INTEGRATIVE FREIGHT DEMAND MANAGEMENT IN THE NEW YORK CITY METROPOLITAN AREA

Cooperative Agreement #DTOS59-07-H-0002

Executive Summary

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1. EXECUTIVE SUMMARY

This project is one of the first in the world that has successfully integrated the use of remote sensing technology—in this case Global Positioning System (GPS) enabled cell phones—as part of a system that effectively reduces truck traffic in the congested hours of the day, through the use of incentives to receivers. In doing so, the project designed, developed, and pilot tested a concept that:

- Exploited the use of GPS technology and its estimates of travel times and delays, for compliance verification, data sharing among participating partners, and validation of the traffic models used to predict the effects of the proposed program on the traffic network.

- Developed state of the art analytical formulations and simulation systems to study and predict the behavior of carriers and receivers—together with the underlying behavioral theories—that were successfully verified during the pilot test conducted.

- Led to new policy paradigms that, by exploiting the nature of Large Traffic Generators and unassisted deliveries, greatly reduce the need for financial incentives to receivers.

- Garnered the enthusiastic support of large corporations involved in urban delivery activities, trade organizations, trade publications, and the industry at large, as they understood the concept’s potential as a business-friendly and effective freight demand management tool they could embrace. It is worthy of notice that some of the companies involved in the pilot test are considering using off-hour deliveries on a permanent basis, or have already decided to commit to off-hour deliveries, and that the Journal of Commerce published two articles on the project (which is highly unusual as its main focus is not on research projects).

- Conducted institutional analyses to identify and preliminarily discuss potential inter-agency arrangements that could support the concept. These analyses—together with a vigorous outreach to relevant agencies, and representatives of the freight industry, shippers, and receivers—have provided the project an outstanding support base. This has engendered the support of the key transportation agencies involved in the project as they were able to appreciate the demand management potential of the concept.

- Has received considerable research acclaim. As of the publication of this report, the research supporting the project has received three awards, was selected to be presented as the Plenary Lecture at the International Transportation Economics Conference in Minneapolis in June 2009, has produced seven journal papers, was featured in two Journal of Commerce articles (Journal of Commerce, 2009; 2010), was written about in the Wall Street Journal (Wall Street Journal, 2010), and was recognized by the NYCDOT Commissioner Janette Sadik-Khan for its potential impact in New York City at a ceremony to publicly recognize the pilot test participants. This is a considerable achievement for a project of this nature, and one that provides testimony of the validity of its conceptual foundations.

In the opinion of the team, the project has opened new doors for the use of remote sensing technology as a central component of a freight demand management concept that is widely supported by both the freight industry and transportation agencies, which is solidly supported by cutting edge research. The team is optimistic that the project will prove to be a watershed in freight demand
management in urban areas. The following sections discuss the key findings in each of the key areas of work. Additional information can be found in the corresponding chapters in the final report.

1.1 Project Background

This project has enjoyed strong industry support since its inception. The foundation of this project is the work conducted for the New York State Department of Transportation (NYSDOT) by team members. The original NYSDOT project entitled “Potential for Off-Peak Freight Deliveries to Congested Urban Areas” was the result of a request made in early 2002 by the New York City Chapter of the then Council of Logistics Management (now Council of Supply Chain Management Professionals) to NYSDOT to find ways to encourage off-hour deliveries in New York City. The NYSDOT agreed that the proposed subject was worthy of study and issued a Request for Proposals on December 2002, which led to the selection of Rensselaer Polytechnic Institute as the lead contractor. The main focus of the original NYSDOT project was Manhattan, and its objectives were to:

- “Define the set of policies and programs that would induce a shift of deliveries to off-peak hours (referred to here as off-peak delivery initiatives).”
- “Quantify stakeholders’ costs and benefits associated with off-peak deliveries initiatives.”
- “Perform an economic analysis of the expansion of hours during which pick-ups and deliveries are made to commercial areas.”
- “Quantify extra costs to stakeholders so that compensation schemes could be implemented, should off-peak deliveries be found to be economically beneficial to Society at large.”

In May 2005 the Southwest Brooklyn Industrial Development Corporation (SWBIDC)—that heard about the project through informal channels—requested NYSDOT to include Brooklyn in the study. NYSDOT agreed and a second phase of the project with a Brooklyn focus was added. A final report for both phases was issued on December 8, 2006 (Holguín-Veras, 2006).

The current project titled “Integrative Freight Demand Management for the New York City Metropolitan Area” was funded by the United States Department of Transportation’s Commercial Remote Sensing and Spatial Information Technology Applications Program in March 2007, in response to a proposal submitted to the BAA DTPH56-06-BAA-0002 by a consortium of Rensselaer Polytechnic Institute, Rutgers University, Rudin Center for Transportation Policy and Management at NYU-Wagner, and ALK Technologies Inc. The original scope of work, which included a pilot test of substantial size, was reduced to place more emphasis on the design of the system, and the large pilot was transformed into a “small scale deployment.”

The main charge of the project could be summarized as follows:

“The project would design and develop a self-sustaining urban freight traffic management system for the New York City metro area that integrates state of the art remote sensing technology, cutting edge freight demand management, traffic simulation, and policy. The project
combines the revenue generation power of time-of-day pricing, with tax deductions to receivers willing to accept off-peak deliveries, and GPS based traffic monitoring, to induce a shift of truck traffic to the off-hours.”

1.1.1 Funding
The work started on July 1, 2007. The total funding provided by the USDOT was about $1.2 million. The project partners provided $0.64 million in matching funds.

1.1.2 Goals and Objectives
In terms of goals and objectives:

“The proposed concept is expected to: (1) induce a significant shift of truck traffic to the off-peak hours (preliminary estimates suggest that, in some industry segments, the shift could reach 20% of local day truck traffic) (Holguín-Veras et al., 2006b); (2) bring about significant improvements in traffic congestion and environmental conditions; and (3) increase the competitiveness of NYC via tax deductions to local businesses, productivity increases from improved traffic conditions, and significant reductions in parking fines (that frequently exceed $1,000 per truck per month). Once the concept has been designed and developed, it will be demonstrated in a small scale field deployment test.”

1.1.3 Project Focus
It is important to stress that the project focused on urban deliveries, i.e., the transportation of cargo to urban locations. The main reason being that they represent the bulk of the freight traffic in urban areas, most likely accounting for more than 80% of the entire freight traffic, and the natural target for freight demand management programs aimed at reducing the congestion they produce. Other segments, e.g., external-external flows that pass through the urban area, are not discussed.

The project focus must be kept in mind as urban deliveries are quite different than other segments of the freight industry. First, they are typically made in relatively long delivery tours—with an average of 5.5 delivery stops per tour in New York City—that start and end at the home base. Second, in cases where there is cordon pricing, the tours incur a toll at the entrance of the urban area in order to deliver to the customers inside (which translates into the toll surcharge being a fixed cost). Third, the shipment sizes tend to be relatively small as they are frequently delivered with relatively smaller vehicles. All these aspects, and others not listed here, make urban deliveries a rather unique operation with characteristics not found in other segments of the freight industry.

