

*Congestion Mitigation Commission Technical Analysis*

## **License Plate Rationing Evaluation**

# technical memorandum

*prepared for*

**New York City Economic Development Corporation  
New York City Department of Transportation**

*prepared by*

**Cambridge Systematics, Inc.**



---

*technical memorandum*

# *Congestion Mitigation Commission Technical Analysis*

## **License Plate Rationing Evaluation**

*prepared for*

New York City Economic Development Corporation  
New York City Department of Transportation

*prepared by*

Cambridge Systematics, Inc.  
33 East 33<sup>rd</sup> Street, Suite 804  
New York, New York 10016

*date*

December 10, 2007

---



# Table of Contents

<b>Executive Summary .....</b>	<b>ES-1</b>
<b>1.0 Introduction .....</b>	<b>1-1</b>
<b>2.0 Case Studies .....</b>	<b>2-1</b>
2.1 Mexico City, Mexico Case Study .....	2-2
Transportation System .....	2-2
License Plate Rationing Program – <i>Hoy No Circula</i> (HNC).....	2-4
Enforcement.....	2-5
Impacts .....	2-6
Future of the Program.....	2-9
2.2 Bogotá, Colombia Case Study.....	2-9
Transportation System .....	2-10
License Plate Rationing Program – <i>Pico y Placa</i> .....	2-12
Enforcement.....	2-14
Impacts .....	2-14
Future of the Program.....	2-16
2.3 São Paulo, Brazil Case Study.....	2-17
Transportation System .....	2-18
License Plate Rationing Program – <i>Rodizio</i> .....	2-19
Enforcement.....	2-21
Impacts .....	2-21
Future of the Program.....	2-22
2.4 Other Implementations.....	2-23
Auckland, New Zealand.....	2-23
Athens, Greece .....	2-23
Santiago, Chile .....	2-24
2.5 Lessons Learned from Case Studies.....	2-24
<b>3.0 Application to New York City .....</b>	<b>3-1</b>
3.1 Implementation of License Plate Rationing .....	3-1
Alternative 1, Number-Based License Plate Rationing .....	3-1
Alternative 2, Color-Coded License Plate Rationing .....	3-2
3.2 Impacts .....	3-2
Traffic Impacts .....	3-2

Transit Impacts.....	3-3
Taxi Service Impacts.....	3-4
Commercial Vehicles Impacts.....	3-4
Socioeconomic Impacts.....	3-4
3.3 Enforcement.....	3-4
3.4 Environmental Effects.....	3-6
<b>4.0 Key Findings and Conclusions .....</b>	<b>4-1</b>
<b>5.0 References and Sources of Additional Information .....</b>	<b>5-1</b>

# List of Tables

Table 2.1	Restriction by Day of Week in <i>Hoy No Circula</i> .....	2-5
Table 2.2	Pico y Placa Restrictions, July 2005 to June 2006.....	2-13
Table 2.3	Pico y Placa Restrictions, July 2007 to June 2008.....	2-13
Table 2.4	Pattern of Bus Ridership.....	2-15
Table 2.5	<i>Rodizio</i> Restrictions by Day of Week.....	2-20
Table 2.6	Before and After Comparison of Traffic Measures.....	2-22
Table 3.1	Cost Estimate for Implementation of ITS Enforcement .....	3-6





# List of Figures

Figure 2.1 Federal District and Greater Mexico City Map .....	2-3
Figure 2.2 Mode Share of Trips per Person per Day in Mexico City .....	2-4
Figure 2.3 Projected Number of Circulating Vehicles from 2003 to 2010 .....	2-8
Figure 2.4 Average Distance Traveled by a Vehicle per Day in Mexico City .....	2-9
Figure 2.5 Bogotá Metropolitan in Cundinamarca State .....	2-10
Figure 2.6 Bogotá Bus Rapid Transit ( <i>Transmilenio</i> ) Station .....	2-11
Figure 2.7 Bicycle Paths in Bogotá.....	2-12
Figure 2.8 São Paulo in São Paulo State .....	2-18
Figure 2.9 Daily Trips by Mode in the São Paulo Metropolitan Region 1967 to 1997.....	2-20
Figure 2.10 Implementation Boundary of <i>Rodizio</i> (Not to Scale).....	2-21



# List of Acronyms

BRT – Bus Rapid Transit

CQL – Congestion Queue Length

GDP – Gross Domestic Product

HNC – *Hoy no Circula*

ITS – Intelligent Transportation System

NYMTC – New York Metropolitan Transportation Council

OD – Origin Destination

VMT – Vehicle Miles Traveled



# Executive Summary

On any given workday, the Manhattan Central Business District hosts nearly two million workers from around the region, hundreds of thousands of tourists, and several hundred thousand residents. Streets are congested with cars, trucks, buses, taxis, pedestrians, and cyclists. The saturated roadways slow bus service, cause emergency vehicles to lose valuable response time, and contribute to the region's air pollution problems.

License Plate Rationing is a possible approach to reduce congestion in New York to restrict some vehicular traffic from entering the Manhattan Central Business District City on particular days. Typically a License Plate Rationing program restricts a set of vehicles from entering a specified area on certain days based on the last digit of the vehicle's license plate.

License Plate Rationing has not been implemented in cities generally considered to be international peers of New York City, such as western European capitals, or Asian cities such as Tokyo or Singapore. For the most part, it has been implemented in Latin American cities with severe air quality problems and very different demographics than New York. This memorandum focuses on the three most enduring and well documented implementations in the Latin American cities of Mexico City, Mexico; Bogotá, Colombia; and São Paulo, Brazil. While there are lessons to be learned from the experiences, the documentation is not as thorough, impartial, or clear cut as might be the case were similar policies to be tried in the United States.

**Mexico City** started the *Hoy no Circula* scheme (No Circulating Day) in 1989. *Hoy no Circula* restricts access by cars with two particular license plate digits every weekday (e.g., license plates ending in the numbers "5" or "6" could not enter the city on Mondays). **Bogotá** implemented the *Pico y Placa* (Peak and License Plate) program in 2000. This program also restricts access to the city based on the last digit of a vehicle's license plate. It differs from Mexico City in that access is restricted during the peak period only, not a full day. Bogotá adds another layer of complexity by changing the numbering scheme every year, making it more difficult for households to maintain the right set of license plates to enable access each day of the week. *Pico y Placa* was implemented along with a Bus Rapid Transit (BRT) system and 180 miles of new bicycle paths to promote use of modes other than the personal vehicle. **São Paulo** implemented a License Plate Rationing scheme called *Rodizio*, restricting two numbers each day of the week since 1997.

The major findings of the studies of these implementations are as follows:

**Short-Term Benefits** – In both Mexico City and São Paulo, short-term benefits in the first year of implementation were well documented. In Mexico City, the trial implementation during the winter months of 1989 resulted in a 20 percent

reduction in daily vehicles in circulation within the urban cordon area, increases in vehicle speed, decreases in fuel consumption, and a 6.6 percent increase in subway ridership. A six-month experimental trial in São Paulo resulted in a two to five percent reduction in peak-period vehicular volumes, an 18 to 23 percent improvement in average speed on two major avenues which were tested, and a reduction of 26 percent (p.m. peak) and 37 percent (a.m. peak) in average congested queue length on the avenues. No mode shift was reported; rather drivers appeared to time shift out of the impacted peak periods. No specific short-term impacts were documented in Bogotá.

**Long-Term Benefits Unclear** – The most extensive and objective documentation of the long-term impacts of License Plate Rationing was found for the Mexico City implementation. These studies found that there was no sustained improvement in air quality, no increase in subway ridership, and worsening air quality on weekends and other times outside of the License Plate Rationing scheme. Mode shift was primarily to taxis and small buses rather than to subways, which counterbalanced any improvements likely to be achieved by reductions in auto travel. Demand for gasoline went up after two months of implementation, and Mexico City became a net importer rather than net exporter of used vehicles from the rest of the country, meaning that residents sought to evade the restrictions by becoming multi-vehicle households (with variably coded license plates) and began to acquire older (and less fuel efficient and more polluting vehicles) from the countryside. Whereas in theory the system should have restricted 20 percent of vehicles from the road on any given day, many vehicles are exempt from the restriction if they meet certain emission standards. In the end, current regulations restrict only about 7.6 percent of vehicles on any given day. The 7.6% is forecast to decline to 2.9 percent by 2010 as newer less polluting vehicles come on-line and are exempted from the restrictions. The policy indicates that the primary motivation for Mexico City's implementation in the long term is air quality improvement, not congestion reduction. Assessing the air quality impacts in Mexico City is further complicated by the phasing out of leaded gasoline and adoption of U.S. vehicle emissions standards during the same period.

In Bogotá, the long-term impacts are affected by the companion implementation of a major BRT system and an extensive network of bicycle paths. Government-commissioned studies found a nine percent mode shift from private auto to BRT. BRT ridership has grown dramatically since its implementation, but there also has been a large corresponding drop in traditional bus ridership. Given the available documentation, it is not possible to isolate the relative impacts of the various strategies being employed during this period. However, Bogotá does demonstrate the importance of combining License Plate Rationing or other vehicular limitation strategies with major improvements in alternative modes of travel.

**Enforcement** – All three cities impose hefty fines for violations: \$200 in Mexico City on per capita Gross Domestic Product (GDP) of \$10,700; \$107 in Bogotá on

per capita GDP of \$6,300; and \$100 in São Paulo on per capital GDP of \$4,500. Given a per capita GDP of \$46,617 in New York State in 2006, this level of penalty would translate into fines close to \$900, far in excess of most comparable penalties currently in effect for non-criminal motor vehicle violations in the United States. In addition, Mexico City devotes a large police presence to the enforcement of *Hoy no Circula* (in the absence of high-technology solutions) and impounds violating vehicles for 48 hours.

**Socioeconomic Bias** – Since households with more than one vehicle are better positioned to avoid the ban, License Plate Rationing is more favorable to households with multiple vehicle ownership, which is highly correlated with income. Thus, the theory that License Plate Rationing reflects a more equitable response to congestion than schemes involving direct pricing strategies is not correct as more affluent households are better able to adopt strategies to circumvent the intent of the policy. This was most clearly apparent in Mexico City.

**Application to New York City Metropolitan Area** – Given the greater wealth of the region relative to the Latin American cities studied, and higher auto ownership rates, it is likely that many area residents would emulate the adaptation strategy of Mexico City residents by acquiring additional vehicles with a different license plates such that they would be able to drive at least one of their vehicles across the cordon on any given day. Combating such strategies (by standardizing license plates across multi-vehicle households) would require a major change in how vehicle registrations are handled in the United States (from an individual vehicle to household vehicle basis), and it would have to be done across multiple state jurisdictions (at a minimum, New York, New Jersey and Connecticut). Even then, one could imagine further adaptation strategies such as neighboring households swapping vehicles on different days of the week if the government rotated the license plate numbering scheme on an annual basis as in Bogotá.

Besides new vehicle acquisitions, other strategies which people might employ that would further reduce the effectiveness of rationing might include increased use of taxis and shifting trips to days that the vehicle is not restricted. Finally, the elimination of trips barred by rationing could induce additional demand – new trips could take advantage of less congested roadways.

