Incorporating Urban Area Truck Freight Value into the Texas A&M Transportation Institute's *Urban Mobility Report*

by

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ABSTRACT

For nearly 30 years, the Texas A&M Transportation Institute (TTI) has developed methodologies and appropriate performance measures for estimating congestion performance and communicating them to technical and non-technical audiences. Historically, TTI's *Urban Mobility Report (UMR)* has focused on passenger-car congestion (i.e., the average commuter). However, roadway traffic congestion certainly impacts both commuters and goods movement. With the documented growth of freight shipments and value, particularly in trucking, researchers developed and applied a methodology to include urban area truck freight commodity value that is impacted by congestion into the *UMR*.

The methodology uses data from Federal Highway Administration's (FHWA's) Freight Analysis Framework (FAF) and Highway Performance Monitoring System (HPMS). Commodity values supplied by FAF are integrated with truck vehicle-miles of travel (VMT) calculated from the HPMS roadway inventory.

Researchers estimated that $7 trillion worth of commodities was trucked on America's urban streets and highways during 2020. At the urban area level, the results of the truck value measure appear intuitive as bigger cities consume more goods, which mean a higher value of freight movement.

The addition of truck value to the *UMR* provides another dimension to inform policy-makers and decision-makers about the congestion problem. It also serves to inform trucking stakeholders by estimating the amount of truck value that is impacted by congestion. Researchers will continue to include the truck freight value performance measure in subsequent releases of the *UMR*.

INTRODUCTION

The *Urban Mobility Report* (*UMR*) is highly cited for urban-area congestion statistics and trends in the 101+ urban areas in the United States (*1*). The *UMR* informs decision-making at the federal, state, and, local levels for infrastructure decision-making.

The *UMR* has traditionally focused on commuter congestion trends in urban areas. However, congestion impacts both commuters and goods movement in urban areas. With the forecasted growth in freight shipments, particularly in trucking, there is an increased need to understand the impact of urban area congestion on trucks.

Urban and rural corridors, ports, intermodal terminals, warehouse districts, and manufacturing plants are all locations where truck congestion is a particular problem. Some of the solutions to these problems look like those deployed for person travel – new roads and rail lines, new lanes on existing roads, lanes dedicated to trucks, additional lanes, and docking facilities at warehouses and distribution centers. Goods are delivered to retail and commercial stores by trucks that are impacted by congestion. Traffic congestion at any time of day causes potentially costly disruptions. An improved understanding of the value of commodities that are impacted by congestion on urban streets and highways in the United States can assist stakeholders in quantifying the problem and telling the freight "story" to interested stakeholders and decision-makers.

RESEARCH OBJECTIVES

Based on the need for a better understanding of the impacts of urban area congestion on trucks, this paper describes the results of satisfying the following objectives:

1. Develop a methodology and measure to estimate urban area truck freight monetary value; and
2. Incorporate the methodology and measure into the *Urban Mobility Report* to aid in communicating truck freight values for stakeholder decision-making.

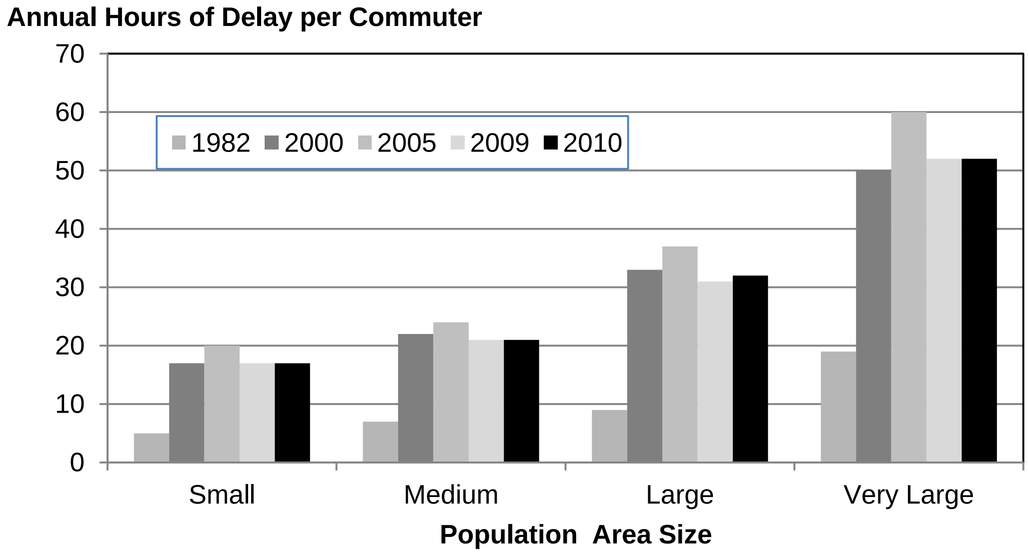
BACKGROUND

TTI's *Urban Mobility Report*

For nearly 30 years, the Texas A&M Transportation Institute (TTI) has developed methodologies and appropriate performance measures for estimating congestion performance and communicating them to technical and non-technical audiences. TTI's *Urban Mobility Report (UMR)* is highly cited for urban-area congestion data and trends in 101+ urban areas in the United States. *UMR* statistics are used at the federal, state, and local levels to inform policy and infrastructure decision-making (*1*).

Figure 1 shows congestion trends in terms of the hours of delay per commuter for selected years from 1982 to 2010 as published in the 2011 *UMR*. The recent decline in congestion brought on by the economic recession has only provided a temporary respite from the growing congestion problem. As the economy recovers, so will traffic congestion. In previous regional recessions, once employment began a sustained, significant growth period, congestion increased as well.

Historically, the *UMR* has focused on passenger-car congestion (i.e., the average commuter). However, there are frequent questions about the economic impact of congestion on freight. Traffic congestion certainly impacts both commuters and goods movement, albeit in differing economic and time valuations. With increased scrutiny and limited budgets facing public sector transportation officials, this type of information can assist project selection processes. For these reasons, researchers were interested in characterizing and including the urban area truck freight monetary value that is impacted by congestion in the *UMR*.



Small = less than 500,000 Large = 1 million to 3 million
Medium = 500,000 to 1 million Very Large = more than 3 million

FIGURE 1 Congestion Trends (Adapted from Reference *1*).