As a result, the conclusions and methodologies developed here should be assumed to be valid only for the urban delivery case. Further research must be conducted to assess how valid they are for application in other types of freight operations.
1.2 Methodology

1.2.1 Remote sensing and pilot test

The pilot test was organized around a set of four industrial partners, i.e., industry leaders with interest in exploring off-hour deliveries. The partners were: (1) Foot Locker and New Deal Logistics; (2) Sysco and a sample of its customers; and (3) Whole Foods Market and its vendors. It is important to mention that all partners are leaders in their respective field of business.

In all cases, these partners switched their distribution chains—particularly the transportation and the receiving end—to the off-hours for at least a month. In total, 25 receivers (30 receivers if partial participation is counted) and eight carriers/vendors participated in the test. Since there were no interactions among each of the industrial partner groupings, the pilot tests were run independently of each other, and started as soon as each group was ready to begin. It is important to mention that the industrial partners committed a significant amount of effort and expenses to participate in the test. High level executives and, in some cases, their entire logistic teams participated in dozens of conference calls discussing the preparations for the pilot test. Although the team decided to give the carriers designated as industrial partners a token payment of $3,000—as a show of appreciation for their efforts—the fact of the matter is that this amount does not cover even a fraction of their staff time. Their investment in this effort provides clear evidence of the industry support for the concept. The dates of participation are shown in parenthesis next to the company names. The partners were:

- **Group 1**: Foot Locker and New Deal Logistics (October 2-November 14, 2009): Eight Foot Locker stores and New Deal Logistics participated.
- **Group 2**: Sysco and a sample of its customers (December 21-January 23, 2010): Thirteen stores successfully completed the test, five participated partially and dropped out for reasons unrelated to the project, and another three agreed to participate but did not order products from the vendor during the pilot test (reasons unknown).
- **Group 3**: Whole Foods Market and its vendors (December 28-January 31, 2010): This group included the four Whole Foods Market locations not subject to night delivery restrictions plus six of their vendors. The other two Manhattan Whole Foods Market locations could not participate; one due to a lease restriction and the other due to neighborhood restrictions on overnight deliveries.

The participating receivers were provided a financial incentive of $2,000 for successful participation in the pilot test. This incentive was larger than the ones considered during the research work—which are associated with a long term commitment to off-hours—to compensate for the setup costs associated with switching to the off-hours at the beginning of the pilot, and then back to the regular hours upon completion. The participating carriers were given an incentive of $300 per truck participating in the pilot test to compensate for the corresponding setup costs. Obviously, since they stand to benefit from delivering during the off-hours, the incentive could be smaller than the one for receivers.
1.2.2 Approach to reducing peak deliveries

The analyses of the data collected from carriers as part of both the Evaluation Study of the Port Authority of New York and New Jersey’s Time of Day Pricing Initiative (Holguín-Veras et al., 2005; Holguín-Veras, 2006), and the NYSDOT’s “Potential for Off-Peak Freight Deliveries to Congested Urban Areas” project (Holguín-Veras, 2006), produced findings that challenge long-held assumptions. The data showed that: (1) the ability of carriers to unilaterally change delivery times is quite limited as it necessitates the concurrence of the receivers (which tend to prefer regular-hour deliveries as they can take advantage of the staff at hand, as opposed to off-hour deliveries that may require extra staff, security, lighting, and other costs); and, (2) cordon tolls are not likely to be effective in inducing a switch to the off-hours, as most segments of the urban freight industry cannot pass toll costs to their customers depriving them of the price signal needed to effect a change. It is very telling that: (1) only about 9% of carriers could pass the toll costs to their customers; and (2) when carriers were asked about why they did not change behavior in response to time-of-day tolls, about 70% of them cited “customer requirements” as the reason (Holguín-Veras et al., 2006c). In essence, the receiver is the key decision maker.

Further analyses (Holguín-Veras, 2008) concluded that the difficulties that carriers have in passing cordon time-of-day tolls to their customers reflect a highly competitive market with delivery rates equal to marginal costs. Since the cordon toll is a fixed cost—as it does not depend on the unit of output—it does not enter into the rates. The empirical data confirmed that only the market segments with market power (i.e., carriers of stone/concrete, wood/lumber, food, electronics, and beverages) could pass toll costs in a meaningful way (Holguín-Veras, 2008). The key insight is that, since the price signal only reaches the receivers in those cases where the carrier has market power (though in a diluted fashion because they allocate the toll costs among the multiple receivers in the tour), carrier centered pricing policies are not as effective as they should be because receivers have no incentive to change behavior. Since the consent of the receivers is needed for the carriers to change behavior, it follows that a new policy paradigm is needed. These new policies specifically target the receivers of the cargoes as they are the ones that determine whether or not the carriers can switch to the off-hours.

The fundamental tenet of this project is that the key to inducing a shift of truck traffic to the off-hours is to convince receivers to accept off-hour deliveries by either: (1) providing incentives in exchange for their commitment to off-hour deliveries; or (2) by fostering the use of concepts such as unassisted deliveries that do not require receivers to provide staff to handle deliveries during the off-hours. Since the carriers stand to benefit from doing off-hour work (delivering in the off-hours is between 20-30% cheaper than delivering during the regular hours), they would be glad to do off-hour deliveries as long as a sufficient number of receivers would be willing to accept off-hour deliveries. This means that, if the carrier is able to switch an entire distribution route to the off-hours, it will save money.
However, it is not likely that a carrier will find it beneficial to split a regular-hour route into two routes, one for regular-hour customers and another for the off-hours, because the cost of the extra route would offset the operational cost savings.

Inducing receivers to accept off-hour deliveries will lead to the following chain of events:
- The barrier that prevents many carriers from doing off-hour deliveries will be removed.
- A significant number of carriers will switch to the off-hours.
- Congestion will be reduced, and environmental conditions will improve.
- The competitiveness of the urban area will increase as business activities will be more productive and efficient.

1.2.3 Behavioral/economic research supporting the concept

The estimation of the potential participation in off-hour deliveries is of great importance as it determines the economic benefits attributable to the practice in terms of travel time reductions, improvement of environmental conditions, and sustainability. Estimating participation in off-hour deliveries necessitates the combined use of behavioral research—to estimate the likely response of the freight industry to various policies—and freight trip generation analyses to get an idea about the total number of deliveries that would switch to the off-hours. It is important to acknowledge that, though state of the art methodologies have been used throughout the project, there is an unknown amount of uncertainty in the estimates provided. To account for this, whenever possible, the estimates are presented in the form of ranges. This section summarizes the process followed and the key results.

The behavioral research produced by the project has significantly advanced freight transportation modeling, and freight behavior research, as well as enhanced the transportation community’s ability to understand and predict the freight industry’s response to various policies. The research conducted included: (1) the development of a Behavioral Micro-Simulation (BMS) (Silas and Holguín-Veras, 2009), and of an approximation model to estimate participation in off-hour deliveries (Holguín-Veras, 2010); (2) the formulation of an analytical model that explains the observed limitations of freight road pricing, and the need for comprehensive carrier-receiver policies (Holguín-Veras, 2008; 2009); and (3) the application of these novel developments to the New York City case.