In conclusion, in combination with good transit, rationing has had an impact in Bogota. Lessons from the Latin American examples show that travelers find ways to evade the ban, often by acquiring an additional vehicle. New York area demographics imply that many of the single vehicle households have the financial means to purchase an additional car.





# 1.0 Introduction

On any given workday, the Manhattan Central Business District hosts nearly two million workers from around the region, hundreds of thousands of tourists, and several hundred thousand residents. Streets are congested with cars, trucks, buses, taxis, pedestrians, and cyclists. The saturated roadways slow bus service, cause emergency vehicles to lose valuable response time, and contribute to the region's air pollution problems.

According to Texas Transportation Institute's Urban Mobility Report, New York City ranks second in the nation in terms of annual hours of delay. The majority of the delay is spent during the peak hour, with travelers experiencing 46 hours of annual delay (per traveler) in 2005, up from 34 hours in 2000, a 35 percent increase. This congestion costs the City and its residents over \$7 billion in 2005, costing each peak traveler approximately \$888.

By 2030, nearly a million more residents, 750,000 more jobs, and millions more visitors are expected to further strain the City's transportation system. The current system cannot handle the anticipated increase in traffic and meaningful infrastructure-based solutions are challenging, costly, and lengthy to implement.

Rising levels of pollution and congestion have led some cities around the world to implement vehicle restrictions that control the entry of vehicles into congested areas. Vehicle restrictions include regulatory strategies that prohibit automobile travel according to time and/or space such as:

- Prohibiting automobiles from parts of a city or corridor to make improvements for pedestrians, bicyclists, or public transit;<sup>1</sup>
- Restricting access to specific vehicles with permits based on residential restrictions, commercial restrictions, restriction by type of vehicle, etc.;<sup>2,3</sup> and
- Restricting access based on vehicle license plate numbers.

One approach to reducing congestion in New York City through vehicle restrictions is License Plate Rationing. Typically a License Plate Rationing program restricts a set of vehicles from entering a specified area on certain days based on the last digit of the vehicle's license plate. Such measures have not

---

<sup>1</sup> Leo Lemmers (1995), *How Amsterdam Plans to Reduce Car Traffic*, World Transport Policy and Practice, Volume 1, No. 1, pages 25-28.

<sup>2</sup> Auckland Road Pricing Evaluation Study, 2005 (<http://www.transport.govt.nz/arpes-index/>).

<sup>3</sup> Victoria Transport Policy Institute, TDM Encyclopedia (<http://www.vtpi.org/tdm/tdm33.htm>).

been implemented in any city in the United States. The most widely known example of License Plate Rationing in the United States was the fuel purchase program during the gas crises of the 1970s, when vehicles with license plates having an odd number as the last digit were only allowed to purchase gasoline on odd-numbered days of the month, while vehicles with even-numbered license plates were only allowed to purchase fuel on even-numbered dates.

For the most part, License Plate Rationing has not been implemented in cities generally considered to be international peers of New York City, such as western European capitals, or Asian cities such as Tokyo or Singapore. For the most part, it has been implemented in Latin American cities with severe air quality problems and very different demographics than New York. This memorandum focuses on the three most enduring and well documented implementations in the Latin American cities of Mexico City, Mexico; Bogotá, Colombia; and São Paulo, Brazil. While there are lessons to be learned from these experiences, the documentation is not as thorough, impartial, or clear cut as might be the case were similar policies to be tried in the United States. This document is organized into the following five sections:

- **Section 1.0** presents a definition of the problem at hand;
- **Section 2.0** provides an overview of case studies in select cities from around the world;
- **Section 3.0** discusses how lessons from these case studies might apply in the New York City environment;
- **Section 4.0** presents a summary of the key findings; and
- **Section 5.0** presents references and sources of additional information.

## 2.0 Case Studies

The License Plate Rationing examples described in this memorandum restrict a category of vehicles from entering or being driven in certain areas of large cities during specified time periods. The primary goal of these policies is to improve air quality. To achieve this goal, the policies are designed to induce motorists to make changes in their travel patterns by not driving in defined areas at certain times of the day; shifting trips to other modes such as transit, ridesharing, bicycling or walking; shifting the time of day of travel; or not making the trip at all. The policy is based on the theory that fewer vehicles on the road would translate into increased vehicle speeds, reduced congestion levels, decreased fuel consumption, and lower levels of pollutants.

There are several important considerations in evaluating the general effects of License Plate Rationing:

- First, public transit (particularly fixed or dedicated guideway systems like subways and bus rapid transit (BRT)) and non-motorized travel are the most desirable alternatives in terms of fighting pollution and congestion. Transit and bicycle paths must have available capacity and must be attractive enough to discourage shifting to modes which are less likely to reduce pollution levels such as taxis and traditional diesel buses running on public streets.
- Second, short-term benefits need to be made sustainable in the long run to address the various ways in which travelers try to circumvent the driving restrictions.
- Third, a robust enforcement system is needed and should include meaningful fines for violators.
- Fourth, License Plate Rationing might lead to an inequity across socioeconomic strata as households owning multiple vehicles, or having the financial capability to acquire multiple vehicles, are better positioned to circumvent the prohibitions.

The three most enduring and well documented implementations of License Plate Rationing are Mexico City, Mexico; Bogotá, Colombia; and São Paulo, Brazil. In all cases, License Plate Rationing was implemented in combination with other air quality improvement strategies. In Mexico City, License Plate Rationing was part of a larger air quality initiative which involved an emissions control program requiring that vehicles have their emissions checked and certified at regular intervals, phasing out of leaded gasoline, and adoption of U.S. vehicle emissions control standards. The License Plate Rationing program in Bogotá was implemented alongside a new BRT system and 180 miles of new bicycle paths to

promote the use of modes other than the personal automobile. São Paulo introduced stricter emissions control at the same time as License Plate Rationing.

All three implementations were first introduced on a trial basis. The short-term benefits had the desired effect of reducing motor vehicle travel, and therefore, the trial programs were made permanent. However, the long-term impacts in Mexico City and Sao Paulo have not proven nearly as effective. During the trial implementations motorists complied with the policies or faced significant fines. Once the policies were made permanent, motorists were willing to invest in solutions to get around the restrictions (such as taking taxis or acquiring additional vehicles).

## 2.1 MEXICO CITY, MEXICO CASE STUDY

The Mexico City Metropolitan Zone (*Zona Metropolitana de la Ciudad de México*) is the largest and densest metropolitan area in the country of Mexico. In 2005, the Zone had a population of 19.23 million. Figure 2.1 shows greater Mexico City. The shaded area represents the most densely populated part of the Zone.

### Transportation System

Transportation in Mexico City is managed by the government of the Mexican Federal District through several public companies that administer the different modes of transportation.

Mexico City is served by the *Sistema de Transporte Colectivo Metro*, the largest subway system in Latin America. The system is 129 miles (207 km) in length, has 11 lines, and 175 stations. A twelfth line is planned to be constructed in the year 2008 and a suburban rail system currently is under construction. The Metro carries approximately four million people every day, surpassed only by the subway systems in Moscow (7.5 million), Tokyo (5.9 million), and New York City (4.9 million).<sup>4</sup> According to the information available through the Metropolitan Transit Authority (MTA) of New York, Mexico City's subway has only 129 miles (207 km) of tracks as compared to 660 miles (1,063 km) in New York City.<sup>5</sup>

---

<sup>4</sup> Mexico City Transit Authority (<http://www.ste.df.gob.mx/index.html>) and [http://www.ntdprogram.gov/ntdprogram/pubs/top\\_profiles/2005/agency\\_profiles/2008.pdf](http://www.ntdprogram.gov/ntdprogram/pubs/top_profiles/2005/agency_profiles/2008.pdf).

<sup>5</sup> MTA (<http://www.mta.info/nyct/facts/ffsubway.htm>) & Mexico City Transit Authority (<http://www.metro.df.gob.mx/operacion/cifrasoperacion06.html>).

Figure 2.1 Greater Mexico City Map

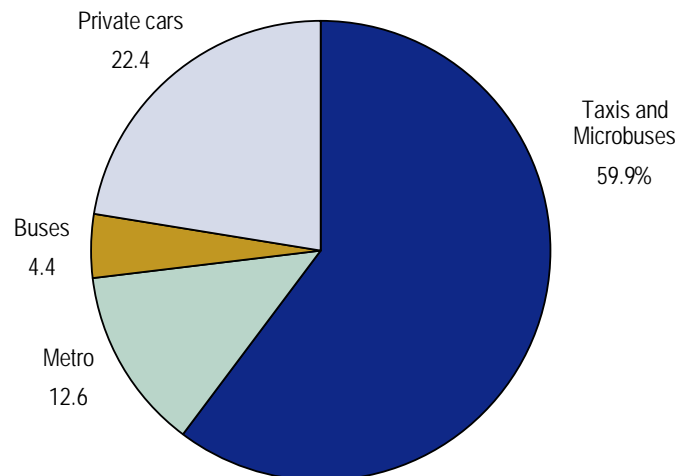


There are approximately 2.5 million registered vehicles in the Mexico City Metropolitan Zone,<sup>6</sup> a total which grows by approximately 160,000 vehicles every year. Severe environmental problems in the area can be partially attributed to this volume together with the age of the vehicles (32 percent of vehicles were made before 1980), the inadequate maintenance, the long distances they travel daily, the insufficient combustion due to altitude, the types of gas

<sup>6</sup> *Metropolitan Mexico City: Transportation Policies and Economic Development* (2001), Alejandro Villegas López.

they use, and the high levels of traffic congestion.<sup>7</sup> As shown in Figure 2.2, private cars are the second most used mode of transport after Taxis and Microbuses (Microbuses are privately operated large vans or small buses).

**Figure 2.2 Mode Share of Trips per Person per Day in Mexico City**



The city does not have an expressway network that connects points within the city; all cross-city trips must be made on arterial roads. In the late 1970s, many arterial roads were redesigned as *eyes viales* (high-volume one-way roads) that cross Mexico City proper. Two freeway ring-roads serve to connect points within the city with the larger metropolitan area. *Circuito Interior* is the inner ring and *Periférico* is the outer, or main ring. Due to the high density of traffic on the main ring, an elevated highway that runs atop and parallel to a portion of the road was constructed and opened in 2007. This elevated highway is colloquially called *segundo piso*, the second level of the *Periférico*.

### **License Plate Rationing Program – *Hoy No Circula* (HNC)**

On November 20, 1989 Mexico City introduced a program that banned all vehicles from driving one day per week based on the last digit of the vehicle's license plate. The program, called *Hoy No Circula* (No Circulating Day), was introduced primarily to control air pollution in Mexico City.<sup>8</sup>

<sup>7</sup> *Towards an Air Quality program for the decade 2000-2010 for the Metropolitan Zone of the Mexico Valley*, Clean Air Initiative.

<sup>8</sup> Lucas Davis (2006), *The Effect of Driving Restrictions on Air Quality in Mexico City*, University of Michigan; Eskeland and Feyzioglu (1997), *Rationing Can Backfire: The Day without a Car in Mexico City*, *The World Bank Economic Review*; Luisa Molina and Mario Molina (2002), *Air Quality in Mexico Megacity: An Integrated Assessment*, Kluwer Academic Publishers, Massachusetts.

