WORLD CITIES BEST PRACTICES

INNOVATIONS IN TRANSPORTATION

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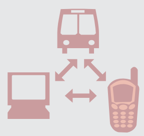
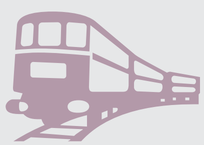
PART I: NEW YORK TODAY

PART II: BEST PRACTICES





PART III: APPENDICES & RESOURCES

EXECUTIVE SUMMARY:

New York City is growing. Our population has swelled to over 8.3 million people. Construction and development in all five boroughs is booming. Far from the problems of neglect and abandonment of the 1970's and 1980's, New York City now faces the challenges of growth and rapid change: to continue to provide the basic services and maintain the infrastructure that allowed us to thrive; to ensure that the city we have inherited and the city we are building will provide future generations with the variety and abundance of opportunities we have today.

Nowhere are these challenges more acute than on the subject of transportation. A shipping hub graced with powerful rivers and a protected harbor, a transportation center banded by some of the nation's most extensive rail networks, home of one of the world's most comprehensive and well used public transportation systems, a locus of regional roads and highways, New York City was, and is, shaped by its transportation resources. Today, with a population projected to reach 9.1 million by 2030 and with world oil and fuel prices at an all-time high, our transportation systems must adapt or risk strangling our city's, and our region's, economic growth. We must continue to foster New York City's economic growth by controlling the city's existing traffic and transit congestion while simultaneously developing our transportation networks to meet the ever growing demands of our rapidly increasing population.

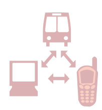
Given these realities, this World Cities Best Practices in Transportation report surveys transportation modes and technologies in use in cities around the globe that could be implemented in New York to reduce congestion and encourage economic and community development. This report is an "idea-sparker," designed to help New York City meet these challenges and to highlight real, technical solutions to the vision set forth in the Mayor's PlaNYC 2030. As a complementary resource to PlaNYC 2030, World Cities Best Practices in Transportation analyzes transportation practices that could allow the city to meet its sustainability goals in transportation and improve the city's air and water quality. Where applicable, this report suggests opportunities, suggesting how the best practices outlined within could be introduced to New York City.

The best practices surveyed in World Cities Best Practices in Transportation are divided into four categories -- Sustainable Modes, Roadway Drainage and Maintenance, Information Technologies, and Infrastructure Enhancements -- each corresponding to a major transportation challenge that the city currently faces.

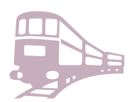
1. Sustainable Modes showcases environmentally sustainable modes of transportation which could be implemented in New York City to relieve pressure on existing transit systems. Recognizing that New York City's ability to build for the future is limited by scarce financial resources and fixed physical space, the models selected represent options that can increase the capacity of our existing transportation networks, often at a lower cost than the construction of new roads, subway tunnels, bridges or highways. In light of rapidly rising and fluctuating world oil prices, this section focuses on options that reduce fuel consumption; which can lower or stabilize operations costs in addition to reducing air pollution.

2. Roadway Drainage and Maintenance focuses on modern water management solutions, primarily from the Pacific Northwest, that can reduce flooding and related traffic delays on our city's roads, rails and highways. These solutions can address the chronic severe flooding and ponding reported by Community Boards from all five boroughs. Modern water management solutions, based on comprehensive hydrology and environmental science research, work to limit flooding by combining water management systems in ways that slow down and reduce the amount of water entering existing storm drains. In addition to reducing roadway flooding, such technologies have also been proven to dramatically increase the quality of water that enters our groundwater and waterways. They provide natural filtration mechanisms and reduce combined sewer overflow events (CSOs), thereby meeting PlaNYC 2030 Water Quality goals.

3. Information Technologies highlights a variety of high- and low-tech solutions to improve communications within the city's public transit system. While frequently seen as secondary in importance to other transportation issues, increasing the quality and quantity of information will allow public transit users to make better choices about their route options and commutes, reducing the impact of delays throughout the system. Data from around the world shows that providing car-users with clear and accurate information about public transit encourages drivers to drive less, reducing traffic congestion.



4. Infrastructure Enhancements explores ways to increase transportation options within New York's current transit network, by increasing the capacity on our roads, subways, buses and encouraging the use of underused existing modes likes bicycles, buses and taxis. Providing public transit users with a breadth of transit options can relieve pressure on overcrowded public transit lines, and congested roads and highways. Such efforts are crucial both for the 8.3 million New Yorkers and for the 47 million tourists who visit the city each year.



WORLD CITIES BEST PRACTICES & PLANYC 2030 GOALS

2030 PlaNYC's Goals: / Best Practices	SUSTAINABLE MODES			ROADWAY DRAINAGE & MAINTENANCE			IMPROVED INFO TECHNOLOGIES		ENHANCING INFRASTRUCTURE				
	Hybrid Ferries	Bike-Share Programs	Streetcars, Cargo Trams, Aerial Streetcars	Combined Roadway Drainage	Permeable Pavement	Drainage Catchtraps	Real-time Info TVs	Wireless and Web Info Systems	Designated ROWs	Bicycle Transit Centers	Internal Gangway Subway Cars	Access for Subways	Taxi Vouchers & Accessible Taxis
Increase Capacity on Congested Routes	●	●	●				●	●	●	●	●	●	
Provide New Commuter Rail Access to Manhattan			●										
Expand Transit Access to Underserved Areas	●	●	●				●	●		●	●	●	
Improve and Expand Bus Service							●	●	●	●			
Improve Local Commuter Rail Service			●				●	●		●	●	●	
Improve Access to Existing Transit		●	●				●	●		●		●	●
Address Congested Areas Around the City	●	●	●	●	●	●	●	●	●	●	●	●	
Expand Ferry Service	●						●	●					
Promote Cycling		●					●	●	●	●			
Pilot Congestion Pricing													
Manage Roads More Efficiently				●	●	●	●	●	●				
Strengthen Enforcement of Traffic Violations													
Facilitate Freight Movements	●		●				●	●	●				
Close MTA's State of Good Repair Gap													
Reach State of Good repair on roads and bridges													
Establish new regional transit financing authority													
Land: Pursue Transit Oriented Development	●	●	●							●			
Land: Reclaim Underutilized Waterfronts	●		●										
Land: Increase Transit Options to Spur Development	●	●	●						●	●			●
Land: Develop Underused Areas to Knit Neighborhoods Together	●	●	●										
Air: Capture Air Quality Benefits	●	●	●						●	●	●	●	
Air: Retrofit Ferries and promote use of cleaner fuels	●												
Air: Replace, Retrofit and Refuel Diesel Trucks			●						●				
Water: Reduce CSO discharges				●	●	●							
Water: Pilot Promising Best Management Practices				●	●	●							
Water: Require Greening of Parking Lots					●								

PROJECT GOALS:

This report is the culmination of the World Cities Best Practices study conducted by the New York City Department of City Planning's Transportation Division. The purpose of this report is to identify and discuss innovations in transportation, currently employed in other cities worldwide, that could positively impact New York City's transportation systems. This study is also meant to serve as a complementary resource to 2030 PlaNYC, the city's sustainability guide recently released by the Mayor's Office. In addition to documenting best practices, a cursory indication of where and how new technologies and innovations could be applied in New York City is included.

METHODOLOGY:

This report divides the topic of transportation innovations into four broad categories: Sustainable Modes, Roadway Drainage and Maintenance, Improved Information Technologies, and Infrastructure Enhancements. Within each category, multiple best practices, illustrated by case study examples are considered. Because transportation is a broad topic and because urban conditions vary greatly from city to city, this report should not be considered a traditional "best practices" study where all possible options are evaluated and ranked. Instead, this report highlights innovative practices in transportation, and provides information and case study analyses of their current uses and providers. As is common with new technologies, in some instances, competing companies have developed virtually identical technologies that would serve to enhance New York City's transportation networks equally well. The "best" provider for New York City would be decided through procurement processes and contract agreements that are beyond the scope of this report.

Research on each "Best Practice" was conducted using both internet and print sources as well as extensive in-person, phone and email interviews with transportation planners and service providers. A preliminary list of "Best Practices" surveyed in this report was developed after extensive research into current trends and innovations in transportation technologies worldwide. This research was conducted between March and May 2007 and included a survey of New York City's transportation needs as outlined in the 2030 PlaNYC and the 2007 Community District Needs Report. On May 10th, 2007, a roundtable forum for the Department of City Planning's transportation planners was convened to discuss these new technologies and innovations. After this session, the preliminary list was narrowed down to the final "Best Practices" list. Subsequent research began in May 2007 and continued through December 2007.

Whenever possible, phone, email or in-person interviews were conducted with technology/innovation developers and operators. In particular, the authors spoke or corresponded with: Thierry Anselot, Domaine Information Voyageurs, Régie Autonome des Transports Parisiens (RATP); Megan Aukema, Aukema & Associates for Foss Maritime; Denise Andrews, Seattle Public Utilities (SPU); Ms. Bekki, Kansai International Aiport (KIAC); David Bragdon, President, Oregon Metro Council; Michael Brown, Bay Area Rapid Transit (BART); Robert Dane, CEO, Solar Sailor; Vicky Diede, Portland Streetcar Project Manager, Portland Office of Transportation; Paul DeMaio, Metrobike LLC; Samara Epstein, Director of Constituent Affairs, NYC Taxi and Limousine Commission; Rose Gandee, Information Specialist, American Public Transit Association (APTA); Jeffrey Garcia, Project Manager, Bay Area Rapid Transit (BART); Richard Grasso, Senior Vice President Business Development, Clear Channel Adshel; Mark Grove, TriMet; Michael Harris, Executive Director, Disabled Riders Coalition; Anthony Haworth, Operating Manager, Captain Cook Cruises; Chris Heald, Head of Rail Vehicles Projects, Toronto Transit Commission; Robyn Hollander, MetroNorth; Assemblymember Micah Kellner, New York State Assembly, 65th District; Marc Klein, President, The Vehicle Production Group LLC; Sophie Klein, Délégation Générale Recherche & Innovation, Régie Autonome des Transports Parisiens (RATP); Dick Lilly, Strategic Policy Advisor, Seattle Public Utilities (SPU); Thierry Marechal, International Association of Public Transport

(UITP); Terry McRae, CEO, Hornblower Cruises; JB Meyer, CEO, Circle Line Downtown; Steve Newsome, Head of International & European Affairs, Transport for London (TfL); George Okvat, MetroNorth; Jori Pearsall, Transit at Google, Google Inc.; Carlos Pujol, Corporate Development Director, CEMUSA; B. Rajaram, SkyBus Inventor, SkyBus-AtriLab; Henry Rosen, Port Authority Trans Hudson (PATH); Tom Sly, Google New Business Development, Google Inc.; Josh Squire, Bicycle System Manager, JCDecaux; Dennis Stallings, President, Aerobus; Tracy Tackett, Low Impact Development Program Manager, Seattle Public Utilities (SPU); Andrea White, Executive Director, Bikestation Coalition; James Wiley, MetroNorth; Ken Yoshioka, Kansai International Airport (KIAC).

During the preparation of this report, the authors attended the following transportation conferences and symposia in the New York metropolitan area: The March 30th, 2007 "New Mobility: The Next Generation of Sustainable Urban Transportation" conference held at the NYU Wagner Rudin Center; the May 6th, 2007 NYU Wagner Rudin Center freight symposium, "Delivering the Goods: The Freight Needs of a Growing Population," and the October 19th, 2007 University Transportation Research Center and the NYU Wagner Rudin Center Visiting Scholar Seminar "Robin Chase: The Window of Opportunity is Now: How Wireless Can Move Us to More Sustainable Transportation" at Baruch College. The authors also attended the "New York Bike Share Project" charrette, held July 7th-11th at the Center for Art and Architecture, and tested various types of Bike-Share technology developed by competing firms. Where available or relevant, technical diagrams and charts are included in the appendices of this report.

PART I: NEW YORK TODAY

THE TRANSPORTATION CHALLENGE:

As New York prepares to meet the challenges of the 21st century, the issue of transportation looms large. For the past hundred years, New York City's transportation networks have dictated our centers of population growth, guided our industries and businesses and shaped our city. Shipping built early New York. Turn of the century ferry service along the Hudson and East Rivers fed and was fed by development in Downtown Brooklyn, Lower Manhattan and New Jersey. In the early 1900's, subway construction spurred residential development in the farmlands of the Bronx, Queens and Brooklyn.

Evening rush at the Broadway Junction Station, a key transfer point in eastern Brooklyn. Image source: NYC Dept. City Planning

Our region's railroads, subways, parkways, thruways, expressways and highways were all built to facilitate movement of people and goods into, around, and through the city. Our patterns of development have always been shaped by our ability to get there.

However, until recently, underinvestment in transportation expansion and innovation, and insufficient maintenance and repair of roads, tracks, highways and bridges has meant that we have been unable to keep our transportation networks growing to match our city's changing demographics. The last major bridge built in New York City was the Verrazano Narrows Bridge in 1964. The last limited-access highway segment in New York City to open was the northern portion of the West Shore Expressway in 1976. It has only been in the last decade, as more and more of the subway system has returned to a state of good repair as a result of the Metropolitan Transportation Authority's (MTA) 1982 Capital Program, that the city and MTA have been able to seriously pursue network expansion. Prior to the most recent 2nd Avenue Subway groundbreaking in 2007, the last significant system expansion was the extension of A Line service to Ozone Park and the Rockaways in 1956. The express tracks and the 57th Street station along the 6th Avenue Line were completed in 1968.

The city's financial crisis in the 1970's accelerated the decline of our transportation infrastructure. In 1973, a cement truck fell through the West Side Highway at Gansevoort Street, causing the closure of the entire highway, dramatically illustrating the extent of the city's infrastructure problems. In order to stem this tide of decay, many of the agencies and authorities responsible for New York's transportation networks focused solely on repairing the damage done throughout the 1960's and 1970's. In 1981, the MTA "halted all new transit expansion until the existing system could be restored."[1] Two projects, the Archer Avenue Extension and the 63rd Street Tunnel were well underway by 1981 and

1 Office of the Mayor of the City of New York, "2030 PlaNYC Transportation Technical Report;" The City of New York, Presented 22 April, 2007, p.75

Morning rush hour at Union Square, a major Manhattan transfer point.
NYC Dept. City Planning

were allowed to continue. In 1988, an emergency closing of the Williamsburg Bridge convinced then-Mayor Koch to embark on a major infrastructure rehabilitation program, one that has been funded by every administration since.[2]

Today the city's and MTA's attention to maintenance and repair work is paying off. New Yorkers who have access to mass transit systems tend to use them. Ridership rates are higher than they have been in half a century. While a full "State of Good Repair," including new track signals and renovated stations is still $15 billion away, the condition of New York City's roads, rails, highways and bridges has improved dramatically. But, New York City's rapidly growing population poses a new set of challenges. New options are necessary to meet the city's growing needs.

The Congestion Challenge:

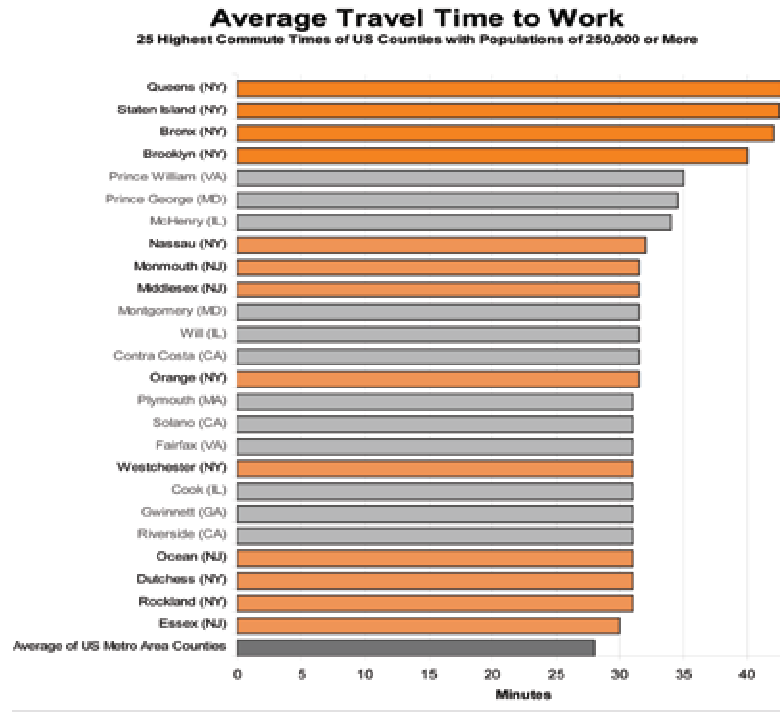
Traffic and transit congestion are nothing new to New York City. Concerns about congestion and its impacts on the city's economic health have been ongoing since the Second World War. Many everyday features of the street landscape—parking meters, municipal parking lots, one-way streets, and "progressively" timed traffic signals—were introduced to New York City as early as the 1960's in attempts to reduce congestion.[3] In the early 1960's, the Daily News arranged a contest to test congestion levels in midtown Manhattan by pitting a bus, a taxi and a pedestrian against each other, going crosstown in rush hour traffic, a race which, "the pedestrian won hands down."[4]

Today, the people of New York and the surrounding counties face longer commute times than much of the rest of the country. The residents of Queens County have, on average, the longest commute times of residents of any of the 231 counties in the US with populations over 250,000 people. Richmond County/Staten

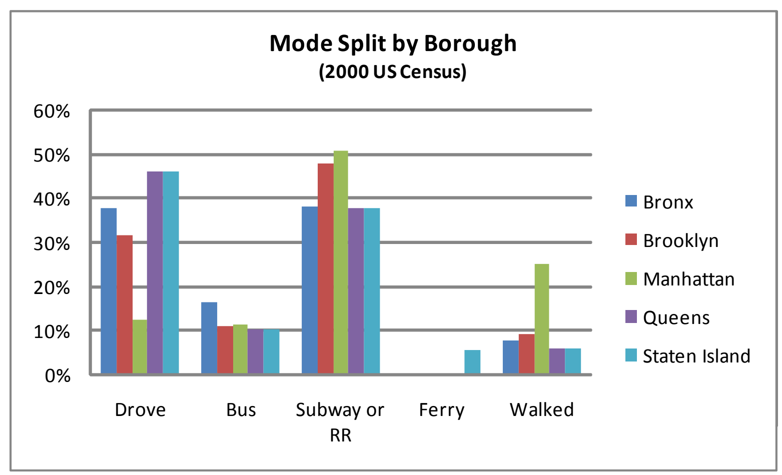
2 Buettner, Russ & Sewell, Chan, "In Ways Large and Small, Many Bridges Meet the Definition of Deficient;" The New York Times, 3 August, 2007

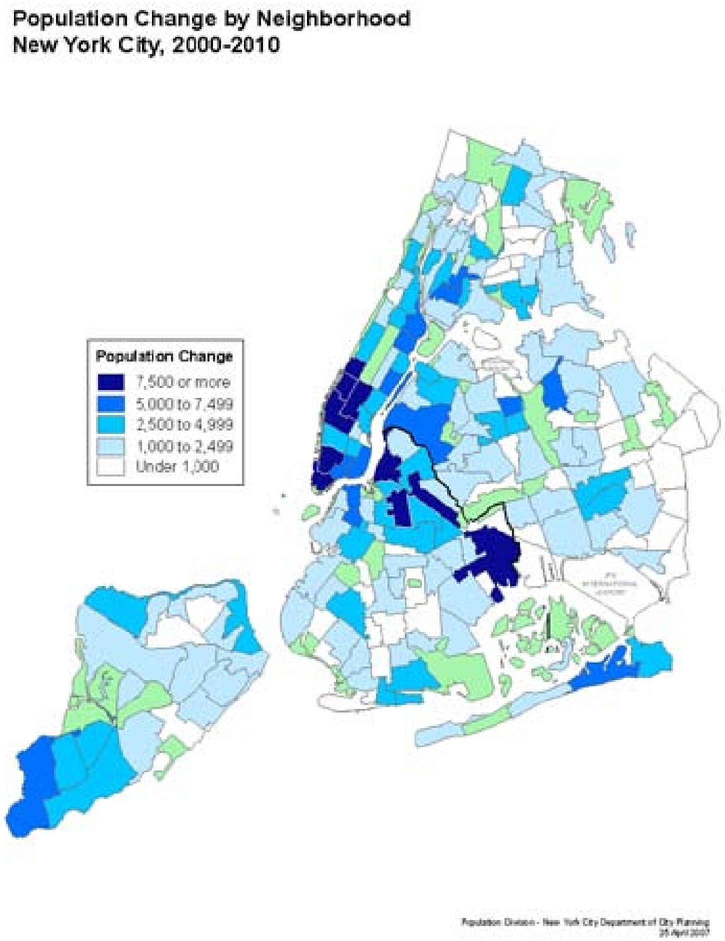
3 Stern, Robert, et al., New York 1960: Architecture and Urbanism between the Second World War and the Bicentenial; The Monacelli Press, 1997, p.21

4 ibid., p.24



The four counties with the highest commute times in the nation are Queens, Staten Island, the Bronx and Brooklyn. These boroughs are are home to 6.6 million New Yorkers or 80% of New York City's population. Data is from the 2000 US Census.





Significant population growth is projected for all five boroughs. Particularly in Brooklyn, Queens and Staten Island, existing transportation infrastructure is insufficient to meet the upcoming demand. NYC Department of City Planning, Population Division.

Island (ranked #2), Bronx County (ranked #3) and Kings/ Brooklyn County (ranked #4) are just slightly better. New York City's nearby suburban counties, Nassau (ranked # 8), Orange (ranked #9), Rockland (ranked #15), Dutchess (ranked #16) and Westchester (ranked #21) also have commute times among the worst in the nation. In neighboring New Jersey, Middlesex (ranked #13), Monmouth (ranked #14), Ocean (ranked #17) and Essex (ranked #25) also fall into the top 25 worst commute times nationwide. All told, 13 of the 25 counties with the worst commute times in the country are in or around New York City.[5]

New York's increasing population means that our fight against congestion is about to get tougher. New York City stands to gain almost 1 million people in the next 20 years. This projected population growth will increase the strain on transportation services many of which are already at or nearing capacity.

Our ability to increase capacity on our transportation systems is limited by the space available and the trades-offs inherent in the allocation of that space. The elevated or depressed highways built throughout the 1940's, 1950's and 1960's to increase the city's transportation capacity often isolated communities. Many of these highways cut off access to city's waterways reducing options for water-transportation. In a 2007 Rudin Center conference on freight and mobility, Astrid Glynn, the New York State Department of Transportation (NYSDOT) Commissioner likened available right-of-ways with capacity to spare to "endangered species;" not many left and going fast.[6]

Nor is building new rights-of-way an easy option. Transportation projects, like all infrastructure projects, are costly and complicated. In New York, most transportation infrastructure projects would run through areas where people live. Much of the city is already extremely densely developed. Excluding Staten Island, New York's overall population density is just shy of 48,000 people per square mile. The city is spread over four distinct land masses, separated by significant waterways, which limits options to build new roads at grade or lay new track for trains and subways. Tunnel and bridge construction for new subways, additional lanes for freight or bus service, all require trade-offs with other uses.

5 Office of the Mayor of the City of New York, "2030 PlaNYC;" The City of New York, Presented 22 April, 2007

6 Glynn, Astrid. NYSDOT Commissioner and Keynote Speaker at "Delivering the Goods: The Freight Needs of a Growing Population;" Symposium hosted by the Wagner Rudin Center (6 May 2007)

Lastly, transportation planning in New York City happens in a rich and complex environment of inter-connected jurisdictions. Transportation planners and advocates work within or alongside a bureaucratic structure that encompasses multiple agencies, city, state and federal regulations, and requires communication across state boundaries. Nor is New York City's best interest always clear. For example, commuters from New Jersey or Long Island or Connecticut are important and positive contributors to both the city and regional economy but also add to New York City's traffic congestion. These overlapping jurisdictions, competing priorities and complex authority structures mean that change can be difficult to negotiate.

Subway Congestion:

Subway congestion affects many New Yorkers. The city's subways run at 85% capacity during their busiest hour, which causes delays on all lines.[7] Subway lines serving neighborhoods with recent population booms are often the most congested. For example, population booms in the Bronx and along Manhattan's east side have increased ridership on the 4, 5 and 6 trains, which are already some of the most congested lines in the city. According to recent MTA figures, the 2, 3, 4, and 5 lines all operate at 100% capacity during peak hours and most of those cars run at more than 100% capacity during their busiest hour.

To meet these challenges, the MTA is exploring extending the length of train platforms to accommodate longer trains, and expanding a computerized signal system that would allow them to run more trains closer together.[8] A pilot bus-rapid-transit system (BRT), called "Select Bus Service," is also being implemented along certain routes in each of the five boroughs.[9]

7 Naanes, Marlene; "Subway Sandwich: With some lines ready to burst, TA looks into easing overcrowding," AM New York, 26, June 2007, p.3

8 Neuman, William, "Some Subways Found Packed Past Capacity;" The New York Times, 26 June 2007

9 MTA/NYCT Website, "What is BRT?" (http://www.mta.info/mta/planning/brt/whatis.htm); Accessed 11/09/07

Almost all of Manhattan is within a ½ mile of a subway station, however, large swathes of the other four boroughs are not served by the subway system. NYC Dept. City Planning.

While some of these congestion reducing measures, such as Select Bus Service can be implemented relatively quickly, others like platform extension, new subway line construction and implementation of computerized signals are costly and time consuming. The first phase of the 2nd Avenue Subway, which is expected to reduce some crowding on the 4, 5 and 6 lines, is estimated at $3.9 billion. This phase, which will run from 96th Street to 63rd Street, is slated for completion by 2015.[10]

Traffic Congestion:

New York's growing population also means increased congestion on our city's roads and highways. As with subway congestion, the costs of traffic congestion link our economy, our environment

10 MTA/NYCT Website (http://www.mta.info/capconstr/sas/index.html); Accessed 11/09/07

and our health. A 2002 Urban Mobility Report by the Texas Transportation Institute (TTI) found that nationally, drivers in the United States wasted 658 million gallons of fuel in 2000 just by sitting in traffic.[11] According to TTI, the yearly financial cost of that congestion comes to $78 billion in lost productivity and wasted fuel.[12]

Traffic congestion limits the ability of distributors and retailers to bring goods into New York which can harm the city's overall economic competitiveness of the city in the region, country and world. Delays caused by congestion can cost freight operators between $144 and $192 per hour per truck.[13] These costs are passed onto consumers in the form of higher prices and reduced options. As New York's population grows, so too will demands on goods and services. As the capacity of New York's rail infrastructure is largely fixed, increased goods demand will further increase congestion. Data also indicates that the volume of goods movement has been growing at a faster rate than population, meaning that our consumption rate and related traffic congestion may be growing even faster than our rapidly increasing population.[14]

Data from the NYC Department of Transportation (NYCDOT) shows that the number of hours of heavy congestion on the city's bridges and tunnels has almost doubled since 1990. In addition, the rush hour "peaks" have expanded dramatically. In 1990, the hours of "heavy" congestion were between 7am and 9am and again between 3pm and 7pm. In contrast, today heavy congestion during rush hour starts at 6am and goes until 10am and starts back up again at 2pm and goes until 8pm.[15]

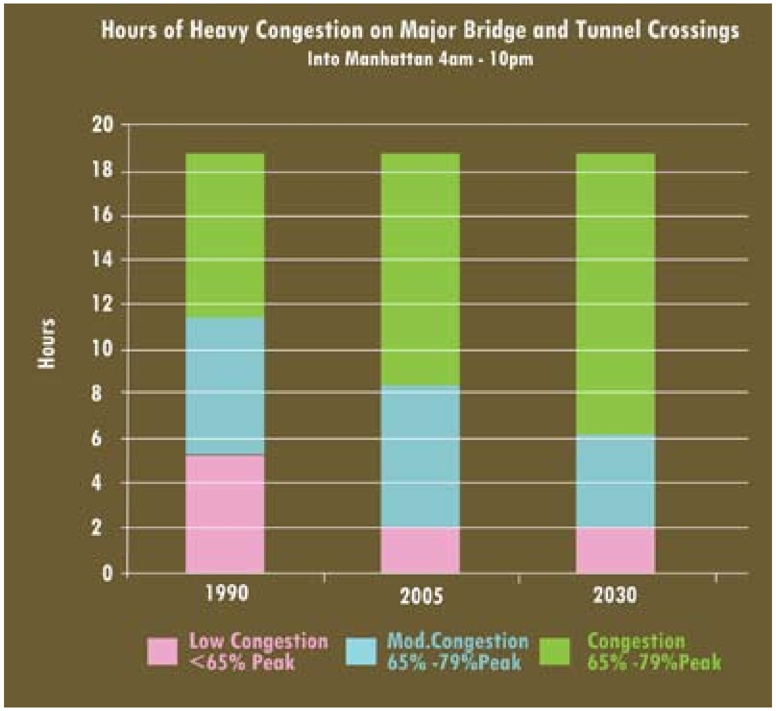
11 Astrid Glynn, NYSDOT Commissioner, keynote speaker at the NYU Wagner Rudin Center freight symposium, "Delivering the Goods: The Freight Needs of a Growing Population." May 6th 2007

12 Shrank, David & Tim Lomax, "2007 Urban Mobility Report," Texas Transportation Institute, September 2007, p.5

13 Office of the Mayor of the City of New York, "2030 PlaNYC Transportation Technical Report;" The City of New York, Presented 22 April, 2007, p.22

14 "Panel 2: Challenges and Next Steps," NYU Wagner Rudin Center freight symposium, "Delivering the Goods: The Freight Needs of a Growing Population." May 6th 2007

15 Office of the Mayor of the City of New York, "2030 PlaNYC;" The City of New York, Presented 22 April, 2007; Congestion p.7



Transportation and population projections indicate that, without intervention, New York City's traffic congestion will get worse over the next 20 years. Data is taken from 2030 PlaNYC Transportation report.