The behavioral research conducted has led to insight of great practical and theoretical significance. More specifically, the research demonstrated on the basis of theory and empirical data that:
- Receiver participation in off-hour deliveries increases with the amount of the incentive provided (though there are industry segments that are more sensitive than others).
- Conducting off-hour deliveries is about 30% cheaper than delivering in the regular hours. The cost estimates produced by the team—and confirmed with the input of the industrial partners—clearly indicate that off-hour deliveries are about 30% cheaper than regular-hours’
(even after premium wages are paid to the off-hour crews). In addition to the lower operational costs, making deliveries in the off-hours leads to highly reduced parking fines. This is a major issue as the parking fines incurred during the regular hours average between $500 and $1,000 per truck per month (Holguín-Veras, 2006). Moreover, since parking fines are not a valid business expense—they are a violation of traffic law—the businesses cannot deduct them from taxes.

- The carriers most inclined to participate are those that have delivery tours with fewer delivery stops. Carriers stand to benefit from off-hour deliveries if a substantial number of the customers in a tour accept off-hour deliveries (if the carrier would have to make two trips to deliver during both regular and off-hours, the operation may not be profitable). Since the smaller the number of customers, the easier it is to have all of them agreeing to do off-hour deliveries (Holguín-Veras, 2009), it follows that carriers with short delivery tours are likely to be the ones most inclined to do off-hour deliveries.

- **Cordon time-of-day pricing is of limited usefulness for freight demand management.** The reason is related to the inherent weakness of the urban delivery industry which has limited ability to pass the toll costs to the customers. (The explanation is rooted in economic theory as the cordon toll is a fixed cost that does not enter in the freight rates which are equal to marginal costs.) As a result, since the toll signals do not reach the customers, they have no incentive to switch to the off-hours. Equally important is that, even if the carriers can pass the toll costs to the customers, the practical range of the tolls is such that the ensuing increases would not induce the receivers to move to the off-hours (Holguín-Veras, 2009).

- **Time-distance pricing is slightly more effective than cordon time-of-day tolls, though in order to produce a significant shift to the off-hours it would require massive tolls.** The research revealed that time-distance tolls can be passed by carriers to receivers—as they enter in the marginal costs that determine the rates in a competitive market. However, in order for time-distance pricing to induce receivers to change to the off-hours, the cost increase to the receivers would have to be larger than their incremental cost of moving to the off-hours. This leads to time-distance tolls that, for the average tour of five receivers, are about five times larger than current operational costs which sounds politically unfeasible (Holguín-Veras, 2009).  

### 1.2.4 Data collection scheme

The remote sensing component was undertaken with GPS enabled smartphones and the Copilot|Live turn-by-turn navigation software. The selected smartphone model was the MWg Zinc ii. It was selected because it contains a powerful 500 MHz processor, bright 2.8” touch screen, high quality built-in SiRf Star_iii GPS receiver, substantial memory, a pull-out QWERTY keyboard, and the Windows Mobile 6.0 operating systems. The smartphones were configured in such a way that the only action required by the driver was to turn the phone on at the beginning of the route; no further interaction between the driver and the smartphones was required while driving. Safety is of the upmost concern and the project team ensured that the smartphone would not be a distraction to the driver. Usage and safety information was personally provided by a representative of ALK Technologies when the smartphones were distributed to
the participating carriers for use during the pilot test. In cases where the carrier already had GPS equipment for fleet monitoring purposes, they were given the option of sharing the data with the team instead of using the phones. A noticeable number of participants elected to do that, and some even provided data for the entire metropolitan area, not just the routes involved in the pilot test. This enabled the team to obtain background performance data for a much larger fleet of trucks. In some cases, passive GPS data loggers were used as a backup. Upon receiving the GPS data, the team analyzed them to obtain estimates of travel speeds, delays, standard deviations, and other useful indicators of performance.

1.3 Results from Base Case Data and Pilot Test

This section discusses the results obtained during the pilot test, which are contrasted with the base case conditions, in terms of both productivity performance measures and the feedback received from the participating companies. The productivity analyses focus on the travel speeds, both from the depot to the first customer in Manhattan and from customer to customer, as well as the service times (time spent doing a delivery) at the stops. The team separated the travel to the first customer from the customer to customer trips, because they have radically different characteristics (the former is a relatively long trip with few stops in between, while the latter are typically short trips with many stops due to urban driving conditions, e.g., signals, pedestrians, etc). Furthermore, the focus on customer to customer travel speeds enables one to consider the collective impact of these traffic delays produced by the urban driving conditions. On the other hand, the analyses of service times provide very useful insight into the delays associated with making deliveries. As discussed later in the document, the team discussed the results with the industrial partners who verified the validity of the conclusions and findings obtained. Since the data from the different groups that participated in the pilot test were not enough to produce statistically representative results for the entire range of times of travel, the different data sets were pooled together to produce a more robust set of estimates.

An important technical note is that the speeds represent space mean estimates, which are defined as the distance traveled from a point of origin to a point of destination divided by the time it takes to make that trip. This obviously includes the interruptions to the traffic created by traffic signals, pedestrians, and other vehicles. Instantaneous speeds are not used in the analyses because they exhibit a great deal of variability and cannot capture the obstructions mentioned above. When interpreting the results, the reader should be aware that there are no data for the time between 10 PM and 4 AM (the 4 - 5 AM time period only contains a handful of observations). Similarly, although the entire data include about 4,000 individual trips, no assurances can be provided about how representative the data are of the overall truck traffic in the New York City metropolitan area. In spite of these caveats, the data do seem to provide a coherent picture of the potential impacts of off-hour deliveries.
The results are displayed in the form of a box and whisker plot that presents the 2nd, 25th, 50th (median), 75th, and 98th percentiles, and the outliers. (The percentile is the value below which a given percent of the observations fall under. For instance the 25th percentile is the value below which 25% of the observations fall under.) In the plot, the 2nd percentile is the tip of lower whisker, the 25th percentile is the lower tip of the box, the 50th percentile (median) is the line in between the boxes, the 75th is the top of the box, and the 98th percentile is the tip of the upper whisker. Values outside these percentiles are shown as crosshatches.

1.3.1 Customer to customer travel speeds

The customer to customer speeds and the corresponding percentiles are shown in Figure 1. The results indicate a clear pattern in which the speeds decrease in the day hours and increase in the off-hours. As illustrated in the figure, while the speeds in the 5 - 7 AM period reach almost 8 miles/hour (mph); they drop to below 3 mph during the day hours. The sparse data in the 4 - 5 AM hour (only four observations) suggest that in the early hours of the day, travel speeds could be much higher.

In terms of the overall productivity of the off-hour tours, these results indicate that a truck that travels for ten miles making deliveries could save 1.25 hours of travel time if the average speeds are assumed to be 8 mph (off-hours) and 4 mph (regular hours) respectively. Obviously, the longer the tours are, the larger the economic savings associated with a switch to the off-hours.

