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Urban Freight Delivery & Loading Spaces

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ABSTRACT

This research project presents an overview of the literature on urban freight and comparison of minimum requirements for freight loading spaces in the 20 largest cities in the United States, as well as the four most populous cities in North Carolina. The study provides insights on a topic that is little understood: how U.S. cities provide and manage infrastructure for urban freight delivery. This multi-methods study assesses the requirements for off-street and on-street loading spaces, drawing from quantitative and qualitative data collected from municipal zoning codes, planning documents, news stories, and interviews with local planners and transportation engineers. The findings indicate that requirements vary widely across the cities. While requirements for off-street loadings spaces are move prevalent, particularly for larger business, requirements for on-street loading spaces are less likely to be codified and depend heavily on the availability of curb space. This study provides a general overview of how freight loading spaces are provided and managed in larger U.S. cities and supports the need for improving the supply of freight loading spaces to meet the growing demand for urban freight deliveries spurred by e-commerce.

Keywords:
Urban freight delivery, loading spaces, on-street, off-street, zoning codes.

EXECUTIVE SUMMARY

Freight deliveries have grown exponentially in recent years, rendering existing freight infrastructure inadequate in some location. This is especially critical in urban areas, at both commercial and high-density residential buildings. With shortages of freight loading spaces, delivery operators often resort to workarounds that are illegal (e.g., double parking) or at least undesirable (e.g., circling while waiting for available loading zones) (Cherrett et al., 2012, Magniol et al., 2018). The lack of adequate loading spaces can exacerbate other problems in urban areas, including traffic congestion, noise, road safety for vehicles and pedestrians, and air pollution (Chatterjee et al., 2008).

Although it is recognized that inadequate supply of freight loading spaces is a problem in the United States, there has been little research on how cities provide and manage these spaces. This project advances the research agenda by building a general understanding of freight planning, management, and enforcement of both off-street and on-street loading spaces in the 20 largest U.S. cities as well as the four most populous cities in North Carolina.

Through a multi-method approach, this research reviews the current literature on urban freight and examines current planning practices related to freight loading spaces. This project collects data on off-street and on-street loading space regulations from municipal zoning codes, planning documents, news stories, and interviews with local planners and transportation engineers. The cities have well-defined, dense urban cores with limited road space, but exhibit a variety of approaches to freight planning.

Overall, planners and transportation engineers find it challenging to provide an adequate supply of loading spaces to meet the growing demand created by urban freight delivery. This study offers several key findings that support the need for improvements to the provision and management of loading spaces in larger urban areas. First, the analysis reveals that loading space requirements vary widely across cities and land use types. Minimum off-street loading requirements for commercial areas are widely used, typically tied to gross floor area. Off-street requirements for high-density residential areas (i.e., condominiums) are less common; cities use various units to establish these requirements that include number of residential units, gross floor area, and land area occupied. Second, on-street loading spaces are an important component of urban freight delivery—even when off-street loading space is available—but are less likely to be codified and often highly dependent on the availability of curb space.

To illustrate the differences in requirements for off- and on-street loading spaces among cities, this project produced hypothetical scenarios for both commercial and residential land use. The minimum loading space required for every city in the study is calculated for each scenario to enable comparison.

A manuscript titled "Freight Loading Space Provision: Evidence from the U.S.A." based on this study has been published (McDonald, N. and Q. Yuan*. 2021. Freight Loading Space Provision: Evidence from the U.S.A. *Journal of Urban Planning and Development* 147(2). The manuscript is found on page 20 in the Appendix.

1.0 INTRODUCTION

In recent years, there has been an increasing demand for urban freight deliveries to commercial and residential areas. In 2016, the U.S. Postal Service delivered more than 5.1 billion packages, up from 3.1 billion packages in 2010 (Zaleski, 2017). Packages and other deliveries require loading spaces, or specific areas used for loading and unloading of goods or commodities from a delivery vehicle. These loading spaces are essential freight infrastructure for deliveries and can be located on-street or off-street.

When a spatial mismatch exists between the supply and demand for freight loading spaces, freight deliveries become inefficient—particularly in busy urban areas where freight vehicles interact with cars, buses, bicycles, and pedestrians. Faced with insufficient availability of loading spaces in the urban core, freight operators often exhibit undesirable delivery behaviors. These behaviors, such as double parking, exacerbate traffic congestion and safety concerns arising from user conflicts on local streets (Cherrett et al., 2012; McDonald et al., 2019). Despite interest in developing better strategies for better accommodating urban freight delivery in urban cores in Europe and North America (Allen et al., 2010), limited research has been done on how U.S. cities currently address planning and managing freight loading spaces.

1.1 Objective

The objective of this research project is to review the current literature on urban freight and analyze the minimum requirements for off-street and on-street freight loading spaces in major U.S. cities to understand how these requirements affect the efficiency of urban freight delivery. The research focuses on two types of land use that are commonly found in urban centers: commercial and high-density residential (i.e., condominiums).

1.2 Scope

The literature review covers recent work in the United States and Europe. The analysis of loading space provision focuses on the 20 largest U.S. cities and the four most populous cities in North Carolina. The research considers the role that planners and transportation engineers play in providing and freight loading spaces in larger urban areas.

This report provides the full literature review and an extended abstract for the loading space analysis as that is currently being reviewed by a journal.

2.0 LITERATURE REVIEW

Urban freight is the movement of goods by or for commercial entities that takes place in an urban area. These movements involve both consumer- and producer-related economic activity and are pivotal linkages in supply chains (Dablanc and Rodrigue, 2017). These movements occur for reasons including the collection and drop off of goods, the transfer of goods, and the service of establishments (Cherrett et al., 2012). While goods movement is common to cities across the world, the ways it occurs is highly dependent on the economic, physical, and social geography of a region. Allen, Thorne, and Browne (2007) state that the ways goods move in an area are influenced by factors including the locations and types of industries present in an area; the supply chains of affected industries; the existing transportation infrastructure; the location and extent of warehousing facilities; the regulations imposed on freight vehicles by local government(s); traffic conditions; and customer behaviors.

2.1 Sociohistorical Context and Importance

Urban freight activity is crucial to the functioning of a city or region. Most urban activities are supported by or interact with the movement of large volumes of goods in some way, and very few activities occurring in a city do not involve the movement of commodities (Cui et al., 2015). Urban freight is important to cities for many reasons, including the industry's role in wealth-generating activities, freight companies' roles as local employers, and the practice's impact on a region's economic efficiency and competitiveness. An efficient, reliable freight system supports an urban economy (Allen et al., 2007). Furthermore, an efficient freight transport system is a major element for urban development, both promoting economic growth and sustaining existing economic activity, thus making an urban economy more competitive (Cui et al., 2015).

However, a fundamental dilemma underpins urban freight planning -- efficiency versus livability. Urban environments must be attractive places for people to live, work, and spend time and money in. Some characteristics associated with walkability such as narrower streets and active mixed-use environments may make efficient movement of goods difficult. Striking the balance between these two conflicting urban necessities is the challenge of urban freight planning (Allen et al., 2007). Because policies and infrastructural changes are not implemented in vacuums, consideration must be given to how a policy addressing one issue may affect another. In the realm of urban freight, for example, a policy addressing passenger vehicle parking will inevitably affect freight vehicle deliveries by impacting freight parking, as space is finite (Nourinejad, Wenneman, Habib, and Roorda, 2014).

Perhaps as cause or perhaps as consequence of the challenges associated with planning for urban freight activity, in most cities such activity is not given adequate attention in planning. Kiba-Janiak (2017) finds that, in many long-term transportation plans in the European Union, the focus is on public transport and transportation infrastructure, not on freight activity. Typically, coherent urban freight transport policies are not as well developed as policies on other transportation issues. A hinderance with adequate development of urban freight policies is the lack of ongoing public data collection, as much of the data associated with urban freight activity is privately held by logistics companies (Cherrett et al., 2012).

2.2 Trends Influencing and Changing Urban Freight

The efficient movement of goods into and through an urban area has always been important for an urban economy, but recent global trends have given it greater importance (Cherrett et al., 2012), as well as reshaped the practice in turn. Economic changes, further complicated by demographic changes and technological innovations, are reshaping urban freight flow patterns and vehicle movements (Visser, Nemoto, and Browne, 2014). These trends include population urbanization, the rise of e-commerce, associated changes in the brick-and-mortar retail landscape, and economic globalization.