Traffic congestion also contributes to poor air quality and reduced health outcomes in our city's neighborhoods. According to PlaNYC 2030, in 2005, vehicles driven in New York City produced 11% of the city's locally-generated soot (PM 2.5), 52% of its nitrogen oxide (NOx) and 32% of its volatile organic compounds (VOC) emissions, all of which have been found to produce smog and contribute to asthma rates.[16] In 2000, children in New York City were twice as likely as children elsewhere in the country to be hospitalized for asthma.[17]

16 Office of the Mayor of the City of New York, "2030 PlaNYC: Air Quality;" The City of New York, Presented 22 April, 2007; p.122

17 Garg, Renu, et al., "Asthma Facts: 2nd Edition;" NYC Department of Health and Mental Hygiene, 2003, p.7

Our elected officials, the MTA/NYCT and NYCDOT recognize their roles in meeting these challenges. PlaNYC 2030 proposed innovative solutions to New York's congestion issues. City and state agencies and authorities are putting these proposals into action. New York City Transit (NYCT) and the MTA are introducing hybrid buses to their joint bus fleet. In addition, NYCT plans to put an additional 850 hybrid buses on the road over the next two years, bringing the total number of hybrid city buses to around 1,000.[18] The Select Bus Service system will increase the speed and capacity of buses on some of the city's most congested routes.[19] Working with the Mayor, the Taxi and Limousine Commission recently passed legislation requiring all black car vehicles to have in-city driving efficiency of at least 30mpg.[20] Other options, such as cleaner fuels, progressively priced parking, and alternative energy sources are also under consideration to meet the rest of New York City's passenger and freight transportation needs.

The Flooding Challenge:

The city's congestion problems are exacerbated in bad weather. Road flooding slows traffic and increases the risk of accidents. Standing water on streets erodes road surfaces and can cause potholes to form. In the winter, standing water can freeze and create hazardous driving conditions. Especially at intersections, flooding makes crossing streets difficult for pedestrians and bicyclists. Although often considered the purview of the Department of Environmental Protection (DEP) or the Department of Sanitation (DSNY), these water management issues are also transportation issues because they limit people's ability to move about the city. As a result, implementing practices that better manage rainwater is a crucial part of transportation planning and an important component of PlaNYC.

18 Staff, "Manhattan: More Hybrid City Buses;" The New York Times, 25 October 2007

19 NYCDOT Website;" Select Bus Services;" (http://www.nyc.gov/html/dot/html/ferrybus/selectbusservice.shtml); Accessed 9/308

20 NYC Taxi and Limousine Commission Website, "TLC Unanimously Approves Regulations Leading to a Cleaner, Greener New York City Black Car Fleet;" (http://www.nyc.gov/html/tlc/html/home/home.shtml); Accessed 9/3/08

Street flooding and ponding happen when rain from storms overwhelms drainage systems, either because the volume of water is too great, or because drains are clogged by debris. Rainstorms that drop significant amounts of rain over small time periods will overwhelm the city's sewers unless mechanisms are in place to detain the water and release it slowly at rates that the sewers can absorb. Impervious surfaces (for example, roads, buildings, parking lots or even highly compacted lawns) exacerbate the chance of roadway flooding by reducing opportunties for the water to seep into the ground. Water that cannot seep into the ground is channeled into the city's sewer system increasing the amount of water any given drain must handle.[21]

Heavy rains and poor water management practices cause flooding and traffic delays on New York City's roads and highways, as well as interrupting subway service. Image used with permission of NYC Office of Emergency Management.

To address these issues, city agencies such as the NYC Department of City Planning (NYCDCP), NYCDOT, and DEP have worked closely to develop new standards and regulations.

21 NYC Department of Design and Construction and Design Trust for Public Space, "High Performance Infrastructure Guidelines," New York City Department of Design and Construction, October 2005, P.12

Recent amendments to the city's Zoning Resolution regarding landscaping and maneuverability requirements for commercial and community facility parking lots, paving and planting in residential front yards and encouraging tree planting are designed to increase pervious surface cover.[22]

Global warming and climate change mean that rain storms may become more common in New York. Customized projections performed for DEP by the Columbia University Center for Climate Systems Research and the NASA Goddard Institute for Space Studies indicate that the city is likely to see a 7.5% to 10.0% increase in precipitation by 2080.[23]

Annecdotal evidence from the past year underscores the seriousness of those projections. The April 2007 Nor'Easter closed down New York's highways, delayed subway and railroad service and flooded local roads throughout the city.[24] Four months later, on August 8th, 2007, another storm dropped 1.7 inches of rain on the city over the course of an hour shortly before rush hour.[25] The resultant flooding disrupted all commuter rail services, flooded major streets like Queens Boulevard and Flatbush Avenue and shut down every subway line in the city.[26] A MTA sign reported upon by *The New York Times* read, "No trains at this time: 1, 2, 3, 4, 5, 6, N, R, S, Q, W, V, F, L, J, 7 to Queens."[27]

Differences in topography make flooding a more serious problem for certain areas of the city. In particular, low lying portions of southern Staten Island, southeastern Queens and southern Brooklyn are particularly hard hit by flooding after storms.[28]

The Information Challenge:

The impacts of congestion, weather and delays are made worse when drivers, riders and mass transit users lack information about road conditions and mass transit services. Insufficient communications systems exacerbate service interruptions because emergency service outage and re-route information cannot be communicated to riders or employees. To provide routine information, the MTA website provides weekly updates about service changes. Emergency text message service alerts have recently been introduced. However, many forms of subway information, such as in-station announcements or paper signs, are still only available once users are already in the system, making it difficult to plan alternative routes that avoid delays or congestion.

Increasing the quality of transit information, as well as the introduction of new communication technologies into the city's transit system, is hampered by a number of physical and financial constraints. These include the system's aging subway signal infrastructure, limited capital funds, and the sheer size of the transportation system. Improvements have been slowed as a result of a struggle to balance priorities. For example, an MTA plan to upgrade the subways' public address systems by 2009 stalled in 2005 during budget revisions.[29] Instead, priority was given to an equally important project that would install computer systems to track the location of all trains and their arrival times at stations.[30]

22 NYC Department City Planning, "Green Initiatives;" (http://www.nyc.gov/html/dcp/html/green_initiatives/index.shtml); Accessed 8/8/08

23 NYC Dept. Environmental Protection, "PRESS RELEASE: NYC DEP Releases its Climate Change Assessemnt and Action Plan;" New York City Department of Evironmental Protection, 6 May, 2008

24 Staff, "Worst Expected to Be Over After April Nor'Easter Pounds the City;" New York 1, 15 April, 2007

25 Barron, James, "A Sudden Storm Brings New York City to Its Knees," The New York Times, 9 August, 2007

26 ibid.

27 ibid.

28 Street flooding also poses severe environmental problems such as excess storm runoff triggering the city's 460 combined sewer outfalls (CSOs). In the "Sustainable New York" Report released in 2006 by the Design Trust for Public Space, "combined sewer outfalls in New York City flood during half of all rainstorms, discharging approximately 27 billion gallons of wastewater in an average rainfall year." The water that is released into New York's waterways after storm events is contaminated by oil, chemicals, pesticides, and chemical fertilizers from roadways as well as raw sewage from the city's households and businesses (human wastewater) which contains bacteria and viruses. According to Riverkeeper, "on average CSO events occur about once per week (and as often as 70 times per year at some outfalls) and the average weekly polluted discharge is about 500 million gallons Citywide." Exploration of best management practices and the creation of a Best Practices Task Force to deal with water quality issues are included in 2030 PlaNYC.

29 Smerd, Jeremy, "Inaudible Announcments in Subways Are Endangering Riders, Critics Say;" The New York Sun, 21 September, 2005

30 ibid.

Ripped service announcement signs at 125th Street A/C/D/B platform. NYC Dept. City Planning

Overall, the clarity of subway announcements has improved dramatically over the past decade. In 1998 the Straphangers Campaign found that "in 78% of the delays and service disruptions experienced by surveyors, there was either no announcement or an inaudible, garbled or useless one."[31] Today, the most recent 2006 Straphangers report found that on average, 90% of all subway announcements were accurate and clear.[32] In the subways, the use of pre-recorded announcements which identify upcoming stations and transfer opportunities may be responsible for the improvement.

Further enhancements in public address and information systems are however still needed, especially in the case of unexpected service changes and emergencies where pre-recorded messages are not applicable. Real-time information technology, which is widely used in other parts of the country, such as Washington DC, Denver, and San Francisco and other cities in the world, such as Shanghai, London, Berlin, and Paris, has recently been introduced in New York to help address these issues. Accurate real-time information systems, such as variable message boards (VMBs), web-based or wireless-based service alerts or schedule information, or informational television screens such as those recently installed by LIRR in Penn Station, are powerful tools because they offer riders current information about wait times and delays, and unlike announcements, cannot be garbled or misheard. The information provided differs from pre-recorded messages because it is specific and time sensitive.[33]

VMBs are currently in use on the L line to widespread approval, and are being introduced on other lines in the city. The MTA recently announced plans to install VMB displays at eleven Manhattan bus stops, including those served by the M15 bus, the city's busiest route.[34] Under the new program, buses will communicate their locations via satellite to an information center in Brooklyn, which in turn will transmit a radio signal to the VMBs at the bus-stops.

31 NYPRIG Straphangers Campaign Website, "Say What? A Summary of Subway Car Announcements;" (http://www.straphangers.org/announcements/summaryano.html); Accessed 11/09/07

32 NYPRIG Straphangers Campaign, "State of the Subways Report Card 2007," New York Public Interest Research Group Fund, Inc., Summer 2007

33 Belson, Ken, "BlackBerry as Weapon In the Fight To Commute," The New York Times, 8 October, 2007

34 Neuman, William, "The Next Bus Will Arrive In Exactly..." The New York Times, 4, October, 2007

A passenger consults the new "Time-to-Next-Train" display at Union Square. NYC Dept. City Planning

Interactive web and wireless based route information services are an increasing part of the transportation information offerings in other cities and can increase transit use. For example, planners in Duluth, Minnesota, saw a 12% increase in bus ridership, and a related decrease in car use, after a Google trip-planner for buses was added to the transit authority website.[35]

The Infrastructure Challenge:

Infrastructure enhancements are typically thought of as large-scale construction of new roads, bridges, tunnels and track. However, relatively small changes to existing physical infrastructure and policies can produce significant transportation gains. In New York City, space for new transportation systems is at a premium. Infrastructure enhancements that boost the capacity of existing systems, for example by making it easier for transit users to move between modes, are particularly important.

As New Yorkers already know, connectivity is the key to the sucess of our transit system. In July 1997, the introduction of the free transfer "gold" MetroCards unified the city's subway and bus systems and dramatically increased ridership. The free transfer MetroCard produced a 17% increase in bus ridership (over July 1996) and a 4% revenue increase.[36] This ridership increase came as a welcome change to 25 years of consistent declines in bus ridership (dropping from 781 million in 1970 to 436 million in 1996) and encouraged the MTA to purchase hundreds of new buses and hire new drivers.[37] In addition, many riders cited the free transfer option as their prime reason for switching from tokens to the MetroCard which, prior to then had been highly criticized and was not widely used.[38]

The New York City subway is already one of the most connected systems in the world. Other large systems, such as Beijing, Boston, London, Moscow, or San Francisco, have fewer lines and transfer points and the walk between stations can easily be over a mile. Increasing that connectivity, especially in the outer boroughs is particularly important, as current transportation trend research indicates that most New Yorkers work in the borough where they reside.[39] Developing exisiting connections to other modes of transportation such as ferries, buses and bicycles, is one of the city's primary infrastructure challenges.

Access to the city's waterways, which are largely untapped potential transportation resources, is particularly challenging. For years, planning practice turned away from New York's rivers, separating them from the city with highways and train tracks. Today, as a result, potentially congestion-reducing transportation systems like ferries are difficult to realize because the waterfront is remote and hard to reach. Most of the city's

35 Dolmetsch, Chris & Ari Levy, "Google May Start New York Transit Guide to Boost Ads (Update2)," Bloomberg.com, (http://www.bloomberg.com/apps/news?pid=email_en&refer=&sid=aSJjKd6PoqZg); Accessed 8/27/07

36 Newman, Andy, "Free Transfers in Bus Ridership Rise;" The New York Times, 19 September, 1997

37 McFadden, Robert, "As Ridership Increases, Officials Seek More Buses;" The New York Times, 11 October, 1997

38 Pierre-Pierre, Garry, "Swipes Gain on Plunks as MetroCard Takes Off;" The New York Times, 30 June 1997

39 NYC Department of City Planning, "Peripheral Travel Assessment," New York City Department of City Planning, 2008

ferry operators provide private bus services to their landings in order to encourage use.

Creating more safe bicycle routes and options secure bicycle parking are also ways to extend the reach of the city's existing transit network. NYCDOT has been particularly agressive on this front building over 60 miles of bike lane in 2007 alone and testing out new protected bike lane models to increase safety. In partnership with MTA/NYCT, NYCDOT is also looking to install more bike racks at major transit stations to encourage multi-modal commuting and has released designs for new city bike racks. Efforts from private sector to build secure bicycle parking facilities also play a role, increasing transportation options for all New Yorkers.

NYCDOT's new protected bike lane on 9th Avenue in Manhattan. NYCDOT

A second infrastructure challenge is increasing carrying capacity and speed of existing transit systems like subways and buses. Current track and signal upgrades are intended to increase the number of trains that serve a given station over the course of day but will not be completed for many years. Recent MTA proposals to remove seats and modify the interiors of rush hour subway cars are an attempt to address these issues now.

For the city's buses, increasing speed is a primary issue. Buses are particularly important because they often serve to connect subway lines, and are the prime mode of public transit in many neighborhoods that lack subway service. But buses tend to get stuck in traffic or bunch together, dramatically reducing their appeal and viability as real transit options. In 2005, bus ridership fell by 0.55% or close to 4 million riders, despite overall ridership increases across the system.[40] NYCDOT's Select Bus Service is designed to address these issues.

Access to and travel within the subway system itself is a third infrastructure challenge. The 2005 American Community Survey (ACS) indicates that about 673,000 New Yorkers (9% of the total population) have a physical disability that could impair movement.[41] At present, 53 New York City subway stations are wheelchair accessible; that number will increase to 100 by 2020. The number of wheelchair accessible stations limits access in many areas. For example, for Brooklyn residents, there are no wheelchair accessible stations on the L train between 14th Street/ Union Square and the end of the line at Canarsie/Rockaway Parkway.

In December 2007, the MTA announced a proposal to invest $1.3 million to develop an automatic monitoring system which would send a message to a central dispatch location for elevator and escalator mechanics.[42] A pilot program that monitors 44 elevators is currently in place.

40 Metropolitan Transit Authority, "2005 Annual Report," Metropolitan Transit Authority, p.10
41 American Community Survey, 2002 & 2005
42 Neuman, William; "MTA Rapid Response Plan for Elevators and Escalators," The New York Times, 17 December 2007

Looking Outward, Looking Ahead:

New York today faces the challenges of growth: housing supply and affordability, health, environmental protection and economic development. Our ability to meet the demands of our growing population depends in many ways on the state and future of our transportation systems, for our transportation infrastructure links our city. Transportation brings people, services and goods into our neighborhoods, connects workers to jobs and residences, offers residents and visitors alike access to stores, restaurants, theatres, cultural institutions, parks and public amenities.

The challenges we face are not unique to New York City. Population growth, globalization, rising oil and gas prices, and climate change all force the issue of ensuring safe, efficient, accessible and environmentally friendly transportation systems to the front and center of public debate in cities across the globe. Today, planners, policy makers, citizens and entrepreneurs from every nation are working to meet these challenges. While every city has different economic, political and physical constraints, the lessons learned in Shanghai, in Bogota, in Portland, and throughout Europe can shed light on transportation opportunities in New York.

This report looks outward and forward, beyond the boundaries of our five boroughs to harness that energy and gather together case study examples of ways other cities have approached their transportation challenges. Working within the vision laid out in the Mayor's PlaNYC 2030 report, this World Cities Best Practices in Transportation report can help prepare New York for the challenges and opportunities the future holds.

CONNECTIONS AND CAPACITY:

THE INTEGRATED MOBILITY FRAMEWORK

Reducing traffic and transit congestion and developing our transportation networks to meet the demands of our growing population are New York City's two largest transportation challenges. Our ability to meet these challenges is constrained by limited space and insufficient funds. Large scale subway upgrades, like the 2nd Avenue line or signal upgrades (to allow for increased headways or platform information systems) are immensely expensive, and their completion dates are far in the future. Other new subway proposals which could increase transit access in the Bronx, Brooklyn, Queens and Staten Island would require extensive land acquisition and potential residential relocation.

Integrated mobility is a transportation framework that provides a different approach to New York's twin congestion and growth challenges. It posits that, in conjunction with buiding new infrastructure, coordinating existing systems can help to increase transportation capacity in the short term. Cities like Hong Kong, Bremen and Toronto have created overlapping networks of transportation modes (subways, buses, streetcars, bike-shares, car-shares, etc.) linked by easily accessible real-time information systems. These integrated mobility efforts have substantially improved transportation networks and increased capacity and ridership.[43]

Integrated mobility strategies encourage cities to focus resources on coordinating existing systems and introducing new infrastructure in ways that can increase connectivity, and thus the capacity, of the system as a whole. For a city like New York, which already has tremendous amounts of transportation infrastructure in place, an emphasis on integration may help direct us toward congestion reduction

43 Much of the literature about integrated mobility has been gathered by Moving the Economy, a partnership between the city of The City of Toronto, Transportation Options and the Federal Government of Canada. Their website is: http://www.movingtheeconomy.ca/content/mte_about.html

The Hiawatha Line (Route 55) station map in Minneapolis also indicates bus transfer and park-and-ride points along the route. This simple feature encourages public transit use by ensuring that users know their transit options. NYC Dept. City Planning

solutions that are relatively quick to implement, cost-effective and do not interfere with other long term infrastructure improvements.

The increased connectivity made possible by integrated mobility strategies can help cities like New York hone and maintain their competitive edge in the world economy. As Susan Zielinski, an integrated mobility advocate, argues, increased transportation connectivity means that people can to do more in a 24 hour day, increasing economic productivity as well as personal happiness and well-being. In an article for the National Academy of Engineering's journal, *The Bridge*, Zielinski says, "on a typical day in Los Angeles, you may drive long distances at high speeds to fit in three meetings. In Bremen, Germany, a more accessible place, you may be able to fit in five meetings and a leisurely lunch, covering only half the distance at half the speed and for half the price."[44]

44 Zielinski, Susan, "New Mobility: The Next Generation of Sustainable Urban Transportation," The Bridge: Linking Engineering and Society, National Academy of Engineering, Volume 36, Number 4, Winter 2006, p. 36

An advertisement for Bremen's "Eierlegendewollmilchsau," the multi-purpose transportation card. Image used with permission of Michael Glotz-Richter, City of Bremen

In some cases, increasing the connectivity of a city is simple. Increasing or modifying signage to reflect the full range of transportation options transit users have at their disposal, promoting bicycle- or car-sharing or providing secure bicycle parking at public transit stations can all increase transit use. Minneapolis, for example, increased the connectivity and ridership throughout the city by making multi-modal transfers easy; signage on the new Hiawatha Line (Route 55) streetcar lists connecting bus options and parking facilities available at each stop. In other places, increasing connectivity may require more investment, building new stations or new transit lines to physically connect existing modes.

One of the simplest and earliest examples of integrated mobility is Hong Kong's OctopusCard which linked a variety of public transportation services and fare systems with a single smart card.[45] The system was adapted in the 1990's to Bremen, Germany and more recently to Toronto, Canada. In Bremen, new *Mobile.Punkte* centers create a hub of services (traffic and route information, bike-shares and car-shares, taxis, bus stops

45 Zielinski, Susan, "New Mobility: The Next Generation of Sustainable Urban Transportation," The Bridge: Linking Engineering and Society, National Academy of Engineering, Volume 36, Number 4, Winter 2006, p. 33

and streetcar stations) making transfers between modes almost seamless.[46] As in Hong Kong, these transportation modes are tied together by a single electronic card that is a combination bank card, fare-card and key for car-sharing programs. The card is marketed as an "eierlegendewollmilchsau" or "egg-laying-wool-milk-sow." Its name is meant to convey the idea that the card allows you to do essentially everything.[47]

Moving the Economy, a partnership between the City of Toronto, Transportation Options (a non-governmental organization) and the Federal Government of Canada, describes an integrated mobility scenario like this:

> "If you were living in Bremen, Germany, you might be hankering for an espresso right around now. So you call your friend Hans across town and you're on for a cup in half an hour. No need to deal with congestion or parking - you have the city at your doorstep with the most seamlessly connected transportation choices you could ask for.
>
> Since Hans needs to borrow your heavy duty floor sander, your best bet for getting there is a car-share vehicle. You book it on your cell phone as you saunter along the tree-lined, traffic-calmed street to the "Mobil Point" at the local church yard. That's where the car-share cars are parked. You wave your electronic smart card over the reader to get in, swing by home to pick up the sander, and off you go, headed for a similar Mobil Point near the café.
>
> To get home Hans has the sander now, so you don't need the car anymore. You head back to the Mobil Point, where cabs, bike parking, and frequent transit service are all waiting, and real-time traveler information tells you a tram is coming in three minutes that will deliver you practically to your doorstep."[48]

Transit data shows that Bremen's integrated mobility experiment has been a success. Bremen's integrated mobility efforts have maximized users' abilities to transfer within the system, further encouraging use. While driving is becoming increasingly popular throughout Germany as a whole, in Bremen transit usage has also steadily increased, rising from 114 million passengers/year in the greater Bremen region in 1997 to 121 million passengers/year in 2003.[49] In contrast to other areas in Germany, mode share in Bremen and the surrounding areas has remained stable. Overall, integrated mobility programs tend to grow quickly. Bremen's car-sharing program began in 1990 with 30 members. By 2004, the car-share program had 3,100 members.[50]

In 2004, Moving the Economy received grants from Government of Canada, the City of Toronto and other partnership organizations to develop Mobility HUBS in Toronto.[51] The first Toronto HUB, which opened in 2006, piloted an number of mobility features including bicycle storage facilities, a BikeShare station, a car share facility (called AutoShare), a taxi hotline, wireless hotspot, and bicycle and transit route maps.[52]

Overall, the Mobility HUB has been met with widespread customer approval. 88% of respondents in a Moving the Economy poll wanted to see the Mobility HUBS expanded around Toronto, citing the benefits of the system ranging from the "integration of fares between transit systems, easier connections and shorter waiting times, easy to find and read schedules...[easily accessible or on-site] bank machines, internet connectivity...[and the] availability of Bikeshare and AutoShare vehicles."[53] As in Bremen, the strength of Toronto's HUB system comes from its connectivity. Surveys found that Toronto transit users liked each individual aspect of the HUB system, but rated the combined benefits of the integrated, multi-modal system even higher than any of its parts.

46 Moving the Economy Website, "Bremen Case Study: Bremen's Integrated Mobility;" (http://www.movingtheeconomy.com/); Accessed 11/09/07

47 Glotz-Richter, Michael, "Moving the Economy: A Guided Tour of the Transport Integration Strategy of Bremen, Germany," Bremen Dept. of Building and the Environment, 2003(http://www.movingtheeconomy.com/); Accessed 11/09/07

48 Moving the Economy Website, (http://www.movingtheeconomy.com/); Accessed 11/09/07

49 Moving the Economy Website, "Bremen Case Study: Bremen's Integrated Mobility;" (http://www.movingtheeconomy.com/); Accessed 11/09/07

50 ibid.

51 Moving the Economy Website, (http://www.movingtheeconomy.com/); Accessed 11/09/07

52 ibid.

53 ibid.

PART II: Best Practices

SUSTAINABLE MODES

Increasing transit capacity, extending the reach of the city's transit network and providing new transit options to New Yorkers are some of the prime transportation goals outlined in PlaNYC 2030. These challenges are particularly pressing in New York City, where there is limited available space and where existing density and logistical challenges drive up construction costs. The best practices featured in this section are modes of transportation that could be implemented in New York City to reduce pressure on existing modes, increase the connectivity and capacity of our public transit system, and take into account rising and fluctuating fuel and oil prices. They represent innovative sustainable planning—environmental, transportation and economic—and may be able to help increase transit capacity with less extensive capital projects.

This report highlights three modes of transportation and/or technologies that have increased the capacities of public transit systems around the world and can reduce traffic congestion and pollution here in New York.

- Hybrid Ferries
  - » Case Study 1: The Solar Sailor
- Bicycle Share Programs
  - » Case Study 2: Bicing & Velib'
- Passenger, Freight & Aerial Streetcars
  - » Case Study 3: The Portland Streetcar
  - » Case Study 4: The CarGo Tram
  - » Case Study 5: Schwebebahn, SkyBus & AeroBus

Rush hour in Manhattan.
Image source: Pete Biggs

HYBRID FERRIES:

New York's island geography makes ferry service an obvious transportation option. However, insufficient waterfront access for pedestrians, poor connections to other modes, high operating costs and air pollution by conventional diesel ferries, have limited the use of ferries in the city. In recent years however, hybrid technologies have become available for ferries, tugboats and other maritime vessels. In addition to decreasing operating costs, hybrid maritime technologies could solve many environmental concerns that deter ferry use including air pollution from diesel emissions, noise pollution and community concerns about ferry landing placement.

This report focuses on the Solar Sailor, a solar-electric-diesel-wind hybrid that is at the forefront of hybrid maritime technology. The Solar Sailor is in operation in Sydney, Australia and proposed by Hornblower Cruises for San Francisco starting in 2009. Solar Sailor was also proposed by Circle Line Downtown for its Statue of Liberty route which has since been awarded by the National Parks Service to Hornblower Cruises. (As of the printing of this report, there has been no indication as to whether Hornblower will consider a Solar Sailor vessel for its New York route.)

Background:

Despite an eratic history, ferry service is part of the daily lives of many New Yorkers. 65,000 people ride the Staten Island Ferry each day.[1] Reports from the city's community boards indicate that ferries are increasingly seen as a desirable transportation mode.[2] However, poor access to the city's waterfronts and the pollution created by conventional, diesel ferries have limited the growth of ferry service in New York.

The sole transportation mode between Manhattan and Brooklyn in the 1800's, ferry service in New York City declined throughout the 1900's due to the construction of the city's bridges and tunnels. Highway construction along the waterfront in the 1930's-1960's further separated New Yorkers from historical ferry landings. The revitalization of New York's waterfronts as recreational areas helped spur a new generation of ferry services (NY Waterways, WaterTaxi for example) in the 1980's and 1990's but access remained limited. In the months following 9/11 ferry service grew quickly providing service across the Hudson River. However most ferry landings were difficult to reach, and the majority of commuters returned to their pre-9/11 transportation modes as soon as they became available.

The pollution created by conventional, diesel ferries has also limited their potential in cities like New York. Diesel ferries produce significant amounts of air pollution and noise, especially when idling at dock. Diesel emission are composed of gases and solids such as nitrogen oxides (NOx), which contribute to ozone production and particulate matter or soot (PM), and pose severe respiratory health risks.[3] As result, many residential communities do not want ferry landings in their midst, further limiting access points.

Addressing these pollution issues can be done through retrofits to conventional diesel ferries and through phasing in hybrid ferry technology. The Port Authority of NY/NJ, in collaboration with the US Environmental Protection Agency, NYCDOT and the US Army Corps of Engineers, has worked to reduce the diesel emissions from the Staten Island Ferry by installing selective catalytic reduction and diesel oxidation catalysts on to existing equipment which reduce nitrogen oxides to benign gases naturally found in air.[4] Their 2006 retrofit of the Alice Austen cut emissions by 16.5 tons of nitrogen oxides per year and reduced particulate matter by 25 percent.[5]

1 NYC Department of Transportation Website, "Staten Island Ferry," (http://www.nyc.gov/html/dot/html/ferrybus/statfery.shtml): Accessed 12/17/07

2 In particular, Bronx Community Boards 2,4 and 7, Brooklyn Community Boards 1 and 10, Manhattan Community Board 1 and Staten Island Community Board 2 all expressed interest in ferry service to ease congestion.

3 Clean Air Task Force Website, "Diesel Engines: Emissions and Human Exposure," (www.catf.us); Accessed 12/18/07

4 US EPA, "Press Release: Cleaner Emissions from Staten Island Ferry just the Beginning -- Northeast Diesel Collaborative Expands Efforts," 31 January, 2006

5 ibid.

Hybrid ferry technology can also reduce pollution by substantial quantities. Some hybrid models, such as the Foss hybrid tugboat which is being introduced in the Los Angeles and Long Beach Ports, have been proven to reduce particulate and nitrogen oxide emissions by 44% without a reduction in power.[6] In addition, most hybrid models show significant reductions in noise pollution, something that retrofits cannot do. Lastly, the use of hybrid technologies reduces fuel consumption. Many hybrid operators report lowered operations costs; especially important in a time of rising world oil prices.

Dolphin Class FOSS tugboats directing a shipping vessel. The FOSS hybrid tugboat will produce a fraction of the air pollution. Image used with permission of Foss Maritime.

6 FOSS Website; "PRESS RELEASE: WORLD'S FIRST TRUE HYBRID TUG TO BE BUILT BY FOSS MARITIME;" (http://www.foss.com/press/Press_Release_030207.html); Accessed 11/09/07 & The Associated Press, "Foss, California ports join to develop hybrid tugboat;" Seattle Post-Intelligencer, 3 March, 2007

Case Study 1: The Solar Sailor (Sydney, Australia; San Francisco, CA)

The original Solar Sailor in Sydney harbor operated by Captain Cook Cruises. The wing panels serve as sails while simultaneously collecting solar energy. Image used with permission of Solar Sailor (www.solarsailor.com).

