TRANSIT LEADERSHIP SUMMIT

2012 – 2014
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Version: June 24, 2015
Regional Plan Association

Regional Plan Association is America’s most distinguished independent urban research and advocacy organization. RPA improves the New York metropolitan region’s economic health, environmental sustainability and quality of life through research, planning and advocacy. Since the 1920s, RPA has produced three landmark plans for the region and is working on a fourth plan that will tackle challenges related to sustained economic growth and opportunity, climate change, infrastructure and the fiscal health of our state and local governments. For more information, please visit www.rpa.org.

Volvo Research and Educational Foundations

The Volvo Research and Educational Foundations is the collective name under which four foundations collaborate to finance research and education in a program called “Future Urban Transport: How to deal with complexity.” VREF finances FUT research for the purpose of contributing to new ideas and solutions within the complex structure underlying the design of sustainable transportation systems in cities. The challenge is to find urban transport systems that will provide accessibility for the masses, while at the same time radically reducing transportation’s negative local and global environmental impacts. Through the FUT program, VREF currently supports eight “Centres of Excellence” in Africa, South and North America, Asia, Australia and Europe, and accompanying events for networking, communication and debate on critical issues for urban transport.

C40 Cities Climate Leadership Group

The C40 Cities Climate Leadership Group is a network of large and engaged cities from around the world committed to implementing meaningful and sustainable climate-related actions locally that will help address climate change globally. C40 convenes networks of cities to accelerate the identification, development and implementation of projects, programs and policies in C40 cities through city-to-city collaboration. C40 Networks are currently being developed within seven initiative areas: transportation, energy, waste management, sustainable development, measurement and planning, water drainage and infrastructure, and sustainable finance infrastructure and green growth.
Rockefeller Brothers Fund

Founded in 1940, the Rockefeller Brothers Fund advances social change that contributes to a more just, sustainable and peaceful world. The RBF’s grantmaking is organized around three themes: democratic practice, peacebuilding, and sustainable development. Though the fund pursues its three program interests in a variety of geographic contexts, it has identified several specific locations on which to concentrate cross-programmatic attention. The fund refers to these as “RBF pivotal places”: subnational areas, nation-states, or cross-border regions that have special importance with regard to the fund’s substantive concerns, and whose future will have disproportionate significance for the future of a surrounding region, an ecosystem, or the world.

Singapore Land Transport Authority

Singapore Land Transport Authority aims to provide an efficient and cost-effective land transport system for different needs. LTA’s vision is to create a people-centered land transport system. It aims to make public transport the preferred choice by making it faster, reliable and more frequent. To keep traffic moving smoothly on Singapore’s roads, LTA is committed to managing road use by optimizing its road networks and enhancing safety. A people-centered land transport system must meet the diverse needs of Singapore’s growing population and expanding economy. LTA is determined to ensure physical accessibility for all, provide affordable transport and promote environmental sustainability in all of its transport solutions.

Greater London Authority & Transport for London

The Greater London Authority was established by the GLA Act of 1999. Its staff is appointed by the Head of Paid Service, the GLA’s most senior official, and serves both the mayor and the London Assembly.

Transport for London was created in 2000 and is the integrated body responsible for the Capital’s transport system. TfL’s main role is to implement the Mayor’s Transport Strategy for London and manage transport services across the Capital for which the Mayor has responsibility.

Disclaimer: This report was written by members of RPA’s staff based on materials prepared for the Summit series and the discussions that took place there. It reflects the views of the authors and not necessarily those of other conference participants or of the above listed collaborating organizations.
What is the Transit Leadership Summit?

The Transit Leadership Summit brings together senior transportation executives to discuss common challenges and share solutions in an intimate, closed-door setting. Summits have been held annually since 2012. With no more than 30 participants representing seven to 12 major cities at each summit, executives engage in a candid dialogue about promising strategies and technologies to improve the transportation experience, as well as seek the advice of their peers regarding obstacles they face.

Summits are organized around the presentation of white papers, commissioned specifically for TLS, and city case studies. The topics have included advances in fare collection and policy, improving the customer experience, capital investment priority-setting, preparing for climate variability, improving first- and last-leg connections, and strategies for value capture. Each topic is organized as a two-hour session that includes complementary presentations by three cities, followed by a facilitated discussion.

The summit generates critical international dialogue about transit planning at the very highest level of executive management. By providing space for discussions in a small group setting, the summit promotes an exchange of ideas that leads to meaningful innovation at the world’s leading transit-planning agencies.
THE SUMMITS

Having a smaller setting gives you a chance to have more in-depth discussions with people and to hear their experiences... this kind of exchange, to closely connect with people, that’s a key opportunity from TLS.

— London, Isabel Dedring
Three Years of TLS: 2012 to 2014

Regional Plan Association, with the generous support of Volvo Research and Educational Foundations and other partners, has convened three multiday summits in New York, Singapore and London that have brought together over two dozen transit executives from 17 different metropolitan areas. This report encapsulates three years of research and conversations that have sought to address the serious management, operational, governance and planning challenges that many transit systems face daily.

In the chapters that follow, each TLS event is summarized, including key details on the venues, activities and discussions. The major takeaways from the summits are also identified and organized by research area. All 17 participating cities are profiled, with background information, a description of innovative practices, and statistics for each public transportation system. The transit systems are compared on key performance measures. The six original research papers commissioned for the summits are collected here. They cover a variety of subjects suggested by summit participants. Finally, biographies of each of the executives who participated in one or more summits are included.

This compendium is the product of thousands of staff hours that RPA has devoted to this effort in the belief that the sharing of ideas and information is critical to the success of metropolitan areas.

The networking opportunities that TLS affords are unparalleled. At a small-format event, senior level executives are able to relax and develop casual relationships, which in turn drive substantive conversations and collaboration beyond the boundaries of the summit. In our post-TLS interviews, several executives testified to interactions with their peers after the summits that wouldn’t have taken place without the personal relationship forged at TLS. Overall, respondents ranked the networking that TLS exposed them to as one of the most valued aspects of their experience, followed closely by the quality of the research.

The research materials, including white papers and comparative statistics, have been useful references for many cities, not only internally but also externally. One city even used information generated by TLS to directly educate their customers. There was a strong desire for future topics to delve into core organizational issues such as labor, service delivery, recruitment, etc. Broader topic areas, including social fares, energy use and governance structures, were also raised.

1 See Post-TLS Interview Summary Report. RPA and VREF interviewed 16 participants representing 14 out of 20 cities.
### April 23-25, 2012

#### Event Partners
- C40 Cities Climate Leadership Group (C40)
- Rockefeller Brothers Fund

#### Participants

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<td>Xavier Roselló</td>
<td>Barcelona Autoritat del Transport Metropolità</td>
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<td>Morris Cheung</td>
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#### Experts

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<td>T.R. “Tom” Hickey</td>
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<td>Guy Nordenson</td>
<td>Guy Nordenson &amp; Associates; Princeton University School of Architecture</td>
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The first Transit Leadership Summit brought together senior executives from 12 of the world’s leading public transport companies for an unprecedented opportunity to discuss and share common transit challenges and best practices, peer to peer, in an intimate and closed-door setting. The 2012 event focused primarily on cities in the Americas, covering a wide geography from Montreal to Santiago. A total of 19 executives convened at the Pocantico Conference Center, a historic Rockefeller estate on the Hudson River located just 20 miles north of New York City, for three days of intensive presentations and discussions. To provide local context and to stimulate discussion, 15 transportation experts from a number of U.S.-based academic and consulting organizations working in transit planning and design also joined executives at the Summit. These participants took advantage of the quiet and secluded environment of Pocantico to delve into the intricacies of their fields of expertise, and exchanged experiences and lessons-learned on topics ranging from finance and governance to advocacy and equity.

Structured presentations and discussions at the Summit often acted as soundboards for deeper exploration and dialogue. Conversations often continued after the conclusion of a formal agenda item, as executives gathered for chats in Pocantico’s hay loft, initiated robust debates in the rustic living room, and conversed during casual strolls along the scenic grounds and gardens of the center. Participants were also offered opportunities to explore key transit developments in New York City – many joined in on a tour of the World Trade Center (under construction at the time) and rode with MTA officials on New York’s Select Bus Service, the city’s first rapid bus system. Organized social activities included dinner receptions and guided tours of the historic Rockefeller mansion, Kykuit, which overlooks the Hudson River and grand Palisades. Furthermore, Summit participants were invited to attend the Regional Plan Association’s 22nd annual Assembly, a large conference that brings over 1,000 urban planning experts, academics, and government officials from New York, New Jersey and Connecticut to Manhattan for one intensive day of plenaries and workshops. Casual exchanges or planned activities, these supplemental opportunities further expanded professional networks and peer learning that the Summit encouraged at Pocantico.

The 2012 Summit was organized around the presentation and discussion of six key transit challenges:

- The growth and diversification of transit revenue sources
- The improvement of customer experience in stations and in vehicles
- The enhancement of interactive platforms for making digital navigation of complex transit systems and schedules easier and more accessible
- The balancing of development and environmental preservation for a smart and sustainable multi-modal network
- The establishment of an equitable fare collection process
The creation of a viable business plan to generate sufficient revenues capable of financially supporting transit without pricing-out transit customers.

Through consultation with Summit staff, cities selected the challenge that was most relevant to their circumstances and developed a case study to present at the Summit highlighting their achievements and failures with the particular topic. In addition to city presentations, a selection of transit professionals provided short talks on supplemental topics ranging from transit-oriented development to climate adaptation.

A number of key takeaways were generated after three productive days of conversation and collaborative analysis of the case study topics.

**Diversification and identification of revenue sources:**

- Farebox recovery ratios vary greatly depending on transit ridership, population density, and operating plans. Summit 2012 cities had a wide range of farebox recovery ratios, with Los Angeles at a low of only 27 percent and Hong Kong at almost 200 percent.

- Involving the private sector in the development of new transit systems can help infuse a project with upfront cash, complement the skills of the public agency, and insulate the public sector from politically difficult situations like fare increases and labor negotiations. The public sector, however, should set the goals of the project and closely monitor its private partners.

- Several transit agencies have engaged in successful partnerships with private developers to build dense, mixed-use nodes around train stations and have captured, via those developments, new revenue. If a transit agency owns the underlying property, it can lease out the land for redevelopment. Even if the agency does not own the property, it can work with the local government to structure a property tax system that generates revenue for the transit system (tax-increment financing, for example). These dense residential or commercial developments have the added benefit of generating new customers.

- Revenues from congestion pricing can, but do not always, support transit. In some cities such as Stockholm and Singapore, this tool is used primarily as a congestion-management measure and the revenues do not go to transit. On the other hand, cities like London use revenue from congestion pricing to subsidize the transit system, which of course helps to provide a viable alternative to driving. New York has considered a congestion pricing scheme that involves a similar cross-subsidy to London.
Adoption of a better fare collection system:

→ Raising fares is always sensitive politically; a structured formula set by an independent governmental body can help to ensure that fares keep up with inflation and increases in labor costs.

→ Fares should be set high enough for the agency to provide quality service and amenities, but also be designed to accommodate those customers for whom transit costs are a significant portion of their income.

→ New fare collection technologies can help facilitate this segmentation of the market.

→ Transit agencies seeking to adopt a merchant-based fare system should work together with other agencies for a unified fare payment standard to reduce costs with banks.

Growing ridership by improving service and the customer experience:

→ Frequent and reliable service ensures that transit stays competitive with other modes of travel.

→ A convenient, attractive and comfortable transit experience is essential to helping transit agencies grow and diversify their customer base, thereby increasing mode-share and farebox revenue.

→ Amenities like comfortable seats, Wi-Fi and other supplements allow riders to work and socialize while traveling – a comfortable and productive commute might even be more important than a fast commute in terms of attracting customers.

Leveraging the latest in technology to better interact with customers:

→ Better communication with customers is particularly important with younger customers who are committed transit users and sophisticated social media users. Real-time information is an expectation of this generation.

→ Branding and good design in physical settings and for social media and advertising is important for building a positive customer perception of transit.

→ Balance between the need for infrastructure expansion and the need for environmental preservation:

→ Many of the most significant challenges that cities face today – stagnating economies, congestion, long commutes, carbon emissions, etc. – are best addressed by building resilient public transportation systems.

→ Building the environmental and economic case for public transportation is critical to ensuring that the government continues to fund transit at appropriate levels. New metrics for measuring the benefits of transit on greenhouse gas emissions, or on the economic climate, would be effective.

It was fascinating to see how similar many of our transit challenges ultimately are.

— New York, Joe Lhota

It was a very powerful group of executives with a strong diversity of perspectives.

— Washington, D.C., Rich Sarles

The discussions at the summit were all very stimulating and thought-provoking.

— London, Elaine Seagriff

The Transit Leadership Summit is very valuable to all participants. As an annual gathering, it allows us to meet our peers and build a professional network.

— Singapore, Lew Yii Der
March 19-21, 2013

Event Partners
Singapore Land Transport Authority (LTA)

Participants

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Year two of the Transit Leadership Summit series was hosted by Singapore, a city internationally known for its world-class transit system, progressive transportation policies, and high quality of life. This year’s event convened a group of 10 senior executives from seven leading international public transport companies for a more focused discussion on fare policy and collection technologies, capital prioritization and customer experience. The Summit concentrated primarily on cities in Asia, and included a number of executives from the Americas and Europe to provide comparative perspectives on shared transit issues. For the executives who attended the 2012 Transit Leadership Summit in New York, the 2013 event provided an opportunity to deepen some of their professional relationships. Similar to the previous year, a small resource team of 15 experts specializing in the fields of transport infrastructure, financing, technology and land-use planning provided additional expertise to the event.

For many Summit participants, the 2013 event was their first chance to see the results of Singapore’s innovative transportation and land-use planning. The Summit’s host, Land Transport Authority, organized city exploration activities that included the Sengkang Interchange, which connects the MRT, LRT and 11 bus lines; the road pricing control room; a Singapore River cruise through the heart of the city’s central business district; and a visit to LTA’s Land Transport Gallery featuring exhibits on the city’s transit history. Furthermore, the 2013 Summit featured a special presentation by the illustrious Liu Thai Ker, who spearheaded the physical transformation of the city-state into a world metropolis. Additional keynote speakers provided participants with opportunities to learn about additional urban planning topics such as Singapore’s water management system and sustainable planning initiatives. These supplemental presentations, in addition to the tours and site visits, encouraged participants to see a fuller picture of Singapore and experience the unique character of the vibrant city. A special presentation by New York City MTA about how they prepared for and recovered from Hurricane Sandy was of great interest to Singapore government employees.

The presentation and discussion sessions of the 2013 Summit were primarily organized around three case study topics. That year also included supporting white papers featuring original research, which were distributed to participants a week before the event. Cities consulted with Summit staff to select the most relevant topic for their case study presentations.

The 2013 Summit opened each case study topic with an introductory white paper presentation. This was followed by two to three city presentations demonstrating a participant city’s relevant experiences with the topic on hand. Each session concluded with a period of open group discussion facilitated by a professional moderator, where cities freely exchanged stories of their struggles, successes, and the lessons learned while tackling a particular challenge. The information shared throughout the three days of the Summit in March highlighted the importance of informed fare policies, strategic branding and design, context-sensitive prioritization of funds, and improving customer perception.

Vigorous discussion by Summit participants included the following topics:
Fare policy and fare collection technology:

- Transit fares could be set by formulas, as they are in Hong Kong and Singapore. Even though fare formulas are designed to take fare-setting out of politics, it remains a delicate process, and politics often still come into play.

- Transit data made available by modern fare collection technology can be an incredibly powerful way to inform business decisions – including how to set fares and how to distribute fare revenue among operators. At the same time, one of the central hurdles to using data to make policy is that policy teams in transit agencies rarely understand the utility of data, and those who analyze the data do not always understand the policy challenges faced by transit.

- The key to increasing fares is to elevate the discussion so that it includes larger urban goals like livability, the environment, public safety, customer convenience, and economic value – not simply fares alone. The more transit can be related to its human elements, the easier it will be to build support for raising fares.

- Issuing fare media does need to be a core component of running a transit agency. Several agencies have successfully experimented with private companies providing the fare cards, including Seoul. A few agencies like Singapore’s LTA even have two farecard providers – one private company owned by LTA and the other a consortium of banks.

- The design of the farecard is important because it is the most widely distributed and recognized symbol of the transit system. Furthermore, a thoughtful and more sophisticated design decreases the likelihood of farecard counterfeiting.

Capital-project prioritization:

- Transit agencies employ a variety of mechanisms to evaluate needs and rank priorities among capital-improvement projects. For example, Hong Kong, London, and Washington, D.C. have a detailed ranking system – Washington, D.C. even incorporates a “return on value.” Both Montreal and Singapore first prioritize their projects and then assess their agencies’ ability to pay for them. While agencies may work with ranking systems, in some instances a capital project is prioritized for other political reasons. In Hong Kong, for example, providing new rail access to the airport was part of the agreement to build a bigger airport in a new location in 1998.

- Involving communities is an effective way to build a constituency for improvement projects. Bringing in consultants from other industries can also help provide a new perspective on transit agencies’ standard operating procedures. For example, WMATA in Washington, D.C.
successfully adopted Enterprise Asset Management after bringing in consultants to adapt assessment management techniques from other industries for transit. EAM systems provide more accurate and real-time information on assets, enabling agencies to identify where best to spend their funds based on asset condition and the risk to service if the asset were to fail. In the long run, deploying EAM will likely reduce costs, increase safety and improve the customer experience.

- Sometimes it is beneficial to change institutional structures, but often it’s disruptive and it takes a lot of time and energy that could be instead devoted to improvements in service provision. One way to work around this resource constraint is to incrementally adopt a new system: for example, EAM could be adopted for a new line, or a new set of assets – it does not have to be adopted on the entire transit system all at once.

- It is challenging to balance the extremes of government-provided transit service (and its possible inefficiencies) with purely privately-provided service (and its propensity to cut corners).

**Customer experience:**

- First and foremost: customer perception is reality. It is particularly important to make the improvements that young riders expect, as this generation could be customers for decades.

- In some cases, customer experience can be improved more easily through smaller scale investments like adding Wi-Fi hot spots and adjusting the temperature in stations and vehicles. In other cases improvement can be more costly and complex.

- The customer experience should extend beyond the environment directly under the agency’s control, such as the experience of walking or biking to the station from the surrounding community.

- Agencies use different strategies to generate ideas about how to improve the customer experience. Some cities like Seoul, Washington, D.C., Singapore and Montreal conduct onsite evaluations either directly by staff or through “mystery shoppers” who observe and evaluate factors like the physical conditions of cars, stations and signage, timing of announcements, and overall system cleanliness. Other cities like Hong Kong structure their agency to include an Innovation Committee, a group of ambitious, inventive people from all different parts of MTR who participate in creative problem solving. Hong Kong also conducts public participation sessions called “Innovation Jams” during which ideas are actively solicited - in one two-hour session alone, the agency received as many as 4,000 ideas.
May 7-9, 2014

Partners:
Transport for London
Greater London Authority

Participants

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<tr>
<th>Montreal</th>
<th>Daniel Bergeron, Montréal Agence Métropolitaine de Transport</th>
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<td>Vienna</td>
<td>Karl Bergner, Metro, Wiener Linien GmbH &amp; CoKG, Vienna, Europe</td>
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<td>Juliette Michaelson, Regional Plan Association</td>
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<td>Richard Barone, Regional Plan Association</td>
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<td>Stephen Glaister, RAC Foundation; Imperial College London</td>
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<td>Elliot Sander, HAKS</td>
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<td>Sotiris Pagdalis, PricewaterhouseCooper LLP</td>
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<td>Jerome Pourbaix, UITP</td>
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<td>Deborah Salon, Institute of Transportation Studies, University of California at Davis</td>
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<td>Elliott Sciar, Center for Sustainable Urban Development, Urban Planning &amp; International Affairs, Columbia University</td>
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<td>William Solecki, Institute for Sustainable Cities, City University of New York, Hunter College</td>
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The third Transit Leadership Summit was held in London – a city renowned for having the world’s oldest metro system as well as one of the current most innovative transportation agencies, which is leading modernization and expansion projects across the city’s historic transit network. The 2014 Summit’s geographic focus was Europe, bringing together 15 senior transit executives from nine leading public transport companies from the continent and beyond. A number of transit experts from the U.S. and Europe joined executives at the event as well, and provided insights into the most promising new strategies and technologies that could improve transit management, planning resiliency, and rider experience. For three days in May, participants convened at London City Hall, right off the shore of the River Thames, to collectively broaden their understanding of the 2014 Summit topics: value capture, first- and last-leg connections, and climate variability.

The host city of London provided participants with an excellent study of how a cohesive local governing body with a strong plan for reform and reinvention can rapidly transform the movement and efficiency of a complex and dense urban environment. The Summit kicked off with an intriguing introduction by Sir Peter Hendy, London Commissioner for Transport, to London’s unique governance structure and impressive vision for transit development. Lunch panel speakers from the Greater London Authority and the Imperial College London supported Sir Hendy’s keynote with a detailed overview of the city’s transit authority transformation from its original structure as London Transport to its current organization as Transport for London. Complementing these talks and highlighting the city’s initiatives for regeneration and improving connectivity were guided tours of the city’s Farringdon Crossrail station and a London Underground control center, as well as a site visit to King’s Cross Station, led by Transport for London and McAsland + Partners respectively. Scheduled evening receptions and dinners allowed attendees informal tours and stunning views of two of London’s most unique and impressive transit-oriented developments – Canary Wharf and the London Borough of Newham’s Green Enterprise District. Both locations showed how good governance paired with a strategic plan for transit development can successfully boost economic viability of previously fallow land.

The 2014 Summit delved into the details of intermodal design and strategies for improving last-leg connections (combined mobility), highlighted the importance of resilient and sustainable transit infrastructure in the face of more extreme weather events, and evaluated the efficacy of value capture funding approaches to support transit. Structurally, the Summit was organized around three sessions, each anchored by a white paper and three tightly paired city presentations. Cities were encouraged to use case studies of past, present and proposed transit projects to highlight the struggles and successes in the assigned topic area; white paper authors focused upon their three specific cities for intensive topical interviews and data inquiries. In London, sessions began with an introduction of baseline research by white paper authors before the attending cities presented their in-depth case studies on
A period of open discussion followed the presentations, which allowed all participants to share inquiries, opinions and experiences about the topic at hand.

A number of innovative projects by participating cities were also featured as lunch panels and supplemental presentations. An interactive charrette prompted cities to design a plan for an existing transit site in Santiago, Chile: Huddled around satellite maps and tracing paper, participants shared their experiences with system expansion and value capture techniques that related directly to the ongoing project at the outskirts of Santiago. Special presentations were also given by Singapore, providing an update on their Master Plan, which focused on boosting intermodal connection and weather-resilient infrastructure, and by McAsland + Partners, a London urban design firm, who presented on the re-envisioning and reconstruction of London’s famous King’s Cross Station.

Three packed days of discussions, presentations, site visits and guest speakers generated a rich pool of information and take-away lessons for participants to digest and apply in their own cities.

First- and last-leg connections, combined mobility:

- Well-designed intermodal connections should allow riders to effortlessly move between a variety of transit modes and complete their trip efficiently and comfortably. “Combined Mobility” adds more transit alternatives to the mix, and provides increased flexibility as well as extending the geographic reach and accessibility of transit.

- Intermodal hubs can also create value-capture opportunities, generating funds to help sustain and improve transit stations and vehicles.

- Challenges may arise when extending intermodal travel, such as sprawling low-density areas that are difficult to serve in a cost-effective manner; polycentric regions that create complex origin and destination patterns; and an increasing demand for 24/7 travel which could strain resources.

- To integrate cars, bikes, buses, trains, pedestrians and other modes, transit agencies must consider factors like new technologies, land use, institutional collaboration, and design. For example, Singapore promotes transit-oriented development by not only increasing bus feeder service and routes, but by also improving cycling lanes, extending the system of covered walking paths, and creating easier fare payment and transfers between modes.

- Institutional collaboration and integration of fares and services is essential to making transit more attractive and operationally efficient. Madrid’s public transit system, for example, is owned and operated by various levels of government and private companies. The Consorcio Regional de Transportes Madrid (CRTM) helps to coordinate and integrate the different modes – their schedules, fares – and monitors and reports on overall system performance.
Cars will continue to be an important mode of travel because of the sprawling development patterns that characterize most places outside of many city centers. Thus, it will continue to be important to complement public transit with easy vehicle transfers (kiss and ride), parking and access to taxis and cars in these less dense areas.

Transit providers have an essential role in coordinating and rationalizing connections that are already happening informally, such as dollar vans, car sharing and bike sharing systems that emerged without intervention by the transit agency.

**Climate variability:**

- The spread of urbanization will continue to drive changes in geography and greenhouse gas emissions. Cities can be very efficient and reduce carbon emissions if they have good public transit systems in place.
- Climate variability will only increase in intensity and frequency, and service providers must be prepared for unprecedented extreme events as well as gradual change, which may impact transit infrastructure and rider experience and safety.
- Service providers must have a keen understanding of changing local climate-related conditions, what crucial measures are, what systems are adaptable now, and longer-term strategies to safeguard the system. If resiliency planning is ignored, the effects on the local economy could be catastrophic.
- It is essential to keep in mind that today’s adaptation strategies cannot be applied indefinitely. Transit needs to be flexible and must continuously adjust its plans to incorporate new information and mitigation strategies as our understanding of earth’s climate improves.
- Many cities are already implementing policies to help with recovery and improving resiliency. JR East in Tokyo, for example, is investing 50 percent of their $4.5 billion annual capital funds on safety, including education of employees on emergency response, equipping stations with flood prevention machines and installing early warning systems designed to alert train operators about track damage or seismic events. New York has issued disaster bonds, a first of its kind. The proceeds of these bonds were used to help recover system losses after Hurricane Sandy in 2013.
- Climate events now happen regularly enough that they should not be thought of as one-off events – agencies, rather, should build the effects of climate change into their operations.

**Value capture:**

- Value capture mechanisms include land value capture, property taxation, development fees, joint development, payroll taxes and parking fees. These mechanisms can be used to fund public transit when it is clear that transit will improve the area, the spatial extent is identifiable and residents and workers within the spatial extent are able to pay.
- Value capture may, however, present a number of equity issues across income levels, space (geographies), and modes of travel when paying for transport service within a metropolitan area. A TIF district, for example, is a good deal for people in the benefit zone because they get local infrastructure without paying higher tax rates, and the extra taxes that they pay due to higher property values go directly into making their neighborhood a better place to live. However, these residents typically contribute less to the overall city budget than other areas outside of the zone until they are no longer paying debt service on outstanding bonds.
- Diversified revenues are critical to ensuring the long-term stability of transit agencies. Value capture is a model that works for agencies with an entrepreneurial bent. Agencies focused purely on service provision and dependent on government subsidy are least likely to use value capture.
- Local governments and transit agencies should be given more freedom to pursue alternative sources of funding for projects that would target contributions from direct local beneficiaries. In Montreal, for example, there is strong local support for transit improvements, yet there is a very weak funding commitment from the provincial government. Value capture is one of the few alternatives that could generate revenues required to make these investments.
- It’s important to not just rely on value capture, since competitiveness concerns could lead to the erosion of public support. In Paris, a French law that supports aggressive taxation of business has helped fund many of its large capital projects. However, concerns about the pressures that excessive taxation has placed on the competitiveness of local businesses have put future plans for more taxes at risk.
- A strong coalition between the business and transportation communities is critical. London highlights the importance of diversifying value capture, collaborating with stakeholders and being patient – with its business rate supplement to fund Crossrail being a strikingly successful example of this collaborative approach.
City Profiles

City profiles were developed for each of the 17 TLS cities. The profiles include an overview of the metropolitan area and background on their transit systems, including select innovative actions taken by the transit properties which they have shared at past summits. While the profiles highlight the geographic diversity of the participating cities, they also clearly show that the majority are large metropolitan areas with extensive heavy rail systems.