Urban populations are growing, and it is projected that 60% of the global population will live in urban areas by 2030 (Browne, Allen, Nemoto, Patier, and Visser, 2012). This growth and concentration of people in urban environments has led to growth in urban economies, yielding increased demand for goods and services both commercially and domestically and creating an increased demand for goods movement. Urban freight traffic volumes are growing in many jurisdictions and are projected to expand (Cui et al., 2015; Browne et al., 2012). There is literature that suggest that, generally, an increase in customer density in a given sales area can yield greater efficiency when coupled with a longer delivery window (Boyer, Prud'homme, and Chung 2011).

The rise of e-commerce and "just-in-time" delivery is adding complexity and stress to supply chains (Marcucci, Gatta, and Scaccia, 2015). Online retail saw a 14.8% growth between 2007 and 2012, substantially outpacing total retail growth. Internet shopping is expected to only become more prevalent, as older populations discover the convenience of shopping online; as younger populations continue to utilize e-commerce; as traditional "brick-and-mortar" establishments generally reduce; and as the types of goods sold online expands (Visser et al., 2014). This growth of e-commerce will result in more delivery vehicles in urban and/or residential areas; growth in online retail has also meant a growth in the rates of home deliveries of parcels, as customers ordering products directly to their homes is the predominant way in which online transactions are carried out (Rodrigue, 2017). This trend adds complexity and cost to the supply chain for multiple reasons because it results in small-lot delivery and higher delivery frequencies to more potential locations, all of which done with increased time sensitivity (Visser et al., 2014; Rodrigue, 2017). There is some debate as to how this economic trend will impact congestion. While it is viewed as certain that small-lot delivery will result in more commercial vehicles – often small vans or trucks – on the road, some argue that home delivery will mean fewer personal vehicle trips related to shopping, resulting in a net reduction of vehicles on the road. This may not be the case, however, as certain goods can still not be purchased online and consumers often combine shopping trips, meaning that, though one item on their shopping list for a trip can now be delivered to their home, others cannot, and the trip will occur nonetheless. In some instances, customers are purchasing goods online and then traveling to a location for pickup (Visser et al., 2014).

The practices of traditional retail establishments have changed as well, in part in response to the e-commerce trends, yielding further implications for delivery practices. Businesses are generally staying open for more days per week and more hours per day. Small businesses are also generally stocking less to reduce overhead costs and the risk of unsold goods, thus requiring more frequent, smaller deliveries with lower load factors. This has implications for congestion and traffic from delivery vehicles (Browne, Piotrowska, Woodburn, and Allen, 2007). E-commerce's rise has also begun to reshape the role that physical retail establishments play. Some now act as pickup points for online purchases, while others offer click-and-collect multi-chanelling options. Others still have begun to act simply as showrooms for products to be purchases online, with no sales actually occurring within the establishment. These economic trends could reshape what retail developments look like and have land use planning implications (Visser et al., 2014).

Finally, as the world economy continues to globalize, effective and efficient freight transport is crucial to the success of cities that hope to compete in the modern economy (Lindholm and Behrends, 2012).

These trends have posed operational challenges for the freight and logistics industry and resulted in adaptations and changes. One industry response to economic change is with new delivery systems, integrating multimodal shipping and the containerization of freight. This decades-old shift results in a decreased need for warehousing space as well as increased dependence of the manufacturing system on a reliable urban freight system (Czerniak, Lahsene, and Chatterjee, 2000). Another industry response has been the shift to smaller vehicles to achieve faster delivery times in congested urban areas. Finally, the increase in home delivery has resulted in increased transparency expectations from consumers, with new technology such as GPS tracking and estimated delivery windows (Hopkins and McCarthy, 2016). The shift in consumer habits and its impacts on the freight industry is exemplified well by FedEx, which, in 2007, reported a growth in its home delivery segment that was stronger than its overall ground delivery growth of 9% (Boyer et al., 2011).

2.3 Associated Externalities

While goods movement is vital to a successful city, it is not without negative impacts. Environmental impacts of urban freight include air pollution, noise, and greenhouse gas emissions. In a study of cities in the European Union, Dablanc (2007) found that, though urban freight represented 20-30% of vehicle kilometers traveled in the studied cities, freight vehicles generated between 16% and 50% of air pollution emissions. In most cities, diesel-powered heavy goods vehicles are the most significant contributor of particulate emissions and, in some instances, contribute carcinogenic emissions as well (Cui et al., 2015).

Such pollution is partly related to another major negative impact of freight vehicles in urban spaces: congestion. The freight sector is generally seen as a major contributor to congestion and other traffic problems (Cherrett et al., 2012). In an analysis of urban areas, it was estimated that freight vehicles parked illegally were the third leading cause of urban congestion that was unrelated to traffic volume, behind crashes and construction (Han, Chin, Franzese, and Hwang, 2005). Congestion can also be caused by large vehicles attempting to maneuver in dense urban areas, either on the way to deliveries or in search of parking. Beyond air pollution caused by congestion, the associated time lost due to idling in traffic has economic impacts on the supply chain, including resource waste, inefficient movement, and unreliable deliveries (Allen et al., 2007; Buldeo Rai, van Lier, Meers, and Macharis, 2017).

Finally, the negative social impacts of urban freight vehicles in affected urban areas cannot be overlooked. Vehicle pollution has negative public health implications; freight vehicles can cause injurious crashes while attempting to navigate urban areas; and the presence of such vehicles can cause noise pollution, visual intrusion, and barrier effects, affecting quality of life and perceptions of safety (Allen et al., 2007; Cui et al., 2015). The perceptions of danger of freight vehicles in urban areas is largely attributed to the perceived exposure of pedestrians increasing risk; however, in literature review done on the United Kingdom, commercial vehicles were found to have low involvement in pedestrian casualty crashes, and more people were found to have been injured or killed in crashes involving private automobiles (Browne, Piotrowska, and Allen, 2007). A phone survey of Maryland drivers found that 48% of those surveyed attributed their safety concerns regarding commercial vehicles to truck driver fatigue, while 30% named trucks moving at high speeds as their biggest concern (Haynes and Wells, 2014). These safety concerns have been found among truck operators as well, with truck drivers surveyed in Knoxville, Tennessee, listing aggressive drivers and congestion as their biggest perceived threats to reduced efficiency and safety (Cherry and Adelakun, 2012).

Freight and service trips contribute more to the negative externalities associated with urban transport than passenger trips (Buldeo Rai et al., 2017). The externalities associated with urban freight are largely due to the size difference between heavy goods vehicles and the dense urban landscape, as well as the fact that many such vehicles are diesel-powered (Kin, Verlinde, van Lier, and Macharis, 2016).

2.4 Sustainable Urban Freight

Urban freight transport as it is currently conducted is viewed as unsustainable due to the environmental impacts of the vehicles, warehouses, and distribution centers used (Buldeo Rai et al., 2017). Though the negative externalities of urban freight make the practice unsustainable, efforts have been focused on planning for a sustainable urban freight system. Sustainable urban freight policy measures would satisfy the economic, environmental, and social needs of a community as they relate to goods movement while minimizing the negative effects of urban freight practices (Allen et al., 2007). Behrends, Lindholm, and Woxenius (2008) explain a sustainable transport system as one that contributes to a community's economic growth and social equity without further polluting the air or hurting the natural environment. Such a system, ideally, would reduce air pollution and greenhouse gas emissions caused by goods movement, improve the efficiency and cost-effectiveness of goods movement, and improve the livability and attractiveness of a city via efficient land use and road safety improvements.

2.5 Planning for Urban Freight

2.5.1 Urban Freight Policy Interventions

Planning policy can be used to address the externalities associated with urban freight activity. Such policy can complement infrastructural changes or stand alone as regulations. Policies that address goods vehicles typically come in the broad form of access restrictions in both time and geographic location.

Some such urban freight policies address time restrictions. Common urban freight policies related to time involve limiting when freight vehicles can be present in certain areas and how long vehicles can be parked in an area. These restrictions can address various environmental and social externalities associated with goods vehicles (Allen et al., 2007). The goal of such time limitations is to limit the interaction of goods and service vehicles with car and pedestrian traffic. Such policies can impact economic efficiency and the operations of businesses that rely on deliveries. These policies require surveillance and enforcement to be effective (Russo and Comi,2010).

Other urban freight policies address vehicle restrictions. Urban freight policies on vehicles often come in the form of environmental zones, low emission zones, and zones with specific vehicle access criteria. In such zones, only vehicles that meet the criteria set by the policy can enter. Such criteria might include regulations on vehicle size, weight, or emissions (Allen et al., 2007), though Dablanc (2007) recommends that access criteria be based on age or other such indicators of a vehicle's environmental impact rather than on a vehicle's weight or size. Access-restricted zones can reduce the infrastructural damage caused by freight vehicles and improve safety for road users (FHWA, 2018).