![Figure 1: Customer to Customer Space Mean Speeds by Time of Day](image-url)
1.3.2 Service times

The second performance measure used is the service time, which is defined as the total time spent by the driver at the customer location. This includes the amount of time that the driver spends: loading/unloading the cart used to transport the cargo, walking from/to the truck to/from the customer location, finding the person that would accept the delivery, waiting for the authorized individual to review the shipment made, waiting for proper signatures and/or payment, sorting out any problems that arise, and other related activities. Figure 2 shows the estimates produced by the team.

Figure 2 shows that service times increase in the day hours, and decrease during the off-hours. The differences in magnitude are significant. While in the morning hours—which is when the bulk of the deliveries are made—the service times consistently exceed an hour, reaching a maximum median value of 1.8 hours in the 10-noon period. During the night hours, the service times drop to a median value of about half an hour. Although no one knows how representative these numbers are of industry-wide conditions, they do indicate that carriers could save up to 1.3 hours per delivery when they switch from the morning to the night hours.

It is important to mention that the team discussed these results with the industrial partners to make sure they conform to their experience. The industrial partners concluded that these results do represent the realities on the ground and that they are part of the “…cost of doing business…” in New York City. They indicated that in the day hours, drivers: typically are forced to park 2-3 blocks away from the customer location, have to wait for loading docks, experience delays in getting access to elevators (either because of other deliveries, or building visitors), have to move their trucks to other locations to avoid fines, and other challenges. In contrast, in the off-hours, they can park closer to the customers and almost all the remaining issues diminish or disappear altogether.

The team also asked about delivery sizes in both the regular and off-hours. The participants indicated that during the off-hours the shipment sizes tend to be larger than in the regular hours (because they take advantage of the larger productivity to transport more cargo). This eliminates any possibility that the larger service times in the regular hours are the result of larger shipments. The implication is that, once the larger shipment sizes in the off-hours are factored in, the productivity savings associated with reductions in service times will be larger than those suggested in Figure 2.
Figure 2: Service Times by Time of Day

These findings have major implications in terms of economic impacts. The most obvious one is that reducing service times will increase the profitability of delivery operations and, ultimately, lower the cost of the products consumed in New York City. A delivery truck that saves 15 minutes at each of the six deliveries, that on average carriers make, will save a total of 1.5 hours (which represents a reduction of $60 per tour). A carrier that saves an average of half an hour per delivery would save about three hours. Regardless of the assumption made, the economic savings are substantial.

Although significant, it is important to keep in mind that these estimates only reflect the benefits of off-hour deliveries to the participating carriers. The benefits associated with lesser truck traffic in the regular hours are discussed in the traffic simulation section.

1.3.3 Feedback from participants

1.3.3.1 Receivers

Mr. Paul Cox, Vice-President for Global Transportation and Supply Chain at Foot Locker, indicated in a call on November 11, 2009, that Foot Locker’s experience with off-hour deliveries was quite positive, particularly in regard to the larger volume stores that had employees dedicated to backroom...
operations. As of the project team’s last communication with Mr. Paul Cox, Foot Locker was considering expanding off-hour deliveries to other stores in Manhattan.

The team also conducted satisfaction surveys. However, in the Foot Locker case, there were some communication problems that impacted the responses from the store managers. More specifically, at the time of conducting the survey, the store managers had not been informed that headquarters had received a financial incentive to compensate them for the additional costs (neither did the survey instruct them to assume that all additional costs would be covered by the financial incentive). Not surprisingly, many of the managers viewed the off-hour deliveries as unfavorable due to the additional costs. On a scale of one to five (with one being the most favorable, and five the least favorable), the average rating was 3.88. For these reasons, these survey results are representative of the attitude towards off-hour deliveries without incentives—which is not what was conducted in the project. In subsequent versions of the survey, the team addressed these issues.

Mr. Rob Twyman, Regional Vice President of Operations for Whole Foods Market - Northeast Region, indicated that he had received good feedback from the stores and that the shifting of delivery times for the participating vendors was “relatively seamless.” The project team has also been informed that many of the vendors of Whole Foods Market that shifted delivery times as part of the pilot test continue to deliver to Whole Foods Market during the off-hours.

The project team received satisfaction surveys from twelve of the participating Sysco receivers. The average response concerning the overall impression of off-hour deliveries was 1.50 on a scale of one to five with “1” being “Very Favorable” and “2” being “Favorable.” In regard to requesting off-hour deliveries in the future, of the twelve, nine were “Very Likely,” one was “Likely,” with the remaining customers responding “May or May Not.” Six of the twelve utilized unassisted deliveries during the pilot test with five of the other six expressing interest in receiving unassisted deliveries during the off-hours in the future if all liability issues were addressed.

### 1.3.3.2 Carriers

Mr. Bobby Heim, Sysco Metro New York Vice-President of Operations, indicated that Sysco was extremely happy with the pilot test results. He added that Sysco had been trying to promote off-hour deliveries for years with limited success. The incentive provided to their receivers for participating in the pilot test helped them to go from one overnight route to five. Since the end of the pilot test and the elimination of the financial incentive, some receivers reverted back to regular-hour deliveries and the number of off-hour routes dropped to four. However, it is worthy of notice that the bulk of the receivers elected to continue to receive off-hour deliveries, which was not anticipated. This must be related to the fact that these receivers were using unassisted deliveries (they provided a key to access the establishment
to the Sysco drivers). The main reasons given for continuing with unassisted off-hour deliveries upon completion of the pilot test were related to the increased reliability associated with this practice.

Mr. Joe Killeen, Chief Operating Office of New Deal Logistics, has indicated that making off-hour deliveries reduced the cost of deliveries. He also indicated there were significant increases in travel speeds, availability of parking, and reductions in service times. On one of the routes, New Deal Logistics saw an increase in travel speed of nearly 75% from the depot to the first stop in Manhattan. During the pilot test, New Deal Logistics only made off-hour deliveries to the participating Foot Locker stores during the 7 - 9 PM which limited them to three off-hour deliveries per route. Mr. Killeen indicated that if receivers were to implement methods for unassisted deliveries during the off-hours, it would dramatically impact the number of off-hour deliveries they could make and would significantly reduce their overall costs.

The project team received six satisfaction surveys from participating vendors of Whole Foods Market. Of the six, one had a “Very Favorable” view of off-hour deliveries, three had a “Favorable” view, one was “Neutral,” and the remaining vendor had a “Very Unfavorable” view. This vendor had encountered an issue with occasionally having to wait for an extended period of time for receiving and indicated that they would be “Unlikely” to perform off-hour deliveries in the future if requested by customers. The other five vendors indicated that they would be “Very Likely” or “Likely” to make deliveries during the off-hours if requested by the customer.

1.3.3.3 Drivers

The participating drivers for the various carriers in the pilot test overwhelmingly preferred delivering during the off-hours. The survey asked seven questions related to how delivering during the off-hour affected various aspects of the delivery process. The scale used “1” to indicate a very positive effect and “5” to indicate a very negative effect. The data show (see average ratings in parentheses) that drivers experienced much faster travel speeds (1.50), much lower congestion (1.17), a large increase in available parking (1.17), much lower levels of stress (1.17), a lower amount of time to deliver goods at each stop (1.58), a lower amount of time to complete the route (1.58), and an increase in the driver’s feeling of safety (2.42). Of the twelve drivers surveyed ten “Strongly Prefer Off-Hour” deliveries, one “Somewhat Prefer Off-Hour” deliveries, and the remaining driver “Strongly Prefer Regular hour” deliveries for an overall impression of 1.42 on the five point scale. The dissatisfied driver worked for the previously mentioned vendor which occasionally had to wait an extended period of time to make a delivery.