Distinguishing Urban Freight and Passenger Travel

It is also important to distinguish between urban freight and urban passenger car travel for system monitoring, system evaluation, and project selection because characteristics of travel differ, especially regarding the value of time. As one example, previous research found that travel times of commercial vehicles were nearly eight percent higher than vehicles in the traffic stream instrumented with toll tags (i.e., the general traffic stream) under free-flow conditions and six percent higher during congested conditions (i.e., speeds less than 30 mph) (*2*,*3*). The study was along an approximately two-mile corridor in Houston, and it is possible that over longer distances these differences could become more significant for trucking (e.g., just-in-time operations). The researchers postulate that the increased travel time is due to slower starts and stops, more difficulty changing lanes in heavier volumes, and more frequent lane restrictions in the urban area – either by policy and regulation or by routing needs.

It is important to note that over the past several years, several state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) have developed elementary project selection processes that incorporate freight elements. The Rhode Island DOT includes freight representatives on the Transportation Improvement Program evaluation committee. Washington implemented a Freight Mobility Strategic Investment Board to prioritize project selection and engage the private sector. Wisconsin DOT established a forum for the freight industry to provide input to the project selection process related to conversion of a U.S. Highway to an Interstate. The Delaware Valley Regional Planning Commission links a standalone freight plan to existing planning efforts. Toledo's Metropolitan Area Council of Governments uses targeted public outreach to freight stakeholders to identify needs. Freight model development has fed project selection processes in many MPOs. In each of these cases, the project selection rankings are generally based on a combination of freight and economic value, cost benefit analysis, and safety improvements. These examples indicate the growing interest in performance measures for freight-specific project selection activities, particularly in light of the recently signed Moving Ahead for Progress in the 21st Century (MAP-21) legislation.

Conceptualizing Freight for Investment Decisions

Prior to developing the freight value methodology for incorporation into the *Urban Mobility Report*, and to better understand general freight mobility and reliability issues, TTI researchers developed and tested a conceptual framework to help transportation professionals communicate, visualize, and understand factors that affect freight mobility and reliability (*4*). The analytical framework demonstrates how mobility and reliability of freight travel can be placed on equal footing with passenger travel for investment decision-making.

The previously developed framework is shown in Figure 2, and it is applicable to all modes of freight (e.g., truck, rail, water, air, pipeline). The trucking mode is the focus of this paper, and it is shown by "Truck Type" in Figure 2. The three axes of the relationship for trucks are geographic area, commodity type, and time period. These axes directly relate to, and visually illustrate, the three critical issues under consideration: where is the study area?; what type of trucks are of interest?; and what are the time periods of interest?

As illustrated in Figure 2, each smaller cube within the box contains mobility information and reliability information by geographic area, commodity type, and time period for the trucking operations. Note that the travel time index and buffer index mentioned in Figure 2 are typical measures to estimate average mobility (travel time index) and reliability (buffer index). More information on these measures can be found elsewhere (*5,6*). Each geographic area of interest would have its box populated with target cubes that incorporate local goals and establish targets for the mobility and reliability performance measures. In concept, there would also be a freight box of observed cubes for each geographic area of interest. This cube would include field observation of trucking mobility and reliability. The two boxes (target and observed) could then be compared to identify where operation is satisfactory or unsatisfactory.

Much more information about the geographic scalability and application of the framework for all freight modes, including trucking, is documented elsewhere (*4*). Clearly, the framework provides a method to visualize the temporal and spatial characteristics of freight movement to better guide decision-making. The methodology described in a later section of this paper identifies how freight value elements using the FAF data can be used to populate the commodity axis of the freight box for performance monitoring.

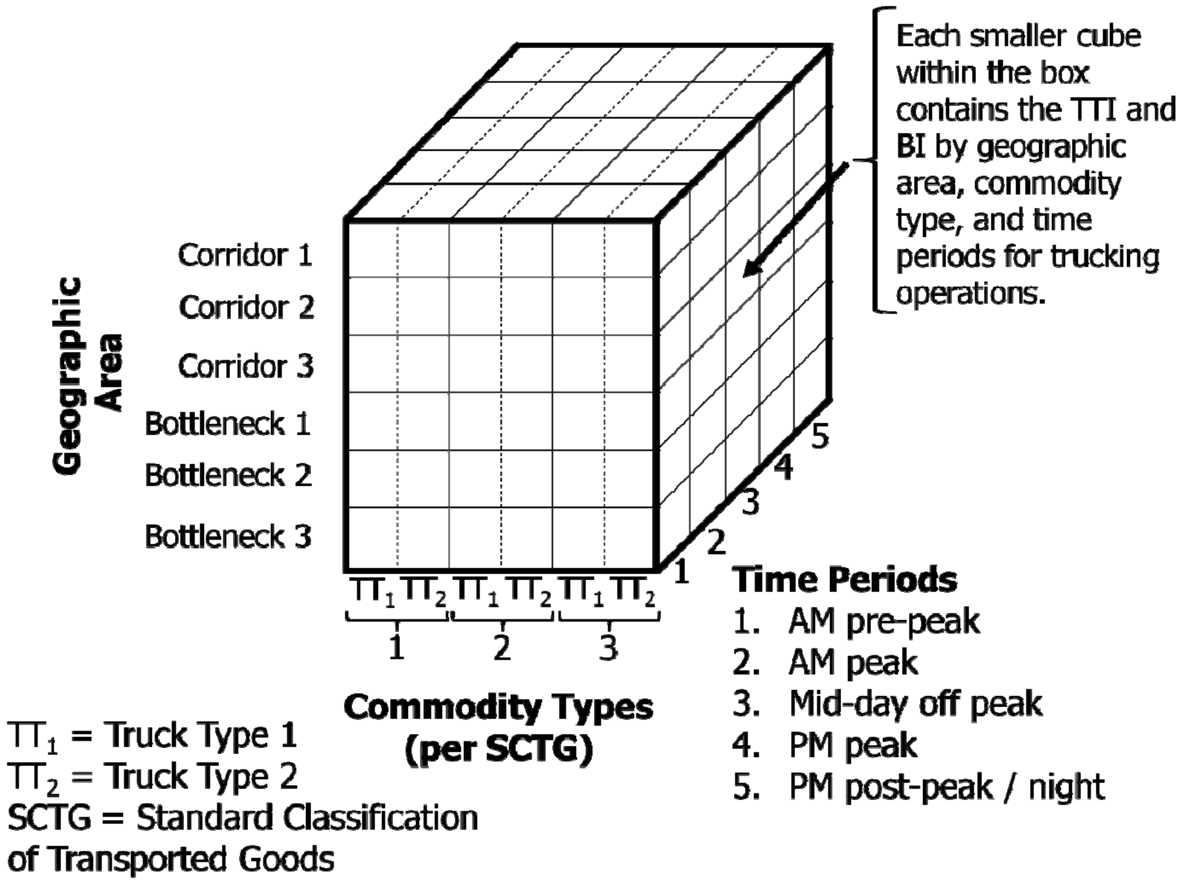


FIGURE 2 Freight Box Conceptual Framework Applied to Trucks (Adapted from Reference *4*).

