TRANSPORTATION INFRASTRUCTURE AND NEW YORK'S COMPETITIVENESS

A Background Paper by the

Citizens Budget Commission

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FOREWORD

Founded in 1932, the Citizens Budget Commission (CBC) is a nonpartisan, nonprofit civic organization devoted to influencing constructive change in the finances and services of New York State and New York City governments. This report was prepared under the auspices of the CBC's Competitiveness Committee, which we co-chair. The other members of the Committee are Deborah Buresh, Lawrence B. Buttenwieser, Herman R. Charbonneau, Denis V. Curtin, Karen Daly, Morton Egol, Patricia O'Donnell Ewers, Bud H. Gibbs, William H. Hayden, H. Dale Hemmerdinger, Peter A. Joseph, Ellen Oran Kaden, Walter T. Kicinski, Marianne E. Kozlowski, William P. Lauder, Frank J. McLoughlin, Felix A. Orbe, Laurence G. Preble, Carol Raphael, Arthur H. Rosenbloom, Heather L. Ruth, Lee S. Saltzman, Joseph V. Salzano, Richard B. Teiman, W. James Tozer, Ronald G. Weiner, Robin L. Wiessmann, and Eugene Keilin, ex-officio.

The Competitiveness Committee was created in early 1997 with a mandate to follow up on an important finding of the CBC's December 1996 report, *Budget 2000 Project*. The Commission found that New York City and New York State suffered from high tax burdens on residents and businesses. The Commission, in its 1996 report, made recommendations to reform and to reduce State and local taxes to make New York more competitive, and several of these recommendations have been acted upon. However, the CBC also recognized that an area's economic competitiveness is not determined by taxes alone. State and local governments enhance the competitiveness of their jurisdictions by delivering high quality services and providing well-functioning public infrastructure. The charge of the Competitiveness Committee is to determine New York’s competitive position in terms of service delivery and infrastructure provision, as well as tax burdens, and to make recommendations for improvement.

The Committee began its work by assigning priority to three areas of infrastructure—telecommunications, ground transportation, and airports. A report on the status of New York’s telecommunications infrastructure was completed in November 1998 and was discussed at a conference in that month. This report considers highway and mass transit systems, and work is being initiated for a future paper on airport facilities.

This report is based on a paper prepared by Jeff Zupan, a Senior Fellow at the Regional Plan Association, and Professor Robert Paaswell, Director of the University Transportation Research Center, City College of New York. The authors benefited from the research assistance of Camille Kamga, Yuko Nakanishi and Phillippe Kraal. Charles Brecher, CBC’s Executive Vice President and Director of Research, edited and revised the consultants’ paper into its current form. Nicolette Macdonald, CBC’s Publications Coordinator, prepared the report for publication. An electronic version of this report is available on the CBC’s website at <http://www.cbcny.org>.

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Background

The fiscal health of New York City is tied closely to its economic health; municipal government depends primarily on local revenues to support itself. To attract and retain economic activity the city must be competitive; in an open society people and firms can and will move to the places that they find most attractive.

In assessing the competitiveness of urban areas, employers weigh many factors, including some over which local government has little influence; for example, climate and the availability of private amenities. However, three related aspects of state and local policy do bear significantly on firms' location decisions—taxes, public services, and the infrastructure.

The research activities of the Citizens Budget Commission (CBC) consider each of these three aspects of competitiveness. Prior work has developed a program of tax reform for State and City government that would enhance competitiveness. This program includes reductions in the State's gross receipts tax, reductions in the City's and State's personal income tax, eliminating the City's unincorporated business tax and other counterproductive business taxes, and equalizing local real property tax rates among commercial and residential property.

In order to provide a competitive package of public services with the resulting reduced revenues, New York State and New York City simultaneously must achieve higher productivity in their delivery of services. This will require better utilization of technology, especially information technology, in delivering services and changes in the way public employees are deployed and compensated. To encourage such positive changes, the CBC monitors the performance of municipal agencies and undertakes research to develop recommendations for better use of technology in specific State and municipal agencies.

The third and most recent component of CBC's research program is an examination of the ways in which State and City government can improve the competitiveness of public infrastructure. A critical first step in this analysis is to gain an understanding of where New York stands currently. One can recommend convincingly that taxes be lowered in part because tax burdens are significantly lower in other cities; similarly, recommendations about investments in infrastructure ought to be guided by information about the relative condition and performance of these facilities.

Accordingly, the CBC initiated studies of the competitiveness of three components of New York's infrastructure: telecommunications, mass transportation and airports. Each, in its own way, is vital to the effective performance of business activity.

In November of 1998 the findings of the telecommunications analysis were published. They indicated New York had a superior physical infrastructure to most domestic competitors, but lagged the newer Asian cities of Hong Kong and Singapore in several respects and trailed Silicon Valley in Internet physical infrastructure. New York also suffers from relatively high cost for telephone service that is of lower quality than in most other major domestic urban markets.

This paper presents the findings of CBC's analysis of New York's competitive position with respect to transportation infrastructure serving the local labor market. A subsequent analysis and report will examine airports, including the ground transportation serving the airports.

Scope of the Study

In analyzing New York's competitive position, the size and performance of New York's systems is compared to those of its leading rivals. Thus, two threshold issues are: (1) to what locations should New York be compared, and (2) on what measures or indicators should these urban areas be compared.

With respect to competitive locations, the analysis focuses on New York's domestic and international rivals. Domestically, the nation's second and third largest metropolitan areas, Los Angeles and Chicago are of primary concern. The prime European and Asian world city, London and Tokyo respectively, are New York's major international competitors. Paris is added because it is a potential example of "best practice" for rail transit.

The selected areas are compared with respect to highway systems, bus systems, and rail transit systems. For each system, the urban areas are compared on five dimensions:

1. Scale— the size of the system in terms of miles of track or roads, number of cars or buses and similar appropriate indicators.
2. Efficiency— the cost of operating the system per passenger, per route mile and other appropriate indicators.
3. Service quality— on-time performance, frequency and duration of delays, and similar appropriate measures.
4. Price to the consumer— the price of the service paid by the user, such as subway fares, highway tolls and gasoline taxes.
5. Level of public investment— public sector rates of investment in each system.

Data relating to these dimensions have been assembled from diverse local, national and international sources. Because there is no widely accepted protocol for defining and collecting these measures, the different data sources were examined carefully for comparability. The analysis summarized below incorporates the authors' best efforts to use comparable indicators from the multiple sources, and acceptable data were not always available for each dimension of each system for each region.

The Cities and Their Transportation Task

In analyzing transportation systems, it is essential to examine an entire urban area. The central city, such as New York City or the City of London, may be politically significant, but for transportation infrastructure the entire metropolitan region is most relevant.

New York is the second largest of the six metropolitan areas. With 18.9 million residents, it is substantially smaller than Tokyo with 31.8 million. But New York is larger than Los Angeles (12.3 million), London (12.3 million), Paris (11.0 million) and Chicago (8.2 million).

Tokyo's large population is housed in a land area smaller than Los Angeles, Chicago or New York. Accordingly, Tokyo is the most densely settled city, with 6,152 residents per square mile. In contrast, Los Angeles has a land area more than six times that of Tokyo and a population density of just 428 residents per square mile. New York, spread over 8,321 square miles, is nearly twice as large as London and Paris, and is less densely settled.

Since transportation infrastructure links people and jobs, it is important to consider the scale and density of employment as well as population. As with population, Tokyo is the largest area with over 16.5 million jobs. New York ranks second with over 8.2 million. Los Angeles is third with over 6.5 million, and Paris and London are at 5.7 million and 5.6 million, respectively. Chicago is smallest with under 3.9 million.

Urban regions vary in the extent to which they concentrate jobs within a central city portion of the region. The employment density of Manhattan is over 71,000 per square mile, and over 211,000 per square mile in the central business district south of 60th Street. Tokyo's central business district has a greater employment density (147,888) than all of Manhattan, but is less dense than Manhattan's central business district. Employment densities in the central business districts of London (88,173) and Paris (92,342) also are greater than in all of Manhattan, but well below that in the Manhattan central business district.

The number and density of jobs in the central area of the cities go a long way to define the transport needs in the central area. The number of people entering the central business district in the course of a business day for New York (3,185,000) is greater than in Tokyo (2,990,000), Paris (2,315,000) or London (1,700,000).

Competitive Strengths and Weaknesses

New York's transportation system is unique in the sense that it is less oriented to auto travel then its urban U.S. rivals, but more auto dependent than its international competition; conversely, it is more oriented to rail transit than its domestic rivals, but less so than its international competitors. This unique position is an important context for summarizing the competitive strengths and weaknesses of each of New York's transport modes.

Strengths

A common strength of New York's transportation systems is their large scale. New York's highway, bus and rapid rail systems are the largest among the regions considered, and likely among the largest in the world.

With respect to highways, New York has more miles of roadway (37,066) than each of the other regions including the more heavily auto dependent regions of Los Angeles (26,320) and Chicago (23,644). Even in terms of miles of roads relative to population, New York (2,278 miles per million residents) exceeds Los Angeles (2,177), although not Chicago (3,052).

Perhaps equally important, New York's roads are less congested than those of most of its rivals. The number of vehicle miles traveled per mile of roadway is nearly one-third less than in Los Angeles, about half that in London, and only slightly greater than in Chicago. Similarly, the cost of roadway delays due to recurring high volumes of traffic is less in New York than in Los Angeles, although greater than in Chicago.

With respect to bus systems, New York also has the largest system. Its bus fleet is more numerous (8,684) than that of any of the other five regions, and well above second-place London (6,311). Similarly, the routes traveled by buses are more extensive in New York (5,616 miles) than any of the other regions for which data are available.

Among the six areas' rapid rail systems, New York again stands out as the largest. The number of cars in its rapid rail fleet (6,164) far exceeds that of the domestic and international competitors and is well above second-place London (3,922). The route miles also are greatest in New York (267)—only London comes close (245), with

New York’s system having twice the miles of Paris’ and almost double Tokyo’s. New York’s system also has more stations than any of its rivals, 514 versus 315 in the second-place Paris system.

The data for commuter rail systems are less complete, but the available figures suggest New York also benefits from a relatively large system. Its 990 miles of commuter rail routes is somewhat less extensive than London’s 1,063 miles, but is more extensive than the systems of Los Angeles, Chicago, and even Paris. In Tokyo, where complete data are not available, the commuter system may be larger than in New York.

Weaknesses

While the scale of New York’s transportation systems tends to put the region in first place on that dimension, size is not the only important criteria. On the dimensions of operating efficiency, service quality, and cost to the consumer, New York suffers some competitive weaknesses.

Each of New York’s mass transit systems has a relatively high cost per passenger. For buses, New York’s cost ($1.79) is nearly identical to that in Los Angeles (where passengers travel greater distances) and is above that in Chicago ($1.55); in both of the European cities the cost is far lower ($1.05 in Paris and $.68 in London).

While New York’s rail system has lower costs per passenger than its domestic competitors, it is inefficient relative to international rivals. For rapid rail, New York’s cost per passenger ($1.39) is well above that in Paris ($.80) and Tokyo ($1.03) and exceeds that in London ($1.35). For commuter rail, New York’s cost per passenger ($7.05) is far in excess of that in Tokyo ($1.05) or Paris ($2.96). (Data are not available for London.)

The New York system’s relatively high average cost per passenger is linked to its relatively low intensity of use during much of the day. While crowded at rush hours, New York’s large system serves relatively fewer passengers at other times and operates for 24 hours per day. As a result, the overall "occupancy rate" of rapid rail transit, measured by the ratio of passenger miles to vehicle miles, is nearly three times greater in Tokyo than in New York, and nearly double in Paris. While London has a somewhat lower occupancy rate, it keeps its cost per passenger down by having greater efficiency in operations as evidenced by lower costs per vehicle mile ($4.90) than New York ($6.10).

Low off-peak ridership plays a large role in keeping New York’s cost per passenger high. While the number of trains is reduced during off-peak periods, the Transit

Authority’s policy of operating at least three trains per hour on most lines causes trains to run with low occupancy for much of the night. During the midnight to 5:00 am period, the average number of passengers per car ranges between only 4 and 11 compared to a peak hour frequency of 115.

New York also lags its international competitors in rail transit capital investments. Per capita annual investment in New York ($81) exceeds that of the two domestic competitors, but falls slightly behind London ($87), significantly below Paris ($153) and far behind Tokyo ($511), where land acquisition and other costs are exceptionally high.

Data relating to the quality of transportation services are limited, but the few available indicators suggest relatively poor service in New York. On rapid rail systems, the "on-time performance" is worse than in Tokyo or Paris, where the standards are tougher, and worse than in London, where the same five minute standard of lateness is used.

With respect to highway performance, New York’s vulnerability is "incident-based" delays. The frequency and cost of these delays (as opposed to recurring delays usually linked to chronic high volume) is greater in New York than in either of the domestic competitors despite their greater reliance on auto travel. The problem in New York is probably linked to its geography, which requires a large number of bridge and tunnel river crossings to serve the central business district. Accidents and other "incidents" near these crossings leave auto commuters relatively few options, and hence they suffer long delays.

Another competitive weakness common to each of New York’s transportation options is a relatively high price for the user. For auto use, New Yorkers pay higher prices for fuel than do drivers in its domestic competitors, although U.S. fuel costs are well below those in Europe and Japan. For bus service, charges in New York are relatively steep—average revenue per passenger ($.89) is higher than in all five of the competitor regions with Paris second ($.80). Similarly, for rapid rail service the revenue per passenger in New York ($1.14) is greater than in all the other systems except London ($1.71). The London system generates an operating surplus with its relatively high fares and lower operating costs. Data are less complete for commuter rail, but New York’s revenue per passenger ($3.72) is significantly higher than in Chicago ($2.62), Tokyo ($1.10) or Paris ($2.99).

Finally, New York’s rail system lacks the "hybrid" characteristics found in its foreign competitors. The British Rail commuter lines serve London with multiple stops on lines parallel or connecting to the Underground; Tokyo’s JR system connects outlying areas to multiple, central city stations; Paris’ RER collects suburban passengers and makes numerous stops in the central city at points that connect to Metro lines without additional charge. These hybrid systems are a major draw for suburban commuters and help explain the relatively high occupancy of both commuter and rapid rail systems in international regions.

Issues for the Future

New York is unique in having a transportation system that combines an extensive highway system that rivals American counterparts and a rapid rail system that rivals those of European competitors. Enhancing this distinctly advantageous balance will require wise investments for the future. In considering these investment decisions, New York's leaders should address three key issues: (1) How to improve transit system efficiency and ridership; (2) How rapidly to achieve a state of good repair for the existing infrastructure; (3) How much new mass transit capacity is necessary.

How to Improve Efficiency and Ridership. New York's mass transit system would be more competitive if it could operate with a lower unit cost of service. The challenge has two components—first, to lower fixed operating costs; second, to increase vehicle occupancy in order to achieve lower costs per passenger.