1.4 Economic Impacts of a Full Implementation

The quantification of the economic impacts of a full implementation of an off-hour delivery program required: (1) the quantification of the total number of truck-trips that would switch to the off-hours in
response to a given financial incentive to compensate them for the additional costs; (2) the use of network models to simulate what would happen in the network for various scenarios involving a shift to the off-hours; and (3) the estimation of the economic value of the impacts produced, in terms of travel time savings, environmental benefits and the like. This chapter succinctly describes the process followed and the chief results obtained.

1.4.1 Quantification of the potential switch to the off-hours

The estimation of the potential participation in off-hour deliveries required a two step process involving estimating the market response to financial incentives and quantifying the number of deliveries generated by the various industry segments.

The estimation of the market response to the financial incentive to receivers was undertaken with the assistance of a BMS (Silas and Holguín-Veras, 2009), and an analytical model (Holguín-Veras, 2010) specifically designed for that purpose. Both models produced similar results. In essence, these models estimate the market response to the incentive (and other policies) by:

- **Estimating how many receivers in the simulated delivery tours would switch to the off-hours.** These estimates are produced on the basis of state of the art discrete choice models calibrated from the stated preference data collected by the team, that quantify what receivers would do if offered an incentive.

- **Simulating the response of the corresponding carriers.** The survey data collected by the team provide great detail on delivery tours, number of delivery stops, and other operational patterns. This allowed the team to estimate the financial impact on the carrier produced by receivers’ decisions to switch to the off-hours, by computing the cost savings/increases associated with delivering to the receivers in their time of choice. Typically, if most of the receivers in the tour switch to the off-hours the carrier saves money and therefore would like to do off-hour deliveries; conversely, if only a handful of receivers do so, the delivery costs may increase and the carrier is likely to refuse to do so.

- **Aggregating the results for the various industry segments.** After simulating the results for randomly generated tours from the data, the team was able to estimate what number and percent of receivers and carriers were willing to do off-hour deliveries for the various industry segments (e.g., food, retail).

The next step was to quantify the total number of deliveries made by the various industry segments, to compute the impacts of off-hours deliveries on the transportation network. As part of this the team:

- Post processed the survey data collected to estimate freight trip generation models (the only models available for New York City conditions).

- Used the models to estimate the total number of deliveries by industry segment and ZIP code for the Manhattan area.

- Computed the number and percentage of deliveries that would switch to the off-hours for each ZIP code.
• Used these estimates to modify the inputs to the Best Practice Model (BPM), and a mesoscopic traffic simulation model developed by the research team for Midtown and Downtown Manhattan.

The analyses revealed that:

• A staggering number of freight deliveries are made to Manhattan. The estimates—based on the freight generation data collected—show that about 113,000 freight deliveries per day are made to Manhattan, which corresponds to an average trip rate of 0.163 freight deliveries/employee, or 2.798 freight deliveries/establishment. Reflecting the consumer nature of the area, the industry segments with the largest share are: Consumer Goods with 54.48% (wholesale and retail), and the Food sector with another 24.28% (Eating / Drinking Places, and Food Stores).

• The best candidates for participation in off-hour deliveries are the Food and Consumer Goods sectors. On the basis of the total number of deliveries generated and the inclination of each industry segment to participate in off-hour deliveries, the team concluded that in terms of potential payoff, the industry segments that are the best candidates are the Food and Consumer Goods sectors. Although there are several sources of uncertainty, the team estimates that financial incentives of $5,000-$10,000/year would switch about 7-15% of the truck trips to the off-hours, which represents 7,000-16,000 truck trips/day.

• Large Traffic Generators (LTGs) generate about 4-8% of the total number of freight deliveries in Manhattan. This is a notable result. Although there are no hard data to accurately quantify the share of LTGs in the total freight traffic, the team estimated that the 88 buildings with their own ZIP code, e.g., Empire State Building, generate about 4% of the total freight traffic in Manhattan. Adding other buildings that do not have their own ZIP code such as Grand Central Terminal and the Javitts Center, plus large establishments that generate considerable truck traffic, it is entirely possible that LTGs in Manhattan generate 4-8% of the total truck traffic. More importantly, since the LTGs tend to have their own centralized delivery stations, it should be possible for the LTG to receive the off-hour deliveries, and then deliver them to the corresponding businesses during the regular hours.

• Unassisted deliveries provide a great alternative to the provision of financial incentives. “Unassisted deliveries” refers to a range of delivery systems that eliminate the need for human intervention at the receiving end. Examples include: (1) “key deliveries” in which the receiver gives a key to the delivery drivers, which enables them to deposit the goods inside the store; (2) double doors that enable the driver to deposit the deliveries in the secured area (between the doors) with a key provided by the customer; (3) delivery lockers in which a delivery is made to an electronically controlled cabinet at which the consignee could retrieve the goods during the regular hours; and (4) the implementation of two-stage delivery systems in which supplies are transported during the off-hours and stored at a container, or storage pod, at a convenient location, e.g., a secured parking lot, from where the carrier staff delivers the goods during the regular hours using small, and/or environmentally friendly, vehicles; among others. Regrettably, there are no behavioral data that could be used to assess how willing the various industry segments would be to participate in unassisted deliveries.

The process followed during network modeling and traffic simulation is described next.
1.4.2 Network modeling and traffic simulation

The team estimated the traffic impacts of alternative off-hour delivery scenarios with the assistance of both a macroscopic travel demand model, i.e., New York Metropolitan Transportation Council’s Best Practice Model (BPM), and a mesoscopic traffic simulation model of an extracted network focusing on Manhattan. In doing this, the team undertook the following activities:

- **Acquisition of the New York Best Practice Model and up-to-date hourly volume data from New York-area transportation agencies.** The acquired data was used to calibrate the model to the most up-to-date truck traffic volumes available.

- **Extraction of a sub-network focusing on Manhattan for more detailed mesoscopic simulation and analysis.** The extracted network, calibrated with available data, enabled estimation of traffic impacts on both the regional level (using BPM) and at the local level.

- **Studied several scenarios of potential traffic shifts in both traffic models.** Using the data and models developed in the behavioral research, percentages of commercial traffic bound for Manhattan were shifted from the regular to the off-hours, simulating the changes to delivery times that would be brought upon by the proposed program.

- **Compiled and analyzed the impacts to the traffic network predicted by both models.** By comparing modeled scenarios to the base case, changes to travel times, link speeds, and other key measures were calculated. The team used a customized post-processor developed by Ozbay et al. (2008).