Freight Growth

Freight transportation is growing. Figure 3 shows the weight of shipments, in millions of tons, comparing 2010 and 2040 based upon data from Federal Highway Administration's Freight Analysis Framework (FAF) (*7,8*). The predominant transportation mode for shipments is truck, which accounts for 68 percent of shipments by weight in 2010 and 67 percent of shipments by weight in 2040.

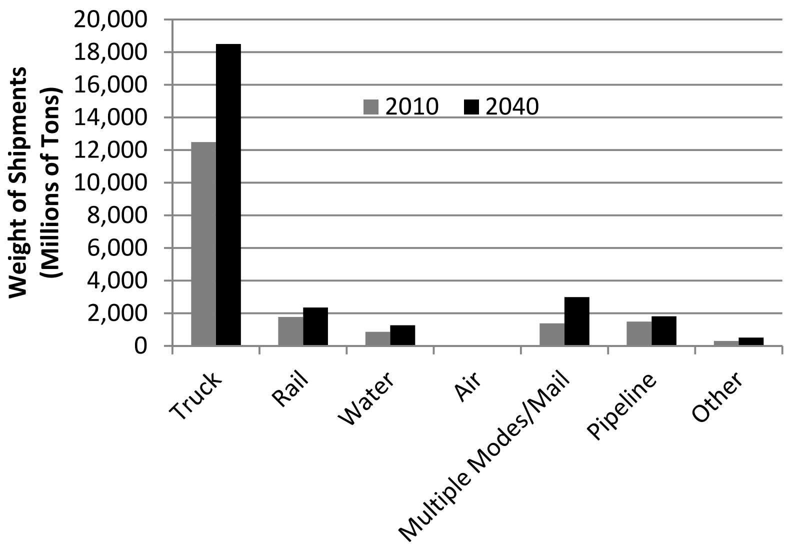


FIGURE 3 Weight of Shipments by Transportation Mode (Adapted from Reference *7,8*).

Similarly, Figure 4 shows the value of shipments in billions of 2007 dollars, the baseline for the FAF forecasts. The value of shipments in 2010 and 2040 are shown in Figure 4. Again, trucking is the predominant transportation mode for freight shipments, and it accounts for 65 percent of shipment value in 2010 and 55 percent of shipment value in 2040. A 107 percent increase in shipment value is forecast for trucking and a 145 percent growth for all modes combined from 2010 to 2040.

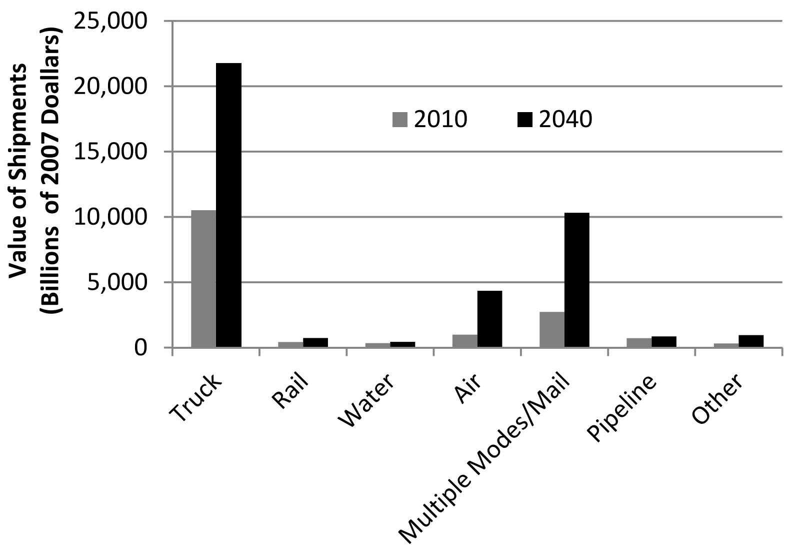


FIGURE 4 Value of Shipments by Transportation Mode (Adapted from Reference *7,8*).

Incorporating Economic Valuation

There is remarkable growth in weight and value of shipments projected for all modes of travel including trucking. In 2010, trucking was the largest freight mode by weight (68 percent) and value (65 percent) according to the latest figures from the Federal Highway Administration. Trucked value of goods is expected to more than double by 2040. Given the growth in all freight shipments (by weight and value), especially trucking, there is a need to better understand freight mobility and reliability issues.

Given these growth estimates, strong investment in freight infrastructure is needed to keep pace with growing demand. To provide a complete picture of the impact of congestion, performance monitoring must incorporate a dollar value for delayed freight and passenger car travel. As shown by the work in Houston, Texas (*2,3*), the extent of the delay is not the same for urban trucks and passenger cars. Commodity movement information is needed to arrive at dollar values for urban trucks. The methodology and application discussed in this paper provides an estimate of the value of trucks moving in congested urban areas. This information is useful for telling the urban "trucking story" and better understanding the scale and importance of truck value in investment decisions.

DATA SOURCES

The methodology described here uses data from two primary data sources:

1. Federal Highway Administration's (FHWA) Highway Performance Monitoring System (HPMS), and
2. FHWA's Freight Analysis Framework (FAF).

Highway Performance Monitoring System

HPMS includes national-level data regarding the condition and performance of the highway system (*9*). The states provide HPMS data elements to FHWA on a yearly basis for use in federal aid allocation and for producing FHWA's "Conditions and Performance" reports (*10*).

Researchers have historically used HPMS data in the development of the statistics for all urban areas in the *Urban Mobility Report.* The following are the specific HPMS-link data elements used in the methodology described in this paper to incorporate truck freight monetary values into the *UMR*.

