

# Congestion Charging & Technology

# A Resource Paper for New York City

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The concept design on the cover of this report shows single pole technology, which combines E-ZPass antennae and cameras for a congestion charging system in an urban environment. Single pole technology has been successfully tested in London. This concept design is by [Q-Free](#), a company working on congestion charging in London and Stockholm.

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## Summary

On Sunday, April 22, 2007, New York City Mayor Michael Bloomberg announced the City's intention to implement a congestion charging pilot program as part of its larger planning effort, PlaNYC 2030. Congestion charging is central to accomplishing some of the main goals of the plan, including reduced travel times, increased transportation capacity, improved air quality and public health, lowered greenhouse gas emissions, and increased funding for transit maintenance and expansion. The City's plan is to use a combination of E-ZPass and cameras to charge drivers entering Manhattan south of 86<sup>th</sup> Street. As the City pursues State legislation to enable the City to implement congestion charging, many important details, including which technology is used, will be determined. This resource report examines a variety of technologies that New York City might use for congestion charging, now and in the future, including:

1. **Automatic Number Plate Recognition**, the camera based system used in London
2. **E-ZPass Radio Frequency Identification**, the same electronic tolling system familiar to drivers in the NY-NJ-CT region
3. **Next Generation Radio Frequency Identification**, which includes some improvements to E-ZPass available now and others that will emerge in the future
4. **Geographic Positioning Systems**, satellite technology for positioning, plus charging technology
5. **Mesh Networking**, wireless networks of vehicles and roadside nodes

The technologies are analyzed according to a set of criteria that encompasses customer experience; privacy and anonymity; costs, administration and enforcement; operations, interoperability and flexibility; and physical presence. The analysis also includes a close look at the examples of congestion charging in London and Stockholm. It concludes with a set of recommendations.

The primary finding is that E-ZPass technology should be used for congestion charging in New York City, however by itself it is insufficient in its current form. Mayor Bloomberg's proposal to combine E-ZPass and license plate recognition may be the best combination currently available, but system enhancement should be examined and encouraged. For example, some "next generation" features not currently used in this region – but available elsewhere – include sticker tags, cash payment accommodation, and single pole structures to replace gantries (as shown on the cover of this report).<sup>\*</sup> The other technologies examined in this report do not yet meet the criteria described as well as the "next generation" E-ZPass. Additional recommendations are made for system implementation, including implementing a monitoring program and an education campaign and potential future enhancements, such as variable charging by time of day and type of vehicle.

Finally, as part of the initial actions that the City is undertaking, the report recommends the following:

- Join the E-ZPass Interagency Group to help design the next generation of E-ZPass.
- Continue and expand the education campaign.
- Design a monitoring program, and collect baseline data.
- Solicit improved equipment design, possibly through a design competition.

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<sup>\*</sup> Single pole technology combines E-ZPass antennae and cameras, and has been tested in London. The [concept design](#) on the cover of this report is by [Q-Free](#), a company working on congestion charging in London and Stockholm.

# I Overview

The concept of charging motor vehicles for using New York City's streets and highways has been gaining momentum, stemming in no small part from the success of congestion charging in central London and Stockholm. New York City is poised to become the next world city to use this approach to traffic relief. The City's current effort to map a plan for the City's future, known as PlaNYC 2030, has brought to public attention a number of key observations that congestion charging will directly address:

- traffic congestion is hampering the economy and quality of life of residents and workers and is likely to get much worse;
- the City is expected to add almost one million people in the next 25 years, which in the absence of strong actions will only make traffic congestion worse;
- accommodating the mobility of the current and future populations will have to primarily rely on public transit;
- the existing transit system is in need of funds to achieve and maintain a state of good repair to ensure its reliability; and
- the cost of transit improvements that would address present and future needs is very high, and is currently badly under-funded.

The City has boldly committed to implementing a pilot program of congestion charges which will address both traffic congestion and the transportation funding gap.

Installing a system of charges on motor vehicles presents technical and logistical challenges. Technical advances made over the last 10 to 15 years have facilitated the consideration of charging as a reasonable option. Earlier, the idea of charging vehicles to enter Manhattan has been discussed usually in the guise of installing a toll on the four currently free East River bridges, owned and maintained by the City of New York. Such an arrangement would have required the installation of toll plazas. The need for toll plazas was one of the primary stumbling blocks to charging in the past, since it would have required expensive and difficult construction problems, and all vehicles would have had to start and stop, creating delays and pollution. The advent of electronic toll collection, including the E-ZPass system in the Northeast, and non-stop lanes on some facilities have reduced and possibly eliminated the problem. E-ZPass lanes can carry more vehicles per hour; nonstop E-ZPass lanes increase capacity by up to five times the rate of cash toll lanes, eliminating queuing at toll plazas. Today, three in every four vehicles crossing the Port Authority's and the MTA's bridges and tunnels use E-ZPass.

This resource paper has three purposes. First, it describes the ideal characteristics of a charging technology. Second, it describes the features of both existing and potential technologies that could be used for charging. Third, it marries the first two purposes by assessing the various technologies against the ideal criteria, and then recommending a technological direction for New York City as it implements the congestion charging pilot. It concludes with a set of policy-related recommendations to guide the City as it designs its charging system.

It is with these purposes in mind that Regional Plan Association sought and received funding from the New York State Energy Research and Development Authority to explore the potential technologies for congestion charging in New York City.

## II Criteria for an Ideal Congestion Charging System

The establishment of a congestion charging system in New York presents challenges beyond the technical. No one likes to pay more than they do now, and much of the public will have to be convinced that it will be sufficiently compensated for the added payments in the way of congestion relief, travel reliability, added transit alternatives and an improved transit system. Still, even if these hurdles are overcome, from the motor vehicle users' point of view the technology employed should be customer friendly. From the governmental perspective the system should be easy to administer, accurate, easy to operate and enforce, and not visually obtrusive. To the extent that the charging technology is capable of varying charges by time of day or week and possibly by real-time level of congestion, it will become more effective as a tool for managing demand and rationalizing road capacity. Beyond that, if the technology can be linked seamlessly with the efforts of other road charging infrastructure, it can create a more effective transportation system for the region. Finally, the technology will have to be sufficiently proven; New York cannot afford to be the proving ground.

The set of criteria that can be loosely arranged under these headings:

- Customer Experience
- Administration
- Operations
- Physical Presence

### Customer Experience

Payment Vehicle owners should be able to participate in congestion charging using cash, credit or debit cards. It is especially important that those drivers without credit cards or checking accounts, or who prefer not to use these methods of payments, be included in the program. Those who do not want to have an automatic payment method or who wish to pay using cash should be able to pay at gas stations and convenience stores, particularly in areas on the periphery of the charging zone. Credit card payments should also be possible online, on the phone, via text messaging and by mail. In sum, a customer should be able to participate in the congestion charging program using a payment system of their choice, without revealing their identity at the point of purchase, and regardless of credit or banking history.

Start Up. Congestion charging technology should not require the customer to purchase or install expensive, delicate or overly-complicated equipment for their vehicle. Any onboard equipment should be removable by the driver. If the customer is required to purchase onboard equipment to participate in the program, the cost should be very low, applicable to future congestion charging payments, and/or refundable.

Fear of Tracking. Ideally, to allay privacy concerns, congestion charging technology would not reveal to any authorities, bureaucracy or public entity the driver's identity, route or location on a given day. The laws around congestion charging should clarify what information can be accessed by law enforcement agencies.

## **Administration**

Costs. The net revenue from a congestion charging project should be substantial enough to support the transportation investments to which the congestion program is intended to contribute. Thus, costs to install, collect, administer, maintain and enforce the program should be kept low relative to the required revenue objectives. Ideally, the capital costs of a congestion charging system are not high enough to require substantial initial investment, and operating costs are low enough to achieve a significant revenue stream. Enforcement should be fair and designed primarily to target traffic relief, rather than revenue maximization. Technology that uses proprietary software may entail higher long term operating costs than other technology.

Enforcement and Accuracy. Technology should be accurate enough so that virtually none of the customers who pay the fee is wrongly ticketed. The accuracy need not be quite so high as to capture payment from all vehicles, but high enough to not raise issues about fairness. The congestion charging technology should be able to supply evidential integrity, meaning that it must be able to reliably show whether and when the fee was paid, and whether the vehicle was correctly charged.