The focus of this paper is physical infrastructure, and it is beyond the scope of this analysis to assess comprehensively the management practices that determine the mass transit system's basic operating costs. These include wage rates and staffing patterns established as part of collective bargaining, as well as practices over which management has more direct control. However, the New York system's high operating cost per vehicle mile relative to Chicago and London suggest its transit leaders might learn from the operations of these systems. An initiative aimed at identifying modern human resource measures could help enhance New York's future competitiveness.

In addition to operating practices, the efficiency of mass transit depends on attracting a high volume of passengers. Relative to most of its competitors, New York's bus and rail systems are less intensively used. Given the substantial fixed costs, attracting more riders to the existing system would reduce average costs per passenger. Since peak hour trains are already relatively crowded, efforts to increase ridership should focus on off-peak hours.

In 1998 ridership increased nearly 8 percent compared to an annual average increase of just over 1 percent during the 1992-1997 years of economic recovery. While some of the 1998 gain is related to continued job growth, the more influential factor was probably new fare policies. Volume discounts and weekly and monthly fares with unlimited use were introduced during the year. They have had the intended effect of increasing ridership, and most of the gain is likely to have been in off-peak hours.

Continued innovation in fare policy holds the potential of making New York competitive with other world cities in terms of more efficient operation of mass transit.

How Much to Invest in Repairing Existing Systems. One of New York's competitive advantages is its extensive highway and rapid rail system. A key issue for the future is how rapidly to achieve a state of good repair for these facilities.

Complete data are not available for the entire region, but the Comptroller of the City of New York recently completed a major study of the capital costs of repairing local infrastructure. The study included an assessment of whether the City's current capital plans would meet the goal of putting the New York City highway network and the New York City transit system in a state of good repair. In both cases, the Comptroller found current capital plans allocated less than was needed.

With respect to highways and related facilities, the Comptroller estimated that about $12.2 billion was needed over the ten-year period spanning fiscal years 1998 to 2007; in contrast, only $8.1 billion is allocated by the City leaving a more than $4 billion gap.

The major source of the gap is in highway maintenance. Using a desired road resurfacing cycle of 15 years and reconstruction cycle of 40 years, the Comptroller estimates the City's roads require nearly $5.3 billion in such work over the ten-year period. The City's capital plan provides less than $2.9 billion, leaving a $2.4 billion gap. This suggests significant deterioration in the City's roads over the next decade.

With respect to mass transit, the Comptroller estimated that more than $20.4 billion is needed to achieve a state of good repair for the facilities operated by the Transit Authority. The Transit Authority currently has a capital budget that extends only through 1999; authorization of a new five-year capital plan is expected in the 1999 or 2000 legislative session. However, the TA has developed spending estimates for the 1997 to 2001 period.

A comparison of the Comptroller's estimates and the TA's plans suggest a state of good repair will not be achieved by the end of 2001. Measured in dollar terms, the major gaps fall in four capital budget categories—line structures, signals, line equipment, and stations and communications. These four items account for $9.7 billion of the $10.7 billion gap.

How Much New Capacity is Needed. Any effort to accelerate the pace at which existing systems are brought to a state of good repair inevitably will compete for resources with initiatives intended to create new transit capacity. Resources are limited, and the goals of achieving good repair and of expanding capacity each have large price tags.

The case for building new rail capacity has four elements: (1) Some rapid rail lines are now highly crowded during the rush hour, and more capacity would alleviate this condition. (2) For some commuters, trips are longer than desired due to lack of direct access to rail lines and to the need for inconvenient transfers between modes. New lines could serve areas not now reached by rail transit and eliminate the need for some transfers, thereby speeding commutation times. (3) Significant future job growth is possible, and new capacity would enable currently crowded systems to transport workers to these potential jobs. (4) Suburban commuters from some areas are poorly served by limited access to some parts of the CBD; new hybrid-type rail capacity could create more rapid and convenient access for Long Island commuters destined for the East Side (the LIRR now terminates only at Penn Station on the West Side), for Westchester commuters headed to the Wall Street area (Metro North now terminates only at Grand Central in Midtown), and for New Jersey commuters destined for the East Side (New Jersey Transit services now terminate either downtown or on the West Side).

In the New Jersey portion of the region, projects consistent with these goals are being pursued. New Jersey Transit is implementing three major expansions of its commuter lines. First, the Kearny Connection, completed in 1996, allows trains from Morris and Essex counties access to the Northeast Corridor line and Penn Station in New York. Second, the Secaucus Transfer, scheduled for completion in 2002, will permit commuters from Bergen, Passaic, Rockland and Orange counties to transfer in the Meadowlands and to reach Penn Station, avoiding Hoboken, and saving 20 minutes or more per trip. Third, the Montclair Connection, will connect two rail lines in Montclair, bringing the Boonton line running through Essex and Passaic counties to Penn Station.

The MTA also has expansion plans to benefit New York commuters. In the 1980s a new tunnel was completed between Queens and Manhattan at 63rd Street. The MTA plans to expand service using the tunnel in two ways. First, the subway tunnels will be extended from the existing Queens station to connect with the E and F lines at Queens Boulevard. This will make it convenient for passengers from Queens to reach the Upper East Side and other Manhattan destinations. Second, a new LIRR service will be established from existing tunnels in Queens through the 63rd Street tunnel and then through new planned underground tunnels to Grand Central Terminal. This will increase the number of LIRR trains that can reach Manhattan during the rush hour and give Long Island commuters an option to arrive at either Penn Station or Grand Central.

Additional expansions to the region's rail systems have been proposed by the Regional Plan Association. Its 1996 plan, *A Region at Risk*, laid out a plan using a hybrid vehicle whenever possible. The plan, dubbed Rx or Regional Express Rail, calls for 25 miles of new rail right-of-way. The estimated cost was $21 billion in 1996 dollars. The portion of the plan dealing with the Second Avenue corridor was expanded in 1999. In coming years the region's leaders will make decisions about how much of the proposed new capacity should be built, and whether it should be financed by deferring repair of existing systems or through new funding raised by taxes, higher fares or other means.

As new projects such as those proposed by RPA are considered, two other ways of relieving peak-hour congestion also should be given attention. Using pricing policies to shift ridership from the peak to "shoulder" periods is one such option. The MetroCard technology could make it possible to determine the effect that peak-hour pricing would have in shifting use from the crowded 8:00 am to 9:00 am hour to the "shoulder" time before and after. To date, the new pricing initiatives have been designed to increase off-peak ridership by giving discounts, and the results in 1998 suggest they have been effective. Experiments with higher fares at the busiest time could identify effective ways to shift some ridership to the less crowded hours. The initiative could be made even more effective if employers were encouraged to cooperate by facilitating flexible working hours.

Another measure for increasing capacity is modernized signaling systems. One element of the existing mass transit system which has not yet achieved a state of good repair is the signaling and train control systems. With current equipment, headways must generally be at least about two minutes. Modern signaling and train control systems are capable of reducing safe headways. If achieved on New York City's busiest subway lines, this could increase the number of rush hour trains from a maximum of 30 to 40.

An additional consideration in assessing large new construction proposals is the future impact of projects underway and likely to be completed in coming years. In addition to the New Jersey Transit projects described earlier, the MTA's Queens subway connection and its LIRR connection to the East Side are expected to be completed within a decade. These projects will add significantly to capacity. The new LIRR connection is projected to permit 24 trains per hour to reach Grand Central, for an increase in capacity of about 35,000 people per hour or over 70,000 during the full morning peak. The expanded Queens subway lines (B and Q) potentially could increase their rush hour ridership from the 1997 level of under 1,900 per hour to an equivalent of the E and F lines, nearly 40,000 in the peak hour. If combined with peak-pricing and new signal systems to reduce headway, these expansions could create significant new capacity to accommodate job growth and reduce rush-hour crowding.

INTRODUCTION

As this century nears its end, New York is recognized as a global leader among cities. New York is a financial capital, a media and entertainment center, a fashion center, and a home to academic institutions. Simply put, New York is a place where people come together to be creative and to make money. It thrives because its density permits all of this to occur in a concentrated area.

Transportation infrastructure is critical for the efficient conduct of these concentrated activities. Roads and transit systems move people to work. This report examines the transportation infrastructure used to transport people on the ground. Not included are the systems that carry freight by rail or over water. A subsequent CBC report will analyze the airport system, including ground transportation to airports.

In analyzing transportation infrastructure, the critical concern of this report is New York's competitive position. The size and performance of New York's systems will be compared to those of its leading rivals. Thus, two threshold issues are: (1) to what locations should New York be compared, and (2) on what measures or indicators should these urban areas be compared.

With respect to competitive locations, the analysis focuses on New York's domestic and international rivals. Domestically, the nation's second and third largest metropolitan areas, Los Angeles and Chicago are of primary concern. The prime European and Asian world city, London and Tokyo respectively, are New York's major international competitors. Paris is added to this list because it is often recognized as a "world class" city and its mass transit system has a reputation for good service.

The selected areas are compared with respect to highway systems, bus systems, and rail transit systems. For each option, the urban areas are compared on five dimensions:

1. Scale— the size of the system in terms of miles of track or roads, number of cars or buses and similar appropriate indicators.
2. Efficiency— the cost of operating the system per passenger, per route mile and other appropriate indicators.
3. Service quality— on-time performance, frequency and duration of delays, and similar appropriate measures.
4. Price to the consumer— the price of the service paid by the user, such as subway or bus fares, highway tolls and gasoline taxes.
5. Level of public investment— public sector rates of investment in each system.

Data relating to these dimensions have been assembled from diverse local, national and international sources. Because there is no widely accepted protocol for defining and collecting these measures, the different data sources were examined carefully for comparability. The analysis presented below incorporates the authors' best efforts to use comparable indicators from the multiple sources, and acceptable data were not always available for each dimension of each system for each region.

The remainder of this report is divided into six parts. Section two describes the fundamental task of transportation—to move people between activities—and how this task is affected by an area's geography, history and economic activity. These key features of each of the selected regions are presented. These distinguishing features are then related to how different modes—roads and public transit—have assumed different roles in each city. Sections three, four and five cover highway, bus, and rail transit systems, respectively. They present findings for each system with respect to New York's standing in terms of scale, efficiency, service quality, price, and level of public investment.

The sixth section summarizes New York's strengths and weaknesses in transportation infrastructure relative to its major competitors. The final section considers New York's future. It identifies the key policy issues that should be addressed in making investment decisions that will shape the future of New York's transportation system.

THE CITIES AND THEIR TRANSPORTATION TASK

The shape, size, density and historical pattern of development in a region determine the characteristics of travel demand and of the transportation systems needed to serve them. Because no two urban areas are alike, the way people move about within them are also different. For this reason, the analysis begins by describing the geography of each region, its size measured by both population and area, and the density of population and employment.

The geographic characteristics of an urban area, particularly barriers to travel such as water bodies or hilly terrain, can make travel more difficult or expensive. The more people in an area, the more trips likely made there, adding to the transportation burden. The level of employment affects the number of trips made for work, which in turn affects the amount of peak period travel and the capacity of the infrastructure needed to support it. The spatial relationship between population or work force and the job location also affects the transportation infrastructure. High commuter volumes can result if there is a substantial imbalance, with job-holders living in one district and the jobs in another.

A population spread over a large land area will stretch the length of their trips and of the transportation necessary to serve them. A compact development pattern will translate into more effective transit systems, since more potential riders will have access to them. But higher density has its price. At higher densities travel by private auto over the road network becomes slow, while at lower densities auto travel is likely to be faster.

Geography and History

New York, like most major cities, grew around a body of water. Four of the five New York City boroughs are on islands. The well-protected New York harbor was the basis for the region’s commerce and economic growth into the first half of this century. New York traded with the whole world by water and the rail network that fanned out to the rest of the nation.

The transportation asset in years when waterfront attracted commerce later became a barrier to growth. To overcome the barrier, rail transit tunnels were built to carry the New York City subway network between Manhattan and the boroughs of the Bronx, Brooklyn, and Queens, as were rail commuter tunnels to cross the Hudson, East and Harlem Rivers. Beginning with the Brooklyn Bridge in 1883 and ending with the Verrazano Bridge in 1964, rubber-tired vehicles assumed a larger share of the transportation burden, knitting together New York’s boroughs and adjacent suburban counties. These massive rail and road public works—33 crossings into Manhattan—

made it possible to concentrate activities there, allowing workers to live outside, but still commute in by road or rail.

Chicago grew along Lake Michigan. The Chicago River, although a less formidable barrier than the water bodies in New York, defined its loop or central business district. Chicago's greatest period of growth came with the expansion of the inter-city rail network. Its central location put it at the confluence of this network. Farm products and manufactured goods could easily be transported between their origins and the markets to the east. Chicago also became the pre-eminent gateway to the growing west. The metropolitan area initially grew around the rail lines. In more recent years, growth has fanned out in all directions (except the east, due to Lake Michigan), where flat farmland has given way to new suburbs.

Los Angeles too grew because of water— the ports of Los Angeles and nearby Long Beach are a substantial part of the metropolitan area's commerce. But until this century, water was also a constraint on growth. Aquaducts from the east were needed to import water for a city that could not survive without it. With this new water supply, Los Angeles was able to grow rapidly at the advent of the automobile age. Early transit lines were plowed under to make way for an extensive freeway network. The shape of Los Angeles' sprawling settlement was made possible by its road network, constrained by the Pacific Ocean to the west and the mountains and desert to the east.

London started as an urban area in the Roman Empire, and grew around both banks of the Thames River, navigable to the North Sea and the North Atlantic**.** London grew as a series of self-contained, but connected villages. The curved, narrow and complicated pattern of streets today reflects the paths people have taken for nearly 2,000 years. This charm in London's appearance makes auto traffic movement quite difficult. London has added some major arterials, and some limited access highways, but auto capacity is relatively low. To sustain reasonable access to central London without building American style highways, the national government improved rail access through development of new underground lines, a new light rail line to serve the Docklands, and improvement of British Rail commuter services within greater London.

Tokyo is the largest city in an island country limited by its geography. Much of Japan is mountainous, but Tokyo lies within the Kanto Plain, one of the few areas of relatively flat land, making it possible to contain its large population. The filling of Tokyo Bay has opened the way for expansion of industry too. Its vast industrial area is centered along Tokyo Bay from the south City to Yokohama. Tokyo, like London is shaped by historic patterns of growth with a complicated street system—many narrow, less than an average block long, and following no simple geometry.

Paris is located on both sides of the Seine River, in the north-central part of France. A Gallic tribe known as the Parisii founded the city approximately 2,000 years ago, and in 987 Paris was established as the capital of France. Paris has become the economic and industrial center of France, as well as one of the premiere cultural centers of the world. Since World War II the population of the city has almost doubled. Growth has been consciously limited in the historic core by focusing development in sub-centers outside the core, but connected to the core and to each other with high quality transit links.

Population Size and Density

Geographic characteristics bear on each region's population size and density. In considering these attributes, it is most relevant to examine an entire urban area. The central city, such as New York City or the City of London, may be politically significant, but for transportation infrastructure the entire metropolitan region is most relevant. In fact, the major function of ground transportation arguably is to link the central city and its highly suburban labor force.

As shown in Table 1, New York is the second largest of the six metropolitan areas. With 19.7 million residents, it is substantially smaller than Tokyo with 31.8 million. But New York is larger than Los Angeles (15.6 million), London (12.3 million) and Paris (11.0 million). Chicago is the smallest of the group with 8.6 million residents.