- Average Daily Traffic (ADT)
- Truck percent (percent of ADT that are trucks)
- Link length

Freight Analysis Framework (FAF)

FHWA collects and produces FAF to provide a national snapshot of freight movements throughout the United States, including the metropolitan areas (*8*). The methodology described in this paper was originally developed using truck value data from FHWA FAF version 2.2 – the most recent version of FAF data available when researchers developed the methodology. There were 114 geographic areas for FAF 2.2, corresponding to the regions used for the 2002 Commodity Flow Survey (CFS). FAF 2.2 included projections for other years in five-year increments. The value of commodities are identified in FAF by the Standard Classification of Transported Goods (SCTG) system.

FAF 2.2 was used for the first application of the truck value methodology in the *2010 Urban Mobility Report.* For the *2011 Urban Mobility Report,* researchers used FAF version 3 (FAF^3). The updated FAF^3 uses the 2007 Commodity Flow Survey as input. FAF provides estimates of tonnage and value, by commodity type, mode, origin, and destination for 2007, the most recent year. Forecasts are provided through 2040 in FAF^3 and include 131 geographic areas.

It should be noted that HPMS includes volume data for each urban area. The FAF data typically contain data for specific regions in a given state and then the remainder of the state is designated as another region (i.e., in Texas, it is a FAF region termed "rest of Texas"). The methodology that follows provides a method to reconcile and match the HPMS and FAF region data as closely as possible in a replicable method for 100+ *UMR* urban areas.

URBAN MOBILITY REPORT TRUCK VALUE METHODOLOGY

As discussed previously, the data for the truck value performance measure come from the Freight Analysis Framework (FAF) and the Highway Performance Monitoring System (HPMS) from FHWA. The basis of this measure is the integration of the commodity value supplied by FAF, and the truck vehicle-miles of travel (VMT) calculated from the HPMS roadway inventory database; truck VMT is computed as the product of ADT, truck percent and link length. There are five steps involved in calculating the truck commodity value for each urban area.

1. Calculate the national commodity value for all truck movements.
2. Calculate the HPMS truck VMT percentages for states, urban areas, and rural roadways.
3. Estimate the state and urban commodity values using the HPMS truck VMT percentages.
4. Calculate the truck commodity value of origins and destinations for each urban area.
5. Average the VMT-based commodity value with the origin/destination-based commodity value for each urban area.

Step 1 – Calculate National Truck Commodity Value

The FAF^3 database has truck commodity values that originate and end in 131 regions of the U.S. The database contains a 131 by 131 matrix of truck goods movements (tons and dollars) between these regions. Summing just the value of the commodities that originate within the 131 regions, the value of the commodities moving within the 131 regions is determined (if the value of the commodities destined for the 131 regions was included also, the commodity values would be double-counted).

The FAF^3 database has commodity value estimates for different years. The base year for FAF^3 is 2007 with estimates of commodity values for 2010 through 2040 in 5-year increments. Note that the *2011 Urban Mobility Report* includes 2010 data.

Step 2 – Calculate Truck VMT Percentages

The HPMS state truck VMT percentages are calculated as shown in Equation 1 using each state's estimated truck VMT and the national truck VMT. This percentage will be used to approximate total commodity value at the state level.

$$\begin{matrix}\text{State Truck}\\\text{VMT Percentage}\end{matrix} = \left(\frac{\text{State Truck VMT}}{\text{U.S. Truck VMT}}\right) \times 100\% \qquad \text{(Equation 1)}$$

The urban percentages within each state are calculated similarly, but with respect to the state VMT. The equation used for the urban percentage is given in Equation 2. Note that the numerator in Equation 2 is for all the urban areas in the state. The rural truck VMT percentage for each state is shown in Equation 3. The rural truck percentage is simply 100 percent minus the result of Equation 2.

$$\begin{array}{c}\text{State Urban}\\ \text{Truck VMT Percentage}\end{array} = \left(\frac{\begin{array}{c}\text{State Urban}\\ \text{Truck VMT}\end{array}}{\begin{array}{c}\text{State Truck}\\ \text{VMT}\end{array}}\right) \times 100\% \qquad \text{(Equation 2)}$$

$$\begin{array}{c}\text{State Rural Truck}\\ \text{VMT Percentage}\end{array} = 100\% - \begin{array}{c}\text{State Urban Truck}\\ \text{VMT Percentage}\end{array} \qquad \text{(Equation 3)}$$

The urban area truck VMT percentage is used in the final calculation of Step 2. The truck VMT in each urban area in a given state is divided by all of the urban truck VMT for the state as shown in Equation 4.

$$\begin{array}{c}\text{Urban Area Truck}\\ \text{VMT Percentage}\end{array} = \left(\frac{\begin{array}{c}\text{Urban Area}\\ \text{Truck VMT}\end{array}}{\begin{array}{c}\text{State Urban}\\ \text{Truck VMT}\end{array}}\right) \qquad \text{(Equation 4)}$$

Step 3 – Estimate State and Urban Area Commodity Value from Truck VMT percentages

The national estimate of truck commodity value from Step 1 is combined with the percentages calculated in Step 2 to assign a VMT-based commodity value to the urban and rural roadways within each state and then to each urban area.

Equation 5 shows how the state urban truck VMT percentage from Equation 2 is multiplied by the U.S. truck commodity value from Step 1 to estimate the state commodity value. Similarly, Equation 6 shows how the state rural truck VMT percentage from Equation 3 is multiplied by the U.S. truck commodity value from Step 1 to estimate the state commodity value. Equation 7 shows that the urban area truck commodity value is estimated by multiplying the state urban commodity value by the urban area truck VMT percentage.

$$\begin{array}{c}\text{State Urban Truck}\\ \text{VMT-Based}\\ \text{Commodity Value}\end{array} = \begin{array}{c}\text{U.S. Truck}\\ \text{Commodity Value}\end{array} \times \begin{array}{c}\text{State Urban}\\ \text{Truck VMT Percentage}\end{array} \qquad \text{(Equation 5)}$$

$$\begin{array}{c}\text{State Rural Truck}\\ \text{VMT-Based}\\ \text{Commodity Value}\end{array} = \begin{array}{c}\text{U.S. Truck}\\ \text{Commodity Value}\end{array} \times \begin{array}{c}\text{State Rural}\\ \text{Truck VMT Percentage}\end{array} \qquad \text{(Equation 6)}$$

$$\begin{array}{c}\text{Urban Area Truck}\\ \text{VMT-Based}\\ \text{Commodity Value}\end{array} = \begin{array}{c}\text{State Urban}\\ \text{Truck VMT-Based}\\ \text{Commodity Value}\end{array} \times \begin{array}{c}\text{Urban Area}\\ \text{Truck VMT Percentage}\end{array} \qquad \text{(Equation 7)}$$