The Solar Sailor, described by Terry McRae of Hornblower Cruises, as "a Prius on steroids," is an award-winning hybrid vessel from Australia.[7] It is unique, even among hybrid vessels, because it adds wind power to the typical diesel-solar hybrid technology.[8] It has been in use as a passenger ferry in Sydney Australia since the 2000 Olympic Games and will begin operations in San Francisco Harbor (National Parks Service Alcatraz concession) in 2008.[9] It was proposed for New York harbor by Circle Line Downtown in their unsuccessful bid for the Statue of Liberty National Parks concession.[10]

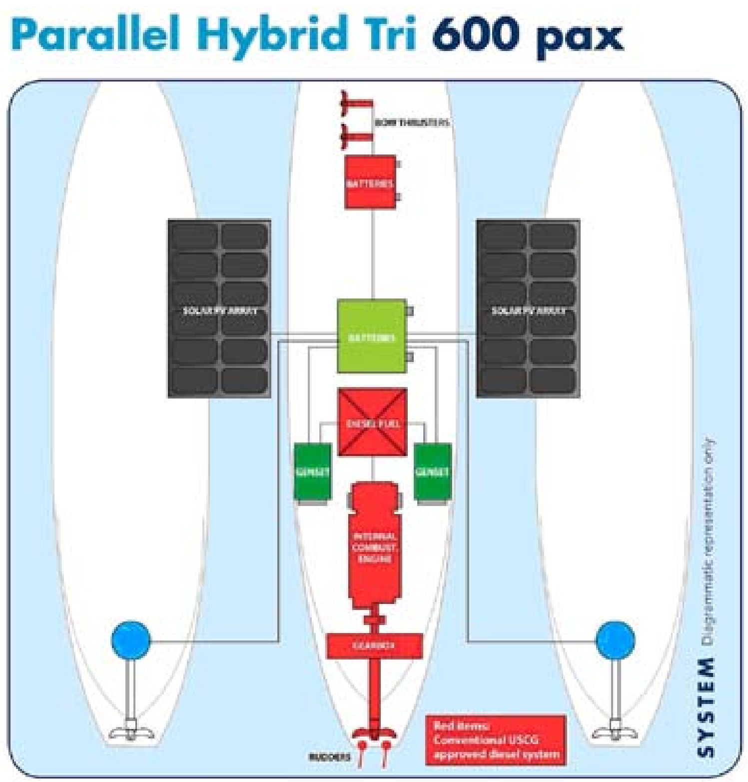
7 Phone Interview with Terry McRae, CEO Hornblower Cruises, 1 June, 2007

8 Since its introduction in Sydney, Solar Sailor has won a number of best technology awards including the 2000 Boating Industry Association of Australia's Best New Product Award, the 2000 International Cargo Handling Co-Ordination Association Award for Cargo Handling, and the 2001 Australian Design of the Year Award in Engineering. Solar Sailor has been awarded two grants from the US Military (2005 and 2007) to develop unmanned ocean vehicles. (Dane, Robert; "Technology Solutions: Safe, Efficient Hybrid Marine Power." Solar Sailor Brochure)

9 Phone Interview with Terry McRae, CEO Hornblower Cruises, 1 June 2007

10 In June 2007, the Parks Service selected Hornblower Cruises as the winner of this concession. There has been no indication as to whether Hornblower will consider Solar Sailor

Solar Sailor vessels are hybrid catamarans equipped with rigid movable "wings" which operate as sails or can be folded flat in extreme wind (40 knots +) conditions. The top surface of these wings are covered with solar paneling, as are other surfaces of the vessel. As hybrid vessels, Solar Sailors can generate power from their internal combustion engines (diesel/liquefied petroleum gas LPG) or from electric batteries charged by the solar arrays and the internal combustion engine. The two power sources to work independently, which slightly reduces the energy efficiency but increases the power and speed of the vessels.[11]



Internal combustion and electric engines give the Solar Sailor a greater degree of flexibility and efficiency. Image used with permission of Solar Sailor (www.solarsailor.com)

On-board control panels allow the ships' captains to choose which power source makes sense at different speeds—solar/electric for low speeds or idling, internal combustion engine for higher speeds or cruising. Such a design is ideal for vessels that must start and stop frequently, like commercial or commuter ferries.[12] In addition, the ability to switch between power sources as needs and conditions change means a dramatic reduction in fuel use. Solar Sailor's Sydney operator, Captain Cook Cruises, reports up to 50% fuel savings on its routes.[13] Since the vessels can be entirely powered by their solar/electric engines while at the dock, they produce zero idling emissions and substantial reductions in air (NOx, PM, CO_2, etc.) and noise pollution. In addition, the vessels are designed with a "Low-Wash" hull design that minimizes impacts on piers and bulkheads.[14]

Unlike other hybrid vessels, Solar Sailor can also reduce fuel use and emissions while in motion or at high speeds, since its wing panels allow it to gain additional speed without expending more fuel. Although this has not been tested outside of Sydney, Hornblower CEO, Terry McRae believes that the 1 ¼ mile Alcatraz route, which typically sees winds of around 25 knots, will be an ideal testing ground.[15]

The Solar Sailor computer systems utilize GPS systems and rely on NASA and National Weather Service data to predict wind direction and the location of the sun allowing the Solar Sailor crew to orient wings and paneling to the best position.[16] In addition, the GPS system allows for certain automatic safety measures, like lowering the wings if the vessel is traveling above a certain speed within 50 yards of a wharf or under bridges.[17]

technology for this route as well as the route for Alcatraz.

11 The slight efficiency loss is not unique to Solar Sailor. Electric motors in general are more efficient than diesel engines because they can use optimally size propellers which internal combustion engines cannot.

12 Dane, Robert; "Technology Solutions: Safe, Efficient Hybrid Marine Power." Solar Sailor brochure provided by Robert Dane

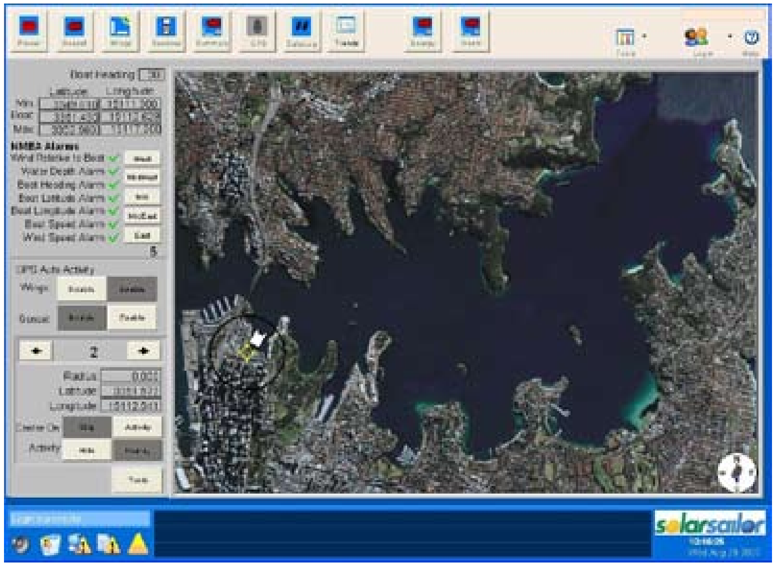
13 Email Correspondence with Anthony Haworth, Managing Director, Captain Cook Cruises 17 May, 2007

14 Solar Sailor, "Hybrid Marine Power Brochure," Courtesy of Robert Dane, www.solarsailor.com

15 Phone Interview with Terry McRae, CEO Hornblower Cruises, 1 June, 2007

16 Solar Sailor Website, (www.solarsailor.com); Accessed 12/18/07

17 Interview with Robert Dane, Solar Sailor, and JB Meyer, NY CircleLine Downtown, 30 May, 2007



Solar Sailor's on-board computer and GPS systems monitor a variety of important aspects of the ship's voyage and route including wind speed and direction, water depth, vessel direction and heading and location. Image permission: Solar Sailor (www.solarsailor.com).

The addition of the solar array, batteries and electric engine means that Solar Sailor vessels cost more than conventional ferries. MacRae estimates that that the Solar Sailors for Alcatraz will cost about $15,000 per seat if they chose to build 600 passenger ships and more, $20,000 per seat, if they build a smaller 300 passenger ship. Hornblower Cruises has budgeted $5 million for the development of the two Solar Sailor vessels.[18]

Reductions in operating costs may offset increased capital costs. JB Meyer, the CEO of New York City's Circle Line Downtown estimated if Solar Sailors were to run on their Statue of Liberty route, Circle Line Downtown would reduce its fuel consumption by up to 30% each year and would recoup the increased vessel cost within 12 years.[19]

18 Phone Interview with Terry McRae, CEO Hornblower Cruises, 6/01/07 & Witherell, Amanda. "Casting Off; New Alcatraz Ferry Service Leaves Unions, Environmentalists, and City Officials Fuming on the Dock;" SF Bay Guardian Online; (http://www.sfbayguardian.com/printable_entry.php?entry_id=1707); Accessed 11/09/07

19 Interview with Robert Dane, CEO Solar Sailor, and JB Meyer, CEO Circle Line Downtown, 30 May, 2007

Examples and Opportunities in New York City:

Expanding ferry service in the New York region is an important 2030 PlaNYC goal and hybrid ferries represent a way to further facilitate environmentally friendly maritime transportation and reduce fuel cost and consumption for ferry operators

In addition to technological advances like catalytic converters that can reduce the amount of air pollution produced by diesel marine engines, this report recommends the further investigation of hybrid power options. Hybrid technologies present options for new private ferry fleets (such as NY Waterways or WaterTaxi) which can be spurred by regulations or tax incentives, and for city-operated ferries, such as future Staten Island Ferry purchases.

BIKE-SHARE PROGRAMS

Bike-share programs are a way to extend the reach of existing transit modes like rail, subway or bus and increase bicycle mode split in cities. Bike-share programs exist in many European cities—including London, Paris, Barcelona, Rome, Berlin, and Oslo—and bike-share programs are in the works in the United States as well. SmartBike, the first US program opened in August 2008. A list of bike-share programs worldwide can be found in Appendix B.

Background:

Barcelona's Bicing bicycle-share program, operated by Clear Channel Adshel. Image used with permission of Clear Channel Adshel.

Bike-share programs are technologically enhanced versions of free public bicycles. Program operators place bicycles at "kiosks" throughout a coverage area. Program members can pick up bicycle by swiping their membership card at any kiosk and return the bicycle to any other kiosk. Bike-share programs tend to increase both commuter and recreational/errand bicycling when spread over a large area with many kiosks at which users can pick-up or return bicycles. The high kiosk density allows the programs to serve the needs of commuters or people running errands who can pick up a bicycle at their front door, ride to the Metro, store or work, and leave the bicycle at a kiosk there without further worry. Bike-share programs are usually priced in 1/2 hour increments to encourage use and rapid bicycle turn-over.

Bike-share programs first appeared in the mid-1960's as fleets of free, brightly painted bicycles placed around a city for public use. However, theft and vandalism of the bicycles quickly ended most of these programs. Subsequent programs attempted to address these issues by using uniquely designed bicycles with parts that could not be interchanged with traditional bicycles, by requiring a coin deposit to retrieve a bicycle, and by creating designated terminals for pick-up and drop-off within the bike-share area.[20] However, theft remained a challenge because there was no way to track the bicycles once they left the bike terminal.

The newest bike-share programs, often called 3rd generation programs, solve the problem of bicycle theft and damage through membership and use fees and automated, wireless technologies. Membership data links customer identification to each bike hire. Customer credit cards are charged for lost or damaged bicycles.[21] Theft in 3rd generation programs is limited since bike-share operators have the ability to fine customers for unreturned or damaged bikes in their name.[22] Like the earlier programs, 3rd generation bikes still utilize distinct bike-sharing designs and colors which make them easily identifiable to potential users. Dismantling 3rd generation bike-share bicycles requires special tools and the parts cannot be interchanged with traditional bicycles making their resale value negligible.

High population density, a dense urban environment and the existence of cycling infrastructure such as bike lanes are some of the most important pre-requisites for successful bike-share programs. New York City's average density (excluding Staten

20 DeMaio, Paul and Jonathan Gifford, "Will Smart Bikes Succeed as Public Transportation in the United States?" Journal of Public Transportation, Vol.7, No.2, 2004, p.3

21 Remarks by Josh Squire, JCDecaux Bicycle System Manager, Keynote Speaker for the Forum on Urban Design and Storefront for Architecture Charette, " The New York Bike-Share Project." 10 July, 2007

22 According to Richard Grass of ClearChannel Adshel, bike theft is common the first year or two a bike-share program is in operation, however, theft diminishes as the novelty of the program wears off. To date, about 300 bicycles have been stolen from Paris's program.

Island) of around 48,000 people per square mile is on par with other cities with sucessful programs; Paris, for example, home of the world's largest bike-share program has around 53,000 people/square mile.

New York City's cycling infrastructure has improved over the past 10 years. With the charge from PlaNYC 2030, New York City will benefit from 1,800 additional miles of bike lanes spanning the five boroughs by 2030. 200 miles are scheduled for completion by the end of 2009.[23] Bicycle lane enforcement is still a challenge as many lanes are used (illegally) as additional parking or driving lanes. NYCDOT is introducing newly designed protected bike lanes. The pilot protected lane, on Ninth Avenue in Manhattan has been highly sucessful and NYCDOT plans to add 15 more miles of protected lanes by 2009.[24]

The City is also promoting bicycling as an intermodal option, encouraging people to bicycle to subway or bus. In July 2007, NYC DOT replaced vehicle parking spots near a Brooklyn subway station to widen the sidewalk for bike racks.

International attention to bike-share programs has not gone unnoticed in the US. Washington DC's SmartBike program opened in August 2008. Chicago and San Francisco have recently sent out requests for proposal (RFPs).[25] Cities such as Boston, Portland, OR, Phoenix, Albuquerque and Philadephia have also begun preliminary feasibility studies. In August 2008, NYCDOT announced a "Request for Expressions of Interest (RFEI)" for a New York bike-share program.

23 NYC Department of Transportation, "Sustainable Streets 2008 and Beyond; NYCDOT Strategic Plan," April 2008

24 ibid.

25 Remarks by Josh Squire, JCDecaux Bicycle System Manager, Keynote Speaker for the Forum on Urban Design and Storefront for Architecture Charette, " The New York Bike-Share Project." 10 July, 2007

Case Study 2: Bicing & Velib' (Barcelona, Spain; Paris, France)

Image by Joseph Simpson/Movement Design Bureau, used under the terms of cc-by-sa-2.0 (http://creativecommons.org/licenses/by-sa/2.0/). Available at http://movementbureau.blogs.com/projects/2007/12/velib---a-photo.html.

Bicing, in Barcelona, and Velib', in Paris, are two of the world's largest bike-share programs to date. Both programs opened in 2007, Bicing in March with 1,500 bicycles and Velib' in July with 10,000 bicycles. Both programs have also expanded substantially since their inception. Bicing, a ClearChannel Adshel program, now boasts 6,000 bicycles and over 400 kiosks. Velib', a JCDecaux program, now has 20,600 bicycles and over 1,400 kiosks. Plans to expand Velib' to 28,500 bicycles to include the Parisian suburbs have recently been announced.[26] Both programs were designed to complement existing public transportation options.

Data from Bicing, Velib' and the other European bike-share programs indicate that bike-share programs can increase bicycle ridership in a city. In Lyon, France, bicycle riding increased by 44% within a year as a result of introducing a bike-share program.[27] 96% of those first year riders had never before bicycled in the Lyon city center.[28] Current data from Paris shows that the city has seen a 70% increase in bicycle use and a 5% reduction in car use and congestion since Velib' was introduced.[29]

Commuters are major users of bike-share programs. In Paris, respondents to a JCDecaux survey indicated that 74% of bicycle trips were made for work purposes.[30] Velib' ridership close to doubled during the transit strike in the winter of 2007-8. Data from ClearChannel Adshel's programs indicates similar results. 60% of ClearChannel Adshel's bike-share subscribers use the bikes in their commute.[31] 45% of Clear Channel's membership bases uses a public-use bike more than five times per week.[32] In general, bike-share bicycles are used 10-15 times per day.[33]

The popularity of bike-share programs can be seen in their membership sales. In Barcelona, Bicing sold almost 100,000 annual memberships in the first six months alone.[34] In Paris,

26 Pirolli, Bryan, "Velib' Hits the Paris Burbs;" Conde Nast Traveler, (http://www.concierge.com/cntraveler/blogs/80days/2008/08/velib-hits-the.html); Accessed 9/2/08
27 NICHES, "New Seamless Mobility Services: Public Bicycles;" European Commission, DG Research, 6th Framework Program, p.2 (www.rupprecht-consult.de/download/niches_public_bikes.pdf); Accessed 06/19/07
28 Holtzman, David, "Bike-Sharing," Planning, May 2008, p.21
29 Bremner, Charles & Marie Tourres, "A year on, the cycle experiment has hit some bumps;" The London Times, 8 July, 2008
30 Velib' Website, "Press Release: Appendices Opinion Poll;" (http://www.velib.paris.fr/espace_presse); Accessed 3/24/08
31 Clear Channel Outdoor Website, "SmartBike™;" (http://www.smartbike.com/); Accessed 3/24/08
32 Clear Channel Outdoor Website, "SmartBike™;" (http://www.smartbike.com/); Accessed 3/24/08
33 Velib' Website, "Press Release: Velib' is Changing the City!" (http://www.velib.paris.fr/espace_presse); Accessed 3/24/08
34 Scholtus, Petz; "The TreeHugger Interview with Mayra Nieto, Barcelona Municipal Service: Bicing, Barcelona's Bike-Sharing System;" (http://www.treehugger.com/files/2008/01/

Velib' had 100,000 annual membership subscribers within the first eight weeks.[35] Twelve weeks after their introduction, Velib' public-use bicycles had been used over seven million times.[36] There have been 30 million Velib' trips in the first year; approximately 120,000 trips per day.[37]

Velib' in Paris has been particularly adept at using its membership and use fees structure to encourage ridership. The Velib' fee structure incentivizes many short trips instead of a few long trips by requiring users to pay increasingly more as any given trip continues past one hour. For example, the first half hour of Velib' usage—enough time to bicycle to a local store or train station—is free; a user would pay €1 for the second 1/2 hour, €2 for the third 1/2 hour and so on which encourages users to return that particular bike to a kiosk for use by other Velib' members. Bicing, in contrast, offers the first 30 minutes for free but charges a flat rate (€.30) for each additional half hour period up to 2 hours. Also unlike Bicing and a number of other programs, Velib' offers daily (€ 1) and weekly passes (€ 5), in addition to its annual pass (€ 29), which allow prospective members to test the system as well as offering options for visitors and tourists. In the first six-months alone, Velib' sold 2.5 million one day passes.[38]

Bike-shares can vary from a few hundred bicycles to several thousand, depending on the size of the city and the purpose of the program. Velib', in Paris, is unique in its size and coverage of the city. Kiosks are placed every few blocks and are place on the sidewalk, in the place of car parking spots, along the edges of public parks and under elevated train tracks. The number of bicycles available and the degree of kiosk coverage allows the program to substantially impact and interact with existing transit services in the city. JCDecaux's other programs are also located in larger French cities like Marseilles (1.6 million people) and Lyon (1.7 million people), and have between 3,000 and 10,000 bicycles, but do not (yet) cover the entire city.

A map of Paris showing the proposed location of every Velib' bicycle-share kiosk. In order to maximize the impact of bicycle-sharing, the city of Paris worked with JCDecaux to place kiosks everywhere. Image used with permission of JCDecaux.

In contrast, ClearChannel Adshel's programs, like Bicing, tend to cover less of the city and provide fewer bicycles (1,000 to 1,500). While geared toward commuters, because they do not offer short-term memberships, their kiosk locations (only in the center city) make them better suited for trips during the work day than a full-scale commuter option. Nibici, a CEMUSA program in Pamplona, Spain, focuses on recreation and thus only provides 350 bicycles at 20 stations across the city.[39] The Deutsche Bahn's Call-A-Bike program avoids the kiosk model entirely by allowing users to lock bicycles to any stationary object near a train station or prominent intersection in the city center. However, such a

the_th_intervie_28.php); Accessed 9/2/08

35 Cardwell, Diane, "In Paris, Bloomberg Eyes Bike Program for Home;" The New York Times, 30 September 2007

36 Rayman, Eric, "Finding Liberté On TwoWheels;" The New York Times, 14 October 2007

37 Erlanger, Steven, "A Fashion Catches On in Paris: Cheap Bicycle Rentals," The New York Times, 13 July 2008

38 DeMaio, Paul; "The Bike-Sharing Blog;" (http://bike-sharing.blogspot.com/); Accessed 6/25/08

39 Remarks by Carlos Pujol, CEMUSA Corporate Development Director, Keynote Speaker for the Forum on Urban Design and Storefront for Architecture Charette, " The New York Bike-Share Project." 11 July, 2007

model makes it difficult for potential users to predict where they might find a bicycle and limits the range which users can take them.[40]

In addition to kiosk location , distribution of bicycles at the kiosks is one of the major operational challenges that bike-share operators like CEMUSA, ClearChannel Adshel and JCDecaux have faced in their European programs. These operators use extensive, on-going monitoring and redistribution vehicles to help manage the location of their bicycles over the course of the day. Bicycles are equipped with radio frequency identification, (RFID) technology which enables program operators to track the location of its fleet and monitor the status of each bicycle.[41] If a bicycle is malfunctioning, the bicycle computer alerts the main computer monitoring system which dispatches a redistribution vehicle to fix the problem. All companies use redistribution vehicles to move bicycles around the city as needed. Velib' employs 400 people to monitor its fleet of 20,600 bicycles.

Bike-sharing programs are self-service. As a result, they cannot enforce the wearing of bike helmets. In addition, because there is no way to effectively monitor structural wear-and-tear on a given helmet, bike-share operators are unwilling to rent helmets to users for liability reasons. However, operators can encourage helmet usage through their own operations. JCDeceaux, has a patent pending on a "smart" helmet which doubles as a membership card.[42] The city of Paris has also introduced a number of safety campaigns to encourage helment use and good bicycling behavior.

40 Call-A-Bike website, English Version (http://www.callabike-interaktiv.de/kundenbuchung/process.php?proc=english&f=500); Accessed 11/14/07

41 Clear Channel Outdoor Website, "SmartBike™;" (http://www.smartbike.com/); Accessed 3/24/08

42 Phone Interview with Josh Squire, Bicycle System Manager JCDecaux, 10 September, 2007

In order to ensure that there are enough bicycles at high-demand locations, most third generation bicycle-share programs have developed a system to redistribute bicycles as needed. Image used with permission of Clear Channel Adshel.

Financing Bike-Shares:

While the earlier bike-sharing programs were predominantly started and operated by local governments or non-profits, most 3rd generation bike-share programs have been developed as public-private partnerships by advertising and street furniture companies (CEMUSA, ClearChannel Adshel and JCDecaux) seeking advertising contracts with municipalities. Velib', for example, is tied into the billboard franchise contract that JCDecaux holds with the city of Paris. In exchange for rights to 1,628 advertising billboards and other street furniture, JCDecaux maintains and operates Velib' and carried the full cost of the initial start-up capital ($142M).[43] JCDecaux expects to earn $94M annually in advertising revenues.[44] In contrast, Bicing, while run

43 Nadal, Luc; "Bike Sharing Sweeps Paris Off Its Feet;" Sustainable Transport, Institute for Transportation and Development Policy; Fall 2007, Number 19 & Erlanger, Steven, "A Fashion Catches On in Paris: Cheap Bicycle Rentals," The New York Times, 13 July 2008

44 Erlanger, Steven, "A Fashion Catches On in Paris: Cheap Bicycle Rentals," The New York

by a street furniture advertising company, ClearChannel Adshel, is paid for directly by the city of Barcelona, as Barcelona's street furniture is already under contract. Bicing is financed with Barcelona's Green Area roadside parking program surplus and subscription revenue.[45]

As different types of advertising space command different prices, cities and companies must negotiate to ascertain how many bicycles will be provided and what types of advertising space will be used. In franchise programs, advertisting revenues are usually split. For example, the Washington DC SmartBike, comes as an extension of Washington DC's bus-shelter agreement and the city earns 35% of advertising revenues.[46]

In Oslo, Norway, Clear Channel Adshel collects revenue from advertising billboards to pay for their bike share program. Image used with permission of Clear Channel Adshel.

A preliminary analysis conducted by Clear Channel Adshel suggests that, using the public-private partnership model, New York City could introduce 500 bikes and locate 36 stations with an initial capital investment of $50,000 per station. The initial investment includes the following elements: bicycles, spare bicycles, docking stations, hardware and software, service trucks and installation of stations. A 500 bike and 36 station program requires $27,000 per kiosk per year for operational expenses which cover the program manager, service personnel, administrative personnel, distribution vehicle maintenance, electricity, wireless connectivity, website platform, smart cards, bike theft, insurance and warehouse costs.[47]

Modifications to kiosk design could reduce costs. Montreal's recently announced bike-share program, Bixi, is anticipated to have lower capital costs because their kiosks are solar powered and mounted on metal plates which are bolted into the ground.[48] Bicing and Velib' kiosks in contrast, require excavation and electrical hook-ups for installation.

Examples and Opportunities in New York City:

Introducing a bike-share programs in New York City is in keeping with the city's 2030 PlaNYC vision to increase bicycle use in the city and provide New Yorkers with more options to access existing transit. In addition, because bike-share programs are designed for short trips they could help to reduce some pressure on overcrowded subway lines.

Proposals for a New York City bike-share program should first consider what benefits the city hopes to realize. Small programs and pilots can generate attention quickly but often fail to produce increases in bicycling or any associated multi-modal transportation gains. Larger programs, although initally more costly, can, as Paris is demonstrating, create substantial shifts in mode-split and may reduce congestion. In general, a bike-share

Times, 13 July 2008

45 Scholtus, Petz; "The TreeHugger Interview with Mayra Nieto, Barcelona Municipal Service: Bicing, Barcelona's Bike-Sharing System;" (http://www.treehugger.com/files/2008/01/the_th_intervie_28.php); Accessed 9/2/08

46 Phone interview with Richard Grasso and Martina Schmidt, ClearChannel Adshel, 30 April 2008

47 Email Correspondence with Richard Grasso, Senior Vice-President, Business Development, Clear Channel Adshel, Inc. 1 October, 2007

48 Phone Interview with Alain Ayott, Executive Vice-President, Montreal Parking Authority; 3 & 11 July, 2008

program will not provide significant benefits without covering a large portion of the city.

New York neighborhoods with high residential and worker population density are strong candidates for a bike-share program. These areas include: Manhattan and western Brooklyn including Coney Island, the Bronx south of Van Cortlandt Park and west of the Bronx River, and Queens west of Flushing Meadon Park, and Flushing and Kew Gardens. Areas around transit hubs should also be considered. In addition, major destinations, like Yankee and Shea Stadiums, the Metropolitan Museum of Art and Coney Island, should also be included in the program coverage, especially if short-term (tourist) passes are sold.

New York City's geography and existing patterns of bicycle use and placement of bicycle infrastructure are also factors in developing a successful bike-share program. Boroughs like Manhattan and Brooklyn, and parts of other boroughs like the southwestern Bronx and western Queens may lend themselves better to bicycle-sharing because they are denser, have considerable existing bicycle lanes and are less car-dependent already.

Other issues that would need to be addressed include identifying locations for kiosks, increasing bicyclist safety, and further analyzing funding and procurement options. A phased roll-out may be useful to build program momentum. Phasing could begin in Manhattan, where population and worker densities are highest and the bike-lane infrastructure is the most robust.

PASSENGER, FREIGHT AND AERIAL STREETCARS:

Throughout North America and Europe, streetcars are making a comeback as a viable mode of urban transportation. In contrast to new roads for cars and buses or tunnels for subways and trains, streetcars typically require less infrastructure investment and provide reliable, fast on-street service. Most run off electricity and so do not directly contribute to air pollution. Aerial streetcars are placed on tracks above existing right-of-ways, thus increasing the capacity of existing transportation corridors without using precious space on the ground. In addition, cities that have invested in streetcars report significant economic development increases related to streetcar use. This report surveys the following three modern streetcar applications:

- Passenger streetcars (Portland, OR)
- Freight streetcars (Dresden, Germany)
- Aerial streetcars (Wuppertal, Germany and Goa, India)

Background:

As in many cities around the US, streetcars were an integral part of New York City's transportation network until the mid-20th century. Nationally, streetcars reached their peak ridership around 1920, just shy of 14 billion rides per year. After the Great Depression, streetcar ridership rose again to around 10 billion rides per year, but was overshadowed by bus ridership, a new force on the transportation horizon that benefited from increasingly car-oriented post-war local, state and federal transportation funding policies.[49] The last streetcar in New York City ended service in 1956.

Modern streetcars differ from historical streetcars, in use in San Francisco or rusting in Red Hook for example, in that they are fully enclosed train systems, built to current safety, noise and Americans with Disabilities Act (ADA) specifications. In general, modern streetcars differ from other forms of urban rail transit, like subways or light rail, in that they are smaller, lighter and

49 Slater, Cliff, "General Motors and the Demise of Streetcars," Transportation Quarterly, Vo. 51, No. 3, Summer 1997

more maneuverable in city traffic. Their relatively low weight means that most streets can handle the weight of a streetcar route without additional infrastructure work thus reducing costs and construction time.[50] Streetcars run on electricity, supplied by the local power grid. A pole attached to the streetcar touches an overhead catenary wire which provides up to 600 volts DC. Modern catenary pole and wire designs are aesthetically pleasing and unobtrusive.[51]

A number of American cities, such as Portland, Oregon, Omaha, Nebraska and Atlanta, Georgia, have built or proposed modern streetcars to compliment their existing transportation networks. Paris, France has recently opened its new T1, T2 and T3 tramway streetcar system which serves Paris' inner suburbs.[52]

50 Omaha Streetcar, "Streetcar FAQ;" Omaha Streetcar (http://www.omahastreetcar.com/education/index.html); Accessed 11/07/07

51 ibid.

52 RATP Website, (www.ratp.fr); Accessed 12/18/07

Case Study 3: Passenger Streetcars (Portland, OR)

The Portland Streetcar is easily integrated into existing traffic patterns. Image by Chris Phan used under the terms of cc-by-sa-2.0 (http://creativecommons.org/licenses/by-sa/2.0/).

In 2001, the City of Portland became the first US city to re-introduce a new streetcar network to augment its existing public transit systems (bus and MAX light rail). In contrast to the city's existing MAX commuter light rail network, these streetcars are shorter, lighter, narrower and have a higher degree of on-street maneuverability. Unlike the MAX, which brings commuters in from Portland' suburbs, the Streetcar is designed to offer an alternative to driving for people already in the city. The Portland Streetcar is owned and operated by the city of Portland.

The Portland Streetcar runs on a 7.2 mile loop that connects Portland's NW and SW (downtown) neighborhoods.[53] The

53 Portland Streetcar Website, "Streetcar History," (http://www.portlandstreetcar.org/history.php); Accessed 11/27/2007

streetcars stop roughly every 3-4 blocks and have stations at a variety of major Portland institutions such as the Good Samaritan Hospital, Pacific Northwest College of Art (PNCA), the Portland Art Museum and Portland State University (PSU). According to Portland Streetcar Project Manager, Vicky Diede, recent development along the streetcar line has made the streetcar an easy choice for many daily activities: going to work or school, doctors' appointments, grocery shopping, visiting museums, dropping children off at daycare or getting morning coffee.[54] The streetcar connects with the city's existing commuter MAX light rail system (which connects Portland's northern, western and eastern suburbs and the Portland International Airport), the Portland Bus Mall and the new aerial Tram (which connects downtown Portland to major hospitals and job centers, the VA Hospital and Oregon Health and Sciences University OHSU).