The HNC was initially implemented for the Federal District (Mexico City proper) but now covers surrounding regions in the State of Mexico as well. The policy currently is operational under the rules listed in Table 2.1.

**Table 2.1**     Restriction by Day of Week in *Hoy No Circula*

Weekday	Plate's Last Digit
Monday	5 or 6
Tuesday	7 or 8
Wednesday	3 or 4
Thursday	1 or 2
Friday	9 or 0

The original implementation of the plan was proposed for one winter season only. The winter season was targeted because thermal inversion increases the adverse effect of pollution. Due to the program's success in its initial stages, the City decided to implement it year round in 1990. As the program progressed, exemptions were provided to low-emission vehicles. For example, in 1997 cars with catalytic converters were exempted from the ban. This exemption was the beginning of a pattern of exemptions for less polluting vehicles, which demonstrates that the primary purpose of the program is air quality improvement, not congestion reduction per se. There is no readily available data on the percent of vehicles exempted.

The HNC implementation was part of the *Proaire* initiative which included a set of measures to counter air pollution. Some other measures in *Proaire* were vehicle emission certifications, development of high-capacity transit, and development of bike paths and pedestrian facilities.

## Enforcement

The License Plate Rationing program in Mexico City experienced high levels of compliance.<sup>9</sup> Substantial fines coupled with a large police presence in the City helped discourage violations. The violation fines are equivalent to around \$200 at 2006 prices, quite high considering that per capita GDP in Mexico in 2006 was \$10,700. The penalty also includes impounding the violating vehicles for a period of 48 hours. In addition, the license plate registration system in Mexico is well regulated in that it would be difficult for people to cheat the system by using fake license plates. In general, the available information points to an effective enforcement of the system, albeit without the use of technically

---

<sup>9</sup> Lucas Davis (2006), *The Effect of Driving Restrictions on Air Quality in Mexico City*, University of Michigan.

advanced equipment. Recently there have been reports of corruption and bribery in the system for illegally classifying low-emission vehicles which are exempt from the ban, however.<sup>10</sup>

## Impacts

During the trial implementation stage in 1989, Mexico City estimated a 20 percent reduction of the vehicles in circulation based on 100% compliance, an increase in mean speeds, decrease in gasoline consumption and an increase of 6.6 percent in subway ridership. As a result the authorities decided to make the program permanent.<sup>11,12</sup>

However, once the program was made permanent, it led to substantially different driver behavior. Travelers found the public transportation system an undesirable long-term substitute for driving. To evade the rationing restrictions, residents of Mexico City purchased more vehicles, in order to have at least one vehicle available for use on any given day.

Studies were conducted to evaluate the impact of this program. Davis<sup>13</sup> studied the effect of driving restrictions on air quality in Mexico City using measures of air quality from monitoring stations. This study found no evidence of long-term improvements in air quality due to License Plate Rationing alone. Some of the key findings of the study were as follows:

- No statistical evidence of improvement in air quality during any hour of the day or day of the week;
- No evidence of sustained increase in ridership on public transit; and
- A relative increase in air pollution during weekends and hours of the day when restrictions did not apply.

The study controlled for various factors influencing air quality in Mexico City and looked at different reasons why the License Plate Rationing policy did not have the desired effect. An important finding was the increase in taxi utilization during restriction periods compared to the degree of mode shifting to public transit. These results imply that mode shift has been primarily toward taxis and

---

<sup>10</sup>Joseph Sussman (2006), *Mexico City: Transportation and the Environment*. Lecture at Massachusetts Institute of Technology.

<sup>11</sup>Ramiro Tovar Landa (2001), *Mobile Source Pollution in Mexico City and Market-Based Alternatives*, The Cato Review of Business & Government, Cato Institute.

<sup>12</sup>The 20% statistic refers to theoretical reductions as the Mexico City report assumed 100% compliance in the short-term trial of HNC.

<sup>13</sup>Lucas Davis (2006), *The Effect of Driving Restrictions on Air Quality in Mexico City*, University of Michigan.



microbuses instead of public transit (buses and subways). Davis<sup>14</sup> suggests that the inability to use private automobiles to access transit stops may be the reason for the preference for taxis over mass transit. Also, the study states that cars are owned by wealthier households that prefer taxis over the cheaper, crowded, and potentially unsafe metro system.

Another study<sup>15</sup> analyzed gasoline consumption for the period of 1984 to 1992 by modeling demand for gasoline before and after the regulation came into effect. The study showed that demand for gasoline went up six months after the rationing implementation. This study, as well as Davis' report,<sup>16</sup> identifies household vehicle ownership as the factor behind observed trends in pollution and gasoline consumption. The increase in household vehicle ownership was estimated by tracking the sale of used vehicles. The findings showed that Mexico City was traditionally a net exporter of used cars to the rest of the country; however, it became a net importer after the HNC implementation in 1989. Hence, households increased their vehicle ownership rates by acquiring used vehicles presumably to avoid the ban. The used vehicles are generally less energy efficient and have higher emissions. This further contributes to increased gasoline consumption and adverse environmental impacts.

Statistics from the Office of Environmental Management (*Dirección General de Gestión Ambiental del Aire*)<sup>17</sup> projects further growth in vehicular ownership. The statistics show that the number of active circulating vehicles is projected to increase from 2.78 million in 2003 to 4.31 million in 2010 as shown in Figure 2.3. (The term *circulating vehicles* is used in order to account for the significant number of vehicles registered outside of Mexico City but that are still active within Mexico City on a given day.)

---

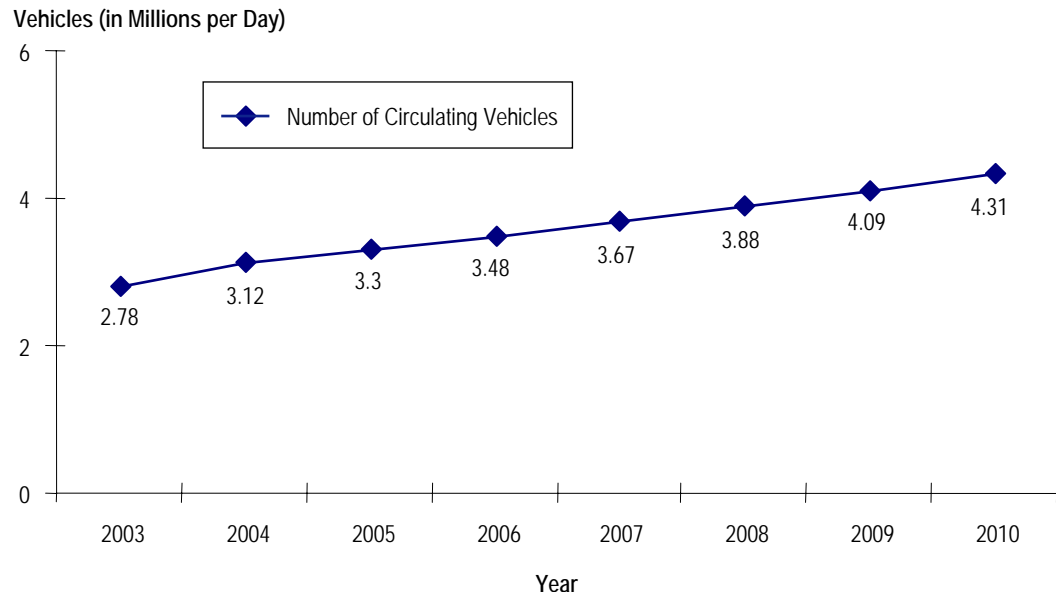
<sup>14</sup>Lucas Davis (2006), *The Effect of Driving Restrictions on Air Quality in Mexico City*, University of Michigan.

<sup>15</sup>Eskeland and Feyzioglu (1997), Rationing Can Backfire: The Day without a Car in Mexico City, *The World Bank Economic Review*.

<sup>16</sup>Ibid.

<sup>17</sup>DIRECCIÓN GENERAL DE GESTIÓN AMBIENTAL DEL AIRE (2004), *Elementos para la Propuesta de Actualización del Programa "Hoy No Circula" de la Zona Metropolitana del Valle de México*.

Figure 2.3 Projected Number of Circulating Vehicles from 2003 to 2010



Source: Gobierno del Distrito Federal, Secretaría del Medio Ambiente, Dirección de Instrumentación de Políticas, 2003.

The same study also shows that the average distance traveled by vehicles has been increasing consistently over three decades (Figure 2.4), a trend that continued despite the HNC program. This trend points toward an inability or unwillingness of drivers to change modes of travel, and perhaps an ongoing trend toward development around the edges of city leading to longer average commutes.

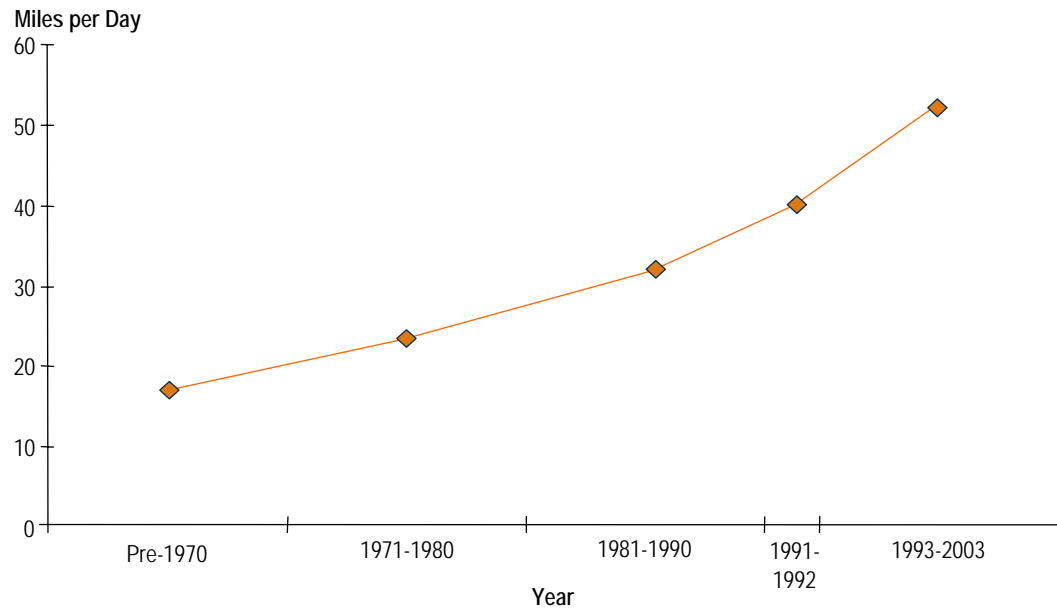
A License Plate Rationing strategy that bans a particular vehicle once every five days could potentially reduce vehicle-miles traveled (VMT) by 20 percent. Many vehicles are exempt from the restriction if they meet certain emission standards, however. The official estimates in 2003 showed that the regulation only restricted around 240,000 vehicles on a given day, accounting for 7.6 percent of the total estimated number of vehicles in the region.<sup>18</sup> The reduction level is forecast to decline to 2.9 percent by 2010 as newer less polluting vehicles come on-line and are exempted from the restrictions. These percentages refer to the number of vehicles affected by the policy, not on traffic.