Tokyo's large population is housed in a land area smaller than Los Angeles, Chicago or New York. Accordingly, Tokyo is the most densely settled city, with 6,152 residents per square mile. In contrast, Los Angeles has a land area more than six times that of Tokyo and a population density of just 460 residents per square mile.

New York, spread over 8,321 square miles, is nearly twice as large as London and Paris, and is less densely settled. New York's average of 2,363 people per square mile is below the comparable figure for London (3,022) and Paris (2,387). Chicago is more densely settled than Los Angeles, but considerably less dense than the other global centers.

To gain additional perspective, it is helpful to plot the cumulative population and area of each region. Figure 1 plots the curves for the three American areas as of 1990. In its densest 1,000 square miles, Los Angeles contains about 2.5 million people, Chicago about 5 million, and New York about 13 million. In this area, New York is five times as dense as Los Angeles, and 2 and one half times as dense as Chicago. Figure 1 can be viewed a different way—how much area does it take to account for a given population level. Five million people are housed in Los Angeles' most dense 2,000 square miles, Chicago's most dense 1,000 square miles and New York's most dense 200 or so square miles. That is, Chicago is denser than Los Angeles near its core, but not nearly as dense as New York's core.

Figure 2 plots the population and area curves for the three foreign regions and New York. At the 2,000 square mile benchmark Paris and London contain about 9 million people each, with New York at the 13 million cited above. But Tokyo has 17 million people living within that area. When examined from the other perspective, all four cities account for their first 5 million people in fewer than 1,000 square miles. Paris and London each take 2,400 square miles to reach 10 million, New York takes about 800 square miles and Tokyo only about 600 square miles.

Employment and Employment Density

Since transportation infrastructure links people and jobs, it is important to consider the scale and density of employment as well as population. The relevant data are summarized in Table 2.

As with population, Tokyo is the largest area with over 16.5 million jobs. New York ranks second with over 8.2 million. Los Angeles is third with over 6.5 million, and Paris and London are at 5.7 million and 5.6 million, respectively. Chicago is smallest with under 3.9 million.

Employment density varies widely among the areas. Tokyo is most dense with 3,200 jobs per square mile, and London and Paris have 1,380 and 1,244 jobs per square mile, respectively. In contrast the New York region has 989 jobs per square mile, well below the international cities' average densities, but significantly more dense than Chicago (584) or Los Angeles (193).

Table 2 figures reflect average employment density for the entire region. However, urban regions vary in the extent to which they concentrate jobs within a central city portion of the region. Table 3 shows employment density for each central city, and for the even smaller central business district within New York City. The relative densities of the central cities remain the same—New York is more dense than Chicago and Los Angeles, but less dense than the three foreign cities. However, the pattern varies if the New York central city is defined more narrowly as Manhattan or as the central business district within Manhattan. The employment density of Manhattan is over 71,000 per square mile, and over 211,000 per square mile in the central business district. Tokyo's central business district has a greater employment density (147,888) than all of Manhattan, but is less dense than Manhattan's central business district. Employment densities in the central business districts of London (88,173) and Paris

(92,342) also are greater than in all of Manhattan, but well below that in the Manhattan central business district.

The number and density of jobs in the central area of the cities go a long way to define the transport needs in the central area. Table 3 also shows the number of people (all modes and auto only) entering the central business district in the course of a business day for New York and its three foreign counterparts. Reflecting its high employment density, the New York central business district is greatest on both an absolute and per square mile basis. In addition, a higher percentage of trips into New York's central business district are by automobiles; New York has almost double the auto entries as Paris, almost triple that of London and almost six times that of Tokyo.

Differing Roles of Transportation Modes

The different geographic configurations and historical patterns of development among the regions have led to different patterns of residential and employment location. These factors also shape the different mixes of transportation modes.

Table 4 presents data indicating the variation in reliance upon autos and rapid transit. For both transit and auto use, New York falls between the other U.S. regions and the foreign ones. Indicators of transit use are lower for New York than for London, Tokyo, or Paris and higher than Chicago or Los Angeles. Chicago's transit use ranges from one-fourth to one-third of New York's; Los Angeles has one-tenth or less transit use than New York. Transit trips per capita in London are somewhat below New York's, but for the other two rapid transit indicators London shows greater use. Tokyo transit indicators are 252 percent, 106 percent, and 43 percent greater than New York's, and Paris shows substantially higher transit use too.

Similarly, the auto and highway indicators show that New York lies between its American competitors and its foreign ones. New Yorkers drive fewer miles and own fewer autos than people in Chicago or Los Angeles, but are more auto-oriented than residents of either London or Tokyo.

HIGHWAY INFRASTRUCTURE

As the previous section suggests, the role of highway systems in urban centers varies among places. Some are far more dependent on auto use than others. Nevertheless, it is instructive to compare the scale, efficiency, and other characteristics of each region's highway infrastructure.

Table 5 presents key characteristics for the highway networks of New York and four competitor areas. The U.S. urban areas have invested substantially more in a roadway system than their international rivals. London, with a population near New York's, has less than one-quarter the roadway miles; Tokyo, with double New York's population, has one-third of New York's roadway miles. Among the U.S. urban areas, New York has more miles of highways, including limited access ones, than Chicago and Los Angeles.

More miles are driven in New York than in any other area except Los Angeles, but when measured per mile of roadway, New York's roads are less intensively used than either Los Angeles' or London's, and considerably more than Tokyo's. New Yorkers drive fewer miles per capita than either residents of Los Angeles and Chicago, but much more than London and Tokyo residents. This is consistent with auto ownership patterns; fewer residents of the two foreign cities own cars. (Refer to Table 4.)

London has had and continues to have a policy of minimizing new highway starts, especially limited access highway development. Tokyo, on the other hand, is building highways rapidly. Their limitation is the availability and cost of land.

The highway network in New York is characterized by a heavy reliance on major water crossings, reflecting the region's water-dominated geography. (See Table 6.) Collectively, these bridges and tunnels carry over 2.5 million vehicles per day. The George Washington Bridge carries over 250,000 vehicles per day, and the Alexander Hamilton, Queensboro, Triboro, Verrazano-Narrows, Brooklyn, Tappan Zee and Bronx-Whitestone bridges, and the Lincoln Tunnel all exceed 100,000 vehicles per day. Because these crossings create pinch-points in the network, they are especially vulnerable to breakdowns, where there are few choices in the event of an incident that slows or blocks traffic.

The Federal Highway Administration and local governments collect data on operating conditions of roads in the United States, and it is converted by the Texas Transportation Institute to measures of congestion and delay. (See Table 7.) Unfortunately, similar data could not be found for the selected foreign regions. The average speed on New York's limited access highways compares favorably with Chicago and Los Angeles, but average speed on the arterial system is slower.

Perhaps more important is the cost associated with delays due to highway congestion. As shown in Table 7, the delays are attributable either to recurring traffic volume or to "incident-based" delays due to more unpredictable events such as accidents. The total cost from both sources is highest in Los Angeles at $10.8 billion annually, lower in New York at $9.8 billion, and lowest in Chicago at $4.0 billion. On a per capita basis, the cost to Los Angeles residents is more than 50 percent higher than to New Yorkers, while Chicago is about 10 percent less. The cost to New Yorkers is disproportionally the result of incidents on the road, rather than predictable and recurring traffic volumes. This suggests that New York's highway network is less able to respond quickly to unexpected events, perhaps a result of its reliance on so many water crossings.

The regions also vary considerably in their level of public investment in highways. Table 8 shows total and per capita investment for five areas. Tokyo's spending is greatest in both absolute and per capita terms, reflecting its expensive land and construction costs as well as its aggressive highway expansion program. On a per capita basis, London spends only about two-thirds as much as New York, while Chicago spends more than twice as much.

Consumers, that is drivers, pay for the use of highways through both tolls and the cost of gasoline. Table 9 shows the average fuel costs in the five regions. The cost in Chicago and Los Angeles is slightly lower than in New York, but the cost in the two foreign cities is about three times higher than in the American cities. In part, this reflects the willingness of other countries to tax gasoline heavily, either for general revenue purposes or for earmarking revenues toward transportation. In the U.S. areas, taxes are about 50 cents per gallon or about 40 percent of the price; in Tokyo and London taxes are $1.75 and $1.50 per gallon, respectively, and constitute about half the price.

Highway tolls are more prevalent in the New York region than elsewhere in the United States. About 45 percent of the toll revenue in the nation is collected in the states of New York and New Jersey. The nations' four highest ranking toll authorities are in the region: MTA Bridges and Tunnels, the Port Authority of New York and New Jersey, the New Jersey Turnpike Authority, and the New York State Thruway Authority.

Chicago has one toll agency that operates toll roads in the suburban areas of the region. Los Angeles has begun to experiment with a specialized toll road—a HOT lane, which allows drivers with no passengers to use high occupancy lanes for a price that varies by level of congestion. Tokyo has independent authorities operating toll roads. The tolls fully support all capital and operating expenses. They are approximately four times the price per mile of tolls on the New York State Thruway.

BUS SYSTEMS

Buses are a form of mass transit that operates on highway infrastructure. Buses may be operated by a public agency or privately, and each region typically has multiple bus operators. For this comparative study it was not possible to obtain data on all bus operations in each region; rather, the analysis focuses on the major systems in each city.

In New York, this analysis includes the Bus Division of the New York City Transit Authority and New Jersey Transit’s Bus Operations. In Chicago and Los Angeles, the analysis includes buses operated by the respective public authorities also operating rail transit systems. In London, it includes the privately franchised bus lines accountable to the London Transport Buses Unit. In Tokyo, the analysis includes public lines operated by the Tokyo Metropolitan Government and numerous private lines regulated by government. In Paris, the analysis includes buses operated by RATP.

Among the six regions, New York has the largest bus system in terms of both number of vehicles and route miles. (See Table 10.) New York’s fleet of 8,689 buses is larger than the fleet in London (6,311) or Tokyo (6,022), and far greater than the fleet in its domestic rivals of Chicago (2,028) and Los Angeles (2,211). The route miles of the New York system (5,616) also are greater than in Tokyo (4,088), Paris (1,633) and Chicago (2,020), but data are not available for London and Los Angeles.

While New York’s system is relatively large, it does not have the high vehicle utilization characteristic of the international competitors. Each bus travels fewer miles annually than in the other five regions, and the occupancy as measured by passenger miles per vehicle mile, is well below that in Los Angeles, London, Paris and Tokyo. This is partly due to the fact that the transit systems in New York City and Chicago operate 24 hours per day. The other systems shut down for at least 5 hours per day, so the buses in New York and Chicago travel with lighter loads during the late night hours, reducing the overall daily passenger miles per vehicle mile.

The relatively limited use of New York’s large fleet makes it a relatively expensive system to operate (See Table 11.) New York’s cost per passenger mile is greater than the figure in each of the other areas and is more than double the cost in London. Similarly, the cost per passenger also is higher in New York than each of the other cities except Los Angeles. Los Angeles has a relatively low cost per passenger mile, but a high cost per passenger, because of the relatively long distances traveled by passengers on its bus routes.

Given its high costs, it is not surprising that New York has high average fares. Revenue per passenger is greater in New York than in each of the other cities. Despite the high fares, New York also has a higher deficit per passenger than Chicago and Paris, and than London, which makes a profit with lower average revenues.

RAIL TRANSIT

Rail transit systems are typically divided into two categories—rapid rail and commuter rail. Rapid rail is the familiar subway, elevated or underground. These systems serve the central city, carrying large numbers of people over a network linking residential neighborhoods with business areas. They trade comfort for speed and reliability. Operated in trains of from two to ten cars, they link stations usually one quarter to one half mile apart and operate on short headways (the time between successive trains). These headways during peak periods can be as low as two minutes.

Commuter rail systems are designed for longer hauls than the rapids. They serve to collect riders from suburban areas, bringing them to terminals in the central city. They operate with longer headways (15 minutes to 30 minutes in peak periods) and with longer distances (often 1 to 4 miles) between stations.

In a few cities an attempt has been made to combine the long haul characteristics of commuter rail with the distributional characteristics of rapid rail. In this "hybrid" arrangement, commuter rail runs parallel to rapid rail, or intersects rapid rail at many points along its route, rather than at just a terminal station. For example, in Tokyo, London and Paris, a rider can leave a commuter rail and make a connection with the rapid rail lines with no new fare payment at a large number of stations. The line, of course, can be used in reverse; a rider can use a rapid rail to access a commuter line and ride it to a desired station.

In London, British Rail has many of its commuter rail lines in stations that connect with rapid rail—the Underground—to increase the access of riders to greater portions of London by rail. Thus a London Southeast Line Rail train makes several stops that are also stops for the Underground (London Bridge for example) coming from south of the Thames before arriving at a terminal—Charing Cross. In London, areas south of the Thames, traditionally underdeveloped, and the Docklands, an area of East London being redeveloped, will be served by Underground development planned to link with commuter rail and other Underground lines.

In Paris and Tokyo the effort to combine the characteristics of rapid rail and commuter rail services has been taken a step further. Each region has a distinctive "hybrid" rail system. In Paris the Réseau Express Régional (RER) picks up passengers in suburban areas and has multiple stops in the central city with free transfers to the rapid rail system. In Tokyo, the Japan Rail (JR) system operates in a similar fashion. There are 34 hybrid stations, and JR serves as an important urban distributor as does Tokyo Metropolitan Subway system. In Tokyo, this concept of "joint access" has permitted the development of nine "downtowns," each with its own identity (government center, shopping, electronics, etc). These areas are similar to Wall Street or Midtown in New York. Tokyo's downtowns are high density, high rise, and served by the hybrid system.

In contrast, New York has only ten points of connection between commuter lines and rapid rail lines, and these are all at rail terminals. The terminals are in New York and Newark and serve as points of transfer from commuter rail to subways. New York lacks a direct central city distributor mechanism as part of the commuter rail system.

The New York region's rail transit system for the purposes of this report includes the New York subway system, operated by the New York City Transit Authority within the Metropolitan Transportation Authority (MTA), the Metro North and Long Island Rail Road, also units of the MTA, and Staten Island Rapid Transit, another arm of the MTA, the PATH rapid transit system operated by the Port Authority of New York and New Jersey, and the commuter rail network in New Jersey, operated by New Jersey Transit.

The rail network in Chicago is operated under the authority of the Regional Transportation Authority, which has as subsidiaries the Chicago Transit Authority (rapid transit) and METRA (commuter rail). The Los Angeles County Metropolitan Transportation Authority operates two light rail lines and one rapid transit line. Metrolink operates the commuter rail network.

In London, the subway or Underground system is operated by London Transport, a regional governmental body, which also supervises private bus lines. Commuter rail services are operated as part of a national railroad service that was privatized by 1993 legislation. The railroad infrastructure is owned by Railtrack, a private company. Rail service is provided through 25 franchises, including 12 operating in the south-east of England where London is located.