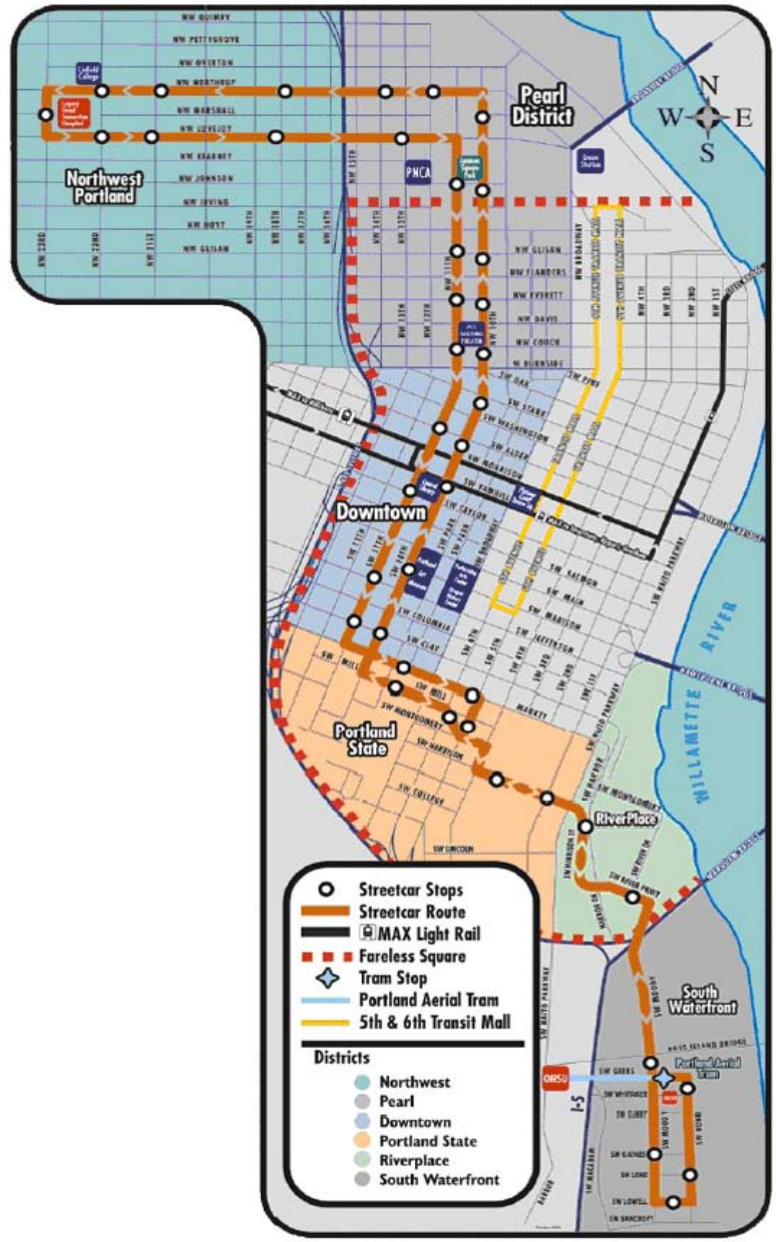
For most of its route, the Portland Streetcar shares the right-hand lane with cars, next to the parking lane. At station stops, the parking lane is replaced by a curb bulb out. Like buses, the streetcars only stop when signaled by riders or when there are people waiting at the streetcar stop. To ensure traffic flow, the streetcars are outfitted with a wireless Opticom System which allows them to communicate with traffic signals in order to extend green lights or clear intersections for wide turns.[55] This system also allows the Portland Streetcar to offer real-time arrival information to passengers waiting at streetcar stops.

Storage yards for the streetcars are located underneath the I-405 freeway on land leased from the Oregon State DOT by the city of Portland. The current facility uses approximately 100,000sf and it will be expanded when additional streetcar lines are added.[56]

54 Email Correspondence with Vicky Diede, Portland Streetcar Project Manager, City of Portland Office of Transportation, 9 July, 2007

55 ibid., 8 May, 2007

56 ibid., 9 July, 2007



The Streetcar route connects riders to a variety of cultural institutions, job centers and other transit modes including Portland Metro's MAX lightrail and the new aerial Tram. Image used with permission of the City of Portland's Office of Transportation.

Ridership on the Portland Streetcar has increased steadily. Planners initially estimated that ridership for the streetcars would be about 3,000 riders/day. When the streetcar opened in 2001, weekday ridership was about 5,000 passengers per day; as of spring 2007, over 10,000 passengers used the streetcar each day. On the weekends, the streetcar is also widely used. In spring 2007, Saturday ridership had reached 9,300 and Sunday ridership stood around 4,700.[57]

Ridership data also indicates some positive spillover effects from the streetcar. Bus ridership in the areas served by the streetcar declined initially after the streetcar began operations but has since rebounded and overall public transit use in the area has increased.[58] Building on the success of the original streetcar route, the City of Portland Office of Transportation is exploring two additional streetcar loops one serving Portland's east side (the Portland Streetcar Loop) and the other serving the nearby suburb of Lake Oswego.[59]

Streetcar systems can be built faster than light rail, commuter rail or subway. In Portland, streetcar track was laid at a rate of approximately one block per week.[60] Since streetcars are lighter than light-rail, most streets can handle the weight of a streetcar route without additional infrastructure work thus reducing construction time.[61]

Placement of streetcar tracks in relation to subterranean infrastructure like water and power lines remains an issue, however, and would be particularly challenging in the more intensely developed parts of New York. In Portland, streetcar planners attempted to avoid overlaps between underground utilities and the streetcar tracks and required private utilities to relocate their lines when they conflicted directly with the streetcar tracks. Shallow water lines located within 5 feet of the streetcar track were moved; deeper sewer lines, unless they ran directly below the tracks, were left alone with offset manhole covers for access. Since the concrete trackbed is structural, places where shallower lines cross under the tracks perpendicularly can be accommodated; the track slab can support up to 10 feet of excavation and still carry streetcars.[62]

In Portland, construction of the first 2.4 miles of track began in September 1999 and service commenced in the summer of 2001. Construction on the subsequent portions of the streetcar track was implemented in three subsequent phases with each extension taking approximately one year from groundbreaking to full service.[63] Streetcars can sustain an 8% grade, or as much as 9% over short distances, so they are easily introduced into most street contexts with minimal street alterations.[64]

Diede describes construction of the streetcar track as follows:

> [The track] is 8 feet wide and 14-16" deep and it is a concrete, structural trackslab. Basically, those dimensions are sawcut out of the street, rock may or may not be needed depending on the condition of the roadbed, rebar is laid, the tracks and rubber boot (for cathodic protection) are installed and then the final pavement is poured. We constructed the trackslab in three block sections and completed the section in three weeks (for straight track sections -- curved sections took longer).[65]

Funding for the Portland Streetcar came almost entirely from state and local, both public and private, funding sources with

57 Email Correspondence with Vicky Diede, Portland Streetcar Project Manager, City of Portland Office of Transportation, 27 November 2007
58 ibid.,9 July 2007
59 Portland Streetcar Website (http://www.portlandstreetcar.org/lakeoswego.php): Accessed 11/09/07
60 Email Correspondence with Vicky Diede, Portland Streetcar Project Manager, City of Portland Office of Transportation, 8 May 2007
61 Omaha Streetcar, "Streetcar FAQ;" Omaha Streetcar (http://www.omahastreetcar.com/education/index.html) Accessed 11/07/07
62 Email Correspondence with Vicky Diede, Portland Streetcar Project Manager, City of Portland Office of Transportation, 5 February, 2008
63 Portland Streetcar Website (http://www.portlandstreetcar.org/history.php): Accessed 11/09/07
64 Email Correspondence with Vicky Diede, Portland Streetcar Project Manager, City of Portland Office of Transportation, 5 February, 2008
65 ibid., 8 May, 2007

limited federal money.[66] The construction costs for the first phase totaled $56.9 million and included the purchase of 7 streetcars. Track construction for the first phase cost $13 million per track mile.[67] Of the $88.7 million total construction cost (Good Samaritan Hospital to SW Gibbs), close to 1/3 of the money was raised through city bonds backed by $.20/hour parking rate increase in city garages and almost 20% came from a one-time assessment on property owners within a Local Improvement District.[68]

The original Portland Streetcars were manufactured by the Czech-based Skoda-Inekon. The city saved money by purchasing streetcars that were a standard Skoda product modified to meet US safety standards rather than designing them from scratch. The cars are four-axle, double-ended, cars with a low-floor that is easily wheelchair accessible from the curb via a metal plate. The initial fleet cost a little under $2M per car. Due to the weak US dollar, the most recent cars cost about $2.56 million per car.[69]

Recently, US Representative Peter DeFazio (D-OR) secured a special authorization of $4 million to foster the domestic production of a streetcar vehicle similar to the Portland Streetcar.[70] This new streetcar prototype will be built in the United States by a U.S.-owned corporation and will be fully compatible with the existing tracks and fleet.[71] The 2007 operating budget for the streetcars is $4.2 million, only $80,000 of which is covered by fares.

66 In 1992 the City of Portland received a $900,000 federal HUD grant which it matched with local funds.

67 Email Correspondence with Vicky Diede, Portland Streetcar Project Manager, City of Portland Office of Transportation, 8 May, 2007

68 Portland Streetcar Website, "History," (http://www.portlandstreetcar.org/history.php): Accessed 11/09/07 & Email Conversation with Vicky Diede, Portland Streetcar Project Manager, City of Portland Office of Transportation, 27 November 2007

69 Email Correspondence with Vicky Diede, Portland Streetcar Project Manager, City of Portland Office of Transportation, (5/8/07)

70 City of Portland Office of Transportation, "Press Release: Oregon Company to Be Awarded Federal Contract for First US-Made Modern Streetcar;" City of Portland Office of Transportation; 26 January, 2007

71 Skochova, Iva, "Portland's streetcar named Škoda;" The Prague Post, 21 February 2007 & Email Correspondence with Vicky Diede, Portland Streetcar Project Manager, City of Portland Office of Transportation, (11/27/2007)

Economic Development Impacts:

Development in Portland indicates that the streetcar may be a factor in the growth of Portland's downtown; catalyzing private investment. Portland has seen a dramatic increase in investment in the areas served by the streetcar. Since 1997, over $2.28 billion has been privately invested within two blocks of the streetcar's route. This represents 7,248 new housing units and 4.6 million square feet of office, institutional, retail or hotel space.[72]

The impact of the streetcar on development patterns can also be seen through a floor-area-ratio (FAR) analysis. Prior to the development of the streetcar, the typical development in

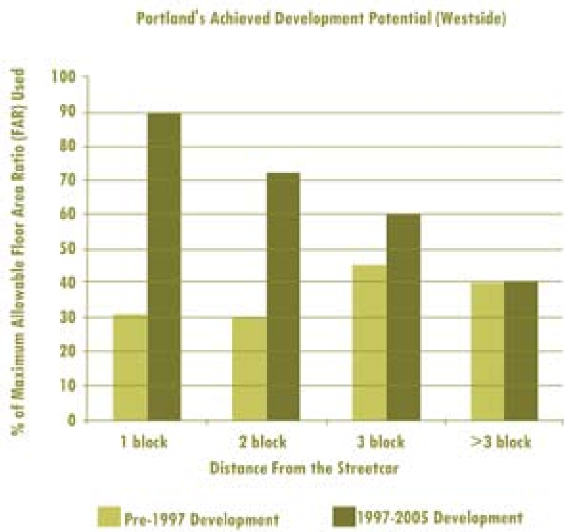
The Pearl District (NW Portland) before the construction of the Portland Streetcar. Image used with permission of the City of Portland's Office of Transportation.

Portland's central business district (CBD) was built to less than half the allowable density.[73] On average, development within

72 Presentation by Richard Brandman, Deputy Planning Director, Portland Metro; "Portland Streetcar Development Impacts: Reconnecting America," December 2006, slide 8

73 Presentation by Richard Brandman, Deputy Planning Director, Portland Metro; "Portland Streetcar Development Impacts: Reconnecting America," December 2006, slide 8, p.3

one block of the streetcar was built at 30% of allowable FAR. In contrast, since streetcar service began, buildings within a block of the streetcar route have been built on average to 90% of allowable FAR, a 300% increase over pre-streetcar development.[74] The streetcar is also encouraging development to cluster in downtown Portland. Prior to the the streetcar, the blocks along the streetcar route captured only 19% of the total development in the CBD. As of 2005, 55% of all CBD development took place within a block of the streetcar route.[75]



The Portland Streetcar has changed development in downtown Portland. Data taken from a 2006 presentation by Richard Brandman, Deputy Planning Director, Portland Metro; "Portland Streetcar Development Impacts: Reconnecting America."

Development along the South Waterfront, the most recent addition to the streetcar route, is also booming. In addition to the new construction pictured in the photos, 5 more buildings were announced in April 2006.[76] The area is also served by the new Portland Tram, which transports people up to Oregon Health and Science University and other medical facilities.

Oregon Health and Science University (OHSU) research facilities and residential development in the formerly industrial Southwest waterfront. The new Portland Aerial Tram is in the foreground. Image source: NYC Dept. City Planning

These economic development impacts are echoed by other street car programs nationwide. Cities like Atlanta, GA, Cleveland, OH, Tampa, FL and Toronto are all looking at streetcars as a way to spur economic development. In Tampa, FL, as in Portland, the streetcar is favored by developers because streetcars "suggest a sense of permanence, unlike bus routes, which can be changed over night."[77] Unlike Portland, Tampa's streetcar system has widely been deemed a failure in transportation terms because of low ridership. Nonetheless, it has brought over $450 million in residential and retail development to the neighborhoods served by the streetcar. Another $450 million is in development and $1.1 billion is in the planning stages.[78] Tampa planners attribute much of this economic growth to the streetcar and anticipate 10,000 new residents within the next decade.

74 ibid.

75 ibid.

76 ibid., slide 22 (This report references a December 2006 photo showing four buildings under construction and notes that six buildings are in development. The DCP photo, taken in May 2007 shows five buildings under construction, hence five buildings in development.)

77 Herrick, Thaddeus; "A Streetcar Named Aspire: Lines Aim to Revive Cities;" The Wall Street Journal, 20 June 2007, B1

78 ibid.

Case Study 4: The Cargo Tram (Dresden, Germany)

In Dresden, Germany, streetcar technology is being applied to freight movement in order to reduce air pollution and congestion caused by trucks. Dresden's CarGo Tram, introduced in 2000, is designed to transport parts and materials from Volkswagen's Friedrichstadt logistics center outside Dresden to its new "transparent" factory in the center of Dresden. The factory, a state of the art assembly plant where luxury D1 Phaeton model cars are built in front of a visitors" gallery, is located in central Dresden.[79] The CarGo Tram is operated by Dresdner Verkehrsbetriebe (DVB), the Dresden Transportation Authority.

The CarGo Trams run primarily on Dresden's existing passenger streetcar lines. Each 5-car tram carries 60 tons of material; the equivalent of 3 trailer truck loads.[80] A spur track leads from the original track directly into the factory itself where the trams can be unloaded. Headway on the trams, once the plant is up to full capacity, will be approximately every 40 minutes. Trams are scheduled to run 21 hours a day and carry roughly 2,000tons/day.[81] At this rate, they will replace over 100 trucks per day. Creative reuse of parts and bi-directional trams have led to additional time and cost savings. The CarGo Tram uses recycled wheel chassis (bogies) and other parts from discontinued high-floor streetcars.[82] Each five-car tram costs about $1.8 million dollars. Engines and drivers cabins at each end allow the CarGo Tram to have quick turn-around times after loading or unloading. Since each tram replaces up to three trucks, DVB also saves money by reducing the number of drivers needed to transport the same amount of materials.

79 Wynne, George, "CarGo Tram Provides Freight Service on Dresden's Light Rail Tracks;" American Public Transits Association
80 ibid.
81 ibid.
82 High-floored streetcars are being replaced with low-floor streetcars all across Europe because low-floored streetcars are more convenient for passengers (and also for passengers in wheelchairs) thus reducing passenger loading and unloading times.

The success of Dresden's CarGo Tram has encouraged planners around Europe to see if similar systems can work in other places where there are multiple companies delivering goods to the same location. In Amsterdam, a pilot CityCargo program began in March, 2007. Companies can avoid central city congestion by bringing their material or goods to CityCargo logistics centers on the outskirts of Amsterdam where it is loaded on to trams. CityCargo Trams move the goods throughout the city, bringing them to strategic offloading points where they are loaded onto small electric trucks for the last stages of delivery.[83] One of the incentives for companies using CityCargo is that it allows those companies to deliver their goods to the logistics centers whenever they want instead of forcing them to follow current regulations in Amsterdam which limit delivery times to between 9am and 11am.[84] Each CityCargo tram will carry up to 30 tons and will replace four 7.5 ton trucks.[85]

CityCargo estimates that the 53 tram cars and 600 electric trucks will replace about 1,200 delivery trucks in Amsterdam.[86] This decrease in truck traffic will result in turn in reduced air pollution (CityCargo estimate up to 16% reduction in particulate matter, carbon dioxide and nitrogen oxides) and less noise pollution since trams are quieter than trucks.[87]

83 CityCargo Website (English Version), "FAQs," (http://www.citycargo.nl/faq_eng.htm); Accessed 11/28/2007
84 ibid.
85 ibid.
86 ibid.
87 ibid.

Case Study 5: Schwebebahn, SkyBus & AeroBus (Wuppertal, Germany; Goa Province, India)

Aerial streetcars have been in use in Wuppertal, Germany since 1901, and have recently been proposed for a number of Indian, Chinese and American cities. They are an important addition to street-level streetcar technologies because they conserve valuable space on the ground. They can be placed in narrow ROWs, in or across rivers, or along existing roads without contributing to traffic congestion.

Wuppertal's Schwebebahn is the oldest example of an aerial streetcar in the world. A suspened monorail that hangs 8-12 meters above the ground, it runs on an 8 mile route between Oberbarmen, Sonnborner Straße, and Vohwinkle in Germany.[88] The Schwebebahn carries close to 80,000 people per day, making it Wuppertal's primary public transit system. It travels at speeds of close to 17mph and maintains 3-4 minute headways during weekdays.[89]

The support structure for the Schewebebahn is constructed out of steel bridge components. The track is attached on the underside of the structure. Cars are suspended from wheels that run on the track and are powered by 600 volt motors.[90] Turn-around points are provided at the ends of each line.[91] The Schwebebahn has an excellent safety record. There have been 5 accidents and one fatality in the Schwebebahn's 100 year history.[92]

88 WSW Website (English Version), (http://www.wsw-online.de/common/welcome.htm); Accessed 7/21/07

89 Bergische Universitat Wuppertal Website (English Version), "Wuppertal's Suspension Railway: overview and history;" (http://www.uni-wuppertal.de/wuppertal/schwebebahn/allgemein-en.html); Accessed 11/28/2007

90 WSW Website (English Version), (http://www.wsw-online.de/common/welcome.htm); Accessed 7/21/07

91 Bergische Universitat Wuppertal Website (English Version), "Wuppertal's Suspension Railway: overview and history;" (http://www.uni-wuppertal.de/wuppertal/schwebebahn/allgemein-en.html); Accessed 11/28/2007

92 Wikipedia Website, (http://en.wikipedia.org/wiki/Schwebebahn_Wuppertal); Accessed 11/28/2007

Wuppertal's Schwebebahn, the oldest aerial streetcar in the world, maximizes transportation uses in the right-of-way.

SkyBus and AeroBus are two newer aerial streetcar systems under development or in prototype form. Like the Schwebebahn, the SkyBus is suspended from a fixed overhead track. Unlike the Schwebebahn, which uses steel supports, the SkyBus track is supported by concrete pillars (approximately 1 meter wide) which are placed every 20 meters, similar to the JFK AirTrain in New York.[93] The SkyBus rails are encased in a concrete box, which prevents derailments.[94]

93 Rajaram, B., "SkyBus Metro: Standard Gauge High Speed Railway System," Document dated 31/10/2007, provided by B. Rajaram, AtriLab & Staff, "SKY BUS METRO IS TOTALLY SAFE," Financial Times/The Hindu, February 8, 2005

94 Gulawani, Sky Bus Of India: 21st Century Innovation In Urban Public Transportation

The SkyBus on the Goa test track. Similar to the JFK Airtrain in New York, SkyBus technology increases the amount of people who can use a transportation right-of-way without increasing congestion. Image used with permission of SkyBus-Atrilab.

The SkyBus technology, developed by AtriLab-Konkan Railway Corp., was first tested in 2004 on a 1 mile trail trial track in Goa, India.[95] SkyBus cars travel in pairs and hold 300 people at a time. SkyBus stations are designed to hold 3 sets of SkyBus trainsets at a time to decrease boarding times and delays.[96] Recent estimates indicated that the SkyBus will have a maximum speed of around 70mph and have a frequency of service/headway of as little as 60 seconds.[97] The SkyBus technology has been approved by the Indian government and SkyBuses are scheduled to open in Hyderabad and Pune in 2009.[98]

95 Staff, "India's sky bus awaits policy, investment push," Indo-Asian News Service. 17 January, 2005

96 Rajaram, B., "SkyBus Metro: Standard Gauge High Speed Railway System," Document dated 31/10/2007, provided by B. Rajaram, AtriLab

97 ibid.

98 Staff, "Skybus to become reality in two years," Daily News and Analysis India, Sunday, April 15, 2007

Aerobus, in contrast, uses high-tension suspension wires like those employed by the Brooklyn Bridge, thus reducing the number of supports that must be placed on the ground. However, despite small scale successful tests of the AeroBus technology (a Canadian ski resort and a 6 month exposition in Mannheim, Germany in the 1970's), AeroBus exists only in prototype form and has never been developed on a commercial or large scale.[99] In the 1980's development began on a 7 mile AeroBus system in Kuala Lampur but financing fell through ending the project. In 1992, AeroBus in conjunction with Milwaukee County (WI) was approved by the Federal Transportation Administration to receive an as-of-yet unfunded federal grant to develop the system. An Aerobus system is scheduled to open in Weihai, China in 2010.[100]

Examples and Opportunities in New York City:

New York City's high population density, significant degree of subterranean infrastructure, coupled with its already substantial public transportation infrastructure and mode-split, suggest that streetcars in New York would play a very different role than those in cities like Portland. The existing density, infrastructure and traffic congestion in Manhattan makes the introduction of streetcars in most of that borough untenable; the already high subway and bus coverage would make streetcars there unnecessary. However, streetcars could be explored as feeder services in less densely developed areas that currently lack rail transit options. The storage of streetcars would also need further consideration.

Streetcar service could be explored on Staten Island as a feeder service for the SIRR, along the Brooklyn-Queens waterfront and connecting to LaGuardia Airport, and crossing the Hudson and Harlem Rivers at 181st Street to connect New Jersey suburbs to the New York City subway system and provide connections to the A, 1, 4, B, D, 2, 5 and 6 trains.

99 AeroBus Website; "Gerhard Mueller—the Creator of Aerobus;" AeroBus; (http://www.aerobus.com/history.html); Accessed 11/08/07

100 Email Correspondence with Dennis Stallings, President, Aerobus, 11/20/2007

ROADWAY DRAINAGE & MAINTENANCE

Street flooding has significant impacts on the city's transportation infrastructure. Road flooding slows traffic and increases the risk of accidents. Standing water on streets erodes road surfaces and exacerbates pothole formation. In the winter, water from flooded streets can freeze and form hazardous driving conditions. Especially at intersections, street flooding makes crossing streets and walking difficult for pedestrians and bicyclists. As residents of New York City have learned in recent years, even a short high intensity storm event can overwhelm the city infrastructure's capacity to handle the resulting flooding – causing widespread road and rail service interruptions.

One can point to unusual weather patterns for New York City's difficulty in accommodating high stormwater volumes, but ultimately much of New York's recent experiences with flooding are the result of the increased paving of the urban landscape which is now incapable of absorbing rainwater. Recent parking lot regulations developed by the DEP and DCP address flooding issues caused by parking lots, but cannot fully deal with problems caused by road design. This report highlights three water management technologies that have reduced roadway flooding and related traffic and transit delays in American cities and can help improve the quality of run-off flowing into New York's rivers and harbor.

Due to the nature of this material, examples of and opportunities for these technologies are presented together at the end of this section.

- Combined Roadway Drainage Systems
    - » Case Study 6: Portland's Green Streets Program
    - » Case Study 7: Seattle Natural Drainage Systems
- Pervious Paving Materials
    - » Case Study 8: Pervious Pavers & Porous Asphalt/Concrete
    - » Case Study 9: Reinforced Grass
- CatchTraps and Storm Drain Filters
    - » Case Study 10: DrainPac

The April and August 2007 rain storms flooded subway stations throughout the city, shutting down train service and creating dangerous conditions for passengers still in the system.
Credit: 2006 Chris J

COMBINED ROADWAY DRAINAGE SYSTEMS

Most roadway drainage strategies, when implemented in isolation, are ineffective. Rather, the most successful water management and roadway drainage strategies are a combination of design solutions that reduce the volume and slow down the rate at which rain water runs off roads and other paved surfaces, reducing the possibility that drains and sewers will flood. This report covers two cities, Portland, OR and Seattle, WA, that have effectively combined a variety of stormwater runoff management practices with highly successful results.

- Portland, Oregon's Green Streets Program
- Seattle, Washington's Natural Drainage Systems (Street-Edge Alternatives SEA-Streets, Green Grids and Cascades Programs)

Originally conceived of as ways to improve water quality, the drainage programs developed in Portland and Seattle have significantly reduced the amount of water run-off after rain storms and lowered the likelihood of street flooding. Both programs report run-off reductions of over 70% after major storms and have been widely praised both locally and in national planning literature.[1] Successful tests of these programs have been implemented in both medium and low density residential and commercial districts.

Background:

Historically, transportation planners and city or municipal governments have attempted to reduce street flooding by channeling rain water run-off into fixed capacity drains and pipes.[2] These methods pose problems, because as the amount of paved (non-porous) surface in a given area increases, the amount of water the pipes must handle also increases, resulting in overwhelmed pipes and subsequent flooding.

1 Vogel, Mary, "Moving Toward High-Performance Infrastructure;" Urban Land, October 2006, pp.75-9

2 City of Portland Bureau of Environmental Services, "Integrating Stormwater into the Built Environment," (http://www.portlandonline.com/shared/cfm/image.cfm?id=5355800; Accessed 11/26/2007

In many neighborhoods throughout New York City, rain storms frequently overwhelm existing sewers and drain pipes causing street flooding and ponding that makes streets dangerous and difficult for pedestrians and cars alike. Image source: NYC Dept. City Planning

Raised continuous curbs which separate paved areas from grass or tree pits often make matters worse by blocking water from reaching areas where it could infiltrate down. In addition, continuous curbs force rain water into channels which creates high velocity torrents of water that can damage infrastructure. Fixed capacity drains and pipes, when faced with high volumes of water carrying sediment and debris, can clog easily, further increasing the chance of flooding.

In contrast, water management practices such as those pioneered in Portland and Seattle attempt to decrease street flooding by increasing opportunities for the water to infiltrate into the ground rather than (or before) channeling it to the fixed capacity drains and pipes. Infiltration trenches, filter strips, vegetated swales and planter beds all work by retaining water; holding it either until it infiltrates naturally into the ground or by slowing down the water, releasing it to existing drains and sewer pipes at a slower, more manageable rate. For the most part, because they do not involve extensive pipe installation, such systems are easier to install as "retrofits" than traditional pipes and drains.

In general, environmental engineering on the street surface is always cheaper than drainage structures below ground.[3]

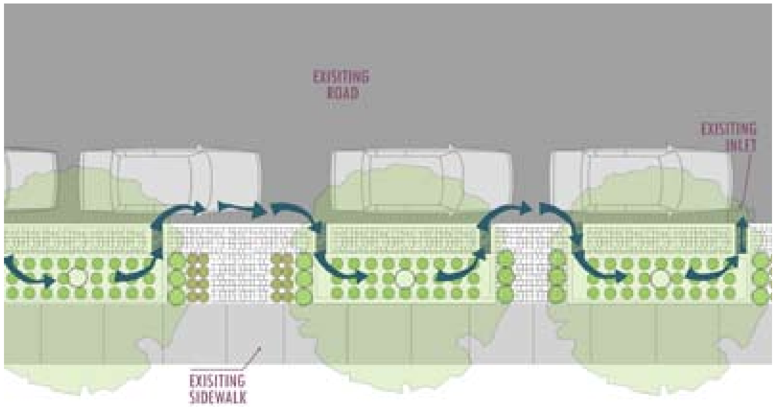
In New York City, modern water management practices are already gaining ground. Recent amendments to the New York City Zoning Resolution have been developed by the Department of City Planning in conjunction with the Department of Environmental Protection, the Department of Transportation and other city agencies, to increase the amount of pervious surface in the city and reduce water run-off. These include allowing pervious paving materials for commercial parking lots, a street tree and planting strip amendment and a planting requirement for front yards.[4] In addition, agencies like the NYC Department of Parks and Recreation already use highly durable pervious pavers on pedestrian walkways in New York City parks to reduce flooding. The New York City Council recently passed resolution Int. 0630-2007, requiring the city to produce a sustainable stromwater managment plan.[5]

3 Sustainable Drainage Website, "Benefits;"(http://www.sustainabledrainage.co.uk/benefits.html); Accessed 11/26/2007

4 New York City Department of City Planning Website, "Citywide Projects, Studies and Proposals," (http://www.nyc.gov/html/dcp/html/subcats/citywide.shtml); Accessed 2/6/08

5 New York City Council Website, "Legislation," (http://www.nyccouncil.info/html/legislation/legislation_details.cfm?ID=Int%200630-2007&TYPE=all&YEAR=2006&SPONSORS=YES&REPORTS=YES&HISTORY=YES); Accessed 2/6/08

Case Study 6: The Green Streets Program (Portland, OR)



Portland's Green Streets divert rain run-off into a series of linked porous planters before directing it to existing storm drains. Greens Streets can be introduced in highly-urban settings without requiring extensive sewer pipe excavation or construction. Image used with permission of City of Portland Bureau of Environmental Services.

Portland's Green Street pilot on SW 12th Avenue in downtown Portland demonstrates the applicability of modern water management programs to developed urban areas. Designed and maintained by the Portland Department of Transportation, the Portland Water Bureau and the Bureau of Environmental Services, the Green Streets Program has reduced on-street water run-off by up to 85% after major 25-year storm events.[6] The Green Street pilot absorbs the rain run-off from 8,000 square feet of paved roadway and sidewalk. It can handle 180,000 gallons of water in any single rain storm before directing water to the existing storm drain.[7]

Portland's Green Streets are retrofits of existing city blocks. The Green Street design diverts stormwater into a series of street

6 City of Portland Bureau of Environmental Services, "2006 Stormwater Management Facility Monitoring Report," City of Portland Bureau of Environmental Services, September 2006, p.6

7 City of Portland Bureau of Environmental Services, "SW 12th Avenue Green Street Fact Sheet," (http://www.portlandonline.com/bes/index.cfm?c=efdig&a=bcdhhg); Accessed 11/26/2007

level planters through small openings in the curb. If the storm produces more rain run-off than the first planter can hold, the excess water flows out of a curb cut on the downhill side of the planter, back into the street, and then is re-channeled into a second planter. Run-off that exceeds the capacity of the first and second planters flows into the third and so on. Only run-off from storms that produce more rain than can be handled by all four planters enters the traditional storm sewer.