## **Operations**

Area-Wide or Cordon. Some technologies can only support a cordon system where vehicles are detected at defined places on the border of the charging area. Other technologies support an area-wide system which can detect vehicles throughout a charging zone. Area-wide systems are preferable because they charge vehicles originating and staying within the congestion charging zone, even if they do not pass a border payment point.<sup>1</sup>

Interoperability. A congestion charging system in New York City should ideally be fully interoperable with the existing electronic toll collection system (E-ZPass) and with future systems that may emerge. Currently, the Port Authority and the MTA each report that 74 percent of their customers use E-ZPass. In counts taken in 2006, Regional Plan Association found about 45 percent of vehicles entering the central business district on the non-tolled roadways had an E-ZPass tag, with the share rising to about 50 percent for those entering from the north and about 40 percent for those using the four free bridges over the East River. Moreover, with E-ZPass electronic technology familiar to drivers throughout the Northeast, a congestion charging system that uses the same technology would be more likely to capture drivers who only occasionally find their way into New York City.

Flexibility. As a [travel demand management](#) tool, having the flexibility to charge a variable fee by time of day and/or level of congestion would be highly desirable.

Reliability. Congestion charging technology should be proven and trustworthy prior to full implementation in New York City. This suggests that the technology chosen either be in place today, capable of testing elsewhere first, or tried on a small area demonstration basis in New York City first.

Physical Presence. The technology's way-side or off-board equipment should minimize the visual and aesthetic impact, and if possible actually be visually attractive. Equipment that can be incorporated with other objects serving other functions (such as traffic lights) are preferable to that which requires new, visible infrastructure.



## Weighing Priorities

There is a natural tension among these criteria. For example, an ideal enforcement system may make an ideal privacy environment less feasible, while interoperability features may conflict with flexibility since the more flexible technology may not be compatible with today's electronic tolling infrastructure. An additional concern in weighing priorities is that different constituencies will have different priorities. For design-oriented interests, for example, a system that requires unsightly structures may be a fatal flaw, while the operating agency's objective of lowering maintenance costs would make structure stability a high priority. Since no technology is perfect, compromises will have to be made. New York City finds itself in the fortunate position of being able to learn from those cities – London and Stockholm – that have already addressed these issues.

## III Successful Charging Programs Elsewhere

### *A Note About Singapore*

*Singapore also employs congestion charging for entry to its downtown central business district. The system is called Electronic Road Pricing and uses technology similar to E-ZPass. It is not examined in this study because its historical context makes the system less comparable to New York City than London and Stockholm. In 1998, Electronic Road Pricing in Singapore replaced the Singapore Area Licensing Scheme, which had been in place since the 1970s. The Scheme had also applied to vehicles entering the central business district. It initially only operated during the morning peak period, was extended to evenings in 1989 and finally to the whole day in 1994. The Scheme consisted of paper licenses that were manually checked at entrances to the CBD. The Scheme was effective in smoothing congestion during rush hour, lowering overall traffic and shifting many drivers to transit. The effect of the new technology, however, can only be viewed in context of the existing system which had evolved over more than 25 years. In addition, due to its historical context, Singapore's experience marketing, enforcing, and gaining political and popular acceptance of congestion charging would not apply to New York City. London and Stockholm, on the other hand, implemented congestion charging recently, with no existing pricing systems in place, and with relatively advanced technology; those cities provide examples for New York and are discussed in this report.*

### London

In February 2003, congestion charging was implemented in an 8.5 square mile area of central London. All private vehicles driving into or within the congestion charging zone between 6 AM and 6 PM paid £5 (\$10) per day. In February 2007, the charge increased to £8 (\$16), the start time changed to 7 AM and 6:30 PM, and the zone extended westward so that it now includes approximately 20 neighborhoods. The charge is generally considered successful, and its champion, London Mayor Ken Livingstone, was re-elected on a pro-congestion charging platform in 2004.

**Figure 1: Congestion Charging Sign in London**



London uses automatic number plate recognition technology. The technology combines the charging event with enforcement. Approximately 300 cameras scattered throughout the zone photograph license plates of vehicles in the zone. The license plate numbers are checked against a database of those who have paid the congestion charge. Those who do not pay the charge by midnight on the day of travel must pay £10 by midnight the next day; after that they are issued a penalty charge notice. There is a series of increasing fees to encourage timely payment. The system is operated by [Transport for London](#), the same entity that operates the buses and subways, and largely championed and administered by the Mayor of London.

In October 2006, Transport for London completed [stage two](#) of a three-stage study of technology options for its congestion charging system. It determined that geographic positioning systems (GPS) in its current form is not appropriate for congestion charging, and that the best option is to transition to using electronic toll collection with dedicated short range communication, similar to New York's E-ZPass technology. The report determined that when combined with automated number plate recognition, a new E-ZPass-like system could increase the London system's accuracy and reliability while lowering costs in the long run.

### **Customer Experience**

Payment. Customers in London pay the congestion charge online, via text message, through the mail and at retail centers (called Pay Point outlets). [Monitoring reports](#) from Transport for London indicate that customers are satisfied with the experience and there are few problems reported at point of payment. It is generally considered a convenient, simple payment system. The most popular form of payment is online (30 percent), followed by retail outlets (27 percent) and text messaging (23 percent). Fifteen percent of payments are through the call center and about 6 percent through an automated phone service.<sup>2</sup> London customers can pay cash at retail outlets. However, most choose to pay using a credit or debit card through an automated system. Discounts of 16 percent are offered for those paying monthly or annually.

Start Up. The London system requires no on-board equipment. Cars are identified through already-existing license plates. As the technology trials progress, it is becoming more likely that London will adopt a tag-and-beacon system. Those who choose to use this system would need an on-board transponder, similar to an E-ZPass transponder.

Fear of Tracking. While cameras constantly record vehicle license plates throughout the day, the back office ensures that data is not accessible unless needed to enforce the charge. In addition, all records are destroyed within a 24-hour period of the charge being paid. For those who have not paid, records are retained to provide evidential integrity. *See also* Reliability *below*.

### **Administration**

Costs. The London system cost £162 million to implement, and costs about £88 million per year to operate. Its gross revenue brought is about £210 million per year (£144 from charges and £66 from enforcement income). Net revenue, then, is about £122 million (\$244 million).<sup>3</sup>

Enforcement and Accuracy. Initially, the number of penalty charge notices – tickets issued to vehicles for which the charge had not been paid – did not accurately reflect the number of vehicles evading the charge. Evidential integrity was also insufficient, and Transport for London revised its agreement with the contractor providing these services (Capita) in August 2003.<sup>4</sup>

## Operations

Area-Wide or Cordon. London's system is area-wide; the same technology could have been used for a simple cordon arrangement.

Interoperability. Prior to congestion charging, London did not have a toll road system or any other existing system that collected payments for road use. There were security cameras set up throughout London. However, over 200 cameras beyond the ones in place were required for congestion charging.

Flexibility. London's system is set up to accommodate a once-a-day payment that does not vary by time of day, level of congestion or any other factor except vehicle classification. London's technology trials indicate that charging based on time of entry to the zone can be accomplished with automatic number plate recognition "theoretically," but the practical difficulties are too great. Among these difficulties are listed the need for the technology to have a higher capture rate, difficulties dealing with cars in the zone overnight, and difficulties in notifying users of the applicable rate and effectively charging that rate.<sup>5</sup>

Reliability. London's system is increasingly reliable. Initially, there were problems matching computer records from camera images with customer payment records. Penalty charge notices, which are sent out to vehicles that do not pay the congestion charge, have decreased over time from a high of 8,500 notices per day in 2003 when the program started, to between 5,000 and 6,000 per day in 2005 (most recent data). The rate of payment has also increased dramatically – from only 35 percent of penalties paid in 2003 to 76 percent in 2005 – indicating fewer notices sent in error.<sup>6</sup>

## Physical Presence

Approximately 300 cameras are mounted on wayside equipment throughout the congestion charging zone as shown in Figure 2. Londoners were already accustomed to the presence of many security cameras prior to congestion charging, but the congestion charging program brought with it a considerable physical impact. The London system also has many signs at the approaches to the zone and within it, as well as markings painted on the street. There are about 900 signs and 300 road markings affiliated with congestion charging in London. Transport for London worked closely with neighborhoods and an arts/design council when developing the brand and sign plan.