Detailed Metrics

Early on it became apparent that TLS was a unique opportunity to develop a set of comparative statistics for the participating cities and their transit systems. In 2012 RPA sent data request forms to all cities, asking for figures on ridership, population and costs, among others. Over the years RPA staff has updated these data through collaborations with the 17 cities and publically available sources. This process has been an education in how data is defined and interpreted. For instance, agencies define ridership, costs and subsidies in various different ways. In some cases ridership includes all trips separately (unlinked trips) whereas others define a trip as the complete journey even if it includes multiple modes (linked trips). Operating costs can include long-term liabilities, such as pension and asset depreciation costs, or not. Annual formula-based subsidies could also cover capital needs or just the operating deficit. All of this makes creating a valid “apples to apples” comparison between cities difficult, if not impossible in some cases.

It’s clear from the feedback we’ve received in our post-TLS interviews that participants have valued these comparatives and have even used them to forward policy goals of their own. Los Angeles, for example, used comparative farebox statistics to advocate for higher fare increases. More recently in London, cities discussed what the optimal farebox recovery ratio – typically defined as fare revenues over operating costs – should be. They also questioned the validity of the comparison and requested that RPA dig deeper. We have. It’s clear that there are two types of farebox recovery ratios, some that include long-term liabilities and others that don’t. RPA has developed two types of farebox ratios to address this, an operating ratio and a “full cost” recovery ratio; the latter includes long term capital costs and employee obligations and the former includes only annual operating and maintenance costs. Variation between cities in the scope of their transit systems creates another challenge for farebox analysis and comparison. For example, the ratio could reflect costs and revenues for the metro only or the entire transit system, which might include more expensive on per-passenger basis modes like buses or commuter railroads. We reconciled this by aiming for the inclusion of the metro systems only, but noting in few cases when the numbers we had did not completely conform.

This following section includes a detailed metrics table that contains over 60 data points for each of the 17 participating TLS cities. This table has been developed and refined over the past three years and serves as the source for all of exhibits that follow. The data collected includes demographic and economic performance statistics for each city and metropolitan area, physical system attributes, ridership by mode, fare costs (operating and capital) and revenues/subsidies. The exhibits are arranged in four sections - the metro area, the system, ridership and costs. Each section includes a description and some additional detail on the exhibits.
Autoritat del Transport Metropolità plans all public transit across the 3,239 square kilometers of the Barcelona metropolitan region, with various private companies operating and maintaining the services. Transit began in Barcelona with a tram network in 1872, a system that by 1971 was entirely replaced by buses and the metro. In the early 21st century, ATM reinstated two tram lines. Today the public transit system covers the region with 763 km of heavy rail, light rail and commuter rail, and 14,487 km of bus networks, including bus rapid transit lanes. The Metro network reaches 2.41 million of the region’s inhabitants, and is expected to cover 2.52 million inhabitants by 2020. To serve the additional 110,000 residents, Barcelona plans to expand both its commuter and heavy rail networks. Two commuter rail extensions and an extension of the L9 Metro are anticipated by 2016.

Host of the 1992 Olympics, Barcelona saw this event as an opportunity to invest in the city’s infrastructure, including its transit system. Eighty-three percent of the city’s total expenditure for the 1992 Games was dedicated to urban improvements, which included extending the Metro, rerouting the coastal railway, and redesigning and expanding the airport.¹ By strategically upgrading its infrastructure, Barcelona successfully reinvented itself and continues to grow in popularity today. More recently, the city has focused on creating connections outside the metropolitan area to other major European destinations. In December 2013 a new high-speed rail link opened between Paris and Barcelona, operating on France’s SNCF and Spain’s RENFE railway networks. This link allows passengers to travel between these two global cities in just six hours and 17 minutes, half of the previous journey time."²


Hong Kong is the financial center of Asia, serving as the regional headquarters for many of the world’s largest corporations. As a premier world business center, it’s befitting that Hong Kong has a world-class transit system. The Hong Kong Mass Transit Railway is a privately held corporation (the government is the largest shareholder), serving 5.57 million passengers a day. Metropolitan Hong Kong, with its 7.2 million people and an average population density of 6,540 persons per square kilometer, includes 211 km of heavy and light rail. MTR plans and operates all rail services, and works with a private bus company to provide feeder services to rail stations.

The first rail line opened in 1979. Six rail extensions have been completed in the last ten years, and at least five more are either under construction or are planned for the next ten years. While MTR determines funding levels for most investments internally, there is still close consultation with the Hong Kong government when it comes to expansion projects.

Public transportation accounts for only a quarter of MTR’s annual revenues. MTR is actively involved in land development and property management activities, generating an additional $491 million annually from property rental and management businesses.

MTR prioritizes the delivery of “outstanding customer service.” To achieve this, a customer service vision has been created to help MTR direct its asset investments as well as shape the customer service organization and process design. MTR was a leader in contactless smart cards, launching the Octopus card in 1997 – the second contactless card system in the world after Korea’s Upass, now called T-money. A precursor to open payments, the Octopus card allows customers to store value and make payments for transit, retail, parking and online goods. ¹

MTR is also engaged in the construction and operation of new metro lines in China, has secured contracts to operate and maintain systems in London, Melbourne and Stockholm, and is a global customer service leader.


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<tr>
<th>Metro Statistics</th>
<th>Residents (millions)</th>
<th>Surface area (km²)</th>
<th>Density (res/km²)</th>
<th>Annual Ridership (millions)</th>
<th>Participating Agency</th>
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<td></td>
<td>7.2</td>
<td>1,104</td>
<td>6,540</td>
<td>1,475 171.7 2,240 51.9</td>
<td>Hong Kong Mass Transit Railway (MTR)</td>
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Source: Mitch Altman (flickr)
First opened in 1863, the London Underground is the oldest operating metro system in the world. Today the transit network has vastly expanded to include metro, commuter rail, light rail, buses and ferries, all of which are planned and operated by Transport for London. Serving a city of 8.3 million people settled at an average population density of 5,262 persons per square kilometer, TfL also regulates London’s taxis, is responsible for traffic signals on many of the region’s main roads, and implemented the congestion charge and service upgrades that led to a 60 percent surge in bus ridership in the ten years leading up to 2013. In 2013, metro ridership rose to a new high with 1.26 billion journeys made on the network, up 15 percent in five years.\(^1\) The Docklands Light Rail system, opened in 1987, also experienced a rapid increase in ridership, rising from 10 million in the early 1990s to over 101 million in 2013. The Overground, a new circumferential rail service completed in 2013 using existing (abandoned or underutilized) tracks, has been a widely popular addition to the network, with ridership to increase by 400 percent from 33 million passengers per year to 165 million between 2007 and 2021.\(^2\) The transit network is continuing to expand, chiefly through its Crossrail project that will soon traverse the region.

Despite the system’s age, London is leading the way today in organizational change and infrastructure investment. Over the past two decades the London Underground’s governance and institutional structures have been upended, moving from public to private operation and then back again to the public sector, this time becoming part of TfL, an agency under the mayor of London. This institutional shake up combined with bold leadership has spurred a remarkable transformation of the London Underground from an underinvested railway to a modern industry leader. Significant investments have addressed most infrastructure repair backlogs, and system expansion is well underway after decades of disinvestment. London is using value capture to pay for 30 percent of a new 21-km Crossrail line. TfL plans to expand the use of value capture in London to pay for an even greater share of its planned Crossrail 2 project and the Northern Line tube extension to Battersea.

London’s willingness to experiment – including the deployment of simplified signage, the latest in signaling technologies, creative funding methods involving the private sector and governance reforms – has resulted in a system that feels more modern than most metros of its era.\(^3\)

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<tr>
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<th>Surface area (km(^2))</th>
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<td>17.6</td>
<td>27,833</td>
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\(^3\) Moving Forward: Accelerating the Transition to Communications-Based Train Control for New York City’s Subways. Regional Plan Association, 2013.
Los Angeles, the quintessential 20th century, car-centric metropolis, has reversed course over the past two decades by investing in transit and embracing greater densities. LA Metro has grown from a bus-operating agency to one that plans, constructs and operates a complex network of metro, light rail, bus rapid transit, express buses, high occupancy lanes, and local buses for a total of 486 million annual riders. A 626-km commuter rail system that consists of seven lines and 55 stations also runs throughout the region, operated by Metrolink. With just 26 km of heavy rail, much of LA’s focus has been on expanding the 110-km light rail network. In 2011, LA Metro adopted an ambitious plan to build 30 years’ worth of transit expansion projects over the next 10 years, including extensions to the Purple Expo, Orange and Gold lines and construction of the Crenshaw line and Regional Connector – a tunnel running through Downtown LA with three new stations to through-run many of the existing light rail lines. To reap the economic benefits of those investments on an accelerated timeline, LA Metro’s annual budget, $4.5 billion in FY2012, increased 27 percent just in one year - exceptional today in the U.S.

To support the expansion program, state and local sources provide 75 percent of the funding, including a half-cent sales tax (Measure R, took effect in July 2009), other dedicated tax revenues, fares and land leases around train stations. National government grants account for the remainder. Measure R is an example of how local funding sources can finance new transportation projects and programs, and accelerate those already in the pipeline. The tax is expected to generate $40 billion in new local sales tax revenues over 30 years, at a cost of only $25 annually for each LA County resident.

LA Metro has also initiated a Joint Development Program to introduce greater density around stations and transit corridors to foster ridership growth. Eighteen joint development sites have been completed since 2007, two are currently under construction and thirty-one are in negotiation or under consideration. Completed developments include apartment complexes with market-priced and affordable units, public plazas, a school, retail and commercial space, and in most cases new and upgraded transit facilities. The revenues and sales proceeds from these projects are reinvested in eligible transportation projects throughout LA County.

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<td>18.1</td>
<td>86,393</td>
<td>209</td>
<td>47.7 53.8 13.2 376.1 9.9</td>
<td>Los Angeles Metropolitan Transportation Authority (LA Metro)</td>
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1 LA Metro Joint Development Program Fact Sheet.
Investments in modern infrastructure, particularly in transit, have transformed Madrid into a cosmopolitan city, now a global competitor in terms of finance and tourism. Part of this success can be attributed to the Consorcio Regional de Transportes de Madrid, serving as a regional authority that fosters integration between the various private and public transit operators in the Madrid Region. CRTM oversees the majority of the network, including 294 km of heavy and light rail and 5,664 km of bus routes in the two inner urban rings. The commuter rail, which is not overseen by CRTM but has an agreement for use of the integrated fare card (Travel Pass), carries 180 million passengers per year. The entire transit network serves 6.4 million residents in the region, which has a population density of 5,345 persons per square kilometer within the city proper. Madrid’s high speed rail network is also far reaching, radiating out to the coasts, borders of Spain and beyond.

CRTM provides the coordination necessary for intermodal connections that allow riders to effortlessly move between various modes to complete their journey. The authority issues branded fare media, ensures schedule coordination, monitors system performance (coordinating responses to service disruptions or emergencies) and has improved intermodality through its five bus/metro interchanges. Moncloa interchange station, the most in-demand of the five interchanges, served 266,267 passengers per day in 2010 – up from 50,000 users a day when it first opened in 1995. CRTM has also constructed accessible, modern, pedestrian-oriented plazas. Since the creation of CRTM in 1986, Madrid’s ridership has increased by 50 percent. This is faster than population growth, which grew by 36 percent during that same period.1

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Heavy rail metro, existing
under construction

Light rail metro, existing
under construction

Commuter rail, existing
under construction

Bus Rapid Transit (BRT)
Bus
Road
Mexico City’s transit system is one of the largest and busiest metro systems in the world. The Mexico City metropolitan area is home to 21 million people, settled at an average population density of 5,956 persons per square kilometer within the city. Residents use 272 km of rail and 6,282 km of bus routes to traverse the region. Planned by the Secretaría de Movilidad, the transportation planning government agency, the entire transit network serves 2.2 billion riders per year. The Department of Planning and Transport, a department within SEMOVI, operates the commuter rail, bus rapid transit and most bus lines within the city. The remaining modes of transportation - metro and light rail - are operated by separate government agencies, the Sistema de Transporte Colectivo and Servicio de Transportes Eléctricos respectively. The metro alone carries 3.86 million passengers on average per day.1 The system was constructed in seven stages beginning in 1967, with the final stage, begun in 2012, currently underway. At five pesos ($0.38) per ticket, the Mexico City metro also has one of the lowest fares in the world.

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Mexico City recently passed a law that is redirecting the city’s efforts away from the automobile and towards all-encompassing mobility solutions. The first step was to establish SEMOVI, creating a new structure that now prioritizes pedestrians and cyclists; then public transit including the metro, bus rapid transit and other bus systems; and finally automobiles. The next step will be to incorporate STC and STE, currently separate agencies, under the larger umbrella of SEMOVI. Physical elements of this shift are evident across the urban center – pedestrian markings and crosswalks are painted where they were once sparse and preferred bus lanes run throughout the city streets. Since Mexico City’s metro lines do not provide enough capacity to handle the current demand for transit, the city implemented Metrobus, a bus rapid transit network, to complement the system. Planned in 2002, 95 km of exclusive bus corridors were constructed across the city by 2012.2 The bus rapid transit network serves some of the busiest corridors in the city, with one of its first routes traversing across the entire urban center.

1 “Mexico City Rapid Transit Metro, Mexico.” Railway-technology.com.
While the Montreal metropolitan area is relatively small, it has an extensive and modern transit system that is very accessible. Agence Métropolitaine de Transport is the umbrella agency responsible for coordinating public transit in the greater Montreal metropolitan region, with a population of 3.8 million settled at an average density of 950 people per square kilometer. This system serves 800 million riders a year. AMT also operates both the 204-km commuter rail system, which carries only 17.5 million people a year, and a small portion of the buses serving the region. The 71-km metro system and most of the bus network are operated by Société de transport de Montréal. STM’s Strategic Plan for 2020 prioritizes expanding services, specifically by extending two metro lines, introducing the first tram route and instituting new rapid bus services in Montreal.

STM is undertaking a variety of projects to modernize Montreal’s transit system. It is replacing the entire system’s rolling stock, incorporating real-time information on buses, and electrifying the surface rail network. The new cars will increase capacity, adding 8 percent more passengers in each train, and provide greater comfort and increased reliability. The bus system will soon incorporate real-time information, allowing passengers to track what time their bus will arrive and determine if any service disruptions will affect their travel. Referred to as iBus, this system will gradually be deployed in the city’s buses following a trial period in late 2014. Montreal is also moving towards electrification of the full surface bus and commuter rail system, setting the goal of having 95 percent of public transit passenger trips powered by electric vehicles by 2030. Montreal was also one of the earliest adopters of the bike share system, which has now been repeated across the world in many top urban destinations. The bike network is closely integrated between the metro and bus systems, allowing for ease of mobility across the city.

1 Societe de Transport de Montreal 2012 Annual Report.
New York City is by far the most populated city in the U.S., and has the busiest and most extensive public transportation network in the western hemisphere. The metro area as a whole is home to more than 22 million people in an area of 33,307 square kilometers. In New York City itself, 8.2 million people live at an average density of 16,871 persons per square kilometer.

The greater New York region saddles three states: New York, New Jersey and Connecticut. The metro area is served by New York’s Metropolitan Transportation Authority, New Jersey Transit, the Port Authority of New York and New Jersey, and a multitude of bus operators. The MTA is responsible for the majority of the multimodal transit network in downstate New York and Connecticut. It moves the bulk of the city’s residents and tourists within the urban center and across the region. Through subsidiaries, the MTA both plans and operates the New York City metro and bus systems and two commuter railroads. It also has jurisdiction over nine toll-collecting bridges and tunnels. Annual transit ridership for all transit in the region stands at 3.2 billion.

Most of the subway network was constructed from 1904 to 1937. The complexity and age of the network, including the fact that it runs 24/7, make it one of the more unique systems in the world. During the 1970s and 1980s, the subway system experienced all-time lows, with annual ridership dipping below one billion, numbers the system had not seen since the first decade of its operation. However, since the introduction of the first Capital Program in 1982, the MTA has invested more than $100 billion into its network, resulting in a spectacular rebound in subway ridership, with a 60 percent increase since 1982. Much of this can be attributed to the MTA reinvesting in its system, which has restored the public’s confidence in using public transit. The MTA is now expanding the system again for the first time in over a generation, with three expansion projects currently under construction. Numerous additional expansion projects are under discussion, but without financial commitments.1

The agency has also spent the last two years rebuilding critical parts of the transit system that were devastated by Hurricane Sandy in 2012, and preparing it for future climate events. To tackle these issues the MTA has established a Sandy Recovery and Resiliency Division, dedicated to overseeing the rebuilding and protecting of all points that are vulnerable to coastal flooding or other events caused by our changing climate. In addition, the agency has taken some creative actions to fiscally insure its system, such as the issuing of disaster bonds, and is exploring options to fund future resiliency projects.

1 Transit Leadership Summit:2013 Briefing Book, pg. 4.
The Paris metro is the second busiest in all of Europe, after Moscow, serving 4.1 million passengers a day – almost twice the city’s population. The majority of public transit in Paris is planned by Public Transportation Authority Ile-de-France Region and operated by the Régie Autonome des Transports Parisiens Group. RATP is a state-owned public transit operator that oversees 16 metro lines, most of the new and growing tram system, the city bus system and parts of the commuter rail (RER) network. The remaining sections of the RER and one tram line are operated by France’s national railway company, SNCF. As a whole, the public transit network carries 4.1 billion passengers annually within the 105 square kilometers of the city and throughout the 12,012 square kilometer metropolitan area. Both its heavy rail and light rail systems are undergoing expansion, with plans to add 28.2 km to the network.

Despite opening its first metro line 113 years ago, Paris is embracing cutting edge technology and new funding mechanisms to upgrade its public transit system. Investments in new technologies, such as “virtual block” signaling, unattended train operations and platform screen doors, have brought the metro system up to modern operating standards. Line 1, Paris’s oldest metro line that opened during the World’s Fair in 1900, was fully automated - driverless - in December 2012. Paris plans to modernize all of its metro lines by the 2040s, with some lines being completely automated/driverless.

The city is utilizing value capture and selling development rights to pay for one of its most ambitious improvement projects: the LAGNY Bus Depot located in the core of Paris. The new structure will ultimately provide an improved transit facility and additional public facilities, with three levels for buses and additional space for offices, parking, a school and nursery.

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The Paris metro is the second busiest in all of Europe, after Moscow, serving 4.1 million passengers a day – almost twice the city’s population. The majority of public transit in Paris is planned by Public Transportation Authority Ile-de-France Region and operated by the Régie Autonome des Transports Parisiens Group. RATP is a state-owned public transit operator that oversees 16 metro lines, most of the new and growing tram system, the city bus system and parts of the commuter rail (RER) network. The remaining sections of the RER and one tram line are operated by France’s national railway company, SNCF. As a whole, the public transit network carries 4.1 billion passengers annually within the 105 square kilometers of the city and throughout the 12,012 square kilometer metropolitan area. Both its heavy rail and light rail systems are undergoing expansion, with plans to add 28.2 km to the network.

Despite opening its first metro line 113 years ago, Paris is embracing cutting edge technology and new funding mechanisms to upgrade its public transit system. Investments in new technologies, such as “virtual block” signaling, unattended train operations and platform screen doors, have brought the metro system up to modern operating standards. Line 1, Paris’s oldest metro line that opened during the World’s Fair in 1900, was fully automated - driverless - in December 2012. Paris plans to modernize all of its metro lines by the 2040s, with some lines being completely automated/driverless.

The city is utilizing value capture and selling development rights to pay for one of its most ambitious improvement projects: the LAGNY Bus Depot located in the core of Paris. The new structure will ultimately provide an improved transit facility and additional public facilities, with three levels for buses and additional space for offices, parking, a school and nursery.

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Heavy rail metro, existing
under construction
Light rail metro, existing
under construction
Commuter rail, existing
under construction
Bus Rapid Transit (BRT)
Bus
Road
0 0 1 Km 1 Mi Scale 1:175,000
Santiago’s transit system is one of the most modern and sophisticated in South America, effectively challenging the stereotype that plagues many South American cities. The metropolitan area and city have undergone a transformation since the creation of Transantiago in 2007, now Directorio de Transporte Público Metropolitano. DTPM is the coordinating transportation authority for the seven million residents in the metropolitan region. The authority directly manages the bus concessions with seven private carriers and major interchanges, and works to unify these services with the metro system – operated separately by Metro de Santiago, serving 1.7 billion total passengers a year on a 104 km metro network and 11,000 km of bus routes. An additional 16 million journeys are made within the Santiago metropolitan area on the city’s commuter rail and bus rapid transit networks. DTPM also helps foster connections to the city’s rail lines, one method being shared taxis that cover local accessibility to train stations and major bus corridors/interchanges. The Santiago metropolitan area is anticipated to grow by about 700,000 residents in the next decade. With ridership already exploding, DTPM is planning to expand its transit network. Key projects include two metro lines currently under construction that will add 37 km to the existing 104 km network, and additional bus rapid transit routes.

DTPM’s governance structure enables it to manage the national subsidies that allow for integrated fares across the bus and metro network. Riders use a contactless fare card, the “bip card!,” which can be purchased and loaded in all Metro ticket offices. Riders are able to add a specific amount of pesos to their personal card based on the fares of their travel preferences. This unified fare system allows for fluid transfers between different modes of transit, improving the customer experience and efficiency of the system. DTPM is also planning and constructing additional intermodal facilities to improve bus connections in communities that currently do not have direct access to transit.
Heavy rail metro, existing
under construction

Light rail metro, existing
under construction

Commuter rail, existing
under construction

Bus Rapid Transit (BRT)

Bus

Road
São Paulo’s Metrô is a very popular and congested system. With 4.5 million subway riders a day on just a 71 km network, the trains are crowded at all times. And no wonder: the São Paulo metropolitan area has 20.4 million residents, its economy is booming, streets are choked with traffic, and the Metro provides an affordable, safe and quick way to get around. São Paulo also offers a commuter rail that extends 261 km with 89 stations, and an extensive bus network operated by a multitude of private operators with close to 2,500 km in routes. Yet this clearly has not been enough. Car ownership rose 32 percent in just the last decade to 7.2 million, adding to the traffic on the already jam-packed streets. In response to such strong demand, SP Metrô has been aggressively expanding its network with plans to increase from ten lines to 19 by 2020.1

However, metro expansion projects will not relieve the system on their own. São Paulo has implemented new technologies, crowd management strategies, and improvements to other transit modes to handle the high demand that continues to stress its transit system. A state-of-the-art signaling system allows São Paulo to operate fully automated trains on some of its lines with operational headways as low as 90 seconds.2 Driverless trains free up employees, adding service staff to the trains and busiest stations to improve the passenger experience. Other technological advances are underway such as modernizing the traction power supply of several rail lines, which will allow for more frequent rapid transit within the urban center.3 In addition, the mayor’s “Give Priority to Buses” program, launched in January 2013, sets goals that will improve bus speed and efficiency to complement the rail system. Within eleven months, São Paulo gained 291.4 km of exclusive bus lanes and saw an increase in the average bus operating speed from 13.8 km per hour to 20.4 km per hour.4 Each of these system improvements aims to ease mobility across this chaotic city and increase the quality of life for its residents.

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4 “Sao Paulo to introduce electric bus fleet, add 300km of priority bus lines.” C40 Cities Climate Leadership Group Blog, 8 Jan. 2014.
Heavy rail metro, existing
under construction
Light rail metro, existing
under construction
Commuter rail, existing
under construction
Bus Rapid Transit (BRT)
Bus
Road
The Seoul Metropolitan Government oversees transit in the 11,808 square kilometer metropolitan area of 25.7 million people, residing at an average population density of 17,260 persons per square kilometer. The rail system is operated by four independent government-owned corporations with 17 lines extending for 940 km and serving almost 600 stations. The first of these lines opened in 1974. Annual ridership on the metro and the bus network combined is estimated at just over four billion. SMG subsidizes the operators based on a complex formula related to ridership; operators decide how they will spend the money for operations and capital investments other than expansions. As of 2012, fourteen expansion projects were under construction, opening over the next four years, including new lines and branch connections, a Maglev line and a light rail line. Another eleven projects are in the planning stage.1

SMG prioritizes customer service, making it one of the more enjoyable transit systems for residents and visitors to ride in the world. It is one of the only metro systems in the world with cell phone service and Wi-Fi available in all stations and moving trains. Real-time subway arrival clocks are placed in all subway stations and are also available on riders’ smartphones. A private company services Seoul’s smart fare card, the T-money card, which incorporates open payment and NFC technology allowing for more complex transfers between modes, distance-based fares, and the use of the same card to pay for parking and tolls. All transit modes benefit from the efficient T-money card. Buses experienced speed increases of 8.3 percent and ridership increased 1.6 percent as a result of this technology.2 Seoul’s high-tech customer service elements add up to seamless, comfortable travel.

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1 Transit Leadership Summit: 2013 Briefing Book, pg. 4.
The Land Transport Authority oversees the planning of Singapore’s transit system, its integration with land use, as well as its road network. Operations of the metro, bus and taxi networks are assumed primarily by two private companies, SMRT and SBS. The island city-state is home to 5.3 million citizens and more than 1 million immigrants, at an average residential density of 7,421 people per square kilometer. Singapore’s rail network, opened in 1987, includes 153 km of heavy rail metro and 29 km of light rail. This rail network carries 901 million riders a year. An extensive bus network carries another 1.2 billion people a year. LTA tightly integrates transportation improvements with surrounding residential and commercial developments, creating compact, well-designed, multi-story intermodal complexes that are full of retail and provide easy transfers between modes.\(^1\) Five rail projects are under active construction and planning, and there are four more on the horizon.

Singapore is a rapidly growing metropolis, with a population twice as large as it was in 1980. In addition, more than 13 million visitors arrived on the island for business or leisure in 2011. The number of daily public transit transactions has exploded to over 12 million, and transit ridership is expected to grow as the island’s population continues to increase and as LTA uses road pricing and parking policies to shift people to transit. On an island with limited space to expand, LTA now finds itself struggling to serve all of these new commuters and continue to provide a reliable public transit service.

In response, LTA developed one of the most sophisticated data warehouses in the world. The system, known as Planning for Land Transport Network, or PLANET, analyzes all daily public transport trips, and supports queries of four billion records based on three years of historical records – all within minutes. PLANET has become an essential part of managing Singapore’s transit system. With access to user information, LTA has incentivized more efficient travel behavior. LTA has shifted demand to less crowded times by offering discounts and by passing real-time information on to their customers, providing them with the opportunity to shift their travel plans. Effectively, PLANET has helped LTA understand how the transit system is used, predict future behavior, and plan accordingly.

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\(^1\) Transit Leadership Summit: 2014 Briefing Book, pg. 45.
Heavy rail metro, existing
Light rail metro, existing
Commuter rail, existing
Bus Rapid Transit (BRT)
Bus
Road

Scale 1:175,000
0 1 Km
0 1 Mi
Stockholm’s public transit system is comprised of an expansive, convenient and affordable network of metro, trams, buses, commuter rail and ferries. The transit system is planned and coordinated by Storstockholms Lokaltrafik, which delegates operations and maintenance to several private transport operators. Serving a population of 1.2 million in its 6,304 square kilometer metropolitan area, the system as a whole sees 761 million passengers per year. The majority of riders are split between the heavy rail metro system and bus network, each hovering around an annual average of 300 million. While the metro serves the most rail users, the light rail system is a slightly longer and more extensive system at 120 km with 115 stations compared to 108 km with 100 stations.

The country’s population is growing – about 2 percent a year, or 40,000 inhabitants – and an expansion of SL’s transit system is needed in order to improve the network and accommodate the new residents. In late 2013, the Swedish government and Stockholm municipality and councils agreed on a 19 km expansion of the metro network. Estimated to begin construction in 2016, the project is expected to be complete by the mid-2020s.1

The expansion project is to include 78,000 houses constructed along the new routes to serve rapidly growing areas of the city. The commuter rail system is also expanding with a 6 km railway tunnel beneath central Stockholm designated for commuter rail trains only. Scheduled for completion in 2017, this tunnel will free up space on the old commuter rail line to serve additional regional and intercity trains.

In the even longer term, by 2070, Stockholm is estimated to experience a 50 percent increase in its population. A study released by the metro operator introduced a long-term planning strategy for the capital to handle its growth. The study suggests a reorganization of its radial metro lines into a semi-circular network, adding 86 km of new metro lines.2 However, the government’s current budget for capital investments is limited and would not be able to fund the proposed investments. Thus, SL is considering innovative financing options such as using property development to fund infrastructure, and public-private partnerships.