Each planter (3 feet by 18 feet at the biggest) is designed to hold up to 6 inches of water and is lined with porous materials that allow the water to infiltrate into the ground at a rate of up to 4 inches per hour.[8] In addition, the planters are planted with native plants which can filter out sediments, limiting the amount of debris that can reach, and clog, the traditional storm drain. The plants are chosen for their ability to thrive in a variety of conditions, thus ensuring that the planters stay green and attractive.

The Green Street program uses indigenous plants in order to ensure that the planters remain green throughout the year. Image source: NYC Dept. City Planning

8 City of Portland Bureau of Environmental Services, "SW 12th Avenue Green Street Fact Sheet," (http://www.portlandonline.com/bes/index.cfm?c=efdig&a=bcdhhg); Accessed 11/26/2007

Portland's planners faced a number of urban design challenges in the implementation of the Green Streets. The full sidewalk width on SW 12th Avenue is 8′ and they struggled to "[find] enough space for pedestrians, on-street parking, street trees, landscaping, street lighting, signage and stormwater planters" within that space.[9] The final design includes a 2′6″ wide parking egress lane between the street and the stormwater planters. Water enters the planters through 12″ curb cuts. An ADA accessible grate on top of the curb cut allows water to flow into the planter without disrupting the sidewalk surface. Smaller cuts in the planter wall allow water from the sidewalks to flow in as well. A full plan diagram is included in Appendix E.

The SW 12th Avenue Greet Street cost $33,000 including street and sidewalk improvements.[10]

In addition to SW 12th Avenue, the City of Portland has tested different elements of the Green Streets system at a number of other locations around the city. The Green Street project at SE Division Street, designed to manage water run-off from a large grocery store, its parking lot and the surrounding streets, combines 6 foot stormwater planters with bioswales. As with the SW 12th Avenue design, water run-off is collected in the "upstream" planter and channeled into subsequent planters as needed. The full system can remove approximately 1,000,000 gallons of stormwater from roadways and the sewer system annually.[11]

9 City of Portland Bureau of Environmental Services, "SW 12th Avenue Green Street Fact Sheet," (http://www.portlandonline.com/bes/index.cfm?c=efdig&a=bcdhhg); Accessed 11/26/2007

10 City of Portland Bureau of Environmental Services, "Green Streets Tour Map," (http://www.portlandonline.com/shared/cfm/image.cfm?id=96962); Accessed 11/26/2007, p.4

11 City of Portland Bureau of Environmental Services, "Sustainable Stormwater Management: Green Solutions;" (http://www.portlandonline.com/shared/cfm/image.cfm?id=123781); Accessed 11/26/2007

A narrow strip of porous pavers provides room for passengers to exit from their cars. The 12" wide, ADA accessible metal grate in the foreground covers the inlet by which rain run-off enters the planter. Image source: NYC Dept. City Planning

Other Green Streets designs in residential neighborhoods have included permeable pavement and pervious asphalt, especially in driveways, parking lots and parking strips. These paving materials allow water to infiltrate down through the paving and off the road surface. Like the planters and swales, designs that include permeable or pervious materials provide storm run-off with alternatives to existing storm drains, reducing the likelihood of street flooding.

Case Study 7: Natural Drainage Systems (Seattle, WA)

Seattle SEA Streets, built primarily in residential neighborhoods, reduce rain run-off and flooding with bio-swales and improved street design. Image source: NYC Dept. City Planning

Seattle's Street Edge Alternatives program (SEA-Streets) is a more radical approach to roadway drainage; in essence a re-envisioning of a residential block to reduce impervious surfaces and increase water infiltration.[12] Developed by planners from Seattle's Public Utilities (SPU) in conjunction with local community groups, SEA-Streets are partially maintained by homeowners on adjacent properties and by SPU.[13]

The SEA-Street program was first implemented in 2001 on a small two-block test site in northwest Seattle (NW 117th and NW 120th Street on 2nd Avenue), a low-density residential area that lacked sidewalks and drainage infrastructure like sewers and drains.[14] Ongoing monitoring by the city of Seattle and

12 Vogel, Mary, "Moving Toward High-Performance Infrastructure;" Urban Land, October 2006, p.77

13 City of Seattle, "Seattle's Natural Drainage Systems;" The City of Seattle, Seattle Public Utilities, 2007, p.7

14 City of Seattle, "Seattle's Natural Drainage Systems;" The City of Seattle, Seattle Public Utilities, 2007. This neighborhood would be equivalent, in terms of density and infrastructure, to parts of southeastern Queens and southern Staten Island.

researchers from the University of Washington has shown a 98% reduction in water run-off in the first year and a 99% reduction in run-off in the subsequent years.[15]

The SEA-Street design places bioswales, carefully planted ditches that can retain large volumes of water for short periods of time, along both sides of the 60 foot right of way.[16] These bioswales collect rain water run-off and, since they are porous, give it the opportunity to infiltrate down instead of sitting on the impervious road surface. The street bed itself was slightly canted to better direct rain water run-off into the swales. As in Portland, the SEA-Street bioswales were planted with native species specifically chosen for their ability to tolerate standing water and filter out pollutants. Thus, the bioswales also improve the quality of water that leaves the site as surface runoff.

The SEA-Street design also introduced slight curves to the street. These curves enhance the street aesthetics and also serve a drainage function, slowing down the velocity of rain water as it runs down the street and giving it more time to infiltrate into the ground.[17] In total, the SEA-Streets design reduced the amount of paved surface by 11% by narrowing the street to 14 feet in some places while including 18 foot "flares" at the corners.[18] Parking spaces and a sidewalk were also added. The modified street layout, approved by the Seattle Fire Department and Emergency Services, doubles as a traffic calming tool for the neighborhood.[19]

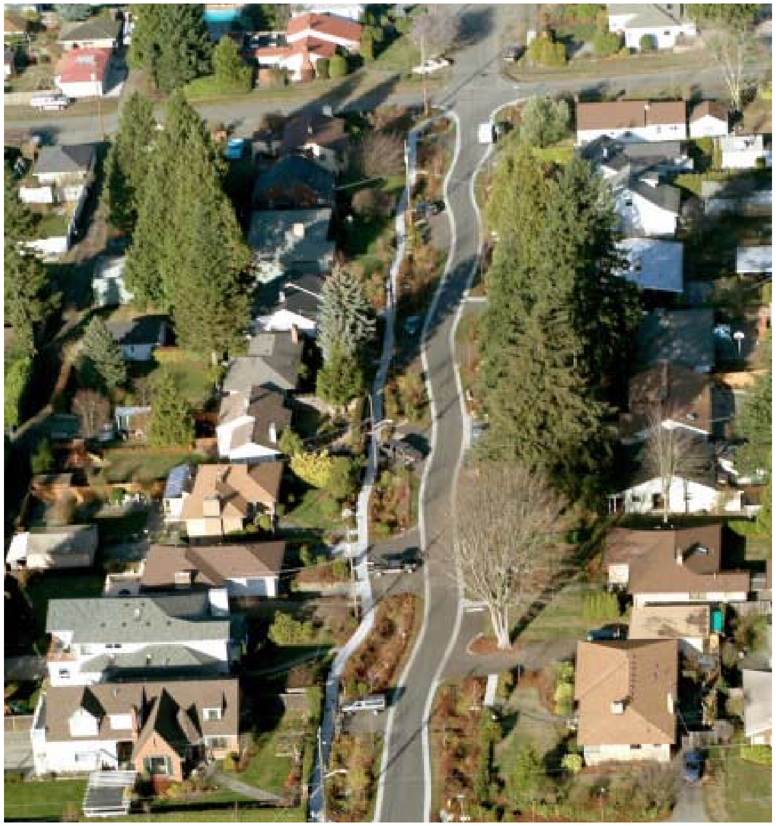
15 City of Seattle, "Seattle's Natural Drainage Systems;" The City of Seattle, Seattle Public Utilities, 2007, p.8

16 ibid., p.6-8

17 Taus, Margaret, "Innovative Design Cuts Street Run-Off," Seattle Post Intelligencer, 20 November 2002 (http://seattlepi.nwsource.com/local/95881_model20.shtml); Accessed 12/11/07

18 City of Seattle, "Seattle's Natural Drainage Systems;" The City of Seattle, Seattle Public Utilities, 2007, p.8

19 ibid. & Email Correspondence with Denise Andrews and Dick Lilly, Seattle Public Utilities, 6/13/2007



The SEA Street pilot (NW 117th and NW 120th Street on 2nd Avenue. The slight curves in the roadway slow the rain run-off as it flows down the street. The SEA Street design also serves as a traffic calming device and added sidewalks to a neighborhood that previously lacked them. Images used with permission of Seattle Public Utilities.

SEA-Streets cost about 25% less to build and maintain than conventional systems ($325,000 per 330 foot block as opposed to $425,000).[20] These costs are lower in part because reducing runoff at the source reduces the need to build additional costly pipes and holding tanks further down the system. Operations costs (ongoing maintenance and replanting) for the SEA-Streets are the responsibility of adjacent home owners. The initial SEA-

20 City of Seattle, Seattle Public Utilities, "Seattle Public Utilities; Natural Drainage System Program," (www.psat.wa.gov/.../II.%20Appendices/F.%20Natural%20Drainage%20System%20Costs.pdf; Accessed 11/26/2007

The bio-swales in Seattle's SEA Streets are planted and maintained by residents. Strong community participation from the outset is cited as an important element of the success of the program. Image used with permission of Seattle Public Utilities.

Street site was selected from a list potential sites, partially on the basis of strong community support and SPU planners cite constant community involvement as a key factor in the success of the SEA-Streets.[21]

Following their success with the initial SEA-Streets, the SPU planners have turned their attention to a variety of related Natural Drainage System projects including: streets with significant slopes (1-8%), known as the Cascade Program, and more densely developed areas, the Green Grids Program and High Point. Tests on the pilot Cascade Program, which employs a series of gated weirs and collected water from a 70 acre site, have shown a reduction of water run-off by between 48% and 74%.[22] Similar to the SEA-Streets, the cost (including survey, design, contract bid documents, construction and operations and maintenance associated with a 3 year plant establishment period) of the Cascade Program was substantially less than that of conventional drainage systems; $285,000/block as opposed to $520,000.[23]

The Broadview "Green Grids" pilot, which uses many of the techniques tested in the original SEA Street, covers an area of 15 city blocks or about 32 acres. It, along with subsequent Green Grids projects such as Pinehurst, has allowed planners to test their water management systems in larger, denser and topographically different areas.[24] The bio-swales in the Green Grid system absorb water run-off at up to 1.5 inches per hour.[25]

21 City of Seattle, "Seattle's Natural Drainage Systems;" The City of Seattle, Seattle Public Utilities, 2007, p.7

22 City of Seattle, "Seattle's Natural Drainage Systems;" The City of Seattle, Seattle Public Utilities, 2007

23 City of Seattle, Seattle Public Utilities, "Seattle Public Utilities; Natural Drainage System Program," (www.psat.wa.gov/.../II.%20Appendices/F.%20Natural%20Drainage%20System%20Costs.pdf0; Accessed 11/26/2007 & Email conversation with Tracy Tackett, Low Impact Development Program Manager, Seattle Public Utilities, 14, January, 2008

24 Seattle Public Utilities Website, "Broadview Green Grid Project;" (http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/Broadview_Green_Grid_Project/index.asp); Accessed 12/11/07

25 City of Seattle, "Seattle's Natural Drainage Systems;" The City of Seattle, Seattle Public Utilities, 2007, p.9

PERVIOUS PAVING MATERIALS

Pervious paving materials are a complementary technology that can—particularly when used in tandem with other modern drainage mechanisms—help to reduce street flooding by allowing water to infiltrate into the ground. Most commonly, pervious materials come either as:

- Pervious Pavers & Porous Asphalt/Concrete
- Reinforced Grass (also known as Plastic Geocells)

Background:

Alternative paving materials may be used in place of impervious materials (traditional concrete or asphalt) in order to reduce surface runoff and flooding. These materials allow water to infiltrate down reducing the amount of water on the surface and limiting the amount of water that would need to be removed via fixed capacity drains and pipes. While cobbles and brick are already somewhat pervious because of the cracks between each piece, many cities are beginning to experiment with new strategies that are sturdier and better mitigate storm sewer costs in the long term. New York City has amended the city's Zoning Resolution to allow the use of pervious materials in commercial parking lot designs. [26]

Parking lots, driveways and sidewalks are the most common places to install pervious paving materials because they contribute substantially to flooding problems but do not face the same intensity of wear and tear as high-volume streets or highways. In addition, these surfaces are relatively small and can be upgraded as part of a low-capital budget project. Alternative paving can also facilitate the biodegradation of oils from cars and allow tree roots to breathe.[27]

Pervious pavers, porous asphalt and concrete and reinforced grass are in widespread use all across North America, Europe and Asia. They complement other modern drainage systems by allowing water to pass through them thus reducing the burden on existing drainage systems.

Case Study 8: Pervious Pavers & Porous Asphalt/Concrete

The Portland Bureau of Environmental Services is experimenting with pervious pavers and porous asphalt in residential neighborhoods. In this image, the pervious pavers serve a dual purpose, clearly marking the parking lane as well as reducing rain run-off and flooding. Image used with permission of City of Portland Bureau of Environmental Services.

The technologies for porous asphalt and concrete have been around for 30 years. However, difficulties in early projects have given them a poor reputation that they no longer warrant. In recent years the technology has modernized and greatly reduced the failure rates seen in the first applications.[28] Porous asphalt is now the paving surface of choice on interstate highways in Georgia and Oregon.[29] Transportation planners and environmental quality agencies in Portland are piloting programs

26 New York City Department of City Planning, "Commercial and Community Facility Parking Lot Amendment," (http://www.nyc.gov/html/dcp/html/parking_lots/index.shtml0; Accessed 11/26/2007

27 Hun-Dorris, Tara, "Advances in Porous Pavement," Stormwater, March/April 2005 (http://www.erosioncontrol.com/sw_0503_advances.html); Accessed 11/26/2007

28 Building Design + Construction Website, "Porous Pavement: Slipping Through the Cracks," (http://www.bdcnetwork.com/article/CA6297622.html0; Accessed 11/26/2006

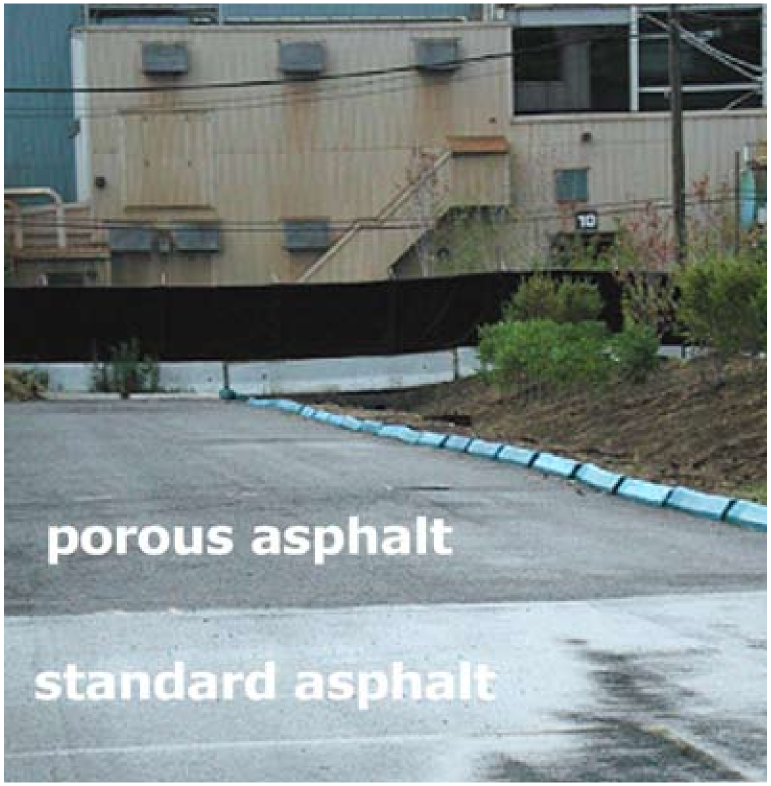
29 City of Portland Bureau of Environmental Services, "Pervious Pavement Projects: A New Approach to Stormwater Management," (http://www.portlandonline.com/BES/index.cfm?a=77074&c=45435#north); Accessed 11/26/2007

to introduce permeable pavers and porous asphalt on residential streets.[30] The city of Chicago is the in the process of repaving 2,000 miles of service alleys with permeable concrete.[31] These programs are intended to reduce the impervious surface area and decrease street flooding.

Porous asphalt and concrete differ from conventional asphalt and concrete because they are made without fine particulates which clog pores in the materials where water could otherwise pass through. As a result, water does not sit on the surface which leads to better traction and visibility for automobiles. Typically, 15% to 25% voids are achieved in the hardened concrete, and flow rates average around 48 in/hr.[32] Both porous asphalt and concrete require maintenance and need to be vacuumed or pressure-washed to ensure that the pores in the material do not get clogged. However, good design can reduce the frequency of vacuuming or washing required.[33]

Porous asphalt usually costs between $.50 and $1 per square foot, on par with conventional non-porous asphalt.[34] Pervious concrete tends to be more expensive – ranging from $2.00 to $6.50 per square foot of installed pavement where conventional non-pervious concrete ranges from $2.00 to $4.00 per square feet.[35] In Chicago, the permeable concrete used in the "Green Alley" program will cost $45 per cubic meter plus the cost of a stone filtration layer beneath the concrete. Chicago pays roughly $50 per cubic meter for conventional concrete making the two materials roughly the same in price. Janet Attarian, the Green Alley project director also notes that the cost of

30 City of Portland Bureau of Environmental Services, "Pervious Pavement Projects: A New Approach to Stormwater Management," (http://www.portlandonline.com/BES/index.cfm?a=77074&c=45435#north); Accessed 11/26/2007
31 Saulny, Susan, "In Miles of Alley, Chicago Finds Its Next Environmental Frontier;" The New York Times, 26 November, 2007
32 Hun-Dorris, Tara, "Advances in Porous Pavement," Stormwater, March/April 2005 (http://www.erosioncontrol.com/sw_0503_advances.html); Accessed 11/26/2007
33 ibid.
34 Low Impact Development Center Inc. Website, (http://www.lid-stormwater.net/permeable_pavers/permpaver_costs.htm); Accessed 12/6/2007
35 PaverSearch Website, "Permeable or Pervious Pavers Cost Comparion;" (http://www.paversearch.com/permeable-pavers-costs.htm); Accessed 11/26/2007



The use of porous asphalt can dramatically reduce the amount of water that remains on the road surface after a storm. This image taken shortly after an intense rainstorm shows essentially dry porous asphalt at the top and water sitting on conventional asphalt at the bottom. Image used with permission of Cahill Associates.

permeable concrete has dropped over $100 per square meter in the past year, as production companies increased production and facility with the material.[36] Chicago also anticipates that the cost of construction of the new alleys will be offset by reduced maintenance and drainage costs associated with conventional non-permeable concrete.[37] Permeable materials can minimize the need for additional stormwater drainage and treatment systems – effectively offsetting the overall cost to a city.[38]

36 Saulny, Susan, "In Miles of Alley, Chicago Finds Its Next Environmental Frontier;" The New York Times, 26 November, 2007
37 ibid.
38 WaterSheds Urban Stormwater Website, North Carolina State University, (http://www.water.ncsu.edu/watershedss/dss/wetland/aqlife/urbstorm.html#sr); Accessed 11/26/2007

Porous asphalt allows water to flow through it, minimizing the amount of water that remains on the surface. Image used with permission of TecEco Pty. Ltd.

Case Study 9: Reinforced Grass (Miami, FL; Houston, TX)

Reinforced grass, in place at Houston's Reliant Stadium and Miami's Orange Bowl, is used to reduce impervious surface cover and decrease parking lot flooding. Reinforced grass is structurally simple. Grass is planted inside short plastic cylinders or hexagons, called geocells. Once installed and allowed to grow in, areas covered with plastic geocells look like grassy fields, however, unlike natural fields, they provide structural support that can accommodate vehicles and prevent erosion. The cells provide protection for the topsoil, allowing cars to park on the grass without worry that their weight will compact it and prevent the grass from growing. During a 24 hour storm that yields 6 inches of rain, geocells developed by Grasspave2, one of the two major manufacturers, can absorb 97-100% of rainfall.[39]

39 Invisible Structures Inc. Website, "GrassPave2," (http://invisiblestructures.com/GP2/grass-pave.htm); Accessed 11/26/2007. The absorptive qualities of Grasspave2 vary by soil type.

In 1995, geocell-reinforced grass was applied to the Orange Bowl Stadium parking lot in Miami. The grass system was installed in three phases, for a total of 261,132 square feet of turf. 2,000 parking spaces are covered with Grasspave2, while the driving lanes were made of asphalt. The reinforced grass lot is capable of storing and cleaning up to 60,000 cubic feet of stormwater, capabilities that were put to the test in 2002 during massive flooding in the Miami area.[40] The Orange Bowl has not received any reports of cars getting stuck in mud on their reinforced grass parking lots.

In2002, following the Orange Bowl example, HOK Architects installed 317,000 square feet of plastic geocells at Reliant Stadium in Houston. This stadium, built to replace the Astrodome now boasts the largest application of engineered grass porous system to date.[41] The introduction of reinforced grass parking lots has also allowed the Stadium to host new summer events. At the old asphalt paved Astrodome, summer events were all but impossible due to the huge amount of heat absorbed and delivered by the blacktop. The new reinforced grass parking lots in contrast stay cool throughout the summer and the Stadium now hosts a range of summer events, festivals and the National Rodeo that would have been impossible before.[42]

The cost of grass reinforced with geocells can range from $1.50 to $5.75 per square foot of installed pavement.[43] They provide larger savings however, because in addition to mitigating flooding they also reduce the need to build other onsite stormwater treatment or storage facilities.

40 Hun-Dorris, Tara, "Advances in Porous Pavement," Stormwater, March/April 2005 (http://www.erosioncontrol.com/sw_0503_advances.html); Accessed 11/26/2007

41 Invisible Structures, Inc. Website, Glist, Dustin, "The Double Life of Porous Pavesr—Curb Appeal with Function;" (http://www.landscapeonline.com/research/article/6558); Accessed 11/26/2007

42 Hun-Dorris, Tara, "Advances in Porous Pavement," Stormwater, March/April 2005 (http://www.erosioncontrol.com/sw_0503_advances.html); Accessed 11/26/2007

43 PaverSearch Website, "Permeable or Pervious Pavers Cost Comparion;" (http://www.paversearch.com/permeable-pavers-costs.htm); Accessed 11/26/2007

Reinforced grass pavers, shown here at the Reliant Stadium in Houston, TX, rely on a hidden structure of plastic cells in which grass is planted. The plastic cells keep the grass from being compacted, even when cars are parked on top. Image used with permission of Invisible Structures, Inc.

Orange Bowl - Reinforced Grass pavers, shown here at the Orange Bowl Stadium parking lot in Miami, FL, has dramatically increased the quality of the parking lot while also reducing the amount of water that storm drains and sewers must handle after rainstorms. Image used with permission of Invisible Structures, Inc.

CATCH BASIN INSERTS / STORM DRAIN FILTERS

In addition to drainage solutions that reshape the streetscape, inexpensive measures, like catch basin inserts and drain filters, can be installed in the interim to remove debris from drains. Such filters make storm drain cleaning easier and can reduce the likelihood that existing storm drains will clog, thus reducing the prevalence of roadway and subway flooding.

Background:

The average street is cluttered with leaves, trash, paper flyers and newspapers, sediment and other small objects. During rain storms, this debris is carried along with the water run off to storm drains. While the debris that remains at street level can typically be handled by routine street cleaning, debris that slips into the drain, below street level, is harder to reach and remove. The resulting clogged storm drains cause street flooding and create hazardous conditions for pedestrians, cyclists and drivers.

Case Study 10: DrainPac (Pacific Northwest, US)

PacTec Inc manufactures the DrainPac storm drain filter that can be placed inside existing curb inlets to capture debris, keeping it separate from the stormwater flow and ensuring effective operation of drains. Essentially hanging metal mesh baskets, the DrainPac filters are attached to the outside of the drain by chains and thus can be easily reached and cleaned. DrainPack filters were originally developed to address compliance issues associated with the Clean Water Act and offer a low-cost solution to localized flooding problems caused by clogged stormwater drains.

Each filter unit can hold up to 150 pounds of material – an adequate capacity for most all urban applications. They are also highly effective, able to collect 97 to 98 percent of the sediment in the water[44] Like all systems, maintenance is required to empty and re-set the filters. However, normal storms do not carry significant amounts of trash and debris to the filter, therefore maintenance is only required following heavy rains. In addition, drain inserts reduce the need for scheduling drain clean-outs by eliminating the amount of solids in drainage systems.[45]

The cost of the filters ranges from $130 to $400 depending on the size and filter design.[46]

PacTech's DrainPac storm drain filter catches debris entering the sewer system before it has a chance to clog the drain. Image used with permission of PacTech.

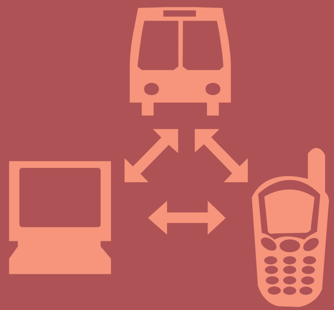
44 DrainPac Website, "Tahoe News," (http://www.drainpac.com/Tahoenews.htm); Accessed 11/26/2007
45 ibid.
46 DrainPac Website, "North Country News," (http://www.drainpac.com/Northcountynews.htm); Accessed 11/26/2007

EXAMPLES AND OPPORTUNITIES FOR ROADWAY DRAINAGE & MAINTENANCE:

Piloting modern water management practices meets 2030 PlaNYC goals and can help reduce flooding, related transportation congestion on our city's roads and some public health hazards.[47]

In looking to apply modern drainage systems in New York, flooding hot spots should be assessed using DEP, 311 and Community District Needs Assessment data. In particular, systems like Portland's Green streets would be applicable in higher density neighborhoods, while Seattle SEA-Streets would be more appropriate in lower density parts of Queens and Staten Island. Catch-traps and permeable pavement could be applied throughout the city.

47 In addition to transportation concerns, street flooding also poses severe environmental problems as excess storm runoff triggers the city's 460 combined sewer outfalls (CSOs). According to the USEPA and the Design Trust for Public Space, "combined sewer outfalls in New York City flood during half of all rainstorms, discharging approximately 27 billion gallons of wastewater in an average rainfall year." The water that is released into New York's waterways after storm events is contaminated by oil, chemicals, pesticides, and chemical fertilizers from roadways as well as raw sewage from the city's households and businesses (human wastewater) which contains bacteria and viruses. According to Riverkeeper, "on average CSO events occur about once per week (and as often as 70 times per year at some outfalls) and the average weekly polluted discharge is about 500 million gallons Citywide." Polluted waterways can make other city plans, like the construction of greenways and riverside parks, and the introduction of commuter and recreational boating, more difficult and dangerous.



INFORMATION TECHNOLOGIES

New York's Metropolitan Transportation Authority (MTA) has several pilot programs—including the "Time to Next Train" arrival displays currcently in use on the L line, new trip planner services for web-enabled cell phones and PDA's, email alerts offered by the MTA, LIRR information screens available at Penn Station, and the recently announced plan to test "Time to Next Bus" displays in Manhattan—that will dramatically improve the quality, clarity and quantity of travel information that transit users receive. These programs are part of a larger body of new information technologies, often called Intelligent Transportation Systems (ITS), which gather traffic and transportation data (e.g. vehicle, bus or subway GPS) and communicate it to customers in real-time and personalized form (e.g. on-line trip planners or digital platform signage).

This report examines ITS-based traveler information systems which complement the programs already in progress by the MTA. They are intended to increase the quality and quantity of transit information that users have available, provide information about alternative routes and modes and reduce the overall impact of delays throughout the transit system. Most require minimal capital investments on the part of transit authorities outside of making information available online and in simplified mobile-forms which can be easily loaded by handheld technologies.

- Real-Time Information Screens
  - » Case Study 11: Information TV Monitors
- Portable Real-Time Systems
  - » Case Study 12: Cell Phone/PDA Arrival Information Systems
  - » Case Study 13: Interactive Text Message (SMS) Arrival Information Systems
  - » Case Study 14: Codes2D Matrix Barcodes

Paper signs announcing service changes on the 2 and 3 lines.
NYC Dept . City Planning

REAL TIME INFORMATION SCREENS

Since the early 1990's, the RATP, Paris, France's regional transportation authority has centralized important, time-sensitive transit information on simple television screens in place throughout their stations. The monitors are easy to locate and understand and their digital format makes it easy to update information as situations change.

Background:

The primary methods of conveying short-term service alerts or emergency information to NYCT riders are station and train announcements, staff guidance, hand-written whiteboard messages in station booth windows, and Service Updates posted on the MTA website.[1] An emergency email alert system was recently introduced. Routine or planned service changes are publicized through posted paper signs, in daily newspapers or on the MTA website.

However, because service information on the website is only updated weekly, many riders are not accustomed to checking the website before using the subway or bus. Paper signs tend only to be relevant for the station in which they are placed or the lines that serve that station. As a result, riders hoping to transfer to other lines may find themselves already in the transit system by the time they learn about changes. The MTA has announced plans to provide wireless reception in subway stations, which would allow transit users to access other widely used information resources. Completion of this project is not expected until 2018.[2]

As city and state transportation authorities and elected officials are aware, the current communication systems employed by the MTA are insufficient, particularly in emergency situations. Often, the ability of transit authorities to communicate information to riders is limited. Under emergency or severe weather conditions, the lack of real-time information options can pose serious safety issues as riders may not know how, where, and when to evacuate or avoid certain stations or make other transportation plans. As in the case of the August 2007 storm and flooding, poor real-time communication between the MTA and its own employees can further hamper operations.