**Figure 2: Cameras Used for Automatic Number Plate Recognition in London**



## Stockholm

From January to July 2006, the City of Stockholm levied a ‘congestion tax’ on drivers at 18 toll points covering 78 lanes. The charge was in place from 6:30 AM to 6:30 PM weekdays, and varied from SEK 10 to 20 (\$1.50 to \$3.00) depending on time of day. Drivers were charged each time they entered and left the congestion tax zone, with a maximum daily charge of SEK 60 (\$8.50). Drivers had five days to pay the charge. The headline the day after congestion charging was introduced read “Every Fourth Car Disappeared.” In fact, traffic was reduced by about 20 percent in the zone and increased by about 4.5 percent in the rest of the city as a result of vehicles bypassing the zone.

In September 2006, two months after the trial had ended, Stockholm residents voted to make the program permanent, although residents also voted to turn over City leadership. The results are generally considered mixed, with many suburban residents who are known to oppose the plan not allowed to vote on the referendum.

The system in Stockholm uses combines E-ZPass-style electronic toll collection and London-like automatic number plate recognition. Gantries are placed around entrances to the congestion charging zone, and these gantries hold both high-resolution cameras with infrared flash and laser detection as well as electronic toll collection antennae and other necessary equipment. IBM and the Norwegian company Q-Free built and operate the system. If a vehicle lacks a pre-paid transponder, the photograph of its license plate is examined against a list of pre-paid accounts. Ninety six percent of drivers pay the charge within the allowable five days.

### Customer Experience

Payment. Drivers may either purchase a transponder that is linked to an account, or pay cash. Over the counter cash payments are acceptable. Those drivers without transponders are required to pay within five days, and can pay cash. Notices are not sent to drivers; rather, it is the drivers’ responsibility to pay the charge. Stockholm includes a customer-friendly feature that allows customers to view where their cars were identified and how much their accounts were charged online, no later than 7AM the day after the vehicle identification. Special kiosks for this purpose are also available at many convenience stores throughout Stockholm and are free to use.

Start Up. A small transponder needs to be placed on the windshield. Other than that, the system simply requires the license plate already issued to the driver.

Fear of Tracking. Stockholm’s camera vehicle identification system automatically crops all pictures so that only the license plate is visible. It is not possible to determine who or how many people are in the vehicle. Strict confidentiality policies prevent use of the location and identity of vehicles in legal cases. In fact, privacy protection was so strict that there were complaints during the Stockholm trial by the rightful owners of stolen cars who were being charged when thieves drove their cars through the zone. By law, the owners had to pay and then object later on.<sup>7</sup>

### Administration

Costs. The cost of operating the system in Stockholm, including reinvestment and maintenance, is SEK 200 million per year (\$31.7 million). Revenue from Stockholm’s relatively low priced congestion charges was SEK 763 million (\$110 million). Net revenue, considering only the primary cost and revenue source, is approximately \$78.3 million per year.<sup>8</sup> A [complete cost benefit analysis](#) of the congestion tax trial is available in English.

Enforcement and Accuracy. Only 1 percent of vehicles entering or exiting the congestion charging zone are unidentifiable.

### **Operations**

Area-Wide or Cordon. The system is a cordon, however payments are levied to drivers each time they cross a payment point, with a maximum daily charge for each vehicle.

Interoperability. There were no other existing toll payment systems in place in Sweden.

Flexibility. The charge in Stockholm varies by time of day. There are three levels of charges, SEK 10, 15 and 20, at nine separate time slots (see Figure 3).

Reliability. Reliability is 99.9 percent<sup>9</sup>, usually credited to IBM's system. Initially there were some problems with the system: the cameras were not operating fast enough to photograph all license plates, causing about 1,000 drivers who had not prepaid to avoid the fee on the first day. Those problems were solved during the course of the trial. The final Stockholm trial evaluation concludes that on an average day in May, 371,300 passages took place across the charge zone, leading to 115,100 tax decisions and a revenue of over SEK 3 million (\$427,000). Of the 115,000 tax decisions, 100 (0.09 percent) were asked to be reviewed by the Swedish Tax Agency and 5 were appealed to the Stockholm County Administration Court.<sup>10</sup>

**Figure 3: Stockholm Congestion Tax Payment Schedule, 2006.**

<b>Time</b>	<b>Charge</b>
06.30-06.59	10 kr
07.00-07.29	15 kr
07.30-08.29	20 kr
08.30-08.59	15 kr
09.00-15.29	10 kr
15.30-15.59	15 kr
16.00-17.29	20 kr
17.30-17.59	15 kr
18.00-18.29	10 kr
18.30-06.29	0 kr

Physical Presence. The Stockholm Trial required substantial off-board equipment including overhead gantries for electronic toll collection and informational kiosks and computers where drivers can check their accounts. The overhead gantries are shown in Figure 4. As in London, Stockholm created a recognizable symbol for the system and placed signs at approaches to charge points, in retail locations where the charge could be paid and tax decisions could be viewed, and at airports and ferry stations.

**Figure 4: Overhead Gantries Used in Stockholm**



Figure 5: The Stockholm Congestion Tax Symbol



## IV Pre-implementation, Communications and Results

Aside from the characteristics of a congestion charging program itself, its success depends on making the case to the public that it is a worthwhile endeavor. No program will be a success if the public is not convinced that it will benefit them, and that they can participate. In both London and Stockholm an extensive program of making the case to the public preceded its implementation. Once the decision to move forward was made, a communication plan was put in place so that the public not only understood how the program would affect them, but what steps they would have to take to participate in it. In addition, substantial transit improvements were made in both London and Stockholm before the first congestion charge was collected. These initial investments facilitated increased transit use and benefited the cities on the whole.

### London

In London the marketing strategy turned to a precedent (the privatization of British Gas), and then sought to gradually roll out the complex messages around congestion charging using a carefully timed multi-media approach. The marketing campaign was monitored and adjusted on an on-going basis. Transport for London describes the campaign as one of **“careful explanation and frequent repetition.”** It identified 15 basic aspects of the scheme to be understood by the public prior to implementation. The campaign aimed to address everyone, allowing those unaffected to opt out of receiving messages. Five months before congestion charging was implemented, the full-scale marketing campaign was launched. Transport for London was limited by legal and regulatory hurdles facing congestion charging that had to be cleared before it could begin marketing the scheme. Widespread advertising was followed up with direct marketing and public relations. A

survey taken just prior to implementation showed that 97 percent of Londoners were aware of the scheme, 75 percent knew they were unaffected and therefore would not needlessly use the call center, and 80 percent of Londoners understood key details such as cost, implementation day, exemptions, and penalties.<sup>11</sup>

In anticipation of a shift to public transit, on the first day of congestion charging, 11,000 new bus seats were added to London's streets during the morning peak. Other improvements included seven new bus routes, increased frequency on 53 existing routes, and the introduction of larger buses on 10 routes.<sup>12</sup>

Surveys taken by an independent firm for Transport for London before and about one year after congestion charging implementation indicate that public opinion changed after implementation. Prior to congestion charging, 37 percent of respondents said they expected to lose out due to congestion charging, and only 18 percent said they would gain as a result of the plan. After it was implemented, 25 percent said they had lost out (a 12 point drop) and 25 percent said they had gained (a 7 point increase). There was also a 12 point increase, to 43 percent, in respondents who said congestion charging did not affect them. In 2004, a poll showed that 57 percent of Londoners approved of congestion charging.<sup>13</sup> Between 2002 and 2003, when the charge was implemented, the share of Londoners who thought traffic congestion was "major problem" shrank from 62 percent to 43 percent, although it grew to 49 percent by 2006.<sup>14</sup>

Central London has experienced significant reductions in traffic congestion due to the charge. Delays measured in minutes per kilometer are down 26 percent as of 2005.<sup>15</sup> The charge was expected to result in an increase in traffic along the ring road that borders the charging zone. Initial results showed small increases, albeit much lower than Transport for London's expectations. As of 2006, traffic on the ring road and radial roads approaching the zone were lower than prior to charge implementation. For its fourth monitoring report, released in June 2006, Transport for London undertook a case study of an area bordering the charging zone and determined there were no significant effects of congestion charging to the area's traffic or economy.