The extensive traffic simulation conducted produced a good estimate of the impacts to the Manhattan and the New York City regional traffic network. The most prominent results indicate that:

- **The proposed program has a net positive impact on the traffic networks of Manhattan and the entire New York City region over the entire day.** Negative impacts to off-hour traffic conditions caused by increased commercial vehicle traffic are eclipsed by benefits seen during regular hours due to a reduced amount of commercial vehicles.

- **Impacts are observed at both the local level in Manhattan and at the regional level, i.e., the entire New York City Metropolitan area.** While most delivery trips in Manhattan originate within Manhattan (as they are part of a delivery tour), a significant number of freight trips also originate outside of Manhattan (from major generators such as the ports located outside of the city and region). Therefore the modeling shows that benefits from reduced commercial traffic during the regular hours are observed, not only in Manhattan, but throughout the rest of the city and region.

- **As an illustration of the results produced by the simulation, 10% carrier participation in off-hour deliveries in Manhattan is estimated to produce a reduction of more than 6% in travel times on Manhattan links during the regular hours.** When averaged with the increase in travel times during the off-hours, this still leads to an overall reduction of 4% in Manhattan link travel times. Estimates for a number of other scenarios corresponding to receiver participation were produced.

The next section discusses the economic impacts of the various alternatives considered.
1.4.3 Economic impacts

The team used the results from both the regional network model (BPM), and the mesoscopic traffic simulation (MTS) to estimate the economic impacts in terms of travel time savings and air pollution reductions. The estimates are based on the use of a composite value of time and valuations of the criteria pollutants. However, due to the uncertainty associated with the exact composition of the traffic in the entire network, the results are presented for a range of values of the composite value of time. Assuming a traffic composition of 83% passenger cars, 13% small trucks, 3% large trucks, and 1% buses; and values of time of $24 (which assumes an average occupancy of 1.2 passengers/vehicle), $35, $55, and $750 (which includes the time value of all passengers plus driver and vehicle) per vehicle class, respectively, leads to a composite value of $33.62/vehicle-hour. Different assumptions lead to values as low as $25/vehicle-hour, and as high as $40/vehicle-hour. The analysis considers three different cases:

- Financial incentives to Food and Retail Sectors. This is the policy identified by the NYSDOT project as the most effective one. It provides a financial incentive for participation in off-hour deliveries.

- Targeted programs aimed at Large Traffic Generators (LTGs). These policies focus on the major generators of truck traffic, which include large buildings that house scores of individual establishments, and large establishments (in this case, those with more than 250 employees). Since there are no data about the incentives that may be required, and how many of these LTGs would accept the incentive, a question mark has been added to the cost column. Two cases are considered: (1) Large buildings, which only includes those buildings that have a unique ZIP code, which is a subset of the total; and (2) Large Buildings & Establishments with more than 250 employees.

- Unassisted deliveries. This group considers policies that encourage off-hour deliveries without the intervention of the staff from the receiving establishment. These concepts have great potential as they could lead to economic benefits comparable to those produced by the financial incentives, at a fraction of the cost. Together with policies targeting LTGs, unassisted deliveries must be the subject of further research.

The total benefits and costs for the various stakeholders are shown in Table 1 (Roadway Users), Table 2 (Carriers) and Table 3 (Receivers and Public Sector). Since there are no data about the incentive costs or the benefits in some of the alternatives, question marks have been added to the corresponding cells. As shown in these tables, the magnitude of the economic impacts depends on the value of times used in the analyses. For reference purposes, the values considered by the team as the most likely ones have been shaded. These values correspond to $30/hour for the composite VOT of roadway users, and $40/hour for the VOT for delivery trucks (large and small).
### Table 1: Summary of Economic Impacts: Roadway Users

<table>
<thead>
<tr>
<th>Trips Shifted</th>
<th>Financial incentives to Food and Retail Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BPM 3 MTS 4</td>
</tr>
<tr>
<td>$5,000</td>
<td>7,262</td>
</tr>
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<td>$10,000</td>
<td>15,982</td>
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<tr>
<td>$15,000</td>
<td>23,617</td>
</tr>
<tr>
<td>$20,000</td>
<td>28,634</td>
</tr>
</tbody>
</table>

**Notes:** (1) Estimated based on changes to congestion, operating costs, noise, and air pollution assuming 250 days/year; (2) The benefits depend on the composite value of time estimate used; (3) BPM refers to Best Practice Model. Benefits are calculated for links covered by the 28-county NYMTC region; (4) MTS refers to Mesoscopic Traffic Simulation. Benefits are calculated based on links located only within Manhattan; and (5) Assume 100% participation in off-hour deliveries.

### Table 2: Summary of Economic Impacts: Carriers

<table>
<thead>
<tr>
<th>Trips Shifted</th>
<th>Average Value of Time Carriers that Shift to the Off-hours</th>
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<tbody>
<tr>
<td></td>
<td>$30</td>
</tr>
<tr>
<td>Financial incentives to Food and Retail Sectors</td>
<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>$10,000</td>
<td>15,982</td>
</tr>
<tr>
<td>$15,000</td>
<td>23,617</td>
</tr>
<tr>
<td>$20,000</td>
<td>28,634</td>
</tr>
<tr>
<td>$25,000</td>
<td>32,856</td>
</tr>
<tr>
<td>Large Buildings 5</td>
<td>8,345</td>
</tr>
<tr>
<td>Large Bldgs. &amp; 250+ 5</td>
<td>17,878</td>
</tr>
</tbody>
</table>

**Unassisted deliveries:**

<table>
<thead>
<tr>
<th></th>
<th>Security incentives</th>
<th>Bonded deliveries</th>
<th>Double doors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>?</td>
<td>?</td>
<td>?</td>
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<td>?</td>
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</tbody>
</table>

**Assumptions:**

- Travel time saved (hours/tour): 0.80
- Days per year: 250.00
- Service times savings (hours/delivery): 0.25
- Delivery stops/tour: 5.50
Table 3: Summary of Economic Impacts: Receivers and Public Sector

<table>
<thead>
<tr>
<th>Financial incentives to Food and Retail Sectors</th>
<th>Trips Shifted</th>
<th>Annual Cost to Receivers (millions) 1</th>
<th>Public Sector Incentives (millions) 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$5,000</td>
<td>7,262</td>
<td>($16.20)</td>
<td>$16.20</td>
</tr>
<tr>
<td>$10,000</td>
<td>15,982</td>
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<td>23,617</td>
<td>($172.91)</td>
<td>$172.91</td>
</tr>
<tr>
<td>$20,000</td>
<td>28,634</td>
<td>($284.13)</td>
<td>$284.13</td>
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<td>32,856</td>
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</tr>
<tr>
<td>$50,000</td>
<td>47,605</td>
<td>($1,244.39)</td>
<td>$1,244.39</td>
</tr>
</tbody>
</table>

Targeted programs aimed at Large Traffic Generators

| Large Buildings 1 | 8,345 | $24.75 | ? |
| Large Bldgs. & 250+ 1 | 17,878 | $53.02 | ? |

Unassisted deliveries

| Security incentives | ? | ? | ? |
| Bonded deliveries | ? | ? | ? |
| Double doors | ? | ? | ? |

Notes: (1) Assumed to be equal to the incentive; (2) Calculated by multiplying the number of receivers expected to participate times the incentive; and (3) Assume 100% participation in off-hour deliveries.