Another urban freight policy type addresses road restrictions. Route designation for freight vehicles involves identifying roads and routes for goods and service vehicle operators to prioritize in usage, with the intent of keeping large vehicles off of a city's more sensitive roads. This can be done through information sharing with relevant stakeholders. A common way to disseminate freight routing is through signage, clearly informing users of the policies (Allen et al., 2007). In some instances, cities extend permission of use of bus lanes to freight vehicles, developing a "sub-network of freight vehicles" (Russo and Comi, 2010, p.6362). Similar to the aforementioned zones, freight vehicle routing aims to minimize the interaction of goods vehicles with other road users as well as improve efficiency.

Not all urban freight policy initiatives take the form of restrictions, however. Russo and Comi (2010) discuss incentive structures to encourage logistics operators to behave in ways that mitigate their negative impacts on the urban space. As is the case with land use, policy can be politically contentious. Allen, Anderson, Browne, and Jones (2000) discussed urban freight policy measures with relevant logistics stakeholders, focusing the conversation on efficiency. The stakeholders identified policies they felt would improve efficiency and policies they felt would hurt efficiency. Among those that were deemed to improve efficiency were traffic management and calming methods, improved information dissemination, and the relaxing of restrictions on freight vehicles and operations. The policies deemed detrimental to efficiency included many of the aforementioned interventions, as well as lowered speed limits and increased space for pedestrians, bicyclists, and mass transit. These results speak to the fundamental challenge underpinning planning for urban freight: striking the balance between operational efficiency and city livability.

2.5.2 Urban Consolidation Centers

One way that cities have attempted to use planning to address urban freight issues takes the form of new infrastructure that is meant to facilitate desirable logistics practices. Such infrastructure is known as the urban consolidation center, which can be defined as a logistics facility situated in close proximity to an area being served, from which consolidated deliveries to that area are carried out (Allen et al., 2007). Such facilities act as nodal points in which cargo can be shifted from heavy goods vehicles onto smaller vehicles that may be more adept to navigate urban environments. This cargo is assembled and regrouped at the urban consolidation center through logistics services occurring within the facility (Gogas and Nathanail, 2017). There are three broad types of urban consolidation centers. The first is the area urban consolidation center, which serves a town or city with a variable number of companies and clients. The second is a single operation urban consolidation center, which serves a single operation, such as an airport retail area. The third is a special project urban consolidation center, which serves a single site for non-retail purposes, such as a construction project (Allen et al., 2007). The purpose of the urban consolidation center is to avoid the need for heavy goods vehicles to enter urban areas, thus mitigating the aforementioned externalities that such occurrences cause (Gogas et al., 2017). Additionally, the goal of the urban consolidation center is to make an area's urban logistics more economically, environmentally, and socially sustainable through reduced vehicle miles traveled and higher load factors (Kin et al., 2016).

Kin, Verlinde, van Lier, and Macharis (2016) define prerequisites for a successful urban consolidation center. Among them were strong public sector involvement with encouragement through regulation; support from local stakeholders; significant problems in the area indicating a need for such a facility; availability of funding; and a single manager or landlord for the facility. Furthermore, these authors state that, for an urban consolidation center to be economically viable, there must be sufficient use by stakeholders and sufficient volume of cargo, as well as the ability to exist independent of government subsidy.

When run successfully, urban consolidation centers can have many positive impacts, and are believed to contribute to an area's urban economy and quality of life (Gogas et al., 2017). Impacts of urban consolidation centers include a reduction in vehicle trips; a reduction in vehicle miles traveled; a reduction of vehicles in an area; improved efficiency of truck loads;

and a greater feasibility of modal shift. While such impacts benefit an area's economy, they also address the social and environmental externalities associated with urban freight. The ability to consolidate loads prior to goods vehicles entering an urban area can reduce the emissions associated with goods vehicles by simply reducing the number of vehicles in the area. Furthermore, such consolidation can enable the opportunity to shift modes to smaller, more environmentally sensitive vehicles in the final stages of a delivery, thus potentially making an area more pedestrian-friendly (Allen et al., 2007).

The reality of urban consolidation centers is that they are challenging to maintain and have a relatively low success rate. Historically, most urban consolidation centers fail once the government subsidy is taken away (Kin et al., 2016). This is due to the fact that urban consolidation centers are expensive. Such facilities have high up-front costs, and the operational and logistic complexity of the consolidation process brings enduring costs (Allen et al., 2007). An added link in the supply chain can further add time-cost to deliveries, which retailers, logistics companies, and other stakeholders are often opposed to (Kin et al., 2016).

2.5.3 Parking

An issue underpinning many of the common urban freight policy initiatives is a shortage of truck parking in urban cores and central business districts. Han, Chin, Franzese, and Hwang (2005) estimate that freight vehicles parked illegally are the third leading cause of urban congestion that is not due to traffic volume, behind crashes and construction. However, without adequate available and well-located parking, operators of freight vehicles often have no choice but to park illegally (Nourinejad et al., 2014), and the unmet demand can create both private and social costs. Private costs include service delays, excess fuel consumption, and fines for illegally parked drivers. Social costs include congestion, infrastructural damage, air pollution, noise, and stress to road users. All of these costs aggravate the situation and contribute to the high costs of last-mile distribution (Marcucci et al., 2015). The management of parking and curb space also has implications for urban aesthetics, pedestrian comfort, and pedestrian safety (Nourinejad et al., 2014).

The literature classifies parking-related urban freight planning policies into four broad categories: time restrictions, pricing strategies, land use and space management, and parking enforcement. Time restriction policies work to separate commercial vehicles and passenger vehicles temporally rather than spatially. Such policies essentially limit the time of day that delivery or service vehicles can be in the central business district. Limitations can be strategized based on peak delivery times (Nourinejad et al., 2014). Pricing strategies use parking fees to encourage efficiency by attempting to bring down dwell times and increase space turnover (Marcucci et al., 2015). Pricing strategies include charging for commercial vehicles, time limiting parking meters, and implementing escalating rate structures, in which the hourly rate of parking increases as time progresses. Some cities have gone as far as to implement dynamic price adjustment for on-street parking facilities, attempting to control and manipulate available parking supply on a block-by-block basis (Nourinejad et al., 2014). Land use and space management target the size, position, and usage of curbside space (Marcucci et al., 2015). In relation to urban freight planning, such space management would include the explicit designation of some curb space to commercial vehicles or the extension of loading zones to better accommodate said vehicles (Nourinejad et al., 2014). "Dual-use drop zones", in which bus stops are also usable as delivery vehicle parking, offer a flexible option in space management (Cherrett et al., 2012). Parking enforcement involves simply bringing consequences for parking violations (Nourinejad et al., 2014). Parking enforcement requires monitoring, either by persons or by technology, and can be helped by physical barriers such as gates or bollards. Enforcement can only be done, of course, when parking regulations are in place (Marcucci et al., 2015).

The main objective of urban freight planning parking policies is to attempt to find solutions to the problems that truck drivers face and cause that are rooted in insufficient parking supply. Such policies should be site-specific and consider the context of an urban area, as the specific built environment will play a role in the strengths and challenges of truck parking (Marcucci et al., 2015).

2.6 Chapter Summary

Urban freight activity is a crucial component in the functioning of a city's urban economy. Recent global trends are causing the importance of efficiency in urban freight activity to increase. However, such activity as it is commonly practiced today is not without environmental and social consequences. Planning in such a way that mitigates these consequences and enables efficiency in goods movement has proven challenging for many cities. Planners have attempted to address the problems in urban freight activity through policies that restrict access to freight vehicles, policies that limit the interaction of freight vehicles and the population, new logistics infrastructure, and manipulation of parking supply.

3.0 METHODOLOGY

The analysis of loading space provision in the U.S. included the assessment of quantitative and qualitative data from 24 U.S. Cities. The following sections describe the data collection and analysis.