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2 Ibid.
The public transit system in the Tokyo metropolitan area consists of a large, complex web of heavy, light and commuter rail. Covering a metropolitan area of 2,188 square kilometers, the rail lines and, to a much lesser extent, bus routes serve a population of 13.2 million. Tokyo Metro, the larger of two subway operators in Tokyo, carries over 3.3 billion passengers a year. With so many passengers, Tokyo still manages to provide tremendous service, with frequent trains, use of queues to regulate crowds at its stations, and staff on-site. Yet unlike most global cities, Tokyo’s population is aging and projected to decline. To account for the changing demographic, TM is shifting its resources to make the system more accessible rather than expanding. One plan includes installing escalators at every station to replace existing stairs.

The Tokyo metro and numerous commuter rail networks, including the largest private commuter operator, JR East, have integrated services and fares. The rail network is particularly unique in that the two systems offer through-service into the city center. As of now, 10 metro lines have been connected to JR East and private suburban lines at 16 points. With over 5.8 billion passengers a year on the JR East commuter rail lines, these two systems combined see close to 9 billion passengers annually. With multiple metro operators, ease of mobility has also improved with the relatively recent adoption of the IC card. This integrated contactless fare card works across all rail and bus networks in Japan, including its unmatched high-speed rail service that runs trains up to 322 km per hour across the country.

Japan is no stranger to natural disasters and has prepared its cities and transit to cope with earthquakes and tsunamis. JR East works closely with the government of Tokyo to deploy the latest technologies not just to prepare its system for natural disasters and changing climate, but also to ensure safe operations during an event. These technologies enable them to detect earthquakes, protect against landslides and manage flood control. TM developed a device to seal off surface and curb ventilation grates, leading the way in flood mitigation measures. Additionally, they have created spaces for people to take refuge temporarily during natural disasters.

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1 Transit Leadership Summit: 2014 Briefing Book, pg. 64.
Vienna repeatedly has been declared the most livable city in the world, coming out on top for the fifth time in a row in 2013. In one of the world's oldest cities, transit has recently served as a catalyst for new development. Wiener Linien, which operates Vienna's metro (U-Bahn), tram and most bus lines, serves a metropolitan population of 2.4 million, with 1.7 million located within the city proper. The transit agency operates a five-line, 74-km metro, 29 tram lines totaling 222 km, and 113 bus routes covering 791 km. All WL modes combined serve 900 million passengers annually. Austrian National Railways operates the 91-km commuter rail (S-Bahn) network serving an additional 108 million passengers per year. Two U-Bahn line extensions totaling 9 km with four stations each are under construction. Two other extensions totaling 13 km are in the planning stage.

Wiener Linien places a strong emphasis on the importance of accessibility. Every metro station is accessible; every train has enough space to accommodate travelers with baggage, mothers with strollers, and offers level boarding. Each of these features allows for a greater ease of mobility. One of Wiener Linien's next efforts is to roll out a contactless multimodal mobility card to integrate transit fare collection with Vienna's existing bicycle and car share programs and the city's parking facilities. The long-term goal of the mobility card is to integrate all public transportation in Austria, including the railway network, creating a networked transportation system that provides a similar degree of mobility to owning a car.

Evidence of a shift away from the car is already apparent. Public transit ridership has been growing and is projected to reach over 1 billion trips in less than ten years. The cost of driving and owning a car is increasing, and transit-oriented development is densifying the region. Over the last decade, the modal split in Vienna has reflected these changes, with than one-third of journeys made on public transit rather than in private automobiles – a trend that is expected to continue.

<table>
<thead>
<tr>
<th>Metro Statistics</th>
<th>Residents</th>
<th>Surface area</th>
<th>Density</th>
<th>Annual Ridership (millions)</th>
<th>Participating Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Res (millions)</td>
<td>km2</td>
<td>res/km2</td>
<td>HR metro</td>
<td>LR metro</td>
<td>Commuter</td>
</tr>
<tr>
<td>2.4</td>
<td>4,212</td>
<td>574</td>
<td>428.8</td>
<td>293.6</td>
<td>108.1</td>
</tr>
</tbody>
</table>

Vienna, Austria, including the railway network, creating a networked transportation system that provides a similar degree of mobility to owning a car.

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1 Mercer International Quality of Living Survey.
3 Wiener Linien 2012 Fact Sheet.
Serving a population of 5.6 million, the Washington Area Metropolitan Transit Authority plans and operates transit in the 3,986 square kilometer capital region, with a core area population of 606,759. The agency operates five metro lines totaling 188 km and a 1,500-vehicle bus fleet. WMATA carries 422 million passengers annually. The commuter rail, operated by Virginia Railway Express and Maryland Transit Administration, serves an additional 13.2 million riders a year in the Washington, D.C. metro area. Transit has played an essential role in reshaping the landscape of Washington, D.C. and the surrounding metropolitan area. The alignment of metro extension plans with land use policies has fostered increases in density through transit-oriented development around stations. In some cases WMATA has actively participated in these through joint development. The 37-km line to Dulles Airport is under construction with the explicit aim to reshape areas it passes through, specifically Tysons Corner - an infamously car-oriented “edge city.” WMATA has also been involved in planning for new light rail and streetcar lines in the Washington, D.C. metropolitan area, namely the 26-km Purple Line proposed to connect to three Metrorail lines1 and the DC Streetcar line, expected to be fully operational by November 2014.2

While the transit system is expanding, WMATA is simultaneously entering its first renewal cycle. With infrastructure nearly 40 years old and approaching the end of its useful life, the agency is significantly reinvesting in its rolling stock, signaling system and fare system hardware. The current contactless fare card (SmarTrip) dates back to 1999 and was one of the first to be implemented. It was adapted to the existing turnstiles and fare vending machines at the time. Now outdated, the SmarTrip technology is restrictive and needs to be updated. As WMATA looks to replace the station hardware, it is also looking to replace its aging fare collection system and adopt the open payment model. Under open payments, WMATA’s role will change from a payment media issuer to more like a retail merchant. Customers will enjoy the convenience of paying their fare using their bank-branded contactless payment cards (prepaid, debit or credit), near-field communications based smart phones or federally-issued identity credentials. Merchant-based fare collection will also improve security, simplify fare structures, and provide greater flexibility to customers.

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1 Purple Line: About the project. Department of Transportation Maryland Transit Administration website.
# METRICS

### Residents

<table>
<thead>
<tr>
<th>City, 2012</th>
<th>City, Metro, 2000</th>
<th>City, Metro, 2012</th>
<th>City, Metro, 2020 (projected)</th>
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<tr>
<td>1,619,839</td>
<td>4,590,000</td>
<td>5,000,000</td>
<td>5,020,000</td>
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<tr>
<td>7,219,700</td>
<td>7,612,000</td>
<td>7,721,700</td>
<td>7,662,000</td>
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### Surface area

<table>
<thead>
<tr>
<th>City (excl. water area)</th>
<th>City (excl. water area)</th>
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<tbody>
<tr>
<td>101</td>
<td>1.104</td>
</tr>
<tr>
<td>1,104</td>
<td>1.104</td>
</tr>
</tbody>
</table>

### Regional GDP per capita

| $36,280 | $48,672 | $51,978 | $56,406 | $40,000 | $19,940 | $36,277 |

### Registered vehicles, city

| 968,000 | 663,707 | 2,651,711 | 2,499,764 | 1,896,280 | 4,164,718 | 827,000 |

### Annual Tourists

| 7,390,777 | 54,298,804 | 31,084,000 | 42,200,000 | 28,838,660 | 11,500,000 | 4,000,000 |

### Annual ridership

| 400,000,000 | 1,474,659,000 | 1,260,000,000 | 47,735,749 | 604,100,000 | 1,608,865,117 | 239,264,000 |

### Number of stations/stops

| 167 | 84 | 270 | 16 | 238 | 195 | 68 |

### Route length

| 134 | 175 | 402 | 26 | 267 | 226 | 71 |

### Stations under construction

| 29 | 36 | 34 | 110 | 36 | 19 | - |

### # of Rail Cars

| 165 | 1,877 | 4,154 | 104 | 2,303 | 390 | 759 |

### Fare

| $2.71 | $5.55 - $6.58 | $2.40 - $34.89 | $1.75 | $2.07 - $4.14 | $0.38 | $2.67 |

### Effective fare (average fare/trip, all customers)

| $0.86 | $1.26 | $2.90 | $0.78 | $0.81 | $0.21 | $0.64 |

### Annual system operating costs

| $629,617,212 | $1,022,840,000 | $4,048,000,000 | $351,862,052 | $1,165,500,000 | $734,579,484 | $675,647,950 |

### Annual revenue

| $352,214,000 | $1,856,001,000 | $3,656,000,000 | $79,318,221 | $487,872,000 | $337,788,440 | $456,011,800 |

### Subsidies (state, city, federal government)

| $258,827,184 | $2,254,400,000 | $265,702,347 | $664,020,000 | $245,934,760 |

### Capital budget (avg expenditures past 5 years)

| $385,560,000 | $768,040,000 | $2,180,800,000 | $459,821,305 | $130,640,000 | $988,720,000 |

### Farebox Operating Ratio

| 56% | 181% | 90% | 23% | 42% | 46% | 68% |

### Farebox Recovery Ratio

| unknown | 119% | 83% | 11% | 40% | unknown | unknown |

See the Notes section for additional information on this table.
<table>
<thead>
<tr>
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<tbody>
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<td>8,199,221</td>
<td>2,262,215</td>
<td>5,062,131</td>
<td>11,822,000</td>
<td>10,442,426</td>
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<td>897,700</td>
<td>8,970,000</td>
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<tr>
<td>21,491,898</td>
<td>11,185,563</td>
<td>6,171,283</td>
<td>17,900,000</td>
<td>21,400,000</td>
<td>4,028,000</td>
<td>1,072,862</td>
<td>12,060,000</td>
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<td>6,945,593</td>
<td>20,400,000</td>
<td>25,715,262</td>
<td>5,512,000</td>
<td>1,207,270</td>
<td>15,190,000</td>
<td>2,419,000</td>
<td>5,603,696</td>
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<tr>
<td>23,228,000</td>
<td>12,900,000</td>
<td>7,300,000</td>
<td>22,243,000</td>
<td>25,957,000</td>
<td>6,000,000</td>
<td>1,347,017</td>
<td>15,350,000</td>
<td>2,640,000</td>
<td>5,851,000</td>
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<table>
<thead>
<tr>
<th>Capital budget</th>
<th>Number of Stations, under construction</th>
<th>Route length</th>
<th>Annual Surcharge at peak times</th>
<th>Fare: flat</th>
<th>zone / distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metro area</td>
<td>City</td>
<td>Metro area, 2012</td>
<td>$3,988,274,000</td>
<td>$2,763,180,000</td>
<td>$547,520,000</td>
</tr>
<tr>
<td>82%</td>
<td>65%</td>
<td>60%</td>
<td>106%</td>
<td>74%</td>
<td>97%</td>
</tr>
</tbody>
</table>
An important metric to consider is a transit system’s farebox recovery ratio, or the percentage of the system’s costs that is covered by the fare revenues. However, through our research we have discovered that this metric is not easily compared across cities with different transit agency structures and accounting methods.

To address the discrepancy across transit agencies, this metric is considered from two perspectives: one that includes long-term liabilities (“farebox recovery ratio”) and one that only includes annual operating costs (“farebox operating ratio”). Long-term liabilities include expenses such as pension costs, depreciation and interest on long-term debt. For the most part, it is possible to make the distinction between the two farebox ratios and thus provide a better understanding of the components included in each metric while making an accurate comparison. However, due to the complexity of some city’s financial reports, there are still a few cities that we were unable to compare.
A heavy rail metro system typically carries passengers within the city on an exclusive grade-separated right-of-way, elevated viaduct or embankment, subterranean tunnels or an open cut. Trains run frequently throughout the system, stations are spaced more closely together and speeds are slower than commuter rail. Journey times range from 15 to 30 minutes on average.

A light rail metro system typically runs along surface streets, in some cases in mixed traffic, or on exclusive lanes. Light rail systems generally operate at lower speeds, can brake faster to avoid conflicts with pedestrians, have a lower capacity and are less expensive to build and maintain.

A commuter rail system typically transports residents from far-flung suburbs to the major job centers in metropolitan areas. Commuter trains run faster than heavy and light rail systems, rely on schedules and make less frequent stops.

A bus rapid transit (BRT) system aims to provide high-quality surface transportation service similar to that of a rail network. Essential to its success are an exclusive right-of-way, off-board fare collection, platform-level boarding, and improved service plans. A BRT system may adapt some or all of these features depending on its urban context, leading to a range of BRT services worldwide.

The modal splits show the proportion of transit riders that use each of the transit modes – light rail, heavy rail metro, commuter rail, bus, BRT and ferries. It serves to highlight the variation of the mode share across the 17 TLS cities. It is important to consider modal share in the context of absolute ridership, since modal shares do not reflect the magnitude of riders on each system. Consider Singapore and Seoul, for example. These two cities appear to be alike with similar modal splits between heavy rail and light rail. Yet Seoul’s ridership levels are three times greater than those of Singapore.
Mode Share, by Ridership

Barcelona 61
Hong Kong
London
Los Angeles
Madrid
Mexico City
Montreal
New York
Paris
Santiago
Sao Paolo
Seoul
Singapore
Stockholm
Tokyo
Vienna
Washington
Annual rides per capita

While each of the participant cities has a metro the number of trips taken per resident tends to vary greatly. Tokyo residents each make 800 transit trips annually, while Los Angeles residents make just over 20. Why? Some systems are more accessible and offer better, more frequent service than others. They also may vary due to differing levels of affordability and the availability of other transportation options.

Annual riders per route-km

The intensity of transit use varies greatly across the cities’ metro systems. While New York is typically thought of as a heavily used system, this chart highlights that many international transit systems experience much greater utilization when considering the size of the system and volume of ridership. Sao Paulo and Tokyo particularly stand up, with 12.5 million and 11.1 million annual metro riders per route kilometer respectively.
Not surprisingly, when we conducted post-TLS interviews, participants suggested that future research should focus more on core institutional areas that they felt were ripe for exploration and reform. These included areas such as labor relations, procurement process, cost reduction, recruitment/retention of talent, standardization of practices/operations, mix of actors (public/private), among others. Participants suggested that we continue to build upon our prior research. There was strong interest in going into more depth on the subjects of value capture, combined mobility and fare policy. Fare policy research questions included: What is a sustainable farebox recovery ratio and what role can social fares play in achieving this goal? Bigger picture issues of energy use, sustainability, rising transit expectations of urban residents, subsidies and others were all raised by the cities.

RPA and its partners endeavor to add another layer to the wealth of existing transportation research. The TLS white papers focus on pressing issues that transit executives are grappling with on a daily basis or that will impact their longer-term capital decision making. They are written to be easily digested by executives but also have the rigor and substance of a research paper.

The Transit Leadership Summit is organized around a powerful core idea: senior public transport officials need a strategic forum to exchange ideas and information on issues critical to fulfilling their vital public service missions. For these deliberative sessions to be productive for these leaders, rigorous background papers are needed that report on the current state of the art in terms of ideas, approaches and the collaborative potentials of alternative solutions to the transit leaders’ challenges.

To date there have been three summits. The first one was organized around several case studies developed in collaboration with RPA staff. This event generated a research agenda for the following year that resulted in the first series of white papers. Over the last two years, RPA has collaborated with subject matter experts and academic institutions to produce six original research papers on a variety of topics.

These white papers were used to generate debate and discussion (summarized in the Summit Profiles) at the TLS meetings in Singapore and London. At the heart of each white paper is consideration of the role of the institutions that govern the delivery of transport service, and how these interact with public and private stakeholders. The composition of the transit organization and its operating environment dictate how it will respond to the challenges it faces. Some transit organizations are ill equipped to address broader issues of funding or climate change due to their narrow operational mission, while others are embedded in government and must contend with a political agenda that can result in suboptimal operational decision making.

Understanding the technical challenges of the six topics covered in the white papers proves to be necessary but not sufficient. Implementing the best practices found in these papers requires an understanding of how the unique organizational dynamics of transit organizations might need to be adapted to achieve positive outcomes. This became especially clear in the third year of TLS. The papers for London – value capture, climate variability and combined mobility – required, in most cases, institutional reform. The transit organizations would need to move away from “business as usual” and radically change their thinking; this was especially true in the cases of climate variability and value capture.
Improving the Customer Experience / 67

A survey of customer amenity improvements that highlights global best practices. What steps can public transportation agencies take to improve their image? How can new technologies – such as communicating with customers through social media and analyzing smart card swipes in real time – improve the experience of commuting?

Fare Collection and Fare Policy / 83

Transit agencies have two goals: serving the public and maximizing revenue. These aims can clash or be complementary. How can we ensure the latter? A study on new fare collection technologies reveals the opportunities for more equitable and flexible fare policies. New fare payment methods make it easier to set and collect fares for multiple purposes, including fares set to be progressive by income, and fares set based on distance, time of day or location. New fare payment systems provide much potential for improving the ability of systems to structure and segment the market more precisely.

Capital Investment Priority-Setting / 91

A survey of the various factors that influence how transit agencies set their capital investment priorities. Transit agencies have limited budgets and a long list of projects. What are the best methods to quantify goals, objectives and trade-offs? How should expansion projects be weighed against existing assets?

Value Capture Opportunities for Urban Public Transport Finance / 101

A study of the value that transit adds to cities, including a focus on contemporary value capture mechanisms used by transit agencies. Examples of such mechanisms include the granting of zoning permission for added building bulk, impact fees, parking fees, payroll taxes, property taxes and tax increment financing. What are the merits of value capture over other forms of non-fare sources such as general taxes or cross-subsidies from fees on private cars?

Urban Transit Systems and Conditions of Enhanced Climate Variability / 113

A study of how erratic weather and the increased threat of flooding, heat and high winds will impact transit systems. The study looked at where climate change has already negatively affected transit, and what actions operators and governments are taking to adjust to the new climate paradigm. What are the economic and societal risks of inaction? What strategies will help transit systems prepare for and be resilient to climate change?

Door to Door: Combined Mobility and the Changing Transit Landscape / 127

A survey of land use, urban design and organizational strategies for achieving new levels of interconnectivity, including ways to expand transit accessibility into complex regional settings. Examples of strategies include the integration of access modes with land use development, pricing, line-haul, egress modes, micro-design features, innovative travel options, transit to transit transfers, technological applications and customer amenities. Which governmental, institutional, land use or market driven options lead to success? How might they be introduced in major transit cities where they are currently lacking?
Improving the Customer Experience

Dr. Young-In Kwon, Korea Transport Institute; Dr. Chang Kyun-Kim, Happy Transport Institute; Prof. Taewan Kim, Chung-Ang University; Jonas Hagen, Columbia University; Richard Barone and Doneliza Joaquin, Regional Plan Association

Introduction

Customer perception of transit service is traditionally informed by the agencies’ ability to run trains and buses frequently, on time and without disruption. Today more than ever, transit agencies are striving to provide more than this basic service; they aim to grow and diversify their customer base by providing a convenient, attractive and comfortable transit experience – so good, in fact, that transit then becomes the first choice for travel. A variety of elements go into making an attractive transit experience – everything from communication to facilities that are comfortable and easy to navigate, with seamless transfers.

This white paper explores how the seven cities participating in the Transit Leadership Summit are addressing the customer experience in Hong Kong, Montreal, New York, Seoul, Singapore, Vienna and Washington, D.C. It investigates the transit agencies’ activities and experiences with respect to communication, stations, vehicles, and accessibility. Although the nature of transit provision and its perception by customers differ due to local context,1 the elements covered in this paper – communication, station and vehicle characteristics, accessibility – can go a long way toward improving the customer experience and increasing the attractiveness of transit.

How Agencies Communicate with Customers

Providing good information about available services is an essential aspect of successful public transportation systems,2 and is a strong factor in helping customers decide to use transit for business or leisure trips.3 The type of information provided can be divided into the following categories: pre-trip, wayside (provided when a trip is underway; often found outside or inside a transit station, on a platform, or at a roadside stop), and on-vehicle.4 Commuters and visitors have different requirements for what information they need from the transit agency. These needs also shift based

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1 Felleson and Friman 2008
2 Balcombe et al. 2004
3 Farag & Lyons 2011
4 Cluet et al.
on normal service, planned service changes and disruptions. Information – especially pre-trip information – is particularly crucial to travelers making multimodal trips. The elderly have a substantially greater need for information in all stages of travel, in order to save physical effort. In addition to transmitting information to customers, transit agencies must also be able to receive feedback from customers to improve service. All seven transit agencies transmit and receive information using various channels, including electronic (websites, mobile applications, social media), and physical (real-time vehicle arrival displays). These tools have evolved dramatically in recent years, especially with the advent and proliferation of real-time technology. Just as it was hard to foresee the advances that communications would make in the last few years, it’s difficult to predict how this field will continue to change in coming years. One thing, however, is clear: it is important for transit agencies to stay abreast of these developments.

Trip Planning

Customers can plan trips using printed timetables and maps, or electronic resources such as websites and mobile applications. Trip planning is a constantly evolving field. Static content, either printed (e.g., timetables and route maps) or electronic (websites), is complemented by more dynamic content in websites and apps (often provided by third parties) and public display signs. In practice, the line between pre-trip and wayside information has blurred in recent years, as customers use real-time information to modify their travel plans (for example, changing lines on a metro as they learn of unexpected service changes). Although printed material is still preferred by many passengers for pre-trip planning, this section focuses on electronic resources.

To plan their trips, transit customers want information about overall travel times (including walking distance at origin and destination), transfers, route alternatives, and irregular events that may disrupt a journey. Some also want to know about express and local service, park-and-ride facilities, bicycle parking, etc. Assisting customers in trip planning is a major service of transit agencies; helping people get the best use out of the system is critical, not only for those that use the system regularly, but also for visitors to a city.

Agency Websites

Transit agency websites typically provide information and services that include system maps, transit schedules, fare information, planned service changes, customer service questions and trip planning tools. Although an increasing number of customers are using mobile applications (covered in the next section), websites are still an important source of information for many.

Most agency sites include real-time service information, which informs customers about the status of the service – whether it’s normal, delayed or suspended. In some cases, planned service disruptions are also indicated. This information is made available for web applications and in other formats – for example,

5 Grotenhuis et al. 2007
6 Cluet et al. 2003
New York’s Metropolitan Transportation Authority and London’s Transport for London include this information on screens at some of their busiest station entrances.

Montreal’s Agence métropolitaine de transport website is characterized by simplicity and clean aesthetics, which make it particularly user-friendly. Launched in April 2014, the central feature of the AMT website is a map on the homepage that is a trip-planning tool. This comprehensive map includes information on a wide range of services: trains, metros, buses, bike routes, bike and car share, park-and-ride, carpooling, and electric car charging stations. Customers can also use the site to order monthly tickets, and find out about accessible transportation for people with disabilities.

The agencies’ trip planning tools offer different types of information. Vienna’s Wiener Linien planner allows a user to enter his origin and destination points as a specific station or as an address. Seoul Metropolitan Rapid Transit’s planner requires a specific station for the origin and destination. Hong Kong’s Mass Transit Railway planner gives the option of entering specific station names or selecting from a pre-set list of attractions that includes “Arts & Culture,” “Major Buildings,” and “Shopping & Dining.” In Washington, D.C., the Washington Metropolitan Area Transit Authority’s trip planner integrates rail and bus services, providing itineraries, door-to-door fares, travel times, walking directions and transfers.

Although websites may traditionally be thought of as for the pre-trip portion of travel, viewed on computers at a home or office, in practice, they can also be accessed by mobile devices (smartphones), and as such can also be used when travel is underway. Further, transit customers can use websites to sign up for text messages (on cellphones) or emails (that can be read on desktop computers or smartphones) regarding transit services, as the WMATA does with its MetroAlerts program.

Besides their own websites, agencies have turned to social media platforms that customers are already using to provide and receive information. All seven transit agencies have a Facebook...
The seven transit systems studied showed varying rates of coverage of public display signs with real-time vehicle arrival. These signs are often placed inside of transit stations only, although having such signs outside stations and at surface transit...
In New York, the MTA has gradually installed electronic signs on platforms that show how many minutes until a particular train arrives. These are now available at 177 stations, but there are still 313 stations that lack them (about a 36 percent coverage rate). In February 2014, the MTA unveiled its first “On The Go” interactive wayfinding kiosks at Grand Central Station, a major intermodal transit hub. The touchscreens provide real-time information, including directions, service alerts and wait times. The MTA plans to install 90 kiosks throughout the subway system.18 LCD signs outside Grand Central Station proved very useful before, during and after a natural disaster (Hurricane Sandy) in 2012. Customers were able to receive up-to-date information on transit service, which was severely affected by the hurricane, from the signs.

Besides websites, mobile applications and public display signs, audio messages can be an effective tool for communicating real-time information, especially regarding arriving vehicles and service changes. These should be delivered in a clear, uniform manner, easily heard and understood. These messages can be delivered in multiple languages to reflect local cultures (e.g., in Dublin, messages are delivered in English and Gaelic), or to help tourists (as in Rio de Janeiro, where information is delivered in Portuguese and English). Just as high-quality audio messages improve customer orientation, low-quality audio disorients customers. These messages should be supplemented by visual

18 http://www.controlgroup.com/mta.html
displays to serve customers who are deaf or have partial hearing loss—a group that will likely continue to increase in number as urban populations around the world age.

Vienna is a standout regarding audio announcements; the Wiener Linien implemented a project to improve all acoustic communication media in 2012. The messages were improved in terms of wording and clarity, re-recorded using the voice of a popular actress (Angela Schneider), and uniformly introduced across the entire network.

The information available for the on-vehicle portion of travel has evolved greatly in recent years. Most on-vehicle displays used to provide minimum information, such as static route maps and printed timetables. Today, many on-vehicle displays truly orient customers, with key stops, real-time frequencies and connecting service information. Further, audio messages often reinforce the information available on the screen, such as announcing the next stop. This information can be of great utility to all transit customers, especially those unfamiliar with their route.

In Vienna, the next station’s name is displayed inside all transit vehicles—trains, trams and buses—together with audio announcements. To help passengers identify their destination, Hong Kong’s MTR is rolling out an on-board Electronic Bus Stop Announcement System that provides voice announcements and LED displays.

Customer Feedback

Besides providing information to the public, many transit agencies strive to create opportunities for the public to provide feedback to the agency. In the past, agencies solicited feedback using customer forums, call centers and surveys. Today, many also use websites, apps and social media to capture feedback. Agencies can use these interactions to inform short- or long-term changes, or provide better information on a particular question, issue, comment or complaint. Like the other aspects of communication mentioned in this section, this area has evolved dramatically in recent years.

Call centers were traditionally the main way transit agencies received feedback, then websites became an important way to receive information and feedback; in the last two years, social media such as Twitter have risen in prominence. Interestingly, social media can improve direct contact with customers, e.g., customers may receive more personalized attention via Twitter than if they speak to an agent at a call center or fill out an online form. Just as the recent rise to prominence of social media was difficult to foresee, it is difficult to predict what customer feedback mechanisms might emerge in coming years.

In Hong Kong, the MTR’s website provides a hotline number, and customers can also submit complaints and suggestions via fax, mail or an online feedback forum. The MTR also actively seeks customer feedback via its “Opinion Zone” and “Voices of the Customer” surveys. “Opinion Zone” is a branded activity organized at different stations for two evenings per month and on trains twice a year. The VoC surveys poll customer interests, expectations, issues and concerns on either a specific initiative or general service. In March 2012, MTR launched the HK$1 billion ($130 million) “Listening x Responding” program, which formulates initiatives that respond directly to customer requests regarding issues such as crowding, reducing wait times for trains and enhancing station facilities to improve access. For example, based on customer feedback, more staff will be deployed at stations to help smooth passenger circulation and provide assistance to passengers.

Recently, Seoul’s MTR has organized a Citizen Monitoring Committee to monitor, advise and participate in many activities regarding customer service enhancement. It consists of many citizen experts in various fields of urban rail operation.