A newly installed LIRR real-time information screen at Penn Station. NYC Dept. City Planning

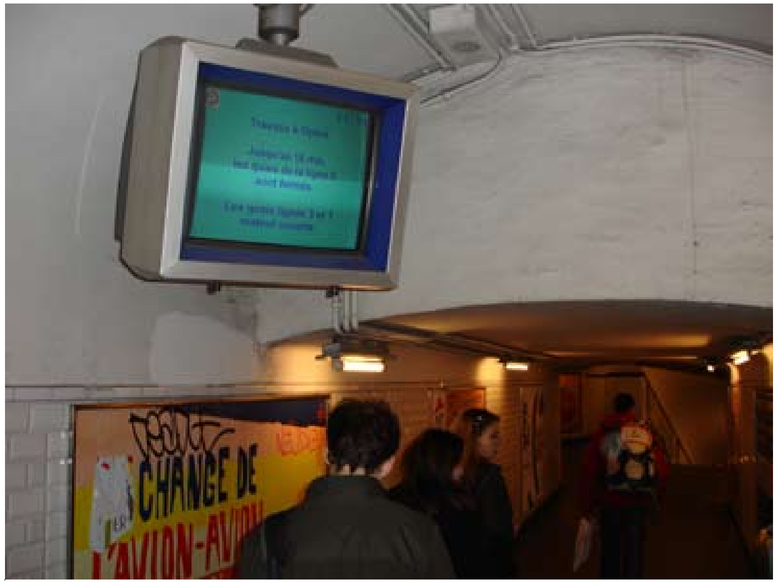
While the overall quality and clarity of the MTA/NYCT's public address systems has improved over the past 20 years, many passengers often find it difficult to hear or understand announcements made in subway stations, especially those

1 NYPRIG Straphangers Campaign Website, "News Release," (http://www.straphangers.org/announcements/2002/); Accessed 11/27/2007

2 Neuman, William, "MTA Makes Deal for Cellphones in Stations;" The New York Times, 20 September 2007

that are not pre-recorded. Subway stations are loud, especially those served by multiple lines or with local and express service arriving on the same platform. Public announcements made when a train is entering or leaving the station are almost inevitably inaudible, despite the quality of the public address system itself. Recognizing this, the LIRR has recently introduced information screens showing information about track work and unexpected train delays at Penn Station. But, as the MTA/NYCT balance out funding and spending priorities, improvements to communications systems often fall by the wayside in the face of major upgrades like signals and track work. For example, an MTA plan to upgrade the subways' public address systems by 2009 stalled in 2005 during budget revisions.[3]

Case Study 11: Information TV Monitors (Paris, France)



An Information TV Monitor installed in the Paris Metro. The blue/green screen indicates routine or scheduled information. Image used with permission of Anthony Rizos.

In 1993, the Régie Autonome des Transports Parisiens (RATP), the transportation authority for the Paris region, began installing information television screens in Metro stations throughout Paris.[4] These screens display real-time service information for the Paris Metro, including unplanned service changes, major delays and station closures as well as planned service changes and track work. They are updated constantly throughout the day.

The average stations has 2-3 monitors, both inside and outside of the fare-zone, at key locations where riders congregate.[5] This placement of the monitors allows passengers who have already

3 Smerd, Jeremy, "Inaudible Announcments in Subways Are Endangering Riders, Critics Say;" The New York Sun, 21 September, 2005 (http://www.nysun.com/article/20304); Accessed 11/09/07

4 Email Correspondence with Thierry Anselot, Domaine Information Voyageurs, Régie Autonome des Transports Parisiens (RATP), 4 October 2007

5 ibid., 9 October 2007

paid their fare and are transferring within the system to make changes to their planned routes as necessary while also providing potential passengers with information about their planned route before they pay their fare.

To a large degree, the effectiveness of the RATP monitors comes from their simplicity. The display on the monitors is text only, without advertisements, graphics or scrolling text which distract the viewer. The displays are color coded—blue/green screens for planned service changes or routine announcements, yellow screens for unplanned service changes and red screens for emergencies—making it easy for users to glance at the monitors in passing and still gain information.[6]

The current television monitors used by the RATP are standard televisions, available in any electronics store, which are protected by a plexiglass cover. As the RATP renovates its stations however, these screens are being replaced by flat screen moniors (TFT 4/3 or 16/9). Independent of the installation, wiring and renovation costs, these screens will cost about 130 Euros per year and last for three years.[7]

Examples and Opportunities:

Enhancing New York City's current information offerings for mass transit can help the city meet a number of important Transportation goals laid out in PlaNYC 2030. These goals include increasing capacity on overcrowded lines and improving access to underserved areas by providing users with information about schedules, delays and alternate routes.

Real-time information screens provide transit users with essential transit information at a glance. In loud places like subway stations, they provide quick information that cannot be garbled or drowned out by other noise. While wireless communications technologies are becoming increasingly popular as a transportation information resource, including "low-tech" solutions as well will allow transit authorities to communicate important and time-sensitive transit information in the immediate future, without waiting for subway stations to be wired for cellular and internet service. In addition, "low-tech" devices can reach all New Yorkers, including those who do not have access to the internet or mobile wireless technologies. A consistent format and placement throughout the NYCT network could help draw attention to the screens and ensure their use. Overall, introducing immediate communication solutions could also improve customer service and satisfaction ratings.

6 Email Correspondence with Thierry Anselot, Domaine Information Voyageurs, Régie Autonome des Transports Parisiens (RATP), 9 October 2007

7 ibid.

PORTABLE REAL-TIME SYSTEMS:

Transit riders are becoming more comfortable with technology-on-the-go and the number of people with wireless web enabled handheld devices is likely to dramatically increase in coming years. With this trend comes the growing public expectation that nearly all web-based transportation information should also be accessible wirelessly. In addition, information systems that utilize cell phone or PDA technologies provide an unique information distribution option for transit authorities, as many New Yorkers already carry cell phones and/or PDA's, making costly capital improvements unnecessary. Three portable real-time systems of note are:

- Cell Phone/PDA Arrival Information Systems
- Interactive Text Message (SMS) Arrival Information Systems
- Matrix Barcodes

Background:

With most riders on the move throughout the day, the challenge for transit authorities is how to get current or emergency service change information to riders before they enter the transit system, while they are at stations, and when they are in the system between stations. Cities like San Francisco, Paris, London, and Shanghai address these issues by offering estimated train/bus arrival times, transit schedules, system maps, emergency alerts and trip planners in mobile-friendly format, allowing riders and potential riders to access information while out and about.

In recent years, MTA/NYCT has dramatically increased the amount of information that transit users can access, both in stationary (in front of a computer) and portable (on the go) formats. For example, if a transit rider, seated at a computer at home or at work, wanted to access basic transit information online, they would have a variety of options, including GoogleTransit, Hopstop.com, Trips123.com and the MTA's tripplanner.mta.info. At any of these sites, that transit rider would find system maps, trip planners and information on planned service changes.

Color-coded real-time traffic congestion message board in Beijing, China. NYC Dept. City Planning

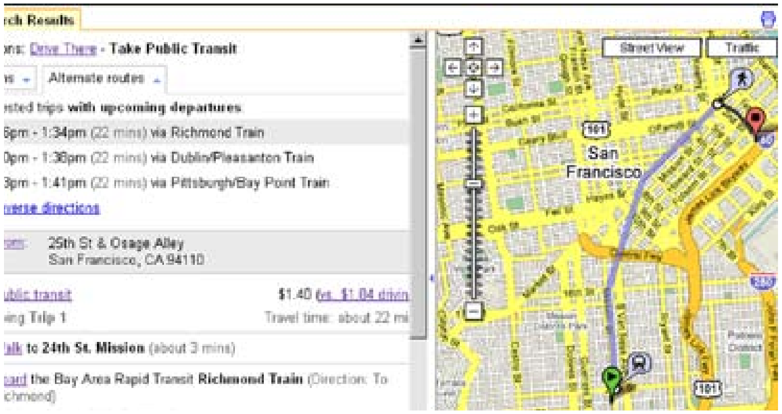
Recent announcements by the MTA indicates that these transit offerings may soon be joined by a more robust GoogleTransit trip planner which would provide maps and schedules and take advantage of existing popularity of Google's mapping services.[8] At this time, GoogleTransit is available for 18 transit systems, including San Francisco and Portland, OR, however none of these systems are as complex as the New York City subway, bus and rail systems.[9]

The MTA's recent introduction of its web-based TripPlanner for mobile-enabled phones and PDA's, provides access to its website and transportation information services (trip planner, planned service changes etc.) to New Yorkers who are moving about the city, and greatly increases the number of portable information systems New Yorkers have at their disposal. This system, like the ones already in place in London or San Francisco, uses a simplified

8 LaForge, Patrick, "Can Google Untangle the New York Transit Web?" The New York Times, 24 August, 2007 & Daily Wireless.org Website, (http://www.dailywireless.org/2007/08/24/google-metro-transit-authority/); Accessed 11/27/2007

9 Like Trips123 previously did, Google will receive access to the MTA's digital schedule data. According to Tom Sly, Google New Business Development, and Jori Pearsall, Transit at Google, Google does not charge transit operators to upload their transit information into the GoogleTransit service. The only costs incurred would be those of formatting and uploading the MTA's digital transit data into the Google Transit Feed Format (GTFS).

website that can be easily loaded by handheld wireless devices (cellphones, PDA's, Blackberries etc.), to provide commuters with route information and planned service changes.[10]



The search results from a GoogleTransit search offer a traditional "Drive There" and a new "Take Public Transit" option. The "Take Public Transit" option provides detailed walking and train directions and offers a price comparison to driving. Images used with permission of Google.

The QuickPlanner interface for PDA's offers users increased site mobility. Image used with permission of Bay Area Rapid Transit (BART).

Case Study 12: Cell Phone/PDA Information Systems (San Francisco, CA)

San Francisco's transit authority, BART, offers real-time arrival and service alert information to users from their mobile phones or internet-enabled PDAs. Information is made easily and quickly available to cell-phone browsers or other hand-held devices by way of simplified interfaces on BART's webpage. A basic root menu serves as a gateway to multiple transit information tools offered.[11] Such wireless technology provides increasingly personalized service information while requiring minimal infrastructure investments.

For example, customers looking for real-time information navigate to the BART website (http://www.bart.gov/index.asp) from their phones as they would if they were looking to access the BART QuickPlanner or other static information. From the main menu, they are given the option of selecting Service Advisories or Arrival Information. For Service Advisories, users are directed to the service advisories page. For Arrival Information, users select their location from a pull-down menu and are directed to a page with estimated arrival times to that location from all directions.

BART users can navigate to the BART website from their handheld device and receive estimated arrival times from any station. Image used with permission of Bay Area Rapid Transit (BART).

10 MTA Website, "Trip Planner on the Go," (http://tripplanner.mta.info/tripPlannerPDA.aspx); Accessed 2/15/08

11 BART Website, "Wireless Trip Planner," (http://www.bart.gov/stations/quickPlanner/wireless.asp); Accessed 11/27/2007

Case Study 13: Interactive Text-Message Information (Paris, France)

Text messages (also known as Short Message Service or SMS) are widely used by transit authorities to provide transit information to customers. Transit authorities in San Francisco, London, Portland, OR., Baltimore, New York and New Jersery all allow riders to sign up for automated text message alerts which are sent out whenever a problem occurs. In Paris, France, however, the Parisian transportation authority, the RATP, has taken text messaging a step further, creating an interactive SMS service that provides real-time arrival estimates to transit users on demand.

The RATP's interactive SMS service offers arrival and departure information for all of Paris's buses, regional rail (RER), and streetcars (trams). To use the system, riders send a text message to a designated phone number (61064*) stating the mode of transportation (bus, RER or tram) and the route number and full station name. For RER service, Paris's regional commuter rail, users enter the RER line (A or B) and the boarding and destination station names.[12] Within minutes, users receive a text message from the RATP with arrival times in both directions.

The RATP's interactive text messaging system allows cellphone users who do not have web-enabled cellphones to receive real-time information about arrivals and departures for Paris's buses, trams and regional RER service.

12 RATP Website, "Ma RATP dans la poche;" (http://www.ratp.fr/); Accessed 12/17/07

On-demand SMS service substantially reduces information distribution infrastructure costs for transit authorities. Transit users themselves provide the distributuion interface (their cell phones); the only infrastructure requirement for the transit authorities is to gather relevant information in a format that can be sent. In addition, because SMS messages can be up to 160 characters in length and all messages are automatically stored on the users' phone for easy retrival, SMS systems are extremely user friendly.[13] Users can access the information provided at a later time even if they are no longer in an area with wireless access.

Case Study 14: Codes2D Matrix Barcodes (Paris, France)

The RATP has also begun experimenting with matrix barcodes as a way to simplify communications between transit authorities and users. Also known as 2-Dimensional Barcodes or QR codes, matrix barcodes are essentially the next-generation of barcodes. Like any other barcode, matrix barcodes store information in a compact format. As a transportation (or marketing or security) device, they can be coded to act as an active hyperlink which, when "scanned" by a cell phone camera, directs users to specific pages on specific websites. Matrix barcodes are more powerful than standard "cereal box" barcodes because they can hold significantly more data and because their format is more dificult to forge.[14] Traditional bar codes carry up to 21 characters per inch; a matrix barcode can represent up to 4,296 alphanumeric characters.[15]

The RATP's six month pilot matrix barcode program, called Codes2D, began in April 2007 at the Noisy-Le-Grand Mont d'Est RER and bus station.[16] Riders use their cell phone cameras to

13 3GPP Website (http://www.3gpp.org/ftp/Specs/html-info/0340.htm); Accessed 11/27/07
14 Stellin, Susan, "Paper is Out, Cellphones are In," The New York Times, 18 March 2008
15 Wikipedia Website, "QR Codes," (http://en.wikipedia.org/wiki/QR_Code); Accessed 11/27/2007
16 Cousin, Capucine; "La RATP expérimente les codes-barres 2D pour l'info voyageur," businessMOBILE.fr, 4 June 2007

"scan" the barcode which directs their mobile browser to specific pages on the RATP webpage. Instead of scrolling through menus or typing in URLs, the matrix barcodes directly link transit users to system maps, schedules, real-time arrival times and service alerts.[17] All information—maps, schedules, arrival times and service alerts that appears on the standard transit agency website—is accessible wirelessly on a one-click basis.[18] In addition, information accessed through the Codes2D program can be stored on the user's phone, allowing them to access it again later, even if wireless service is no longer available.

The RATP's Code2D system takes users directly to the information they request on the RATP's website. Image used with permission of the RATP.

Placards displaying the Codes2D are easy to find; the RATP has placed them at all the bus stops at Noisy-Le-Grand Mont d'Est, on the RER platforms, and throughout the central waiting room.[19] Transit users access the service by first downloading and installing the Codes2D application to their mobile phone from the Scanbuy website which produced the Codes2D technology for the RATP.

In the United States, matrix barcodes are most frequently used on shipping labels. However, in addition to the transit uses being tested by the French, manufacturers and advertisers in Japan and South Korea have begun coding matrix barcodes to directly link potential customers to commercial websites.[20] Users can see a barcode on an advertisement, "scan" it with their phone and are directed to the product website where they can purchase the products from their cell phones. All Nippon Airways allows passengers to check in for domestic flights via a matrix-barcode sent to their cellphone.[21] Continental Airlines has recently followed suite, working with the Transportation Security Administration since December 2007 to test the system at Continental's Houston hub.[22]

Examples and Opportunities in New York City:

Enhancing New York City's current information offerings for mass transit can help the city meet a number of important transportation goals laid out in PlaNYC 2030, including increasing capacity on overcrowded lines and improving access to underserved areas by providing users with information about schedules, delays and alternate routes.

Because users themselves supply the majority of the infrastructure (cellular phones, PDA's, iPods etc.) web-based and wireless information services can be implemented relatively quickly and at minimal costs to transit providers. In partnership with companies like Google and others, existing information websites such as the MTA website and Transcom's Trips123 can be enhanced to include a wide variety of transit information options. These can be done without impeding efforts to develop the city's long-term transportation communications systems, like real-time digital platform signage. In addition, as not all New Yorkers have access to wireless technologies, introducing non-wireless low-tech immediate solutions could also improve the information offerings and increase customer service and satisfaction ratings.

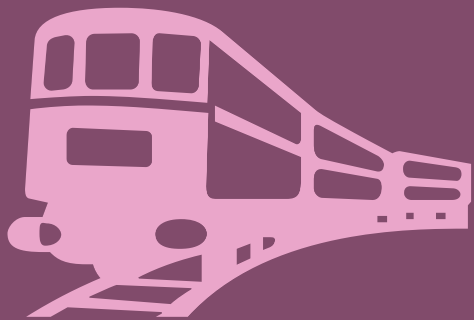
A key step in enabling wireless information services throughout

17 RATP Website, (http://ratp.fr); Accessed 11/27/2007
18 Cousin, Capucine; "La RATP expérimente les codes-barres 2D pour l'info voyageur," businessMOBILE.fr, 4 June 2007
19 ibid.
20 CNET Asia Website, "QR Code Smudges Japanese Daily Life," (http://asia.cnet.com/reviews/blog/mobileojisan/0,39050793,62020373,00.htm); Accessed 11/27/2007
21 Story, Louise; "In a New Web World, Bar Codes May Talk With Your Cellphone;" The New York Times, April 1, 2007
22 Stellin, Susan, "Paper is Out, Cellphones are In," The New York Times, 18 March 2008

the transit system is outfitting subway stations with the cellphone reception. The city is planning to install cellphone equipment in all of the transit system's stations – a task that will take several years to complete. In the meantime, wireless services would still be valuable at bus stops, above-ground at station entrances and throughout the rest of the city.

Information systems that could be introduced in New York City are as follows:

- Increased publicity for the MTA's new cell-phone-friendly http://tripplanner.mta.info/tripPlannerPDA.aspx website.
- Increase publicity for the MTA's Service Alert text messages.
- Use SMS technology to disseminate train arrival times (for the lines where signal upgrades are completed) on demand.
- Code2D matrix barcode technology could be incorporated into bus signage and all above-ground subway signage to direct customers to important information.



ENHANCING INFRASTRUCTURE

New York City's historical development and pre-eminence, as well as its current growth and success are predicated in part on its transportation offerings. Today, ensuring that we can use the infrastructure we have, and that our current systems are truly accessible to all New Yorkers is a key goal. Such efforts are vital not only for the 8.3 million New Yorkers but also to encourage and promote economic growth stemming from the 47 million visitors to New York each year. Indeed, enhancing our public transit system so that travel throughout the city is easy and "seamless" is one of the city's most important transportation goals. As New York embarks upon a massive re-branding campaign to increase New York's visibility as a tourist destination, increasing access to the city's transportation systems and enhancing the connectivity of the system has never been more important.

This report highlights five technologies and systems that have increased access and improved subway connections in other cities around the world and which could be implemented in New York.

- Designated ROWs
    - Case Study 15: Physically Separated ROWs
    - Case Study 16: Non-Physically Separated ROWs
- Internal Gangway Subway Cars
    - Case Study 17: Articulated Subway Cars
- Bicycle Transit Centers
    - Case Study 18: BikeStation and the McDonalds Cycle Center
- Wheelchair Access for the Subways
    - Case Study 19: Wheelchair Escalators and Emergency Lifts
    - Case Study 20: Universal Access Turnstiles
- Taxi Vouchers and Accessible Taxis
    - Case Study 21: Chicago's Taxi Access Program

Cars double-parked in the bicycle lane on Lafayette Street in 2007.
NYC Dept . City Planning

DESIGNATED RIGHT-OF-WAY (ROW)

Many cities have attempted to solve their congestion problems by creating dedicated right-of-ways (ROW) on existing roadways. Traffic on dedicated ROWs is limited to a single type of vehicle (e.g. buses, trucks etc.) in order to increase speed and reliability. This report surveys two designated ROW scenarios:

- Physically Separated ROWs: TransMilenio, Bogotá, Colombia
- Non-Physically Separated ROWs, London, England and Rouen, France

Background:

A physically separated, designated right-of-way for buses in Xian, China. NYC Dept. City Planning

Designated ROWs reduce travel times and increase the reliability of scheduled services like buses or deliveries. Dedicated ROWs are typically associated with buses (for example New York's Select Bus Serivce) or carpool lanes, but are also used for bicycles (usually for safety reasons). Planners in Southern California, hoping to increase their capacity to move goods from the highly trafficked Los Angeles and Long Beach ports, are exploring options for designated ROW for trucks.[1]

ROWs for buses are an established concept in New York City. In 1971 the Port Authority of New York and New Jersey (PANYNJ) began operating a 2.5 mile exclusive bus lane (XBL) that runs contra-flow through the Lincoln Tunnel weekday mornings between 6:15 and 10:00 a.m..[2] In addition to the XBL the MTA and NYCDOT have recently begun a BRT demonstration project with one corridor in each borough.[3] More recently NYCDOT has designated five priority bus right-of-ways, one in each borough, to speed bus traffic and has begun another test project involving painting bus lanes a distinctive color.[4]

New York City's newly introduced designated right-of-ways for buses, shown here on lower Broadway in Manhattan, are already improving traffic conditions for buses and providing a safe haven for bicyclists. NYC Dept. City Planning

1 Pisano, Mark; Executive Director of the Southern California Association of Governments; Panel discussion at the NYU Wagner Rudin Center freight symposium, "Delivering the Goods: The Freight Needs of a Growing Population." May 6th 2007

2 Port Authority of New York New Jersey Website, "Lincoln Tunnel;"(http://www.panynj.gov/Commuting-Travel/tunnels/html/lincoln.html); Accessed 10/10/07

3 Metropolitan Transit Authority Website, "What is BRT?" (http://www.mta.info/mta/planning/brt/whatis.htm); Accessed 1/7/08

4 NYC Department of Transportation Website, "Press Release: DOT Paints Bus Lanes to Increase Visibility;" (http://www.nyc.gov/html/dot/html/pr2007/pr07_73.shtml); Accessed 8/17/07

Because constructing new roads is rarely an option in New York, the creation of dedicated lanes require planners and city officials to make decisions about the allocation of space on the roadway. In particular planners must weigh the public benefits gained from increased transit flow or faster goods movement against the cost of reducing space for personal cars. By and large, dedicated lanes for buses or trucks only make sense in areas that have significant traffic and high demand.

Beyond roadway allocation issues, the success of designated ROWs depends on sufficient enforcement. Clogged lanes can lead to reduced ridership and increased traffic congestion. For delivery trucks and freight uses, clogged lanes increase delivery times and transportation costs. For bicycles, poor enforcement of designated bicycle ROWs can lead to serious safety concerns as bikers find themselves suddenly competing for space with cars. Overall, poor enforcement mechanisms which lead to private cars clogging designated lanes reduces their efficiency and value and may drive away legitimate users.

Enforcement of designated ROWs is typically done through two main methods: physical separation, often achieved via physical barriers or grade separation, and non-physical separation, usually accomplished through visual cues and signage.

Physically separated ROWs are most often used for buses or bicycles and have proved to be effective at increasing speed, capacity and safety. The physical separation means that the lanes are self-enforcing as unauthorized motorists cannot enter the ROW. Physically separated ROWs for bus service are often implemented as a less costly alternative to rail service. Cities using physically separated ROWS also tend to build infrastructure for pre-boarding fare collection at stations, instead of on the bus, minimizing delays caused by boarding and alighting and allocate space for a passing lane at bus stops/stations. Some of the best examples of these ROWs are found in Bogotá, Colombia.

However, the physical separation also increases the logistical challenges to the implementation of such ROWs. For exmaple, a bus that breaks down in a one-lane physically separated ROW blocks all other buses behind it, but cordoning off two lanes for buses (express & local or stopping & passing) only is rarely a feasible option in a space-starved city like New York. In addition, New York has a significant amount of subterranean infrastructure (water, sewer, power) which must be accessible at short-notice; roadwork can cause disruptions to designated lanes.

Non-physically separated ROWs are more common than the physically separated. There is a large degree of variation in this type of ROW including signage listing hours of vehicle exclusion, painted lanes, contra-flow lane, shared use (ex. buses, HOVs, taxis, motorcycles, bicycles, trucks, etc.). Enforcement issues increase for non-physically separated ROWs since unauthorized vehicles can easily enter the lane. However, the lack of physical separation also makes it possible for the lane to accommodate different types or levels of traffic at different points throughout the day. This type of ROW is typically used on narrower streets where there is not sufficient room for physical separation and/or traffic is light enough that a 24-hour lane is unnecessary.

Case Study 15: Physically Separated Right-of-Ways (Bogota, Colombia)

A Transmilenio station in Bogota, Colombia. The double lane designated right-of-way allows for express and local service, while the physical barrier between the bus lanes and regular traffic reduce the need for enforcement.

Bogota, Colombia's TransMilenio Bus Rapid Transit (BRT) system is the world's largest network of physically separated ROWs. It was introduced in 1997 as a means to reduce Bogota's considerable traffic congestion and pollution. It was designed in two phases, encompasses six "trunk" lines and covers 51.2 miles.[5] Modeled off a BRT system already in operation in Curitiba, Brazil, TransMilenio uses high capacity articulated buses running on exclusive, dedicated ROWs that are two lanes wide, to allow buses to pass one another.[6] Construction of the lanes required significant road widening and some demolition.

The introduction of the physically separated ROW to Bogota's highly congested existing bus system has reduced travel times by 38%, reduced noxious emissions by 40% and increased ridership since buses are no longer caught in traffic or slowed by private cars.[7] Before the implementation of the TransMilenio BRT service, bus speeds on some of the routes now served by trunk lines were as low as 7.5 mph (Calle 80). After implementation average speeds for local service were 13 mph and 20 mph for express service.[8]

The double lane system also allows local and express service to operate on the same trunk line, with ROW capacities of 280 buses per hour per direction (phpd), nearly 45,000 passengers phpd.[9] Ridership has soared. By 2003 there were nearly 800,000 passengers per day using the system. With the opening of the second phase in 2004 ridership rose to 900,000 and by 2006 ridership was 1,050,000 passengers per day.

To further reduce travel times, Bogota has introduced pre-boarding ticketing which allows passengers to board buses as quickly as they arrive. These factors combined allow the system to maintain 2 minute headways during peak hours and 6 minute headways off-peak.[10] Due to the physical divider, a thin raised concrete barrier which is often painted a bright color to increase visibility, little is needed to enforce the separation of designated lanes from general traffic or to keep private cars out.

The cost per kilometer has increased from US$5.1 million for phase 1 to US$7.5 million for phase 2. Infrastructure costs are

5 Alasdair Cain, Georges Darido, Michael R. Baltes, Pilar Rodriguez, Johan C. Barrios, "Applicability of Bogotá's TransMilenio BRT System to the United States," Federal Transit Administration, US DOT, Final Report, 2006, (www.nbrti.org/media/documents/Bogota%20Report_Final%20Report_May%202006.pdf); Accessed 8/23/07

6 ibid.

7 ibid.

8 Hidalgo, D., "TransMilenio Bus Rapid Transit System Expansion 2002-2005 – Bogotá, Colombia," Akiris de Colombia S.A., Bogotá, Colombia, (www.codatu.org/english/publications/proceeding/conference/codatu11/Papers/hidalgo.pdf); Accessed 8/22/07

9 ibid.

10 Alasdair Cain, Georges Darido, Michael R. Baltes, Pilar Rodriguez, Johan C. Barrios, "Applicability of Bogotá's TransMilenio BRT System to the United States," Federal Transit Administration, US DOT, Final Report, 2006, (www.nbrti.org/media/documents/Bogota%20Report_Final%20Report_May%202006.pdf); Accessed 8/23/07

covered with local revenues from a gasoline tax (25% surcharge), about US$70 million/year, and national grants, about US$100 million/ year, from 2004 to 2016.[11] In 2006, the estimated daily revenue was about US$573,000. Annual ridership was 315 million passengers in 2005, with operating revenues of about $172 million.[12]

11 Hidalgo, D., "TransMilenio Bus Rapid Transit System Expansion 2002-2005 – Bogotá, Colombia," Akiris de Colombia S.A., Bogotá, Colombia, (www.codatu.org/english/publications/proceeding/conference/codatu11/Papers/hidalgo.pdf); Accessed 8/22/07

12 Alasdair Cain, Georges Darido, Michael R. Baltes, Pilar Rodriguez, Johan C. Barrios, "Applicability of Bogotá's TransMilenio BRT System to the United States," Federal Transit Administration, US DOT, Final Report, 2006, (www.nbrti.org/media/documents/Bogota%20Report_Final%20Report_May%202006.pdf); Accessed 8/23/07

Case Study 16: Non-Physically Separated Right-of-Ways (London, England; Rouen, France)

Bicycles, motorcycles and buses share a non-physically separated bus right-of-way in London. The colored asphalt increases the visibility of the right-of-way. Crown copyright, from DfT TAL207, reproduced with permission.

Designated ROWs for buses were first introduced in London in the late 1960's. Initially a success, London's bus lanes deteriorated throughout the 1980's and 1990's due to lack of funds and insufficient enforcement. In 2000, London's bus system, including its designated bus ROWs, underwent a massive overhaul in preparation for London's Congestion Pricing plan.[13] Revenue from the Congestion Pricing is funneled

13 Transport for London (TfL), "The case for investing in London's buses: Presenting the results of the London Buses Strategic Review;" September 2003

back into the bus system, guaranteeing an on-going funding source for enforcement, future repairs and upgrades. Some of the bus lane improvements that the city of London and the bus operator Transport for London (TfL) have implemented are pre-boarding fare collection at some locations, distinctive lane color, GPS signal priority at traffic lights, closed circuit TV (CCTV) enforcement of the lanes, and shared use by certain vehicles. Today, designated ROWs in London carry over 6,500 scheduled buses holding around 5.4 million passengers on over 700 different routes per day or 1.5 billion passengers annually.[14] Rouen's system, called TEOR, is considerably smaller. First introduced in the late 1990's, it carries 90,000 passengers per day on approximately 200 buses.[15]

London's dedicated ROWs tend to be curb side bus lanes (running along the left lane parallel to the curb) which limits delays caused by private vehicles pulling into and out of parking spaces. Many of the lanes are painted a distinctive red to further visually remind motorists not to enter the lanes. Rouen's ROWs are also painted a distinctive color, but rather than operating in the curb lane the ROW is the center lane. In addition to the color, the lanes are demarcated by a different type of pavement at the border between the exclusive lane and the general traffic lane, giving motorists a physical and audible reminder if they enter the lanes.[16]

In London, which has a far larger population than Rouen and thus higher demands on its roads and space, the lack of a physical divider separating buses from the general traffic increases the flexibility of the bus lanes. For example, while highly-trafficked major arteries need exclusive ROWs for buses at all times, streets that have heavy peak traffic loads but low traffic volumes in the off-peak hours or infrequent bus service do not. At off-peak hours, bus lanes can be used by general traffic, thus increasing the amount of road space available. In such cases, signs posted along the bus lane inform users of the hours of use (unless it is a 24-hour lane) and the types of vehicles that are allowed to use the lanes.