The initial impact of congestion charging was a 38 percent increase in the number of passengers entering the zone by bus, with bus speeds up 6 percent and bus delays due to traffic congestion down 60 percent. Those changes have been largely steady since congestion charging was implemented. The impact of charging on Underground (subway) ridership was difficult to measure due to major service disruptions following, and unrelated to, congestion charging.

The impact of congestion charging on the economy of Central London and the rest of the city has been broadly neutral.<sup>16</sup> The impacts monitoring reports from Transport for London track economic indicators in and around the zone, and have found little if any fluctuations in businesses attributable to the congestion charge.

## Stockholm

In Stockholm, the communication objective was stated as, “Everyone who drives a Swedish registered vehicle in the Stockholm inner city area after the turn of the year 2005/2006 shall know of the existence of the congestion tax and that it must be paid without having been prompted to do so.” The system in Stockholm allows drivers to use either an E-ZPass-like transponder or simply to pre-pay, but the system is much more efficient if more drivers use the transponders. Another goal, then, was to **have as many drivers purchase on-board units in advance as possible**. Initially, the marketing campaign used direct communication through flyers, mailings, and leafleting at malls and other centers. This was followed up with advertisements in the press, radio, at parking meters, and via public transit. An informational video was broadcast on television. Six months prior to implementation, a letter was sent to all vehicle owners in Sweden, and pamphlets were heavily distributed at stores and gas stations. A website was used throughout the campaign.<sup>17</sup>

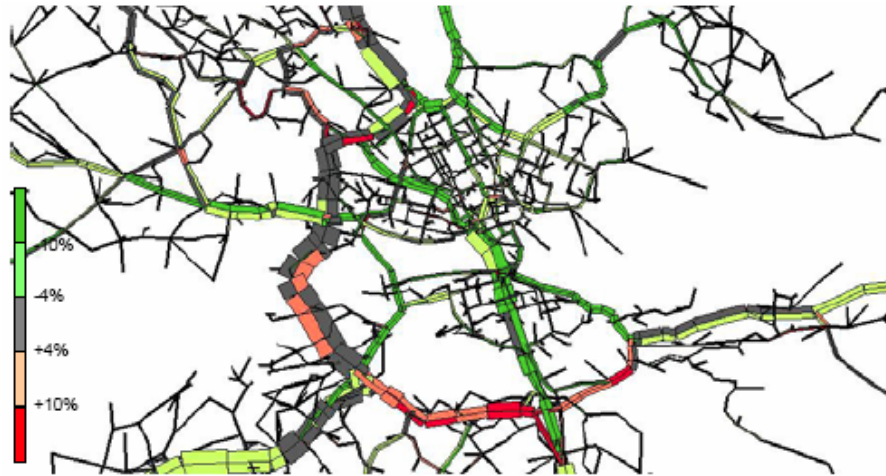
Stockholm considers the beginning of its congestion charging trials to be five months prior to any charging taking place, in August 2005 when public transportation was improved dramatically. Improvements included 200 new buses, more subway service, improved transit information, and more park and ride facilities built outside the congestion charging zone.

Prior to starting the congestion tax trial, in autumn 2005, approximately 51 percent of all county inhabitants felt that congestion charging was a “fairly/very bad decision.” Since the congestion tax was introduced in January 2006, this proportion has fallen steadily. In May 2006 54 percent felt it was a “fairly/very good decision,” while 42 percent felt it was a “fairly/very bad decision.” Those who had traveled by car to and from the inner city over the past two days were more negative towards the trial than county inhabitants in general, but even this group had become more positive during the period by several percentage points. These changes were observed in several studies on different groups of county inhabitants.<sup>18</sup>

There was a 22 percent reduction in the number of vehicles driving in the congestion tax zone on weekdays. The greatest reductions were experienced within the congestion tax zone, especially in the afternoon peak. Surrounding areas, arterial and approach roads also saw traffic reductions. Some bypass roads experienced traffic increases of 4 percent to 5 percent. Figure 6 shows the change in traffic volumes due to the congestion tax. The congestion tax caused an increase in transit ridership of 4.5 percent. The long- and short-term effects on the regional economy were estimated to be marginal, at most less than regular variations in the economy overall.<sup>19</sup>

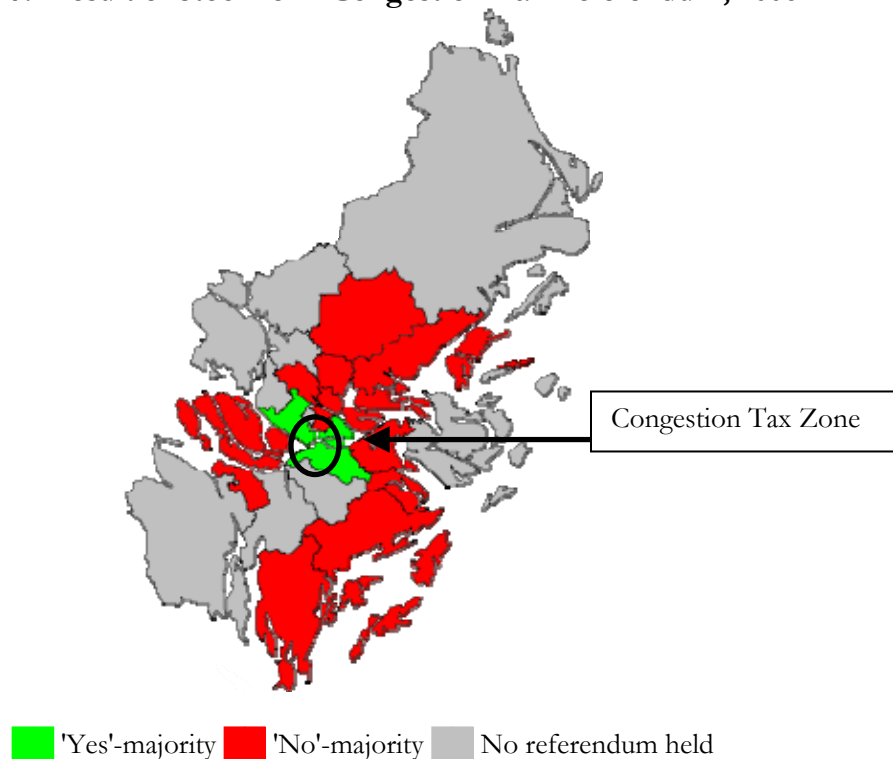


**Figure 6: Change in Stockholm Traffic Volumes, Weekdays, April 2005 Compared to April 2006<sup>20</sup>**



After the seven month trial period, congestion taxes were lifted. A referendum was held two months later. While only the city residents could vote on whether to reinstate the congestion tax, municipalities surrounding Stockholm held their own advisory referendums to establish public opinion. In Stockholm, 51.3 percent voted in favor of the congestion tax, while in most surrounding municipalities only 39.2 percent voted in favor (see Figure 7). At the same time, all municipalities – in and around the center of the city – held general elections, wherein the Mayor of Sweden and her party, the Social Democrats, were defeated. Some press blamed the defeat on an overall disapproval.

**Figure 7: Result of Stockholm Congestion Tax Referendum, 2006<sup>21</sup>**



## V Assessment of Technology Options

In this section the criteria discussed earlier are used to evaluate the possible technologies that might be used for congestion charging in New York City. For each of the technologies a qualitative ranking is given for each criterion in this range: excellent, good, fair, poor. The evaluation is made in the context of New York City, and is only applicable to the charging event. It is assumed that camera-based enforcement would be used in all cases. The rankings are comparative. For example, “Start Up” for mesh networking is ranked as “Fair,” because it compares favorably to “Start Up” for GPS (ranked “Poor”) and unfavorably to “Start Up” for the other three technologies assessed (ranked “Good” and “Excellent”).

### **Automated Number Plate Recognition (ANPR)**

Using ANPR in New York City would entail placing cameras in and around the congestion charging zone. The size and shape of the zone could be defined in any way desired, which would determine the number of cameras needed.

#### **Customer Experience**

##### Payment - Excellent

Payment can be made through a variety of convenient outlets, including online, over the phone, at retail outlets and through the mail.

##### Start Up - Excellent

ANPR requires no on-board equipment.

##### Fear of Tracking - Good

The City will need to assure the public that no record of a single vehicle’s itinerary is kept, and that all records are destroyed regularly, as they are in London. Legal issues, including whether records can be used to establish a person’s location at a given time, would need to be resolved. A watchdog group may be used to audit this process on occasion for further assurance. If all these steps are taken, ANPR can provide a high level of privacy. ANPR can be used without a credit card.