3.1 Data Collection

Data for this study comprises planning practices for the provision of loading zones in the 20 largest U.S. Cities and four most populous cities in North Carolina.[1] For all cities in the study, zoning codes were assessed to identify the minimum requirement for the number of off-street loading spaces provided. Planning practices for providing on-street loading space are more

[1] The cities include in this study are: New York, Los Angeles, Chicago, Houston, Phoenix, Philadelphia, San Antonio, San Diego, Dallas, San Jose, Austin, Jacksonville, San Francisco, Columbus, Fort Worth, Indianapolis, Charlotte, Seattle, Denver, and Washington D.C., and the North Carolina cities of Charlotte, Raleigh, Greensboro and Durham.

varied. Consequently, the study assessed multiple sources of evidence on the provision of on-street loading spaces through searching municipal codes, reviewing planning documents and news stories, and interviewing municipal planners and engineers. Additionally, 16 planners and transportation engineers from 15 cities were interviewed about practices relating to on-street loading spaces.

3.2 Data Analysis

Data on loading space requirements were compiled and used to create commercial and land use scenarios to reveal the variations in loading zone regulations across cities (see Appendices). The interviews with planners and transportation engineers were transcribed and analyzed for similarities and differences in policies and practices used to provide and manage on-street loading spaces.

4.0 RESULTS

This section describes key findings from the analysis for requirements for off-street and on-street freight loading spaces from the 24 cities examined in this study.

4.1 Off-street Loading Requirements

Minimum off-street loading requirements are common in zoning codes in major U.S. cities, found in all but two of the 20 largest cities in the country (Forth Worth, Texas, and Denver, Colorado). Typically, the minimum number of on-street loading spaces are assigned progressively, tied to gross floor area. As gross floor area increases, so does the number of loading spaces. Land use type is another factor that should be considered when establishing minimum requirements, as different types of uses (particularly commercial) generate varying level of freight demand (The Rensselaer Polytechnic Institute et al., 2012). Yet this nuance is often ignored in less refined approaches to calculating minimum requirements, leading to a mismatch between the demand and supply of freight loading spaces in some urban areas. Additionally, a minimum is not always required for small and medium local businesses, which can also contribute to the mismatch.

Land Use Scenarios

To illustrate the difference in minimum requirements for off-street loading spaces among the 24 cities, this project created four hypothetical scenarios. Each scenario contains a commercial or residential land use commonly found in urban areas, and the minimum number of off-street loading spaces required is calculated for each city based on its regulations or policies. The land use scenarios found many cities require zero off-street loading for smaller commercial uses (e.g., 2000 sq. ft and 4,000 sq. ft). Nine of out 20 cities required no off-street spaces for a large condominium building (e.g., 120 units, gross floor area of 100,000 sq. ft., occupying 1.5 acres). See Appendix A for the commercial land use scenarios and Appendix B for the residential scenarios.

4.2 On-street Loading Requirements

Given the findings from the land use scenarios, it is obvious that freight deliveries depend on on-street loading spaces in many cities. This finding was corroborated by the interviews with municipal planners and transportation engineers.

The interviews offer insights into the provision of on-street loading spaces. A few themes emerged across the cities, which are summarized in Table 1.

TABLE 1: SUMMARY OF INTERVIEW THEMES AND RESULTS

Interview Themes	*Major Results*	*Representative Cities*
On-street loading provision approach	On an ad-hoc basis; Constrained by existing pattern of curb space allocation	Durham, Greensboro, Houston, Charlotte, etc.
Institutional involvement	Involving multiple departments and agencies;	Raleigh, Chapel Hill, Phoenix, etc.
	Establishing independent agencies to deal with the issue	Philadelphia and Washington, D.C.
Loading space request process	Requested by local businesses with delivery demand	High Point, Philadelphia, etc.
Law enforcement of loading space uses	Relying on police department	Asheville, High Point, Raleigh, etc.
	Relying on independent agencies	Philadelphia, Washington, D.C.
Relevant initiatives and programs	Developing pilot programs to optimize curb space management	Washington, D.C., Raleigh, Charlotte, Philadelphia
Concern over conflicts between transportation modes	Loading zones and activities may affect walking environment	Seattle, Philadelphia

5.0 CONCLUSION

We find the need for urban planners to be knowledgeable about and engaged in conversations about urban freight are rising, and the literature review highlighted critical reasons for this including economic productivity. Overall, planners and transportation engineers in major U.S. cities find it challenging to provide an adequate supply of loading spaces to meet the growing demand created by urban freight deliveries. Among the cities included in this study (the 20 largest cities and the four most populous cities in North Carolina) requirements for off-street loading spaces vary widely. Furthermore, zoning regulations in most cities do not require off-street spaces for small and medium local businesses and apartment buildings.

The provision of on-street zones also vary widely among these cities, although they are less likely to be codified. Instead, they tend to be established on an ad-hoc basis and depend heavily on the availability of curb space—as on-street spaces compete with cars, buses, bicycles, and pedestrians. However, on-street loading zones are a critical element of the freight delivery infrastructure, serving to supplement the off-street spaces.

This research offers important insights into the regulation of off- and on-street loading spaces. This comprehensive view—illustrated by hypothetical scenarios—broadens the understanding of the provision, management, and enforcement of freight loading spaces for commercial and high-density residential buildings in major U.S. cities.

6.0 RECOMMENDATIONS

This study demonstrates that local municipalities could make improvements to their freight loading infrastructure to better support urban deliveries. Recommendations for further research include:

- Accurate estimations of supply and demand for freight loading, especially in city centers.
- The role of collaboration with key partners (e.g., Public Works Department, Police, freight receivers, logistics service providers, etc.) in supporting or hindering the provision, management, and enforcement of loading spaces.
- Successful practices for off-street loading space design and curb space allocation for on-street loading.

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8.0 APPENDICES

8.1 Appendix A: Off-Street Scenarios for Commercial Land Use

TABLE 2: NUMBER OF MINIMUM LOADING SPACE REQUIRED FOR MAJOR U.S. CITIES IN FOUR COMMERCIAL LAND USE SCENARIOS

	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**
	An average Starbucks (2,000 square feet)	An average McDonald's (4,000 square feet)	An average City Target (20,000 square feet)	An average Whole Foods (38,000 square feet)
Top 20 in the U.S.				
New York	0	0	1	1
Los Angeles	0	0	0	0
Chicago	0	0	1	2
Houston	0	0	1	1
Phoenix	0	0	0	1
Philadelphia	0	0	1	1
San Antonio*	1 (reduced size)	1 (reduced size)	2	2
San Diego	0	0	1	2
Dallas	0	0	1	1
San Jose	0	0	1	2
Austin	0	0	1	1
Jacksonville	0	0	1	2
San Francisco	0	0	1	1
Columbus	0	0	1	1
Fort Worth	0	0	0	0
Indianapolis	0	0	1	2
Charlotte*	1 (reduced size)	1 (reduced size)	1	2
Seattle	0	0	1	1
Denver	0	0	0	0
Washington D.C.	0	0	2	2
Top 4 in the N.C.				
Charlotte*	1 (reduced size)	1 (reduced size)	1	2
Raleigh	0	0	0	0
Greensboro	0	0	1	1
Durham	0	0	1	1

*For Scenario 1 and 2, San Antonio and Charlotte required commercial land uses to provide off-street loading spaces with reduced sizes.

8.2 Appendix B: Off-Street Scenarios for Residential Land Use

TABLE 3: NUMBER OF MINIMUM LOADING SPACE REQUIRED FOR MAJOR U.S. CITIES IN THREE RESIDENTIAL LAND USE SCENARIOS

	Scenario 1	**Scenario 2**	**Scenario 3**
	A small condo apartment (30 units, 25,000 square feet, occupying land of 0.7 acres)	A medium condo apartment (60 units, 50,000 square feet, occupying land of 1 acre)	A large condo apartment (120 units, 100,000 square feet, occupying land of 1.5 acre)
Top 20 in the U.S.			
New York	0	0	0
Los Angeles	0	0	0
Chicago	1	1	1
Houston	1	1	1
Phoenix	1	1	1
Philadelphia	0	0	1
San Antonio	1	2	2
San Diego	0	0	1
Dallas	0	0	0
San Jose	0	1	1
Austin	0	0	0
Jacksonville	1	1	2
San Francisco	1	1	1
Columbus	0	0	0
Fort Worth	0	0	0
Indianapolis	1	1	2
Charlotte	0	0	0
Seattle	0	0	0
Denver	0	0	0
Washington D.C.	1	1	1
Top 4 in the N.C.			
Charlotte	0	0	0
Raleigh	0	0	0
Greensboro	0	0	0
Durham	0	0	0

8.3 Manuscript of Paper Published in Journal of Urban Planning and Development

Freight Loading Space Provision: Evidence from the U.S.A

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ABSTRACT

Limited freight loading space provision in city centers increases illegal loading behaviors such as double parking or parking in bicycle lanes or sidewalks. Such traffic violations have caused concerns among urban planners, engineers, and the public about localized congestion and safety impacts on delivery workers and other road users. Despite the importance of these issues, research on the planning processes that determine freight loading provision is very limited. Our study addresses this gap by reviewing the zoning code requirements for loading zones in the twenty largest US and the four largest North Carolina cities and interviewing professionals about loading zone policies and practices. We discovered significant variations in off-street loading requirements across large cities; in some of them like Los Angeles and Houston, the requirements are so low that most small buildings in city centers are exempt from any required loading space provision. While on-street loading spaces are currently an important supplement to off-street ones, interviews with transport planners revealed that the provision of on-street loading spaces is often ad-hoc based on requests by local businesses. The findings can help transportation planners and engineers better understand how the accommodation of urban freight delivery demand links to urban planning zoning requirements for off-street loading zones and practices around on-street loading space provision. The empirical results suggest a localized spatial mismatch between freight loading demand and overall loading supply given the current zoning systems. Such mismatch, which contributes to congestion delays for freight and people as well as road safety impacts, calls for special attention from policymakers by revising off-street loading requirements in zoning codes and considering proactive processes to ensure adequate on-street loading zones in high-demand areas.