In Paris, the Metro, most of the RER, and buses are operated by the Régie Autonome des Transports Parisien (RATP). It is operated as a national company with a board accountable to the national government. The Societé National des Chemins de Fer Français, a state-owned company, operates regional railroads and a part of the RER. Overall responsibility for regional transport policy and coordination of services rests with the Syndicat des Transports Parisiens.

In Tokyo, there are two subway operations— the Teito Rapid Transit Authority with eight lines and the Bureau of Transport of the Tokyo Metropolitan Government with four subway and one tram lines. Commuter train service is divided almost equally between Japan Railways (JR) and several private operators; both JR and the private lines have arrangements with the two subway authorities to run commuter trains on the subway track lines, permitting the hybrid-type service described earlier.

Scale of Rail Systems

Table 12 presents a portrait of the scale of rail transportation systems in each region. Two key points emerge from the data.

First, in terms of physical infrastructure New York has the largest systems, and this is especially true for rapid rail. New York's rapid rail fleet of 6,164 cars is more than 50 percent larger than that of London (3,922) or Paris (3,469); New York's 267 miles of track routes is slightly larger than London's 245, and well above Tokyo's 149; similarly, New York has 514 stations, well above Paris' 315 and London's 261.

The evidence is less clear-cut with respect to commuter rail systems, in part because the data are incomplete. In terms of route miles, London's system (1,063 miles) is somewhat larger than New York's (990), and both London and New York exceed the 801 in Paris (872 including the RER), but comparable figures for the commuter lines in Tokyo are not available. New York's 414 commuter rail stations are somewhat less than the 457 in London, but greater than the 397 in Paris. In terms of fleet size, New York's commuter rail system with 2,888 cars is significantly smaller than that of Tokyo (6,756) or London (4,777).

The second significant point is that despite the relatively extensive physical infrastructure, New York's system is smaller than that in Tokyo, London, and Paris, in terms of the number of passengers carried. In each case, the foreign regions' systems are able to carry more passengers primarily because of the greater role played by the commuter rail systems, and the "hybrid" elements of that system. Tokyo's commuter system carries more than 20 times as many passengers as New York's; London's commuter system nearly five times as many, and Paris' system more than twice as many. When the separate hybrid systems in Tokyo and Paris are added to the mix, the entire rail system in Tokyo carries about eight times as many passengers as in New York; and both London's and Paris' rail system handles substantially more passengers than does New York's.

In brief, the foreign cities' rail transportation systems carry far more passengers than New York's, but *not* because they are bigger in terms of physical infrastructure. Rather, they are used much more intensively; this is partly a function of operating efficiencies (discussed below), partly related to the greater attractiveness of the "hybrid" operations which distribute commuter rail passengers more effectively in the central city than do New York's commuter lines, and partly tied to the more limited highway systems available to potential auto users in the foreign cities.

Operating Efficiency

In general, New York's rail system is more efficient than those of its domestic competitors, but is less efficient than its foreign competitors. (See Table 13.) In 1995, the average cost per passenger in New York on rapid rail trains was $1.39; this is below the cost in Chicago ($2.05) and Los Angeles ($3.61), similar to the cost in London ($1.35), but well above the cost in Tokyo ($1.03) and Paris ($.80). New York's relative cost is even more striking on commuter rail systems; its average cost per passenger ($7.05) is nearly seven times greater than in Tokyo ($1.05), more than twice that in Paris ($2.96) and about 50 percent higher than in Chicago ($5.24). Only the new and relatively underutilized commuter system in Los Angeles costs more per passenger.

A system's efficiency as gauged by cost per passenger is determined by two factors. One is the management practices and labor costs related to operating a train; that is, the cost of running a train regardless of how many people opt to ride on it. This element of efficiency is reflected in the statistic "operating cost per vehicle mile." The second factor is the extent to which trains are filled with passengers; the more a train is used, the lower will be the cost per passenger. This aspect of efficiency is reflected in the statistic, "passenger miles per vehicle mile."

As shown in Table 13, these two elements play a varying role in explaining New York's relative inefficiency for rapid rail transit. The operating cost per vehicle mile in New York ($6.10) is greater than in London ($4.90), but is actually lower (i.e., more efficient) than in Tokyo ($13.88) and Paris ($7.01). For Tokyo and Paris, the lower cost per passenger is attributable exclusively to the more intensive use of the system; the ratio of passenger miles to vehicle miles is nearly twice as great in Paris (42) as in New York (22), and the ratio in Tokyo (62) is nearly triple New York's figure. In contrast, New York does somewhat better than London (18) in this respect, and London's lower cost per passenger is attributable exclusively to its lower operating costs per vehicle mile.

To the extent lower costs per passenger are related to more intensive system use in other systems, it is worth repeating that New York's relatively low utilization reflects in part two important policies. First, national transportation policies have created more extensive highway systems in New York and other U.S. cities, creating more attractive options for auto use then are available in foreign regions. Second, the New York City system, unlike its foreign competitors, operates 24 hours per day with less intensive use during the late night hours.

The importance of 24-hour operations in explaining the relatively low overall utilization of the New York system is illustrated in Table 14. The hourly number of Transit Authority passengers traveling into the CBD varies from over 370,000 in the peak morning hours to less than 2,000 in the 2:00 am to 3:00 am period. While the number of trains is reduced significantly for the off-peak periods, the policy of sustaining headways of no more than 20 minutes for most lines causes trains to run with low occupancy in off-peak periods. During the "owl-shift" of midnight to 5:00 am, the average number of passengers per car ranges between 4 and 11 compared to a peak hour figure of 115.

Less complete data are available to analyze commuter rail efficiency. With respect to Tokyo, its operating cost per vehicle mile ($8.40) and its passenger to vehicle mile ratio (69) are better than New York’s cost of $9.65 and ratio of 35. With respect to Paris, its cost per vehicle mile ($6.98) is well below New York’s, but its ratio of passenger to vehicle miles (25) is actually worse than New York’s. Chicago outperforms New York in the ratio of passenger to vehicle miles (41), but has a higher operating cost per vehicle mile ($10.02).

While the data are not shown in Table 13, it should be noted that the independent "hybrid" systems in Tokyo and Paris are highly efficient. The cost per passenger on the RER was $1.21 and on the JR $1.13; both figures are below the cost for rapid rail in New York.

Price to the Consumer

The regions have varying fare policies. For rapid rail, Chicago and Los Angeles each have a flat fare—one price to ride within the central city. In 1997, that fare was $1.50 in Chicago and $1.35 in Los Angeles. New York, until recently, had the same policy. In 1997 the New York City transit system had a flat fare of $1.50 and the PATH fare was $1.00. Beginning in 1998 a new system was introduced for New York City mass transit. The basic fare is still $1.50, but 11 rides are available for the price of ten if the swipe card known as MetroCard is used. MetroCard can also be used for unlimited use weekly and monthly passes for $17.00 and $63.00, respectively, as of July 1998. In January 1999 a day pass at $4.00 was introduced.

The non-U.S. regions have distance-based or zoned fares. They also have discounted fares through weekly or monthly passes. London, Paris and Tokyo also offer passes that enable the rider to use the "hybrid" feature; that is, connect from the commuter rail line operating in the central city to the rapid transit system on the same ticket or pass. This intermodal operation is important in attracting and distributing large numbers of passengers in the dense cores. In 1998 New York’s MTA introduced an option for monthly commuter passes that also serve as a MetroCard, thereby facilitating movement between commuter and subway lines.

All commuter rail systems are based on a distance based fare— the longer the ride, the greater the fare. All systems also have discounted commuter fares— the monthly ticket.

Given the varying fare policies, a meaningful basis for comparison is average revenue per passenger for each system. (See Table 15.) Among the rapid rail systems, London generates the most revenue per passenger ($1.71). This is more than its average operating cost per passenger, permitting the system to generate a significant operating surplus. After London, New York has the highest average revenue per passenger ($1.14); those revenues are well above the average in Tokyo ($1.05), Paris ($.60) and Chicago ($.85).

Despite its relatively high revenue per passenger, New York’s low operating efficiency means it has a relatively high deficit as well. While the domestic competitors have per passenger deficits greater than New York’s, two foreign competitors do better. As noted above, London’s system operates with a surplus, and this is also the case in Tokyo. In Paris the deficit per passenger ($.14) is slightly greater than in New York ($.11).

With respect to commuter rail, complete data are not available for London. Among the other regions, New York has relatively high revenues per passenger. Its average of $3.72 is just below the Los Angeles figure ($3.80), but exceeds the per passenger revenue in Chicago ($2.62) and in Paris ($2.96), and is more than triple those in Tokyo ($1.10). Moreover, because of the relatively inefficient operations, New York has a relatively high deficit per passenger ($2.99) despite the high revenues. The commuter systems in Tokyo and Paris each have a surplus, and the deficit per passenger in Chicago is a lower $2.03. Only the new and highly subsidized system in Los Angeles has a higher deficit per passenger than New York.

While the data for the two separate hybrid systems are not shown in Table 15, it is worth noting that their charges are well below those of the commuter lines and that they operate with a surplus. The RER has average revenues per passenger of $1.32 and a surplus per passenger of $.16; the JR’s respective figures are $1.30 and $.29.

Service Quality

Two important aspects of rail transit quality are comfort and reliability. For mass transit, comfort is related to the degree of crowding, particularly at rush hour. Good indicators of this aspect of quality are not available, but the data on the ratio of passenger miles to vehicle miles suggest a tradeoff. The systems with higher efficiency due to higher occupancy of trains are probably also more crowded.

However, it again is important to note the impact of 24-hour operations and wide variation in ridership during the day on New York City's mix of efficiency and comfort considerations. The low off-peak ridership and associated overall relative inefficiency coexist with significant crowding during peak hours. As shown in Table 16, the indicator of comfort, square feet per passenger, is a comfortable 11.1 for the 24-hour period in total; however, during the peak morning hours it falls to 4.2. On some specific subway lines the rush hour figure falls to an even lower 3.6 (the F line from Queens) and 3.7 (the Lexington Avenue line from the Bronx). However, even at this peak the system in 1997 exceeded the minimum "crush" standard set by the MTA of 3.0 square feet per passenger, which is higher than the standard set by the Paris Metro of 1 square meter for every four passengers. Nonetheless, organizations in New York such as the Regional Plan Association advocate higher standards, which would cause several subway lines to be defined as "overcrowded" during peak periods.

With respect to reliability, the most common measure is "on-time" performance. The standard used to gauge on-time performance varies among the regions; New York and London define "on-time" as within five minutes of schedule, while in Paris the tolerance is three minutes and in Tokyo just one minute. The areas with the more stringent standard also had the best performance. In 1995, Tokyo's rapid rail system performed on-time 98 percent, in Paris the figure was 87.5 percent, and in London 85 percent; New York had the worst performance (80 percent).

Public Investment

In the New York region, a sizable investment was made in recent years in improving the rail transportation systems. Since the early 1980s, nearly $30 billion in 1998 dollars has been invested. (See Table 17.) Of the $30 billion, just over half ($15.2 billion) was spent by the MTA for its subway system—almost $1 billion per year for the 16-year period. The Port Authority spent over $1.3 billion on PATH, and the three commuter rail networks received $9.7 billion to upgrade their facilities. Another $3.2 billion was spent on the region's bus systems.

Capital investments have three basic objectives—to sustain the system at a state of good repair, to replace the fleet on a regular basis, and to expand the system. In New York the MTA's investments were primarily to bring the system to a state of good repair after years of neglect; this purpose accounted for fully 62 percent of the funds. The subway system restored over 500 miles of track and refurbished over 60 stations. The two commuter rail networks rehabilitated stations and maintenance facilities, upgraded track and signals, and added parking. Replacing the bus and rail fleet accounted for 32 percent. Fully 5,600 subway cars, more than 1,000 commuter rail cars and 4,300 buses were purchased or overhauled. Only 6.4 percent of the capital spent since the early 1980's went into expanding the rail network.

The level of investment in rail transit in New York, nearly $1.6 billion annually, trails that in Tokyo, where the astounding figure of $16.2 billion is driven by high land acquisition and other costs. New York also lags Paris in transit investments in both absolute and per capita terms. When these investments are compared per capita, New York ($81 per capita) exceeds its two domestic competitors, but falls slightly behind London ($87) as well as Paris ($153) and Tokyo ($511). (See Table 18.)

The balance or relative priority of rail versus highway investment varies among the regions. London has much more strongly favored rail, investing $1.74 in these projects for every dollar spent on highways. Similarly, Tokyo, despite strong pressure to build new roads, spent $1.29 on rail for each highway dollar. In contrast, Chicago and Los Angeles each gave much greater priority to highway investment, spending only 31 cents and 17 cents, respectively, on rail transit for each highway dollar. In this respect, New York seems more like its international competitors giving transit greater priority than highways with a ratio of $1.12 per highway dollar.

COMPETITIVE STRENGTHS AND WEAKNESSES

As noted earlier, urban transportation systems have developed in different ways in different regions due to particular geographic and historical circumstances. New York's system is unique in the sense that it is less oriented to auto travel then its urban U.S. rivals, but more auto dependent than its international competition; conversely, it is more oriented to rail transit than its domestic rivals, but less so than its international competitors. This unique position is an important context for summarizing New York's competitive strengths and weaknesses.

Strengths

A common strength of New York's transportation systems is their large scale. New York's highway, bus and rapid rail systems are the largest among the regions considered, and likely among the largest in the world.

With respect to highways, New York has more miles of roadway than each of the other regions including the more heavily auto dependent regions of Los Angeles and Chicago. Even in terms of miles of roads per capita, New York exceeds Los Angeles, although not Chicago.

Perhaps equally important, New York's roads are less congested than those of most of its rivals. The number of vehicle miles traveled per mile of roadway is nearly one-third less than in Los Angeles, about half that in London, and only slightly greater than in Chicago. Similarly, the cost of roadway delays due to recurring high volumes of traffic is less in New York than in Los Angeles, although greater than in Chicago.

With respect to bus systems, New York also has the largest system. Its bus fleet is more numerous than that of any of the other five regions, and the routes traveled by buses are more extensive in New York than any of the other regions for which data are available.

Among the six areas' rapid rail systems, again New York stands out as the largest. The number of cars in its rapid rail fleet far exceeds that of the domestic and international competitors; the route miles also are greatest in New York—only London comes close, with New York's system having twice the miles of Paris' and almost double Tokyo's. New York's system also has more stations than any of its rivals, 514 versus 315 in the second-place Paris system.

The data for commuter rail systems are less complete, but the available figures suggest New York also benefits from a relatively large system. Its 990 miles of commuter rail routes is somewhat less extensive than London's 1,063 miles, but is more extensive than the systems of Los Angeles or Chicago, and even greater than in Paris. In Tokyo, where complete data are not available, the commuter system also may be larger than in New York.

Weaknesses

While the scale of New York's transportation systems tends to put the region in first place on that dimension, it is important to remember that size is not always the most important criteria. On the dimensions of operating efficiency, service quality, and cost to the consumer, New York suffers some competitive weaknesses.

Each of New York's mass transit systems has a relatively high cost per passenger. For buses, New York's cost ($1.79) is nearly identical to that in Los Angeles (where passengers travel greater distances) and is well above that in Chicago ($1.55); in both of the European cities the cost is far lower ($1.05 in Paris and just $.68 in London).