#### **Administration**

##### Cost – Fair

ANPR compares somewhat unfavorably to other technologies in terms of cost. The back-office costs of ANPR are higher than other technologies because more employees are required to manually review images and data. Capital costs of roadside equipment are comparable to or less than electronic toll collection gantries and antennae, in part because the cameras required for ANPR are generally required in any case to enforce congestion charging systems.

##### Enforcement and Accuracy - Fair

In London, the ANPR system was initially difficult to enforce, with many false penalties being issued. Improvements have been made, and newer ANPR technology has increased the accuracy of vehicle detection. However an ANPR system in New York would have to overcome the complexities of numerous vehicle types and license plate designs.

## **Operations**

### Area-Wide or Cordon - Good

ANPR can be configured as an area-wide charging program, which is preferable to a cordon.

### Interoperability - Fair

ANPR is not necessarily interoperable with the existing E-ZPass toll system, although it can be made interoperable with increased operating costs

### Flexibility – Poor

ANPR can be configured to vary charges by time of day; this may require dynamic signage that depletes the physical presence of the system and increases cost. However, for ANPR to work, payments must be accepted after the vehicle has driven within the charging zone. Since payments are made after the fact, changes to the payment schedule can occur less frequently. Therefore, while a regular schedule that varies by time of day may be feasible, a schedule that alters less predictably (such as one that varies by level of congestion) may not be feasible.

### Reliability – Fair

While the system has gained acceptance and resulted in considerable mode shifting and congestion relief, ANPR has also not proven to be 100 percent reliable in London.

### Physical Presence - Good

ANPR requires many cameras to function. Some of these cameras would be necessary to enforce any system, however more are needed for ANPR to act as a charging system. Security cameras have multiplied in New York City in recent years, and New Yorkers have grown more accustomed to seeing cameras in trees and attached to buildings.<sup>22</sup> Nonetheless, this system is inferior to one that would not require as much visible off board equipment.

## **E-ZPass Radio Frequency Identification**

E-ZPass is well-known and well-used in the New York metropolitan region and in the entire Northeast [megaregion](#). Using E-ZPass for congestion charging would entail establishing a cordon, which could encircle any part of the city where all vehicle entry points could become charging points. The cordon could be of any size. E-ZPass transponders would make payments. Those vehicles that do not have a transponder or whose account has insufficient funds would be identified by a camera-based system and fined according to City policies. Note that the system assessed here would use exactly the technology currently in place at Port Authority and MTA tolled facilities.

## **Customer Experience**

### Payment – Fair

The current system requires users to establish an account, via mail or online, that is tied to a credit or debt card number. While this is inferior to a system that allows users to pay at any time, or one that permits cash payments and anonymity, it has been successful: 75 percent of vehicles crossing tolled facilities in New York that accept E-ZPass have a transponder and account.

### Start Up – Good

The familiarity with E-ZPass, with  $\frac{3}{4}$  of those crossing New York City bridges and tunnels and almost  $\frac{1}{2}$  of the vehicles entering the Manhattan central business district using it today, makes introduction of the technology for congestion charging in New York City relatively easy. Brand

awareness is already in place. However, transponders now cost about \$25 each, which presents a barrier to entry for some drivers.

#### Fear of Tracking – Fair

E-ZPass records have been used in legal cases. If the E-ZPass system were extended to congestion charging in New York City, legal use of vehicle identification records would need to be limited to assuage fear of tracking.

### **Administration**

#### Costs – Fair

Operational costs are significant: the back-office management is not as intensive and costly as ANPR, however since video and camera images are used for enforcement purposes the costs are still quite high. The cost of the on board units now used with E-ZPass is quite high compared to other systems. Capital costs of setting up gantries are also high compared with systems requiring less roadside equipment.

#### Enforcement and Accuracy – Excellent

Accuracy of E-ZPass is very high, nearly 100 percent. Those who do pay are charged accurately nearly all the time, reducing costs of enforcement on the whole by eliminating nearly all false penalties.

### **Operations**

#### Area-Wide or Cordon – Fair

E-ZPass detection requires physically stable, substantial roadside equipment that cannot be scattered throughout a congestion charging zone. A congestion charging system for Manhattan using E-ZPass would therefore need to be configured as a cordon, rather than the preferable area-wide system. This has the deleterious effect of essentially exempting vehicles originating and terminating within the congestion charging zone. To create an area-wide system, the City could use automatic number plate recognition cameras throughout the congestion charging zone, however that would require an administratively expensive secondary charging system: even drivers with E-ZPass transponders would need to pay separately for an intra-zonal trip.

#### Interoperability – Excellent

Since E-ZPass is already in use at some New York facilities, it would be possible and relatively simple to ensure no motorist is charged more than a daily maximum in total fees and tolls. For example, if the City adopted a policy of charging motorists \$8 per day to drive into Manhattan, and a driver using the Holland Tunnel already paid a \$5.00 toll, it could be a policy decision to require that driver to pay only an additional \$3.00 when exiting the Holland Tunnel in Manhattan. The collecting agencies could work out a revenue sharing agreement in such instances. This policy of “no double tolling” is proposed in the City’s PlaNYC 2030.

#### Flexibility – Good

E-ZPass can be adapted to change by time day; in fact, it is done today on Port Authority facilities. Varying the price levels more frequently and less predictably (for example, by level of congestion) is also possible. However, the physical placement of roadside equipment impedes complete flexibility: the size and shape of the congestion charging zone cannot be easily altered.

#### Reliability - Excellent

E-ZPass has proven to be very reliable.

#### Physical Presence – Fair

Necessary hardware includes overhead gantries that hold antennae which are about the size and shape of pizza boxes. At least 1.5 antennae are necessary for each lane. Gantries need to be very stable and cannot be mounted on traffic signals. One reader cabinet, which is a roadside box approximately two feet high, is necessary for every eight antennae. In Manhattan, where cars often crowd the street and disregard lane markers, more overhead equipment is necessary to detect all vehicles.

### **Next Generation Radio Frequency Identification**

Radio frequency identification (RFID), also described as dedicated short range communication, is the same technology used by E-ZPass; it is used for congestion charging system in Stockholm, and London plans to use it in the future. Next generation radio frequency identification refers to recent and expected improvements to the technology, namely:

**Smaller, Cheaper Transponders.** On-board devices available now, but not yet used by E-ZPass, are smaller and less expensive. Sticker tags can be used instead of the bulkier transponders.

**Cash Payments.** In addition to payment systems now in place, anonymous, temporary and cash-based accounts, unconnected to a credit or debit card, can be used.

**Less Noticeable Roadside Equipment.** The London technology trials have found that radio frequency identification devices can be mounted on a single pole alongside enforcement cameras (see Figure 8). This may be an aesthetically superior option to the overhead gantries now in use in the Northeast.

**Figure 8: Next Generation “Single Pole” Radio Frequency Identification<sup>23</sup>**



**More Vehicles with Built In Transponders.** The vehicle infrastructure initiative (VII) is a federally funded initiative that aims to enable vehicle-to-infrastructure and vehicle-to-vehicle communications, for a variety of safety applications such as collision avoidance. Essentially, the VII is creating policy that will result in the next fleet of cars built in the United States having transponders built into them. This will enable improvements to electronic toll collection, such as the ability to hold multiple “purses” or accounts within the same transponder, allowing various agencies and authorities to use the same infrastructure for their pricing plans. It will make E-ZPass more of a universal fare card for tolling: drivers will be able to pay for parking, highway tolls, bridge tolls and perhaps even transit fares using the same transponder or smart card/transponder combination, even though the funds come from separate accounts and go to separate agencies.<sup>24</sup>

Some of the “next generation” features listed are already in use in Stockholm’s system or available from vendors, while others, like the built-in transponders, are yet to be realized. All of them together are used to compare the new technology to existing E-ZPass as it is known in the Northeast.

## **Customer Experience**

### Payment - Excellent

Unlike the current E-ZPass system, next generation RFID will allow cash payments in addition to credit and debit card account payments. New developments in RFID technology make multiple payment options possible, including those made without a credit card and those made anonymously. On-board units would be required, but these might be as small and temporary as sticker tags.

### Start Up - Excellent

Currently, E-ZPass users must have a credit card or bank account. Next generation RFID will lower the barrier to entry for users by allowing the purchase (or lease) of smaller, more temporary transponders for very little money.