Keywords: Urban freight delivery loading spaces on-street off-street zoning codes

INTRODUCTION

Demand for urban freight deliveries to both businesses and residences has increased substantially in the past decade. In 2010, the United States Post Office, the largest parcel-delivery service in the U.S., delivered 3.1 billion packages nationwide while in 2019 it delivered more than 6.2 billion packages (Zaleski, 2017; USPS, 2020). Along with the benefits of this increased economic activity, the uptick in freight volumes has led to complaints from the public about impacts on our streets. A 2019 *Boston Globe* editorial stated, “delivery trucks double-park, squat at bus stops, lurch to a halt in travel lanes, and generally make nuisances of themselves” (The Boston Globe, 2019). Newspapers have also chronicled conflicts between freight vehicles and other road users related to road safety (Shaver, 2014; Haag and Hu, 2019; Smith, 2019). Logistics firms themselves face concern for driver safety as well as negative impacts on efficiency from the lack of space in cities for deliveries (Berger, 2019). These issues are not unique to the largest cities but also appear in commercial and residential areas in the suburbs (Kuntzman, 2018). The academic literature echoes these concerns with researchers linking freight operations road safety (Cherrett et al., 2012; McDonald et al., 2019) and high levels of near-roadway air pollution (Magniol et al., 2018; Yuan, 2018).

The underlying cause of congestion, safety, and pollution concerns related to city logistics is the mismatch between supply of freight loading zones and demand for these spaces. When loading zones are not available, delivery drivers use available spaces including the travel lanes, bike lanes, and sidewalks. Loading spaces, which refer to areas used for the loading or unloading of goods or commodities from a vehicle, are essential infrastructure for urban freight deliveries. The two types of loading zones are on-street and off-street. While both types are used for moving goods and making deliveries, the provision mechanisms vary. Off-street loading zones must be planned with new construction; on-street loading zones can be flexibly determined by municipalities.

Despite attention to the knock-on impacts of limited freight loading and unloading infrastructure, there has been little examination of the urban planning policies and practices that determine the supply of loading zones in the United States. This paper addresses this gap in planning scholarship by examining the regulations and practices that control the provision of loading spaces in major American cities and identifying how the current approach to providing loading zones is not sensitive to supply needs. Future efforts by communities to better balance the supply and demand of freight loading zones and minimize associated problems such as congestion, air pollution, and crashes will require this detailed description of current practice. Through this research, we develop a foundation for further discussions on rebalancing the supply and demand of loading spaces and reorganizing freight loading in a coordinated way. The analysis can help transportation engineers and planners understand how policies that determine the supply of freight loading zones can affect freight delivery efficiency and curb space organization. The paper starts with a literature review of relevant scholarly progress on the topic. In the next section we present methodology and data sources. Then we present the results of our assessment of the state of the practice around planning for on- and off-street loading zones. The paper ends with a summary of findings and several policy implications associated with these findings.

BACKGROUND

The dramatic growth in freight demand in recent years has made freight deliveries, especially in the urban centers, more inefficient (Giuliano et al., 2018; Sanchez-Diaz, and Browne, 2018). Truck drivers have found it increasingly difficult to make last-mile deliveries because of the lack of space to drop off goods at businesses or residences. Bomar et al. (2009) noted that, "*the limited number of loading/unloading zones available, in addition to the number of vehicles using the spaces for long-term parking, has forced many trucks and other large vehicles to double-park, thereby reducing the capacity of the affected street by one lane of traffic*." Such difficulties in finding loading spaces have caused increased congestion, air pollution, noise, road safety concern, and fuel consumption (Chatterjee et al., 2008). Problems related to freight movement have been more prevalent in the city centers, even many small or mid-size ones.

While many studies in the field of freight planning acknowledge the problem of inadequate loading spaces, few of them provide empirical evidence on how cities in the U.S. supply and manage on-street and off-street loading zones. Research attention has focused on better accommodation of urban freight delivery demand in city cores through innovative strategies such as urban consolidation centers and congestion pricing (Allen et al., 2010). Other demand-side research assessed the parking behaviors of commercial vehicles in different land uses (Giron-Valderrama et al., 2019) and the roles of stakeholders who use the loading zones (Goodchild, and Ivanov, 2017).

While the focus has been on the demand side, a limited number of empirical studies have examined factors impacting the supply of freight loading zones. Morris (2004) pointed out that New York City's regulations for the number of bays required for off-street loading facilities have not changed in several decades, but deliveries to commercial properties increased by 300% over the past 30 years. Compared to other cities including Atlanta, Boston, Chicago, Dallas and Seattle, New York had lower off-street loading requirements despite its much higher employment density and freight demand in the city center. Chatterjee et al. (2008) focused on mid-size cities including Greensboro in North Carolina and Fargo in North Dakota to assess how the cities provided on-street and off-street loadings spaces. Greensboro had increased the number of curbside loading zones and required new buildings to provide off-street loading spaces since 1991. However, in Fargo, all curbside loading zones were eliminated and converted to 15-minute parking spaces. To accommodate freight delivery demand, double parking was allowed on roads with more than one lane in one direction. The sharp distinctions in loading space provision between these two cities reflected varying approaches among local planners and transport engineers.

Outside the U.S., a few recent studies have explored the supply and demand of loading spaces using empirical data. Demand for loading varies across cities of different sizes. Big cities like Paris need as many as 10,000 loading bays but for small ones such as Winchester, UK, the number is much smaller (Browne et al., 2007; McLeod and Cherrett, 2011). To accommodate the high demand for loading, the Paris Transport Department provided a technical guide for the provision of on-street loading spaces. The guide imposed a minimum of one delivery space every 100 meters in the city streets (Giuliano et al., 2013). In its 2006 Paris Local Land Use Plan, the city also required main generators of freight to provide loading and unloading areas in their premises proportional to the freight volume they generate (City of Paris, 2006). While these building prescriptions, which did not specify the exact number of off-street loading space required, were vague, the minimum off-street loading requirements in Barcelona were more specific. The Municipal Ordinance for Off-street Loading/unloading Spaces of Barcelona listed the compulsory provisions for loading/unloading spaces in new buildings. For instance, commercial land uses with area between 400 m^2 and 1,300 m^2 were required to provide a minimum of one off-street loading space (City of Barcelona, 1999).

While the supply and demand of loading spaces largely determines how effectively cities accommodate urban freight deliveries, the efficient use of those spaces is equally important. Browne et al. (2007) found on-street loading spaces in Paris were only used legitimately 6% of the time, were unused 47% of the time, and occupied illegally by cars for the remaining 47% of the time. Oliveira and Guerra (2014) found that in Belo Horizonte, Brazil, curbside loading/unloading spaces were occupied by passenger cars 57% of the time, while freight vehicles used the spaces only 35% of the time. A direct consequence of the use of loading zones for non-freight purposes is increased illegal freight delivery behaviors such as double parking on a driving lane. The 2006 survey in Paris indicated 70% of all deliveries in the city were made illegally (Browne et al., 2007). Meanwhile, many cities tolerated the illegal parking or loading behaviors and seldom issued fines on them. In some London boroughs, parking attendants were instructed not to issue fines to drivers of goods vehicles loading or unloading between 8:30 pm and 11:00 pm (Browne et al., 2007). Such leniency can also be found in cities of all sizes in the U.S. For instance, in Asheville whose population was less than 100,000, double parking of freight vehicles were quite common and most of the illegal behaviors did not result in any fines or towing (WLOS News 13, 2015).