Washington, D.C.’s WMATA hosts “Metro Lunchtalk Online” chats, which give customers the opportunity to present questions and comments to the general manager and other top staff. WMATA’s board and committee meetings also provide an opportunity for members of the community to comment. Such forums have the ability to bring customers, management and staff together in meaningful ways, versus more passive ways of gathering feedback, such as call centers.

Social media platforms such as Twitter allow transit agencies to be more transparent about their process. Instead of responding to an individual, information can be shared with many people at once. Except Hong Kong’s MTR, all of the studied transit agencies have at least one Twitter account. WMATA has four Twitter accounts for rail, bus, general information and transit crime prevention tips and updates. New York’s MTA has various social media feeds for its different divisions, including New York City Transit, Long Island Rail Road, Metro-North Railroad, Bridges & Tunnels, and Arts for Transit.

The MTA’s general Twitter account has more than 171,000 followers. The agency uses this account as an information portal, and as a way to respond directly to customer issues and questions. For example, in the image below, a customer asks what to do to report a lost item.

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19 The LCD displays in trams in Bern (Switzerland) are a standout, showing upcoming stops in real-time and all connecting services available at those stops.

22 http://www.wmata.com/community_outreach/lunchtalk_online_chats/
23 http://www.wmata.com/rider_tools/metro_service_status/connect_with_twitter.cfm
24 http://web.mta.info/social/
25 https://twitter.com/mta
White Papers

Figure 11: Twitter exchange between New York MTA and a customer

@kpeters821 Sorry to hear that. I am looping in @NYCTSubway, but the lost item claim is your best bet with a high rate of return. Good luck

Kelly Peters @kpeters821 Aug 18
@MTA, I lost my ONLY remaining childhood stuffed animal in transit. Is there ANYTHING else I can do besides filing a lost item claim?

MTA @MTA

@MTA @kpeters821 @NYCTSubway Thank you!

In The Stations: Design, Wayfinding and Other Customer Amenities

For many people, particularly newcomers to a city, entering a public transportation system is an intimidating, even daunting experience. Often, transit users find themselves amid rushing torrents of people, in a labyrinth of corridors and stairs, and faced with a confusing constellation of signs. One of the main tasks for agencies that seek to make their systems more customer-friendly is to make the journey to and from trains easier and more pleasant. Good station design and wayfinding can significantly improve customers’ perception of a transit system, as can amenities such as Wi-Fi, phone reception, platform screen doors and public art. While this section mainly explores elements of metro stations, these lessons can easily be transferred to any type of public transportation facility, including facilities for trams, buses, ferries and other modes.

Station Design

The path a customer takes from the street to a metro platform is fundamental to his or her experience of the system. Stations can grant direct access to nearby destinations, such as important office buildings or shopping centers. Distances should be kept as short as possible, in order to reduce the time and effort spent. Changes in elevation should be minimized, and when unavoidable, escalators and lifts should facilitate movement, especially for people with special needs – the elderly; people with children (and strollers), luggage, bikes or other bulky items; and wheelchair users (this issue will be discussed further in the section on accessibility). Spaces should be uncluttered, easy to navigate, with clean aesthetics to help customers feel at ease.

When discussing station design, it is illustrative to reference two recent examples: King’s Cross in London and Nuevos Ministerios in Madrid. A major intermodal hub, King’s Cross integrates two intercity and suburban rail stations (King’s Cross and St. Pancras) with six tube lines (it is the busiest tube station in London), over 15 local bus routes, and six bicycle share stations with over 400 public bike spaces. Formerly described as “depressing,” the station underwent a major renovation that was completed in March 2012. This project involved extensive restoration and re-use of existing elements, as well as newly built features, transforming an unwelcoming place into a modern transport superhub. The train sheds have been decluttered, a new customer service center and restaurant installed, and once-dormant tracks re-activated. Platforms were enlarged, and all now connect to the centerpiece of the project, an impressively designed superstructure on the western concourse that protects travelers from the elements. Access to the superhub is facilitated by numerous points of entry and exit that make the station

26 73.7 percent of Twitter users worldwide are aged 15 to 25 - http://www.beevolve.com/twitter-statistics/#a2

particularly porous, and thus convenient and comfortable for travelers going to its many different destinations. The renovation won a Europa Nostra prize for conservation in 2013.

Figure 12: King’s Cross.

Nuevos Ministerios, the third busiest station in Madrid, integrates three metro lines with seven regional commuter rail lines and over ten urban bus routes. The station has direct service to the Madrid-Barajas airport, and as such is an important transit hub for air passengers as well as local customers. Wide passageways, and ubiquitous escalators and elevators make it ideal for air travelers, even if they have two pieces of rolling luggage. Open vistas, clean aesthetics and an intuitive layout make it easy to navigate for all types of users. Its large open spaces also lend themselves to cultural events, such as the concerts and dance performances regularly held there.

Figure 13: Nuevos Ministerios Station.

Numerous stations in Singapore have excellent design, comfort and convenience. Singapore’s LTA makes a special effort to make travel and shopping convenient by tightly integrating bus interchanges with metro stations and shopping malls. The six existing transport-shopping hubs will be joined by a new one in Bukit Panjang in 2015, with an additional six integrated transport hubs to be implemented over the next 10 years. Pedestrian comfort is also an important priority for the LTA, with a program underway to provide a total of 200 km of sheltered walkways within 400 meters of all metro stations by 2018.

Opened in 2012, Singapore’s award winning Marine Bay metro station makes maximum use of natural light to illuminate underground levels, and permits views from the hall below up to the sky. The station is seamlessly integrated into an underground network of pedestrian walkways, and has connections to bus and taxi services. While the station has a strong visual identity, it blends in well with the park that surrounds it. Reflective pools in front of the station entrance are covered by a canopy; these are not only aesthetically pleasing, but act as rainwater collectors and create a cooler microclimate that offers metro customers greater comfort. Inside the station, large open areas and a clean aesthetic enhance the customer experience.

Hong Kong’s Central Station, another standout, is one of the city’s major transport hubs, and connects a dizzying array of services: four metro corridors, an airport express train, numerous trams, regional and urban buses, and ten ferry lines. Some of these services are connected via an extensive network of covered walkways – for example, the airport express train is at the nearby Hong Kong Station, and a major ferry pier is also a short walk away. The line between the public and private sectors is blurred at Central Station, as many of these walkways are surrounded by retail spaces and include entrances to office buildings. The station has three levels, but ubiquitous escalators ensure that customers do not have to expend great amounts of energy to reach their destinations. The MTR has also improved connectivity for passengers and enhanced station environments by changing the configuration of the Kwun Tong Station; major renovations are underway at other important hubs.

In New York, the MTA has been renovating Fulton Center, with a current total project budget of $1.4 billion. Ten subway lines meet at the station, including a previously confusing assembly of stairs and passageways. The new Fulton Center includes a highly visible aboveground entrance, new passageways, a sizable area for retail and a simplified layout for easier navigation. The underground Dey Street Passageway connects Fulton Center to the World Trade Center and Courtland Street stations, facilitating connections for customers from the PATH system, and on the N/R subway lines, respectively. The renovation expanded the capacity of the 4/5 subway lines by adding space to the platforms. Restoration of the adjacent historic Corbin Building was completed in 2013, and it has been integrated into the station. Escalators, elevators and ramps have been added, making the station accessible to all customers. Fulton Center is scheduled to open at the end of 2014.

The stations covered in this section include the following elements in their designs: large, open spaces that facilitate air flow and vistas, comfortable vertical circulation for customers with ubiquitous escalators and elevators, seamless connections to other transit services and the street for intermodal trips, access to shopping and restaurants, and thoughtful aesthetics. Creating such appealing environments can help create a sense of

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28 The station won the Small Project Award at the World Architecture Festival in 2012, and the International Association of Public Transport’s Grow with Public Transport award in the Design Innovation category at the Asia Pacific Level.

29 PATH is separate metro system that operates in the neighboring state of New Jersey, as well as in New York.
place, transforming formerly utilitarian stations into destinations for visitors, and uplift the daily experience of regular transit customers.

**Platform Screen Doors**

Platform screen doors have many benefits, including safety, noise and climate control. PSDs are becoming much more commonplace, and are now standard equipment on world class metro systems. They usually consist of a wall of glass that stands between the open tracks and the platforms. When a train enters the station, it lines its cars up with doors in the glass wall, which then open to let passengers on and off. PSDs increase safety because people can no longer easily be pushed or jump in front of arriving trains. PSDs also:

- Save cleaning costs by preventing trash from entering the tracks
- Reduce track fires and resulting delays
- Dampen noise from arriving trains
- Improve system safety by securing subway tunnels against unauthorized access
- Prevent riders from holding open subway doors, thereby enabling trains to enter and depart stations faster
- Allow the installation of heating, ventilation and air conditioning at stations

PSDs are more easily installed on newer metro lines, and many of the newest lines in the cities examined here have them. Older systems must surmount greater challenges, including stations that are curved, have limited platform space, or require significant reinforcing (rebuilding) of platforms to support the screen doors and rolling stock with varying door positions. Despite such issues and elevated costs, Paris was able to install PSDs on older platforms, and has seen considerable improvements in boarding and alighting at stations. This has allowed operators to more closely adhere to scheduled dwell times.30

Seoul stands out for its record in having equipped almost all of its 300-plus stations with PSDs. Over two-thirds of these were retrofits. Seoul paid for this expensive effort by selling long-term leases for electronic advertising above the doors. Hong Kong’s MTR has completed PSD installation at 30 underground stations, and Automatic Platform Gates at eight aboveground stations. Half the installation cost has been recovered through a 10 cents per journey surcharge.

All of Singapore’s underground MRT stations were outfitted with PSDs when they were first constructed. Over the past few years, half-height PSDs were also installed at elevated stations. However, air circulation at these stations suffered because the doors blocked the natural cross ventilation, requiring the agency to install fans to improve customer comfort.

**Wayfinding**

Successfully executed wayfinding provides guidance and the means for people to navigate transit systems from their trip origin to their destination, as well as feel comfortable in their surroundings and effectively navigate space.31 In this sense, wayfinding can be thought of on two levels – systemwide, as in finding the way to your final transit stop, and on the station scale, as in finding your way to the platform or street level. Systemwide wayfinding has considerable overlaps with trip planning. In this context, it is worth noting the difference between geographic maps, which represent spatial relationships accurately, and topological maps, which are line diagrams of transit systems that have little relationship to actual distances.32 Topological maps are now used by most transit systems, as they allow greater legibility and conveyance of relevant information for transit customers.

For both systemwide wayfinding and more localized wayfinding, it is important to provide adequate amounts of information about connecting services, local attractions, etc. However, while agencies should include sufficient information to orient passengers, too much information leads to clutter that confuses customers; as new information is added, other information might need to be taken away to ensure clean visuals that passengers can easily comprehend. The aviation industry has made a special effort to guide passengers to their gates at airports; transit systems can improve customer satisfaction by providing similarly effective wayfinding for their customers.

Transit agencies use a variety of tactics and strategies to help customers find their way to the correct train, and then make their way afterward to the correct destination. Seoul has a simple but effective program of numbering its entrances and exits at each station; this numerical system is also used on the platforms where customers get on and off trains. For example, customers leaving a train can see signs indicating that Exits 1 to 4 are to be found using one staircase, and Exits 5 to 7 another staircase, and so on. Even larger stations with more than a dozen entrances are easily navigated by customers using the numbering system. This not only aids customers while they are in the station, it helps in communication and planning while outside the station; for instance, a customer can say, “Meet me at Exit 3,” or direct someone to use Exit 3 and then walk one block to a destination. Hong Kong has a similar system, but uses letters instead.

New York often labels its exits with compass indicators, such as an exit that leads to the “southwest” corner of an intersection. This has some value, but can be confusing to those unfamiliar to the city or without a consistently excellent sense of direction. Nor does the system help customers on the platform make their way quickly to the right exit. New York is aided by a historical factor: Most of its underground lines, some more than a century old, were built via the “cut and cover” method – lines are close to the surface and riders often only have to descend one or two staircases to reach the train platforms. This makes the system easier to

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30 For a more complete description of the function of PSDs in Communications-Based Train Control metro systems, see the Regional Plan Association report, “Moving Forward” (2014): http://library.rpa.org/pdf/RPA-Moving-Forward.pdf

31 For a more comprehensive overview of wayfinding design in general, see Donald Gibson’s The wayfinding handbook: information design for public places, 2009, Princeton Architectural Press.

32 Henry Beck is credited with creating the first topological map of the London tube system in 1933.
navigate, with less time lost in getting to and from trains. Many modern “bored” systems\(^\text{33}\) have deeper stations, and rely on long, motorized escalators that must be maintained, and add to egress time.

In Seoul, signage is written in multiple languages, including Korean, English, Chinese and sometimes Japanese. In Hong Kong, all signage is in Chinese and English, and in some stations a third language, Simplified Chinese, is also provided. While this multilingual signage can be very helpful to tourists, it also complicates signs and makes them more difficult to read at a glance.

Figure 16: Signage at a subway station in Seoul

Source:

Montreal is now testing new signage. At the end of the project, the Société de Transport de Montréal will have outlined precise signage guidelines throughout the network in order to guide customers during travel. This policy requires that signage conforms to universal accessibility principles and corporate brand image; adapts information according to various customer groups in the network; organizes and classifies information according to content (emergency, directional, service, etc.); shows the location of automatic fare vending machines, service points, elevators, etc.; and reviews messages and designations. This trial period will assess the legibility, contrasts, visibilities, positioning and sign dimensions around the whole Montreal metropolitan region.

In Vienna, designs of metro (U-Bahn), tram and bus stations have standard, distinctive formats. U-Bahn stations are marked with a “U” sign, which glows at night. Only 27 stations out of 101 need to have ticket offices, because of the high percentage of season ticket holders, and the fact that tickets are available on trams.

Wi-Fi and Cellular Phone Reception

As internet access becomes more essential in customers’ lives, a central challenge transit agencies face is whether and how to make this service accessible inside the subterranean areas of metro and commuter train service. A survey of the seven cities of this study shows that all of them are making efforts, but that the extent of the coverage varies tremendously.

A customer inside Seoul’s metro system can use his or her cellphone or smartphone in the stations, on the platforms and inside the trains. For better or worse, messages and calls continue unabated during transit trips. In Hong Kong, all MTR stations and trains were upgraded to 4G cellular service (with speeds faster than Wi-Fi) in 2013. Fourteen stations have “iCentres” that provide passengers with convenient, free access to the internet at computer terminals, or customers can take advantage of free Wi-Fi using their own laptops or mobile devices. Designated Wi-Fi services are available on board all Airport Express and Kowloon Through Trains, and on the concourses and platforms of 49 MTR stations. In Vienna, cell phone service is available throughout the entire metro network, including tunnel sections and underground stations. The municipal government plans to implement Wi-Fi at major transit hubs.

By comparison, New York is just beginning to offer Wi-Fi and cellular services. Customers are accustomed to travel time being inside “a dead zone” where all electronic communication ceases. New York does have pilot programs in some stations, and has signed a contract to roll out service to 277 subterranean stations.\(^\text{34}\) There are no current plans to offer service inside tunnels.

<table>
<thead>
<tr>
<th>City</th>
<th>Wi-Fi or Cell Service on Platform</th>
<th>Wi-Fi or Cell Service on Train</th>
<th>Platform Screen Doors</th>
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<tr>
<td>Washington, D.C.</td>
<td>Select stations</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Public Art

Art in public transportation systems can serve multiple goals. First, a city may have a policy goal to promote the arts. Commissioning public art for transit systems can be an effective way to support cultural activity, with significant returns for the general public, as these works are often viewed by many thousands of people daily. Art can transform the overwhelmingly utilitarian transit infrastructure into a place of artistic expression, more interesting and diverse. All seven transit agencies surveyed in this paper have programs to foster public art, not only including visual arts, but poetry, music and dance performances as well.

In Montreal, the design for each station was assigned to a different and visually distinct architect. Thus, each station is unique, and almost all display the works of world-famous artists. During the construction of system extensions in the 1970s and 1980s, architects were asked to integrate artwork into station architecture. In some cases, the artwork even became functional. For instance, stainless steel tubular elements at Fabre station are not only decorative, but they also serve as hand rails and support the station benches.

New York’s MTA has a robust program called “Arts for Transit” that promotes permanent artworks in stations, as well as posters, music and poetry. Some of these initiatives have won prizes for excellence.\(^\text{35}\)

\(^{33}\) Many modern systems are constructed using tunnel boring machines, and require 20 feet or more (typically equal to the diameter of the bored tunnel) of space between the roof of the tunnel and surface to ensure the integrity of the structure.


\(^{35}\) The “Poetry in Motion” program was awarded the 2013 Grand Prize for Graphics by the American Public Transportation Association, and an LED exhibit at the Bleeker Street subway station was selected in 2013 as one of the best public art projects in the nation by Americans for the Arts.
On The Street: Bus and Tram Stops

Waiting for transit on the street, with its mix of pedestrian, bike and vehicular traffic, is a very different experience than waiting in a metro system, where conditions tend to be much more uniform. Designers of surface transportation stops face different challenges than those designing for the metro.36

For buses and trams, the styles of stops vary tremendously, even within the same city. For example, in New York, a bus stop can be simply a sign on a pole, or a relatively large glass shelter with a roof and bench. Maps are usually located on a pole outside the shelter; in inclement weather a customer must walk out into the rain to see where the bus goes, or when it is going to arrive. Only a few shelters in New York have pilot displays with real-time bus information, although Bus Time is available for mobile devices.

Singapore’s LTA has been making bus shelters more comfortable and convenient. The LTA has introduced weather screens, lighting and seats with armrests. Information panels with increased font size meet the needs of the aging population. The agency has also extended shelters at the entrances of MRT stations to provide shelter from inclement weather conditions during boarding/alighting of buses. Bus stations in Singapore are progressively being upgraded into air-conditioned transport hubs, and are integrated with adjoining metro stations and commercial developments. Commuters can wait for buses and transfer to trains in air-conditioned comfort, or they can do some shopping in the hub before transferring to their buses or trains.

Vienna’s tram and bus stations have separate designs; “Strassenbahn” (tram) or “Autobus” (bus) is on the sign beside the station name. At tram stations, information regarding connections between metro and rail and disability access is available. Five hundred real-time arrival time displays were installed in 2010, and this will rise to 1,000 by 2015.

The Seoul Metropolitan Government is improving both bus shelter facilities and locations, and bus interiors. The SMG upgraded all shelters, and is planning to install 2,784 Bus Information Terminals, as well as 400 touch-screen BITs. The former uses voice recognition, and features electronic maps, road-finding, tourist information and bus arrival information. In addition, bus stops are being made more convenient for all customers, including those with disabilities, with heated seats, braille blocks, and information in four languages. The SMG is also improving transfers by relocating bus stops to more convenient locations or closer to metro stations, and removing unnecessary obstacles at bus stops. Some systems have gone beyond offering arrival displays only at surface transport stations, and now include these in nearby businesses. For example, at a major tram node in the center of Dublin, some adjacent businesses have public display signs on their interior walls. This way, customers can do some shopping or have a meal while they wait for their tram to arrive. A similar system has been instituted with success in Chicago.

36 Versus other surface transit modes, conditions for stations on Bus Rapid Transit systems are more similar to those of metros.

In the Vehicles: The Customer Experience on Trains, Buses and Trams

The quality of transit vehicles, including exterior appearance, cleanliness, interior layout, seating, displays and audio, can have an important effect on the quality of a customer’s experience. In general, most of the surveyed systems have fairly updated equipment and all are in the process of modernizing their fleets. The Ultra-Low-Floor tram in Vienna stands out as a unique vehicle among the surveyed cities. Operating only in Vienna and Oradea, Romania, ULFs have the lowest floor height of any such vehicle,38 putting the tram floor at the same level as the sidewalk. This greatly facilitates boarding for children (strollers), the elderly, those with luggage, wheelchairs and people with disabilities. Three hundred trams out of 450 are ULF, and the remaining 150 will be replaced by 2024. All 480 buses are low-floor. Metro, tram and bus vehicles have well positioned seats for passenger convenience, and display standardized route maps. Magazines are available for passengers to read during their trip. In 2006, Wiener Linien began a process to replace the existing metro fleet with modern vehicles, scheduled to conclude in 2016.

Hong Kong’s MTR cleans the compartments of their trains daily before service begins and washes the exterior of trains every two days. The MTR maintains the temperature of the train.
compartment at or below 26 degrees Celsius throughout the year. MTR purchased six new double-decker buses to enhance feeder service for the West Rail Line and Light Rail, strengthening the existing 121-bus fleet. Double-decker trams have been operating in Hong Kong for over a century. Colorfully painted with advertising, these iconic trams constitute an important link to the city’s past and are a tourist attraction, in addition to providing vital services for transit customers.

Figure 15: Double-decker tram, Hong Kong.

The Montreal metro was the first entirely rubber-tired metro in the world, which made it easier to go up slopes, allowed for faster acceleration and deceleration, and reduced the noise and vibrations transmitted to buildings around the stations. Each metro train consists of three, six or nine cars. A nine-car train corresponds to the length of a station platform, 152 meters (498 feet), and can transport up to 1,200 passengers, including 360 seated. There are two types of cars: the MR63, in service since the opening of the metro, and the MR73, acquired for the metro extensions during the 1970s and 1980s. Recent renewals include city buses (hybrid motorization, low-floor), commuter railway cars (bi-level) and metro cars.

Figure 16: Bi-level train in Montreal

Source: AMT - Agence métropolitaine de transport

Only a decade ago, New York still employed a substantial number of subway trains that were beyond their useful life. At the turn of the millennium, the MTA began an aggressive program to modernize its fleet, and retired its oldest trains. These were replaced by cars made by various manufacturers, featuring plastic seats, chrome handles and the brightest illumination of any subway cars. As for buses, the newest three-door articulated vehicles have clean diesel engines, and can accommodate more than 110 people. These buses are part of the recently implemented Select Bus Service, where off-board fare collection, dedicated bus lanes, and bus lane enforcement cameras have reduced some route travel times by nearly 20 percent. Low-floor buses are increasingly common in New York, and the current capital program includes the purchase of almost 2,500 new buses, plus investments in onboard security cameras.

By 2020, the Singapore LTA aims to have a full fleet of wheelchair accessible, low-floored and step-free buses. New trains will have fewer seats to create more standing spaces and mitigate crowding in trains during peak periods. In addition, new train designs remove the vertical poles near train doors, thus creating more space and preventing overcrowding near train doors. Handrails in the trains are being shifted away from train doors for the same purpose. The temperature of trains and buses of SMRT is set between 24 and 22 degrees Celsius, and some buses are fitted with intelligent climate control.

Many of the metro trains in Washington, D.C. date back to the system’s founding in the 1970s and 1980s, and the WMATA currently has plans to replace much of its fleet. Most trains now are equipped with priority seating for people with disabilities and senior citizens, as well as emergency intercoms accessible to wheelchair users.

Seoul City is making efforts to improve lighting, air quality and noise inside buses, so that not only the general public, but also the elderly, children and pregnant women can comfortably use the bus lines.

Travel for business and pleasure has grown dramatically and consistently in recent decades. For example, international tourist arrivals have shown virtually uninterrupted growth – growing over 43 times from 1950 (25 million) to 2013 (1,087 million), according to the U.N. World Tourism Organization.

Accessibility of Transit, People with Disabilities and Other Customers

The cross-cutting issue of accessibility relates to all of the previously discussed elements of the customer experience – communication, station design, vehicle characteristics, etc. In most cities, legislation requires transit facilities to address the mobility needs of people with disabilities, including passengers with visual, hearing, and mobility impairments. Many transit agencies strive to provide even better and more convenient facilities than are required by law. This can have great benefits for customer satisfaction, as many other types of passengers benefit, including children, seniors, parents with strollers and people traveling with luggage.

Nonetheless, accessibility varies tremendously among the seven systems examined. The older systems, such as New York, have the greatest challenge in that their networks were built before accessibility features such as escalators and elevators were common; only 22 percent of all 486 subway stations are accessible to people with disabilities. Accessibility rates are much higher for other cities, and three even have 100 percent accessibility (see Table 3).

The systems that perform best with respect to accessibility continuously improve station premises to facilitate barrier-free use for customers with disabilities. Metro systems in Singapore, Vienna, Seoul, Hong Kong and Washington, D.C. have features such as handrails on ramps and stairs, ubiquitous wheelchair-accessible escalators and elevators, audible warning signals and large-print and tactile-braille signs for visually impaired passengers. Hong Kong has induction loops installed at all stations, and tactile strip navigation. Seoul has made a point of making it easy for passengers including children, seniors, parents with strollers and people traveling with luggage.

Table 3: Accessibility of Transit Systems

<table>
<thead>
<tr>
<th>Hong Kong</th>
<th>Montreal</th>
<th>New York</th>
<th>Seoul</th>
<th>Singapore</th>
<th>Vienna</th>
<th>Washington, D.C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>98%+</td>
<td>10%</td>
<td>22%</td>
<td>Most</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>metro stations are wheelchair accessible</td>
<td>metro stations have elevators</td>
<td>subway stations are ADA accessible</td>
<td>metro stations have at least one barrier-free entry (90% have 2+)</td>
<td>metro stations are wheelchair accessible</td>
<td>metro stations are wheelchair accessible</td>
<td>metro stations are wheelchair accessible</td>
</tr>
<tr>
<td>80%+</td>
<td>100%</td>
<td>100%</td>
<td>Some</td>
<td>50%+</td>
<td>Most</td>
<td>100%</td>
</tr>
<tr>
<td>low-floor, wheelchair accessible bus fleet</td>
<td>low-floor, wheelchair accessible bus fleet</td>
<td>low-floor, wheelchair accessible bus fleet</td>
<td>wheelchair accessible (goal of 100% by 2020)</td>
<td>low-floor, wheelchair accessible bus fleet</td>
<td>low-floor, wheelchair accessible bus fleet</td>
<td>low-floor, wheelchair accessible bus fleet</td>
</tr>
<tr>
<td>MTR has incorporated aids for visually-, hearing-, and physically-disabled passengers including tactile station maps, induction loops, and wide gates.</td>
<td>STM lets passengers with disabilities apply for a Companion Card so their companion rides free. STM also provides the STM Companion Service which can be requested at a station and an STM employee will bring you from one station to another.</td>
<td>MTA offers Transit Training, a program to help passengers with disabilities learn how to navigate the system. MTA also offers a paratransit service, Access-A-Ride which is either shared-ride, door-to-door, or feeder service.</td>
<td>SMRT uses braille tiles to help navigate visually-impaired passengers within a station.</td>
<td>LTA uses many aids to help disabled passengers including tactile ground surface indicators to guide within a station and light cues on platform.</td>
<td>Wiener Linien introduced the POPTIS program with its focus on improving accessibility for all through including standardized pictograms, height-adapted ticket buying stations, and tactile strips to navigate passengers.</td>
<td>WMATA offers a Travel Training program for passengers with disability to get accustomed to navigating the system. WMATA also offers MetroAccess, a paratransit alternative.</td>
</tr>
</tbody>
</table>

40 Travel for business and pleasure has grown dramatically and consistently in recent decades. For example, international tourist arrivals have shown virtually uninterrupted growth – growing over 43 times from 1950 (25 million) to 2013 (1,087 million), according to the U.N. World Tourism Organization.

41 A dynamic display that lights up to indicate travel progress, as on a subway line.
A few agencies stand out regarding the care they have taken to make it easy for customers with disabilities to use surface transportation. For people with disabilities, Singapore’s LTA has removed barriers at bus stops so that buses can easily deploy wheelchair access ramps for boarding and alighting. The LTA also ensures that all furniture sited within the shelter allows sufficient space for users to maneuver wheelchairs with ease while accessing information in the bus shelter. The entire bus fleet (more than 6,000 buses) of New York’s MTA is accessible, as is Washington, D.C.’s. In Singapore, the SMRT has 245 wheelchair accessible buses with plans to increase this number. The WABs are distinguished by a blue icon of a passenger-in-wheelchair displayed at the front of the bus. Each WAB service can accommodate up to two passengers in wheelchairs.