To enforce the low-emissions exemption, vehicles in the city are required to be tested for emissions regularly. They are categorized according to their emission levels, with those in the “low emissions” category being exempted from HNC. The exemption program was implemented to encourage motorists to shift to newer, cleaner vehicles. Estimates by the Office of Environmental Management (*Dirección General de Gestión Ambiental del Aire*) indicate that the restriction levels

<sup>18</sup>Ibid.

would only apply to 2.9 percent of the circulating vehicles by 2010 as the older, restricted high emission vehicles are replaced by newer low-emission vehicles which are exempt from HNC.

**Figure 2.4 Average Distance Traveled by a Vehicle per Day in Mexico City**



Source: Gobierno del Distrito Federal, Secretaria del Medio Ambiente, Dirección de Instrumentación de Políticas, 2003.

### Future of the Program

Mexico City still faces stiff environmental challenges. The government of Mexico City has proposed various measures aimed at reducing vehicles and emissions on the streets.<sup>19</sup> The proposed measures include expanding the weekday License Plate Rationing restrictions to Saturday, imposing stricter emission standards, and requiring mandatory busing for school trips. In addition, 8,000 new cameras and 100 radar installations are being proposed to monitor traffic infractions.

## 2.2 BOGOTÁ, COLOMBIA CASE STUDY

As the capital city of Colombia, Bogotá is the largest and most populous city in the country with 6.8 million inhabitants.<sup>20</sup> Approximately 20 percent of the population depends upon automobiles as their primary mode of transport.<sup>21</sup>

<sup>19</sup><http://ipsnews.net/news.asp?idnews=39090>.

<sup>20</sup>Government of Bogotá (<http://www.bogota.gov.co/portel/libreria/php/decide.php?patron=01.0101>).

Bogotá (Figure 2.5) is also the capital of Cundinamarca State. However, the city itself is a separate state, referred to Bogotá D.C. (*Distrito Capital*). Figure 2.5 shows the Cundinamarca State and highlights the Bogotá D.C. area.

Figure 2.5 Bogotá Metropolitan in Cundinamarca State



## Transportation System

Buses are the primary mode of public transportation in Bogotá. Before 2001, the city was served mainly by privately operated buses, *busetas* (medium-sized buses), and *colectivos* (vans, minivans, or microbuses). Bogotá also has a large fleet of taxis that serve the capital district and surrounding areas.

---

<sup>21</sup>Department of Statistics, Government of Colombia ([http://www.dane.gov.co/files/censo2005/resultados\\_am\\_municipios.pdf](http://www.dane.gov.co/files/censo2005/resultados_am_municipios.pdf)).

An extensive BRT system called *Transmilenio* (see Figure 2.6) has been implemented since 2000. This system is being expanded and is planned to serve the entire metropolitan area by 2030. Bogotá also has an extensive system of bicycle paths totaling close to 180 miles (300 km) in length – the largest of any metropolitan area in South America (see Figure 2.7).

**Figure 2.6** Bogotá Bus Rapid Transit (*Transmilenio*) Station



Some of the salient features of the transportation system in Bogotá prior to the 2000 referendum for License Plate Rationing are presented below.<sup>22</sup>

- Approximately 140 cars per 1,000 habitants, notably lower than European and North American cities which average more than three times this number;
- Annual addition of approximately 70,000 new cars to an estimated 832,000 existing vehicles;
- Average vehicle speed of 12 miles per hour (19 kilometers per hour);
- Average bus speed during peak hours of seven miles per hour (10 kilometers per hour); and

---

<sup>22</sup><http://ecoplan.org/votebogota2000>.

- The average duration of daily trips in public transportation was two hours and 20 minutes.

Figure 2.7 Bicycle Paths in Bogotá



### License Plate Rationing Program – *Pico y Placa*

The City of Bogotá is located at a height of 8,661 feet (2,640 meters) above sea level and, therefore, has a rarified supply of oxygen. Pollution levels in the city are among the highest in South America and vehicular emissions form almost 60 percent of the contaminants in the air. The City of Bogotá has implemented a number of traffic control measures over the years to combat pollution and improve traffic circulation especially in the downtown area, including reversible and counterflow lanes on key arterial routes.

A referendum was held in 2000 and the License Plate Rationing scheme (*Pico y Placa*) was approved by the voters, 51 percent to 34 percent. The *Pico y Placa* (Peak and License Plate) program was instituted and a commitment was made to follow-up this implementation with an intense development of the mass transit system, specifically the *Transmilenio* BRT service. As part of the same referendum, the city implemented a day without cars on the streets, called *El Día*



*sin Carro* (No Car Day). It takes place on the first Thursday in the month of February each year. Voters approved this measure 63 percent to 26 percent.<sup>23</sup>

The *Pico y Placa* program restricts peak-hour vehicle entry into the city based on the last digit of the license plates. Restriction hours were instituted from Monday through Friday, 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. The restriction applies to all vehicle movement within the whole city and is not limited to crossing a cordon. Bogotá adds another layer of complexity by changing the numbering scheme every year, making it more difficult for households to maintain the right set of license plates to enable access each day of the week. For instance, starting July 1, 2005 vehicles were restricted entry into the city according to the scheme in Table 2.2. Comparatively, starting July 1, 2007 the vehicle restrictions follow the scheme shown in Table 2.3.

**Table 2.2 Pico y Placa Restrictions, July 2005 to June 2006**

Weekday	Plate's Last Digit
Monday	9, 0, 1, 2
Tuesday	3, 4, 5, 6
Wednesday	7, 8, 9, 0
Thursday	1, 2, 3, 4
Friday	5, 6, 7, 8

**Table 2.3 Pico y Placa Restrictions, July 2007 to June 2008**

Weekday	Plate's Last Digit
Monday	1, 2, 3, 4
Tuesday	5, 6, 7, 8
Wednesday	9, 0, 1, 2
Thursday	3, 4, 5, 6
Friday	7, 8, 9, 0

Vehicles with license plates from Bogotá and Cundinamarca State are subject to the *Pico y Placa* restrictions between 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. while vehicles from outside these jurisdictions are restricted from 5:30 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. This is done to discourage people in outer states from starting their travel early to avoid the restrictions.

<sup>23</sup><http://ecoplan.org/votebogota2000>.

The restriction excludes the following vehicles:

- Emergency vehicles (such as ambulances, fire trucks, police cars, etc.);
- Diplomatic vehicles, due to their special jurisdiction;
- Presidential caravan;
- Operative vehicles of public utility companies; and
- School and company buses carrying more than 10 passengers.

This means that around 99.9 percent of private and official vehicles and 90 percent of the vehicles registered in the region must adhere to the restriction.<sup>24</sup>

## Enforcement

One of the unique characteristics of the *Pico y Placa* system is that it does not restrict vehicles for the whole day but rather only during the peak periods. As such, its implementation and compliance standards are different from Mexico City.

Since the rotating numbers can cause some confusion to commuters, there is a grace period for drivers every time a new rotation comes into effect, during which only warning tickets are issued. These fines are steep considering that the 2001 per capita GDP in 2001 was \$6,300.<sup>25</sup>

The City of Bogotá data showed that only three percent of traffic summonses in 2005 corresponded to *Pico y Placa*.<sup>26</sup> Also, during the 2005 “No Car Day,” only 43 vehicles were issued tickets for violating *Pico y Placa* traffic restrictions.<sup>27</sup>

## Impacts

The long-term impacts of *Pico y Placa* are affected by the companion implementation of the BRT system and extensive network of bicycle paths. Given the available documentation, it is not possible to isolate the relative impacts of the various strategies being employed during this period. However, the Bogotá experience does demonstrate the importance of combining License Plate Rationing or other vehicular limitation strategies with major improvements in alternative modes of travel.

Transportation in Bogotá has experienced major changes during the last decade. The introduction of the *Transmilenio* BRT system induced a mode shift from earlier modes of transport such as buses and microbuses to the BRT system.

---

<sup>24</sup><http://ecoplan.org/votebogota2000>.

<sup>25</sup><https://www.cia.gov/library/publications/the-world-factbook/geos/co.html>.

<sup>26</sup><http://www.bogota.gov.co/portel/libreria/php/decide.php?patron=01.0101>.

<sup>27</sup><http://ecoplan.org/votebogota2000>.



Table 2.4 shows the split in daily ridership between the different modes of Transit from 1980 till 2004. The four years following the introduction of *Transmilenio* experienced a significant increase in BRT ridership and a corresponding reduction in bus usage, with *Transmilenio* ridership doubling to 1.2 million by 2006.<sup>28</sup>

The decision to restrict four digits per day implies a theoretical daily vehicular reduction of 40 percent. Rotating the numbers for each day means there would be fewer ways to avoid the restrictions.

**Table 2.4** Pattern of Bus Ridership  
*1980 to 2004*

Vehicle Type	Year							
	1980	1991	1995	1999	2001	2002	2003	2004
Buses	3,863,298	3,379,419	3,264,645	2,520,871	1,934,318	1,837,675	1,848,456	1,625,133
Busetas	1,274,500	2,289,581	1,810,935	1,988,129	1,825,812	1,808,389	1,740,511	1,597,789
Microbuses		253,581	534,419	248,226	679,513	670,622	643,422	780,744
<i>Transmilenio</i>					466,267	642,777	617,522	690,411

Source: Study of urban public transport conditions in Bogotá, 2005.

Consecutive governments, starting with ex-Mayor Antanas Mockus and continuing with the former administration under Mayor Enrique Peñalosa, focused on reducing vehicular traffic within the city by making alternative modes available and more accessible. Extensive programs were created for developing bicycle paths and pedestrian-friendly facilities. Bogotá now has almost 180 miles (300 km) of bicycle paths in the city.

Although the impacts cannot be quantified for each isolated measure, the package of measures has produced benefits in terms of mode shift to transit and bicycle, reduced travel times, and improved average roadway speeds. The availability of energy efficient, faster, and higher capacity *Transmilenio* buses has reduced the demand for privately owned buses. BRT operations offer a 32 percent<sup>29</sup> improvement in travel time for users over other available modes of transit. There have been claims of a mode shift of 9 percent from private vehicles to BRT.

<sup>28</sup>Baltes, M.R., Barrios, J.C., (2006) *Applicability of Bogota's TransMilenio BRT (Bus Rapid Transit) System to the United States*. Arturo Ardila, (2005), *Study of Urban Public Transport Conditions in BOGOTÁ*.

<sup>29</sup>Government of Bogotá (<http://www.bogota.gov.co/portel/libreria/php/decide.php?patron=01.0101>).

Although the impacts discussed above are attributable to the package of measures, there are two notable findings that are specific to the implementation of the *Pico y Placa* program. The first is that the annual rotation of restricted numbers and the corresponding days helped discourage commuters from beating the system. At the onset of the program, the demand for license plates ending in 1, 2, 3, 4, 5, or 6 was high as these vehicles could move around in the city on Fridays. The annual rotation addressed this bias as those vehicles ending in 7, 8, 9, and 0 were permitted on Fridays the following year.