### Fear of Tracking - Good

Unlike the current E-ZPass system, drivers can ensure anonymity by using a cash-based account based only on a name or identification number which the driver can invent. Other than that feature, privacy is subject to the challenges faced by the current E-ZPass system. Laws, such as those in Stockholm, preventing the use of vehicle location data gathered from the congestion charging system by law enforcement or any other entity can also help insure privacy. If needed for public acceptance, an independent entity can be charged with auditing the system periodically to ensure privacy is maintained.

## **Administration**

### Costs – Good

On board units would be less expensive than E-ZPass. Roadside equipment would be smaller and more compact, probably reducing at least a small part of the cost. With built-in transponders in most of the fleet, back office costs would likely drop. However, the main costs now associated with E-ZPass would remain.

### Enforcement and Accuracy – Excellent

E-ZPass is already nearly 100 percent accurate. Next generation RFID will not affect that.

## **Operations**

### Area-Wide or Cordon - Good

The new single pole roadside equipment may be small and innocuous enough to permit poles to be distributed throughout a congestion charging zone, facilitating area-wide charging. However, next generation RFID is still inferior in this respect to technologies that do not require roadside equipment, and can reconfigure the size and shape of the zone more flexibly.

### Interoperability – Excellent

Assuming next generation RFID would be interoperable with the existing E-ZPass system, it could be used, as described earlier, in conjunction with other tolled facilities. The addition of multiple purses or accounts on the same tag or transponder may facilitate expanded interoperability with businesses that may want to accept the form of payment, such as parking garages, gas stations, or inter-modal transportation hubs.

### Flexibility - Good

RFID is already capable of varying charges by time of day and, if desired, by congestion level. The physical placement of roadside equipment still impedes complete flexibility. The improvements to E-ZPass from next generation RFID technology will have little effect on this.

### Reliability – Excellent

Next generation RFID should be at least as reliable as the existing E-ZPass system.

### Physical Presence – Good

One of the major benefits of next generation RFID over the existing E-ZPass system is that roadside equipment is much smaller and more attractive. All the equipment necessary for vehicle identification, charging and enforcement can be located on a single pole that does not need to reach all the way across the street. While this is an improvement over the existing system, it is still inferior to systems that require less visible roadside equipment.

## **Geographic Positioning Systems**

Geographic positioning systems or global navigation satellite systems (GPS or GNSS) technology is available now that can be used to determine the position of vehicles outfitted with a GPS device. GPS could be used for congestion charging in any area. Since roadside equipment is not necessary, the congestion charging zone could be defined and re-defined very flexibly. The main challenge is accuracy. GPS is vulnerable to the multi-path effect, wherein radio signals reflect off surrounding terrain including tall buildings. This causes a delay in reaching the receiver, and the delay causes inaccuracy. At least one company claims to have overcome this challenge with recent technological advancements.<sup>25</sup> An additional challenge is the cost on-board units, which remains well above \$100 for each unit. However, the cost is expected to come down over time.

While GPS can be used for positioning, other infrastructure is needed to calculate charges and make payments. GPS needs to be used with a communications infrastructure for the payment to take place. Skymeter Corporation, for example, has a system, in which “telecommunications and operations have all been engineered down to a minimum, using a patent-pending process that does not require map matching for accuracy.”<sup>26</sup> Another option, discussed below, is a wireless ‘mesh’ network.

GPS has been used for road pricing in a pilot project in Oregon, and on trucks in Germany. For the Oregon project, the state outfitted about 300 cars with GPS to enable charging based on vehicle miles traveled instead of fuel consumption. GPS is used to record distance and time of travel, and to facilitate peak period charging. It is a pilot program and no final report has yet been issued.<sup>27</sup> In Germany and some other places, GPS has been used to track freight traffic. These programs have not required the level of accuracy and evidential integrity that would be necessary for congestion charging in New York City.

Assuming the cost of each on-board unit comes down to \$25 or less, multi-path effects can be mitigated without overly-expensive proprietary technology, and charging technology is the same as would be used for mesh networking, GPS would rank fairly well according to this report's criteria.

## **Customer Experience**

### Payment – Excellent

The method of payment would depend on the communications infrastructure used for GPS. Most options could be used: prepaid accounts linked to license plate data or post-payment as in Stockholm, using cash, credit or debit.

### Start Up – Poor

The on-board unit is relatively expensive compared with other technology options. It can be made tamper-proof. However, that diminishes its flexibility. It can also be built in to the automobile directly. Installation can be costly, around \$300 including labor. The unit would require a power source from either a battery or the vehicle.

### Fear of Tracking – Poor

If GPS were used for congestion charging, privacy and tracking would likely emerge as a major concern. This is because, unlike other technologies, GPS is capable of determining the vehicle's location at multiple points over time in effect establishing the path taken by the vehicle. Strong policies would need to be in place to ensure that private information is not made public.

## **Administration**

### Costs – Uncertain

Start-up costs are now high but likely to decline over time. Data for costs of back office, capital or operations are not available at this time.

### Enforcement and Accuracy - Good

While accuracy has long been a challenge for GPS technology, it is quickly being overcome.

## **Operations**

### Area-Wide or Cordon – Excellent

A main advantage of GPS is that it can be used to create a charging zone of any shape or size, and it can easily ensure vehicles are charged for travel within the zone, not just when entering or leaving.

### Interoperability – Poor

GPS congestion charging would not operate with existing systems, since transponders are not capable of communicating with satellites. E-ZPass could be used in the same vehicle, but for different charging events.



### Flexibility – Excellent

GPS is enormously flexible. Charges can be made to vary by time of day, distance or time traveled, vehicle type, or any other specification desired.

### Reliability – Excellent

The system depends on satellites, which are reliable.

### Physical Presence – Excellent

A major advantage of GPS is that there is no visible off-board equipment necessary. Off board equipment is comprised of the 5 to 8 satellites above the horizon at any given time.

## **Mesh networking**

Mesh networking is communication among many individual transceivers, often called nodes. Each node can detect other nodes and form links among nodes over which packets of data can be routed. The mesh network determines which collection of links gets the packet to the end user fastest, and chooses that one. Wireless mesh networking is mesh networking over a Wireless LAN (local area network). Wireless LAN uses radio communication to allow two or more computers to communicate without wires.

Since devices in a mesh network are connecting to each other, and not to a single access point, less bandwidth is needed to accommodate each additional device. The software that runs the mesh network (sometimes referred to as routing protocol) is widely available. There are many different kinds, and most are free. Mesh networking does not necessarily imply access to the internet, but it easily facilitates free access to the internet in the area covered. All a laptop or computer needs to do to get free internet in an area covered by mesh networking is join the mesh using free downloadable software.

Mesh networking can communicate the location of a vehicle. If used for congestion charging, each car would be outfitted with a chip or antennae, probably smaller than an E-ZPass transponder, which would communicate with small WiFi antennae placed throughout the congestion charging zone. These could be mounted on traffic lights or existing infrastructure. Unlike the E-ZPass system, these antennae need not be placed in a physically stable structure to function; if it wobbles or swings in wind, for example, it will still work. When the outfitted vehicle is passing through the congestion charging zone, its location information is communicated via the mesh network to a back office for the charge to be levied against a pre- or post-paid account. The back office is essentially a billing network. It can be a private digital network, such as the type used for ATMs, or it can be the Internet itself.

Strictly speaking, mesh networking is a tool for communication, not for positioning. However, if some nodes on the network are in fixed, known locations, it is possible to combine GPS and WiFi technology to accomplish both positioning and communication. This is known as Wireless Positioning Services (WPS). Combining GPS and WiFi technology yields a compelling synthesis, as evidenced by the recent collaboration between [SiRF](#) (a GPS manufacturer) and [SkyHook Wireless](#) (a WPS provider). This combination of technologies has some potential for location-based applications in an urban environment, but has not been used or tested for tolling or congesting charging.

## **Customer Experience**

### Payment – Excellent

A variety of payment methods could be used: prepaid accounts linked to license plate data or post-payment as in Stockholm, using cash, credit or debit. This is the same as GPS.

### Start Up – Fair

The mesh card, chip or antennae on board would probably be smaller than an E-ZPass transponder. The unit would require a power source from either a battery or the vehicle. This compares unfavorably to RFID, where many drivers in New York already have the on board unit, and to ANPR where no on board unit is required, but favorably to GPS where the unit is more expensive.