While New York's rail system has lower costs per passenger than its domestic competitors, it is inefficient relative to international rivals. For rapid rail, New York's cost per passenger ($1.39) is well above that in Paris ($.80) and Tokyo ($1.03) and exceeds that in London ($1.35). For commuter rail, New York's cost per passenger ($7.05) is far in excess of that in Tokyo ($1.05) or Paris ($2.96). (Data are not available for London.)

The New York system's relatively high average cost per passenger is linked to its relatively low intensity of use. This, in turn, is linked to its 24-hour operations and exceptionally low use during off-peak hours. The "occupancy rate" of rapid rail transit, measured by the ratio of passenger miles to vehicle miles, is nearly three times greater in Tokyo than in New York, and nearly double in Paris. While London has a somewhat lower occupancy rate, it keeps its cost per passenger down by having greater efficiency in operations as evidenced by lower costs per vehicle mile ($4.90) than New York ($6.10).

A similar problem characterizes New York's commuter rail system. As noted above, cost per passenger far exceeds that in Tokyo and Paris. The causes of this inefficiency are related to management practices that push the cost per vehicle mile in New York ($9.65) above those in Tokyo ($8.40) and Paris ($6.98), and probably to relatively low occupancy in New York (complete data are not available for the other systems).

New York also lags its international competitors in rail transit capital investments. Per capita annual investment in New York ($81) exceeds that of the two domestic competitors, but falls slightly behind London ($87), significantly below Paris ($153) and far behind Tokyo ($511), where land acquisition and other costs are exceptionally high.

Data relating to the quality of transportation services are relatively limited, but the few available indicators suggest relatively poor service in New York. On rapid rail systems, the "on-time performance" is worse than in Tokyo or Paris, where the standards are tougher, and worse than in London, where the same five minute standard of lateness is used.

With respect to highway performance, New York's vulnerability is "incident-based" delays. The frequency and cost of these delays (as opposed to recurring delays usually linked to chronic high volume) is greater in New York than in either of the domestic competitors despite their greater reliance on auto travel. The problem in New York is probably linked to its geography, which requires a large number of bridge and tunnel river crossings to serve the central business district. Accidents and other "incidents" near these crossings leave auto commuters relatively few options, and hence they suffer long delays.

Another competitive weakness common to each of New York’s transportation options is a relatively high price for the user. For auto use, New Yorker’s pay higher prices for fuel than do drivers in its domestic competitors, although U.S. fuel costs are well below those in Europe and Japan. For bus service, charges in New York are relatively steep—average revenue per passenger is higher than in all five of the competitor regions. Similarly, for rapid rail service the revenue per passenger in New York is far greater than in all the other systems except London. The London system generates an operating surplus with its relatively high fares and lower operating costs. Data are less complete for commuter rail, but New York’s revenue per passenger is significantly higher than in Chicago, Tokyo or Paris.

Finally, New York’s rail system lacks the "hybrid" characteristics found in its foreign competitors. The British Rail commuter lines serve London with multiple stops on lines parallel or connecting to the Underground; Tokyo’s JR system connects outlying areas to multiple, central city stations; Paris’ RER collects suburban passengers and makes numerous stops in the central city and points that connect without additional charge to Metro lines. These hybrid systems are a major draw for suburban commuters and help explain the relatively high occupancy of both commuter and rapid rail systems in international regions.

ISSUES FOR THE FUTURE

The previous discussion of New York’s strengths and weaknesses suggests that it already has considerable advantages and that the area’s position could be further enhanced by addressing relative weaknesses. However, New York’s leaders should not seek simply to replicate what exists elsewhere. New York is unique in having a transportation system that combines an extensive highway system that rivals American counterparts and a rapid rail system that rivals those of European competitors. Enhancing this distinctly advantageous balance will require wise investments for the future. In considering these investment decisions, New York’s leaders should address three key issues: (1) How to improve transit system efficiency and ridership; (2) How rapidly to achieve a state of good repair for the existing infrastructure; (3) How much new mass transit capacity is necessary.

How to Improve Efficiency and Ridership

New York's mass transit system would be more competitive if it could operate with a lower unit cost of service. As noted earlier, its current cost per passenger exceeds that of rail and bus service in other world-class cities.

The problem has two components—first, to lower fixed operating costs; second, to increase vehicle occupancy in order to achieve lower costs per passenger.

The focus of this paper is physical infrastructure, and it is beyond the scope of this analysis to assess comprehensively the management practices that determine the mass transit system's basic operating costs. These include wage rates and staffing patterns established as part of collective bargaining, as well as practices over which management has more direct control. However, the New York system's high operating cost per vehicle mile relative to Chicago and London suggest its transit leaders might learn from the operations of these systems. An initiative aimed at identifying modern human resource measures could help enhance New York's future competitiveness.

In addition to operating practices, the efficiency of mass transit depends on attracting a high volume of passengers. Relative to its competitors, New York's bus and rail systems are less intensively used. Given the substantial fixed costs, attracting more riders to the existing system would reduce average costs per passenger. Since peak hour trains are already relatively crowded, efforts to increase ridership should focus on off-peak hours.

For the largest component of New York's system, the Transit Authority subway lines, ridership currently is well below its previous high levels. Peak use occurred in 1946, before auto ownership and suburbanization flourished in the post-World War II period. In that year over 2.0 billion trips were made on the subways, about 80 percent more than the 1.1 billion trips in 1998. (See Figure 3.)

In the post-war period, ridership declined partly in response to the shift from a six-day to a five-day workweek. However, over most of the period ridership has followed the trend in central business district (CBD) employment. CBD employment declined in the late 1940s and continued to 1959; from then until 1969 CBD jobs grew slightly; from 1969 to 1977 the CBD lost over 20 percent of its jobs. As shown in Figure 3, subway ridership followed the same pattern, declining in the 1950s, stabilizing in the 1960s, and then dropping rapidly after 1969.

An economic recovery began in the late 1970s and reached a temporary peak in 1987; CBD jobs then declined again in the early 1990s, and bounced back after 1992. Unlike past situations, subway ridership did not respond positively in the early 1980s to the improvement in the economy. The subway system was at its most deteriorated condition then. During this period off-peak ridership was particularly hard hit, a consequence of the deteriorated condition of the subways and of growing affluence and car ownership. Beginning in the early 1990s subway ridership stabilized, and it has grown in the latest economic recovery.

The increase in ridership in 1998 is particularly striking. It increased nearly 8 percent compared to an annual average increase of just over 1 percent during the 1992-1997 years of economic recovery. While some of the 1998 gain is related to continued job growth in the CBD, the more influential factor was probably new fare policies implemented by the MTA. Volume discounts and weekly and monthly fares with unlimited use were introduced during the year. The data suggest they have had the intended effect of increasing ridership, and most of the gain is likely to have been in off-peak hours. Continued innovation in fare policy holds the potential of making New York competitive with other world cities in terms of more efficient operation of mass transit.

How Much to Invest in Repairing Existing Systems

One of New York's most positive attributes is that it already has an extensive highway and rapid rail system. A key issue for the future is how rapidly to achieve a state of good repair for these facilities.

Complete data are not available for the entire region, but the Comptroller of the City of New York recently completed a major study of the capital costs of maintaining local infrastructure. The study included an assessment of whether the City's current capital plans would meet the goal of putting the New York City highway network and the New York City transit system in a state of good repair. In both cases, the Comptroller found current capital plans allocated less than was needed.

Highways

With respect to highways and related facilities, the Comptroller estimated that about $12.2 billion was needed over the ten-year period spanning fiscal years 1998 to 2007; in contrast, only $8.1 billion is allocated by the City leaving a more than $4 billion gap. (See Table 19.)

The major source of the gap is in highway maintenance. Using a desired road resurfacing cycle of 15 years and reconstruction cycle of 40 years, the Comptroller estimates the City's roads require nearly $5.3 billion in such work over the ten-year period. The City's capital plan provides less than $2.9 billion, leaving a $2.4 billion gap. This suggests significant deterioration in the City's roads over the next decade.

A second major source of the gap relates to maintenance of bridges. The Comptroller estimates repair of the East River Bridges will require nearly $1.1 billion, while the City allocates $766 million. The major source of the difference is that the Comptroller believes costs will rise from the City's current estimate because of change orders to the contracts, a factor that has been evident in the past but is not fully incorporated in the City's current investment plans. This creates a gap of about $300 million. Another $500 million gap is attributable to the difference between the Comptroller's estimate of the cost of fixing bridges not now in good repair and the City's estimate. The Comptroller includes repairs of bridges expected to deteriorate over the ten-year period as well as higher repair costs for bridges already in fair or poor condition. If the Comptroller's estimates are correct, then not all the City's bridges will be in good repair in ten years despite the significant outlays.

Mass Transit

Since 1982 the MTA has implemented a series of capital plans to improve the condition of its systems after an extended period of neglect. However, as of 1998 the Comptroller estimated that more than $20.4 billion would still be needed to achieve and maintain a state of good repair for the facilities operated by the Transit Authority. (See Table 20.)

The Transit Authority currently has a capital budget that extends only through 1999; authorization of a new five-year capital plan is expected in the 1999 or 2000 legislative session. However, the TA has developed spending estimates for the 1997 to 2001 period. These estimates are shown in Table 20.

A comparison of the Comptroller's estimates and the TA's plans suggest a state of good repair will not be achieved. Measured in dollar terms, the major gaps fall in four of the fifteen capital budget categories—line structures, signals, line equipment, and stations and communications. Together these four items account for $9.7 billion of the $10.7 billion difference in the two estimates.

The greatest gap, nearly $4.7 billion, is in spending for stations and communications. The TA reports that only 122 of its 468 stations are in a state of good repair. The Comptroller's estimate includes rehabilitating all the other 346 stations as well as improvements to the communications systems serving those stations. The TA plans to rehabilitate only a portion of this number of stations, leaving most stations not in good repair at the end of the period.

Another $1.9 billion of the gap relates to line equipment. Included in this category are terminal lighting, pump rooms, fan plants and under-river standpipes. While 73 percent of the pump rooms are in good repair, a much smaller share of the other types of facilities are in good repair. Fixing all the facilities in need would require about $2.5 billion, but the TA plans to spend only $529 million.

Line structures and signal equipment each account for about $1.6 billion of the gap. Only about 60 percent of the system has signal equipment that is in good repair, and the TA does not plan to upgrade all of it in the next five years. Line structures include 59.6 miles of steel elevated structures of which 56 percent are in good repair; 137.4 miles of subway tunnels of which only one-third are in good repair, and 25.3 miles of at-grade track structure of which 24 percent are in good repair. The Comptroller estimates the cost of necessary repairs at over $2.0 billion, of which the TA plans to achieve $474 million in the five-year period.

In sum, despite large investments over the past 15 years, New York City's mass transit system is still not in a condition of good repair. While many needs are now well met, including replacement of cars and maintenance of track and switches, significant gaps remain in line structures, line equipment, signals, and stations. And these gaps will not be closed in the near future under current spending plans.

How Much New Capacity is Needed

Any effort to accelerate the pace at which existing systems are brought to a state of good repair inevitably will compete for resources with initiatives intended to create new transit capacity. Resources are limited, and the goals of achieving good repair and of expanding capacity each have large price tags.

The case for building new rail capacity has three elements: (1) Some rapid rail lines are now highly crowded during the rush hour, and more capacity would alleviate this condition. (2) Significant future job growth is possible in the CBD, and new capacity would enable currently crowded systems to transport workers to these potential jobs. (3) Suburban commuters from some areas are poorly served by limited access to some parts of the CBD; new hybrid-type rail capacity could create more rapid and convenient access for Long Island commuters destined for the East Side (the LIRR now terminates only at Penn Station on the West Side), for Westchester commuters headed to the Wall Street area (Metro North now terminates only at Grand Central in Midtown), and for New Jersey commuters destined for the East Side (New Jersey Transit services now terminate either downtown or on the West Side).

In the New Jersey portion of the region, projects consistent with these goals are being pursued. New Jersey Transit is implementing three major expansions of its commuter lines. The first, the Kearny Connection, now called MidtownDirect, was completed in 1996. It allows trains from Morris and Essex counties access to the Northeast Corridor line and Penn Station in New York. Previously, commuters to midtown were forced to travel circuitously through Hoboken and transfer to PATH to reach Manhattan. The second commuter rail project, the Secaucus Transfer, is under construction and scheduled for completion in 2002. The transfer will permit commuters from Bergen, Passaic, Rockland and Orange counties to transfer in the Meadowlands and to reach Penn Station, avoiding Hoboken, and saving 20 minutes or more per trip. It will also make it possible to travel by rail among many communities within New Jersey without a trip into New York and then out again. The third commuter rail project is the Montclair Connection, which will connect two rail lines in Montclair, bringing the Boonton line running through Essex and Passaic counties to Penn Station. This project is cleared for construction following a recent agreement between the City of Montclair and New Jersey Transit.

New Jersey Transit is also advancing two light rail projects in northern New Jersey. The 22-mile light rail line along the Hudson River waterfront is under construction with the first segment from Bayonne to Hoboken to open in 2001. The second segment will extend into southern Bergen County. The other light rail project is the Newark/Elizabeth Rail Link. The first segment will run just over one mile and connect the commuter rail stations in Newark, Broad Street Station and Penn Station.

The MTA also has expansion plans to benefit New York commuters. In the 1980s a new tunnel was completed between Queens and Manhattan at 63rd Street. It has two levels, one for subway service and one for LIRR commuter rail service. The subway level is now used by the B and Q lines to serve Roosevelt Island and one station in Western Queens; the LIRR level currently is not used. For the future, the MTA plans to expand service using the tunnel in two ways. First, the subway tunnels will be extended from the existing Queens station to connect with the E and F lines at Queens Boulevard. This will make it convenient for passengers from Queens to reach the Upper East Side and other Manhattan destinations. Second, a new LIRR service will be established from existing tunnels in Queens through the tunnel and then through new planned underground tunnels to Grand Central Terminal. This will increase the number of LIRR trains that can reach Manhattan during the rush hour and give Long Island commuters an option to arrive at either Penn Station or Grand Central. The LIRR project is estimated to be completed in 2009 at a likely cost of about $3 billion, with over $350 million in federal funds earmarked for the early stages. The new Queens subway connection is scheduled for completion in 2001; about $645 million was spent on the project prior to 1999 and sufficient funding for completion is anticipated in future MTA capital plans.

Additional expansions to the region's rail systems have been proposed by the Regional Plan Association. Its 1996 plan, *A Region at Risk*, laid out a plan using a hybrid vehicle whenever possible. The plan, dubbed Rx or Regional Express Rail, calls for 25 miles of new rail right-of-way. The estimated cost was $21 billion in 1996 dollars. The 1996 plan was revised in 1999 with expansions to the Second Avenue subway component.

The Rx Plan has four major components. The first is the LIRR connection to Grand Central Terminal described above and being implemented by the MTA.