Because Federal law in the U.S. mandates that any agency providing fixed-route bus or subway service also provide paratransit service for individuals unable to use the regular transit system, the MTA also operates Access-A-Ride service. Access-A-Ride has a fleet of 1,970 paratransit vehicles, 1,300 of which are vans with wheelchair accessibility. The program provides three types of service – shared-ride, door-to-door, and feeder service – 24 hours a day, seven days a week. However, customers have a maximum number of rides based on trip distance. The fares are the same as full fare on public transit. In Washington, D.C., Metro Access is a similar program.

Some agencies offer special services to non-disabled customers as well. In Montreal, Between Stops is available to women who travel alone at night. Also in Montreal, TaxiBus is a public transit alternative for districts where there is no regular bus service. The shared TaxiBus service is available from Monday to Friday, except on legal holidays. It runs mostly between the major train stations on a regular route, and customers must reserve a seat at least 40 minutes in advance. Similarly, Vienna offers 17 night route buses and 14 on-demand buses on weekdays and weekends. The metro runs every 15 minutes Friday and Saturday from midnight until morning. These night services transport about 45,000 passengers a month. New York’s MTA allows customers to exit the bus between stops during the overnight hours, if the driver determines it is safe to do so.

Conclusions, Challenges and Lessons Learned

While it’s safe to say that all the agencies examined in this study are striving to improve the customer experience, it’s also clear that that experience varies tremendously from system to system. In some cities, customers travel on metros where stations and platforms are quiet and well lit, where platform screen doors are ubiquitous, as is access for special needs users. In other systems, train stations are dark, noisy and difficult to navigate, and complete accessibility for customers with disabilities is rare. The availability of information for trains, trams, buses and other modes also varies greatly.

There are several interventions that are critical to improving the overall customer experience. These include:

Open and Proactive Communication

Recent developments in communication can facilitate an entrepreneurial, proactive posture for transit agencies. For example, providing data in an open way can unleash the creativity of third parties, who typically develop more creative mobile apps due to their ability to leverage other data and think beyond the scope of just transit operations – such as a trip-planning app that shows your caloric consumption for each of your travel options. Also, social media such as Twitter can allow interactive, personal feedback that also provides information to a broader audience. Sharing information and a more proactive approach can help leverage communication activities and foster creativity, leading to richer experiences for transit customers.

Design and Amenities at Transit Stations Matter

Elements like station design, wayfinding and public displays should be taken very seriously, focusing on the details of the experience. Care should be taken to create a comfortable metro station that is easy to navigate, an ease that must also continue throughout the system, especially at intermodal hubs. Station overhauls, or thoughtful designs for new stations, can help make systems more attractive by creating open areas that attract users and provide plenty of space for circulation, as opposed to claustrophobic places that result in congestion and repel customers. Other amenities, such as shopping, restaurants, Wi-Fi, public art and platform screen doors, can also help create a more pleasant and environment for customers.

Raising the Bar on Surface Transportation

Transit agencies should be as detail oriented when it comes to the customer experience on buses and trams as they are with metros. The best transit systems use low-floor vehicles, provide
ample information on services via various means, and make sure stops are comfortable and easy to use for all customers. Agencies can encourage the use of surface transit by providing amenities to protect customers from bad weather and strong sun, such as covered walkways and ample (sometimes heated or cooled) shelters at stops.

**A Transit System That’s Accessible to All Customers**

This is a cross-cutting issue that affects not only people with disabilities, but a much larger population that includes travelers with luggage, the elderly and children. Making transit more accessible increases its attractiveness for all customers, even the most able-bodied ones. Given recent demographic trends, such as growth in elderly populations and international travel, transit agencies must create truly accessible systems to effectively serve this population.

The recommended actions range from capital-intensive station retrofits and vehicle procurements to relatively inexpensive investments in website design and new signage. Some, like wayfinding, platform screen doors and station design can have a real impact on system capacity and service reliability. All of these improvements take transit beyond its utilitarian trappings, making it more attractive to its large and upper middle class clientele – an important constituency that serves as the backbone of political support for transit. This support is critical to securing funds for existing services and expansion of public transit, urgently needed in many places. As transit turns the corner from one century to another, making transit customers’ experience easy, comfortable and even uplifting are goals that all systems should strive to achieve.

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No longer do mass transit riders have to fumble for coins, a line of angry commuters stretching behind them. Most transit systems are making use of new technology to make payment faster and easier. There are a variety of payment technologies to consider: smart cards are becoming mainstream, international technology standards are progressing, and near field communication – the cutting edge of fare payment technology – is increasingly being enabled in mobile devices.

As a result of these innovations, fare policy is now limited only by institutions and ideas. Automated fare technology can bring substantial benefits to transit operators, including the potential for virtually limitless fare structures. Also, newer technologies have significantly lower life cycle costs than older ticketing systems. This paper reviews the range of transit ticketing systems and fare policies in operation or soon to be implemented in the cities represented at the 2013 Transit Leadership Summit: Hong Kong, Montreal, New York, Seoul, Singapore, Vienna and Washington, D.C.¹ By discussing the benefits of new capabilities in the context of these major transit agencies, this report aims to highlight how transit agencies might learn from one another as they consider future fare policies and structures.

Table 1 briefly describes the fare payment technology used by, and planned by, Transit Leadership Summit participants.

### Technologies and Potentialities

Table 2 shows the variety of potentialities – fare products, data observations and passenger conveniences – that are available with different types of automated fare collection. Magnetic stripe cards, which require a physical swipe, have been common in transit systems for more than 30 years. Smart cards, first introduced in the late 1990s, are microprocessor-embedded devices issued by the transit agency that communicate with readers at a very short range so that they do not have to touch the readers, i.e., they are contactless. Smart cards may be configured for use only in a transit system (such as in Montreal and Washington, D.C.) or they

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¹ This report is informed by questionnaires completed by representatives from MTR Corporation (Hong Kong), Agence métropolitaine de transport (Montreal), Metropolitan Transportation Authority (New York), Seoul Metropolitan Government (Seoul), Land Transport Authority (Singapore), Wiener Linien (Vienna), and Washington Metropolitan Area Transit Authority (Washington, D.C.).
may be accepted for small purchases such as for retail and parking (in Hong Kong and Singapore). Open payment/NFC refers to transit operators using readers that accept payment from third party smart cards (such as MasterCard PayPass or VISA Wave) and near field communication-enabled mobile phones (referred to in the industry as NFC).

Of the Transit Leadership Summit participants, most use smart cards (Montreal, Hong Kong, Washington, D.C., Singapore and Seoul). New York City uses a magnetic stripe system; Vienna uses a time-stamp paper ticket and cardboard yearly pass with a photograph and the honor system, and is considering a smart card system. Seoul has incorporated open payment/NFC with its smart card system, and Washington, D.C. is planning to transition to open payment/NFC systems in the future. None of these operators uses all of the potential applications listed in Table 2, either due to explicit policy, proprietary agreements restricting the use of technology, or political considerations.

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**Table 1: Fare Payment Technologies**

<table>
<thead>
<tr>
<th>City, Transit Agency</th>
<th>Primary Fare Technology</th>
<th>Fare Structure</th>
<th>Recent Developments or Future Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong, MTR</td>
<td>Smart card</td>
<td>Distance-based</td>
<td>Considering open payment/NFC</td>
</tr>
<tr>
<td>Montreal, AMT</td>
<td>Smart card</td>
<td>Distance-based</td>
<td>Considering Open Payment/NFC</td>
</tr>
<tr>
<td>New York, MTA</td>
<td>Magnetic stripe card</td>
<td>Flat fare</td>
<td>Has piloted Open Payment/NFC</td>
</tr>
<tr>
<td>Seoul, SMG</td>
<td>Smart card &amp; Open Payment/ NFC</td>
<td>Distance-, Time- and Mode-based</td>
<td>Mid-2000s reorganization integrated fare systems</td>
</tr>
<tr>
<td>Singapore, LTA</td>
<td>Smart card</td>
<td>Distance-based</td>
<td>Plans to reduce redundancies among multiple operators via cloud computing</td>
</tr>
<tr>
<td>Vienna, W.L.</td>
<td>Photo-card</td>
<td>Zone-based</td>
<td>Considering multi-function smart card</td>
</tr>
<tr>
<td>Washington, D.C., WMATA</td>
<td>Smart card</td>
<td>Distance-based</td>
<td>Implementing Open System/NFC</td>
</tr>
</tbody>
</table>

* Fare structure: Note that all transit agencies have more complex fare structures than shown in this table. The table reflects the primary basis for fare prices. Transit operators may also provide concessions by passenger class, free or reduced transfers, discounts for bulk purchases, period passes, benefits for retail related loyalty, different fares depending on payment media, and other variations.

---

**Table 2: Potential Applications of Fare Technologies**

<table>
<thead>
<tr>
<th>Potential Applications</th>
<th>Magnetic Stripe</th>
<th>Smart Card</th>
<th>Open Payment System / NFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discounts by passenger class (senior, student)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Daily, monthly passes</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Seamless intermodal transfer (a)</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Distance-based fares</td>
<td>x(b)</td>
<td>x(b)</td>
<td>x(b)</td>
</tr>
<tr>
<td>Time-of-day-based fares</td>
<td>x(c)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Real-time origin and destination data</td>
<td>x(b)</td>
<td>x(b)</td>
<td>x(b)</td>
</tr>
<tr>
<td>‘Best Fare’ policy(d)</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Use fare card as debit/credit card</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use fare media for retail purchases, parking, tolls, bike share</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Use credit card for transit system entry</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use mobile phone for transit system entry</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fare cards are insurable</td>
<td>x (e)</td>
<td>x</td>
<td>n/a</td>
</tr>
<tr>
<td>Passengers top up cards, check past transactions online</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Use employment/student identification cards for transit system entry</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personalized marketing (f)</td>
<td>x(g)</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

(a) Seamless Intermodal Transfer: Passengers can transfer between buses and trains without acquiring a ticket or other proof of payment.
(b) Distance-based fares and real-time origin and destination data collection require the passenger to swipe or tap (also called “tag”) at egress (when exiting the station or bus). Among Transit Leadership Summit participants, Singapore and Seoul require tapping when exiting all modes; Hong Kong and Washington require it for rail only; Montreal and New York City do not require interaction with readers when exiting any mode.
(c) Time-of-day-based fares could be accomplished with a magnetic stripe system, but it would preclude other functions such as daily passes simultaneously. This is because the magnetic stripe system cannot access more than one “purse”; while the cards can potentially hold both a monthly pass and cash, for example, one of those “purse”s must be expended before the other can be accessed.
(d) “Best Fare” policy refers to restricting the total amount a passenger can pay in a given duration. In London, for example, passengers using multiple single-journey fares find the total they’ve paid at the end of a day capped at the price of the daily pass.
(e) Each magnetic stripe card has a unique serial number that could allow for insurability.
(f) Personalized marketing based on data from fare collection may be restricted by regulations intended to preserve privacy. Some data (i.e. gender, residential location and consumer behavior) may be collected by transit operators when passengers register their smart cards, or by third parties when passengers use their credit cards. These data may be linked, however, depending on regulations of both the credit card/payment industry and transit agency jurisdiction.
(g) Magnetic stripe or simple cardboard cards can be linked to a specific passenger who pays by automated debit. For example, in Vienna, passengers use cardboard cards with their photos affixed and the transit operator markets directly to these passengers using data provided when setting up automatic payments for yearly passes.
Benefits of Advanced Fare Technology

Advanced fare technology offers a wide range of benefits. For passengers these include convenience, and for the operators better ways of managing demand and/or addressing equity concerns through differentiated fares, cost savings, revenue-raising and improved data collection.

Passenger Convenience & Throughput

Conventional level of service indicators for transit agencies are speed, reliability, frequency and coverage. Advanced fare technology can provide improvements to speed of ingress. In Singapore, for example, commuter throughput at train stations doubled when the system switched from magnetic stripe to contactless smart cards. Bus dwell times (the time spent at the curb waiting for passengers to pay and take their seats) are reduced as well. In Seoul, the T-money card permitted more complex transfer allowances, distance-based fares and pricing, resulting in faster buses (by 8.3 percent) and more bus riders (by 1.6 percent). An equally important improvement that results from advanced fare technology is increased passenger convenience.2 Passengers using smart cards pay less frequently and have more choice in how they pay; they can refill cards automatically from their bank accounts and can attach transit cards to credit cards. NFC-enabled phone users purchase fares directly from any NFC-enabled poster or sign, including from maps. Passengers handle their cards less often; entry and exit are made without removing the card from a wallet or handbag. Smart cards come in many forms such as fobs, bracelets, mobile phone cases and other devices that are easier to access than cards. Open payment systems further expand convenience by decreasing the number of separate payment media a passenger must carry, and increasing the information directly available to passengers regarding routes and arrival times. These improvements may seem peripheral to transit system operations, but there is evidence that they attract and retain passengers. Passenger experience may be a greater determinant of travel behavior than conventional metrics; passenger attitude is largely shaped by features such as convenient payment systems, and passenger attitude helps explain mode choice.3

Differentiated Fares

Advanced fare technologies vastly increase the potential fare structures available to transit agencies. Single-journey tickets or tokens are restricted to a single price. Magnetic stripe cards can provide period passes (such as monthly passes) or bulk discounts (e.g., 10 percent bonus for purchase of $20 or more) and may be enabled for zone charges. Smart cards and open payment/NFC systems enable the transit agency to charge different amounts depending on the time of day, mode, route, number of transfers, and (where passengers tap their cards at exit) by fine gradations of distance. These differentiated fares, when informed by rich data sets provided through advanced fare technology (discussed below), can be used to manage demand, increase revenue and address equity considerations.

There is a wealth of literature around the use of price to manage demand. The full body of evidence and theory will not be explored here; much of it reinforces the general principle that fare price can shift ridership patterns enough to moderately reduce crowding and increase operational efficiency in the long term.4 Along with simple peak period pricing, transit operators can use differentiated fares to exploit different sensitivities to fare price by payment method, income class and fare structure.5

New fare technologies expand the potential for addressing equity concerns and raising revenue by differentiating fares by passenger class. Most agencies offer reduced fares to students, seniors and disabled passengers using specialized cards. In some cases the transit operator internalizes the cost of the reduction, while in others it is paid by a government agency that administers programs for students, seniors or the disabled. While reduced fares are possible with conventional fare technology, advanced technologies can make them more convenient and flexible. Instead of requiring a station agent to visually confirm a discount pass, advanced fare payment systems read the pass and process the appropriate fare. Open payment systems can be interoperable with smart cards provided by social service agencies. For example, in Germany, France and other countries citizens are issued a smart card for use of the healthcare system; in the U.S., “food stamp” cards are embedded with microprocessors; these could potentially be used for free or reduced transit access for certain passengers, perhaps according to a reimbursement arrangement with the social service agency. Colleges and universities regularly issue smart cards as student identification as well as to ration printing, gain access to facilities, and receive discounts from retailers; these could be accepted on transit as well. Washington, D.C. has a complex fare structure to address differing abilities to pay that could be rationalized by using smart cards. Currently, low income jurisdictions sell lower priced fares locally and reimburse the transit agency (WMATA) for the difference. By directly subsidizing the passenger, rather than all travelers originating in the low-income jurisdiction, WMATA could create

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2 Vienna’s system, while not an “advanced” fare technology, is able to offer many of the same conveniences listed here because of its gate-free honor system and use of ancillary internet-based payment applications.


a more equitable, simplified and expanded system. Passengers in need could be directly subsidized through a social service office, employer or institution which in turn purchases full-fare passes from WMATA. Because smart cards can be remotely programmed, it is possible to personalize the level of fare discount benefits. For example, when an unemployed passenger finds a job, his smart card could be updated from charging discounted “job search”-level fares to charging the full fare, or perhaps a discounted fare for a low wage job.

Overpayment can become a problem as fare structures become more complex.6 Smart cards and open payment systems can enable a “best fare” policy wherein a single passenger does not exceed a given expenditure limit on transit fares in a set duration. For example, London’s “capping” system corrects the problem of passengers purchasing incorrect fares and spending more than necessary for a trip.

Both “social fare” policies discussed here – a “best fare” policy that guarantees the price regardless of ability to pay for all trips in advance, and a set of discounts available to lower income and marginalized groups – would free transit agencies from the affordability and equity considerations that have historically depressed base fare prices. Transit systems that were built prior to magnetic stripe technology – including New York and Vienna – historically used a single flat fare for all journeys. The base fare was kept low to maximize overall affordability, with extra concessions for seniors, students and the disabled. New technology enables transit operators to consider higher fares as socially just when implemented alongside expanded discounts.

The adoption of these social policies must be weighed against the effect on revenue and diversion from transit agencies’ core mission. It would require a shift to an explicit statement of institutional goals for affordability, not often considered by transit agencies, along with demand management and cost recovery. Among the agencies surveyed for this report, all provide discounts for seniors, students and the disabled, but none includes affordability in its fare-setting formula.7 Only Singapore explicitly addresses affordability in its fare policy. There, the Public Transport Council estimates the burden of the fare on a representative household in the second-income quintile to determine whether the fare is becoming less affordable.8 As income inequality grows in urban areas, fare affordability is becoming a more relevant and more complex metric.9

Transit operators may be institutionally disinclined to address affordability and interagency concessions. Transit agencies often tout their ability to operate “like a business,” unlike typical government agencies. “Social fares” emphasize that transport is a public service that in some cases is delivered based on need rather than ability to pay. This may be ideologically uncomfortable for transit agencies. The prospect of “social fares” also raises the issue of transit agencies entering agreements with non-transit government agencies, specifically inter-agency reimbursement relationships. Inter-agency relationships require resources management and political acumen, and may not be viewed as central to the transit operator’s goals.10

Operational Cost Savings

Smart card and open payment/NFC systems generally cost less to operate than conventional ticketing technology. There is no comprehensive analysis of costs available; transit agency organizational structures vary widely, and each agency accounts for fare collection costs differently.11 Anecdotal evidence and a review of the literature suggests a few generalizations: the capital cost of smart cards is higher than magnetic stripe or paper tickets,12 but life-cycle costs are dramatically lower; likewise, the initial capital expenses of installing new readers is more than compensated by declining costs of collection. While a comparative cost-per-transaction is not known, and there are fees related to each transaction, in general costs have declined with new fare technology. In Singapore, agency accounts related to fares and ticketing (life-cycle costs) declined by 6 percent after implementation of smart cards. In Hong Kong, the cost of operating magnetic stripe technology is at least double the cost of the smart card system. Part of these savings is due to lower cost for ticket recycling, equipment maintenance, cash handling and the cards themselves. Hong Kong began phasing out magnetic tickets in 2013. In Washington, D.C., for example, the average cost per dollar for collecting cash fares is more than twice the cost of collecting credit/debit fares ($0.10 versus $0.04). Accepting cash slows the transaction process time, and requires a very labor-intensive cash handling process. Credit card fees are low by comparison.

Other cost savings are derived from lower maintenance expenditures. Smart cards are much more durable than magnetic tickets; in Hong Kong, smart cards need to be replaced after 30,000 cycles (trips with use at entry and exit) while magnetic tickets only last about 60 cycles. In Singapore, the failure rate for smart cards is one in 25,000 transactions compared to one in 5,000 for magnetic stripe cards.13

Finally, the cost of the fare media is rapidly declining. In Singapore, a new smart card that cost $4.00 SGD in 2009 is now $1.80 SGD.14 An open payment system reduces costs further by minimizing in-station ticketing infrastructure and the number of cards a transit operator issues. It also off-loads back office revenue allocation as the transit agency becomes one of many merchants.

7 Hong Kong, Singapore, Montreal and Washington, D.C. use a fare setting formula that accounts for costs and wages. The fares are adjusted according to the formula with some regularity, although the timing and frequency of adjustments may not conform to an established schedule.
8 In the U.S., the transit operators comply with federal regulations (Title VI) by examining whether changes to fare structure disproportionately burden racial/ethnic minorities. They must also ensure that discounts are available to all regardless of ability to pay. While these in effect produce lower and therefore more affordable fares, the policies do not require examining affordability per se. Fares are therefore maintained at universally low levels for universal affordability.
10 Despite the ideological challenge, some transit agencies are leveraging advanced fare technology for social fares. Reisman, Will. “Muni and Other Agencies Consider Basing Fares on Income.” The Examiner, November 30, 2012.
11 In the U.S., the Smart Card Alliance has attempted to consolidate information on costs. See “Planning for New Fare Payment and Collection Systems: Cost Considerations and Procurement Guidelines”: Smart Card Alliance, March 2010.
12 A full-featured contactless smart card costs between 90 cents and $1.00 to produce, and Procurement Guidelines”: Smart Card Alliance, March 2010.
14 In the U.S., the Smart Card Alliance has attempted to consolidate information on costs. See “Planning for New Fare Payment and Collection Systems: Cost Considerations and Procurement Guidelines”: Smart Card Alliance, March 2010.
15 A full-featured contactless smart card costs between 90 cents and $1.00 to produce, which is 25 times more expensive than a magnetic stripe card that costs four cents on average. Quibria, N. “Emerging Payments Industry Briefing: The Contactless Wave: A Case Study in Transit Payments.” Boston, MA: Federal Reserve Bank of Boston 9 (2008).
17 $4.00 SGD equals approximately $3.20 USD or €2.48. $1.80 SGD equals $0.44 USD or €1.12
in an established payment-system architecture. Washington, D.C. anticipates substantial cost savings when it implements its planned open payment system. The savings will come from shedding a proprietary technology, reduced reliance on agency-issued fare media and increased availability of self-service functionality.

**Data Collection**

Automated fare collection creates data on station entry that can help transit operators diagnose crowding as well as route and station underutilization. Smart cards are capable of storing considerably more data than magnetic stripe cards: with magnetic or other stored value “memory” cards, the data stored is limited to the number of memory cells. Magnetic stripe cards can typically carry about 140 bytes of data, while smart cards carry anywhere from 1KB to 5MB. Smart cards include microprocessors which are capable of performing multiple functions. Smart card and open payment/NFC systems also enable agencies to adopt account-based models where data are stored on the host system and not on the card.15 Smart card data can thereby show individual passenger flows, allowing a more robust investigation of travel behavior and greater ability to estimate and manage demand.16 When coupled with exit gate tapping, operators can observe the origin and destination of journeys in real time.17 These data are regularly used by transit agencies, including those represented at the Transit Leadership Summit, for daily operations, strategic planning, and transport demand modeling. Finally, open systems can match travel patterns with consumer behavior, creating data sets of great value to marketers.

Despite improved potential data collection, transit agencies with even the most advanced fare systems may not realize the full benefits of that potential. Transit operator use of the data often depends on institutional, rather than technical, arrangements. For example, a back office “data warehouse” may be operated under a proprietary agreement that precludes easy access to data for transit agency managers. The use of data to inform routing, scheduling or fares may also be impeded by institutions that are reluctant or lack the capacity to utilize the data (as in Singapore). In open systems, credit card privacy regulations prevent linking personal data with trip patterns; in Hong Kong, the benefit of the data collected accrues mainly to the private, retail-oriented corporations that accept Octopus cards. Thus despite a wealth of new data, institutional arrangements – largely established prior to implementation of advanced fare technology – restrict realization of the benefits of these data. Some transit agencies – including in Washington, D.C. and Hong Kong – are using voluntary passenger registration to collect more data: passengers can opt-in to a registration system wherein they agree to make some passenger-level data available for the operator’s use. Transit agencies have used incentives, including card discounts, to encourage registration. However, these methods involve self-selection and therefore may not be valid for all purposes.

**Common Experiences and Lessons Learned**

Each transit agency approaches the issue of fare technology and fare structure in its unique historical, institutional and political context. Its existing physical infrastructure and regulatory climate shape the options that a transit agency can realistically pursue. The agencies at the Transit Leadership Summit represent a wide variety of contexts, each presenting its own challenges to implementation of new technology or innovative fare structures. There are several commonalities, however, which may be informative for agencies regardless of context.

**Beware of proprietary arrangements**

For transit operators, off-the-shelf technology can be very attractive. Developing technology in-house can be expensive, redundant to efforts already underway in the payment industry, and can distract from the transit operator’s core mission. Buying technology, however, often requires entering a proprietary arrangement which can inhibit flexibility. Singapore’s experience with Sony FeliCa smart cards is informative. The off-the-shelf technology was successful for seven years (2002-2009) but ultimately proprietary restrictions limited the scope of applications. Only after developing a set of national standards could Singapore begin charging distance-based fares by the kilometer, for example. Seoul and Washington, D.C. had similar experiences: in Seoul, the proprietary MiFare card limited intermodal transfers and fare structure complexity; in Washington, D.C., the Cubic GoCard chip technology became obsolete and was no longer manufactured, requiring an expensive hardware and software retrofit to read and process a new contactless chip. Washington, D.C. and New York exemplify how proprietary arrangements can limit back office data management. Restricted to a single vendor and outdated hardware, the transit agency is unable to access real-time data or even updated origin and destination flows without a tedious process. Any change to the fare structure is expensive for the transit agency in both cost and time.

**Expect passenger acceptance**

In all cases studied for this report, passenger acceptance of new fare technology quickly exceeded expectations: pilot projects with small groups of commuters proved successful, and passengers using the first stations with available readers adopted the new technology quickly. Fare incentives can spur usage, but agencies report passenger convenience as the most important factor.

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15 Account-based models are also possible in low-tech, honor systems such as in Vienna.
17 Entry-only systems can use algorithms to link passenger station origins with likely destinations. This is true of both magnetic stripe systems such as New York City and smart card systems such as Montreal.
Specifically, both Hong Kong and Washington, D.C. found that the ability to maintain higher stored values on smart cards was the convenience that led many passengers to switch to the new technology; in Washington, D.C., the further improvement in card durability (from paper magnetic stripe cards to smart cards) led to passenger acceptance. This is the case even though advanced fare technology often provides less information at the reader – the point of use – than conventional fare payment. Contactless smart card readers can provide remaining balance information when the passenger taps the card at the gate, but not all do; open payment systems generally do not provide this information at the gate. The cost of the trip is generally only available through station-based kiosks and online/mobile applications, rather than at the turnstile. Also, distance-based fare structures do not allow passengers to easily know the cost of the journey before embarking. Discovering the cost requires using a trip planning tool or reading a complex matrix. There is evidence that this switch from information provided at the turnstile to information-on-demand has little effect on passengers (except to speed ingress). In Washington, D.C., a survey of smart card users found that passengers were ignorant of the amount left on their cards at any given time, but did not consider it a substantial problem.

**The cash fare can be accommodated**

To comply with universal service obligations, transit agencies must provide a way for passengers to pay cash for their fare. The potential for differentiated fares raises the additional problem of equitable fare prices for those passengers who will continue to pay for a single journey with single-use fare media: unbanked passengers, infrequent travelers, and the unplanned trip. Transit agencies must consider the extent to which they can justly offer lower fares to passengers who pay in cash, without undermining the revenue they need to operate the system. Passengers must change their behavior at one time, and not all passengers must offer the choice of paying with smart cards. It is less than 10 percent. In Hong Kong, 94 percent of passengers purchase single-journey tickets in the station; in Washington, D.C., it is less than 10 percent. In Hong Kong, 94 percent of passengers use smart cards, and in Montreal around 90 percent. Advanced fare technology decreases the share of passengers using cash by attracting them with greater convenience and boarding speed. This is followed by a public awareness campaign to widely introduce the technology to passengers. Finally the new readers, information booths and other infrastructure are installed in stations, and the new fare media is sold. While integrating legacy systems comes at a cost, systems can operate with older methods of fare payment in tandem with the new method over a fairly long transition period. **Smart card and NFC readers have been successfully integrated with magnetic stripe technology in Hong Kong, Montreal, Seoul and Washington, D.C. In Montreal, for example, some of the transit operators in the AMT region added smart card readers to their existing magnetic stripe readers, while others replaced their readers with new ones that had both magnetic stripe and smart card capability. NFC readers are now available that use the same infrastructure as smart card readers.**

**Institutional intransigence limits the benefits of new technology**

From the passenger’s perspective, the convenience of new fare technology is realized as soon as readers and fare media are available system-wide. From the agency’s perspective, however, the benefits (other than cost savings) may require

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18 Passengers without a bank account.
19 The share of urban residents with smart phones grows each year, as does the income diversity of this population: Few finds that lower- and middle-income urban residents are discontinuing land lines and cable television in favor of smart phones. Herrigan, J. “Home Broadband Adoption 2009.” Pew Internet & American Life Project (2009).

