.

Q10. Do you have any suggestions on how stakeholders could be involved in the FELU process?

- The need to involve people who benefit from the projects/programs to voice out their preference, and explain the advantages of the initiatives the benefits to the community
- Engage other professional organizations in a distilled form of this conversation. Collaboration between agencies such as the Institute of Transportation Engineers (ITE) and the American Planning Association (APA) may improve local level planning
- Piggyback on high-profile transportation/freight meetings and proactively address FELU issues before participants get combative (e.g., State Freight Advisory Committee includes land-use topics)
- Planning and decision making is not necessarily coordinated. Land-use decisions are vested in local government. Encourage multi-jurisdiction cooperation with some provision from the federal level.
- The funding sources of transportation and land-use projects are different. Hence, the dynamics and projects selected are different. The federal government funds transportation but not land use. There may be a need to align them for mutual benefits.
- Federal funds are not distributed ideally; instead, they tend to follow over-simplified guidelines. For example, the top 15 containers ports get funding, but they may not have the capacity to take on more traffic, while the port that ranked 16 may really need the funding for improvement.
- There is a disconnect between policy and enforcement, as they are performed by and upheld by different agencies. The policymakers should get support from the enforcement agency before implementing the policy.
- There is a need to meet and educate elected officials on freight and land-use issues. Issues should be framed in a way which they can relate to.
- Talk to land-use planners at the local level and the people making decisions, or even a retired mayor or city council members, to understand how they make decisions.

APPENDIX D: WORKSHOP PARTICIPANTS

Aaron Zimmerman
Site Development Program Manager
District Department of Transportation
aaron.zimmerman@dc.gov

Bala Akundi
Principal Transportation Engineer
Baltimore Metropolitan Council
bakundi@baltometro.org

Brian Hunter
Freight Coordinator
District Seven Florida Department of Transportation
brian.hunter@dot.state.fl.us

Caroline Miller
Transportation Planner city
Formerly City of Minneapolis
caroline.miller@minneapolismn.gov

Christina Kupkowski
Project Manager
Will County Land Use Department
ckupkowski@willcountyillinois.com

Daniel Studdard
Principal Planner
Atlanta Regional Commission
dstuddard@atlantaregional.org

Darrin Roth
Director of Highway Operations
American Trucking Associations
droth@trucking.org

Darryl Fields
Engineering Technical Lead
Mid-America Regional Council
Kansas City
dfields@MARC.ORG

David Greensfelder
Founder/ Managing Principal
Greensfelder Commercial Real Estate LLC
david@greensfelder.net

Elizabeth Irvin
Transportation Director
Center of Neighborhood Technology
eirvin@cnt.org

Evandro Santos
Transportation Strategic Planner
City of Norfolk
Evandro.Santos@norfolk.gov

Jean-Philippe Ducasse
OIG Research
United States Postal Service
jpducasse@uspsoig.gov

Jill Lemke
Manager of Strategic Planning
Maryland Port Administration
jlemke@marylandports.com

Jon Schermann
Transportation Planner
Metropolitan Washington Council of Governments
jschermann@mwcog.org

Kristin Calkins
Senior Transportation Planner
DC Planning Department
Kristin.Calkins@dc.gov

Mary Lamie
Executive Vice President – Multi Moda1 Enterprise
St. Louis Regional Freightway
mclamie@thefreightway.com

Mavrick Fitzgerald
Freight Planning
Memphis MPO
Mavrick.Fitzgerald@memphistn.gov

Ryan Hand
Senior Economic Planner
DC Planning Department
ryan.hand@dc.gov

Stacey Hodge
Founder
SBI Strategies
stacey@hdgstrat.com

Steve Brown
Manager, Regional Planning
Planning & Regional Development Department
Port Authority of New York and New Jersey
sbrown@panynj.gov

Steve Carter
Chief Operating Officer
Metropolitan Transportation Network
swcarter77@gmail.com

Tom Murtha
Senior Planner
Chicago Metropolitan Planning Agency
TMurtha@cmap.illinois.gov

Troy Mandy
Real Estate Manager
Philadelphia Industrial Development Corporation
tmandy@pidcphila.com

Panel

Gabriel B. Sherman
Panel Chair
Minnehaha Creek Watershed District
Formerly Massachusetts Department of Transportation

Caroline A. Mays, AICP
Interim Freight Planning Branch Manager
Texas Department of Transportation
Caroline.Mays@txdot.gov

Jose I. Marquez-Chavez
Senior Transportation Planner
California Department of Transportation
jose.marquez@dot.ca.gov

Jung-Hwi "David" Lee
Assistant Director, Long Range Planning Division
Tennessee Department of Transportation
david.lee@tn.gov

Peter C. Martin
Senior Transportation Engineer
CDM Smith
martinpc@cdmsmith.com

Spencer Stevens
Federal Highway Administration
spencer.stevens@dot.gov

Steven E. Bowman
Policy Coordinator
Iowa Department of Transportation
steven.bowman@dot.iowa.gov