Regarding the shortage and inefficient use of loading spaces, cities have considered adjusting the off-street loading requirements or reallocating curb space to on-street loading zones. For instance, Washington, D.C. implemented a “Downtown Curb-Space Management Program” to improve the efficiency of curb space use and reduce congestion. The program increased commercial vehicle loading space by lengthening loading zones from 40 feet to 100 feet wherever possible and introduced metered loading zones to increase the vehicle turnover rates (Bomar et al., 2009). In addition to the direct measures of increasing loading supply, several cities around the world have also developed innovative strategies to improve the efficiency of freight deliveries. Barcelona required restaurants, bars, cafes and other similar establishments to provide a storage space so that they can reduce the frequency of freight deliveries (City of Barcelona, 1999). The city, as well as a few other cities in the Europe, implemented “multi-use lanes” which can accommodate freight vehicles, buses, bicycles and other different modes in different periods of time. Space management for urban delivery has been increasingly popular among European countries when urban delivery problems become more prevalent (NICHES, n.d.). Such practices have not gained adequate attention in cities in the U.S. although urban deliveries are equally difficult in the city centers.

METHOD AND DATA

Our research goal is to assess current planning practices guiding the supply of loading zones in American cities. In most municipalities different processes control the provision of off- and on-street loading zones. Off-street loading zone requirements are part of municipality zoning codes and impact new construction. On-street loading zones are determined by municipalities and rely on the allocation of curb space. Therefore, we developed separate processes to assess policies and practices regarding on- and off-street loading zones.

For off-street loading zones, we assessed city practices by reviewing zoning codes. Off-street loading spaces are usually part of buildings and city zoning codes set requirements for their provision. We conducted the code review to identify the minimum number of off-street loading space requirements in each jurisdiction. Specifically, we conducted an online search of each municipalities zoning code using the search terms: “loading spaces”, “loading berths”, and “loading zones.” The search term allowed us to identify the section of code controlling minimum off-street loading requirements. We then compiled all the requirements together.

To further illustrate variation across cities, we developed scenarios for proposed commercial developments and identified what the off-street loading space requirements would be in each city. We present four commercial scenarios; Starbucks (2,000 square feet), McDonald’s (4,000 square feet), City Target (20,000 square feet), Whole Foods (38,000 square feet); and three multi-family residential scenarios (apartments of 30, 60, and 120 units). While these scenarios do not represent all possible development situations, they provide a common basis to illustrate the application of the zoning code requirements.

Practices for providing on-street loading spaces are more heterogenous and less likely to be formally incorporated in municipal codes. Because of this, we assessed how cities provide on-street loading zones by 1) conducting online searches of municipal codes and websites, and 2) interviewing municipal planners and transport engineers to understand the way each municipality determines the provision of on-street loading spaces. For example, interview questions asked how the city determined on-street loading zones and how they enforced regulations about the use of those spaces. Below we describe the process for identifying interview respondents.

Study Area

While freight conflicts occur in jurisdictions of all sizes, media reports suggest they are most prevalent in the largest cities. These cities have strong urban cores where freight deliveries are difficult due to the high density and limited road space. We therefore focused on the 20 largest US cities. We also included several cities in North Carolina to provide strong representation of a high-growth state and gain better understanding of the influence of state Department of Transportation policies. Based on these selection criteria, our study area included New York, Los Angeles, Chicago, Houston, Phoenix, Philadelphia, San Antonio, San Diego, Dallas, San Jose, Austin, Jacksonville, San Francisco, Columbus, Fort Worth, Indianapolis, Charlotte, Seattle, Denver, and Washington D.C. along with Charlotte, Raleigh, Greensboro, Durham, Chapel Hill, High Point, and Asheville in North Carolina.

We conducted the online review of municipal code requirements for off-street loading zones for all cities. We also conducted a separate online search to identify policies for on-street loading zones policies for all municipalities. For the interviews, we generated a list of 50 potential respondents by searching the municipality website for senior staff responsible for transportation planning or engineering. We contacted each potential interviewee via email or phone to request an interview. Sixteen individuals from 15 jurisdictions agreed to participate in a phone interview. We conducted interviews with staff from New York, Chicago, Houston, Phoenix, Philadelphia, Dallas, Seattle, and Washington D.C. as well as Charlotte, Raleigh, Durham, Chapel Hill, High Point, Asheville, and Greensboro. Interview response rates were higher in North Carolina than the rest of the country likely because of the research teams' affiliation with the University of North Carolina.

Interviews were conducted in 2019 based on a pre-designed research protocol and script. Transcripts from the interviews were analyzed to identify similarities and uniqueness of policies and practices related to on-street loading provisions across all the cities were summarized and discussed. In addition, general plans, transportation plans, local media outlets including newspapers and websites, and other public documents were also collected and examined to provide a comprehensive understanding of on-street loading space provision.

RESULTS

Off-street loading requirements

Minimum off-street loading requirements (MOLRs), like minimum off-street parking requirements, are a common item in the zoning codes of major cities in the country. Out of the largest twenty municipalities in the U.S., only Fort Worth, and Denver do not include specific requirements on off-street loading spaces for new land uses. But unlike minimum parking requirements, MOLRs, in a *progressive* way, define the minimum number of loading spaces each type of land uses should provide with regard to the gross floor area of operation. The minimum number of required loading spaces increases by one when the gross floor area increases and reaches the next stage.

Minimum off-street loading requirements are supposed to be consistent with the amount of freight delivery trips different land uses can generate, however the design of MOLRs is relatively rough in many cities. While minimum parking requirements cover almost every possible land use category, minimum loading requirements are only applied to a few land use types presumably with high freight generation rates. Some cities even combine different land use types in the application of MOLRs. For instance, Charlotte only applied MOLRs to non-residential uses and the requirements did not distinguish specific land use types within this category. In this way, a restaurant which generates three freight trips per day is required to provide the same amount of off-street loading spaces as a manufacturing plant which generates 1.6 freight trips per day (The Rensselaer Polytechnic Institute et al., 2012). Therefore, when freight demand varies across places, the unrefined MOLRs could fail to balance freight loading zone supply and demand.

To compare the MOLRs among the major cities in the U.S., we focus on two critical types of land uses that are most common in high-density city centers: commercial and residential. All cities with MOLRs included commercial land uses in the requirements, although the definitions of those land uses can differ. Comparing New York and Los Angeles, we can see in Figure 1 how the standards of MOLRs in the two cities work. New York required zero loading space for the first 8,000 square feet (gross floor area), one space for the next 17,000 square feet, another one for the next 15,000 square feet, etc. Between zero and 100,000 square feet, the requirements in New York contained five stages. However, the requirements in Los Angeles were much less structured. Any commercial land uses with less than 50,000 square feet would not have compulsory provision of off-street loading spaces in Los Angeles. The comparison between New York and Los Angeles indicates the wide variations in the MOLRs across the major cities.

Figure 1 here

FIGURE 1 ILLUSTRATION OF MINIMUM OFF-STREET LOADING REQUIREMENTS IN NEW YORK AND LOS ANGELES

To better illustrate the differences in MOLRs, we report the number of off-street loading zones required in the zoning code required for four common commercial buildings. The selected business types vary in size between 2,000 and 38,000 square feet and land use type (Table 1). Los Angeles, Fort Worth, and Denver did not require any off-street loading space provision for any scenarios of commercial land uses listed in the table. For the smallest buildings (Starbucks and McDonald's), only San Antonio and Charlotte required a reduced-sized loading space. In all the other cities, small businesses such as coffee shops and fast food restaurants were not required to provide any loading spaces. Those businesses have to rely on on-street loading spaces or other strategies to receive deliveries.

Table 1 here

As online shopping becomes increasingly popular in this era of e-commerce, the demand for home deliveries soars. In the city centers with many high-density multifamily apartments, the frequency of home deliveries had recently increased in these areas (Zaleski, 2017). To understand how the MOLRs address loading zone demand, we consider the required loading spaces for small medium and large apartment buildings in each city (Table 2). Note that the MOLRs in different cities used various units including residential units, gross floor area, and land area occupied. Nine out of the twenty cities required no off-street loading spaces in the Scenario 3 of the large condo apartment with 120 units and gross floor area of 100,000 square feet. In those cities, home delivery vehicles such as UPS and FedEx trucks have to make deliveries in the on-street loading spaces which may not be always available. Double parking of these delivery vehicles is thus easily seen in the downtown areas.