The absence of a physical divider also means that London's bus lanes can be, and are, shared by other modes of transportation such as bicycles and taxis. Bus lanes are designed to be wide enough for buses to overtake cyclists and are intended to increase bicycle safety (TfL's preferred width is 13 feet). This multi-use ROW dramatically increases the bicycle lane network across the city. In addition, TfL is examining the introduction of motorcycles and motor scooters (known as powered two wheelers or PTW) into designated lanes. This is part of the City's plan to promote PTW use as a way to reduce congestion and emissions. This is still being studied and a final decision has not yet been made.[17] Elsewhere, traffic planners in Scotland have considered allowing smaller freight vehicles (lorries) to use their designated bus lanes, presumably this would be for through traffic not for deliveries.[18]

However, that same absence of a physical divider that increases lane and use flexibility means that the city of London and TfL must provide significant monitoring and enforcement mechanisms that are unnecessary in Bogota's closed system. Like many other cities with bus lanes that do not have self-enforcing physical separation London has had problems with cars illegally entering the designated bus ROWs and causing delays for buses and dangerous conditions for cyclists.

Beyond normal police enforcement, closed circuit television cameras (CCTV) are the primary monitoring and enforcement tool. Introduced in pilot form in 1999, the camera enforcement

14 Transport for London (TfL), "The case for investing in London's buses: Presenting the results of the London Buses Strategic Review;" September 2003

15 Transportation Research Board, "Bus Rapid Transit Volume 1: Case Studies in Bus Rapid Transit" TCRP Report 90 Volume 1 BRT Case Studies, (gulliver.trb.org/publications/tcrp/tcrp_rpt_90v1.pdf) Accessed 8/22/07

16 Transports en Commun d'Agglo. Rouen Website, (http://www.tcar.fr/presentation/index.asp?rub_code=52&thm_id=317&gpl_id=); Accessed 12/21/07

17 Department for Transport, "The Use of Bus Lanes by Motorcycles: TRAFFIC ADVISORY LEAFLET" Department for Transport, February 2007, (http://www.dft.gov.uk/pgr/roads/tpm/tal/trafficmanagement/trafficadvisoryleaflet207); Accessed 8/23/07

18 BBC News Website, "Bus lanes 'could open to freight';" July 3, 2006. (http://news.bbc.co.uk/2/hi/uk_news/scotland/5143396.stm); Accessed 12/21/07

produced remarkable results, a reduction of violations by up to 80% in some areas, and a significant increase in bus speed and reliability.[19] By 2000 about 300 bus lanes were being monitored by cameras and 151 cameras had been mounted on buses for additional enforcement.[20] The cameras record images of license plates and the surrounding conditions (for example, if a vehicle entered a lane to avoid an emergency vehicle no ticket is issued) and issue a ticket to the owner of the vehicle. The fine for driving or parking in a bus lane is high enough to serve as a deterrent. It was set at £80 ($161) in 199, increased to £100 ($201) in 2004, and has since been raised again to£ 120 ($242).[21]

In addition to stationary CCTV cameras and bus mounted cameras, some boroughs have introduced additional mobile enforcement units, consisting of cars with CCTV cameras driving around to identify violators.[22] By 2004 there had been an increase to 900 bus mounted cameras and 500 roadside cameras, issuing as many as 100,000 summonses a year and saving an average of 10 minutes in travel times for bus commuters. The revenues generated from the bus lane inforcement have repaid the cost of their installation.[23]

TfL's study of bus lanes in London found that between 2000 and 2005 waiting times for buses fell by 15%, largely due to enforcement. Over the same time period, buses in bus lanes traveled about 13% faster than those on routes with out designated bus lanes. With enforcement, violations have decreased, there has been an 85% decrease in fines for bus lane infractions between 2003 and 2005.[24]

Both London and Rouen augment their bus service with signal prioritization and pre-paid boarding options that allow buses in their designated ROWs to travel even faster and more efficiently. An overview of these technologies is included in Appendix C.

Examples and Opportunities in New York City:

Designated ROWs can help New York meet the PlaNYC 2030 goal of improving and expanding bus service. NYCDOT's Select Bus Service, modeled in part off BRT services in other cities, has substantially increased bus speeds on specific routes throughout the five boroughs. In addition, designated ROWs could be used to increase bicycle safety and improve freight movement around the city.

Larger streets with high levels of congestion and significant bus traffic or streets that are underserved by transit may benefit from a physically separated bus ROW. Some major roads, like the Grand Concourse and Queens Boulevard, already have some degree of physical separation and may lend themselves to further introduction of physically separated ROWs. On-going maintenance and handling roadwork would be major issues.

In addition, designated ROWs could be of particular value for bicycles and freight. Physically separated bike-lanes, including lanes that use parked cars as a buffer, can significantly increase bicyclist and pedestrian safety. For freight, the creation of priority "Truck Lanes" along major New York City truck routes could reduce goods transportation time and costs and lower air pollution.

19 Department for Transport, "Bus Priority: The Way Ahead," Department of Transport, 2004, (http://www.dft.gov.uk/pgr/regional/buses/bpf/busprioritythewayahead12/); Accessed 8/29/07

20 Michael McCahill and Clive Norris, "Working Paper No.6 CCTV in London" Center for Criminology and Criminal Justice, University of Hull, June 2002, (www.urbaneye.net/results/ue_wp6.pdf) Accessed 8/28/07

21 Transport for London, "Keep London Moving," Transport for London, 2006, (http://www.tfl.gov.uk/roadusers/finesandregulations/963.aspx); Accessed 8/24/07

22 London Borough of Lambeth Website, "CCTV enforcement of parking and traffic contraventions;" (http://www.lambeth.gov.uk/Services/TransportStreets/Parking/CCTV.htm); Accessed 12/21/07

23 Transportation Alternatives Magazine Website, "More Lessons from London: Bus Lane Enforcement Cameras;" 2004 (http://www.transalt.org/press/magazine/041Winter/16buscameras.html); Accessed 12/21/07

24 BBC News Website, "Bus lanes 'improves journey times';" June 13, 2006 (http://news.bbc.co.uk/2/hi/uk_news/england/london/5075520.stm); Accessed 12/21/07

ARTICULATED SUBWAY CARS:

The reconfiguration of the interiors of train and subway cars is another technique employed by cities around the world to increase the capacity of their subway systems while minimizing costly, long-term infrastructure overhauls. As specific seating layouts are based on a variety of city-specific policy decisions (commuter rail vs. short-hop transit for example require different seating configurations), this report focuses on overall subway car redesigns.

Background:

The interior of the MTA's new R160 subway car.

Four major options exist for increasing subway capacity:
1) increasing the number of trains, 2) increasing the length of current trains sets (ie adding cars to the trains), 3) building new subway lines and, 4) reconfiguring train designs to accommodate more passengers.

Despite their obvious benefits, most of these options would be costly and time-consuming. As New York's almost 80-year experience with the 2nd Avenue subway attests, building new subway lines is a slow, costly and politically fraught endeavor.[25] Adding more subway cars to trains, proposed as early as 1920 as a way to reduce congestion on the IRT lines, would require extensive platform extensions and track reconfiguration.[26] In addition, since New York's subway runs 24 hours, platform extensions could increase congestion in the short term while the work is underway.

More recently, the MTA has proposed adding trains to the 4 and 5 trains to reduce pressure, but Howard Roberts, the NYCT president cautions that such an undertaking would take years.[27] Increasing train frequency (decreasing headway between trains) requires substantial upgrades to the subway signal system to prevent accidents. Some of these upgrades are already in progress. But, even when upgrades are made, the number of trains that a single track can hold is limited. The 4 and 5 trains, for example, which are the most congested lines in the city, already run at a frequency of 27 trains per hour during rush hour.[28]

In contrast, redesigning the subway car itself can be implemented relatively quickly as part of planned subway car upgrades. Articulated subways, essentially subway trains with open passages between all the cars on a train as opposed to discrete, closed cars, are a prime example of car redesign. Unlike the other options which require intensive capital campaigns and massive transit disturbances as the MTA retrofits existing stations, installs new signals or builds new tunnels, car redesign does not impact the existing subway infrastructure. In addition, since subway cars are constantly being upgraded, redesigned cars can be phased in with normal replacement and within existing budget allocations.

25 According to the MTA, plans for an underground 2nd Avenue Subway date back to 1929. The 2nd Avenue Elevated was torn down in 1942 and the 3rd Avenue Elevated in 1956.
26 Staff, "Have Plan to Raise Capacity of Subway," The New York Times, 26 January, 1920
27 Neuman, William, "Some Subways Found Packed Past Capacity;" The New York Times, 26 June 2007
28 ibid.

Case Study 17: Articulated Subway Cars (Toronto, Canada; London, England; Shanghai, China)

The exterior of one of Shanghai's internal gangway subway cars. Similar to an elongated bus, the moving gangway between subway cars is protected by a flexible "accordion" casing allowing passengers can travel freely throughout the length of the train. NYC Dept. City Planning

Articulated subways are in use in a variety of transit systems, including Shanghai, Bangkok, Barcelona, Berlin, Brussels, Bucharest, Delhi, Hong Kong, Melbourne, Paris, Singapore; and Stockholm and will be introduced in Toronto and London by 2009.[29] Developed by Bombardier, articulated subways (Bombardier's MOVIA series) convert the unused open space between the cars into usable, enclosed space increasing the carrying capacity of each train by providing additional standing room. Passengers can move within the train which alleviates crowding in specific cars. Importantly, articulated subways can be built to the same dimensions as existing cars allowing them to be phased in without requiring costly and time-consuming station renovations and track work.

Over the past few years, both Toronto and London have released plans to purchase articulated cars as part of their system upgrades. In 2006, the Toronto Transit Commission (TTC), the system operator, ordered 234 Toronto Rockets, articulated cars, from Bombardier to replace Toronto's old H4 and H5 trains. Like the current trains, these cars will be grouped into six-car trains.[30] The TTC estimates that the new articulated Bombardier trains will have 7.5% more usable interior space than their newest T1 trains which began operations in 1996 and by 13% over the H4 and H5 trains that they will replace.[31]

In addition, because passengers can move freely throughout the length of the articulated train, Toronto also expects to see a variety of passenger safety improvements, including a 50% reduction in emergency evacuation times and shorter emergency detection times.[32] The Toronto Rockets also boast of dramatically increased reliability, a maximum fire load reduction of 25% and reduced costs through car design of approximately $45 million.[33]

The city of London is also preparing to introduce articulated trains to its Underground lines. In December, 2006, MetroNet released plans to add 190 Bombardier MOVIA 237 and Bombardier MOVIA 238 trains for Circle, District, Hammersmith & City and Metropolitan lines.[34] The trains will run in 7-8 car trainsets. TfL estimates that the new articulated Circle, District, Hammersmith & City and Metropolitan trains which feature a new seating layout will have 8.7% more room than London's existing rolling stock.[35]

29 Email Correspondence with Thierry Marechal; International Association of Public Transport (UITP); 11/07/07

30 Toronto Transit Commission Website, "New Subway Trains;" (http://www.toronto.ca/ttc/new_subway_train/new_train_preview.htm); Accessed 12/18/07

31 Email Correspondence with Chris Heald, Head of Rail Vehicles Projects, Toronto Transit Commission, 11/16/07 & Toronto Transit Commission Report; "Proposal No. P31PD05761;" August 2006

32 Email Correspondence with Chris Heald, Head of Rail Vehicles Projects, Toronto Transit Commission, 11/16/07

33 Toronto Transit Commission Report; "Proposal No. P31PD05761;" August 2006 ("Fire Load" is defined as the heat at which an enclosed space burns. A reduction in the maximum fire load means that the new internal gangway cars would burn at a lower temperature, thus increasing passenger safety.)

34 MetroNet Website, "MetroNet Reveals Look of Future Underground Trains;" (http://www.metronetrail.com/default.asp?sID=1165400503609); Accessed 11/19/07

35 http://www.metronetrail.com/default.asp?sID=1165400503609

Top: The interior of one of Shanghai's articulated subway cars. NYC Dept. City Planning
Bottom: A rendering of Toronto's new Rocket articulated trains. Image used with permission of Toronto Transit Commission and Bombardier.

The Circle, District, Hammersmith & City and Metropolitan trains are comparable to New York City's own R142 trains which run on the 2, 4, 5, and 6 Lines. They have similar lengths and widths (51' long by 9'-9'6" wide) and have similar seating capacity (37 seats per car for the NYCT R142 and 38 seats per car for the London trains). As seen in Table 1, NYCT's R142 trains have a standing capacity of 73 people per car, assuming 3 square feet per passenger. When adjusted to take differing loading standards into account (TfL estimates 2.15 square feet/passenger; MTA guidelines are 3 square feet/passenger), the articulated Circle, District, Hammersmith & City and Metropolitan trains will carry 78 per car, a 7% capacity increase over New York City or 50 additional people comfortably per train.[36] At NYCT crush capacity (1.7sf/px), the articulated Circle, District, Hammersmith & City and Metropolitan trains would have a 9% capacity increase over R142 trains at crush capacity.[37] In other words, at peak hours, London's iarticulated trains could accommodate 110 more people per train than the R142 trains.

Toronto's new trains will have larger increase in capacity (23%) over the NYCT R142 trains. However most of this increase is due to the fact that Toronto's trains are a full foot wider than NYCT's IRT trains. A fairer comparison for Toronto's trains is NYCT's wider R160 trains which are anticipated to run on the J, Z, L, M, N and Q lines in 8-10 car trainsets. The R160 trains will have a standing capacity of 101 passengers per car. Toronto's trains, when adjusted for the NYCT loading standards and the shorter length of the R160, will carry 106 passengers per car, a 5% increase or 40 additional passengers comfortably per train on the J, Z, M and L and an additional 50 passengers comfortably per train on the N and Q.[38] Once adjustments have been made for differing train lengths and loading standards, London's new

36 Email Correspondence with Steve Newsome, Head of International & European Affairs, Transport for London, 11/12/07
37 NYCT data provided by the NYC Department of City Planning, Transportation Division
38 The Toronto Transit Commission's guideline loading standards are 4 people per square meter. At this level, the new Toronto trains would carry 142 people per 75' car or about 115 people per 60'6" car (60'6" is the length of the R160 trains). Data provided by Chris Heald, Head of Rail Vehicles Projects, Toronto Transit Commission (Email conversation with Chris Heald, Head of Rail Vehicles Projects, Toronto Transit Commission, 11/16/07)

trains have 8% less room than the NYCT R160 trains, however this is also most likely due to the greater width (10') of the R160 trains.

Table 1: Capacity Comparison	NYCT R1421	NYCT R160	Toronto Rocket2	Circle, District, Hammersmith & City and Metropolitan (TfL)3
Car Length	51'	60'6"	75'	51'
Car Width	9'	10'	10'2"	9.5'
Number of Cars Per Train	10	8	6	8
Seats Per Car	37	44	65	38
Total Train Capacity Guideline	1100	1160	1279	1182
Original Capacity Assumption	3sf/px	3sf/px	2.7sf/px	2.15sf/px
Standing Capacity per Car	73	101	148	110
Adjusted Standing Capacity—Guideline (3sf/px)	Same	Same	132	78
Adjusted Standing Capacity—Crush (1.7sf/px)	128	186	235	139
In Comparison to NYCT R142 (51')—Guideline	NA	17%	23%	7%
In Comparison to NYCT R160 (60'6")—Guideline	-14%	NA	5%	-8%

Both London and Toronto's transit authorities explored the possibility that the articulation would reduce the turning radius on their trains and have concluded that the impact is negligible.[39] In general, a reduction in turning radius would limit the speed at which a train could make a turn, thus reducing headway speeds along the system. In Toronto, the TTC has ordered extensive tests including laser measurement of their tunnels in order to better understand the potential impacts of the articulation on the turning radius of their trains. They have concluded that the Toronto Rocket will meet TTC's minimum service curve radius of 380 feet and minimum yard curve radius of 230 feet.[40]

39 Email Correspondence with Steve Newsome, Head of International & European Affairs, Transport for London, 11/15/07 and Email conversation with Chris Heald, Head of Rail Vehicles Projects, Toronto Transit Commission, 11/16/07

40 Email Correspondence with Chris Heald, Head of Rail Vehicles Projects, Toronto Transit Commission, 11/16/07

The cost of the new articulated Bombardier cars is similar to that of "closed car" trains purchased by other major transit systems including NYCT, SEPTA (Philadelphia) and MARTA (Atlanta). In 2006, the adjusted unit price for Toronto's trains was just under $2 million US dollars.[41] In contrast, NYCT's R142 cars cost between $1.8 and $2.3 million. MARTA and SEPTA both spent more than Toronto for their new subway car purchases. NYCT's R160's and CTA's new cars cost slightly less.

Table 2: Price Comparison	TTC	NYCT R142	NYCT R142	NYCT R160	MARTA	SEPTA	CTA
Quantity	234	710	120	660	100	104	406
Adj. Unit Price (2006 US $)	$1,989,000	$1,827,000	$2,268,000	$1,575,000	$2,565,000	$2,088,000	$1,746,000
Price Difference	NA	($162,000)	$58,000	($414,000)	$355,000	$99,000	($464,000)

Examples and Opportunities in New York City:

Introducing articulated subway cars to NYCT's existing subway fleet could help to temporarily address overcrowding on some of New York's congested transit routes.

Articulated subway cars do not require additional infrastructure, platform or track enhancements, thus these cars represent a way to increasing capacity without impeding future track enhancements. In addition because new subway cars have already been budgeted for, introducing articulated cars may be possible even in the MTA's tighter budget environment.

Articulated cars demonstrate a capacity increase over the narrower A division lines and could be studied as a way to further boost capacity on the wider B division lines. Articulated cars should be considered for the 2nd Ave. "T" line.

41 Toronto Transit Commission Report; "Proposal No. P31PD05761;" August 2006. The report normalized the cost information to account for inflation and converted it all to Canadian dollars to facilitate easy comparison. In this analysis, all cost information has been reconverted into US dollars based on the spring 2006 dollar.

BICYCLE TRANSIT CENTERS

Secure bicycle parking options are an important part of New York's bicycle infrastructure. Placing Bicycle Transit Centers at transportation hubs and/or in central business districts enhances bicycle options and can encourage bicycle use as part of a multi-modal commute.

Background:

Bicycles parked on E. 5th Street in Manhattan. Bicycle users in New York City cite the lack of bicycle parking as the biggest deterrent to bicycle use. NYC Dept. City Planning

With the increase of on-street bicycle lanes and greenways, as well as a rising interest in sustainable modes of transportation, bicycle commuting is becoming more common. Increasingly popular as a mode of transit with women and older adults, the bicycle riding demographic has grown beyond just those who sport spandex.[42] More bicycles are on the street today, thus increasing the need for secure bicycle parking, as well as more bicycling paths.

Bicycle r commuting tends to increases when commuters know their bicycles will be safe. In New York City however, bicycle commuting is often discouraged by insufficient bicycle parking options. Every make and model of bicycle is a target for theft and bicycles can easily be resold on websites such as craigslist and eBay. As identified in the NYC Department of City Planning's 2007 New York City Bicycle Survey, 51% of the 1,400 respondents cited a lack of safe and secure bicycle parking as the prime deterrent to bicycle use in the city.[43] Commuters who would or could otherwise commute to work by bicycle, or to bicycle to a subway or train station that is out of walking distance, may be unwilling to do so if there is any concern that their bicycle will not be where they left it at the end of the day.

To address the scarcity of legal bicycle parking, the NYC DOT sponsors and operates the CityRacks program which has installed 4,672 racks since 1996.[44] DOT plans to add 1,200 more CityRacks through the five boroughs by 2030.[45] DOT has also introduced 37 covered bicycle parking kiosks as part of the Coordinated Street Furniture Franchise and has taken the unprecedented step of replacing car parking spots with bicycle racks outside a subway station in Brooklyn.

New York City's Zoning Resolution also offers options for bicycle parking in special districts like Hudson Yards, Downtown Brooklyn and Long Island City. In these areas, commercial buildings must set aside up to 400 square feet for interior bicycle parking; enough room for about 33 bikes.[46] Also in accordance with PlaNYC 2030, the city will "pursue legislation to require that large commercial buildings make provision for bicycle storage either on site or reasonably nearby."[47] A zoning text amendment that would require bicycle parking in new buildings is currently

42 Reagan, Gillian, "The Spokes-Models;" The New York Observer; 4 September 2007.

43 NYC Dept. City Planning, "The New York City Bicycle Survey;" NYC Dept. City Planning, May 2007, p. 2

44 Phone Interview with Jason Accime, CityRack Director, NYC Department of Transportation, 11/21/2007.

45 Bicyclists CityRacks Program, "CityRacks," NYC Department of Transportation, < http://www.nyc.gov/html/dot/html/bicyclists/bikerack.shtml> Accessed 11/16/07

46 The Zoning Resolution of the City of New York: ZR93-85 Hudson Yards Indoor Bicycle Parking, ZR 101-45 Downtown Brooklyn District Indoor Bicycle Parking, ZR 117-541 Long Island City Mixed Use District Indoor Bicycle Parking

47 Office of the Mayor of the City of New York, "2030 PlaNYC;" The City of New York, Presented 22 April, 2007, pp.87-88.

in public review. For city employees, the City of New York has recently begun to offer secure bicycle parking for city employees who work in Lower Manhattan.

Case Study 18: Bikestation & McDonalds Cycle Center (California; Arizona; Seattle, WA; Chicago, IL)

The McDonalds Cycle Center in downtown Chicago, offers amenities such as lockers and showers and a café. Image used with permission of McDonalds Cycle Center

Bicycle transit centers such as the Bikestation facilities and the McDonalds Cycle Center encourage bicycling by providing secure bicycle parking and other amenities targeted toward bicyclists. Bikestation, a major bicycle transit center proponent, operates facilities in Berkeley, San Francisco, Long Beach and Santa Barbara in California, Seattle, Washington, Tempe, Arizona; and has provided consulting services for other bicycle transit centers, including the McDonalds Cycle Center which opened in 2004. The newest Bikestation, the Union Street Bicycle Transit Center in Washington D.C, is breaking ground in fall 2008.

At the McDonalds Cycle Center and most Bikestation facilities, members have 24 hour access to secure bicycle storage, repair shops and other amenities—using either a membership card or a key pass. Lockers and showers, food services and internet access are typically provided; the Washington DC Bikestation, however, will provide a changing room, but no restroom and showering facilities.[48] The added amenities are intended to make bicycle riding more attractive to business commuters who otherwise have no place to change into work attire. The centers are located at transit hubs and near bike paths to further encourage bicycle commuting.

Membership fees—which provide access to lockers, showers and other amenities—range from around $90/year (Palo Alto and Santa Barbara Bikestations) to $149/year (McDonalds Cycle Center). In most facilities, daily memberships of around $1/day are also available. Most Bikestations, as well as the McDonalds Cycle Center, allow non-members to park their bicycles for free but charge a nominal fee for locker room access.

Data from Chicago and the various Bikestation facilities indicates that the demand for secure bicycle parking is high. Bikestation Seattle opened in 2003 with 75 spaces and was already maxing out its available space within the first 18 months.[49] Bikestation Berkeley, located on the mezzanine level of a BART station, reaches 100% capacity almost every day.[50] Bikestation Long Beach expanded in 2005 to 44 self-serve spaces and 32 valet spaces due to overwhelming demand.[51] The McDonalds Cycle Center in Chicago has 300 parking spaces and 150 lockers; all 200 annual memberships were sold in the first two weeks.[52] The McDonalds Cycle Center in Chicago now has capacity for 500 annual members.[53] The Union Street Bicycle Transit

48 District Department of Transportation, "Union Street Bicycle Transit Station;" District Department of Transportation, December 2006
49 "City of Santa Barbara Bikestation Needs Assessment"
50 ibid.
51 Steptoe, Sonja, "How Valet Parking Could Save the Planet;" Time Magazine, 24 May 2007
52 Technical Glass Products Website, "Chicago's Millennium Park Bicycle Station;" (http://www.fireglass.com/email/hot_topics/2005_05/); Accessed 9/9/08
53 Phone Interview with Josh Squire, Bike Chicago Rentals & Tours, 09/10/07

Center in Washington D.C will provide parking for 150 bicycles.[54] Bikestations are planned for Madison, WI, Hollywood, and Pasadena.

Chicago's McDonald's Cycle Center in particular is affected by the seasons. In the winter months, the McDonald's Cycle Center uses only 10% of its bicycle parking capacity.[55] To address this, the center is located near mass transit stations and Cycle Center users have access to the Chicago Transit Authority (CTA) trains and the Metro commuter rail or buses, which encourages year-round use. As in many cities, the McDonald's Center doubles as a multi-modal transfer points. As such, the Center may increase the distance that people will travel to reach public transit by several miles.[56]

Funding for the planning and installation of a bicycle transit center typically comes from a variety of sources including the federal government, transit agencies, state and local government, non-profit organizations and private sponsors. Bikestation, for example, is a non-profit organization and relies on grants to provide its services. The cost to build and maintain secure bicycle parking ranges from $1,500 for a locker to $5,000 per bicycle at full-service bicycle transit centers.[57] The McDonalds Cycle Center was built with a $3.1M federal Congestion Mitigation and Air Quality grant.[58] Despite the low fees, Bikestation facilities can cover significant portions of their operation costs, if capital costs are subsidized. In Bikestation Long Beach, membership and use fees cover more than two-thirds of the $150,000 annual operating costs.[59]

The indoor bicycle parking provided at the McDonalds Cycle Center. Image used with permission of McDonalds Cycle Center.

A rendering of the upcoming Washington DC Bikestation which hopes to encourage bicycle commuting in the District of Columbia. Image used with permission of the District Department of Transportation.

54 District Department of Transportation, "Union Street Bicycle Transit Station;" District Department of Transportation, December 2006

55 Phone Interview with Josh Squire, Bike Chicago Rentals & Tours, 09/10/07

56 Bikestation Website, "Top Bikestation Questions," (www.bikestation.org) Accessed 10/10/2007

57 Bikestation Website, "Reinventing the Park and Ride For Bicycle Transportation," (www.bikestation.org) Accessed 10/10/2007

58 Technical Glass Products Website, "Chicago's Millennium Park Bicycle Station;" (http://www.fireglass.com/email/hot_topics/2005_05/); Accessed 9/9/08

59 Steptoe, Sonja, "How Valet Parking Could Save the Planet;" Time Magazine, 24 May 2007

Examples and Opportunities in New York City:

Encouraging the creation of bicycle transit stations at major transportation hubs throughout the five boroughs could help New York City meet the goal of providing "necessary bicycling infrastructure such as bike racks and lockers..." outlined in PlaNYC 2030 and could encourage New Yorkers to add bicycles to their list of transportation and commuting options.

The secure bicycle parking provided by bicycle transit centers could be a major draw for many bicyclists, and potential bicycle commuters. Placing bicycle transit centers near protected greenways and at transit hubs in the Bronx and the eastern portions of Brooklyn and Queens could encourage use by commuters who currently must drive to the train. Bicycle transit centers west of Port Authority and east of the Queensboro Bridge could encourage residents of upper Manhattan to commute by bicycle even if they are afraid of traffic in midtown or lower Manhattan. A bicycle transit center at St. George could encourage Staten Island commuters to do part of their trip by bicycle. A bicycle transit center in lower Manhattan could be a boon to the many workers there.

Bicycle transit centers can be developed by the public sector, the private sector or through public-private partnerships. Mechanisms to encourage private sector creation of bicycle transit centers could include but are not limited to zoning requirements or incentives or tax incentives. Advertising or sales within the transit center could increase revenues.

WHEELCHAIR ACCESS FOR THE SUBWAY

Increasing wheelchair options in New York City's subways can dramatically increase the accessibility of the city's transit systems for a wide variety of New Yorkers including people in wheelchairs or with limited mobility, passengers with strollers and those carrying heavy packages. This report looks at three technologies: Wheelchair Accessible Escalators, Portable Wheelchair lifts and Universal Access Turnstiles.

Background:

Accessing the city's subway system can be difficult for many New Yorkers. There are a limited number of wheelchair accesible subway stations (elevators exist in 53 of the system's 468 stations) in the New York City transit system.[60] Riders often find elevators and escalators out of service. For riders with limited mobility, elevator and escalator outages can become, in the words of Howard Roberts, NYCT President, an "absolute bar" to use.[61]

Despite the MTA's understanding of the challenges that elevator and escalator outages pose to riders, repairing broken elevators can be difficult and is often time consuming. New York City's competitive procumement rules mean that there many different manufacturers providing elevators in the subway system, which makes it hard to stockpile standardized parts. In addition, each elevator is custom designed to its location which increases the maintenance challenges. At the extreme, advocacy groups have documented elevators that have remained out of service for up to nine months.[62]

The limited number of wheelchair accessible subway stations also poses problems. While many of these stations are major transfer points in the system—such as Times Square, Atlantic Avenue or Queens Plaza—the lack of elevators throughout the

60 Disabled Riders Coalition Website, "Subway Accessibility;" (http://www.disabledriders.org/NYC%20Subways.htm); Accessed 11/26/2007

61 Neuman, William, "Taking the Guesswork Out of Which Subway Escalators are Broken," The New York Times, 1 August, 2007

62 Interview with Michael Harris & Assemblyman Micah Kellner, Disabled Riders Coalition, 29 August, 2007

system restricts subway access in many portions of the city. For example, for Brooklyn residents, there are no wheelchair accessible stations on the L train between 14th Street/Union Square and the end of the line at Canarsie/Rockaway Parkway. There are eight wheelchair accessible stations in the Bronx. In Manhattan, there are five wheelchair accessible stations north of 72nd Street.

Under the terms of the settlement steming from the 1979 Eastern Paralyzed Veterans Association (now the United Spinal Association) lawsuit, the MTA is obligated to increase the number of accessible stations to 100 by 2020. However, the age and density of the subway infrastructure makes retrofitting stations to include elevators complicated, time consuming and expensive.

To address immediate concerns about escalator and elevator outages, the MTA announced in August, 2007, that it would post information about elevator outages on its website. Information will updated three times a day. However, roughly 2/3 of the elevators in the system require outages and problems to be reported manually to a station agent, (the other 1/3 are equiped with real-time automatic monitoring) which can limit the timeliness of the information.[63] The PATH Train's PATHVISION information monitors provide elevator outage information within the PATH system which could serve as a model for NYCT.