Step 4 – Calculate Origin/Destination-Based Commodity Value for Each Urban Area

The results of Step 3 are the commodity values for the U.S. distributed based on the truck VMT flowing through states in both urban areas and the rural portions of each state. The results of Step 3 place equal weighting on a truck-mile in a rural area and a truck-mile in an urban area. It essentially ignores what the specific origin and destinations are. Certainly not all origins and destinations share similar characteristics. For example, port cities such as Los Angeles/Long Beach, Chicago, or New York/New Jersey should be expected to have more truck value traveling than urban areas where ports play less of a role. Because FAF does not include trips that are less than 50 miles, and port (or inland port) cities are assumed to have more of these trips, this is another reason to incorporate higher truck value in these locations. Step 4 redistributes the truck commodity values with more emphasis placed on the urban regions where the majority of the truck trips were originating or ending.

The values of commodities with trips that began or ended in each of the 131 FAF regions were summed and the results were combined to get a total for the U.S. The percentages of the total U.S. origin/destination-based commodity values corresponding to each of the 131 FAF regions were computed as shown in Equation 8. Equation 9 shows how these percentages were used to redistribute the national freight commodity value estimated in Step 1, which was based only on the origin-based commodities, to each of the 131 FAF regions.

Equation 10 shows that this redistribution was first done at the state level by summing the FAF regions within the given state. After these FAF region O/D-based commodity values were estimated, researchers needed to assign the remainder of the Step 1 commodity value to *UMR* urban areas that were outside the 131 FAF regions. *UMR* urban areas that were not included in a FAF region were assigned a commodity value based on their truck VMT relative to all the truck VMT which remained unassigned to a FAF region in the state. This computation is shown in Equation 11.

$$\begin{array}{c}\text{FAF Region}\\ \text{O/D-Based Commodity Value \%}\end{array} = \left(\frac{\begin{array}{c}\text{FAF Region}\\ \text{O/D-Based Commodity Value}\end{array}}{\begin{array}{c}\text{U.S. O/D-Based}\\ \text{Commodity Value}\\ \text{from 131 FAF Regions}\end{array}} \right) \times 100\% \qquad \text{(Equation 8)}$$

$$\begin{array}{c}\text{FAF Region O/D-Based}\\ \text{Commodity Value}\end{array} = \begin{array}{c}\text{FAF Region O/D-Based}\\ \text{Commodity Value \%}\end{array} \times \begin{array}{c}\text{U.S. O/D-Based}\\ \text{Commodity Value}\\ \text{from Step 1}\end{array} \qquad \text{(Equation 9)}$$

$$\begin{array}{c}\text{O/D-Based}\\ \text{Commodity Value}\\ \text{for State 1}\end{array} = \begin{array}{c}\text{FAF Region 1}\\ \text{Value from}\\ \text{State 1}\end{array} + \begin{array}{c}\text{FAF Region 2}\\ \text{Value from}\\ \text{State 1}\end{array} + \cdots + \begin{array}{c}\text{FAF Region } n\\ \text{Value from}\\ \text{State 1}\end{array} \qquad \text{(Equation 10)}$$

$$\begin{array}{c}\text{Non-FAF Region}\\ \text{Urban Area O/D-Based}\\ \text{Commodity Value from State 1}\end{array} = \begin{array}{c}\text{Remaining Unassigned}\\ \text{State 1 FAF O/D-Based}\\ \text{Commodity Value}\end{array} \times \left(\frac{\begin{array}{c}\text{Non-FAF Urban}\\ \text{Area Truck VMT}\end{array}}{\begin{array}{c}\text{Remaining Unassigned}\\ \text{State 1 Truck VMT}\end{array}} \right) \qquad \text{(Equation 11)}$$

Step 5 – Calculate Final Commodity Value for Each Urban Area

Researchers averaged the VMT-based commodity value and the O/D-based commodity value as shown in Equation 12 for each urban area to create the final commodity value provided in the *Urban Mobility Report*. The average in Equation 12 provides an arithmetic mean of two urban area estimates. The first commodity value estimate ("Urban Area VMT-based Commodity Value") is estimated as a distribution based on the truck VMT flowing through a given area, and the second commodity value estimate ("Urban Area O/D-based Commodity Value) provides more emphasis on where truck trips originate or end. The arithmetic mean provides a simplified method for incorporating both of these estimates. While the arithmetic average of these two estimates may not be the optimal estimate for all urban areas, it does provide a replicable process for 100+ urban areas, given processing resource constraints.

$$\begin{matrix}\text{Final Commodity}\\ \text{Value for}\\ \text{Urban Area}\end{matrix} = \left(\begin{matrix}\text{Urban Area}\\ \text{VMT-Based}\\ \text{Commodity Value}\end{matrix} + \begin{matrix}\text{Urban Area}\\ \text{O/D-Based}\\ \text{Commodity Value}\end{matrix}\right) \div 2 \qquad \text{(Equation 12)}$$

RESULTS AND DISCUSSION

Table 1 presents the results of the methodology in terms of truck commodity value aggregated by city size. Delay statistics are also included in Table 1. Table 2 presents the state truck commodity values. The total truck commodity value in Table 2 is the result of Step 1 of the methodology. Table 1 and Table 2 are the results as presented in the *2011 Urban Mobility Report* (*1*).

Visual inspection of Table 1 demonstrates a correlation between commodity value and truck delay (e.g., the top four very large urban areas for truck delay are the same for truck commodity value, just in a different order). This is intuitive because Higher commodity values are associated with more people; more people are associated with more traffic congestion. Bigger cities consume more goods, which means a higher value of freight movement. While there are many cities with large differences in commodity and delay ranks, only 17 urban areas are ranked with commodity values much higher than their delay ranking. For example, urban areas like Washington, D.C. have a high delay ranking but relatively low commodity value ranking. Mid-sized cities like Austin, Texas also exhibited this difference.