Table 4 and Figure 3 show summaries of the economic impacts to stakeholders for the case in which the composite VOT of roadway users is $30/hour, and the average value of time of delivery trucks is $40/hour. As noted previously, the costs to receivers have been assumed to be equal to the incentive cost. As shown, the economic benefits to carriers and roadway users increase with receiver participation in off-hour deliveries. However, the rate at which these benefits grow decreases with the amount of off-hour deliveries and the incentive amount. The cost to receivers, and consequently the associated incentive costs, increases at an accelerating pace due to the effect of the incentive amount and the number of establishments that take the incentive.

Table 4: Economic Analysis Results

<table>
<thead>
<tr>
<th></th>
<th>Cost to receivers</th>
<th>Benefit to carriers</th>
<th>Benefit to road users</th>
<th>Total benefits</th>
<th>Total Incentive Costs</th>
<th>Net benefits</th>
<th>Marginal B/C (AB/AC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial incentive to food and retail sectors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$5,000</td>
<td>(16.20)</td>
<td>$28.72</td>
<td>$57.10</td>
<td>$85.81</td>
<td>($16.20)</td>
<td>$69.62</td>
<td>5.30</td>
</tr>
<tr>
<td>$10,000</td>
<td>(76.07)</td>
<td>$63.20</td>
<td>$84.42</td>
<td>$147.62</td>
<td>($76.07)</td>
<td>$71.55</td>
<td>1.03</td>
</tr>
<tr>
<td>$15,000</td>
<td>(172.91)</td>
<td>$93.39</td>
<td>$100.24</td>
<td>$193.63</td>
<td>($172.91)</td>
<td>$20.72</td>
<td>0.48</td>
</tr>
<tr>
<td>$20,000</td>
<td>(284.13)</td>
<td>$113.23</td>
<td>$146.15</td>
<td>$259.38</td>
<td>($284.13)</td>
<td>($24.75)</td>
<td>0.59</td>
</tr>
</tbody>
</table>

Targeted programs aimed at Large Traffic Generators

| Large Buildings 1 | ? | $24.75 | $24.36 | $49.11 | ? | ? | ? |
| Large Bldgs. & 250+ 1 | ? | $53.02 | $53.60 | $106.62 | ? | ? | ? |

Unassisted deliveries


Notes: (1) Assume 100% participation in OHD.
These analyses show that beyond the $15,000/year incentive, the total costs outweigh the benefits brought about by off-hour deliveries. However, the optimal amount of incentive is about $10,000/year. The table shows the marginal benefit/cost ratio. This economic indicator measures the ratio of the increase in benefits brought about by a given alternative, with respect to the increase in costs. It is optimal when the marginal benefits equal marginal costs, for a $B/$C = 1. As shown in the table, increasing the financial incentive to $10,000/year leads to a marginal benefit of $61.81 million/year ($147.62 million/year - $85.81 million/year), at a marginal cost of $59.87 million/year ($76.07 million/year - $16.1 million/year). This translates into a $B/$C of 1.03.

The results indicate that:

- Both the BPM and MTS produce consistent results, though they cover different areas and are built on different assumptions.
- In all cases, the economic benefits associated with increasing off-hour deliveries exhibit diminishing returns though the incentive costs continue to grow.
- The optimal financial incentive is about $10,000 per year, depending on the composite value of time. For certain combinations of financial incentive and composite value of time, the economic benefits exceed the total incentive cost.
- Policies aimed at increasing off-hour deliveries at large traffic generators have great potential. As shown, switching to the off-hours the truck traffic generated by the 88 large buildings that have their own ZIP code (which are only a fraction of all large buildings in Manhattan), produces economic benefits comparable to the ones for the $5,000/year incentive at only a small fraction of the cost.
• Policies that also target large establishments with more than 250 employees could produce significant economic benefits. As shown, shifting all truck-trips produced by these LTGs to the off-hours would lead to economic benefits comparable to the ones for the $10,000/year incentive at, yet again, a fraction of the cost.

• Unassisted deliveries represent a huge opportunity, though not much is known about their market potential. However, a small survey of the receivers that participated in the pilot test indicated that 80% would do unassisted deliveries if the liability issues are satisfactorily addressed. Should this finding be confirmed by future research, it could lead to a situation in which a small public investment could produce economic benefits similar to the ones brought about by the financial incentives.

• Future research must tackle the design of policies and quantification of market potential, and implementation costs for both LTGs and unassisted deliveries. Both concepts offer the potential to shift significant number of truck-trips to the off-hours at a fraction of the cost. This must be a high priority research area.

It should be noted that the economic impacts estimated here are the ones associated with reducing truck traffic in the regular hours. Since in the absence of complementary policies, passenger car traffic is likely to increase to take advantage of the road capacity made available by the trucks that switched to the off-hours (as part of a process of induced demand), congestion may again increase. This does not mean, however, that off-hour deliveries have not produced these economic benefits. Instead, the correct interpretation is that these economic losses (due to the increased congestion produced by the induced passenger car traffic) are the cost of not having appropriate passenger car demand management. The key implication is that coordinated demand management policies—targeting both passenger car traffic and freight deliveries—are a must.

1.5 Conclusions and Suggested Next Steps

This project has been lauded by the freight industry, agencies, and by the research community, as a path-breaking effort to be emulated and expanded. The most visible demonstrations of these were the highly successful meetings with the Industry Advisory Group (IAG) and the Technical Advisory Group (TAG) comprised of representatives of key transportation agencies held on December 9, 2009; and the publication of two highly complimentary articles by the prestigious and influential Journal of Commerce (Journal of Commerce, 2009; 2010). Also, the project was written about in the Wall Street Journal (Wall Street Journal, 2010), and was recognized by the NYCDOT Commissioner Janette Sadik-Khan for its potential impact in New York City at a ceremony to publicly recognize the pilot test participants. In essence, the work done has clearly and unambiguously established that the proposed concept: (1) is effective in inducing a shift of urban deliveries to the off-hours; (2) enjoys broad-based industry support; (3) would bring about substantial reductions in congestion and environmental pollution thus increasing quality of life; and (4) would increase the competitiveness of the urban economy. The fact that this is a
win-win concept that benefits all the participants in urban deliveries provides a unique opportunity for expansion and full implementation. The analyses conducted by the team indicate that:

- **Financial incentives to receivers** will be effective in inducing a shift of carriers to the off-hours. Once the receivers are compensated for the extra costs of off-hour deliveries they have an incentive to switch to the off-hours; while the carriers—that benefit from off-hour work because of the lower delivery costs and parking fines—happily follow suit. The analyses indicate that, depending on the industry segment and incentive provided, the shift could be between 10% and 20% of the truck traffic in these segments.

- **The traffic simulations** indicate that the switch of truck traffic to the off-hours brings about substantial economic benefits. The estimates produced by the team indicate that the optimal financial incentive is slightly higher than $10,000 a year. This incentive would be accepted by about 7,600 establishments at a total cost of $76 million. The economic benefits would range between $83 and $129 million, depending on the value of travel time used in the calculations. Beyond the $10,000 incentive, the marginal benefits get smaller while the incentive costs continue to increase.