Table 2 here

On-street loading

Freight deliveries in many cities depend on on-street loading spaces. This results from the prevalence of older buildings that may predate requirements for off-street loading zones as well as the relatively modest off-street loading zone requirements in place even for new development. Results from interviews with transportation engineers and planners confirmed this hypothesis. An interviewee from North Carolina acknowledged that most downtown businesses do not have access to designated off-street loading spaces and have to compete for store-front spaces.

Interviews with planners and engineers involved in the allocation of on-street loading zones identified several themes including ad-hoc approaches to provision, need for cross-agency coordination, enforcement of on-street loading spaces, innovative initiatives, and conflicts with other priorities. Table 3 below summarizes these themes and illustrates how policies and practices related to on-street loading provision vary across the cities.

Table 3 here

Ad-hoc Provision Processes

Despite the importance of on-street loading zones to urban goods movement, the provision of these spaces is often ad-hoc. As a traffic operations engineer from Durham noted: "*The need for loading zones is dependent on the number and type of businesses, which is a moving target. But the sizes and location of these zones depends on many factors. After all, loading zones compete with parking spaces, which is more valuable depending on who you ask.*" Moreover, the flexibility of on-street loading space allocation, which is not a new event, has been much constrained by the existing curbside space arrangement. A transport engineer talked about the allocation of curb space to on-street loading zones in Greensboro, "*The location of on-street loading spaces was a legacy from historical curb space allocation. We have not really made changes to those spaces in the recent years.*" Similar comments were also made by interviewees from High Point, Houston, and Charlotte.

In most cities, requests for installing new loading zones can be made by local businesses. For example, the Philadelphia Parking Authority provides an online loading zone application form, which can be used by local businesses to submit a request for establish a new loading zone. The form contains information on 1) the business (name, address, and nature of business); 2) loading zone (location, size, present parking regulations, and curb space ownership); and 3) loading demand (number of daily pickups/deliveries, hours to be uses, and length of delivery vehicles) (Philadelphia Parking Authority, 2019). But the request for new loading spaces does not necessarily result in a final installation of those spaces. "*If there is a bus lane, the request can lead to a major conflict and would be denied. But if it is a parking space, the likelihood of getting it approved is much higher*." (An interviewee from Philadelphia, August 28, 2019) A transportation planning administrator from the City of High Point said the city would generally discuss with local businesses before assigning any curb space to freight loading/unloading functions (Interviewee from High Point, August 26, 2019). The information can greatly help transportation engineers and managers better match the supply and demand of loading in a precise way.

Requires high degree of coordination across agencies

The provision of on-street loading spaces can involve multiple city departments increasing the institutional complexity of managing these zones. For example the District Department of Transportation (Washington D.C.) works with the Metropolitan Police Department and the Department of Public Works on the provision of on-street loading spaces. In Durham, the Department of Public Works has the authority to install or remove loading zones but works with the Department of Transportation which provides the expertise on the size and location of the zones. When receiving a request for a loading zone from local businesses in Downtown Durham, the Department of Transportation asks Downtown Durham Inc., a 501 c(6) organization, to work with nearby residents and businesses to see if they support the proposed change. Similarly, Philadelphia established a state-controlled agency—the Philadelphia Parking Authority. As a respondent from Philadelphia stated: "*Our Department of Streets in the city works with the Office of Transportation and Infrastructure Systems (OTIS). We set the rules and publish the regulations of parking spaces, loading spaces, and a lot of variations. The Philadelphia Parking*

Authority does the implementation: put the sign and do the enforcement. We all work together, especially when making any kinds of changes."

These examples highlight the high degree of coordination across agencies required to make changes to on-street loading zones. Such collaboration can be particularly vital in the design of loading zones as well. While engineers in the departments of transportation and public works can accurately complete the design work based on existing technical standards, they may still need to closely work with colleagues from departments of planning and police, who are more familiar with the actual use of the zones in real world. For instance, on-street loading spaces are usually used by a mixed group of businesses and occupied by various forms of freight vehicles. Planners and police officers can offer valuable suggestions on how the spaces can be designed to accommodate the varying demand of loading.

Enforcement

Respondents mentioned difficulties in enforcing the rules of on-street loading spaces. Even in small cities like High Point, "*more and more violations are found in the downtown area and police officers have been issuing warning tickets to make sure the loading spaces are better used*" (Interviewee from High Point, August 26, 2019). But warning tickets are far from enough in many other downtown areas. "*Loading spaces are often occupied by non-freight vehicles. Delivery vehicles have to double park on the streets. It is hard to really eliminate those behaviors by issuing warning tickets*," a traffic engineer from Asheville talked about their concern. While the city DOTs had noticed the illegal occupation of those spaces by passenger cars in many locations, engineers acknowledged that enforcement is complicated and can be difficult. A traffic engineer from Raleigh mentioned the difficulty in addressing illegal parking by themselves. "*We definitely know the loading zones are not always used by freight delivery trucks. But it is not our business to rule out those illegal parking or loading.*" Such difficulties can also be found in cities such as Asheville, Houston, and Dallas. This common dilemma, which is deeply rooted in the aforementioned institutional fragmentation of freight related policy making, could greatly weaken the benefits of on-street loading zones for freight deliveries.

Innovation

Some cities included in the interviews have recently adopted initiatives or pilot programs to improve the allocation of loading spaces. Philadelphia had initiated a six-month pilot program of optimizing curb space on Chestnut Street, one of its major downtown streets. "*The Office of Transportation and Infrastructure Systems redesigned all the parking and loading spaces on the street to open up more opportunities for all-day deliveries. The city will evaluate the data after the installation of new loading spaces and consider whether to expand the program to other major streets. Philadelphia is also considering an overnight delivery program for soda companies and other delivery firms*" (An interviewee from Philadelphia, August 28, 2019). Chicago launched a Downtown Loading Zone Reform Pilot Program in 2017 to convert business-paid commercial loading zones to user-paid loading zones in the central business district. The program helped "*reduce misuse of loading zones by non-commercial vehicles and increase the turnover of the loading zone uses through charging commercial vehicles for using the zones*" (An interviewee from Chicago, August 30, 2019). Raleigh is also considering restructuring its curb space management. "We hired a consulting company to make a curb lane management study and we hope to develop a plan of reallocating the curb space. To improve the efficiency of deliveries to our local businesses is our major goal." A transport engineer from Raleigh quoted their recent downtown development and future parking needs study (An interviewee from Raleigh, August 26, 2019; also see Kimley-Horn and Associates, 2017).

Conflicts with other Priorities

Finally, people from cities including Philadelphia and Seattle expressed their concern regarding installing more loading spaces. "*Our city is a very pedestrian-oriented city, especially the downtown area. We do not want to do anything in terms of making curb cuts across sidewalks that would damage our walking environment. So if loading zones would affect our pedestrians, we have to reevaluate the proposal*" (An interviewee from Philadelphia, August 28, 2019). The conflicts between different modes of transportation in the dense urban cores have become a major barrier for addressing the urban freight loading problem, according to many of the interviewees.

DISCUSSION

This study provides a comprehensive examination of the urban planning policies and practices that determine freight loading zone supply in major American cities. We find that most cities have requirements in place through their zoning codes for off-street loading zones. But off-street loading is unlikely to independently resolve the difficulty in urban deliveries. First, these requirements only apply to new construction and therefore will only have modest impacts in most cities. Second, off-street requirements often fail to correlate with freight traffic demand. In some cities, the same off-street loading zone requirements were applied to commercial land uses with very different freight trip generation rates. We also found current MOLRs paid inadequate attention to high-density residential development. The massive growth in home deliveries makes residential land uses more and more relevant in off-street loading provision. However, a large proportion of the top twenty cities in the U.S. failed to take this trend into consideration and did not require loading zones for large apartment buildings. Third, even well-designed requirements for loading zones face the same challenges as minimum parking requirements which have been shown to be inflexible and raise development costs.

Due to limited provision of off-street loading zones, all cities rely heavily on on-street loading zones for freight delivery. Our analysis revealed that the planning of on-street spaces is highly complex. Current provision of spaces is determined by historical precedent with few cities reporting systematic approaches to reviewing and allocating on-street spaces. Changing the supply of on-street spaces relies on requests from businesses coupled with review often by multiple city agencies and even quasi-public actors. Enforcement of on-street loading regulations is a difficult task and is likely to become more difficult as ridehailing services search for pick up and drop off areas. The shortage of on-street loading spaces combined with illegal occupation by passenger vehicles contributes to the temporal and spatial mismatch of loading supply and demand.