The second major component is a rail loop at JFK airport combined with new hybrid capacity rail lines serving Jamaica in Queens, Brooklyn and Manhattan. The plan calls for a track loop on the airport that would carry an Rx-type vehicle with stops at the major air terminals. It would then operate over an unused right-of-way (the Rockaway Beach Branch) with one leg turning east connected to the LIRR's Jamaica Center station and the other leg turning west over the LIRR Atlantic Branch tracks, which would be converted from commuter rail to Rx use. This leg would then go to Atlantic Terminal in downtown Brooklyn, and then extend into a new tunnel under the East River to lower Manhattan. In Manhattan it would connect with the third major element of RPA's plan, an Rx line up the East Side under Second Avenue with connections to Grand Central Terminal. In addition to rail access to Manhattan from JFK airport, the new capacity will be able to carry added riders to Manhattan from Brooklyn and Long Island.

The Port Authority of New York and New Jersey won approval to use the funds from the airport passenger facility charge ($3 per passenger) to construct the loop on the airport and extend it to Jamaica, with one leg terminating at the subway in Howard Beach. This has many of the features of the Rx plan. It creates a right-of-way that can carry a hybrid-like vehicle, and it connects to Jamaica Center, but along a different right-of-way than RPA recommended. The MTA expects to examine how the airport line can be incorporated into either the Long Island Rail Road or the subway system.

The RPA's third major proposed expansion is a new rail line under Second Avenue, called Metrolink. It would require a new rail line from 125th Street to lower Manhattan, connecting with the line from Brooklyn described above. The line would also connect to the west side, to new subway service from Queens, and to Grand Central Terminal. The hybrid line under Second Avenue would have four or five new stops in midtown, three more in lower Manhattan, and additional stops on the upper East Side and the East Village and the lower East Side section of Manhattan.

The fourth element in RPA's plan is a new hybrid line from the Secaucus Transfer in the Meadowlands, under the Hudson River, across 43rd Street to Grand Central Terminal, and connecting with the new Second Avenue line. This would give access from all ten New Jersey Transit lines to the East Side of Manhattan via an escalator transfer in Secaucus.

An alternative to the fourth RPA proposal was developed as part of the Access to the Region's Core (ARC) study by the MTA, New Jersey Transit and The Port Authority. This study concluded that a new commuter rail tunnel into Penn Station was preferable, which would then extend across Manhattan and turn north into Grand Central Terminal, thereby offering access to east Midtown. This alternative, while offering the twin benefits of more trans-Hudson capacity and east side access, would have complex effects on both Metro North and the LIRR (which will become a user of Grand Central Terminal), which should be studied carefully. In geo-political terms, the ARC project will have a difficult time being financed; its benefits are disproportionately to New Jersey, while the construction and operating impacts are felt exclusively in New York.

In coming years the region's leaders will make decisions about how much of the proposed new capacity should be built, and whether it should be financed by deferring repair of existing systems or through new funding raised by taxes or other means. As new projects such as those proposed by RPA are considered, two relevant points should be kept in mind.

First, need for new capacity exists only at the peak hour, and there are alternatives to new constructions for relieving peak-hour congestion. The MetroCard technology could make it possible to determine the effect that peak-hour pricing would have in shifting use from the crowded 8:00 am to 9:00 am hour to the "shoulder" time before and after. To date, the new pricing initiatives have been designed to increase off-peak ridership by giving discounts, and the results in 1998 suggest they have been effective. Experiments with higher fares at the busiest time could identify effective ways to shift some ridership to the less crowded hours. The initiative could be made even more effective if employers were encouraged to cooperate by facilitating flexible working hours.

Another alternative to new construction for increasing capacity is modernized signaling and train control systems. As noted earlier, one element of the existing mass transit system which has not yet achieved a state of good repair is the signaling system. (Refer to Table 20.) Investments in new technology could increase the capacity of the system by allowing more trains to serve the CBD during the rush hour. With current equipment, headways must generally be at least about two minutes; the frequency of trains on the busiest lines at rush hour does not exceed 30 per hour.

Modern signaling and train control systems such as those used in Vancouver, Toronto and San Francisco are capable of reducing safe headways by about 25 percent or from about 120 seconds to 90 seconds. If achieved on New York City's busiest subway lines, this could increase the number of rush hour trains from a maximum of 30 to 40. Of course, effective operations at these short headways must be accompanied by other equipment and necessary station alterations to allow brief stops during which passengers can quickly get on and off. Nonetheless, exploration of such an option seems desirable since it could prove more cost-effective than construction of new lines as a way to expand rush-hour capacity.

A second important consideration in assessing large new construction proposals is the future impact of projects underway and likely to be completed in coming years. In addition to the New Jersey Transit projects described earlier, the MTA's Queens subway connection and its LIRR connection to the East Side are expected to be completed within a decade. These projects will add significantly to capacity. The new LIRR connection is projected to permit 24 trains per hour to reach Grand Central; each 12-car train can seat 1,440 passengers for an increase in capacity of about 35,000 people per hour or over 70,000 during the full morning peak. The expanded Queens subway lines (B and Q) potentially could increase their rush hour ridership from the 1997 level of under 1,900 per hour to an equivalent of the E and F lines, nearly 40,000 in the peak hour. Over the full morning rush peak this represents an added capacity of more than another 70,000. These projects, already underway, represent a significant increase in the number of workers who could reach the CBD during the morning commuting period.

FOOTNOTES

[1]This analysis builds on the comparative analysis in the recently published Caralampo Focas, editor, *The Four World Cities Transport Study* (London: The Stationery Office, 1998). The authors are grateful to that study's sponsors for making an early draft available. This study extends that work by including additional cities (Chicago and Los Angeles) by presenting financial information including operating expenses and revenues and public investments, and by drawing conclusions about the competitive position of New York.

2 New York is defined as a 25-county tri-state region consisting of the 31-county Regional Plan Association region less the six largely rural counties of Hunterdon, Sussex, and Warren in New Jersey, Sullivan and Ulster in New York and Litchfield in Connecticut. The Chicago metropolitan area consists of 13 counties in Illinois, Indiana and Wisconsin. The Los Angeles metropolitan area consists of five counties. The Tokyo metropolitan area consists of 23 wards which form Tokyo's densely built-up area, 27 cities mainly developed as the residential area, and three prefectures which surround the Tokyo Metropolis. The Paris metropolitan area is the administrative region known as Ile-de-France; it consists of the city of Paris and seven surrounding departments. The London metropolitan area is the 33 boroughs comprising Greater London.

3 The Manhattan central business district is defined as the area south of 60th Street.

4 Tokyo's central business district is defined as the three central wards of Chigoda, Chao and Minato.

5 London's central business district is defined as the "central statistical area" and includes the Corporation of London and portions of six other boroughs. The Paris central business district includes 11 *arrondisements* in central Paris.

6The definition used for the three American metropolitan areas is for the urbanized area, smaller than the area definitions used elsewhere in this report since the highway extent and use data are available only on this basis. Urbanized area is an official U.S. Census definition that excludes undeveloped minor civil divisions (municipalities) in some counties. The precise definition is available in U.S. Bureau of the Census, *County and City Data Book:1994, 12th Edition* (DC: U.S. Government Printing Office, 1994).

7 The costs of delay consist of the value of time lost and costs associated with the additional use of fuel. In the calculations, travel speed reductions from congestion are converted to time losses, and time is valued based on national average wage rates. Fuel costs are based on average miles per gallon of cars and trucks separately and the local price of fuel.

8 Highway investments for New York and Chicago are the annual average calculated from each region's metropolitan planning organization's multi-year Transportation Improvement Program or TIP. The estimate for New York consists of two parts: the annual average from the 1993-1994 to 1998-99 TIP for New York Metropolitan Transportation Council (NYMTC) plus the TIP from the North Jersey Transportation Planning Authority for the 1998 to 2002 period. For Chicago, the estimate is for 1997 based on a tabulation from their most recent 5-year TIP. For Los Angeles it is based on the TIP developed by the Southern California Association of Governments for the 1996 to 2003 period.

9 In addition to gasoline taxes, auto buyers in the U.S. also pay local and state sales taxes and registration fees. In London, purchasers pay a value-added tax as well as a registration fee. In Tokyo, auto buyers pay a value-added tax as well as local registration and use fees. The registration fees are annual fees while the purchase fee is a one-time fee. Per mile comparisons are difficult as length of ownership and annual use vary substantially among the cities.

10 U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics, 1996* (DC: U.S. Department of Transportation, 1997).

11 Metropolitan Expressway Public Corporation, *Tokyo Metropolitan Expressway Annual Report* (Tokyo: Metropolitan Expressway Public Corporation, 1995).

12 Department of the Environment, Transport and Regions, *Transport Statistics for London 1997* (London: The Stationery Office, November 1997); Syndicat des Transports Parisiens, *Memento de Statistiques 1996* and <www.stp.paris.fr>, quelques chiffres 1996, rapport d'activite 1996, Public Transit Systems at the Service of Ile-de- France Travelers; Caralampo Focas, editor, *The Four World Cities Transport Study* (London: The Stationery Office, 1998).

13 Syndicat des Transports Parisiens, *Memento de Statistiques 1996* and <www.stp.paris.fr>, quelques chiffres 1996, rapport d'activite 1996, Public Transit Systems at the Service of Ile-de-France Travelers; Caralampo Focas, editor, *The Four World Cities Transport Study* (London: The Stationery Office, 1998).

14 Metropolitan Transportation Authority, *Strategic Business Plan 1999-2003* (NY: Metropolitan Transportation Authority, July 1998), 1269(d) Appendix, p. 5; and Caralampo Focas, editor, *The Four World Cities Transport Study* (London: The Stationery Office, 1998), p. 144.

15 Focas, *op. cit.*

16 New York Metropolitan Transportation Council, *Regional Transportation Statistical Report 1996* (NY: New York Metropolitan Transportation Council, 1997).

17 Comptroller of the City of New York, "Dilemma in the Millennium: Capital Needs of the World's Capital City," August 27, 1998.

18 See Tom Parkinson and Ian Fisher, *Rail Transit Capacity*, Transit Cooperative Research Program Report 13 (DC: National Academy Press, 1996), pp. 19-22 and 32-37.

19 STV Incorporated, "Major Investment Study for the Long Island Transportation Corridor: Long Island Rail Road East Side Access Project," (March 1998), pp. 4-26.

Figure 4.1
Cumulative Population and Area
in Rank Order of Population Density
Three American Cities

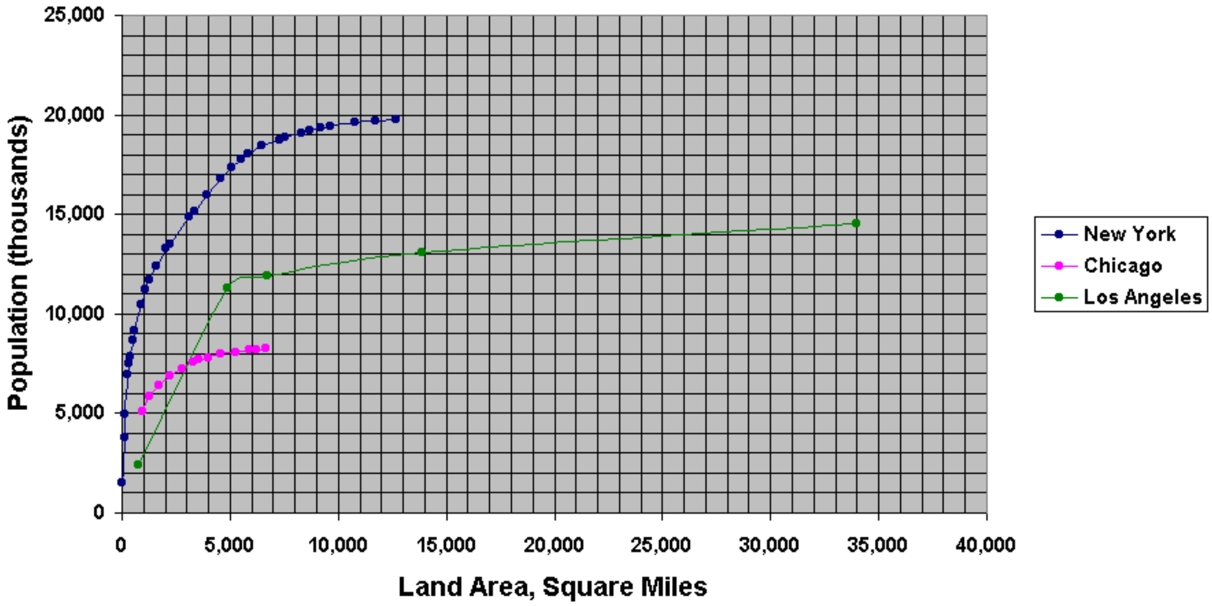
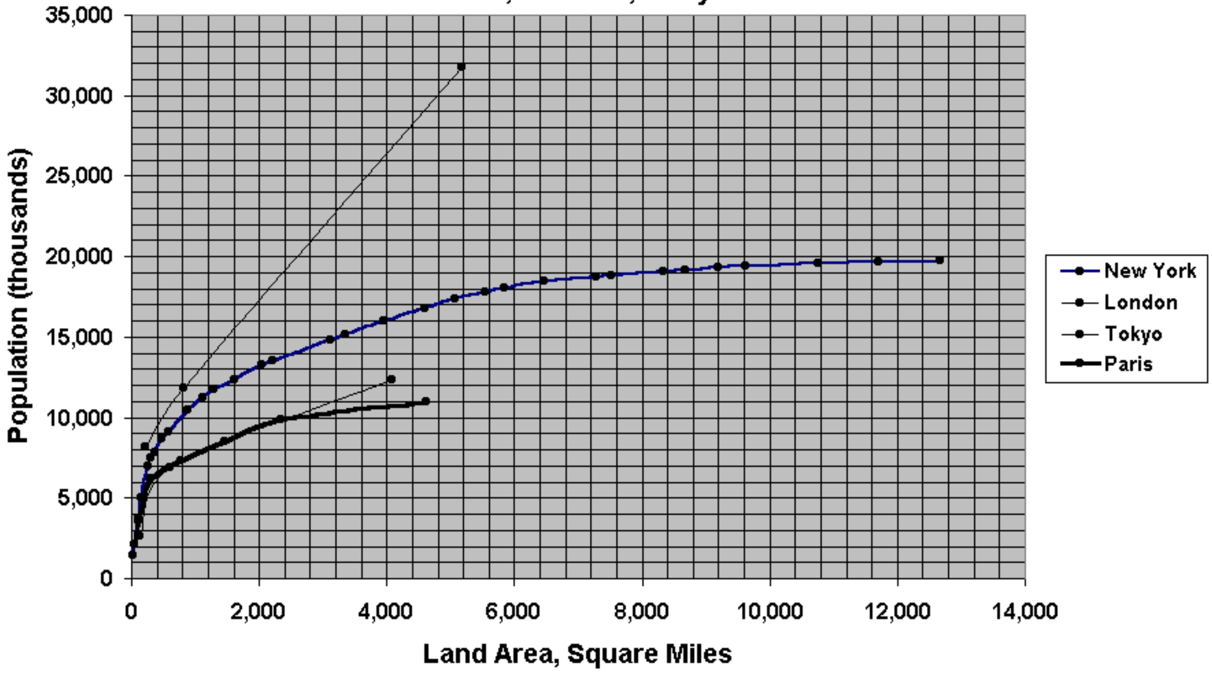