The second lesson learned involves the restriction hours. *Pico y Placa* was implemented for peak hours only due to the presumption that restricting for a complete day would increase a commuter's incentive to purchase an additional vehicle that could be used to access the city on other days of the week. Initially, the plan was implemented from 7:00 a.m. to 9:00 a.m. and 5:00 p.m. to 7:00 p.m., but had to be extended to 6:00 a.m. to 9:00 a.m. and 4:00 p.m. to 7:00 p.m. due to peak spreading. This raised some questions regarding effectiveness of peak-hour implementation as critics of the program argued that increasing restrictions to earlier hours increased congestion in the middle part of the day.<sup>30</sup>

In summary, studies show that the success of *Pico y Placa* in Bogotá is not a singular event.<sup>31</sup> It was implemented as part of a larger effort to simultaneously improve air quality and provide alternatives to the private auto. Perhaps the most significant long-term impact is the positive change in the public's perception of public transit and bicycle use.

## Future of the Program

The Bogotá government continues to pursue the goal of reducing the role of the private automobile in the transportation system. The measures proposed for transportation and traffic improvements include the following:

- Expansion of *Transmilenio* service;
- Integrating private bus operators into the *Transmilenio* framework;
- More car-free days (*Un Día sin Carro*);
- Possibly restricting all private autos during weekday peak hours starting in 2015;<sup>32</sup>
- Renewal of public vehicles, buses, and taxis; and
- Promoting bicycle usage along with clustered land use development in future.

---

<sup>30</sup><http://list.jca.apc.org/public/sustran-discuss/2005-November/004139.html>.

<sup>31</sup><http://www.globalurban.org/Issue1PIMag05/Montezuma%20article.htm>.

<sup>32</sup>World Bank Council for Sustainable Development, *Mobility 2001: World Mobility at the End of Twentieth Century and its Sustainability*.

## 2.3 SÃO PAULO, BRAZIL CASE STUDY

São Paulo is the capital city of the State of São Paulo in southeast Brazil, as shown in Figure 2.8. The city has an area of 588 square miles (1,523 square kilometers) and a population of 11 million<sup>33</sup> making it the most populous in the southern hemisphere.

Greater São Paulo (*Grande São Paulo*) is the metropolitan area around the city and consists of 39 municipalities with a total population of 19.8 million.

Insufficient infrastructure, large population, low gasoline prices, high number of transit and personal vehicles, and a large number of factories in the city have contributed to making São Paulo one of the most polluted cities in the southern hemisphere.

---

<sup>33</sup>[http://www.ibge.gov.br/home/estatistica/populacao/estimativa2006/POP\\_2006\\_DOU.pdf](http://www.ibge.gov.br/home/estatistica/populacao/estimativa2006/POP_2006_DOU.pdf) – Instituto Brasileiro de Geografia e Estatística.

Figure 2.8 São Paulo in São Paulo State



## Transportation System

São Paulo has three main modes of mass transit – São Paulo Metro, a suburban rail network serving the metropolitan area, and a bus system.

The Metro currently operates three lines serving 44 stations in the city. The total length of the network is 37 miles (61 km) and two new lines are under construction. The metro has a daily ridership of around 2.4 million.<sup>34</sup>

The suburban rail system, *Companhia Paulista de Trens Metropolitanos* (CPTM), has six lines that serve the metropolitan region. The CPTM network has average daily ridership of around 1 million.<sup>35</sup>

<sup>34</sup><http://www.metro.sp.gov.br/empresa/relatorio/2005/RAmetro2005.pdf>.

The BRT system, called *Passa Rápido*, and regular buses operate on 394 lines in the metropolitan region with an average daily ridership of around 1.5 million.<sup>36</sup>

São Paulo has a number of expressways that connect to the suburban areas and other large cities. Private vehicles still remain the largest mode of travel. Figure 2.9 shows the usage of different modes of travel between 1967 and 1997. As shown, in 1997 (the most recent data available associated with the implementation of the rationing program) motorized travel accounted for more than 20 million daily trips as compared to 8 million for bus (public road) and around 2 million trips for public rail (metro). (The “Public Rail” category includes the metro and excludes the suburban rail system, and “Public Road” includes all public transport by road, such as buses). The “Motorized Travels” line depicts the sum of trips made by Public Road, Car and Taxi, 2 Wheelers and Other (small motorized vehicles).

The number of personal vehicles in the São Paulo metropolitan area was estimated to be more than 4.5 million in 1997, and there were 12,000 buses circulating within São Paulo. At this time traffic congestion was considered a serious problem: average speed for personal vehicles was around 14 miles per hour (20 kilometers per hour) and an average of 3.2 million personal vehicles circulated every day.<sup>37</sup>

### License Plate Rationing Program – *Rodizio*

A License Plate Rationing scheme known as *Rodizio* was initially implemented as an emergency measure to control pollution levels in the City of São Paulo in 1995 by São Paulo State’s environmental agency, *Companhia de Saneamento Básico do Estado de São Paulo* (CETESB). The implementation proved successful in reducing the level of pollutants, especially Carbon Monoxide, in the air.

In 1996, the State’s environmental agency sought to reestablish the program in 10 municipalities but was only allowed to implement it on an experimental basis for the month of August for the peak hour of 7:00 a.m. to 8:00 a.m. The fine for violating the restriction during this time was equivalent to \$200 at 1996 exchange rates.<sup>38</sup> In 1997, the program was extended to include the entire central area of São Paulo throughout the year. This License Plate Rationing program continued in 1998 and followed the scheme shown in Table 2.5.

---

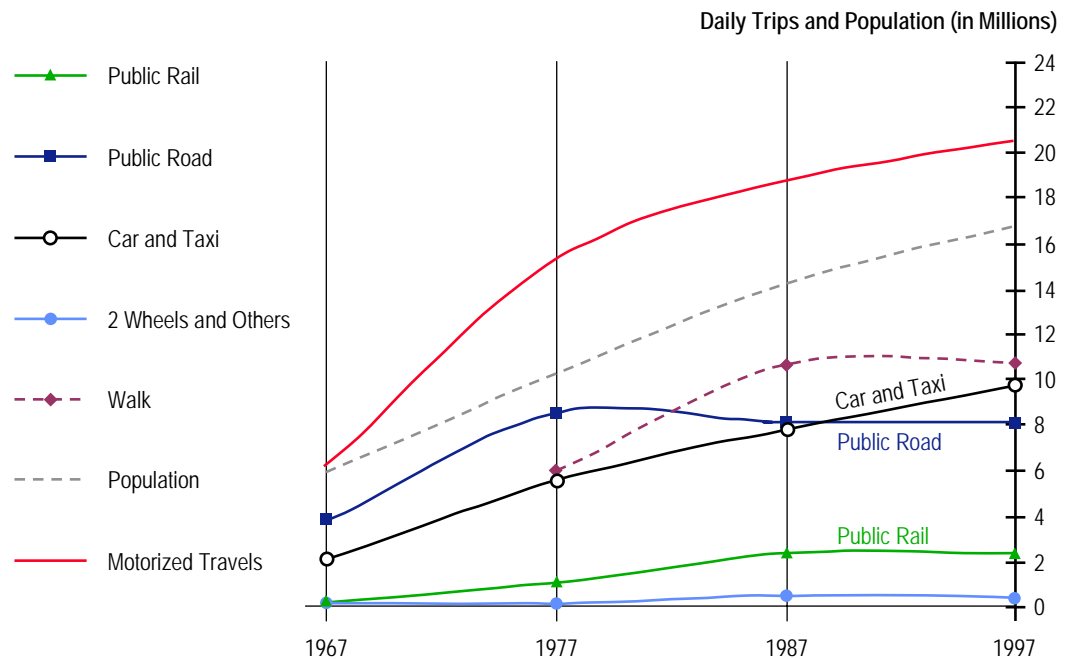
<sup>35</sup><http://www.stm.sp.gov.br/ingesp/english.html>.

<sup>36</sup><http://www.stm.sp.gov.br/ingesp/english.html>.

<sup>37</sup>Pedro Jacobi, Denise Baena Segura and Marianne Kjellén (1997), *Governmental responses to air pollution: summary of a study of the implementation of Rodízio in São Paulo*.

<sup>38</sup>Pedro Jacobi, Denise Baena Segura and Marianne Kjellén (1997), *Governmental responses to air pollution: summary of a study of the implementation of Rodízio in São Paulo*.

**Figure 2.9** Daily Trips by Mode in the São Paulo Metropolitan Region  
1967 to 1997



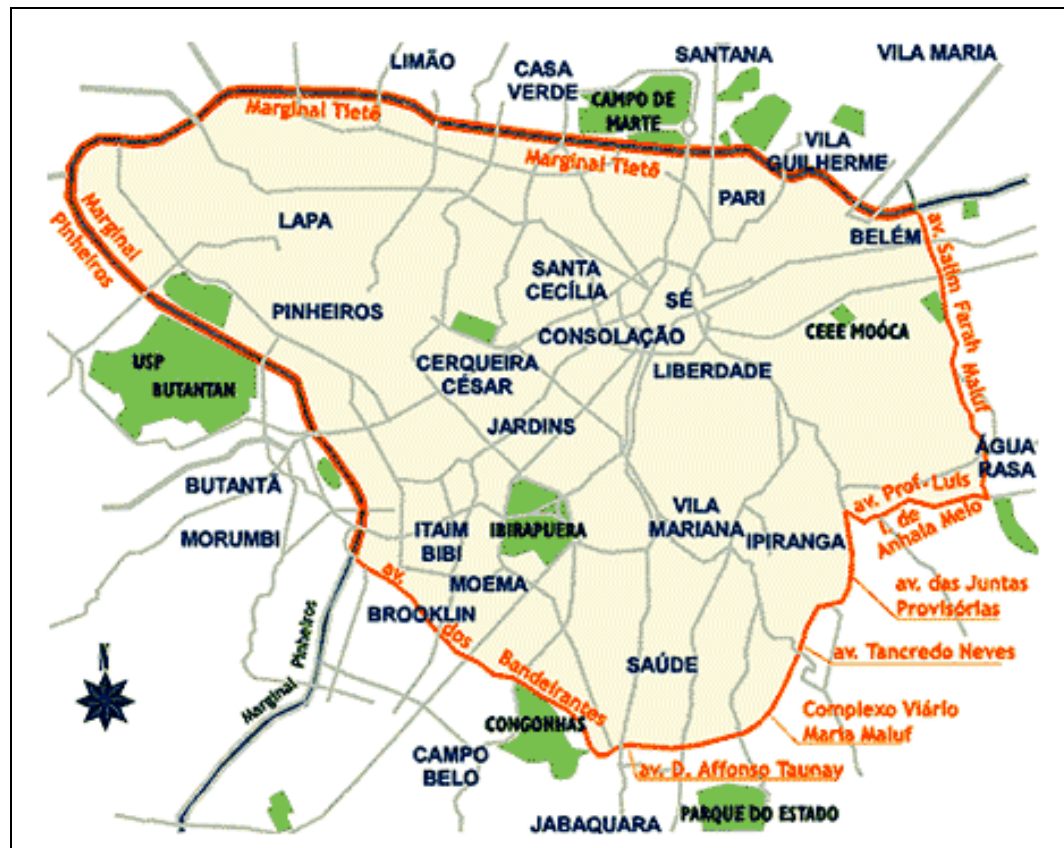
Source: Motorization and Mobility Contrasts in Mega-Cities, World Bank Transport Forum 2000, Washington, D.C. (EH, CMSP, IBGE, and OnibuLis surveys data).