23 For example, last year, Philadelphia began rolling out a smart card system by first issuing renewable smart cards only to students and university employees and a small pilot group of commuters. It was later expanded to monthly pass buyers and then weekly pass buyers at certain venues. Vending machines will be the next stage. Schmitz, Jon. “Pa: Weekly Transit Passes Now Smart Cards.” Pittsburgh Post-Gazette December 21, 2012.
24 Singapore focused on stakeholder buy-in when replacing the magnetic card system. It took nine months. Student cards and a commuter pilot period were important, along with passenger education. Prakasam, S. “The Evolution of E-Payments in Public Transport’s Experience.” Japan Railway & Transport Review 50 (2008): 36-39.
institutional shifts to fully realize. Institutional arrangements can limit the extent to which the technology is used for innovative fare structures, or how data is mined for improved operations or marketing. Advanced fare technology lends itself to experimentation: There are myriad fare structures available and data can be gathered at a very fine level. Experiments with innovative fare structures are difficult to accomplish, however. Some transit agencies must undergo a political process to change fare prices, while others are tied to a formula; changing fare structure is complex and politically charged in all cases. Issues of fraud and cost can present political hurdles even when there are feasible solutions. The use of data is likewise constrained by the parties using it. As discussed above, contractual arrangements and regulations intended to promote security can create barriers to an agency’s access to fully disaggregated travel behavior data.

Conclusion

As the payment industry advances, passenger expectations are likely to change. Passengers are already learning to expect transit systems to provide real-time arrival information, interactive maps, and seamless intermodal and inter-agency transfers. The payment industry is further raising consumer expectations for fast, contactless, cashless payments; rewards for frequent purchases; easy transaction tracking; and negative balance protection. Transit operators in Singapore, Hong Kong, Seoul and other major cities have found that incorporating these features into their transit ticketing technology has boosted passenger convenience and operational efficiencies. Transit operators planning to adopt new fare technology in the future, such as those in New York and Washington, D.C., hope to maximize the benefits of new technologies. There are challenges for all involved. Proprietary structures can limit innovative fare structures and experiments with routing, scheduling and fares enabled by both the payment technology and data collected with it. These structural impediments to change must be addressed alongside decisions regarding fare technology implementation.

Appendix: Advanced Fare Technology Studies

Improving Fares and Funding Policies to Support Sustainable Metros

Argues that transit operators would benefit from a more principled approach to fare setting and regulation. Fares should be adjusted regularly and systematically; fares should better reflect the costs of inputs and affordability, support the imperative to renew assets and enhance service quality and, through differential pricing, more closely reflect the variable cost of travel.


Pervasive Technology and Public Transport: Opportunities Beyond Telematics

Reviews the range of advanced traveler information systems that provide real-time information to passengers. The range includes static and dynamic versions of transit agency data as well as crowd-sourced data. Also discusses the benefit of in-transit services such as Wi-Fi connectivity, as compared with conventional operational improvements.


Avoiding the Crowds: Understanding Tube Station Congestion Patterns from Trip Data

Devises a simple tool to predict crowding on a per-station basis using one month of data from London’s Oyster cards. In residential stations, there is a steep morning peak period where passengers enter the station, and a less-steep evening peak when passengers exit; in business district stations, the pattern is reversed. In transport hub stations, the peaks are consistently steep at both morning and evening. Evening peaks are further characterized by three distinct sharp peaks at 30-minute intervals, suggesting both business and social adherence to hourly schedules. Considers how providing information to passengers on crowding might alter travel behavior, relieving crowding and better utilizing trains at the shoulders around peak periods.


Establishing a Fare Elasticity Regime for Urban Passenger Transport

Estimates cross-elasticities for mode and fare classes (single- vs. multi-trip ticket) using an extensive survey from metropolitan Sydney and advanced microeconomics techniques. Finds that increasing the price of a multiple-trip transit ticket leads to higher revenue growth and smaller patronage declines than increasing the price of single-trip tickets, especially in bus riders. Also finds that passengers are more likely to switch modes (train to bus and vice versa) than to switch fare classes. Changes in public transport fares regardless of fare class do not necessarily lead to greater car use, whereas changing the cost of car use does affect the use of public transport.

Consumer's Perception of Fare When Using Farecard in Urban Railway Route Choice
A statistical analysis of attitudinal data for passengers on non-work trips on Tokyo's rail system. Tested hypotheses related to how passenger price perception varies according to payment method and fare media. Findings are mixed, but overall finds smart card users perceive the price of travel as lower than regular ticket users. Includes a literature review on fare media and payment methods and finds very little research on the subjects, suggesting a need for further study.


Modeling Transit Rider Preferences for Contactless Bankcards as Fare Media
Surveys from Transport for London and Chicago Transit Authority show that most riders prefer to use transit agency-issued fare media rather than bank-issued smart cards to pay their fare. In its 2009 survey, TfL showed that 55 percent of riders prefer the TfL (Oyster) card, 31 percent prefer contactless bank cards, and 14 percent prefer the paper tickets. In a 2008 CTA survey, passengers were asked how likely they would be to use contactless bank cards to pay the fare. Forty-eight percent were very unlikely, 15 percent somewhat unlikely, 17 percent somewhat likely, and 20 percent very likely. In both places, those passengers more likely to prefer bank-issued smart cards included younger passengers and those who already have credit and debit cards.


Mining Mobility Data to Minimise Travellers' Spending on Public Transport
Links ticket purchasing behavior and public transport usage datasets to examine the relation between mobility and purchase habits. Finds that travelers overspend by approximately £200 million per year by buying incorrect fares. Passengers are relatively uninformed; there are few transparent links between passenger class and trip characteristics that reveal the best fare; and travelers have trouble identifying the best way to pay. Develops an algorithm for personalized ticket-purchase recommendations based on travel history data that can be accessed from fare technology.


Smart Card Data Use in Public Transit: A Literature Review
Reviews smart card and NFC technology, privacy concerns and uses of data by transport operators. Anticipates linking socioeconomic data to the totally disaggregate data produced by advanced fare technology to overcome the privacy regulations preventing exploitation of this data. Finds the most promising research avenues include comparison of planned and implemented schedules, systematic schedule adjustments, and the survival models applied to ridership.


Fair Fare Policies: Pricing Policies That Benefit Transit-Dependent Riders
Analysis of a “best fare” system using smart cards. Finds that capping the aggregated cost of single passenger’s trips at the cost of a multi-trip pass would create an equitable system for those passengers who cannot afford to pay for multi-trip passes in advance. Models a “best fare” system coupled with a base fare increase and finds it saves money for low income riders while raising revenue for the transit agency. Research is premised on the idea of multiple elasticities for multiple fare products, rather than broadly characterizing low income passengers as inelastic to fare prices.


Controlled Public Transport Fares in the Developing World: Help or Hindrance to the Urban Poor?
Uses data from a transport planning survey of 57,000 households in Cairo, Egypt, to consider public transportation pricing for the urban poor. Referring to several case cities in the developing world and Europe, recommends Cairo incorporate transport into various welfare programs, none of which currently directly addresses transport. Emphasizes shifting subsidies from agencies to passengers.


Does Transit Mean Business?
Surveyed U.S. transit agencies on the potential for differentiated fares given new fare technology. Finds that political and institutional resistance is the greatest obstacle to marginal cost pricing or any type of variable pricing. Transit agencies are found to be reactive to budgetary pressures, reluctant to change fare structures when changing the price, and focused on avoiding risk and minimizing public scrutiny. Transit agencies hold competing goals and ambiguous missions, leading to reactive rather than rational fare setting.

Transit agencies must spend their scarce capital funds judiciously. The investments they make must be targeted to keep and attract riders, maintain a large and complex network to insure its dependability, and to anticipate and serve growing markets, all the while keeping the public trust that the public’s money is well spent. When the needs are greater than the funds available, which is often the case, the choices become still more critical; to make one investment may preclude another. These choices have many dimensions. Repair the system or upgrade it; expand the network to serve new or underserved markets or focus only on the current network; replace a component that might fail at some distant time or take the risk of delay; satisfy one constituency at the expense of another; invest in one mode but not the other; introduce a new technology or stay with the current one.

This paper sets out to discover how major transit agencies make their choices about spending their available funds to maintain, upgrade, and expand their systems. Although it is difficult to generalize based on the sample of eight agencies examined in this paper, particularly given their many and varied characteristics, it may still be possible to draw conclusions that could be applied to other transit systems.

The agencies interviewed for this paper operate in widely varying environments, government settings and responsibilities with respect to their formulation of their transit agencies’ capital spending program and priorities. The agencies surveyed serve metropolitan areas ranging in population from less than two million to 25 million. Some have systems built in the last 20 years, while others are responsible for transit systems built early in the 20th century. Some are in charge of both transit and highways in their region; others control only transit, and still others operate some modes of transit but not all. Some of the interviewees are government entities that oversee the transit operating agencies at a policy level but do not operate the systems, while others both formulate policies and operate the system. Still others are set up to be private profit-making institutions. Some are transit agencies that make the decisions about system expansion, while others are directed by a different general-purpose and higher government entity. A few agencies have stable and sufficient funding, while others do not. As might be expected, these differences carry over into how they address the process of capital priority decision-making.

The questions addressed in this paper include:
To address each of these questions, the material collected from the agencies was culled to provide some representative practices. This material is not intended to be exhaustive, but rather to highlight different approaches where they exist, and to prompt a discussion. In the final section, the themes that emerge from this review are highlighted.

Internal Organization for Capital Priority Setting

The governance structure in each of these metropolitan areas is distinct, and has a bearing on the transport decision-making process. In some cases the decision-making process is more centrally located within the highest level of government, such as the country or city/state, and in others the decision-making is more decentralized, with the transit operator having more latitude about where it directs its capital investments. However, in all cases there is at least some control of the choices made at a level higher than the transit operator. And in all cases the choices about system expansion investments are made at a more centralized level than investments in maintenance, repair, replacement and upgrading projects.

All the agencies have a process for establishing a capital program for the short and longer term. Typically, the short-term program is developed and revised annually, and the long-term program, which is revised less often, is for five years or more. Some base the program on a longer-term vision. Hong Kong’s capital program covers a period of 50 years. Washington has a vision plan for 2025 and then beyond to 2040. Singapore has a long-term Master Plan keyed to its projected cash flow of ten years. Seoul has a ten-year urban rail plan. Montreal has a ten-year strategic investment plan with a vision statement, goals and objectives. New York uses its 20-year capital needs assessment to drive its five-year capital program. Vienna relies on its five-year capital program.

As might be expected, all the agencies have an internal management process to collect information to be able to pool all the possible elements of the capital program. Each has internal staff committees to consider the proposals; each places the decision-making in the hands of the top executive; and each seeks the advice and consent of its board or similar group. Each agency has an external process for gaining input into the capital program from the stakeholder groups, local governments and from the general public, and each vets the resulting program with these groups.

Hong Kong relies heavily on an internal process. Mass Transit Railway’s program is developed by its Capital Works Budget Vetting Committee, which is chaired by the head of Operations Strategic Business Management, with representatives from all line and support departments. MTR’s shorter-term program is reviewed by the Operations Director, and the longer-term program is reviewed by both the Operations Director and Finance.

A business plan covering a ten-year period and updated annually guides Transport for London’s capital program. Its board is chaired by the mayor of London. Accordingly, its priorities are guided by the mayor’s transport strategy, which lays out the strategic direction of TfL; TfL’s business plan then sets the corporate strategies to achieve the mayor’s goals. The capital program is established through submissions of the operating subsidiaries to the leadership team, which is chaired by the commissioner and made up of representatives from Finance, Planning, Communications, the legal department and the operating agencies. The decisions are based on consensus.

In contrast to London, the New York Metropolitan Transportation Authority’s capital program does not emanate from a grand vision, but from a “bottom-up” 20-year needs assessment that is organized by more than 100 asset categories, each with its own strategic plan. This is done by each of the modal operating agencies. A major influence on this assessment is consideration of the useful life and risk of failure of the infrastructure. The 20-year needs assessment process tends to be constrained by operational concerns and the agency’s historic capacity to do each work element. This is a particular challenge for the 24-hour operation of the subway system. Fiscal constraints may further affect the needs assessment. From the 20-year needs, a five-year capital program is developed and usually updated annually, based on a more realistic assessment of available funds. This is done with guidance from the MTA umbrella agency, including consideration of impacts on the agency’s operating costs. The shares allotted in the program to each operating agency are largely predetermined based on history and the need to balance city and suburban interests, so the funding received by each agency may not be in proportion to where need is greatest.
Integration of Land Use Development and Transit Planning

Hong Kong and Singapore are two very dense and confined city-states with substantial resources and a well-planned integration of transit and land use development. Their networks are relatively new, and they are expanding despite their limited quarters; they act on and benefit from the mutually supportive link between transit and land use. The linkage between the two is well understood by transportation professionals, but not fully appreciated by the general public. Often, the decisions on transit priorities and on land use development are not made by the same people, or even people with similar motives, leading to sub-optimal investments. In an ideal world these decisions would be made hand in glove, and the relatively best practice in of these two metropolitan areas would be followed elsewhere. However, each of these two metro areas has the advantage of a centralized government. Moreover, the confined regions in which they operate force them to be efficient in the use of their limited land areas. In most other places the constituencies are more diverse and their land use options are less limited, which can lead to a mismatch of land use and transit service. It remains a challenge as to whether the “best practice” found in both Hong Kong and Singapore can find its way to other less constrained environments.

External Input and Communication

All the agencies have some form of information gathering from groups outside of the agency. Some are more elaborate and inclusive than others. Those that have a more substantial process seemed to be pleased with it, observing that there can never be too much interaction with the public and with stakeholder groups to gain their trust and ultimately acceptance of the decisions made.

Input to Hong Kong’s capital program comes from legislative bodies, stakeholder groups and from the public through many formal and informal channels, including customer service research, a customer service hotline, an “Opinion Zone,” a radio program, liaisons with district councils, etc. The customer research consists of some 50 projects to get responses from the public on agency performance, travel behavior and other areas to identify room for improvement. All the channels are fed to the Customer Service Steering Committee, and then to the appropriate internal departments for evaluation.

Because Washington, D.C.’s transit system serves the nation’s political center, it is the recipient of attention (and ultimately resources) beyond the usual local constituencies. And, because of the constant tension for resources among its three local governments representing city and suburb, as well as two distinct suburbs in two states, Washington Metropolitan Area Transit Authority has been compelled to find a way to not only defend its decisions, but gain broad consensus for them. The process WMATA has created has broad stakeholder buy-in and agreed-upon mission, goals and objectives. The elaborate process has enabled WMATA to navigate the shoals, not without considerable effort, of the disparate political and geographic divisions found in its region. This model can certainly be applied even in locations with less diversity.

The WMATA process relies heavily on an extensive system of outreach and feedback that is marked by a variety of mechanisms used to reach the stakeholders and the riding public. Central to all communication is the presentation of Momentum, the strategic plan framework for the agency that guides its capital program, and is found on its website. In addition to WMATA’s website, the agency is present on MindMixer (a dedicated online forum which poses questions for discussion), Twitter and Facebook. A forum with online links was hosted by the region’s leading newspaper. Materials are developed for presentations in multiple languages, and a variety of venues are used, including libraries and houses of worship. Presentations are made to many governmental units, rider groups and other stakeholders. Highlights of the feedback received:

- From customers: Provide better in-system information, better amenities, more off-peak service and reduced crowding.
- From employees: Protect our assets.
- From public officials: Fix the funding problem.
- From the business community: Help the region be competitive.

Funding and Decision-Making

The sources for capital funding are reflective of the governance structure and the relationship of the metro area to the nation. Some are more self-reliant, either because they are profitable, are self-contained governments, or raise enough through local taxes. The three Asian cities fall in this category. Others depend on where they fit within the government structure around them – a predominant city in a province or nation, a nation's capital or part of a very complex metropolitan area. The tensions between the larger governmental units and the metro area often come into the picture.
London and Seoul have in common the heavy influence resulting from their political structure; London’s entire transport network is the responsibility of its mayor, who sets the mission and overarching agenda; Seoul’s system is overseen by its metropolitan government. London nicely integrates the objectives of its mayor into its capital decision-making process, as does Seoul. This suggests that a system where a strong mayor with transportation responsibilities can be a successful model. Of course, this depends on whether the vision of one individual is the “correct” one; a government leader who emphasizes roads and auto travel over transit can be disastrous “worst practice” for transit. In Seoul, transport funding comes from taxes on gasoline and diesel levied by the Seoul Metropolitan Government, and is used for both the road and transit systems. A tax is also imposed on land and buildings within the transit district, with 10 percent of that tax used for parking facilities. Expansion of the system is funded with a subsidy from the central government.

Singapore’s Land Transport Authority and Hong Kong’s MTR are also dependent on the central government, but, as we have stated here, in these two places the metro area and the central government are one and the same. The LTA’s funding comes directly from the national government, with the individual investments subject to the approval of the central government of the city-state.

In the city-state of Hong Kong, the funding levels are determined internally, aided by the MTR’s profitability. Funding levels are decided according to its cash flows and borrowing power. MTR’s 2011 operating profit was over $2 billion, and it funds the capital program. MTR is the decision-maker when it comes to most investments, but for expansion projects there is close consultation with the Hong Kong government.

Montreal and Vienna must rely to a large extent on the next highest level of government for their funding. Here, there can be a conflict between decision-making and funding if the higher level of government is not in tune with the operating transit agency’s needs and priorities. Montreal does have strong provincial support, consistent with its position as the largest city in Quebec. Decision making is an internal process with representation from the major department, and guided by a 10-year strategic plan, which is used to develop a three-year investment plan. The process is informal and involves negotiation at the local and provincial level. A more formal prioritization process is under consideration.

In Vienna, Wiener Linien relies on national funding for half of its expansion funding, the rest accrues from local taxes. The decision making process is similar to the one described for Montreal, with representation from major departments and with input from a variety of sources, included towns affected by their services, the national government and local stakeholders.

New York also has a “disconnect” between operator and funding sources. It is by far the nation’s largest transit system, and has capital needs that outstrip available funding levels. This is compounded by the MTA service area being located in downstate New York, while it must seek funding from government that serves the entire state. The Governor and a committee of the legislature have veto power. Bonds backed by fares, dedicated tax sources and federal formula contributions pay for its capital program. While direct state aid is relatively small, the governance mechanism gives much of the control of the program’s size to the state, although the choices for most of the priorities are left to the operator. The positions it must take are to first protect its aging assets and reduce risk as much as possible. System modernization upgrades, such as new fare payment systems and other new technologies, can only be deployed over extended time frames. This drives much of the capital decision making down to the operating level, where the detailed knowledge of the system is found. This is appropriate as long as funding is in very short supply. The downside is the system upgrades projects get short shrift. By contrast, expansion projects are decided upon at a higher level, influenced for better or worse by a host of players and factors, though the MTA plays a role in documenting the need for such projects. But they, too, are inevitably delayed when funding is tight and day-to-day maintenance affecting safety and reliability are forced to take precedence.

WMATA’s sources for capital funding are heavily influenced by two factors. First, Washington, D.C. is the nation’s capital, which leads to greater funding participation of the federal government. Second, the transit agency’s service area, which includes the city itself and the surrounding suburbs in two states – Maryland and Virginia – results in strong participation by each. The six-year capital program is updated each year, aided by an agreed-upon formal evaluation process that helps reduce conflicts about priorities. It is described elsewhere in this paper.

System Expansion

To varying degrees, the capital programs for the transit agencies have separated the evaluation and decision-making for expansion projects from decisions about investments in maintenance, replacement and system upgrades. There are good arguments whether this is the best approach. The argument for separation asks whether it is wise to add a wing to your house while the roof is still leaking. After all, if the existing transit system is unreliable and unattractive, it should be fixed first before expansion is considered. This side argues that investments in expansion are very expensive, and if resources are scarce, then investments in the existing system will necessarily be shortchanged.
New York City’s public transit system is not only one of the largest in the world by ridership and scope, it is also administered by one of the most complicated governance systems—a factor that profoundly affects how, why and what it decides to build.

New York’s elevated trains and subways long predated the state-created Metropolitan Transportation Authority that now oversees them. As the agency in charge of implementing a unified mass transportation policy for the city and its suburban region since 1968, the MTA coordinates the work of seven once-independent operating agencies (legally: “The Related Entities”), each of which has its own capital program and construction department to manage routine capital work.

The MTA itself is governed by a 17-member board that is structured to represent its service areas—the city’s five boroughs and seven surrounding counties—as well as the MTA’s full range of significant interests and stakeholders. (See main text for more details.)

The MTA is not the only agency managing and building public transit in New York—there is also the Port Authority of New York & New Jersey, which runs the PATH trains from the World Trade Center and Manhattan’s West Side through the Hudson Tubes to New Jersey cities, for an average 242,000 passenger trips every weekday, a small fraction of the MTA’s 8.4 million daily.

The construction of megaprojects has been fraught with issues of cost and timelines for both the MTA and PANYNJ. The MTA’s solution in 2003 was to create the MTA Capital Construction Company to manage the system’s expansion (Second Avenue Subway, East Side Access, 7 Line Extension to Far West Side), as well as Lower Manhattan infrastructure projects, which include the MTA’s South Ferry Terminal and Fulton Center. Both of these are near the PANYNJ’s World Trade Center rail hub, which is at least eight years behind schedule and $2 billion over budget. MTACC also manages MTAs security-related capital construction.

New York’s public transit operates in a highly complex, competitive and political environment. Even in the best of times, transit executives are seldom left alone to make major capital decisions as they see fit based on neutral, analytic criteria or engineering standards.

Why Does It Cost So Much And Take So Long To Build In New York?

New York cannot function without its subway, and while most New Yorkers understand this, they tend to balk at expansion of the system, in part because of the extraordinary costs, delays in delivery and years of broken promises. By almost every criterion, it costs more to build in New York City than in its fellow world cities such as Hong Kong or Tokyo, or even major but smaller American cities, such as Washington, D.C. or Los Angeles.1 While the cost per track mile for London’s Crossrail is closer to the three New York City projects, it includes nine large new underground stations constructed in a very dense urban environment that are tightly integrated with existing tube and commuter stations; the projects must proceed without seriously disrupting the existing transit services.2 But what if New York’s costs were seriously analyzed, and waste and redundancy pared to the bone, freeing up resources for additional building? MTA executives and other experts have many ideas how to do this.

Urban environment—and its required mitigation measures—may be the most important single contributor to cost increases over reasonable estimates. Projecting costs in New York requires anticipating the regulations and vagaries of the urban environment—hourly restrictions that mandate construction within a 7 a.m. to 7 p.m. period, relocation of utilities (often more than once), remediation of older buildings, and treatment of redundant power substations even when not necessary. Most serious, the federal- and state-mandated environmental impact statements are more often than not written without regard to consequences, casually imposing unwarranted limitations on construction that will cost the taxpayers millions of dollars.

Recent MTA megaprojects have started the community outreach too late, which has resulted in the need to change scope previously defined, slowing projects and adding costs. The obvious action is to start earlier, as London did, which the MTA has learned the hard way.

Because labor costs constitute 65 percent or more of major projects, any attempt at cost efficiencies must include labor savings—but labor reforms are often the most political and controversial of all, even in clear-cut instances. The MTA, for example, must use 30-40 workers on a tunnel-boring machine, versus in Europe, where six to eight will do. The Second Avenue Subway expense per tunnel-boring machine is about $70K/shift or $200K/day.

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1 Source: Interviews with MTA executives who have been tracking capital construction costs in relation to those of other systems. The MTA hopes that its estimated costs of $860,000 per km for the 7 Line Extension hold, which would bring it in under London’s $1 million plus per km for Crossrail. But this remains to be seen. As it is, the analytic web site Pedestrian Observations (pedestrianobservations.wordpress.com) calculates East Side Access at $4 billion per km, Second Avenue Subway at $1.7 billion per km, and the 7 Line Extension at $1.3 billion per km. It sets Crossrail substantially lower at $1 billion per km. All capital cost projections for public transportation are rough and almost never strictly comparable.

2 Crossrail Website, ‘Route, stations’. http://www.crossrail.co.uk/route/stations/
New methods of construction are often blocked in New York either by code or by union contract or both. The MTA has evaluated some technologies used by others that have potential for reducing costs in New York. Conversely, the MTA is also aware that some of its old, very costly methods of construction are used less frequently elsewhere—for example, the practice of coating attractive-looking bedrock with concrete, rather than leaving it exposed as an amenity, as is done in Stockholm and some other European cities.

New institutional arrangements for construction show that it is possible to build cheaper and faster. The extension of the MTA’s 7 Line subway,3 for example, was accomplished efficiently in part because the Hudson Yards Development Corporation constantly monitored progress and expenses. Established in 2005 to implement the Hudson Yards development plan, HYDC pushed and negotiated with all partners—public and private—to ensure completion. As one MTA official summarized the partnership, “HYDC brought a higher level of focus and intensity to the job. They had both the developers and City Hall behind them. City Hall being so interested gave the project more muscle.” This kind of public-private partnership, especially one initiated by City Hall, shows great promise.

Similarly, London’s immense 73-mile Crossrail is being built by a company, established in 2001, that is owned by Transport for London, but able to secure separate private-sector partner funding.4 Because TfL itself is answerable to the mayor of London, Crossrail is automatically analogous to HYDC. In both cases, the original organization dissolves once the project is built and turned over to another group for operations.5

This may be an especially auspicious time for public transit in New York. The MTA has been able to demonstrate substantial operational improvements over the last few years, particularly those visible to the public. It has, for example, cleaned up the trains, installed countdown clocks, provided subway and bus time apps, and introduced a number of innovations no one had predicted. Breakdowns are far fewer than in the past, and most trains run fairly close to schedule. On the capital front, the MTA has been successfully repairing huge segments of the system, and is about to complete and open two capital expansion projects—the 7 Line Extension and Fulton Center. Thus, its record of recent achievements positions it well for seeking additional funding, both government and private sector. Identifying ways for the MTA to significantly reduce its costs and increase its efficiency will enable the agency to build more, which will be essential to facing the dual challenges of global competitiveness and growth.

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3 A 1.5 mile extension of the 7 line from its existing terminus at 8th Avenue and 41st Street to 11th Avenue and 25th Street, with a new terminal at 34th Street that will service an estimated 35,000 passengers in the peak. The project will cost $2.1 billion and will be completed in early 2015.

4 Crossrail website: About Us. http://www.crossrail.co.uk/about-us/

5 Crossrail Articles of Association, March 2014.
The other side of the argument points out that expansion is just another way of making the existing systems more attractive by adding capacity where congestion exists, adding connections to existing services and offering new services to areas without them. These benefits cannot wait until all the maintenance and repair is fully in place, and, moreover, these repairs are a never-ending process that will forever preclude needed expansion, which can provide the opportunity for economic growth by opening up areas that are transit inaccessible.

Complicating the issue is the fact that expansion projects and other investments are difficult to compare using the same criteria and metrics. Economic development, congestion relief, new service coverage and more sustainable land uses may be the criteria for expansion, while investments in the current system address issues of reliability, safety, risk and service life. This suggests that it may not be possible to create a system that allows for comparisons of both expansion and other investments using the same evaluative tools. In practice, where there is a prioritization process the two are separate, in large measure because the funding sources are different.

For Singapore’s LTA and Vienna’s Wiener Linien, decisions to proceed with expansion projects must meet some minimum thresholds. For the LTA, expansion projects must meet two criteria: financial viability and economic viability. To meet the more narrow financial viability criteria, the project must be able to cover its operating costs and the costs of depreciation of the asset through the revenue it attracts. The second criterion is economic viability threshold, where the project’s economic benefits to the region and the riding public must equal or exceed the total costs of the expansion project. Once both criteria are met, LTA seeks government approval to fund and implement the expansion. In Vienna, the threshold is measured by ridership; if it meets the ridership criterion of 10,000 passengers per direction in the peak hour in the most heavily used section, and it can provide needed capacity to substitute a metro for a tram line that is at capacity. Then, a project moves ahead once the city of Vienna guarantees the 50 percent match, at which time the federal share is also committed.