William C. Rogers, Ph.D.
Senior Program Officer
National Cooperative Freight Research Program
Transportation Research Board
wrogers@nas.edu

Principal Contractors

José Holguín-Veras, Ph.D.
Principal Investigator
Professor Department of Civil and Environmental Engineering
Rensselaer Polytechnic Institute
jhv@rpi.edu

Cara Wang
Co-Principal Investigator
Associate Professor Department of Civil and Environmental Engineering
Rensselaer Polytechnic Institute
Wangx18@rpi.edu

Catherine Lawson
Co-Principal Investigator
Associate Professor Department of Geography and Planning
State University of Albany
lawsonc@albany.edu

Daniel Haake
Co-Principal Investigator
Senior Transportation Planner
HDR Inc
Daniel.Haake@hdrinc.com

Jeffrey Wojtowicz
Senior Research Engineer
Rensselaer Polytechnic Institute
wojtoj@rpi.edu

Juvena Ng
Research Associate
Rensselaer Polytechnic Institute
ngh@rpi.edu

Diana Ramirez-Rios
Research Assistant
Rensselaer Polytechnic Institute
ramird2@rpi.edu

Oriana Calderon-Quevedo
Research Assistant
Rensselaer Polytechnic Institute

6 REFERENCES

Boyd, A. (2014). The Once Great Port of New York. The Engines of Our Ingenuity.
Bureau of Economic Analysis (2009). Concepts and Methods of the U.S. Input-Output Accounts. U.S. Department of Commerce. https://www.bea.gov/sites/default/files/methodologies/IOmanual_092906.pdf.

Holguín-Veras, J., J. Amaya-Leal, J. Wojtowicz, M. Jaller, C. González-Calderón, I. Sánchez-Díaz, X. Wang, D. Haake, S. Rhodes, S. D. Hodge, R. J. Frazier, M. K. Nick, J. Dack, L. Casinelli and M. Browne (2015). *NCFRP Report 33: Improving Freight System Performance in Metropolitan Areas.* Transportation Research Board, Washington, DC.
https://www.trb.org/Publications/Blurbs/172487.aspx

Holguín-Veras, J., C. Lawson, C. Wang, M. Jaller, C. González-Calderón, S. Campbell, L. Kalahasthi, J. Wojtowicz and D. Ramirez-Rios (2017a). *NCFRP Report 37: Using Commodity Flow Survey and Other Microdata to Estimate the Generation of Freight, Freight Trip Generation, and Service Trips: Guidebook.* Transportation Research Board, Washington, DC.
https://www.nap.edu/catalog/24602/using-commodity-flow-survey-microdata-and-other- establishment-data-to-estimate-the-generation-of-freight-freight-trips-and-service-trips-guidebook.

Holguín-Veras, J., D. Ramirez-Rios, T. Encarnacion, J. González-Feliu, E. Caspersen, C. Rivera-Gonzalez, C. González-Calderón and R. Da Silva Lima (2019). Metropolitan Economies and the Generation of Freight and Service Activity: An International Perspective. Urban Logistics: Management, Policy and Innovation in a Rapidly Changing Environment. M. Browne, S. Behrends, J. Woxenius, G. Giuliano and J. Holguín-Veras, Kogan Page Limited**:** 19-51.

Holguín-Veras, J., D. Ramirez-Rios and J. Wojtowicz (2021). "Initiative Selector for Fostering Freight System Performance, Energy Efficiency, and Freight-Efficient Land Use." Posted: Retrieved 1 October 2021, from https://cite.rpi.edu/iselector/.

Holguín-Veras, J., D. Ramírez-Ríos and J. Wojtowicz (2017b). "Freight and Service Activity Trip Generation Software (FASTGS)." Posted: Retrieved 30 July 2017, from http://54.200.164.152/home.

Holguín-Veras, J., E. Thorson, Q. Wang, N. Xu, C. González-Calderón, I. Sánchez-Díaz and J. Mitchell (2013). Urban Freight Tour Models: State of the Art and Practice. Freight Transport Modelling. M. Ben-Akiva, H. Meersman and E. Van de Voorde. U.K., Emerald Group Publishing Limited**:** 335-352.

Lueck, T. J. (1986). "New York Port Changes with Shifting Economy." The New York Times. 01 June 1986, Retrieved from https://www.nytimes.com/1986/06/01/nyregion/new-york-port-changes-with-shifting-economy.html.

Port Authority of New York and New Jersey (2019). "History of the PANYNJ." Posted: Retrieved 11 March 2020, from https://www.panynj.gov/port/en/our-port/history.html.

Rhodes, S., M. Berndt, P. Bingham, J. Bryan, T. Cherrett, P. Plumeau and R. Weisbrod (2012). *NCFRP Report 14: Guidebook for Understanding Urban Goods Movement.* Transportation Research Board of the National Academies, Washington, DC. http://onlinepubs.trb.org/onlinepubs/ncfrp/ncfrp_rpt_014.pdf.

Wood, R. T. (1970). Measuring Freight in the Tri-State Region. The Urban Movement of Goods. Paris, OECD**:** 61-82.