To put the truck congestion problems into perspective, $7 trillion worth of commodities was trucked on America's urban streets and highways during 2010. This value includes both American-made products and imports. This value is the product of the 439 urban area average ($16 billion) multiplied by 439 urban areas as shown at the bottom of Table 1.

Table 1 also illustrates the role of long corridors with important roles in freight movement. Some of the smaller urban areas along major interstate highways along the east and west coast and through the central and Midwestern U.S., for example, have commodity value ranks much higher than their delay ranking. High commodity values and lower delay might sound advantageous—lower congestion levels with higher commodity values means there is less chance of congestion getting in the way of freight movement. At the areawide level, this reading of the data is correct, but in the real world the problem often exists at the road or even intersection level – and solutions should be deployed in the same variety of ways.

Table 2 shows the state truck commodity values. The total truck commodity value is shown for each state, along with the associated values for the rural and urban truck commodity value. The sum of the commodity value being trucked on America's urban and rural roadways is $12 trillion—the sum of the total truck commodity values by state shown in Table 2. California has the highest total truck commodity value ($1.2 billion), followed by Texas ($1.15 billion) and then Florida ($553 million).

Possible Solutions for Truck Congestion

Urban and rural corridors, ports, intermodal terminals, warehouse districts, and manufacturing plants are all locations where truck congestion is a particular problem. Some of the solutions to these problems look like those deployed for person travel—new roads and rail lines, new lanes on existing roads, lanes dedicated to trucks, additional lanes and docking facilities at warehouses and distribution centers. New capacity to handle freight movement might be an even larger need in coming years than passenger travel capacity. Goods are delivered to retail and commercial stores by trucks that are affected by congestion. But "upstream" of the store shelves, many manufacturing operations use just-in-time processes that rely on the ability of trucks to maintain a reliable schedule. Traffic congestion at any time of day causes potentially costly disruptions. The solutions might be implemented in a broad scale to address freight traffic growth or targeted to road sections that cause freight bottlenecks.

Other strategies may consist of regulatory changes, operating practices or changes in the operating hours of freight facilities, delivery schedules, or manufacturing plants. Addressing customs, immigration and security issues will reduce congestion at border ports-of-entry. These technology, operating and policy changes can be accomplished with attention to the needs of all stakeholders and can produce as much from the current systems and investments as possible.

The Next Generation of Freight Measures and Future Work

The dataset used for Table 1 and Table 2 provides origin and destination information, but not routing paths. The *2011 Urban Mobility Report* developed an estimate of the value of commodities in each urban area using aggregate data sources. Better estimates of value will be possible when new freight models are examined. Those can be matched with detailed private-sector company speed data to investigate individual congested freight corridors and their value to the economy. Improved disaggregate truck data can better inform local decisions for specific improvement strategies and projects.

There are a number of assumptions made in the methodology presented here in an attempt to create a replicable cost-effective analysis method using available data for 100+ urban areas represented in the *Urban Mobility Report*. A number of these assumptions are inherent in the methodological steps and below is a list of some of the key assumptions and limitations of the methodology as described in this paper:

- Monetary freight value in this paper is based only on commodity value, while the actual value of a truck delivery is a function of a number of considerations. These considerations include the type of truck (e.g., single unit, articulated), the truck operation (e.g., truckload, less-than-truckload, owner-operator, for-hire, private), trip type (e.g., long-distance/rural, drayage/urban), any late delivery penalties, and the form of driver payment (e.g., hourly, by trip, mileage) in addition to the commodity value itself.

- The paper assumes the value of a commodity is directly proportional to the value of a freight movement. As stated in the first bullet, the value of the freight movement is much more than just the monetary value of the commodity.
- Value of truck time is also dependent on travel direction and this research assumes equal value by direction. For example, the value of time for a truck delivering a container to an intermodal terminal is different than the value of time of a truck re-positioning an empty container.
- Researchers assume an equal distribution of commodity types across urban areas distributed proportionally by VMT. Proportional weighting is also done for rural (non-FAF) regions.
- In Step 4, commodity values for urban areas are re-distributed by origin-destination, in part because FAF does not include trips that are less than 50 miles. This is performed to place more emphasis on those urban regions where the majority of truck trips were originating or ending. In Step 5, this estimate is averaged with the VMT-distributed commodity value estimate; therefore, assuming a simple average of these two estimates is appropriate for all urban areas.

Future work should focus on these key areas; particularly as improved disaggregate data become available.

TABLE 1 Truck Commodity Value and Truck Delay, 2010

Urban Area	Total Delay (1000 Hours)	Total Delay Rank	Truck Delay (1000 Hours)	Truck Delay Rank	Truck Delay Congestion Cost ($ million)	Truck Commodity Value ($ million)	Truck Commodity Value Rank
Very Large Average (15 areas)	**187,872**		**9,696**		**895**	**206,375**	
Chicago IL-IN	367,122	3	25,102	1	2,317	357,816	3
L.A.-Long Beach-Santa Ana CA	521,449	1	24,278	2	2,254	406,939	2
New York-Newark NY-NJ-CT	465,564	2	24,148	3	2,218	475,730	1
Houston TX	153,391	6	7,439	4	688	230,769	4
Washington DC-VA-MD	188,650	4	7,363	5	683	95,965	17
Dallas-Fort Worth-Arlington TX	163,585	5	7,230	6	666	227,514	5
Philadelphia PA-NJ-DE-MD	134,899	8	7,176	7	659	172,905	7
Atlanta GA	115,958	11	6,767	8	623	189,488	6
Miami FL	139,764	7	6,566	9	604	153,596	9
Phoenix AZ	81,829	15	6,511	10	603	129,894	12
San Francisco-Oakland CA	120,149	9	5,246	11	484	130,852	11
Seattle WA	87,919	12	5,037	12	467	150,998	10
Boston MA-NH-RI	117,234	10	4,982	13	459	128,143	13
Detroit MI	87,572	13	4,149	15	382	159,328	8
San Diego CA	72,995	18	3,453	17	321	85,686	20

Very Large Urban Areas—over 3 million population.
Large Urban Areas—over 1 million and less than 3 million population.
Medium Urban Areas—over 500,000 and less than 1 million population.
Small Urban Areas—less than 500,000 population.
Total Delay—Travel time above that needed to complete a trip at free-flow speeds for all vehicles.
Truck Delay—Travel time above that needed to complete a trip at free-flow speeds for large trucks.
Congestion Cost—Value of travel time delay (estimated at $88 per hour of truck time) and excess diesel fuel consumption (estimated using state average cost per gallon).
Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the urban area.
Note: Please do not place too much emphasis on small differences in the rankings. There may be little difference in congestion between areas ranked (for example) 6th and 12th. The actual measure values should also be examined.
Also note: The best congestion comparisons use multi-year trends and are made between similar urban areas.