Figure 4.2
Cumulative Population and Area
in Rank Order of Population Density
New York, London, Tokyo and Paris



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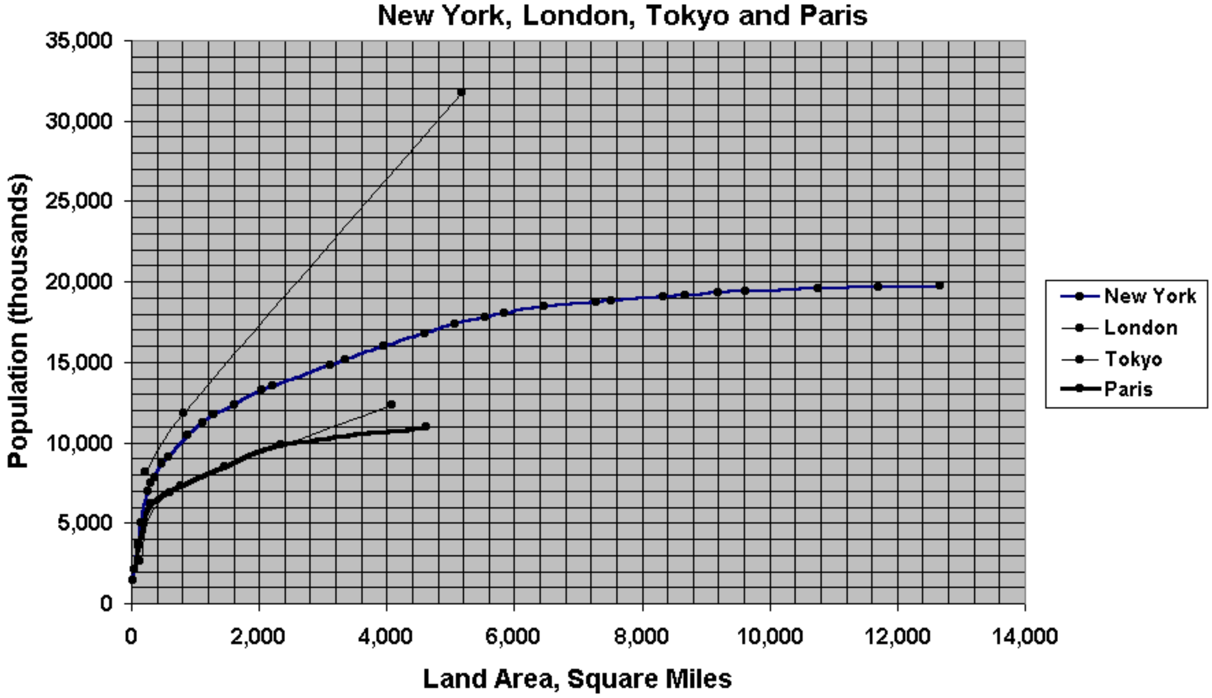

Table 1
Population Size and Density for Six Urban Areas

Region	Population (thousands)	Area (square miles)	Population per square mile
Tokyo (1995)	31,800	5,169	6,152
New York (1997)	19,659	8,321	2,363
Los Angeles (1997)	15,609	33,966	460
London (1990)	12,337	4,083	3,022
Paris (1995)	11,019	4,616	2,387
Chicago (1997)	8,642	6,631	1,303

Sources: U.S. Bureau of the Census, U.S. Census Population Estimates, July 1, 1997; New York Metropolitan Transportation Council, *Selected Public Transportation Statistics 1996* (NY: New York Metropolitan Transportation Council, 1996); Tokyo Statistical Association, *Tokyo Statistical Yearbook* (Tokyo: Tokyo Statistical Association, 1995); Department of the Environment, Transport and Regions, *Transport Statistics for London 1997* (London: The Stationery Office, November 1997); Syndicat des Transports Parisiens, *Memento de Statistiques 1996* and <www.stp.paris.fr>, quelques chiffres 1996, rapport d'activite 1996, Public Transit Systems at the Service of Ile-de-France Travelers; Llewelyn-Davies, *Four World Cities: A Comparative Study of London, Paris, New York, and Tokyo* (London: Llewelyn-Davies, 1996).

Table 2
Employment and Employment Density in Six Regions, 1990

Region	Employment (thousands)	Area (square miles)	Employment per square mile
Tokyo	16,542	5,169	3,200
New York	8,227	8,321	989
Los Angeles	6,543	33,966	193
Paris	5,741	4,616	1,244
London	5,635	4,083	1,380
Chicago	3,874	6,631	584

Sources: See Table 1.

Table 3
Employment and Employment Density in Six Central Cities, 1990

Central City	Employment	Area (sq. mi.)	Employ. per sq. mi.	24-Hr. Entries: All Modes	Entries by Auto	Auto Percent	Entries per sq. mi.	Auto Entries per sq. mi.
Tokyo	7,393,000	238.0	31,063	NA	NA	NA	NA	NA
Tokyo CBD	2,381,000	16.1	147,888	2,990,000	330,000	11.0	18,571,429	2,049,689
Los Angeles	4,188,526	4,060.0	1,032	NA	NA	NA	NA	NA
New York	3,505,300	347.0	10,102	NA	NA	NA	NA	NA
Manhattan	2,070,000	29.0	71,379	NA	NA	NA	NA	NA
Manhattan CBD	1,967,000	9.0	218,556	3,185,000	1,030,000	32.3	35,388,889	11,444,444
Chicago	2,572,353	946.0	2,719	NA	NA	NA	NA	NA
London	1,836,000	124.0	14,806	NA	NA	NA	NA	NA
London CBD	917,000	10.4	88,173	1,700,000	420,000	24.7	16,346,154	4,038,462
Paris	1,815,000	40.4	44,926	NA	NA	NA	NA	NA
Paris CBD	1,025,000	11.1	92,342	2,315,000	660,000	28.5	20,855,856	5,945,946

Sources: See Table 1.
Note: New York central city is defined as 5 boroughs plus Hudson County.

Table 4
Indicators of Rapid Transit and Auto Use for Six Regions, 1995

Indicator	Rate in New York		Index Relative to New York: New York	Chicago	Los Angeles	London	Tokyo	Paris
Rapid transit trips per capita	72.8		1.0	0.23	0.02	0.85	3.52	2.00
Rapid transit trips per core job	825.6		1.0	0.37	0.13	1.20	2.06	1.30
Percent of trips to core via rapid transit	64.3	*	1.0	0.30	0.10	1.31	1.43	1.29
Miles of roadway per million people	2,280		1.0	1.34	0.96	0.30	0.20	NA
Percent of households without autos	30.4		1.0	0.57	0.30	1.30	1.77	NA
Vehicle-miles traveled per capita	14.7		1.0	1.31	1.48	0.60	0.10	NA

Sources: Urban Transportation Center, *Changes in Work Trip Travel Patterns 1970-1990* (IL: University of Illinois at Chicago, 1995); Chicago Area Transportation Study, *Destination 2020: Regional Transportation Plan* (IL: Chicago Area Transportation Study, November 1997); U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics, 1996* (DC: U.S. Department of Transportation, 1997); New York Metropolitan Transportation Council, *Selected Public Transportation Statistics 1996* (NY: New York Metropolitan Transportation Council, 1996); U.S. Department of Transportation, Federal Highway Administration, *Journey-to-Work Trends in the United States and its Major Metropolitan Areas, 1960-1990* (DC: U.S. Department of Transportation, 1993); U.S. Department of Transportation, Federal Highway Administration, *National Transit Database* (DC: U.S. Department of Transportation, 1995); Pierre Merlin, *Les Transports en Region Parisienne* (Paris: les etudes de la documentation Francaise, 1997); Japan Transport Economics Research Center, *Railroads 1996* (Tokyo: Japan Transport Research Center, 1996); Road Division, Ministry of Construction, *Road Statistics Annual Report* (Tokyo: Ministry of Construction, 1996).
*The low percent for New York is partially based on the high percent of Manhattan CBD workers reaching their jobs on foot. The percent of non-auto trips, including walkers, is 83.9 percent.

Table 5
Highway System Characteristics for Five Regions, 1995

Region	Miles of roadway	Miles of limited access roadway	Miles of roadway per million people	Daily VMT (thousands)		Daily VMT per mile of roadway	Daily VMT per capita
New York	37,066	1,146	2,278	238,625		6,438	14.7
Chicago	23,644	475	3,052	148,659		6,227	19.2
Los Angeles	26,320	628	2,177	262,809		9,985	21.7
London	8,374	409	678	108,160		12,916	8.8
Tokyo	14,515	145	456	44,620	*	3,074	1.4

Sources: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics, 1996* (DC: U.S. Department of Transportation, 1997); Tokyo Statistical Association, *Tokyo Statistical Yearbook* (Tokyo: Tokyo Statistical Association, 1995); U.S. Department of Transportation, Federal Highway Administration, *Highway Performance Monitoring System Data, 1996* (DC: U.S. Department of Transportation, 1997); Department of the Environment, Transport and Regions, *Transport Statistics for London 1997* (London: The Stationery Office, November 1997).

Note: American metropolitan areas defined as urbanized areas.

*Estimate provided by Japan International Transport Institute.

VMT = vehicle miles traveled.

Table 6
Average Weekday Vehicle Volume for Major Water Crossings in the New York Region, 1996

Hudson River	
Kingston-Rhinecliff Bridge	16,096
Mid-Hudson Bridge	32,802
Newburgh-Beacon Bridge	56,337
Bear Mountain Bridge	14,833
Tappan Zee Bridge	122,026
Verrazano-Narrows Bridge	166,266
George Washington Bridge	266,069
Lincoln Tunnel	111,028
Holland Tunnel	89,580
Total - Hudson River/ NY Harbor	**875,037**
Arthur Kill-Kill Van Kull	
Bayonne Bridge	14,336
Goethals Bridge	67,208
Outerbridge Crossing	74,093
Total - Arthur Kill-Kill Van Kull	**155,637**
East River	
Brooklyn-Battery Tunnel	47,774
Brooklyn Bridge	131,872
Manhattan Bridge	81,075
Williamsburg Bridge	88,570
Queens-Midtown Tunnel	65,202
Queensboro Bridge	161,965
Tri-Boro Bridge (Manhattan)	82,323
Tri-Boro Bridge (The Bronx)	71,218
Bronx-Whitestone Bridge	102,580
Throgs Neck Bridge	97,021
Total - East River	**929,600**
Harlem River	
Willis Avenue Bridge	70,229
Third Avenue Bridge	67,206
Madison Avenue Bridge	17,948
145th Street Bridge	27,156
Macombs Dam Bridge	40,031
Alexander Hamilton Avenue Bridge	176,856
Washington Avenue Bridge	56,204
University Heights Bridge	35,280
Broadway Bridge	40,040
Henry Hudson Bridge	54,852
Total - Harlem River	**585,802**
Grand Total	**2,546,074**

Source: New York Metropolitan Transportation Council, *Regional Transportation Statistical Report 1996* (NY: New York Metropolitan Transportation Council, 1997).

Table 7
Average Highway Speed and Congestion Costs for Three U.S. Regions, 1996

Indicator	**New York**	**Chicago**	**Los Angeles**
Speed on limited access highways (mph)	42	40	35
Speed on arterial roads (mph)	26	27	28
Annual cost of delay - recurring, (millions of dollars)	$3,390	$1,855	$4,980
Annual cost of delay - incident-based, (millions of dollars)	$6,420	$2,150	$5,825
Total cost of delay per capita	**$572**	**$510**	**$884**

Source: Texas Transportation Institute, *Urban Roadway Congestion*, *Annual Report, 1998* (TX: Texas Transportation Institute, 1998).

Table 8
Average Annual Highway Capital Investment for Five Regions

Area	**Highway investment (billions of dollars)**	**Highway investment (per capita)**
New York	$1.40	$72
Chicago	$1.32	$161
Los Angeles	$2.71	$185
London	$0.61	$50
Tokyo	$12.57	$395

Sources: Tokyo Statistical Association, *Tokyo Statistical Yearbook* (Tokyo: Tokyo Statistical Association, 1995); Chris Bushell, editor, *Jane's Urban Transport Systems, Seventeenth Edition 1998-1999* (UK: Jane's Information Group Ltd., 1998); London Transport webpage <www.londontransport.co.uk>, April 1998, Department of the Environment, Transport and Regions, *Transport Statistics for London 1997* (London: The Stationery Office, November 1997); See also text footnote 8.

Table 9
Average Auto Fuel Costs in Five Regions, 1998

Area	**Cost per gallon**	**Taxes per gallon**
New York	$1.21	$0.50
Chicago	1.13	0.51
Los Angeles	1.12	0.46
London	3.03	1.50
Tokyo	3.48	1.75

Source: Correspondence from Beth Duffy, American Automobile Association, Washington, DC, February 23, 1998.

Table 10						
Characteristics of Bus Systems in Six Regions						
Indicators	**New York 1995**	**Chicago 1995**	**Los Angeles 1995**	**London 1997**	**Tokyo 1995**	**Paris 1996**
Fleet (number of buses)	8,689	2,028	2,211	6,311	6,022	3,986
Route miles	5,616	2,020	NA	NA	4,088	1,633
Passengers (millions)	764	302	335	1,234	2,188	817
Passenger miles (millions)	2,024	736	1,241	2,584	4,813	2,151
Vehicle miles (millions)	173	68	88	206	173	92
Vehicle miles per bus	19,900	33,500	39,800	32,600	28,700	23,100
Passenger miles per vehicle mile	11.7	10.8	14.1	12.5	27.8	23.4

Sources: Chris Bushell, editor, *Jane's Urban Transport Systems, Seventeenth Edition 1998-1999* (UK: Jane's Information Group Ltd., 1998); London Transport webpage <www.londontransport.co.uk>, April 1998, Regie Autonome des Transports Parisiens (RATP), *Annual Report 1996*, *RATP in Numbers, 1996*, *RATP Finances, 1996*, *Les Statistiques Annuelles*, 1995 and 1996; Syndicat des Transports Parisiens, *Memento de Statistiques 1996* and <www.stp.paris.fr>, quelques chiffres 1996, rapport d'activite 1996, Public Transit Systems at the Service of Ile-de-France Travelers; Department of the Environment, Transport and Regions, *Transport Statistics for London 1997* (London: The Stationery Office, November 1997); Road Division, Ministry of Construction, *Road Statistics Annual Report* (Tokyo: Ministry of Construction, 1996); U.S. Department of Transportation, Federal Highway Administration, *National Transit Database* (DC: U.S. Department of Transportation, 1995).