### Fear of Tracking - Poor

As with GPS, privacy and tracking would likely emerge as a major concern. Strong policies would need to be in place to ensure that private information is not made public.

## **Administration**

### Costs – Excellent

Costs to cover an area with mesh networking are very low: \$350 per node, plus \$300 more if each is equipped with an emergency backup battery. One cost estimate for cities is \$70,000 per square mile, or only \$600,000 for the 8.5 square miles of Manhattan south of 60<sup>th</sup> Street.<sup>28</sup> Each node operates on 10 watts of power; power costs will be nominal. These estimates apply to covering an area with mesh networking, not necessarily pricing. The back office administrative and billing costs are unknown, but would likely be comparable to GPS. The cost of on board units is uncertain, but likely inexpensive compared to GPS units.

### Enforcement and Accuracy - Untested

The accuracy of mesh networks' location sensing capabilities is not well known. As with other technologies examined in this report, camera enforcement would be necessary for those vehicles that have not purchased the on-board unit.

## **Operations**

### Area-Wide or Cordon – Excellent

Like GPS, mesh networking facilitates any size or shape congestion charging zone. Both area-wide and cordon designs are feasible.

### Interoperability – Poor

Mesh networking does not function with the existing E-ZPass system.

### Flexibility – Excellent

Like GPS, a location-enabled mesh network is highly flexible. Charges can be made to vary by time of day, distance or time traveled, vehicle type, or any other specification desired.

### Reliability – Good

Testing is needed to determine the reliability of mesh networking for charging. However, the ability of a mesh network to 'self heal' and the fact that there is no single point of failure indicate that it may be sufficiently reliable for congestion charging.

### Physical Presence - Excellent

Mesh networking requires 802.11 transceivers, aka nodes, which are shoe-box sized devices, plus wireless mesh software. The nodes can be placed within existing roadside equipment, including traffic lights.

## **VI Recommendations**

Congestion charging in New York is an ideal means to meet the goals of New York City's Mayor Michael Bloomberg's ambitious PlaNYC 2030 program. The plan calls for reduced travel times and increased transportation capacity, for improved air quality and public health, and for the needed funding for transit maintenance and expansion. These multiple objectives can all be met with congestion charging. The City has designed a pilot program with a charging zone of south of 86<sup>th</sup> street, a flat daily fee, and E-ZPass plus camera recognition for both charging and enforcement. It has also laid out policies around use of revenue, exemptions, and interagency coordination. As these details and others are debated at the State and City level, the recommendations in this section are meant to provide guidance for that debate.

### **Which Technology?**

Figure 9 summarizes how various congestion charging technologies compare to one another. Automatic number plate recognition, which is used in London, ranks fairly well on most criteria but there are technologies available that are as good or better on all criteria. GPS and mesh networking promise the highest level of flexibility, the best potential for a truly area-wide or distance-based congestion charging system, and minimal physical presence on the street, however there are unknown factors and other barriers that make these systems, in their present state of development, less favorable for use in New York City. The E-ZPass system, as we now know it in the NY-NJ-CT region, ranks better than the other technologies in most criteria, however it has two major flaws: the reliance on large, unsightly gantries straddling the street, and reliance on relatively expensive transponders that require a credit card account from the driver. There are solutions to these issues available now. London has tested more attractive, smaller poles that can be used in place of the gantries. The new poles can also facilitate area wide charging instead of a cordon, because unlike the gantries the poles can be placed throughout the congestion charging zone. Less expensive sticker tags are also available in place of the transponders now used by E-ZPass customers. In addition, it is possible to establish an E-ZPass-like account with nothing but cash and a license plate number, as it is done in Stockholm. These features alone show why 'Next Generation Radio Frequency Identification' ranks higher than E-ZPass for six separate criteria.

**Figure 9: Technology Scorecard**

	Automatic Number Plate Recognition	E-Zpass Radio Frequency Identification	Next Generation Radio Frequency Identification	Geographic Positioning Systems	Mesh Networking
<b>Criterion</b>					
<b>Customer Experience</b>					
Payment	Excellent	Fair	Excellent	Excellent	Excellent
Start Up	Excellent	Good	Excellent	Poor	Fair
Fear of tracking	Good	Fair	Good	Poor	Poor
<b>Administration</b>					
Cost	Fair	Fair	Good	Unclear	Excellent
Enforcement and Accuracy	Fair	Excellent	Excellent	Good	Unclear
<b>Operations</b>					
Area/Cordon	Good	Fair	Good	Excellent	Excellent
Interoperability	Fair	Excellent	Excellent	Poor	Poor
Flexibility	Poor	Good	Good	Excellent	Excellent
Reliability	Fair	Excellent	Excellent	Excellent	Good
Physical Presence	Good	Fair	Good	Excellent	Excellent

This report concludes that New York City should rely initially on “Next Generation” E-ZPass technology supplemented with camera-based enforcement. E-ZPass is used today by the majority of motorists who would be affected, and other technologies are not yet far enough advanced or inferior to this option on key criteria. However, the City should not simply adopt the E-ZPass system already in use around the region. The City should ensure that congestion charging brings with it some improvements to E-ZPass that are available now, but not yet in use in this region. Specifically, the City should encourage the next E-ZPass vendor to supply less expensive sticker tags, and to allow cash based and anonymous payments. The City should also assess whether using single-pole technology, which was successful in [London’s technology trials](#), would be feasible in New York. The smaller roadside equipment, with cameras for enforcement mounted on the same poles as E-ZPass antennae, would be aesthetically preferable to road-straddling gantries.<sup>29</sup> As in Stockholm, the congestion charging system would not involve any toll booths, slowing or stopping to pay.

To bring these improvements to our current electronic tolling system to New York City so they can be used for congestion charging, the City should become involved with advancements now underway that will change E-ZPass in the future. The contract for the current E-ZPass vendor, [Mark IV](#), is expiring in 2007. The new contract is being organized by the [Interagency Group](#); a performance-based Request for Proposals for a new E-ZPass vendor will be issued in summer of 2007. The City should work with the Interagency Group to choose a vendor that would best facilitate congestion charging technology trials, specifically including single-pole mounted transceivers with camera enforcement capable of covering multiple lanes of traffic. The City should also solicit improved equipment design outside of the Interagency Group structure. The City should ask private vendors such as Mark IV, Accenture, Skymeter and others to design the least visible or most attractive roadside charging equipment. Depending on the phasing of a congestion charging plan, this could be accomplished through a design competition.

The City should also become involved with emerging in-vehicle systems technology that could affect congestion charging in New York. The City should ensure that as new technology emerges it is

consistent with and useful to the congestion charging system. Specifically, the federal government has committed to adopting the new 5.9GHz standard for dedicated short range communication devices that are built in to vehicles. This is being built into many new cars now, and over the next 10 or 15 years most cars on the road will have essentially a built-in transponder. The technology is primarily being pursued for safety applications such as collision avoidance. However, it can be used for tolling as well. The group exploring that possibility is the [OmniAir Consortium](#), which works closely with the I-95 Corridor Coalition and others. If the City adopts congestion charging, its system will likely be used by vehicles with built-in dedicated short range communication technology in the future, and it should ensure these are interoperable.<sup>30</sup>

In the short term, however, it is possible to meet many of the criteria described above with existing technology. The City would require a vendor with smaller and less expensive transponders than exist now, would establish purchase points at retail outlets and easier electronic payment options, and accept cash payments in addition to credit card accounts. Enforcement would occur, as in London and Stockholm, with cameras recording license plates of vehicles without transponders and with under- or un-paid transponders. Appropriate privacy safeguards, such as prompt destruction of records, should be adopted. Violators would be mailed bills with surcharges. Late payments would be accepted by phone, on-line, or at retail outlets. Perhaps the City could follow the example of Stockholm and create special kiosks throughout the city where users can view their accounts for free.

## **Related Issues**

The issues involved in system implementation go well beyond what technology is selected. Based upon the successful experiences in London and Stockholm, the documentation of these efforts, and RPA's research in the field, a number of important features of a congestion charging program in New York suggest themselves.