**Table 2.5** *Rodizio* Restrictions by Day of Week

Weekday	Plate's Last Digit
Monday	1 or 2
Tuesday	3 or 4
Wednesday	5 or 6
Thursday	7 or 8
Friday	9 or 0

The restrictions were implemented every workday, 7:00 a.m. to 10:00 a.m., and 5:00 p.m. to 8:00 p.m. The implementation limits of *Rodizio* in São Paulo were defined by the ring road that circles the city as shown by the orange line in Figure 2.10.

Figure 2.10 Implementation Boundary of *Rodizio* (Not to Scale)



## Enforcement

Once *Rodizio* was introduced as a permanent measure in 1997, the fines were reduced to amounts equivalent to approximately \$100. The fines were still quite significant considering that per capita GDP at that time was around \$4,500. The compliance levels in the experimental period were reported to be around 95 percent.<sup>39</sup> Reliable data was not readily available on compliance for the period after the *Rodizio* was made permanent.

## Impacts

Most of the data related to impacts of License Plate Rationing in São Paulo were obtained from the municipality. Independent data sources were not found.

The City of São Paulo's traffic management agency conducted surveys of traffic volume during the peak periods at seven important avenues of the city between October 1997 and March 1998. Compared to volumes before implementation of

<sup>39</sup>Ibid.

*Rodizio*, the results showed a two percent reduction in hourly volumes during the a.m. peak and five percent reduction during the p.m. peak. The City of São Paulo also conducted a field survey to monitor traffic performance on two major city avenues during the same period. Table 2.6 indicates the improvement in both travel time and average speed<sup>40</sup> as concluded by the study.

**Table 2.6 Before and After Comparison of Traffic Measures**

		Before the <i>Rodizio</i>	During the <i>Rodizio</i>	Change
Travel Time	Morning	21 minutes 27 seconds	17 minutes 37 seconds	-18%
	Afternoon	22 minutes 46 seconds	18 minutes 42 seconds	-18%
Average Speed	Morning	11.6 mph (18.6 kmph)	14.25 kmph (22.8 kmph)	23%
	Afternoon	11 mph (17.5 kmph)	13.5 kmph (21.6 kmph)	24%

The City's traffic management agency developed the concept of CQL (Congestion Queue Length) in 1991 to quantify traffic congestion. The measure was based on the empirical distinction between traffic categories by classifying them as free-moving, slow, stop-and-go, or standing. The CQL can be defined as the sum of the queue lengths of the latter three categories.

Average CQL was reduced by 37 percent in the a.m. peak and by 26 percent in p.m. peak after implementation of *Rodizio*. The reduction in CQL during the a.m. peak hour only implementation (7:00 a.m. to 8:00 a.m.) was 17.7 percent.

However, the total number of vehicles on city streets is currently estimated at more than six million, up from 4.5 million in 1997. This large increase of 33 percent indicates that License Plate Rationing has not discouraged vehicle ownership rates.

The impacts of the *Rodizio* after the initial experimental phase are difficult to determine due to a lack of independent studies. The 33 percent increase in the total number of vehicles on city streets by from 1997 to 2007 indicates a lack of effectiveness in reducing traffic. However, a lifting of the *Rodizio* restrictions during the school holidays in July 2007 resulted in record levels of congestion, leading to its immediate reinstatement. In place for a decade, *Rodizio* has become ingrained in São Paulo residents' way of life.

## Future of the Program

The implementation of the *Rodizio* scheme in São Paulo is part of a larger overall initiative to improve the air quality in the city. This initiative, known as *Proconve*, began in 1986. The *Proconve* program is being expanded and will continue to focus on enforcing lower vehicle emissions standards on car manufacturers in Brazil and reducing dependence on gasoline-based vehicles by

---

<sup>40</sup>L Biezus and A.J. Rocha (1999), *Does congestion management improve public transit*.



promoting diesel and ethanol powered vehicles. Also, there are a number of projects underway<sup>41</sup> to develop the city's overall transportation infrastructure.

## **2.4 OTHER IMPLEMENTATIONS**

License Plate Rationing has been implemented in other cities in similar fashions to the programs in Mexico City, Bogotá, and São Paulo. Although there is a limited amount of available research regarding the effects of License Plate Rationing on traffic, pollution, and compliance, a brief description of the implementations in Auckland, New Zealand; Athens, Greece; and Santiago, Chile follows.

### **Auckland, New Zealand**

Auckland is the largest metropolitan area in New Zealand with a population of 1.3 million. A color-based scheme of License Plate Rationing was implemented in Auckland whereby license plates were restricted by color coding rather than by numbers. The program was implemented more than 20 years ago and data sources are very limited. No data was readily available on the impacts of this program.

### **Athens, Greece**

Athens is the capital and largest city of Greece with a metropolitan population of around 3.8 million.<sup>42</sup> Since June 1982, private car traffic has been restricted in Central Athens based on a License Plate Rationing scheme. The restricted areas lie inside the city's ring road system. Taxis also were restricted in the first two years of the implementation, but are now allowed. Buses, bicycles, and motorcycles are exempt from the restriction. The license-plate-based traffic restrictions were introduced in Athens to address high pollution levels and to limit access to the vehicles on alternate days based on odd-even license plates. The License Plate Rationing scheme is implemented inside the ring road that goes around the city. A five square-mile (13 square-km) central area is bounded by the inner ring road and the enforcement is mainly through police patrol at the main entrances to the restricted area. The large coverage area and number of entry points into the city make effective patrolling nearly impossible. A steep fine of 100,000 Greek Drachmas (312€ or \$440)<sup>43</sup> is charged to violators.

---

<sup>41</sup><http://www.stm.sp.gov.br/ingesp/english.html>.

<sup>42</sup>[http://www.statistics.gr/Main\\_eng.asp](http://www.statistics.gr/Main_eng.asp).

<sup>43</sup><http://www.leda.ils.nrw.de/database/measures/meas0205.htm>.

The License Plate Rationing measure was implemented in the summer of 1982 and proved to be useful for the initial period of implementation.<sup>44</sup> The scheme is still in place in the central part of the city and recent discussions have emerged about the complete banning of vehicles from certain parts of the city. However, there has not been any comprehensive proof of the long-term benefits of this measure.<sup>45</sup>

It is widely believed that the measure was rendered ineffective as households with financial means purchased second vehicles to avoid the ban. Car ownership per household in Athens has gone up since the measure came into effect.<sup>46</sup> There has been an increase in taxi usage and a shift in traffic flow from the side streets to the ring roads that surround the city. Athens has moved towards road pricing and other traffic management strategies to address their traffic problems.

### **Santiago, Chile**

Santiago is the largest metropolitan area in Chile with a population of about 5.5 million (2005). A number-based scheme of License Plate Rationing is in effect which is dependent on the pollution levels in the city. As such, drivers have to watch for advisories that prohibit them from using their cars on certain days with high pollution levels.

## **2.5 LESSONS LEARNED FROM CASE STUDIES**

License Plate Rationing has been adopted in a number of places as a measure to alleviate pollution and congestion. Some important lessons can be learned from the adoption of the various vehicle restriction schemes provided in the above case studies. It should be noted that the most prominent and sustained implementations have been in Latin American cities such as Mexico City, Bogotá and São Paulo. Other implementations have occurred in cities such as Athens and Auckland which are substantially smaller than New York City. There have been no implementations of License Plate Rationing in cities which are considered New York's international peers such as London, Paris, Berlin, Tokyo, or in any U.S. city.

- License Plate Rationing is tied to an increase in vehicle ownership rates at more than one location as commuters tried to circumvent the ban. Mexico City serves as a prime example of this consequence, with evidence of increasing levels of vehicle ownership also in São Paulo.

---

<sup>44</sup>G Argyrakos (1986). *The Influence Of Private Car Restrictions On Commuting The Case Of Athens*. International Conference on Commuting, Rome.

<sup>45</sup>*Sustainable Transport: A Sourcebook for Policy-Makers in Developing Cities*.

<sup>46</sup>*Ibid*.

- The increase in vehicle ownership per household drove up the demand for preowned vehicles in Mexico City. This affected the average fleet age in Mexico City, and the older vehicles typically have higher gasoline consumption and higher emissions levels.
- Off-peak traffic was found to increase with the implementation of License Plate Rationing confined to peak periods. Bogotá and Mexico City both saw greater congestion levels during off-peak hours and weekends indicating trip deferrals to times when restrictions are not in effect. This counterbalances the objective of License Plate Rationing to eliminate vehicle trips, but could still have some benefit in decreasing congestion and pollution levels during the restricted periods.
- Taxi usage increased. This was another reason why License Plate Rationing did not result in the projected decrease in gasoline consumption in Mexico City. A number of motorists substituted trips from private vehicles to taxis rather than shifting to low-emission and low-energy consumption modes such as public transportation.
- Improvements in air quality were attributed to better emission standards. When License Plate Rationing was implemented alongside stricter emissions controls (São Paulo and Mexico City), the impacts were more effective.
- License Plate Rationing is more effective when paired with improvements to alternate modes of travel. Bogotá experienced positive impacts of the simultaneous implementation of License Plate Rationing, BRT, and bicycle paths. Mexico City did not show an increase in mass transit ridership after implementation of License Plate Rationing.
- A test period for a License Plate Rationing program can be an effective way to refine the various elements of the program to obtain the best results. However, those affected by the program may react differently over the long term, in ways that reduce the program's effectiveness, as evident in Mexico City.



## 3.0 Application to New York City

New York City is the most populous city in United States with more than 8 million residents. It also is the most densely populated major city in the United States at 26,403 people per square mile (10,194 square km). The island of Manhattan is the business and cultural center of the five boroughs and has a population of around 1.6 million with a population density of 66,940 people per square mile (25,846 square km). New York County (Manhattan) is the densest county in the country.<sup>47</sup>

### 3.1 IMPLEMENTATION OF LICENSE PLATE RATIONING

License Plate Rationing implementation in New York City is presented in this document using two methodologies: the first option would prohibit travel of vehicles into the restricted zone when the last digit of the license plate matches the last digit of the day in the month. The second option would involve color coding the license plates to correspond with a particular weekday on which the vehicle would be prohibited from entering the zone. For the purpose of this analysis, the restricted zone is assumed to be the area south of 86<sup>th</sup> Street in Manhattan.

#### **Alternative 1, Number-Based License Plate Rationing**

In Alternative 1, vehicles would be restricted according to the last number of their license plate and the last number of the numerical date (e.g., a license plate ending in “5” would be restricted on the 5<sup>th</sup>, 15<sup>th</sup>, and 25<sup>th</sup> of each month). This strategy essentially would ban a particular vehicle once every 10 days with a target of reducing weekday traffic by 10 percent.

The number-based rationing is easier to implement since no changes would need to be made to current license plates. This option requires that the implementation policy address issues related to license plates that do not end in numbers and vanity plates. One simple way to address the issue of license plate identifications not ending in numbers would be to base the rationing on a specific digit elsewhere in the license plate identification. For example, if a license plate identification is “123-ABC,” the last numerical digit (in this case, 3) could be the basis for the ration.