TABLE 1 Truck Commodity Value and Truck Delay, 2010, Continued

Urban Area	Total Delay (1000 Hours)	Total Delay Rank	Truck Delay (1000 Hours)	Truck Delay Rank	Truck Delay Congestion Cost ($million)	Truck Commodity Value ($ million)	Truck Commodity Value Rank
Large Average (32 areas)	**33,407**		**1,619**		**148**	**62,310**	
Baltimore MD	87,199	14	4883	14	449	94,943	19
Denver-Aurora CO	80,837	16	3,459	16	319	76,023	22
Minneapolis-St. Paul MN	78,483	17	3,258	18	300	95,819	18
St. Louis MO-IL	47,042	21	3,073	19	283	107,010	15
Riverside-San Bernardino CA	40,875	25	2,464	20	229	108,218	14
Orlando FL	38,260	26	2,285	21	207	63,106	32
Tampa-St. Petersburg FL	53,047	19	2,274	22	210	61,906	33
Pittsburgh PA	41,081	24	2,204	23	200	69,290	25
Portland OR-WA	41,743	23	2,037	24	185	64,964	30
San Juan PR	50,229	20	1,934	25	174	23,130	60
Nashville-Davidson TN	26,475	33	1,569	26	142	65,449	29
New Orleans LA	20,565	39	1,487	27	135	34,270	50
San Jose CA	42,846	22	1,452	28	133	52,079	36
Milwaukee WI	26,699	32	1,397	29	127	66,629	28
Sacramento CA	29,602	30	1,350	30	123	51,883	37
Cincinnati OH-KY-IN	23,297	35	1,328	31	120	64,323	31
Indianapolis IN	20,800	38	1,326	32	119	83,984	21
Kansas City MO-KS	24,185	34	1,313	33	119	72,545	23
Austin TX	31,038	28	1,309	34	119	32,824	52
Raleigh-Durham NC	19,247	40	1,255	35	115	49,468	40
San Antonio TX	30,207	29	1,142	37	105	50,600	39
Charlotte NC-SC	17,730	43	1,106	38	101	68,196	26
Virginia Beach VA	36,538	27	1,075	40	98	43,056	42
Memphis TN-MS-AR	17,197	44	956	42	87	98,356	16
Louisville KY-IN	17,033	45	936	43	85	55,226	35
Jacksonville FL	18,005	42	926	44	84	41,508	44
Las Vegas NV	27,386	31	913	45	83	35,458	49
Cleveland OH	21,380	36	813	46	75	67,808	27
Salt Lake City UT	18,366	41	658	50	61	56,160	34
Columbus OH	14,651	51	582	51	53	69,664	24
Buffalo NY	11,450	56	558	55	51	48,387	41
Providence RI-MA	15,539	48	488	59	45	21,633	61

Note: See notes on page 1 of Table 1.

TABLE 1 Truck Commodity Value and Truck Delay, 2010, Continued

Urban Area	Total Delay		Truck Delay			Truck Commodity Value	
	(1000 Hours)	Rank	(1000 Hours)	Rank	Congestion Cost ($ million)	($ million)	Rank
Medium Average (33 areas)	**9,513**		**462**		**42**	**18,478**	
Baton Rouge LA	14,577	52	1,215	36	110	32,636	54
Bridgeport-Stamford CT-NY	21,233	37	1,104	39	102	11,205	73
Tucson AZ	11,412	57	1,030	41	92	28,654	58
Birmingham AL	15,832	47	777	47	71	38,401	45
Albuquerque NM	10,477	58	770	48	69	14,035	67
Oklahoma City OK	16,848	46	730	49	66	37,779	46
Hartford CT	15,072	49	573	52	52	42,403	43
El Paso TX-NM	10,452	59	571	53	52	31,703	55
Charleston-North Charleston SC	9,160	62	561	54	51	10,552	76
New Haven CT	11,643	55	541	56	49	8,276	86
Allentown-Bethlehem PA-NJ	9,777	60	478	60	43	15,827	65
Honolulu HI	15,035	50	476	61	42	10,125	78
Tulsa OK	9,086	63	450	63	42	28,827	57
Richmond VA	13,800	53	424	64	39	37,643	47
Oxnard-Ventura CA	9,009	64	423	65	39	9,187	83
Colorado Springs CO	11,897	54	407	66	37	6,546	91
Albany-Schenectady NY	7,467	71	387	67	35	32,655	53
Grand Rapids MI	7,861	68	357	69	32	37,551	48
Sarasota-Bradenton FL	8,015	67	357	69	32	7,591	89
Knoxville TN	7,518	70	351	71	32	11,989	72
Bakersfield CA	4,005	90	340	72	31	10,838	75
Fresno CA	5,999	78	317	73	29	9,474	81
Indio-Cathedral City-Palm Spr. CA	5,633	80	311	74	28	5,455	94
Dayton OH	7,096	73	306	75	28	33,645	51
Springfield MA-CT	8,305	66	302	76	27	9,238	82
Omaha NE-IA	9,299	61	251	79	23	8,668	85
Lancaster-Palmdale CA	6,906	74	242	80	22	2,728	99
Rochester NY	6,377	76	236	81	21	26,077	59
Akron OH	6,198	77	232	82	21	9,828	80
Wichita KS	6,858	75	224	84	21	7,901	87
Poughkeepsie-Newburgh NY	4,271	85	218	85	20	13,714	68
Toledo OH-MI	4,223	86	198	90	18	10,950	74
McAllen TX	2,598	96	100	99	9	7,678	88

Note: See notes on page 1 of Table 1.