Efforts by the MTA to place automatic monitoring systems in all the elevators and escalators is hampered by the presence of easement elevators and escalators such as the escalators at Union Square or the elevator on the 7 platform at Times Square. These elevators and escalators are maintained by the entity providing the easement; they are not under the MTA's jurisdiction. Problems with easement elevators and escalators are not reported to the MTA.

New York's traditional rotary turnstiles can also pose access problems for people with limited mobility. Designed to deter turnstile-jumping, these turnstiles are too narrow to allow people in wheelchairs to pass through and can pose problems for people on crutches, people with strollers or bicycles, or people carrying large packages. The MTA provides the "auto-gate" automatic entry and exit system at all accessible locations which allows approved riders to access the subway system with their Reduced-Fare AutoGate MetroCard. However, the waiting period to receive the card can be up to four months, making subway access difficult for any tourists or visitors who use wheelchairs.[64]

63 Neuman, William, "Taking the Guesswork Out of Which Subway Escalators are Broken," The New York Times, 1 August, 2007

64 Interview with Michael Harris & Assemblyman Micah Kellner, Disabled Riders Coalition, 29 August, 2007

Case Study 19: Wheelchair Accessible Escalators & Lifts (Osaka & Yokohama, Japan)

Wheelchairs are secured by a guardrail in the back and an attendant who holds the wheelchair in place. Image used with permission of Kansai International Airport (KIAC).

Wheelchair-Accessible Escalators and Emergency Wheelchair Lifts are two options for increasing access to public transit systems while working within limited space confines. While both have technical and operational issues that may limit their immediate applicability in New York, they are included here as technologies to watch in the future.

Wheelchair-accessible escalators are found in Japan. They are manufactured by Hitatchi and are in use at Kansai International Airport near Osaka and throughout the city of Yokohama in their subway and rail stations. Portable Wheelchair Lifts, produced and marketed by a number of commercial vendors, are in widespread use in a variety of public and private settings throughout the United States.

Wheelchair-Accessible Escalators

Installed in 1994, there are 10 wheelchair-accessible escalators currently in use in the Kansai International Airport.[65] Most of the time, the wheelchair-accessible escalators operate as conventional escalators; when needed, however, three escalator stairs fuse to form a single platform large enough for a wheelchair, baby carriage or grocery cart. To initiate the platform function, a station attendant stops the escalator and puts it into "wheelchair" mode. The fusing process takes a little less than one minute.[66]

The Kansai Airport policies mandate that wheelchairs be secured on the escalator platform in three ways; wheel locks on the wheelchair itself, a rear guard strip on the back of the escalator platform and the presence of an airline employee who holds the wheelchair throughout the trip. Because the platform only takes up three escalators stairs, other passengers can ride the escalator while it is in "wheelchair" mode. However Kansai Airport regulations forbid this practice.[67]

At Kansai, wheelchair accessible escalators do not serve as a replacement for elevators; rather they are used where elevators are infeasible. Indeed, Kansai Airport staff report that the wheelchair accessible escalators are a second choice to elevators for most passengers. Elevators, which do not require assistance and are familiar technology, are clearly preferable.

Wheelchair-accessible escalators cost more than conventional escalators; Kansai's escalators cost about 40,000,000JPY (approximately $350,000), as opposed to 10,000,000JPY (approximately $90,000) for a conventional escalators and may be more difficult to maintain.[68] In addition to Hitatchi, other manufacturers are developing wheelchair accessible escalators. Costs, operations and maintenance may vary.

65 Email Correspondence with Ken Yoshioka, Kansai International Airport (KIAC), (12/7/2007)
66 ibid.
67 ibid.
68 ibid., (12/7/2007 and 12/11/2007)

Garaventa's Super-Trac portable wheelchair lift allows wheelchair users to go up and down stairs easily. No permanent infrastructure is required and the operator does not do any lifting. Image used with permission of Garaventa.

Emergency Wheelchair Lifts

Portable wheelchair lifts offer emergency access options for subway stations. Super-Trac, manufactured by Garaventa Lift, is one example. Super-Trac is self-propelled stair climber with a platform large enough to accommodate most manual and electric wheelchairs. Its dual electric motors allow it to carry up to 440 pounds and it can climb up to 30 flights of stairs before needing to be recharged.[69] Smaller auxiliary wheels allow the Super-Trac to roll easily on stair landings which makes the system feasible in locations with multiple landings and flights of stairs.

Wheelchairs are secured on the Super-Trac by means of four adjustable straps and a seatbelt. Like all other portable lifts, Super-Trac requires a standing aide to operate the manual controls. However, unlike many other portable lifts on the market, the Super-Trac system does not require the standing aide to do any lifting.[70] Super-Trac can bring wheelchairs up stairs at a rate of about 21 feet per minute and down stairs at a rate of around 35 feet per minute. Motion both up and down is regulated by an electromagnetic fail-safe brake.[71]

Garaventa also produces an emergency-specific evacuation lift, called Evacu-Trac, that combines the user's body weight with a speed controlling mechanism and fail-safe brakes to quickly move people with limited mobility down stairs in case of an emergency. The Evacu-Trac system uses fire-retardant slings and securing straps to hold users in place and can carry up to 300 pounds.[72]

69 Garaventa Lift Website, "Super-Trac," (http://www.garaventa.ca/portable-wheelchair-lift/); Accessed 12/7/2007
70 ibid.
71 Garaventa Lift Website, "Specifications," (http://www.garaventa.ca/portable-wheelchair-lift/spc.html); Accessed 12/7/2007
72 Garaventa Lift Website, "Evacu-Trac Features," (http://www.garaventa.ca/et/feat.html); Accessed 12/7/2007

Case Study 20: Universal Access Turnstiles
(San Francisco, CA; Boston, MA; Washington DC; PATH, JFK AirTrain)

The Washington D.C. Metro features an universal access turnstile in every station which provides people in wheelchairs or with strollers or bulky packages easier access to the Metro. NYC Dept. City Planning

Universal Access Turnstiles are turnstiles with an electronic retractable gate instead of the typical spinning bar. Their configuration allows all riders, including people in wheelchairs or on crutches, people with strollers or bicycles, or people carrying large packages, to easily enter or exit stations.

Low Universal Access Turnstiles are the primary turnstiles for the JFK AirTrain, Bay Area Rapid Transit (BART) in San Francisco Bay, the Washington DC Metro, and the Massachusetts Bay Transit Authority (MBTA) "T". These turnstiles are typically placed in view of stations agents to avoid fare beating. Tall Universal Access Turnstiles, like those used in the NY/NJ PATH Train system, address access issues while still deterring fare jumping.

Cubic Transportation Systems designed the turnstiles for PATH, which include sensors that detect wheelchairs and baby strollers and allow them to pass through. PATH has not heard of any major

Universal access turnstiles in use for the JFK AirTrain. NYC Dept. City Planning

malfunctions regarding the use of these turnstiles.[73]

The cost is approximately $70,000 per gate.[74]

Examples and Opportunities in New York City:

Embracing wheelchair-friendly technologies in the New York City subway system can dramatically increase transit options for New Yorkers with limited mobility or people with baby strollers or large packages and, in accordance with PlaNYC 2030 improve access to subways and commuter rail.

Elevators are preferable to escalators because they are faster, easier and do not require users to ask for additional assistance. However, there are some stations and locations within the NYCT system where elevators are not feasible. In these places, wheelchair accessible escalators may be appropriate. The escalator technology would need to be thoroughly evaluated to see if it could be adapted to MTA/NYCT standards. Negotiations

73 Phone Interview with Henry Rosen, PATH 9/26/2007
74 Email Correspondence with Jeffrey Garcia, Project Manager, BART, 9/7/2007

and training with MTA/NYCT employees would also be required. In addition, such escalators could only be installed in proximity to 24-hour staffed booths. NYCT should continue to monitor wheelchair accessible escalator technology as it improves and could consider a New York City pilot in order to spur further research and development.

Emergency wheelchair stair climbers, while not sufficient for everyday use, could be stored in every station to aid in emergencies or to serve as a back-up when elevators are out of service.

While low universal access turnstiles are infeasible in New York due to concerns about fare-beating, tall universal access turnstiles could be added to the NYCT system. In particular, tall universal access turnstiles, opened with a typical MetroCard, could limit the use of the emergency gate in non-emergency situations.

TAXI VOUCHERS AND ACCESSIBLE TAXIS

Increasing the number of wheelchair-accessible taxis and offering taxi-vouchers for people in wheelchairs who cannot take the subway are two ways to increase transportation options for New Yorkers and visitors with limited mobility while utilizing an existing city resource, the licensed taxi fleet.

Background:

Public transportation around New York for people in wheelchairs is limited. The city's subway system, as discussed in previous chapters, has a limited number of wheelchair accessible stations. The city's bus fleet, which is entirely wheelchair accessible, picks up some of the unmet demand and has a wheelchair ridership of 64,000 per month.[75] However, the buses make frequent stops and as a result are slower than subways or regular traffic. New York's third option, the Access-A-Ride (AAR) a door-to-door para-transit service, is meant to fill the gaps for riders with disabilities who are unable to ride the subway or bus. AAR service, which provides transportation 24 hours a day, seven days a week, is mandated in order to comply with the 1990 Americans With Disabilities Act. AAR service costs the MTA $55.72 per scheduled trip and serves, on average, 10,500 riders per day.[76]

However, AAR service has substantial limitations. Trips on AAR must be scheduled at least 24 hours in advance and service is not guaranteed. Nor are there guarantees or estimates about the length of a trip, making it difficult for users to rely on the service for important appointments. Passengers may not bring more than two small bags (for a total maximum of 40lbs) or bulky objects like "rolls of paper towels" into an AAR vehicle, making a trip to the grocery store, for example, difficult on AAR.[77]

75 Luo, Michael. "A Little Movement Toward More Taxis for Wheelchairs." The New York Times, 25 August 2004

76 Niblack, C. Preston; "Using Taxi Vouchers to Lower the Cost of Paratransit Services;" NYC Independent Budget Office, June 2007 (www.ibo.nyc.ny.us/iboreports/webTaxiVouchersJune07.pdf); Accessed 11/16/07 & Luo, Michael. "A Little Movement Toward More Taxis for Wheelchairs." The New York Times, 25 August 2004

77 Levy, Michael; "When to Shop and When to Stop;" On The Move, Access-A-Ride, Summer/Fall 2006, Volume 4, p.7

Taxis represent a fourth and growing option for New Yorkers and visitors in wheelchairs. In 2004, only 3 of New York's 12,487 taxis were wheelchair accessible.[78] Today, 81 taxis are accessible.[79] At the most recent individual taxi medallion auction, most of the 150 medallions up for sale were for wheelchair accessible cabs.[80] Since riders cannot guarantee that the taxi they hail will be wheelchair accessible, the city has begun experimenting with 311 technology to allow New Yorkers to better utilize this growing wheelchair accessible taxi fleet. On November 13th, 2007 the Taxi and Limousine Commission (TLC) announced a new pilot program to connect wheelchair user with wheelchair accessible taxis using the city's existing 311 system.[81]

Case Study 21: Taxi Access Program (Chicago, IL)

Chicago's Taxi Access Program (TAP) allows the city to increase options for disabled residents by encouraging them to use the city's existing taxi fleet for spontaneous trips, for example to the store or doctor's appointment or for social purposes. Routine trips, such as trips to work or school which have fixed origin and destination points are handled through Chicago's Mobility Direct subscription service. Chicago also has a conventional para-transit service similar to AAR.

Under TAP, residents apply for a Paratransit ID and then can purchase vouchers to use taxi cabs up to four times per day. As of September 1st, 2007, vouchers cost $5.50 and provide the user with up to $13.50 in taxi fare (an $8 subsidy).[82] To use the service, individuals call their local taxi service, inform them that they plan to use a TAP voucher, and schedule a ride anytime of the day. Since not all of Chicago's taxis are wheelchair accessible, riders must call a dispatcher at least 20 minutes in advance who will then locate an appropriate taxi. All taxi companies and drivers are required to accept the vouchers. RTA reimburses the taxi company for fare amounts up to $13.50.[83] If the fare is above $13.50, the customer is responsible for the difference. The average Chicago taxi ride is about 5 miles and costs $12.70.[84] This three-option para-transit system allows the RTA to allocate services in a way that accounts for cost differences between short and long trips.

Advances in Wheelchair Accessible Taxis:

Advances in taxi technology also present opportunities for New York. For riders with limited mobility, wheelchair accessible taxis are more reliable and convenient than a crowded bus or limited subway access. In particular, many people who use wheelchairs like the idea of wheelchair-accessible taxis in addition to contracted services like AAR because it allows them an increased degree of freedom and "spontaneity."[85]

Standard Taxi, the presenting sponsor of the Taxi '07 exhibit at the 2007 New York International Auto Show, is an example of a wheelchair-accessible taxicab. In addition to a built-in wheelchair ramp, Standard Taxis boast increased interior seating (four passengers plus a wheelchair), large easily loaded trunks and standardized, interchangeable body panels, windows and bumpers for reduced repair costs. Standard Taxi is currently being designed with a GM V6 engine that gets 12-15 mpg (below

78 Luo, Michael. "A Little Movement Toward More Taxis for Wheelchairs." The New York Times, 25 August 2004

79 New York City Taxi and Limousine Commission. Demonstration Project: Accessible Vehicle Dispatch Proposal. 10 May 2007. (http://www.nyc.gov/html/tlc/html/news/info_presentations.shtml); Accessed 11/26/2007

80 Miller, Winter, "Cabdrivers Sweat It Out Bidding on Medallions;" The New York Times, 2 November 2007

81 NYC Taxi and Limousine Commission, "Press Release: Taxi and Limousine Commission Approves Accessible Dispatch System Pilot Program;" NYC Taxi and Limousine Commission Website (http://www.nyc.gov/html/tlc/html/home/home.shtml); Accessed 11/16/07

82 Transit Future Website, "Transit Future Update: 13 August 2007;" (http://transitfuture.cnt.org/2007/08/13/transit-future-update-august-13-2007/); Accessed 11/20/2007

83 Chicago Transit Authority (CTA), "PRESS RELEASE: CTA Increases Mobility Direct Subsidy;" 13 May, 2005 (http://www.transitchicago.com/news/archpress.wu?action=displayarticledetail&articleid=105235); Accessed 11/20/2007.

84 Woodward, Whitney, "Cab-Fare Hike Plea Goes Nowhere;" Chicago Tribune, 24 October 2007.

85 Luo, Michael. "A Little Movement Toward More Taxis for Wheelchairs." The New York Times, 25 August 2004

New York City's recently proposed standards) but has an engine

The Standard Taxi features a lowered chaisis and a built-in wheelchair ramp. It holds four passengers in addition to a wheelchair. Image used with permission of The Vehicle Production Group LLC (www.standardtaxi.com).

cavity that can fit a variety of different conventional and hybrid motors allowing operators to upgrade as desired.[86]

Standard Taxi, manufactured by the Vehicle Production Group in partnership with AM General LLC, is scheduled to go into full production in 2009.[87] Numerous North American cities, such as Alexandria, VA and Ottawa, Canada have expressed interest in purchasing Standard Taxis for their fleets.

Examples and Opportunities in New York City:

The introduction of a taxi vouchers to supplement the existing Access-a-Ride (AAR) program could reduce the cost of the city's legally mandated disability access programs and help meet the PlaNYC 2030 goal of improving access to existing transit.

In order for taxi vouchers to be successful, the city must increase the number of wheelchair-accessible taxis. The Taxi and Limousine Commission (TLC) has already taken strides in acquiring and auctioning more wheelchair-accessible taxis in recent months. New taxi technologies could be considered by the TLC in order to help meet this goal. In addition, in keeping with other 2030 PlaNYC goals, hybrid engine or high-performance technologies should be considered in any new taxi authorization.

A 2007 report on taxi vouchers recently released by the NYC Independent Budget Office suggests that a similar system could provide substantial savings to New York City. For example, AAR trips cost the MTA $55.72 per scheduled trip. However, in Manhattan AAR trips are typically less than a mile—usually a less than $10 taxi fare—whereas AAR trips in Queens and Staten Island are usually over seven miles—substantially more. In general, 90% of New York City's AAR rides are between .25 and 5.3 miles; but with AAR these trips cost the same.[88] Selling vouchers to subsidize taxi rides up to $10 (roughly the average cost of a taxi ride in 2007 according to the City's Independent Budget Office) and using AAR only for longer trips could result in substantial cost savings. In its 2007 report on taxi vouchers, the Independent Budget Office found that NYCT would save approximately $13 million dollars per year if a $10 taxi voucher system were put in place.[89]

86 Phone Interview with Marc Klein, CEO Standard Taxi (11/15/2007)
87 Standard Taxi, "Standard Taxi E-Mail Newsletter: Made in the U.S.A.! VPG partnerswith AM General to build the Standard Taxi;" 12/20/07

88 Niblack, C. Preston; "Using Taxi Vouchers to Lower the Cost of Paratransit Services;" NYC Independent Budget Office, June 2007 (www.ibo.nyc.ny.us/iboreports/webTaxiVouchersJune07.pdf); Accessed 11/16/07
89 ibid.

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APPENDIX B: BIKE-SHARE PROGRAMS WORLDWIDE

3rd Generation Bike-Share Programs

City	Country	Program Name	Operator	Website
Aix-en-Provence	France	V'Hello	JCDecaux	http://www.vhello.fr/
Barcelona	Spain	Bicing	Clear Channel Adshel	http://www.bicing.com/
Beijing	China	Beijing Bicycle Rental Co.	Owner Operated	http://www.bjbr.cn/wd/wd.htm
Berlin and Others	Germany	Call-A-Bike	Deutsche Bahn	http://www.callabike-interaktiv.de
Brussels	Belgium	Cyclocity	JCDecaux	http://www.cyclocity.be/
Burgos	Spain	BiciBur	ITCL	http://www.bicibur.es
Drammen and Others	Norway	Bysykkel	Clear Channel Adshel	http://www.adshel.no/index2.html
Dublin and Others	Ireland	Hourbike	Hourbike	http://www.hourbike.com/hourbike/home.do
Gigón	Spain	Cyclocity	JCDecaux	http://www.gijon.es/Contenido.aspx?id=19315&leng=en&zona=0
Central London	England	TBA	TBA	TBA
Greater London	England	OYbike	OYBike Systems	http://www.oybike.com/
Lyon	France	Vélo'v	JCDecaux	http://www.velov.grandlyon.com/
Marseille	France	Le Vélo	JCDecaux	http://www.levelo-mpm.fr/
Montreal	Canada	Bixi	Montreal Parking Authority	http://bixi.ca/index.php?page_id=1&lang=en
Pamplona	Spain	nbici	CEMUSA	http://www.c-cycles.com/
Paris	France	Vélib'	JCDecaux	http://www.velib.paris.fr/
Parma and Others	Italy	Bicincittà	Communicare	http://bicincitta.com
Rennes	France	Vélo à la Carte	Clear Channel Adshel	http://veloalacarte.free.fr/index2.html

3rd Generation Bike-Share Programs Worldwide (Cont.)

City	Country	Program Name	Operator	Website
Rome	Italy	Roma'n'Bike	CEMUSA/Bicincittà	http://www.roma-n-bike.it/
Salzburg	Austria	Citybike	Gewista Urban Media	http://www.citybikesalzburg.at/
Sevilla	Spain	sevici	JCDecaux	http://www.sevici.es/
Stockholm	Sweden	City Bikes	Clear Channel Adshel	http://www.stockholmcitybikes.se/en/Home/
Toulouse	France	Vélô	JCDecaux	http://www.velo.toulouse.fr/
Various	The Netherlands	OV-Fiets	Unknown	http://www.ov-fiets.nl/
Viennna	Austria	Citybike	Gewista Urban Media	http://www.citybikewien.at/
Washington D.C.	USA	Smark Bike DC	Clear Channel Adshel	https://www.smartbikedc.com/default.asp

APPENDIX C: SIGNAL PRIORITIZATION AND PRE-PAID BOARDING

Bus-Rapid-Transit (BRT) is one of the most common applications for designated right-of-ways (ROWs). In addition to the designated ROW, buses in BRT systems move quickly and reliably because they employ signal prioritization and pre-paid boarding options. A brief description of signal prioritization and pre-paid boarding options, as they are used in London and Rouen, follows. NYC DOT and the MTA/NYCT use versions of these systems in New York City's Select Bus Service program.

Signal Prioritization:
In 2006, London introduced Selective Vehicle Detection technology to its Intensified Bus Priority program (SVD) to give buses priority at intersections and increase speeds and service reliability. Implemented at 1,450 sites throughout the bus network, the SVD technology utilizes GPS, odometer output, and door monitors to communicate bus location and speed to virtual detection points. That information is then sent to a traffic signal transceiver which will either shorten a red signal or lengthen a green signal for the bus. On routes with widespread rollout of the SVD technology, the average delay savings were 32%.[1] In addition, TFL found that bus prioritization decreased travel times for both buses and cars outside of the lanes, and increased ridership by 22% (compared to the system wide increase of 19%).[2] The associated cost savings means that, on average, SVD technology pays for itself within 18 months.[3] TfL estimates that, if introduced all over London, SVD technology increase bus speeds overall by 5-8%.[4] However, in order to bring about these time and cost savings, bus priority would need to be implemented on more than 50% of route mileage.[5]

1 Transport for London (TfL), "Bus priority at traffic signals keeps London's buses moving Selective Vehicle Detection (SVD);" January 2006.
2 Department for Transport, "Bus Priority: The Way Ahead," Department of Transport, 2004, (http://www.dft.gov.uk/pgr/regional/buses/bpf/busprioritythewayahead12/); Accessed 8/29/07
3 Transport for London (TfL), "Bus priority at traffic signals keeps London's buses moving Selective Vehicle Detection (SVD);" January 2006.
4 Transport for London (TfL), "The case for investing in London's buses: Presenting the results of the London Buses Strategic Review;" September 2003
5 ibid.

In Rouen, signal prioritization is coupled with an optically guided driving system.[6] An onboard computer linked to a dashboard camera that compares the bus' trajectory to stripes painted on the roadway. The bus is driven by the computer but has a human driver to take over if a problem occurs. GPS monitors on the bus communicate with signal prioritization transmitters, further prioritizing bus service. Computerized guidance allows for a narrower ROWs, typically about 5 feet narrower, than buses that rely on human drivers.[7] The precision of the optical guidance system allows buses to pull up to stations within 2 inches of the curb eliminating the need for wheelchair ramps. In addition, the information from the GPS monitor can provide "time-to-next-bus" information to passengers waiting at bus stops.

Pre-Paid Boarding Options:
London and Rouen, as well as Bogota, also provide options for pre-paid boarding allowing buses in designated ROWs to reduce the amount of time they spend waiting for passengers to board and thus to increase the overall speed and reliability of the system. Studies show that, in London, currently those passengers paying by cash take more than twice as long to board as those who have already pre-paid. This would be true in New York as well where NYCT buses spend up to 30% of their time in passenger boarding and alighting.[8] London's pre-pay pilot project was launched in the West End in August 2003. All customers boarding a bus within this area are required to have pre-purchased a ticket before boarding, as the driver will not accept cash.[9]

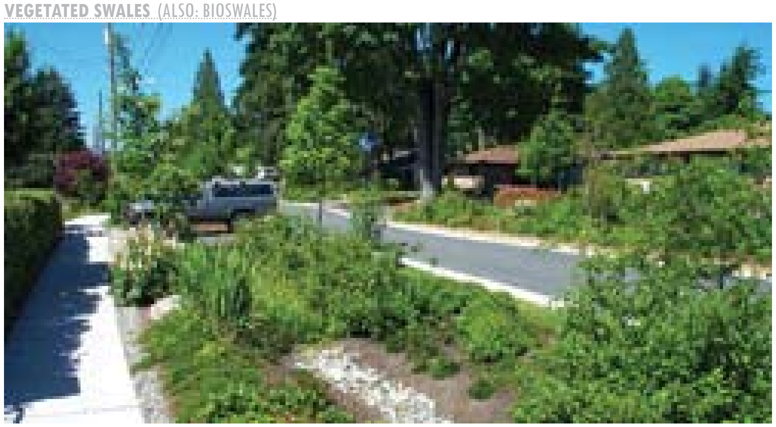
6 Transports en Commun d'Agglo. Rouen Website, (http://www.tcar.fr/presentation/index.asp?rub_code=52&thm_id=317&gpl_id=); Accessed 12/21/07
7 Transportation Research Board, "Bus Rapid Transit Volume 1: Case Studies in Bus Rapid Transit" TCRP Report 90 Volume 1 BRT Case Studies, (gulliver.trb.org/publications/tcrp/tcrp_rpt_90v1.pdf) Accessed 8/22/07
8 Schaller Consulting, "Bus Rapid Transit For New York City: Prepared for Transportation Alternatives and NYPIRG Straphangers Campaign;' 2002 (http://www.straphangers.org/pokeyaward/letter.html); Accessed 11/09/07
9 Transport for London (TfL), "The case for investing in London's buses: Presenting the results of the London Buses Strategic Review;" September 2003

APPENDIX D: GLOSSARY OF MODERN DRAINAGE PRACTICES

INFILTRATION TRENCHES

In an infiltration trench, stormwater runs through a swale or into a basin that has a porous bottom usually of sand, gravel or larger rock. This substrate allows the water to infiltrate into the ground. As the stormwater percolates through the ground, particles are trapped within the soil. The remaining treated water migrates to the groundwater. This is akin to the secondary treatment stage at municipal water treatment facilities.

VEGETATED SWALES (ALSO: BIOSWALES)



Bioswales in Seattle reduce street flooding. Image used with permission of Seattle Public Utilities.

The primary objective of a vegetated swale is the short term retention of large volumes of stormwater. In suburban or rural areas, a vegetated swale is often an existing ditch or depression that has been modified into a chain of small ponds and planted with native species. In vegetated swale designs, rain run-off is allowed to accumulate in large volumes. In the days following a storm, water is slowly removed through the combination of infiltration into the ground, plant uptake, and evaporation. Swales can retain large volumes of stormwater and provide excellent pollution removal.

Portland's planted curb extensions enhance the aesthetics of the streetscape while reducing water run-off and flooding and calming traffic. Image used with permission of City of Portland Bureau of Environmental Services.

PLANTER BEDS (ALSO: RAIN GARDENS, FRENCH DRAINS)

Planter beds are similar to bioswales, but are typically better suited to high-density urban space because they are shallower. Planter beds are not meant to retain large volumes of water for extended periods of time. Like bioswales, planter beds are planted with indigenous plants which are especially absorbent and can thrive in wet environments.

To find space in dense urban areas, cities, like Portland, often place planter beds directly into the sidewalk. Since such planters make use of existing sewers and drains, they do not require modifications to sewer systems. In neighborhoods that can sacrifice parking spots and where traffic volumes can accommodate a narrowing of the street, planted curb extensions can also be used to reduce water run off after storms.

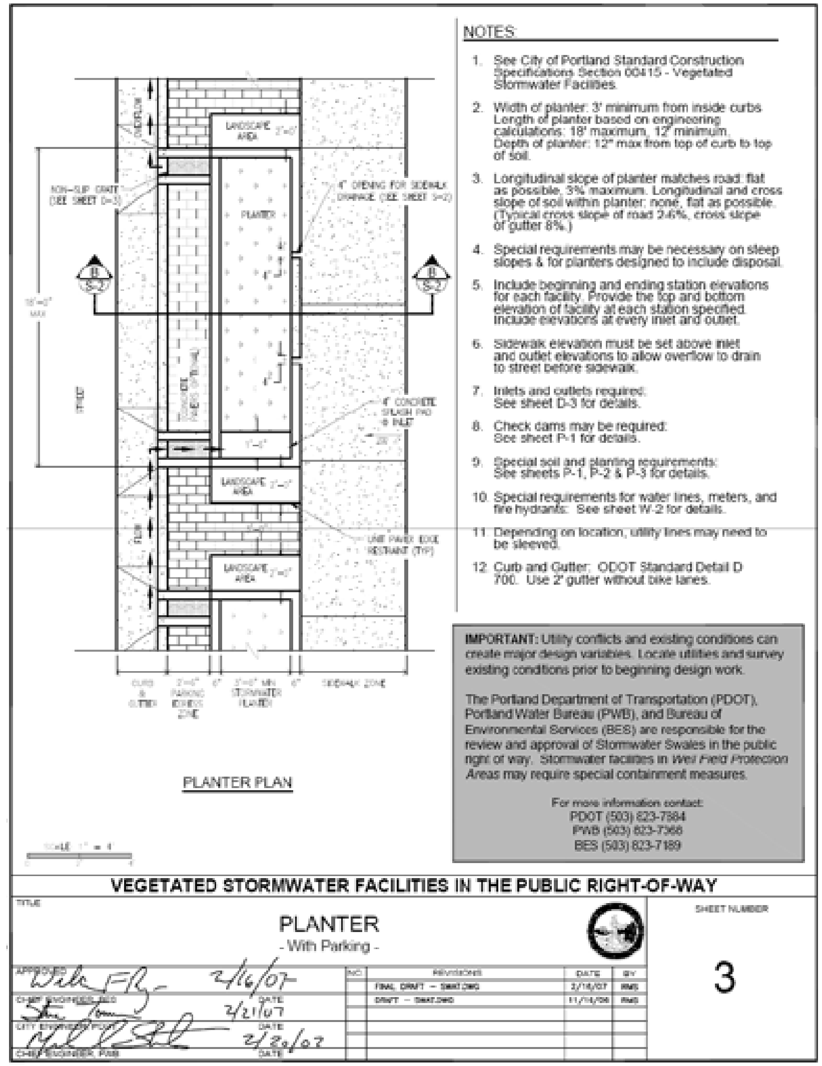
In both planter beds and bioswales, it is advantageous to utilize indigenous plants as indigenous species tend to have root systems that are deeper than typical grasses, and as a result provide greater absorptive capacity.

CURB ALTERATION / ELIMINATION

Simple design features like cut-outs allow water to flow off the pavement and into porous areas thus reducing flooding. Image used with permission of City of Portland Bureau of Environmental Services.

In Seattle and Portland, planners have removed or altered existing curbs to reduce water run-off after storms. Typically, curbs tend to channelize water resulting in high velocities and high content of sediment and pollution. Removing short sections of the existing curb allows water to be strategically distributed over large vegetated areas or directed into natural infiltration and retention systems.

APPENDIX E: PORTLAND GREEN STREET PLANTER PLAN WITH PARKING



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WORLD CITIES BEST PRACTICES

INNOVATIONS IN TRANSPORTATION