Alternative 1 also provides the flexibility to change the number of restricted vehicles by changing the number scheme in the future. For example, license

---

<sup>47</sup><http://www.census.gov>.

plate restrictions in Bogotá (see Section 2.2) restrict four numbers each day of the week. The Bogotá concept probably provides the best implementation blueprint for a number-based scheme. Also, the yearly rotation of these numbers makes it more difficult to beat the system over time. However, like all other License Plate Rationing schemes, it would still be easier for households with multiple vehicles to avoid the ban.

### **Alternative 2, Color-Coded License Plate Rationing**

Alternative 2 would restrict a vehicle one day per week based on a color coded license plate. This strategy essentially would ban a particular vehicle once every five days with a potential target of reducing weekday traffic by 20 percent. Color coding avoids some of the implementation issues associated with the letters and numbers under Alternative 1 and would aide in enforcement, making violators more readily identifiable. The color coding also could be used to ensure all vehicles in one household have the same color, avoiding a major issue with number-based rationing.

This alternative, however, presents a major implementation challenge in terms of providing color codes to all registered vehicles in New York and outside states. Providing the necessary access to out-of-state vehicles would introduce a significant level of complexity. Color coding by household would make the implementation even more challenging. Standardizing the colors across multi-vehicle households would require a major change in how vehicle registrations are handled in the United States (from an individual vehicle to household vehicle basis), and it would have to be done across multiple state jurisdictions (at a minimum, New York, New Jersey, and Connecticut). Therefore, Alternative 2 assumes the color coding scheme applies to individual vehicles (rather than across multi-vehicle households).

## **3.2 IMPACTS**

This section presents an analysis of the impacts and issues that may be anticipated from the implementation of Alternatives 1 and 2 in the area of Manhattan south of 86<sup>th</sup> Street.

### **Traffic Impacts**

A License Plate Rationing program that restricts a vehicle once per week could theoretically affect each vehicle that travels all five days per week. However, the target reduction for weekday traffic may be lower if drivers who currently drive fewer than five days a week have the flexibility to shift their travel to days on which their vehicles are not prevented from entering the CBD. Currently, 32% of drivers using the Battery and Queens-Midtown Tunnels drive less than five times per week and may have the flexibility to shift to days that their vehicles are not restricted from entering the zone.

The potential traffic impact would also be affected by the number of multiple-vehicle households in the region. The 1997/1998 Regional Travel Household Interview Survey<sup>48</sup> (RT-HIS) reports an estimated 45 percent of the households in the New York-New Jersey-Connecticut metropolitan region (excluding Manhattan) have two or more vehicles.<sup>49</sup> These households are better positioned to avoid the ban by using their own alternate vehicle.

Some single-vehicle households might choose to purchase a second car in order to avoid the ban. Given the greater wealth of the region relative to the Latin American cities studied, and higher auto ownership rates, it is likely that many area residents would emulate the adaptation strategy of Mexico City residents by acquiring additional vehicles with a different license plates such that they would be able to drive at least one of their vehicles across the cordon on any given day. As in Mexico City, at least initially many of these additional vehicles might be less expensive, older, less efficient, more polluting vehicles.

Besides new vehicle acquisitions, other strategies which people might employ that would further reduce the effectiveness of rationing might include increased use of taxis and shifting trips to days that the vehicle is not restricted from entering the zone. Finally, the elimination of trips barred by rationing could induce additional demand – new trips could take advantage of less congested roadways.

Considering the above factors, License Plate Rationing impacts on VMT in the New York City CBD will be modeled in a separate analysis using the New York Metropolitan Transportation Council (NYMTC) Best Practices Model, the region's travel demand model.

## **Transit Impacts**

Most of the existing implementations of License Plate Rationing were in cities without a comprehensive public transit system (e.g., Mexico City, Athens) or a system that was introduced or expanded along with the License Plate Rationing implementation (e.g., BRT in Bogotá). New York City has an extensive public transit system in place, but one that is highly congested in certain places during peak periods and may not have the capacity to absorb those restricted from a License Plate Rationing implementation.

The motorists who currently drive into the city already are experiencing delays, in some cases paying tolls, and in some cases high parking costs for access into

---

<sup>48</sup>*Regional Travel Household Interview Survey* (2000) New York Metropolitan Transportation Council (NYMTC) and the North Jersey Transportation Planning Authority (NJTPA).

<sup>49</sup>Survey was conducted in the 28 county New York-New Jersey-Connecticut metropolitan area, including 12 counties in New York, 14 counties in New Jersey, and 2 counties in Connecticut.

Manhattan. In facing these disincentives, the mode choice between the existing modes available to these drivers already has been made. As Mexico City's experience shows, a License Plate Rationing scheme that only looks to push drivers to transit without providing new alternatives could make these drivers pursue a variety of strategies other than shifting modes.

### **Taxi Service Impacts**

As mentioned in Section 2.0, the implementation of License Plate Rationing led to increased taxi usage in all of the cases studied. Mexico City experienced an increase in not just the taxi usage but also in microbus usage. New York City, which already has a taxi fleet of 13,000 vehicles, is likely to witness an increase in taxi usage as well.

### **Commercial Vehicles Impacts**

A License Plate Rationing implementation in New York City could include separate regulations for commercial vehicles. License Plate Rationing could have a profound influence on commercial vehicle behavior by pushing more vehicles to off-peak and weekend periods. In the Mexico City case, many commercial vehicles were exempt from the restrictions (based on a separate emissions scale from passenger cars). The issues associated with various strategies for shifting commercial vehicle travel times are described in a separate technical memorandum.

### **Socioeconomic Impacts**

Since households with more than one vehicle are better positioned to avoid the ban, License Plate Rationing is more favorable to households with multiple vehicle ownership, which is highly correlated with income. More affluent households are better able to adopt strategies to circumvent the intent of the policy. This was most clearly apparent in Mexico City.

## **3.3 ENFORCEMENT**

The first step in enforcing a License Plate Rationing program in New York City would be to develop an implementation strategy. The license plate registration process would need to be modified to enable a fair implementation of the program. This would include involvement of different New York State agencies as well as Departments of Motor Vehicles from surrounding states.

For the program to be most effective, a revised registration process would be needed to issue license plates based on household so that all household vehicles are restricted on the same day. Standardizing the restriction (based on colors or numbers) across multi-vehicle households would require a major change in how vehicle registrations are handled in the United States (from an individual vehicle



to household vehicle basis), and it would have to be done across multiple state jurisdictions (at a minimum, New York, New Jersey, and Connecticut).

The program also would need to be managed proactively as in Bogotá, by changing the restricted number or color scheme annually, to ensure that long-term adjustments by users are not rendering the system ineffective.

The applications of License Plate Rationing in other places have been accompanied by steep fines: \$200 in Mexico City on per capita GDP of \$10,700; \$107 in Bogotá on per capita GDP of \$6,300; and \$100 in São Paulo on per capita GDP of \$4,500. Given a per capita GDP of \$46,617 in New York State in 2006, this level of penalty would translate into fines close to \$900, far in excess of most comparable penalties currently in effect for non-criminal motor vehicle violations in the United States. In addition, Mexico City devotes a large police presence to the enforcement of *Hoy no Circula* (in the absence of high-technology solutions) and impounds violating vehicles for 48 hours.

The international applications of License Plate Rationing have not seen a widespread use of any enforcement via intelligent transportation system (ITS) technology. The Latin American implementations were accomplished with large police presences. For the most part, the cost to enforce the program in the Latin American cities is equal to the law enforcement costs of monitoring vehicles, issuing violations, and collecting the fines.

Although the New York City Police Department Highway Patrol has a Traffic Enforcement fleet of approximately 300 personnel, it would be prudent to consider License Plate Recognition technology to aid in enforcement, allowing the Highway Patrol to focus their resources elsewhere. As with the implementation of additional red light enforcement cameras in New York City, using technology for law enforcement purposes requires new state legislation.

License Plate Recognition is an Intelligent Transportation System (ITS) technology that uses digital photography and optical character recognition algorithms to identify vehicles that pass by a particular location. License Plate Recognition has been used successfully in cordon applications (London, England) and in many toll road projects (Highway 407 in Toronto, Ontario; Citylink in Melbourne, Australia; and the Cross-Israel Highway). License Plate Recognition systems require access to vehicle registration databases in order to extract address information for sending citations to violators. For areas such as New York City, where motorists come from numerous states, the technology would need to be set up to read and recognize license plates from multiple states (including all the variations of customized and specialized plates).

A License Plate Rationing scheme for the Manhattan CBD would likely require the use of License Plate Recognition technology at all bridges and tunnels entering the island of Manhattan. In addition, detectors would be needed at strategic locations inside the city to identify trips originating within Manhattan and crossing the northern boundary of the rationing zone. An estimated 20 License Plate Recognition locations at key entry points to the island would be

required. Inside the city, detectors could be placed along the highways and avenues at constant intervals. An estimated 115 License Plate Recognition locations would be required to cover just the region south of 86<sup>th</sup> Street, including the river crossings. Table 3.1 provides rough cost estimates of implementation of rationing at 115 locations in the city.

**Table 3.1 Cost Estimate for Implementation of ITS Enforcement**

	Readers on Street Grid, East and West Side Highways, and Major Entry Points
Estimated Number of Rationing Stations	115 <sup>a</sup>
Estimated Cost per Rationing Installation	\$412,000
Estimated Total Field Equipment	\$47,380,000
Estimated Central Processing Capital Cost	\$100,000,000
Estimated Annual Field Maintenance	\$9,476,000
Field Visit to Download Images	\$7,774,000
Annual Transaction Cost	\$183,070,000
Annual Operating Cost	\$200,348,000
Annualized Capital Cost	\$17,277,000
Total Capital Cost	\$147,000,000
Total Annualized Cost	\$200,348,000

<sup>a</sup> The actual number of locations would depend on the License Plate Rationing Scheme.

### 3.4 ENVIRONMENTAL EFFECTS

The environmental effects resulting solely from the License Plate Rationing case studies were unclear. The most extensive and objective documentation of the long-term impacts of License Plate Rationing was found for the Mexico City implementation. These studies found that there was no sustained improvement in air quality at any time of the day, no increase in subway ridership, and worsening air quality on weekends and other times outside of the License Plate Rationing scheme.<sup>50</sup> Mode shift was primarily to taxis and small buses rather than to subways, which counterbalanced any improvements likely to be achieved by reductions in auto travel. Demand for gasoline went up after two months of implementation,<sup>51</sup> and Mexico City became a net importer rather than net

<sup>50</sup>Lucas Davis (2006), *The Effect of Driving Restrictions on Air Quality in Mexico City*, University of Michigan.

<sup>51</sup>Eskeland and Feyzioglu (1997), *Rationing Can Backfire: The Day without a Car in Mexico City*, The World Bank Economic Review.

exporter of used vehicles from the rest of the country, meaning that residents sought to evade the restrictions by becoming multi-vehicle households (with variably coded license plates) and began to acquire older (and less fuel efficient and more polluting vehicles) from the countryside. Assessing the air quality impacts in Mexico City is further complicated by the phasing out of leaded gasoline and adoption of U.S. vehicle emissions standards during the same period.