The process is more complicated in New York, where the availability of funding takes precedence. Expansion projects compete for federal “new starts” money with many projects nationally. The funds cover up to half of the cost, and without which the project would not proceed. A project must score well in areas of cost-benefit ratios, environmental impact and a number of lesser criteria, running the gantlet of complex analyses. Projects not only must compete well against the political competition nationally, and have approval locally, but also be looked on favorably by an array of influential local stakeholders, including the governor, the mayor, the New York State legislature and public interest groups. One exception to this process has been a project funded by New York City via a tax increment financing mechanism. In addition, the MTA also secured federal funds in the wake of the 2001 terrorist attack to assist in the construction of two major station complexes in lower Manhattan.

For Hong Kong projects are prioritized by a value assessment process that divides the projects into asset upkeep, improvements, and initiatives that have a commercial revenue payoff. It is based on seven corporate business objectives, some quantitative and some qualitative in nature. The resulting evaluation places the project for each of the objectives in either a significant, beneficial, measurable or marginal category.

TfL has a process that works back from outcomes (objectives) collectively known as the Mayor’s Transport Strategy, which are then nested under the three broad objectives established by TfL: keep London working (reliability and crowding), keep London growing (capacity, regeneration, job access), and make life in London better (safer). Projects are scored against these objectives and checked back against TfL’s strategic pillars – customers, staff, mayor and value.

WMATA prepares an unconstrained capital needs inventory. A leadership team develops consensus “weights” for the four goals provided, then scores how each of the strategies meet the goals. Department heads score each project. A theoretical example of how this might be scored by one individual is provided in the Appendix A. This system does not explicitly account for the cost of the project, but it includes a “return on value” concept.

Those agencies with more rigorous processes are pleased with them. They admit they require more time and can be onerous, but they express belief that the extra effort is worth the expenditure of time and resources. They believe that a rigorous process leads to greater buy-in internally, which in turn leads to a more productive work force acting as a team. And it leads to greater acceptance externally, because stakeholders and the public come to recognize that the process is not an arbitrary one. However, even this rigor
is occasionally overridden by compelling priorities, such as the project in Hong Kong to provide transit access to their new airport.

New York has a no less rigorous process at the asset category level, but has a more intuitive one when choices among assets must be made.

Some agencies have a formal evaluative process used as a guide, but rely on a collaborative leadership team to reach decisions. Others have a less formal and more decentralized structure tied to a vision that guides their priorities. Montreal, New York and Vienna are receptive to a process that would be more rigorous and structured, and express dissatisfaction with the absence of a process. Each is buffeted by outside forces. Some agencies, such as New York, are in a perpetually scarce funding environment and must safeguard the transit system first. Hong Kong, Seoul and Singapore have more leeway because they are more financially secure. Some are more directly influenced by the political structure or their funding sources, including Montreal, Vienna and New York.

Findings and Emerging Themes

There is not one way to decide on capital priorities for a transit agency. Some establish an elaborate quantitative process, while others are purely qualitative. Some seek public input, others hardly at all. Some have a very centralized leadership structure to make decisions, while others are more decentralized. Some are buffeted by political forces, others much less so.

This investigation suggests that having a process of some kind is of great value. It can stimulate rational thinking, create transparency, avoid arbitrary decisions, increase efficiency and effectiveness, and limit unwarranted influences. There are bound to be many major cities and transit systems, each spending huge sums, that have a less evaluative process for making transit investment choices, and would benefit in these ways. And there are a number of models to choose from, only some of them discussed here. Key features can include acknowledgment of the land use-transit connection, open two-way communication with the public, strong central leadership and a structure that more closely links the funders with the operators. Whether all these features can be incorporated in each situation is problematic for reasons of culture, history, government structure, funding availability, and size and type of transit needs.

The arguments for a formal and open process for decision making are strong. It forces the agencies to collect and examine data thoroughly; it inoculates the agency against criticism for making arbitrary decisions; it causes greater introspection among managers. On the other hand, it requires much more work. It can breed resentment among line managers and operating departments, who may believe decisions are made too bureaucratically, and by people who know less than they do about daily operations.

An agency that recognizes the two-way, cause-effect relationship between transit service and land uses can better tailor its capital investment program to the growth in its metropolitan areas. This linkage is well established in Hong Kong and Singapore, but not elsewhere. In these two confined city-states, it is imperative to consider this linkage; it may be less true in other places.

Agencies with an open process of communication with the public, providing them with easy to obtain information about their systems and their capital programs, can create an attitude of trust that leads to public buy-in. In Washington, D.C. and Hong Kong, systems have been successful in accomplishing this.

A strong central government structure that gives its leader a strong say and even control over the choices made, can be an effective way make choices. However, this can be counterproductive for transit should the leader be less supportive of transit, as is often the case. Similarly, if the transit agency is beholden for its funding to a higher level of government, it can be hampered in making the most effective capital investment choices if that level of government is not supportive of transit.

Operating and investing in a transit system is a very complex undertaking. Perhaps the most efficient way to convey current and, hopefully, best practices is to convene transit agencies in an information sharing and learning environment targeted to this topic. The Transit Leadership Symposium has been dedicated that goal.
Appendix A: WMATA
Theoretical Score of Project – Track Replacement

1. Build and Maintain a Premier Safety Culture and System – Weight = 4
   Fix and Maintain the System – 5
   Create a Shared Climate of Safety – 2
   Expect the Unexpected – 1
   Prepare for Extreme Weather – 1
   Score for this goal 1: 4 x (5+2+1+1) = 36

2. Meet or Exceed Expectations by Consistently Delivering Quality Service – Weight = 2
   Become a Self Service System – 1
   Focus on the Customer – 1
   Fix It First and Fast – 3
   Be On Time – 3
   Make it Easy to Plan, Pay and Ride – 1
   Score for goal 2: 2 x (1+1+3+3+1) = 18

3. Improve Regional Mobility and Connect Communities – Weight = 1
   Be the Region’s Transit Leader – 1
   Maximize What We Have – 2
   Enhance Access – 1
   Expand for the Future – 1
   Support the Region’s Economic Competitiveness – 1
   Score for goal 3: 1 x (1+2+1+1+1) = 6

4. Ensure Financial Stability and Invest in our People and Assets – Weight = 2
   Add New Sources of Predictable Funding – 1
   Increase Efficiency and Lower Costs – 2
   Be Green – 1
   Recruit and Keep the Best – 10
   Score for goal 4: 2 x (1+2+1+1+1) = 10

Total Score for Track Replacement = (36+18+6+10)/9 = 70/9 = 7.67
A good public transport system is often one of the defining features of a city, attracting residents, businesses and tourists. However, even in the case of the world’s great public transport systems, fares do not fully cover costs. The ratio of farebox revenue to costs for many of the most famous public transport systems is significantly less than one (see Table 1). Substantial government subsidies are required to build, maintain, and operate most public transport systems. One of the challenges faced by cities is where this money should come from.

An often discussed set of options to solve this financing challenge comes under the umbrella title “value capture.” Successful public transport systems generate substantial economic value for cities because they improve accessibility in station areas. They increase the value of land in the immediate areas around stations, and they support the “agglomeration economies” that make cities the vibrant engines of our global economy. Value capture is the concept that government may be able to capture part of the economic value generated by public transport systems, and use these funds to help finance the system. The topic of using value capture financing mechanisms to support public investments in infrastructure has received significant academic and practitioner attention in the past five years.

Table 1: Examples Illustrating Range of Farebox Recovery Ratios of Operating Costs

<table>
<thead>
<tr>
<th>City</th>
<th>Public Transport System</th>
<th>Year</th>
<th>Ratio of Fares Collected to Operating Expenses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong</td>
<td>Mass Transit Railway Corporation</td>
<td>2012</td>
<td>1.8</td>
</tr>
<tr>
<td>London</td>
<td>Underground</td>
<td>2012</td>
<td>0.9</td>
</tr>
<tr>
<td>Washington, D.C.</td>
<td>Metro</td>
<td>2013</td>
<td>0.7</td>
</tr>
<tr>
<td>Montreal</td>
<td>Subway</td>
<td>2013</td>
<td>0.7</td>
</tr>
<tr>
<td>Paris</td>
<td>Metro</td>
<td>2012</td>
<td>0.6</td>
</tr>
<tr>
<td>New York</td>
<td>New York City Transit (subway and city bus)</td>
<td>2012</td>
<td>0.4</td>
</tr>
<tr>
<td>San Francisco</td>
<td></td>
<td>2012</td>
<td>0.3</td>
</tr>
</tbody>
</table>

This paper presents a comprehensive discussion of the value capture mechanisms that cities can and do use to help finance their public transport systems. It highlights the most important findings from the literature and adds new insights gained through case studies of public transit finance in six European and American cities. The objective is to inform a lively and productive
dialogue on non-fare sources of public transport finance, and ultimately to find the best ways to finance the maintenance and extension of transit service in cities around the world.

The original meaning of “value capture” refers specifically to land value capture. The definition we adopt in this paper is broader, including strategies to capture any sort of location-based value. These include property taxation strategies such as Tax Increment Financing, special assessment districts, and “betterment” taxes; joint development strategies and sale or lease of land, development rights, or air rights; transit-focused development fees (often with associated density bonuses); and even other location-based taxes that fund transit, such as Paris’ transport tax on income. Appendix A provides brief definitions of each value capture mechanism discussed. It is worth noting, however, that even this is not an exhaustive list; capturing the value of location and access is a task to be approached with creativity.

Case Study Approach

In an attempt to shed light on some of the remaining questions about using value capture to finance public transport systems, interviews were conducted with high-level transit staff in six cities in Europe and North America: New York, London, Paris, Washington, D.C., Montreal and San Francisco.¹ In these interviews, we discussed current major value capture initiatives as well as the past experiences and future plans of the agencies implementing value capture strategies.

There is a long story behind the decision to utilize location value capture funding mechanisms in each of these cities, and from these stories emerge key themes that are relevant for understanding the process by which a city/transit agency decides to rely on value capture to raise a significant amount of revenue. Appendix B provides summaries of these stories.

Table 2 provides examples of specific large transit infrastructure projects in the case study cities that have been or are planned to be financed partly using location value capture strategies. Four of the case study cities have paid or are currently paying for significant new infrastructure through value capture, and Montreal is likely to begin raising significant funds through value capture in the near future. San Francisco raises more than 25 percent of its total budget from location-based value capture mechanisms, but is not included in the table because the money is not dedicated to a specific large project. Using these financing mechanisms for large projects is a relatively new phenomenon in all of our case study cities.

How Much Value Does Transit Create?

A clear prerequisite to implementing a value capture strategy to raise funds is that there is actually value to be captured. Theory suggests that because public transport increases accessibility, willingness to pay for nearby properties should increase as well. The question is by how much, and how does this created value vary by property type, public transport characteristics, and local land use characteristics? Broadly, the increase in value attributable to new transportation infrastructure should be a function of the type of service (bus, rail, highway), the distance of the property to the new infrastructure, the use of the property, the quality of the service, and transportation alternatives. This section presents some existing estimates of the price premium attributable to urban transit systems in developed and developing city contexts.

The Royal Institute of Chartered Surveyors provides an exhaustive report on the impact of rail-based public transport on land values in the United States and Europe, reviewing approximately 150 studies. They found that rail transit generally has a positive effect on both commercial and residential property values. Importantly, they also found that this impact is influenced by both the public transport mode and the presence of complementary policies to encourage changes in land use or discourage automobile use. Since the RICS report, some important studies have been done in North America and Europe. One study provides a meta-analysis of the impact of public transport stations on residential and commercial property values based on 57 previous estimation results. They find that commercial property prices are 16.4 percent higher and residential properties are 4.2 percent higher within one-quarter mile of stations, and that the effect is largest for commuter rail.

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¹ Interviews were not conducted in key cities in Asia. This choice was made for two main reasons. First, the use of value capture mechanisms to fund transit in Asian cities is more thoroughly studied and documented than its use in US and European cities. Second, there have been recent high profile examples of value capture implementation in many of the case study cities.
Comparison of Value Capture Mechanisms

Once it is determined that transit generates location-based value in a city, financing that transit system using value capture becomes an option to consider. Three main questions arise:

- When is it appropriate to use value capture mechanisms to fund public transport?
- How does value capture compare with other forms of non-farebox funding sources for transit?
- How do value capture mechanisms compare with each other?
- These questions are addressed in the existing literature. This section summarizes the main findings.

When value capture is appropriate

When identifying the most efficient set of financing sources for transportation, one approach is that costs paid should be proportional to benefits received. There are three sets of beneficiaries of urban transport infrastructure: (1) the general public (because the urban economy is enabled by the infrastructure), (2) property and business owners in the vicinity of infrastructure (because the access afforded by that infrastructure increases the value of their holdings), and (3) direct users of the infrastructure. The first and last of these beneficiaries contribute to public transport finance routinely through general taxes and fares, respectively.

It is the second group of beneficiaries that experiences sustained value from upkeep of existing infrastructure and gains from the construction of new infrastructure. This is value over and above that which they derive either as part of the general public or as riders. However, these beneficiaries are not always asked to help pay for the cost of the infrastructure. Value capture mechanisms allow for public transport systems to be paid for in part by these beneficiaries. There is "consensus among scholars that public investment costs should be at least partially covered by the [private] financial benefits that these investments generate." In addition, "As long as the spatial distribution of project benefits can be internalized within a well-defined ‘benefit zone,’ it is economically efficient to finance infrastructure projects by tapping the increments in land values resulting from them." It is worth noting that it is not actually desirable to capture all of the location-based added value of transit, for two related reasons. First, it’s in the transit agency’s and the city’s interest to encourage people to live close to transit stations. Thus, leaving some windfall value on the table for developers to cash in on is a good way to incentivize the construction of higher density development near transit. Second, in trying to capture all the value, the public sector may overreach and actually depress development near transit. This second point is an important one that will be made clearer in the Grand Paris Express case documented later.

Value capture revenue versus general public revenue

One large difference between location-based value capture financing mechanisms and most general public revenue-based transit funding is in the potential for revenue stream volatility. Value capture mechanisms that are tied to specific real estate markets can fluctuate with the rhythms of those markets. Mechanisms that are tied to new development will yield revenue streams that rise and fall with booms in construction. Similarly, value capture mechanisms that are tied to payroll are subject to business cycle fluctuations. Sales tax receipts and public sector budgets will also rise and fall with the cycles of the overall economy, but these fluctuations are often not as large as those in individual economic sectors.

It is possible to compensate for the volatility of a revenue stream with smart financial management practices, such as putting money in a “rainy day” fund in the high years to compensate for the revenue shortfall in the low years. However, most public agencies do not have experience with managing such volatile revenue streams, and it’s rarely clear whether a given situation is part of a cycle or part of a trend. An interviewee at Transport for London said, “When one of the developers at one of our stations went insolvent, it felt like quite a grim day.” It may be both politically and practically difficult for historically cash-poor institutions to avoid overspending in the high years, making heavy reliance on volatile revenue streams imprudent.

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2 Debrezion et al.
3 Gibbons and Machin
4 Salon and Shewmake
5 Iacono et al.
6 Ingram and Hong
7 Peterson
8 Cornia and Nelson
Another difference of note is the equity implications of the financing mechanisms. Of interest is equity across income levels, across space, and across modes of travel in paying for transport service within a metropolitan area. Equity across income levels is mechanism-specific, both for location value capture mechanisms and general revenue financing. Income and property taxes are generally regarded as less regressive than sales taxes, but the details of the taxation instrument do matter. In terms of spatial equity, location value capture mechanisms fare much better than general revenue financing because the local group that is benefiting most from the infrastructure is the group that pays.

It is worth noting that it also matters whether the property is commercial or residential. Residential property can go up in value faster than the incomes of the owners. On the other hand, commercial rents are more closely aligned with property values. This is likely the reason that many value capture mechanisms target commercial rather than residential properties.

A popular non-fare transit financing strategy is to have car users pay via charges such as vehicle license fees, tolls and parking fees. This raises the issue of equity across modes of travel. The two basic arguments for car users to pay for transit are that car use leads to substantial negative externalities in cities and transit use does not (so car users should subsidize alternative modes), and that car users directly benefit from improvements to transit because the roads are less congested. While these basic arguments are theoretically sound from an efficiency perspective, the question remains of the fairness of transfer from car users to transit.

### Comparison among value capture mechanisms

There are clear dimensions along which value capture strategies can be compared. These dimensions include who is asked to contribute (i.e., property owners, businesses, developers), the timing of the contribution (i.e., one-time, ongoing), and the spatial extent of the benefit zone within which value capture contributions are collected (i.e., immediate vicinity of station, zones within city, whole metro area). With this framework as background, Table 4 provides an overall look at which value capture mechanisms have been used to raise revenue for transit in each of the case study cities. An annotated version of this table is available in Appendix C, providing details of the implementation schemes, funds raised and what they are used for.

#### Table 3: Key Dimensions of Value Capture Mechanisms

<table>
<thead>
<tr>
<th>Value Capture Mechanism</th>
<th>Contributor</th>
<th>Timing of Contribution</th>
<th>Spatial Extent of Benefit Zone*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Value/Property Tax</td>
<td>Property owners</td>
<td>Ongoing</td>
<td>Metropolitan Area</td>
</tr>
<tr>
<td>Tax Increment Financing</td>
<td>Property owners</td>
<td>Ongoing</td>
<td>Neighborhood of Improvement</td>
</tr>
<tr>
<td>Special Assessment District</td>
<td>Property owners, Businesses</td>
<td>Ongoing</td>
<td>Neighborhood of Improvement</td>
</tr>
<tr>
<td>Transit-Focused Payroll Tax</td>
<td>Businesses</td>
<td>Ongoing</td>
<td>Metropolitan Area</td>
</tr>
<tr>
<td>Transit-Focused Real Estate Transaction Tax</td>
<td>Property owners</td>
<td>One-time</td>
<td>Metropolitan Area</td>
</tr>
<tr>
<td>Transit-Focused Development Fee</td>
<td>Developers</td>
<td>One-time</td>
<td>Metropolitan Area</td>
</tr>
<tr>
<td>Development Rights/ Air Rights</td>
<td>Developers</td>
<td>One-time</td>
<td>Specific parcels at or near station</td>
</tr>
<tr>
<td>Joint Development</td>
<td>Developers</td>
<td>One-time</td>
<td>Specific parcels at or near station</td>
</tr>
</tbody>
</table>

* The spatial extent of the benefit zone for each mechanism is more fluid than the other characteristics, and can be specified in a variety of ways for each of them. This table reports the most common spatial extent used.

#### Table 4: Value Capture Mechanisms in Case Study Cities

<table>
<thead>
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<tbody>
<tr>
<td>Land value tax/Location benefit levy</td>
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<tr>
<td>Tax Increment Financing (TIF)</td>
<td>X</td>
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<tr>
<td>Joint development</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Sale or lease of land</td>
<td>X</td>
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<tr>
<td>Sale or lease of development rights or air rights</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>Transit company business diversification</td>
<td>X</td>
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<tr>
<td>Payroll-based tax</td>
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<tr>
<td>Transit-focused development fees</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Transit-focused property transaction taxes</td>
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<tr>
<td>Special Assessment Districts (SAD)</td>
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<td>X</td>
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</tbody>
</table>

There are two points of note. First, all of the cities are implementing at least two mechanisms on this list, and a number of the cities are implementing most of them. Second, in all of these cities except for Montreal, revenues that capture the value of location are significant. Transport for London estimated that value capture revenues cover approximately 10 percent of total system costs. Payroll taxes in Paris and New York cover 40 percent of operating costs and 10 percent of system costs, respectively, and each of these cities has other important sources of location-based revenue as well. The San Francisco Municipal Transportation Agency raises 25 percent of their transit operating costs from parking fees. In coordination with local business interests, the Washington Metropolitan Area Transit Authority has raised a substantial portion of the capital costs for two infrastructure projects using special assessment districts (see also Table 2).
The remainder of this section provides some context for thinking about value capture mechanisms from both an efficiency standpoint and an equity standpoint.

Efficiency

An efficient value capture strategy captures the increment in the value of locations that is associated with a public investment. The most economically efficient value capture mechanism, then, would be a pure location value tax, such as a land value tax. There are at least three challenges in implementing such a tax, however. First, the pure value of location cannot be easily separated from the value that is created by the efforts of the developer or business or property owner. Second, the value of location is related to many aspects of that location. It is hard to disentangle the value added by one piece of infrastructure, such as a transit line, from the value of other intrinsic elements of the location. Finally, it is not clear how large the circle of location value influence is for a given piece of infrastructure.

To the extent that a value capture mechanism uses privately created value as its basis, it actually puts negative pressure on local economic growth. Nearly all of the value capture mechanisms in use have this drawback. Development fees directly penalize construction. Payroll taxes directly penalize business activity. Property value-based mechanisms (i.e., property taxes, TIF, SAD) can have a negative effect on development as well, since the larger the improvement on a piece of land, the higher the property tax will be. In the case of the Grand Paris Express project – slated to be mainly financed through a high tax on new office development – it has been suggested that the tax is so high in some areas that it will actually forestall office development.

In cases where the taxes are levied chiefly on existing buildings that are expected to become substantially more productive as a result of new transit access, this efficiency issue is less important. London’s Business Rate Supplement currently being collected to fund a large portion of the Crossrail project is a good example of such a tax. However, the BRS value capture mechanism has a different efficiency drawback, which is that its tax rate is not differentiated according to location. One possible way to improve the efficiency of the mechanism is that the BRS be restructured such that those areas of the city that gain most from the Crossrail also pay the most.

Equity

Equity issues loom large when considering large-scale financing of public infrastructure via value capture. Who is the group that is actually providing the value capture funds? Is this the same group that will experience windfall benefits from the new infrastructure? Are these location benefits liquid, or are the benefits tied up in real property value increases? What is the group’s ability to pay? Different value capture mechanisms lead to different answers.

Increasing residential property taxes can be challenging for less well-off households because the increase in their property value is not liquid. This question of ability to pay can arise even if the property tax rate is unchanged (such as in a TIF zone) but property values rise due to a major infrastructure improvement.

Tax Increment Financing is a mechanism that assigns the property taxes on the increment in value above a certain baseline level to pay for local infrastructure within a specified benefit zone. TIF is a good deal for people in the benefit zone because they get local infrastructure without paying higher tax rates, and the extra taxes that they pay due to higher property values go directly into making their neighborhood a better place to live. If all of the above-baseline value can be directly tied to the infrastructure improvement, then TIF mechanisms are a win-win proposition. However, to the extent that increased values in the benefit zone are due to overall economic trends, building owners in the zone contribute less to the overall city budget than they would otherwise. This creates an equity imbalance between those in the zone and those outside of it. A TIF-like mechanism was recently implemented in New York to help fund the Hudson Yards redevelopment and the Metropolitan Transportation Association’s 7 Line Extension. This is an extreme case where the baseline value was set at zero, meaning that all of the property tax proceeds from the area go to pay for local infrastructure, and the people who live there (or who will live there in the new developments) do not pay into the general city coffers.

Special Assessment Districts are geographically equitable financing mechanisms as long as the taxed benefit zone coincides with the actual benefit zone. Often, however, most or all residential properties are exempt, which creates problems with efficiency and equity. This difference in treatment between residential and commercial properties will be discussed more below.

Development fees generally satisfy both geographic equity and income equity concerns, but their revenue-raising potential is limited in that they are paid only by new development. They also raise another equity issue: existing residents do not contribute.

Site-specific mechanisms

Joint development projects and strategies such as sale or lease of development or air rights do not pose significant efficiency or equity concerns. Since they are individualized contracts between a public agency and the private sector for specific projects, the result should be reasonably efficient and equitable for both sides. However, these strategies can be somewhat risky for the public agency if that agency does not have the internal capacity to properly negotiate a good contract. Some observers have criticized the development rights arrangements recently negotiated by New York’s Metropolitan Transportation Authority for its Atlantic Yards and Hudson Yards sites as being too favorable to developers.

In the U.S. and Europe, most site-specific development projects are relatively small in terms of the potential to raise funds when compared with benefit zone-wide, tax-based value capture mechanisms. However, it can be argued that both Hong Kong

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10 Note that a land value tax is a tax on only the value of the land, not including the value of any improvements that have been made on that land. This is not the same as a property tax.
11 Jérôme
12 Roukouni and Medda
13 Jaffe
and Tokyo have financed a large portion of the cost of their transit systems using these value capture mechanisms. Specifically, Hong Kong has primarily used land sales and leases and Tokyo has used privatization of transport service and joint development.

Figure 1: Hong Kong’s International Finance Center mall and cinema with an MTR station integrated into the building.

Hong Kong’s Mass Transit Railway Corporation model is known as “Rail + Property” whereby the corporation concurrently develops property and the MTR system. To enable this, the Hong Kong government provides a large indirect subsidy to the MTRC in the form of land provision at pre-MTR rates. The corporation then sells or leases those lands at post-MTR rates, using the difference in value to pay for the transit infrastructure. While this model of value capture is clearly successful, it is perhaps impossible to implement where the city or transit agency cannot assemble land at favorable prices near a planned rail line.

In Tokyo, numerous private corporations claim rail as their “core” business, but most of these in fact earn more of their profits from associated real estate ventures in and around their rail stations. Some of these corporations have branched out even further from rail, and also operate major department stores, construction businesses, education facilities, and other services. This is called a “rail integrated community” model of transit finance.

Adoption and Implementation of Value Capture Mechanisms

This paper has established that there is often location-based value created when transit infrastructure is built or service is improved, and has compared non-fare transit financing mechanisms on the basis of economic efficiency and equity. The important question remaining is about adoption and implementation of value capture mechanisms. What are the factors that provide opportunities and impetus for the adoption of value capture mechanisms to fund transit? What are the barriers? Which political and institutional considerations affect how value capture is implemented? Four factors that impact the implementation and adoption of value capture to fund transit are highlighted here.

Institutions

Where value capture is being implemented on a large scale to finance transit, basic institutional arrangements have been critical. Notably, among our six case study cities, London and Paris have created new governmental bodies that have enabled value capture implementation, Montreal has formally requested that the Quebec provincial government consider a similar move, and the San Francisco Municipal Transportation Agency made important changes to its charter in 2007 that enable certain value capture mechanisms. The governmental bodies created in these cities have authority over region-wide transport planning and finance. As such, they are able to work with the relevant provincial (in Canada), national (in France and the U.K.), and city (in San Francisco) governments to develop taxation schemes to help fund transit. In London and San Francisco, the transit agencies also govern the roads and manage car user fees in the region. This makes cross-mode transportation subsidies relatively seamless, allowing transit to capture part of the location value of central destinations by charging private vehicles for driving and parking there.

In contrast, the transit agency in Washington, D.C. is institutionally stuck in a place where large-scale value capture financing is “a very attractive yet very impossible way to generate funding” (WMATA interviewee, February 2014). The WMATA is funded directly by multiple local and state governments in their region, and there is no realistic way to coordinate a taxation scheme across that many different governments. Where the agency does have significant value capture financing of infrastructure, it is Special Assessment District-based and entirely the initiative of the local community to tax themselves (see Table 2).
Transit finance crisis

For transit agencies in the U.S. and Europe, serious consideration of location value capture financing strategies is usually precipitated by a financial crisis. Crises in financing for operation and maintenance of existing infrastructure or a need for additional infrastructure without a clear mechanism to pay for it forces cities and their transit agencies to think out-of-the-farebox about financing solutions. In three out of six case study cities, such a crisis was at least a part of the motivation for implementing value capture.

New York’s MTA has repeatedly faced severe operations and maintenance finance crises and has not been politically able to increase fares sufficiently to solve them. In part to solve one of the most recent crises, New York State authorized the Payroll Mobility Tax to be collected from all eligible employers within the New York State portion of the MTA region.

Figure 2: London’s Crossrail project will provide high frequency and high capacity rail service for London and the South East.

In London, crowding has increased on the transit system due to sustained economic and population growth, implementation of a congestion charge for cars, and other programs to encourage transit ridership. Together with the institutional changes discussed above, this has pushed and enabled the city to develop and implement a set of value capture mechanisms to raise a large amount of funding for the new Crossrail infrastructure.