Our analysis of freight loading zones finds modest connection between the policies and practices governing the supply of these spaces and demand. Requirements for off-street loading zones are not based on freight trip generation rates nor have they been updated recently in many cities. On-street loading zones are more responsive to business needs as they are generally based on requests from local businesses. However, planners and engineers must balance these requests with fiscal pressures for parking revenue, preferences of other nearby residents and business owners, and difficulties coordinating action among multiple city agencies. Taken together, it is small surprise that in many cities there is a mismatch between supply and demand for freight loading areas that results in negative externalities such as congestion, safety impacts, and air pollution.

However, transportation planners have strategies available to improve the situation. A first step is acknowledgement that city logistics patterns have changed with the rise of e-commerce requiring identification of freight generation hotspots. The review of current delivery patterns should focus on temporal and spatial variation. This information can be used to update MOLRs in zoning code to better match supply and demand. It can also assist planners to prioritize areas for installation of on-street loading spaces as well as areas to consider for enforcement of current loading space regulations.

Second, cities need to engage the departments and organizations related to the installation and management of freight loading spaces in improving the efficiency of loading supply and services. The inter-departmental collaboration can effectively address the fragmentation problem in the provision and law enforcement of the loading system. As we argued earlier, urban planners, transport engineers, police officers, and public workers can all make a useful contribution to the reorganization of curb space. Planners can also involve stakeholders from logistics firms and business groups to identify other strategies for coordinated action.

The next option is to test innovative practices for freight loading zones that promote flexibility. Some cities have converted on-street spaces to fee-based commercial loading zones. Pricing the spaces reduces enforcement problems. Cities are also looking at flexible implementation of these fee-based loading zones which might be exclusive to freight only during certain hours and available to all vehicles at other hours. App-based solutions for parking payment have made these new solutions possible. Another option is to follow the example of cities including New York, Philadelphia and San Antonio that offer the option of joint/sharing off-street loading spaces in their minimum loading requirements. These options can guarantee a minimum level of loading supply without dramatically increasing development costs.

Finally, the interviews emphasized the need for freight delivery solutions to fit with each communities existing priorities. For example, in cities with strong Vision Zero programs that aim to reduce road fatalities, it will be critical that loading zone solutions do not create conflicts between delivery vehicles and vulnerable road users. This might require strong design requirements for off-street loading zones to avoid excessive curb cuts in areas with high pedestrian traffic.

The growth in urban freight volumes is unlikely to slow. Urban planners and engineers will be increasingly challenged to develop strategies to promote efficient delivery and reduce externalities such as congestion, crashes, and air pollution. These issues are likely to be most significant in the downtown areas of major cities where strong demand for freight deliveries combine with limited road space, low stock of available curbside space, and high density of passenger transportation activities. This article provides planners and engineers with information on current practice in major American cities and strategies to begin considering how regulations and practices in their community align demand for freight loading zones with the supply of these spaces.

Our research is subject to some limitations. We did not interview people at departments of public works and police who were also usually involved in the provision and management of loading spaces. Their opinions and practices could be important but our research scope focused on urban planning. Second, we examined the current adopted zoning code to identify off-street loading zone requirements. This means we were unable to identify cities in the process of updating their zoning code which could impact these requirements.

CONCLUSION

As demand for freight deliveries increases in American cities, there is a growing mismatch between supply and demand of loading zones. Without adequate loading spaces, delivery vehicles rely on available space such as travel lanes, bike lanes, and sidewalks. The result is increased congestion, air pollution, and safety concerns for delivery drivers and other road users. This study examined how planners and engineers manage the supply of freight loading zones through zoning codes and practices in major cities in the United States and North Carolina.

We found that the current freight loading supply system is not well-designed to meet rapidly growing needs for freight delivery in cities. Most large cities have provisions to require off-street loading zones for new constructions. However, we found that most of the cities required zero off-street loading zones for small-and-medium-size businesses and apartment buildings despite rapid increases in deliveries particularly to residences. On-street loading zones are, in most cases, installed on an ad-hoc basis and largely depend on the availability of curb space.

Strategies exist to better match freight loading space supply with the need for these spaces. These include analysis of current freight delivery patterns to update zoning codes and prioritize allocation of on-street spaces; increased collaboration among city agencies including planning, engineering, public works as well as external stakeholders from business groups and logistics firms; and conducting pilots of innovative solutions around fee-based commercial loading zones.

DATA AVAILABILITY

Some or all data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request. The data available upon request includes municipal codes regarding minimum loading space and summaries of interview results.

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TABLE 4 NUMBER OF MINIMUM LOADING SPACE REQUIRED FOR MAJOR U.S. CITIES IN FOUR COMMERCIAL LAND USE SCENARIOS

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	An average Starbucks (2,000 square feet)	An average McDonald's (4,000 square feet)	An average City Target (20,000 square feet)	An average Whole Foods (38,000 square feet)
Top 20 in the U.S.				
New York	0	0	1	1
Los Angeles	0	0	0	0
Chicago	0	0	1	2
Houston	0	0	1	1
Phoenix	0	0	0	1
Philadelphia	0	0	1	1
San Antonio*	1 (reduced size)	1 (reduced size)	2	2
San Diego	0	0	1	2
Dallas	0	0	1	1
San Jose	0	0	1	2
Austin	0	0	1	1
Jacksonville	0	0	1	2
San Francisco	0	0	1	1
Columbus	0	0	1	1
Fort Worth	0	0	0	0
Indianapolis	0	0	1	2
Charlotte*	1 (reduced size)	1 (reduced size)	1	2
Seattle	0	0	1	1
Denver	0	0	0	0
Washington D.C.	0	0	2	2
Top 4 in the N.C.				
Charlotte*	1 (reduced size)	1 (reduced size)	1	2
Raleigh	0	0	0	0
Greensboro	0	0	1	1
Durham	0	0	1	1

*For Scenario 1 and 2, San Antonio and Charlotte required commercial land uses to provide off-street loading spaces with reduced sizes.

TABLE 5 NUMBER OF MINIMUM LOADING SPACE REQUIRED FOR MAJOR U.S. CITIES IN THREE RESIDENTIAL LAND USE SCENARIOS

	Scenario 1	Scenario 2	Scenario 3
	Small apartment building (30 units, 25,000 square feet, occupying land of 0.7 acres)	Medium apartment building (60 units, 50,000 square feet, occupying land of 1 acre)	Large apartment building (120 units, 100,000 square feet, occupying land of 1.5 acre)
Top 20 in the U.S.			
New York	0	0	0
Los Angeles	0	0	0
Chicago	1	1	1
Houston	1	1	1
Phoenix	1	1	1
Philadelphia	0	0	1
San Antonio	1	2	2
San Diego	0	0	1
Dallas	0	0	0
San Jose	0	1	1
Austin	0	0	0
Jacksonville	1	1	2
San Francisco	1	1	1
Columbus	0	0	0
Fort Worth	0	0	0
Indianapolis	1	1	2
Charlotte	0	0	0
Seattle	0	0	0
Denver	0	0	0
Washington D.C.	1	1	1
Top 4 in the N.C.			
Charlotte	0	0	0
Raleigh	0	0	0
Greensboro	0	0	0
Durham	0	0	0

TABLE 6 SUMMARY OF INTERVIEW THEMES AND RESULTS

Interview Themes	*Major Results*	*Representative Cities*
On-street loading provision approach	• On an ad-hoc basis; Constrained by existing pattern of curb space allocation	Durham, Greensboro, Houston, Charlotte, etc.
Institutional involvement	• Involving multiple departments and agencies;	Raleigh, Chapel Hill, Phoenix, etc.
	• Establishing independent agencies to deal with the issue	Philadelphia and Washington, D.C.
Loading space request process	• Requested by local businesses with delivery demand	High Point, Philadelphia, etc.
On-street loading space design	• Lack of interdepartmental collaboration	Chapel Hill, Raleigh, etc.
Law enforcement of loading space uses	• Relying on police department	Asheville, High Point, Raleigh, etc.
	• Relying on independent agencies	Philadelphia, Washington, D.C.
Relevant initiatives and programs	• Developing pilot programs to optimize curb space management	Washington, D.C., Raleigh, Charlotte, Philadelphia
Concern over conflicts between transportation modes	• Loading zones and activities may affect walking environment	Seattle, Philadelphia