TABLE 1 Truck Commodity Value and Truck Delay, 2010, Continued

Urban Area	Total Delay (1000 Hours)	Total Delay Rank	Truck Delay (1000 Hours)	Truck Delay Rank	Truck Delay Congestion Cost ($ million)	Truck Commodity Value ($ million)	Truck Commodity Value Rank
Small Average (21 areas)	**4,166**		**230**		**21**	**12,275**	
Columbia SC	8,515	65	521	57	47	12,404	70
Jackson MS	5,488	81	518	58	47	16,984	64
Cape Coral FL	7,600	69	454	62	41	5,962	93
Little Rock AR	7,345	72	366	68	33	15,221	66
Greensboro NC	4,104	87	290	77	26	50,964	38
Spokane WA	4,306	84	258	78	23	7,230	90
Winston-Salem NC	4,054	89	230	83	21	8,679	84
Pensacola FL-AL	4,699	83	209	86	19	6,339	92
Worcester MA	5,639	79	207	87	19	10,115	79
Salem OR	3,912	91	205	88	18	3,864	97
Madison WI	3,375	93	202	89	18	17,361	63
Provo UT	5,056	82	192	91	18	12,681	69
Beaumont TX	3,814	92	189	92	17	20,504	62
Laredo TX	2,041	99	170	93	15	30,799	56
Brownsville TX	2,323	98	165	94	15	2,380	100
Stockton CA	2,648	95	162	95	15	10,264	77
Anchorage AK	3,013	94	146	96	13	4,454	96
Corpus Christi TX	2,432	97	138	97	13	12,327	71
Boise ID	4,063	88	110	98	10	4,772	95
Eugene OR	1,456	101	78	100	7	3,658	98
Boulder CO	1,612	100	38	101	3	820	101
101 Area Average	**42,461**		**2,152**		**198**	**58,981**	
Remaining Area Average	**1,582**		**95**		**9**	**3,183**	
All 439 Area Average	**10,987**		**568**		**52**	**16,021**	

Note: See notes on page 1 of Table 1.

TABLE 2 State Truck Commodity Value, 2010

State	Total Truck Commodity Value ($ million)	Rural Truck Commodity Value ($ million)	Urban Truck Commodity Value ($ million)
Alabama	225,316	140,281	85,035
Alaska	17,161	12,082	5,079
Arizona	266,930	102,058	164,872
Arkansas	160,049	130,440	29,609
California	1,235,308	295,145	940,164
Colorado	153,998	62,081	91,917
Connecticut	110,515	7,578	102,937
Delaware	35,030	12,397	22,633
Florida	552,621	138,470	414,151
Georgia	417,906	182,728	235,178
Hawaii	16,307	5,592	10,715
Idaho	57,974	47,004	10,970
Illinois	548,431	174,621	373,810
Indiana	368,446	199,151	169,296
Iowa	157,013	130,758	26,255
Kansas	142,534	100,076	42,458
Kentucky	222,880	146,951	75,929
Louisiana	217,425	101,396	116,029
Maine	44,693	36,143	8,550
Maryland	205,976	51,098	154,878
Massachusetts	164,871	10,433	154,438
Michigan	348,470	101,493	246,977
Minnesota	189,643	86,720	102,923
Mississippi	155,821	121,572	34,249
Missouri	297,147	150,722	146,425
Montana	41,673	39,489	2,184
Nebraska	96,020	84,448	11,572
Nevada	78,514	37,075	41,440
New Hampshire	38,649	23,312	15,338
New Jersey	295,927	12,901	283,026
New Mexico	111,128	91,403	19,725
New York	482,018	111,566	370,451
North Carolina	373,822	146,171	227,652
North Dakota	47,109	42,718	4,391

Total Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the state.
Rural Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the rural areas of the state.
Urban Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the urban areas of the state.

TABLE 2 State Truck Commodity Value, 2010, Continued

State	Total Truck Commodity Value ($ million)	Rural Truck Commodity Value ($ million)	Urban Truck Commodity Value ($ million)
Ohio	447,564	177,760	269,805
Oklahoma	205,346	137,892	67,453
Oregon	153,382	82,144	71,239
Pennsylvania	443,946	195,660	248,286
Rhode Island	21,139	3,786	17,353
South Carolina	192,648	97,765	94,883
South Dakota	44,693	39,879	4,813
Tennessee	349,114	156,776	192,337
Texas	1,150,012	441,184	708,828
Utah	143,138	60,146	82,992
Vermont	24,158	21,648	2,510
Virginia	253,058	110,587	142,471
Washington	273,611	91,855	181,756
West Virginia	85,762	62,040	23,722
Wisconsin	326,741	190,205	136,536
Wyoming	48,921	46,372	2,549
District of Columbia	9,059	-	9,059
Puerto Rico	38,653	3,494	35,159

Total Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the state.
Rural Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the rural areas of the state.
Urban Truck Commodity Value—Value of all commodities moved by truck estimated to be traveling in the urban areas of the state.

CONCLUSIONS

For nearly 30 years, the Texas A&M Transportation Institute has developed methodologies and appropriate performance measures for estimating congestion performance and communicating them to technical and non-technical audiences. Historically, the *UMR* has focused on passenger-car congestion (i.e., the average commuter), but there are frequent questions about the economic impact of congestion on freight. Traffic congestion certainly impacts both commuters and goods movement. With the documented growth in freight shipments and value, particularly in the trucking freight mode, researchers were interested in characterizing and including the urban area truck freight value that is impacted by congestion into the *UMR*.

The methodology discussed in this paper uses data from the Freight Analysis Framework and the Highway Performance Monitoring System, both from FHWA. Commodity values supplied by FAF are integrated with truck vehicle-miles of travel (VMT) calculated from the HPMS roadway inventory. The methodology application discussed in this paper serves to estimate the aggregate monetary value of the commodity type axis of the freight box conceptual framework described in this paper.

Researchers found that $7 trillion worth of commodities was trucked on America's urban streets and highways during 2010. These values include both American-made products and imports. The urban area results appear intuitive and demonstrate a correlation between commodity value and truck delay—higher commodity values are associated with more people; more people are associated with more traffic congestion. Bigger cities consume more goods, which means a higher value of freight movement.

The addition of truck value to the *UMR* provides another dimension to the report to inform policy-makers and decision-makers on the amount of economic value delivered by commercial trucking that is impacted by congestion. This information helps to characterize the magnitude of congestion's impact on urban areas in the United States. Researchers will continue to include the truck freight value performance measure in subsequent releases of the *Urban Mobility Report*.

This paper also discusses possible solutions for truck congestion and that these congestion-reducing strategies should be accomplished with attention to the needs of all stakeholders to produce as much from the current systems and investments as possible.

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