Table 11						
Operating Cost and Revenue of Bus Systems in Six Regions						
(in U.S. dollars)						
Indicators	**New York 1995**	**Chicago 1995**	**Los Angeles 1995**	**London 1997**	**Tokyo 1995**	**Paris 1996**
Operating cost (millions)	1,370.0	469.4	606.5	844.9	NA	857.5
Fare revenues (millions)	677.2	235.9	198.0	937.7	1,434.1	718.6
Total revenues (millions)	756.2	248.9	216.6	1,010.0	NA	656.6
Deficit (millions)	613.8	220.5	389.9	-165.1	NA	200.9
Revenue to cost ratio	0.55	0.53	0.36	1.20	NA	0.84
Operating cost per vehicle mile	7.91	6.88	6.89	4.10	NA	9.32
Operating cost per passenger mile	0.67	0.64	0.49	0.33	NA	0.40
Operating cost per passenger	1.79	1.55	1.81	0.68	NA	1.05
Revenue per passenger	0.89	0.78	0.59	0.76	0.66	0.80
Revenue per passenger mile	0.33	0.32	0.16	0.36	0.30	0.31
Deficit per passenger	0.80	0.73	1.16	-0.13	NA	0.17
Deficit per passenger mile	0.30	0.30	0.31	-0.06	NA	0.06

Sources: See Table 10.

Table 12
Scale of Rail Transportation Systems in Six Regions

Mode	New York 1995	Chicago 1995	Los Angeles 1995	London 1997	Tokyo 1995	Paris 1996
Rail Rapid						
Fleet (number of cars)	6,164	1,134	84	3,922	3,039	3,469
Routemiles	267	86.5	25.2	245	149	130.8
Number of stations	514	118	41	261	214	315
Annual passengers (millions)	1,422	142	26	772	2,546	1,092
Commuter Rail						
Fleet (number of cars)	2,888	1,110	122	4,777	6,756	NA
Routemiles	990	546	334	1,063	NA	801
Number of stations	414	244	44	457	1,001	397
Annual passengers (millions)	209	65	5	1,038	4,619	510
Hybrid Rail						
Fleet (number of cars)	0	0	0	0	6,756	940
Routemiles	0	0	0	0	685	71.5
Number of stations	0	0	0	0	142	66
Annual passengers (millions)	0	0	0	0	5,429	351
Total Rail						
Fleet (number of cars)	9,052	2,244	206	8,699	NA	NA
Routemiles	1,257	632.5	359.2	1,308	NA	1,003
Number of stations	928	362	85	718	1,215	778
Annual passengers (millions)	1,631	207	31	1,810	12,594	1,953

Sources: Chris Bushell, editor, *Jane's Urban Transport Systems, Seventeenth Edition 1998-1999* (UK: Jane's Information Group Ltd., 1998); London Transport webpage <www.londontransport.co.uk>, April 1998; Department of the Environment, Transport and Regions, *Transport Statistics for London 1997* (London: The Stationery Office, November 1997); U.S. Department of Transportation, Federal Highway Administration, *National Transit Database* (DC: U.S. Department of Transportation, 1995); Information about the Chicago commuter rail system provided by Gary Foyle, Director, Office of Planning and Analysis, METRA, March 16, 1998; Data on London's transportation system provided by John Day, Department of the Environment, Transport and the Regions, London, March 30, 1998; Interview with Keiichi Yoshihara from the Consulate General of Japan-New York office, January 26, 1998; Regie Autonome des Transports Parisiens, *Annual Report 1996*, *RATP in Numbers, 1996*, *RATP Finances, 1996*, *Les Statistiques Annuelles*, 1995 and 1996; Caralampo Focas, editor, *The Four World Cities Transport Study* (London: The Stationery Office, 1998).

Table 13

Indicators of Rail Transit Operating Efficiency for Six Regions

Mode	New York 1995	Chicago 1995	Los Angeles 1995	London 1997	Tokyo 1995	Paris 1996
Rapid Rail						
Passenger miles (millions)	7,130.0	875.1	162.0	3,823.0	11,694.3	5,261.5
Vehicle miles (millions)	323.3	50.2	5.0	212.7	188.1	124.2
Operating cost (millions)	$1,972.7	$287.8	$94.7	$1,042.1	$2,610.9	$870.2
Pass-mile per passenger	5.01	6.16	6.18	4.95	4.59	4.82
Pass-mile per veh-mile	22.06	17.45	32.47	17.97	62.17	42.36
Pass per routemile (millions)	5.33	1.64	1.04	3.15	17.09	8.35
Operating cost per veh-mile	$6.10	$5.74	$18.98	$4.90	$13.88	$7.01
Operating cost per pass-mile	$0.28	$0.33	$0.58	$0.27	$0.22	$0.17
Operating cost per passenger	$1.39	$2.03	$3.61	$1.35	$1.03	$0.80
Commuter Rail						
Passenger miles (millions)	5,311.7	1,382.0	193.3	9,052.0	39,516.0	5,512.0
Vehicle miles (millions)	152.6	33.8	4.8	NA	576.0	216.5
Operating cost (millions)	$1,472.0	$338.0	$56.7	NA	$4,838.9	$1,512.0
Pass-mile per passenger	25.45	21.43	35.54	NA	8.56	10.81
Pass-mile per veh-mile	34.81	40.95	39.95	NA	68.60	25.46
Pass per routemile (millions)	0.21	0.12	0.016	NA	NA	0.64
Operating cost per veh-mile	$9.65	$10.02	$11.72	NA	$8.40	$6.98
Operating cost per pass-mile	$0.28	$0.24	$0.29	NA	$0.12	$0.27
Operating cost per passenger	$7.05	$5.24	$10.43	NA	$1.05	$2.96

Sources: See Table 12.

Table 14

New York City Subway Passengers and Trains by Hour, 1997

Hour	Number of passengers	Number of trains	Number of cars	Passengers per car
12 am to 1 am	5,714	73	652	9
1 am to 2 am	2,744	58	513	5
2 am to 3 am	1,919	53	465	4
3 am to 4 am	2,152	59	511	4
4 am to 5 am	5,624	57	514	11
5 am to 6 am	27,956	84	757	37
6 am to 7 am	90,282	166	1,493	60
7 am to 8 am	233,618	279	2,543	92
8 am to 9 am	371,001	353	3,228	115
9 am to 10 am	181,822	251	2,280	80
10 am to 11 am	89,448	212	1,930	46
11 am to 12 pm	69,577	205	1,856	37
12 pm to 1 pm	59,206	197	1,778	33
1 pm to 2 pm	58,582	207	1,881	31
2 pm to 3 pm	63,343	207	1,882	34
3 pm to 4 pm	78,216	224	2,042	38
4 pm to 5 pm	80,134	263	2,391	34
5 pm to 6 pm	81,760	299	2,735	30
6 pm to 7 pm	54,942	241	2,202	25
7 pm to 8 pm	36,060	206	1,869	19
8 pm to 9 pm	26,292	172	1,562	17
9 pm to 10 pm	21,359	138	1,247	17
10 pm to 11 pm	16,079	119	1,062	15
11 pm to 12 am	13,254	93	836	16
Total	**1,671,084**	**4,216**	**38,229**	**44**

Sources: Surveys conducted by New York City Transit Authority and made available through the New York Metropolitan Transportation Council. Figures are for inbound travel to the central business district.

Table 15
Revenues For Rail Transportation Systems in Six Regions
(in U.S. dollars)

Mode	New York 1995	Chicago 1995	Los Angeles 1995	London 1997	Tokyo 1995	Paris 1996
Rapid Transit						
Fare revenues (millions)	1,622.5	120.9	10.4	1,320.4	2,675.5	660.3
Total revenues (millions)	1,820.2	128.2	11.4	1,422.0	3,009.6	714.4
Deficit (millions)	152.5	159.6	83.3	-379.9	-398.7	155.8
Operating cost (millions)	1,972.7	287.8	94.7	1,042.1	2,610.9	870.2
Revenue per passenger	1.14	0.85	0.40	1.71	1.05	0.60
Revenue per pass-mile	0.23	0.14	0.06	0.23	0.23	0.13
Revenue to cost ratio	0.92	0.45	0.12	1.36	1.15	0.82
Deficit per passenger	0.11	1.12	3.18	-0.49	-0.16	0.14
Commuter Rail						
Fare revenues (millions)	776.7	169.1	20.7	2,082.0	5,101.9	1,523.9
Total revenues (millions)	846.9	207.2	23.1	NA	5,709.4	1,801.8
Deficit (millions)	625.1	130.8	33.6	NA	-870.5	-289.8
Operating cost (millions)	1,472.0	338.0	56.7	NA	4,838.9	1,512.0
Revenue per passenger	3.72	2.62	3.80	NA	1.10	2.96
Revenue per pass-mile	0.15	0.12	0.11	NA	0.13	0.28
Revenue to cost ratio	0.58	0.61	0.41	NA	1.18	1.19
Deficit per passenger	2.99	2.03	6.18	NA	-0.19	-0.57

Sources: See Table 12.

Table 16
Indicators of Crowding for New York City Subway Lines, 1997

	Peak Hour (8:00 am to 9:00 am)					24-Hour Total				
Line	**Number of passengers**	**Number of trains**	**Number of cars**	**Passengers per car**	**Square feet per passenger**	**Number of passengers**	**Number of trains**	**Number of cars**	**Passengers per car**	**Square feet per passenger**
Queens Sector										
E	18,374	12	120	153	3.9	91,437	160	1,600	57	10.5
F	21,152	16	126	168	3.6	90,138	173	1,384	65	9.2
N	13,476	10	90	150	4.0	59,785	124	1,104	54	11.1
R	11,438	10	82	139	4.3	44,107	107	860	51	11.7
7	24,256	25	275	88	5.1	103,802	240	2,640	39	11.4
B, Q	1,878	8	80	23	25.6	12,520	130	1,204	10	57.7
Total	**90,574**	**81**	**773**	**117**	**4.7**	**401,789**	**934**	**8,792**	**46**	**12.1**
60th Street Sector										
4	15,210	14	140	109	4.1	80,745	165	1,650	49	9.2
5	15,541	13	130	120	3.8	64,646	108	1,080	60	7.5
6, 4 (Local)	25,817	21	210	123	3.7	135,757	223	2,230	61	7.4
2	14,086	12	120	117	3.8	67,885	135	1,360	50	9.0
3	9,466	10	90	105	4.3	48,342	116	1,035	47	9.6
1/9	16,846	15	150	112	4.0	100,547	201	2,010	50	9.0
A	13,021	10	82	159	3.8	61,050	141	1,211	50	11.9
D	11,119	9	72	154	3.9	55,825	130	1,040	54	11.2
A, B, C (Local	9,107	11	88	103	5.8	44,069	205	1,656	27	22.5
Total	**130,213**	**115**	**1,082**	**120**	**4.0**	**658,866**	**1,424**	**13,272**	**50**	**10.0**
Brooklyn Sector										
2	7,372	8	80	92	4.9	33,501	139	1,390	24	18.7
3	8,211	9	81	101	4.4	31,993	115	1,035	31	14.6
4	16,275	14	140	116	3.9	70,788	182	1,820	39	11.6
5	11,087	11	110	101	4.5	34,772	75	750	46	9.7
A	17,631	16	140	126	4.8	77,353	144	1,270	61	9.9
C	6,518	7	56	116	5.2	29,857	87	696	43	14.0
F	11,914	13	104	115	5.2	54,646	174	1,392	39	15.3
N	4,898	6	54	91	6.6	23,825	122	1,072	22	27.0
R	6,438	7	56	115	5.2	24,434	99	792	31	19.4
M	2,331	7	56	42	14.4	7,543	41	328	23	26.1
L	12,398	12	96	129	4.6	54,630	141	1,128	48	12.4
D	9,613	11	88	109	5.5	44,528	135	1,080	41	14.6
Q	10,800	11	110	98	6.1	35,266	90	900	39	15.3
B	10,850	7	56	194	3.1	37,302	103	824	45	13.3
J/M/Z	13,878	18	144	96	6.2	49,991	211	1,688	30	20.3
Total	**150,214**	**157**	**1,371**	**110**	**5.1**	**610,429**	**1,858**	**16,165**	**38**	**14.7**
System Total	**371,001**	**353**	**3,226**	**115**	**4.2**	**1,671,084**	**4,216**	**38,229**	**44**	**11.1**

Sources: Surveys conducted by New York City Transit Authority and made available through the New York Metropolitan Transportation Council. Figures are for inbound travel to the central business district.

Table 17
Cumulative Capital Expenditures for Mass Transit in the New York Region, 1982-1998
(in millions of 1998 constant dollars)

Mode	MTA (1982-1997)	New Jersey Transit (1985-1998)	Port Authority (1982-1997)	Total
Rapid rail	$15,221	0	$1,354	$16,575
Commuter rail	5,807	$3,892	0	9,699
Bus	1,819	1,189	160	3,168
Light rail	0	476	0	476
Total	**$22,846**	**$5,557**	**$1,514**	**$29,918**

Sources: Correspondence with each agency.

Table 18
Annual Transit Capital Investment for Six Regions

City		Rail transit investment (billions of dollars)	Rail transit investment (per capita)	Ratio- Rail to Highway Investment per Capita
New York	(1995)	$1.57	$81	1.12
Chicago	(1995)	$0.42	$50	0.31
Los Angeles	(1995)	$0.46	$31	0.17
London	(1997)	$1.08	$87	1.74
Tokyo	(1995)	$16.25	$511	1.29
Paris	(1996)	$1.63	$153	NA

Sources: See Table 8 and Table 12. Note that, due to data limitations in each region, the time period for rail investment differs from the time period for highway investment.

Table 19

Planned Capital Investments and Estimated Cost of Achieving State of Good Repair for New York City Highways, 1998-2007

(dollars in millions)

	Planned investment	Estimated cost of good repair
Bridge repairs	$4,340.6	$5,293.8
East River bridges	766.2	1,070.8
Reconstruct bridges in poor and fair condition	3,266.5	3,806.4
Other bridge work	307.9	416.6
Road resurfacing and reconstruction	2,470.6	5,323.0
Traffic signals, street lights and parking facilities	363.5	398.8
Vehicles	91.4	91.4
Ferries	316.0	342.0
Pedestrian ramps	100.0	258.0
Sidewalks	177.6	184.8
All other	263.8	263.8
Total	**$8,123.5**	**$12,155.6**

Source: Comptroller of the City of New York, "Dilemma in the Millennium: Capital Needs of the World's Capital City," August 27, 1998.

Table 20

Planned Capital Investments and Estimated Cost to Achieve State of Good Repair for New York City Mass Transit

(dollars in millions)

Category	**Planned investments 1997-2001**	**Estimated cost of good repa 1998**
Subway cars and overhauls	$2,555.30	$3,005.3
Mainline track and switches	697.4	709.5
Line structures	473.5	2,023.5
Power	174.2	393.0
Signals	924.2	2,468.7
Subway yards	119.8	213.0
Line equipment	528.7	2,475.2
Subway car maintenance shops	314.1	407.4
Stations and communications	1,819.9	6,488.3
Emergency/Miscellaneous/Police facilities	742.2	742.2
Staten Island Rapid Transit Operating Authority	112.4	126.0
Service vehicles	32.1	44.2
Buses	708.5	753.1
Bus depots and maintenance shops	444.6	502.7
Added capacity*	56.0	56.0
Total	**$9,702.9**	**$20,408.2**

Source: Comptroller of the City of New York, "Dilemma In The Millennium," p. II-6 and II-7.
*This category only details network expansion initiatives which do not enter into current infrastructure conditions.