- **The GPS devices installed in the participant vehicles** indicate that, on average, a truck traveling in the off-hours achieves speeds of about 8 miles per hour, while in the regular hours they typically fall below 3 miles per hour. A truck that travels 10 miles delivering from customer to customer would save 1.25 hours per tour shifted to the off-hours.

- **There are substantial reductions in service times during the off-hours.** In the regular hours, due to the effects of longer walks from parking to customer, elevator congestion, waiting for customers to check deliveries and the like, service times exceeding 1.5 hours per customer are common. In the off-hours, all these impediments to expedient deliveries all but disappear, leading to service times that average half an hour. Since delivery trucks serve the needs of multiple customers in the same tour, the total service time savings are bound to be substantial and likely larger than the travel time savings.

In spite of the concept’s great promise and the encouraging results obtained in this project, there are a number of important questions that need to be answered before proceeding to a full implementation. These questions are related to: (1) noise impacts on surrounding communities; (2) statistical validity of the results obtained in the small pilot test conducted; (3) the potential role of targeted programs aimed at large traffic generators; (4) fostering of unassisted off-hour deliveries; and (5) inter-agency coordination and policy development. These are important questions to be addressed because:

- **Noise impacts were not assessed during the project.** Although no community complaints were received during the execution of the small pilot test, it is natural to expect that
community members would be concerned about noise impacts. In this context, it is important to both assess noise impacts, and define appropriate mitigation strategies should noise be deemed a potential obstacle for implementation. The goal here is to ensure that local communities are not negatively impacted.

- The small size of the pilot test conducted does not support the estimation of statistically representative results. Although a significant and important effort, the test conducted is minuscule when compared to the number of deliveries made in New York City. An increase in the size of the pilot will lead to greater insight into how best to integrate remote sensing into a workable prototype, and to assess the overall benefits attributable to off-hour deliveries. It is important to mention that the size of the pilot test has been recognized as an issue by both team members and USDOT. At the end of 2008, an expansion of the pilot test was considered though USDOT and the team ended up deciding against it because the economic climate prevailing at the time—in the midst of the collapse of the finance industry—was not conducive for business participation in such research efforts. However, the marked improvement in economic conditions, the stability of financial markets, and the success of the project provide a unique opportunity to conduct another path-breaking effort by expanding the pilot test.

- About 4-8% of all deliveries to New York City are generated by Large Traffic Generators. As a result, inducing LTGs to do off-hour deliveries could have a noticeable impact on traffic congestion. Equally important is that since the number of LTGs is small (between 90 and 500, depending on what definition of LTG is used), the coordination effort is insignificant when compared to the potential payoff. It is therefore possible that the City of New York could play a key role in convincing the owners of the LTGs to switch to the off-hours as part of the City’s sustainability efforts.

- Unassisted deliveries could play a key role as part of a sustainability strategy involving off-hour deliveries. Unassisted off-hour deliveries provide a unique opportunity to achieve the benefits attributable to financial incentives, at a fraction of the cost. In this context, public sector programs that successfully address the liability issues that deter businesses from doing unassisted off-hour deliveries will increase off-hour activity. Over time, as the business sector gets accustomed to unassisted off-hour deliveries, more establishments will join the practice. As an illustration of the potential of the concept, it suffices to mention that 80% of the participating receivers indicated that they would do unassisted off-hour deliveries if the liability issues were resolved.

- Inter-agency coordination of efforts will facilitate implementation. As established in the project, off-hour deliveries have significant economic, environmental, and energy consumption impacts. For that reason, it is natural to involve all agencies whose primary mission is to promote economic development, environmental improvements, and energy conservation. Involving these agencies in the definition of a common off-hour delivery strategy is bound to lead to robust policies and a smooth implementation of the concept.

Fostering off-hour deliveries at large traffic generators and fully exploiting the use of unassisted deliveries are extremely important because they eliminate the need (and the cost) for the receiver to be
present when the off-hour deliveries are made. As a result, they are very cost-effective as they only require a fraction of the incentives required by the broad-based off-hour delivery program. However, in spite of their considerable potential, major questions remain concerning policies to foster off-hour deliveries at large traffic generators and the use of unassisted deliveries. These include: (1) how to integrate remote sensing elements to ensure compliance; (2) liability issues; (3) cost/benefits to participants; and (4) effectiveness of alternative policies, among others.

Both macroscopic and mesoscopic traffic models show beneficial impacts in terms of congestion reductions and improved environmental conditions. Both the regional and sub-regional models showed benefits though the estimates produced by each differed. The integration of two levels of models is essential in order to realistically assess different types of impacts such as dynamic traffic impacts at the facility level. Modeling has also focused mainly on short-term impacts of the proposed program, with long-term network-wide impacts requiring a more significant process of data collection and study. Moreover, an extended pilot test will allow the team to collect and have access to more data, and ensure a better calibration of the models. The use of these simulation models is crucial for a better understanding of the various scenarios, to quantify their impacts, and to garner support of the involved agencies. The research team is now in a unique position due to the extensive experience it has gained to expand these simulation studies beyond what has been done so far.

All of this suggests the steps outlined below:

- **Research and design:**
  - Conduct behavioral research to identify and select the most cost-effective incentive policies to foster unassisted off-hour deliveries, and off-hour deliveries at large traffic generators.
  - Expand and improve the traffic simulation models to ensure they provide a meaningful representation of the transportation network in New York City.
  - Engage the city and state agencies and stakeholder groups that could collaborate in the full implementation of such policies to define their potential roles as part of a comprehensive implementation. This could include: New York City Economic Development Corporation, New York State Energy Research and Development Agency, Real Estate Board of New York, among others.
  - Launch a publicity campaign to get industry support and sign up potential participants in an expanded pilot test.
  - Conduct research on noise impacts and potential mitigation strategies.
  - Design community feedback programs to ensure concerns are properly addressed.
  - Design and establish compliance verification mechanisms.
• **Expanded pilot test and Implementation:**
  o Roll out a comprehensive set of incentive policies; recruit participants.
  o Design a monitoring plan involving: the use of GPS devices to assess performance of delivery operations before and after the pilot; the installation of noise measuring devices to assess noise impacts; the use of the GPS data currently being collected by NYCDOT to monitor network-wide impacts.
  o Launch and monitor the expanded pilot test.
  o Use behavioral models to predict participation in the implementation phase.
  o Use the traffic simulation models to assess the network impacts of both the expanded pilot test, and a full implementation.
  o Organize community hearings and gather stakeholder input.
  o Decide on implementation.

The team is of the opinion that an expansion of the pilot test, combined with the steps outlined above, could bring about an enhanced understanding of the potential benefits of integrating cutting edge remote sensing technology as part of a novel freight demand management concept. Furthermore, a revised focus on LTGs and unassisted deliveries could provide much needed empirical evidence on the practical challenges as well as the benefits and costs of what is likely to become a business-friendly way to do freight demand management in congested cities.