The environmental benefits achieved during License Plate Rationing at most locations were likely due to the improved emission standards that were enforced along with License Plate Rationing (*Proaire* in Mexico City, *Proconve* in São Paulo). Similarly, the expected benefits of License Plate Rationing in New York City might not be realized without complementary measures associated with vehicle emissions standards, strategies to address increased taxi usage, evasion via increased vehicle ownership, and improvements to public transportation.



## 4.0 Key Findings and Conclusions

License Plate Rationing has not been implemented in cities generally considered to be international peers of New York City, such as western European capitals, or Asian cities such as Tokyo or Singapore. For the most part, it has been implemented in Latin American cities with severe air quality problems and very different demographics than New York. This memorandum focuses on the three most enduring and well documented implementations in the Latin American cities of Mexico City, Bogotá, and São Paulo. The experience of these cities offer valuable lessons that shed light on what might be experienced from a License Plate Rationing scheme in New York City. The most relevant conclusions are presented below.

- **Better Chances of Congestion Mitigation when Implemented in Conjunction with Other Strategies** – The Bogotá and Mexico City cases experienced two different effects on transit ridership. The main difference was that in Bogotá drivers were provided with a better public transit system over the existing one, whereas no such measures were taken in Mexico City. It is reasonable to conclude that a driving restriction would not be as effective in influencing commuters to switch modes unless they are provided with transit options that are considerably more attractive than the ones they currently have.
- **Short-Term Benefits May not be Sustainable** – Short-term congestion and air quality benefits may be realized but these may be reduced in the long run as travelers adopt various coping strategies. In each case study, rationing policy was first introduced on a trial basis, then expanded to full-time as the trials seemed to have the desired effects in the short term. Once the policies were made permanent, some motorists were willing to invest in solutions to evade the restrictions (such as taking taxis or acquiring additional vehicles). In addition, some of the mileage reduced from the initial restrictions was offset over the long term by greater off-peak usage, trip deferrals, and induced demand.
- **Socioeconomic Equity** – Since households with more than one vehicle are better positioned to avoid the ban, License Plate Rationing is more favorable to households with multiple vehicle ownership, which is highly correlated with income. More affluent households are better able to adopt strategies to circumvent the intent of the policy. This was most clearly apparent in Mexico City.
- **A robust Enforcement System is Needed** – All three cities impose hefty fines for violations: \$200 in Mexico City on per capita GDP of \$10,700; \$107 in Bogotá on per capita GDP of \$6,300; and \$100 in São Paulo on per capita GDP of \$4,500. Given a per capita GDP of \$46,617 in New York State in 2006, this

level of penalty would translate into fines close to \$900, far in excess of most comparable penalties currently in effect for non-criminal motor vehicle violations in the United States. Mexico City devotes a large police presence to the enforcement of *Hoy no Circula* (in the absence of high-technology solutions) and impounds violating vehicles for 48 hours. Although not currently used elsewhere, ITS technology is available for enforcement purposes.

- **Implementation is a Complex Undertaking** – A significant effort would be required for effective implementation of a License Plate Rationing program in New York City. Outside states would need to actively be involved in the planning stages. To further complicate matters, high auto ownership in the metropolitan area makes it likely that many area residents would emulate the adaptation strategy of Mexico City residents by acquiring additional vehicles with a different license plate code to avoid the ban. Combating such strategies (by standardizing license plates across multi-vehicle households) would require a major change in how vehicle registrations are handled in the United States (from an individual vehicle to household vehicle basis), and it would have to be done across multiple state jurisdictions (at a minimum, New York, New Jersey and Connecticut). Even then, one could imagine further adaptation strategies such as neighboring households swapping vehicles on different days of the week if the government rotated the license plate numbering scheme on an annual basis as in Bogotá.
- **Better Chances of Air Quality Improvements when Implemented in Conjunction with Other Strategies** – Although most implementations of License Plate Rationing around the world were introduced to address environmental problems, the License Plate Rationing strategies alone have not been able to achieve significant benefits. The implementation of stricter vehicle emissions standards together with License Plate Rationing strengthened the effort to improve air quality. License Plate Rationing itself has not provided long-term environmental benefits.

## 5.0 References and Sources of Additional Information

2006 NYC Taxi and Limousine Commission – State of New York Taxi – [http://www.nyc.gov/html/tlc/html/news/info\\_presentations.shtml](http://www.nyc.gov/html/tlc/html/news/info_presentations.shtml).

Arturo Ardila, (2005), *Study of Urban Public Transport Conditions in BOGOTÁ*.

Athens Urban Transportation Network in Facts and Figures, [http://www.oasa.gr/pdf/OASA\\_AR05\\_eng.pdf](http://www.oasa.gr/pdf/OASA_AR05_eng.pdf).

Auckland Road Pricing Evaluation Study, 2005 (<http://www.transport.govt.nz/arpes-index/>).

Baltes, M.R., Barrios, J.C., (2006) *Applicability of Bogota's TransMilenio BRT (Bus Rapid Transit) System to the United States*.

Carfree Cities Network Web Site ([www.carfree.com](http://www.carfree.com)).

DIRECCIÓN GENERAL DE GESTIÓN AMBIENTAL DEL AIRE (2004), *Elementos para la Propuesta de Actualización del Programa "Hoy No Circula" de la Zona Metropolitana del Valle de México*.

Eskeland and Feyzioglu (1997), *Rationing Can Backfire: The Day without a Car in Mexico City*, The World Bank Economic Review.

Frantzeskakis, John M., *Athens 2004 Olympic Games: Transportation Planning, Simulation and Traffic Management*. Institute of Transportation Engineers, ITE Journal, October 2006.

Leo Lemmers (1995), *How Amsterdam Plans to Reduce Car Traffic*, World Transport Policy and Practice, Volume 1, No. 1, pages 25-28.

Joseph Sussman (2006), *Mexico City: Transportation and the Environment* Lecture at Massachusetts Institute of Technology.

Haynes Goddard (1997), *Using Tradable Permits to Achieve Sustainability in the World's Large Cities*, Environmental and Resource Economics, Volume 10, 1997, pages 63-99.

<http://news.bbc.co.uk/1/hi/world/americas/476540.stm>.

<http://ipsnews.net/news.asp?idnews=39090>.

<https://www.cia.gov/library/publications/the-world-factbook/geos/co.html>.

<http://www.bogota.gov.co/portel/libreria/php/decide.php?patron=01.010310>.

[http://www.ecoplan.org/votebogota2000/general/challenge.htm#\\_ednref1](http://www.ecoplan.org/votebogota2000/general/challenge.htm#_ednref1).

Athens Urban Transportation Network in Facts and Figures.

[http://www.oasa.gr/pdf/OASA\\_AR05\\_eng.pdf](http://www.oasa.gr/pdf/OASA_AR05_eng.pdf).

<http://www.leda.ils.nrw.de/database/measures/meas0205.htm>.

[http://www.ibge.gov.br/home/estatistica/populacao/estimativa2006/POP\\_2006\\_DOU.pdf](http://www.ibge.gov.br/home/estatistica/populacao/estimativa2006/POP_2006_DOU.pdf) – *Instituto Brasileiro de Geografia e Estatística*.

<http://www.metro.sp.gov.br/empresa/relatorio/2005/RAmetro2005.pdf>.

<http://www.stm.sp.gov.br/ingesp/english.html>.

<http://www.inegi.gob.mx/est/contenidos/espanol/proyectos/conteos/conteo2005/sintesis.pps>.

<http://www.ste.df.gob.mx/index.html>.

[http://www.ntdprogram.gov/ntdprogram/pubs/top\\_profiles/2005/agency\\_profiles/2008.pdf](http://www.ntdprogram.gov/ntdprogram/pubs/top_profiles/2005/agency_profiles/2008.pdf).

<http://www.dcp2.org/features/47> June 23, 2007, *Clearing the Smog: Fighting Air Pollution in Mexico City, Mexico, and São Paulo, Brazil* by Eliza Barclay – Accessed September 10.

<http://www.mta.info/nyct/facts/ffsubway.htm>.

<http://www.metro.df.gob.mx/operacion/cifrasoperacion06.html>.

<http://www.cato.org/pubs/regulation/reg18n2h.html>.

<http://www.bogota.gov.co/portel/libreria/php/decide.php?patron=01.0101>.

[http://www.dane.gov.co/files/censo2005/resultados\\_am\\_municipios.pdf](http://www.dane.gov.co/files/censo2005/resultados_am_municipios.pdf).

[http://www.idhbogota.pnud.org.co/joomla/index.php?option=com\\_content&task=view&id=37&Itemid=2](http://www.idhbogota.pnud.org.co/joomla/index.php?option=com_content&task=view&id=37&Itemid=2).

<http://ecoplan.org/votebogota2000/>.

<http://bogota.gov.co/portel/libreria/doc/civism%20marked%20cp.doc>.

<http://www.globalurban.org/Issue1PIMag05/Montezuma%20article.htm>.

[http://www.statistics.gr/Main\\_eng.asp](http://www.statistics.gr/Main_eng.asp).

<http://www.leda.ils.nrw.de/database/measures/meas0205.htm>.

<http://www.census.gov/>.

<http://www.mta.info/nyct/facts/ffsubway.htm>.

<http://www.mta.info/nyct/facts/ffbus.htm>.

<http://quickfacts.census.gov/qfd/states/36000.html>.

L. Biezu and A.J. Rocha (1999), *Does congestion management improve public transit*.

Lucas Davis (2006), *The Effect of Driving Restrictions on Air Quality in Mexico City*, University of Michigan.



Luisa Molina and Mario Molina (2002), *Air Quality in Mexico Megacity: An Integrated Assessment*, Kluwer Academic Publishers, Massachusetts.

*Motorization and Mobility Contrasts in Mega-Cities*, World Bank Transport Forum 2000, Washington, D.C. (EH, CMSP, IBGE, and OnibuLis surveys data).

NHTS 2001 Highlights Report, BTS03-05 (PDF). U.S. Department of Transportation, Bureau of Transportation Statistics (2001).

Pedro Jacobi, Denise Baena Segura and Marianne Kjellén (1997), *Governmental responses to air pollution: summary of a study of the implementation of Rodízio in São Paulo*.

Ramon Arigoni Ortiz and Ronaldo Serôa da Motta (2002), *PROCONVE Analysis Part III: The Economic Impact of PROCONVE on Air Pollution Health Effects in São Paulo, Brazil: A benefit transfer exercise*.

Research on Innovative and Strategic Policy Options (RISPO) Good Practices Inventory, UNEP Collaborating Centre on Energy and Environment, 2003 – <http://www.iges.or.jp/APEIS/RISPO/inventory/db/pdf/0043.pdf>.

*Sustainable Transport: A Sourcebook for Policy-Makers in Developing Cities*.

*Towards an Air Quality program for the decade 2000-2010 for the Metropolitan Zone of the Mexico Valley*, Clean Air Initiative.

Travel Demand Forecasting for the Olympic Games Athens 2004.

Victoria Transport Policy Institute, TDM Encyclopedia (<http://www.vtpi.org/tdm/tdm33.htm>).