### **Monitoring**

The City should commit to a [monitoring program](#), similar to that of Transport for London. The monitoring program should track the traffic, community, economic, and environmental impacts of congestion charging. The City should collect baseline data prior to implementation. Once congestion charging begins, monitoring should be ongoing, and updates should be published every six months to one year. Results should be publicly available throughout the process. A formal monitoring program with a clear timetable will address legitimate concerns, putting the City in a position to continue, alter or suspend the program over time. The baseline study will be useful in determining the effectiveness of the technology and the program as a whole. It can also help target the best transit improvements the City can make by quantifying the impact of congestion charging on the transit system, the amount of new capacity that can be accommodated on the street, and the potential for more express buses.

### **Dynamic Pricing**

During the pilot program, the City should evaluate the potential for improving effectiveness by varying the price by time of day or level of congestion. Following the [Vickrey principle](#), congestion charges in New York could be more effective at reducing congestion if prices are lower during less congested times and higher during peak travel times. This encourages a shift in travel time and to travel by transit when transit service is more frequent and widespread. Dynamic pricing, varying either by time of day or by congestion levels, tends to result in a smoother transition from rush hour

to off-peak hours, discouraging vehicles from rushing to avoid the charge. For example, the City could charge \$5 from 5 AM to 7 AM, \$8 from 7 AM to 5 PM, and \$5 from 5 PM to 7 PM. E-ZPass technology has this flexibility allowing the City to move toward a system of dynamic pricing.

### **Education Campaign**

Congestion charging is highly controversial. The public needs to be informed and engaged if congestion charging is to be a success. The City has begun this effort and will need an ongoing campaign to educate the public on the way congestion charging works and its multiple benefits. It should develop a means of getting the message out, and answering the inevitable questions and concerns of the public. Such a program to “market” the idea will need to communicate the strong case that congestion charging is by far the most effective means to ease traffic, while acknowledging that other policies would also be helpful and should be pursued at the same time. Also, the argument that congestion charging is by far the most effective way to raise the revenue needed for the transportation program, and to argue that other revenue sources, such as borrowing, are poorer choices, must continue to be emphasized.<sup>31</sup>

Beyond the initial education, the City will need to develop a recognizable brand and communication strategy to inform the public about the program. Branding should tie together official information about the program in many media. The physical street signs themselves will be an important ongoing communications tool used by the City. Signs should be clear, large and plentiful enough to be effective, yet they should not be a visual blight. To make use of the system’s flexibility, dynamic signs – such as LED screens – may be warranted in addition to regular signs demarcating the congestion charging zone. A design competition, or perhaps a sign streamlining program to eliminate dated or redundant signs, could help the City.

### **Next Steps**

The most critical action is to proceed with the pilot program proposed by the City. All of the recommendations in this report can be implemented in the context of the pilot, and there is now way to test their effectiveness without it. Even prior to implementation of the pilot, system planning should include the following:

- **Join the E-ZPass [Interagency Group](#)** to help choose the vendor to supply new technology and determine what the next generation of E-ZPass will look like.
- **Continue and Expand an Education Campaign.**
- **Design and a Monitoring Program**, and collect baseline data.
- **Solicit Improved Equipment Design**, possibly through a design competition for roadside equipment.



## Endnotes

<sup>1</sup>A further logical extension of the congestion charging concept is distance- or time-based charging. The London Technology Trials examined the potential of using GPS for distance-based charging, however it is not considered here. Instead, since New York City is planning to implement charging in the near future, this report has shaped the criteria for an ideal system to accommodate the potential of existing and tested technology.

<sup>2</sup>Transport for London. Central London Congestion Charging Impacts Monitoring, Fourth Annual Report. June 2006: 183.

<sup>3</sup>Transport for London. Congestion Charging Greater London Authority Act 1999, Schedule 23, Four Year Programme. August 2006: Annex A, page 5.

<sup>4</sup>Transport for London. Central London Congestion Charging Impacts Monitoring, Second Annual Report. April 2004: 116

<sup>5</sup>Transport for London. London Congestion Charging Technology Trials, Stage One Report. February 2005: 59.

<sup>6</sup>Transport for London. Central London Congestion Charging Impacts Monitoring, Fourth Annual Report. June 2006: 188.

<sup>7</sup>“Owners Must Pay Tolls for Stolen Cars.” The Local, Sweden’s News In English 5 January 2006.

<sup>8</sup>Jonas Eliasson, Transek AB. Cost-Benefit Analysis of the Stockholm Congestion Charging System. Note that there are other direct public costs and benefits to consider, including necessary transit capacity increases, decreases in revenue from fuel taxes and road maintenance, and revenue from fines.

<sup>9</sup>The system was operational for over 99.9 percent of lane hours. Vagverket. Trial Implementation of a Congestion Tax in Stockholm, 3 January – 31 July 2006. Second Edition, August 2006.

<sup>10</sup>Stockholmsforsoket. Facts and Results from the Stockholm Trials. Final Version, December 2006.

<sup>11</sup>Transport for London. Central London Congestion Charging Impacts Monitoring, First Annual Report. 2003: Appendix 9.

<sup>12</sup>Transport for London. Central London Congestion Charging Impacts Monitoring, First Annual Report. 2003.

<sup>13</sup>“YouGov Poll.” The Evening Standard. 5 January 2004. “Congestion Charge Should Be Extended.” Friends of the Earth. Press Release, 17 February 2004.

<sup>14</sup>Mayor of London. “Annual London Survey 2006, Final Topline Results.” 30 January 2007.

<sup>15</sup>Transport for London. Central London Congestion Charging Impacts Monitoring, Fourth Annual Report. June 2006.

<sup>16</sup>Transport for London. Central London Congestion Charging Impacts Monitoring, Third Annual Report. April 2005.

<sup>17</sup>Vagverket. Trial Implementation of a Congestion Tax in Stockholm, 3 January – 31 July 2006. Second Edition, August 2006.

<sup>18</sup>Stockholmsforsoket. Facts and Results from the Stockholm Trials. Final Version, December 2006.

<sup>19</sup>Ibid.

<sup>20</sup>Ibid.



<sup>21</sup> Kommunförbundet Stockholms Lan. “TRÄNGSELSKATT – RESULTAT AV FOLKOMRÖSTNINGAR.” <<http://val.cscs.se/>>

<sup>22</sup>Justin Rocket Silverman. “Thousands More Surveillance Cameras.” amNEWYORK. 14 December 2006. “The number of surveillance cameras in Manhattan is increasing so fast that there are almost as many in Greenwich Village and SoHo now as there were in the entire city in 1998.” Councilman Vallone is quoted saying “there is no expectation of privacy on our city streets.”

<sup>23</sup>Transport for London. London Congestion Charging Technology Trials, Stage Two Final Report. October 2006: 18. Example of single pole dedicated short range communication and automatic number plate recognition in one of London’s Urban Charge Points, established as a trial in 2006.

<sup>24</sup>Next generation radio frequency identification, including built-in transponders, will use the 5.9 GHz band, which has been allocated by the Federal Communications Commission for intelligent transportation system purposes. It is specifically for the type of communication pursued by the Vehicle Infrastructure Initiative. While transponders using the 5.9 GHz band are the basis for currently-conceived VII safety applications, the VII Coalition and USDOT are also considering wireless and other technologies to achieve the same ends.

<sup>25</sup>“Product Brief: Skymeter Vehicle Location Billing Systems.” Skymeter Corporation. Toronto, Canada: 2002-2006.

<sup>26</sup>Ibid.

<sup>27</sup>Oregon Office of Innovative Partnerships and Alternative Funding. Road User Fee Pilot Program. See <<http://www.oregon.gov/ODOT/HWY/OIPP/mileage.shtml>>.

<sup>28</sup>Tropos Networks. Metro-Scale Mesh Networking with Tropos MetroMesh Architecture: A Technology Whitepaper. February 2005.

<sup>29</sup>It is uncertain whether existing E-ZPass transponders would remain useful if used with London’s single-pole technology, however it is likely. Even if the improved roadside equipment is not interoperable with the existing E-ZPass system, it is feasible to switch current E-ZPass users to another type of tag. The current E-ZPass system requires mailing addresses and full contact information of each user, and new tags can be distributed if necessary.

<sup>30</sup>One opportunity to demonstrate congestion charging technology may be the 2008 Intelligent Transportation Systems World Congress, to be held in New York City.

<sup>31</sup>Currently, there are approximately \$35 billion worth of transit projects that have been proposed in New York, for which the majority of the funding has not been identified.

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