In Montreal, the provincial government has changed its policy, and now requires a certain percentage of local match funding before it will commit funds to build new railways. This means that if Montreal is going to build additional rail lines, these local match funds are likely to come from the jurisdictions that will benefit from the infrastructure. The city’s transit agency is currently in negotiations with the provincial government regarding what institutional framework should be used to collect the needed funding so that projects can move forward.

Washington, D.C.’s WMATA is in the unusual position of having to negotiate its budget each year with local and state governments in the region. This process has its own challenges – it is reportedly an “extensive and excruciating negotiation with all the jurisdictions” – but if the agency had a major financing crisis, then its member governments would be responsible to raise funds to solve it.

Interestingly, the narratives from our case studies suggest that, at least within these cities, value capture mechanisms were turned to as a “last resort” of sorts for transit finance, when no other sources of funding were available for critical new infrastructure and/or for basic operations. This is not the case where value capture has been implemented on a much larger scale, such as in Hong Kong and Tokyo. In fact, these systems were built on a platform of value capture, integrating land development with transit development virtually from the start.

Transit agency mission

Transit agency institutional culture and mission can also be important. The New York MTA and Washington, D.C. WMATA have clear transit-provision missions, while other transit agencies also have road transport in their purview. Still other transit agencies may actually be partly or wholly privatized with much more diversified business models, as is the case in both Tokyo and Hong Kong.

These differences in mission translate into differences in the ways that agencies view opportunities. For instance, in response to a question about commercial leasing of space in stations, a WMATA interviewee explained, “Our spaces are used to move passengers, and we don’t have a lot of excess [space].” In contrast, Montreal’s Agence métropolitaine de transport shared the viewpoint that all transit agencies in that city are working to increase their non-fare revenue sources, and they aim to lease commercial space in their stations wherever it will be profitable to do so. Both the San Francisco MTA and Transport for London are actively working to increase value capture revenue-raising opportunities wherever they are politically and practically feasible.

Public acceptance of new taxes

Finally, for value capture to be successful, the public must either accept new taxes or approve the reallocation of existing taxes to fund transit. The first question that arises is whether the public is willing to accept any new taxes. In places where the status quo has been for the state, provincial, or national government to pick up the tab, new taxes are not easily accepted. An interviewee from WMATA spelled this out clearly, saying, “This is Washington. Everybody likes to point the finger at Capitol Hill and beg for money. I think that that ends up being the default position.”

Another important question that arises is who is paying these taxes – households or businesses? Almost exclusively in the cities studied for this paper, businesses are providing the lion’s share of the location value capture revenues. Despite the fact that in many cities, most of the benefit value to be captured accrues to residential properties, none of the cities had existing programs or future plans to directly add taxes to existing residential properties.

17 Previously, the provincial government paid 100% of new railway capital costs.

18 Cervero and Murakami, Calimente
The reason for this strong trend is a combination of the equity and efficiency concerns described earlier in this paper, as well as simple politics. An interviewee from Transport for London said, “An Englishman’s home is his castle,” explaining that residential properties in the U.K. are given favorable terms across many sorts of taxes. It is a political nonstarter to suggest increasing the property tax on residences. Certainly cities and transit agencies would like to tax residential properties that receive location benefits from proximity to transit. In San Francisco, there is a new tax law being considered that would extend the current transit-focused development fee for commercial properties to residential development. Despite the fact that the proposal is only to tax new development rather than existing residential properties, the new tax is expected to be controversial.

In contrast, there can be surprisingly little controversy over new taxes that target businesses. For instance, the Business Rate Supplement in London is raising a large sum to pay for the Crossrail project, and there has been “remarkably little fuss” about it. The reason is likely two-fold. First, most of the valuable businesses in London that are close to the route expect the value of their buildings to go up by 10-15 percent as a direct result of Crossrail. The BRS is lower than that, so they can easily see that they will profit overall. Second, the Crossrail project has a long history. It had been considered for about 20 years as a strategy to relieve congestion in the existing transport system in central London. An interviewee from London explained that when the time came to actually implement the BRS and the project, “the general feeling from the population was kind of ‘get on with it.’”

Conclusion

This paper has synthesized recent literature with additional lessons learned from the value capture experience of six public transport systems. There has been a substantial amount of thinking and research done in this area over the past decade. Consensus has been reached regarding the concept of using value capture to fund public transport: A comprehensive review of the literature with a focus on East Asia. Available at SSRN 1753302.

References

Appendix A: Value Capture Mechanism Definitions

**Land value tax/Location benefit levy:** Tax on the value of land in the vicinity of a public transport amenity. Note that this mechanism is a tax on the land only, and that this is distinct from a conventional property tax.

**Tax Increment Financing:** This mechanism allocates any increase in total property tax revenues toward public investment within the designated TIF district.

**Joint development:** Joint development is a partnership between the private sector and the local government or public transport agency to build a real estate project on land controlled by the public sector. The local government or public transport agency captures value by requiring a private developer partner to build a portion of the station amenity as part of their real estate project, thereby reducing their capital costs.

**Sale or lease of land:** The local government or public transport agency acquires developable land in the vicinity of the public transport facility at the going price before the public transport system is built. After the system is in place, the owner can sell or lease the now higher-value land on the open market, capturing the added value in the transaction.

**Sale or lease of development rights or air rights:** The local government or public transport agency acquires land and adjacent to the public transport facility at the going price before ground is broken to build the public transport system. After the system is built (or concurrently), the owner can then enter into long-term leases with developers for ground, air, or subsurface development rights. The added value from the public transport system is capitalized into the lease price.

**Leasing of commercial space in and around stations:** The public transport agency or local government develops and retains ownership of the commercial space in and around stations, and leases it out to businesses at market prices.

**Transit company business diversification:** The public transport company diversifies its business to include real estate and other station-area commercial businesses.

**Income or payroll-based tax:** Income earners or employers in the region served by the transit system pay an extra increment of income or payroll tax that goes to the public transport agency.

**Transit-focused development fees:** Developers working in the vicinity of a public transport system pay extra fees for the privilege of building new real estate projects.

Special Assessment Districts: Districts benefiting from a public transport improvement may choose to self-impose an additional tax to help finance the improvement. These special assessments are generally approved through some form of vote by the group that will be paying the tax. This group could be local landowners, local residents, or local businesses. The taxes are usually meant to finance a portion of the local infrastructure investment rather than to subsidize the system operating costs.

Appendix B: Case Study Summaries

This appendix provides short narratives that summarize the story of value capture mechanism adoption to fund public transit in each case study city.

**Washington, D.C.**

The Washington Metropolitan Area Transit Authority has an active joint development program, and has been fortunate to be the recipient of Special Assessment District financing from three separate SADs that are helping to finance two major projects. Despite this relatively successful track record of using value capture mechanisms to fund system expansion, WMATA is not optimistic about a large role for value capture to finance the system going forward because of the institutional structure of the region and therefore the agency. WMATA was jointly created by the District of Columbia, the State of Maryland and the Commonwealth of Virginia, and receives subsidies from each of these governments for both operations and capital expenses. The fact that the transit agency serves communities in two states plus the District of Columbia makes it virtually impossible for the agency to implement a large-scale, coordinated, system-wide value capture financing program. The legal frameworks for taxation are substantially different in each government.

**Montreal**

Although Montreal has not yet financed major infrastructure using value capture mechanisms, it is expected that significant value capture-funded projects may soon begin. Historically, the Quebec provincial government has financed 100 percent of rail expansions but only 75 percent of the cost of most other local infrastructure projects. This system clearly incentivizes local jurisdictions to request rail extensions over other transport investments, and the provincial government has indicated that they are planning to change the funding formula. Rail is expensive, however, so local jurisdictions will need a new way to raise revenue to pay for their share of these projects. The region’s transit agency – Agence métropolitaine de transport – has begun to seriously consider value capture as a way forward. First, AMT sponsored a study to verify that proximity to commuter rail in the

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White Papers
Montreal region adds value to properties; the particular rail line studied generates an additional $11 million in annual property tax revenue for local jurisdictions. Then, in June 2013, AMT submitted a formal request to the Quebec provincial government to suggest the use of value capture to fund subway and commuter rail expansion in the region. The Quebec government is expected to respond positively, at which point AMT will work with local governments in the Montreal region to develop specific value capture-based strategies to help finance both commuter rail and subway extensions.

London

Transport for London is a regional public service provider created in 2000 with a publicly elected leader – the Mayor of London. TfL has authority over the region’s rail-based public transport infrastructure as well as its streets (including implementing the city’s congestion charge), bicycle routes, and pedestrian infrastructure. The many new transit initiatives in London have led the city to look to new forms of financing, including value capture strategies. In addition, rising commercial values in London have led TfL to reassess the commercial possibilities within their own real estate holdings. The largest location value capture mechanism currently being implemented in London is a supplement to an existing property tax on commercial buildings, called the Business Rates Supplement. Revenue raised through the BRS will be used to finance a portion of the construction of the new 21-km Crossrail line that will soon traverse the region. In addition to the BRS, the Crossrail is partially funded through a tax on new development that is spatially graduated according to the property’s proximity to the new line. Due to a lull in construction, however, this tax has not brought in as much money as expected. Looking forward, TfL is working to convince the national government that all of the business rates paid in London should be devolved to the regional and local governments that provide services to the Greater London area. Because London’s growth has been strong recently, someone is going to have to pay for it, and it is logical to ask London funding sources to pay rather than funneling money from outside the city. One of our TfL interviewees remarked, “I think we’ve got half a chance.”

New York

The New York Metropolitan Transportation Authority is the owner and operator of two major commuter rail systems (the Long Island Railroad and the Metro North Railroad), the New York subway system, the Staten Island Railroad, and New York City buses. The agency’s use of value capture mechanisms to fund its system has been limited even though New York’s real estate market is responsive to proximity to transit, and the agency has had financial difficulties. One important explanation is related to the agency’s mission and culture as a transit service provider rather than an entrepreneurial business, and related lack of capacity in the area of real estate. That said, a portion of the NYMTA operating subsidy comes from location-based value capture mechanisms, and the agency has recently negotiated real estate deals for two of its largest holdings (Atlantic Yards and Hudson Yards). The portion of the operating subsidy raised via location value capture is from the New York State-implemented tax on the payrolls of all businesses above a certain size within the NYMTA service area – the Payroll Mobility Tax – and a tax on real estate transactions called the Mortgage Transfer Tax. The latter of these is well established, but the PMT was implemented in its current form starting in 2010. This makes the tax more politically controversial and its future therefore uncertain.

San Francisco

The San Francisco Municipal Transportation Agency has authority over the majority of the streets, sidewalks, and rails in the city of San Francisco. It was established by a voter proposition in 1999 as a merger of the Municipal Railway (Muni) and the city’s Department of Parking and Traffic. SFMTA now oversees the Muni, parking and traffic, bicycling, walking and taxis. The advantage of having a city’s streets, bicycle infrastructure, sidewalks and most of its rails managed by the same agency is clear in terms of coordination opportunities, but for historical reasons, many cities are not organized this way. As an SFMTA interviewee said, “We’re an experiment. Can you manage the right of way in a congested city?” Part of managing this right of way has been considering and implementing location value capture finance mechanisms to help pay for Muni. Thus far, the largest example is the subsidy provided to Muni out of parking revenues, providing 25 percent of Muni’s operating budget. In addition, there is a serious proposal to amend the city’s longstanding Transit Impact Development Fee with a more holistic Transportation Sustainability Fee that would raise substantially more revenue because both residential and commercial development would be subject to the fee. It is worth noting here that San Francisco is a much smaller city than the others considered here, with fewer than one million residents.

Paris

Three main entities in Paris play important roles in the finance, operations, and expansion of the city’s public transit system. The Syndicat des transports d’Île-de-France, or Paris Transport Authority, provides the budgets for operation, maintenance, and modernization. The Régie Autonome des Transports Parisiens

19 Dubé et al. 2013
operates much of the actual system, including the Paris Metro system, trams, buses, and two of the regional rail lines that serve the city. The Société du Grand Paris is a regional governmental body created by the French government in 2010 with the goal to build a 200 kilometer extension to the rail system in the Paris region – the Grand Paris Express.

Two main location value capture mechanisms are used to finance public transport in the Paris region. The first is a longstanding payroll tax that was implemented in the 1970s. This tax – the *versement transport* – varies depending on which part of the region the business is located in. The most central areas pay a 2.6 percent payroll tax, less central areas pay 1.7 percent, and areas at the edge of the region pay 1.4 percent. These taxes go to STIF, which then distributes them to RATP and to other public transport operators in the region. The *versement transport* provides 40 percent of the STIF budget. The second major use of value capture in the Paris region is a newly-implemented development tax on office space that is slated to pay for the construction of the new Grand Paris Express. This tax is projected to raise €350 million per year starting in 2014, but there is considerable ongoing discussion about whether this value capture strategy is a good idea. Specifically, the concern is that the tax is high enough that it might actually depress the regional economy through reduced new development, and not raise sufficient funds for the rail extension.

### Appendix C: Table 4 Notes

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<td>Advertising and lease of commercial space in stations</td>
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<tr>
<td>Transit company business diversification</td>
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<tr>
<td>Payroll-based tax</td>
<td>Xh</td>
<td></td>
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<tr>
<td>Transit-focused development fees</td>
<td>Xm</td>
<td>Xn</td>
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<tr>
<td>Transit-focused property transaction taxes</td>
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<tr>
<td>Special assessment districts</td>
<td>Xq</td>
<td>Xp</td>
<td></td>
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</tr>
</tbody>
</table>

- **a** This tax is called the “Business Rate Supplement”, and is collected on all existing commercial buildings that rent for more than £55,000 per year in the Greater London area. The rate of the tax is 2 percent, and it is the largest source of value capture-based revenue to fund the Crossrail project. The BRS is expected to provide £4.1 billion for the project, which is slightly more than 25 percent of the total projected cost of the project.

- **b** TIF districts in London are called “Enterprise Zones.” As in the U.S., these areas are run-down, but expected to have potential for transformation with the boost of incremental tax revenues to finance local infrastructure.

- **c** The City of New York is using a TIF-like financing mechanism to develop the Hudson Yards site in lower Manhattan. The difference between this mechanism and a traditional TIF is that all of the property tax proceeds from the Hudson Yards site will fund local infrastructure, rather than only the increment over and above a baseline amount. Much of the money will pay for the 7 Line Extension, which is projected to cost $2.4 billion (IBO, 2013)

- **d** Joint development is a widely used tool that allows developers to share in paying for infrastructure investments that will add value to their real estate holdings. These are generally projects that are confined to a single site, building, or transit station.

- **e** Two large long-term land leases were recently negotiated: Atlantic Yards in Brooklyn and Hudson Yards in downtown Manhattan.

- **f** Sale or lease of development rights or air rights is a relatively low-yield and location-specific value capture strategy.

- **g** Virtually all transit agencies take advantage of opportunities to earn advertising revenue through ad placement in stations, on vehicles, and sometimes also on their land (e.g. at Park-and-Ride facilities). Similarly, commercial leasing of space in major stations is done by most agencies, though the level of integration between shopping and transit varies tremendously.

- **h** The largest transit operator in Paris (RATP) has subsidiary companies that are active both in the transit operation business outside of Paris (in multiple cities around the world), as well as in other industries such as telecom and engineering.

- **i** Montreal’s largest transit operator (STM) has subsidiary companies active in real estate and the telecom industry.

- **j** With changes to their charter in 2007, the SFMTA diversified from being chiefly a transit operator to being in charge of all transportation in the city. This has meant that they can set car user fees (mainly parking, both street and in garages), and subsidize across the transport modes. Approximately 25 percent of the transit operating budget now comes from private vehicle parking charges.

- **k** The payroll-based versement transport in the Paris region raised approximately €3.1 billion in 2012, which is nearly 40 percent of the total operating budget for public transit in Paris. This tax has been in place since the 1970s, and is not controversial. It is paid by all employers in the region with 10 or more employees, and the rate of tax ranges from 1.4 percent to 2.6 percent, depending on how centrally-located the business is.

- **l** The Payroll Mobility Tax in the MTA portion of New York State began collection in 2010 and is controversial. The tax is paid by all employers in the region with more than $312,500 in payroll expenses per quarter. The tax rate ranges from 0.44 percent to 1.36 percent, depending on the size of the total payroll expenses, where larger firms pay a higher rate. The PMT provides approximately $1.3 billion per year to the MTA, which is about one-fifth of the total subsidy provided to the agency from all government sources.

- **m** These fees are called the Community Infrastructure Levy and are collected on most new building permits in the Greater London area. The CIL revenue will finance part of the Crossrail project, but is not as large of a source of funding as the BRS (see note a).

- **n** There are two kinds of development taxes being collected in the Greater Paris region, both earmarked to finance the Grand Paris Express project. The first is fees collected on new office space. These fees are large, and expected to provide €350 million per year in transit financing. The second is fees collected for new building permits, expected to raise approximately €120 million per year.

- **o** San Francisco put a transit-focused development tax in place in 1981 with its Transit Impact Development Fee. This development tax exempts residential development, which means that it is not a large source of revenue for the
SFMTA since most recent development in San Francisco has been residential. Currently, there is a serious proposal to replace this tax with a Transportation Sustainability Fee. The main differences between the old and new programs would be that the TSF would include a charge for residential development, and the collected funds would be available for all sustainable transportation projects (i.e. transit, plus also pedestrian and cyclist infrastructure).

New York City collects the Mortgage Recording Tax when properties are sold. The collection rate fluctuates with the real estate market, but in 2012, this tax raised slightly less than $300 million for the transit agency.

These taxes have been collected from existing commercial buildings in specific station areas to fund public transit improvements related to those stations. Examples include the New York Avenue Metro Station (2001), now the NoMa-Gallaudet U Metro Station, and the Tysons Corner Metro Station (current project). The mechanisms are championed by local businesses themselves as a way to improve the transit network in their neighborhoods.
Metropolitan public transit sectors will be impacted in a variety of ways by climate change, principally from rising temperatures, rising sea levels, higher storm surges, changing precipitation patterns and extreme events such as floods and droughts.1 This paper documents state-of-the-art understanding of current and future climate risk for urban transit systems. Increasing climate variability is driving urban transit systems to be more flexible and adaptive in response. Transit systems are designed and managed to operate within an expected range of environmental conditions. Climate change is associated with gradual and punctuated shifts in this environmental baseline of cities. Urban transit systems are already experiencing the effects of climate change, and greater impacts are expected with the onset of an increasingly dynamic climate.

According to global climate modeling scenarios, cities can expect directional shifts in average annual climate-related conditions such as higher average annual temperature and more rapid sea level rise, as well as more frequent and intense extreme weather events. Observed climate data from the early 20th century to the present illustrate a shift in the frequency and magnitude of extreme events, particularly heavy precipitation events and heat waves. Worst-case scenarios for future climate change include instances where multiple extreme events occur at the same time – for example, a large coastal storm with tidal surge and flooding coincident with an extreme heat event.

Climate change will increase the exposure and vulnerability of urban transit systems to hazards. Climate-related shifts represent significant challenges as well as potential opportunities for these systems and their managers. In this paper, the new challenges and opportunities brought by climate change are discussed within the context of climate impacts, vulnerabilities and the potential for enhanced resiliency across a set of cities: London, Los Angeles, Madrid, New York, Santiago, Tokyo and Vienna. This paper brings forward general observations and statements drawn from detailed city case studies as well as from other cities experiencing changes in climate.

The paper also examines how urban transit system managers have begun to recognize and respond to the challenge of climate change. In many cases, response has come after a severe disruption and devastating loss caused by an extreme event. In other situations, managers have been more proactive. Central to all discussions is how to finance the necessary adaptations and promote the resiliency that climate change requires, and how to integrate capital investing and management into the everyday operations of transit systems. This analysis also discusses how
local, national, and international organizations and networks such as The C40 Cities Climate Leadership Group and the International Association for Public Transport can play a critical role in helping transit managers better understand, and act on, current and future climate risks. In this paper, the terms “resilience” and “preparedness” refer to different qualities of response capacity to extreme to extreme events while “adaptation” is used to describe a broader effort to respond to a diversity of climate change challenges, including gradual shifts in baseline conditions as well as extreme events.

### Key Climate Risk Impacts on Urban Transit Systems

Climate change will bring a range of impacts for urban transit systems – both acute and gradual. In the short term, the most likely impacts will be acute – more frequent extreme weather events and increased climate variability. Over the longer term, other threats such as sea level rise will compound the potential for more frequent intense coastal storms. Cascading system impacts and associated vulnerabilities, together with transit service disruption, could result in wider-scale, secondary social and economic costs.

Urban climate change impacts will result from the following four broad categories:

1. Increased frequency of extreme precipitation events
2. Increased frequency of extreme heat days and heat waves
3. Sea level rise and coastal storm surge events
4. Increased frequency of extreme wind events

Drought also could affect urban transit systems but not to the degree seen in the other categories. Table 1 provides a listing of climate risks within each of the four categories.

Major investments in transit infrastructure and emergency plans will be necessary to adapt to climate change, and will have to be site-specific. For example, whether infrastructure is at ground level, underground or elevated changes the impact of flooding.2 Flooding can come from a variety of sources, including storm surge in coastal communities, riverine and lake flooding in inland areas, and street level flooding from intense precipitation events. Infrastructure in low-lying areas in the floodplain and areas below ground such as tunnels, vent shafts, and ramps are clearly at risk. To recover from flooding, transportation managers will require the use of numerous, large-scale pumps, debris removal and the repair or replacement of key infrastructure, such as motors, relays, resistors and transformers.

<table>
<thead>
<tr>
<th>Climate Hazard</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increased frequency of extreme precipitation events</td>
<td>Inland and street level flooding, Landslides, Heavy snowfall</td>
</tr>
<tr>
<td>2. Increased frequency of extreme heat days and heat waves</td>
<td>Threats to customer and worker health safety, Overhead electric equipment - excessive heating, Stretched overhead catenary wires, Overheated vehicles and failed air conditioning systems, Blackouts - e.g., from power failures during peak load demand</td>
</tr>
<tr>
<td>3. Sea level rise / coastal storm surge</td>
<td>Inundation, Wave action and scour, Salt water corrosion</td>
</tr>
<tr>
<td>4. Increased frequency of extreme wind events</td>
<td>Blackouts and large scale power loss, Loss of equipment - e.g. localized loss of power and overhead wiring, c. Obstructions - e.g., downed trees</td>
</tr>
</tbody>
</table>

Source: Adapted from FTA 2011.

Besides sea level rise and storm surge vulnerability, steel rail and overhead electrical wires in transportation systems are particularly vulnerable to excessive heat. Overheating can deform transit equipment, causing steel rail lines to buckle and throwing them out of alignment, which can cause train derailments.3 Additionally, heat can reduce the expected life of train wheels and vehicle tires. Roadways made of concrete under extreme heat conditions can buckle and asphalt roads can melt. Downed power and telecommunication systems can create additional risks in the transportation network via power shortages or by limiting communication, particularly during extreme events and emergencies. Passengers also may experience more heat-related illnesses due to higher temperatures and more frequent heat waves. Transit managers need to assess the capacity of their systems to respond to worst-case scenarios, including situations where multiple hazards occur at the same time – e.g., an extreme flooding event during a heat wave.

Transit managers will also need to ensure high standards of safety, maintain infrastructure in a state of good repair, and provide service to transit-dependent populations equitably—all while minimizing costs and responding to new and changing climate risks.

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2 Prasad et al.
3 Mehrotra et al.
Dynamic Climate Risk

This section reviews the most recent global climate change scenarios and predictions for climate impacts for the 21st century as prepared by the International Panel on Climate Change, and then examines examples of climate conditions specifically for the case study cities.

Temperature and Precipitation Change

Observed global temperatures show an increase of approximately 1 degree Celsius since late 19th century, with more rapid warming during the latter part of the data record. While projections continue to show wide variation in the range of possible future conditions, there is greater understanding regarding the factors behind the variation and the level of uncertainty in the model results.

Projections of future climate show a possibility of greater change in the 21st century. Current projection estimates indicate that global temperatures will increase 2 degrees Celsius in the mean annual temperature by the mid 21st century and 3.7 degrees Celsius by the end of the century. Model results for future precipitation patterns are more variable, but most of the findings illustrate higher amounts of precipitation and greater hydrologic variability.

Projected Sea level rise

Climate warming will result in sea level rise. Sea level rise is caused by the thermal expansion of the upper layers of the world’s oceans and seas and from the melting of glaciers and ice sheets. Large continental scale ice sheets such as the Greenland ice sheet are melting more rapidly than expected. Global mean sea level rise for 2081–2100 relative to 1986–2005 will likely be in the ranges of 0.26 to 0.55 meters (10 inches to 21.66 inches) for a low global greenhouse emission scenario, and from 0.45 to 0.82 meters (17.72 inches to 32.28 inches) for a high emissions scenario (see Figure 1). The range of possible future sea level rise is defined by the variation in the scenarios and the level of uncertainty in the models. It should be noted that local rates of sea level rise can vary widely based on rates of erosion, groundwater withdrawal and other local factors. In the case of New York City, the projected rate is roughly double these numbers, with a high estimate of just under 2 meters (78.73 inches) of sea level rise by 2100.

Extreme Weather and Climate Event Frequency

Changes in many extreme weather and climate events have been observed since about 1950. It is very likely that the number of cold days and nights has decreased and the number of warm days and nights has increased on the global scale. It is likely that the frequency of heat waves has increased in large parts of Europe, Asia and Australia. In most areas, the number of heavy precipitation events annually has increased. The frequency or intensity of heavy precipitation events has likely increased in North America and Europe. In other continents, confidence in changes in heavy precipitation events is at most medium. There is low confidence in observed trends in small-scale severe weather phenomena such as hail and thunderstorms because of historical data alterations (e.g., new sampling regimes, changes in sensors) and inadequacies in monitoring systems.

It is expected that climate change will influence the frequency and severity of weather and climate events defined as extreme. This potential extreme event frequency change can take several different complex trajectories, as highlighted by the following graphic presentation (Figure 2).

Changes in extremes include a simple shift in the mean resulting in, for example, fewer extreme cold days and more extreme hot days (Figure 2a). Another scenario illustrates a condition of increased variability with a greater number of extreme events at both tails of the distribution (Figure 2b). Another possibility includes a change in overall symmetry in the distribution of extreme events (Figure 2c). Translating these projected shifts to specific cities and their transit systems indicates there will be more frequent extreme heat days. For example, in New York City, the number of days with temperatures greater than 32.2 degrees Celsius (90 F) will rise from a baseline of 18 days during the period 1971-2000 to as many as 57 days in the 2050s. In Vienna, by 2040 every fourth day in the summer will

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4 The IPCC Working Group I Report (IPCC Fifth Assessment Report 2013, known as AR5), provides updated information on the observed global climate trends. This state-of-the-art report is the latest in the series produced by the science-based Intergovernmental Panel on Climate Change under the auspices of the World Meteorological Organization and the United Nations. The IPCC assessment reports have been released since 1990. With each iteration, the amount of observed data and model sophistication have increased as have the strength of the argument that the world’s climate is warming and that human action is at least partially responsible.

5 NPCC

6 IPCC

7 NPCC CRI 2014
be an excessive heat day, and the number of heat days in the urban core of Vienna will increase from 3.1 days per year (1961-1990) to 17.7 days per year during the period 2010-2039.

Figure 2: Change in distribution of weather and climate extremes.

![Image](Figure_2.png)

Extreme event frequency can be best understood by examining the past, current, and future conditions of heat stress. It is virtually certain that there will be more frequent hot and fewer cold temperature extremes over most land areas on daily and seasonal timescales as global mean temperatures increase. It is very likely that heat waves will occur with a higher frequency and duration. Occasional cold winter extremes will continue to occur. This is an average value; in some areas rapid urban development and land use change will create or exacerbate urban heat island conditions, resulting in substantially greater temperature increases. Urban heat islands result from intense urban development that causes warmer temperatures in cities as opposed to outlying areas. The urban heat island phenomena are particularly observed at night.

8 Observed global temperature data has been partially corrected for the urban island effect. It is unlikely that any uncorrected urban heat-island effects and land use change effects have raised the estimated centennial globally averaged land surface air temperature trends by more than 10 percent of the reported trend.

Globally, there is medium confidence that the length and frequency of warm spells, including heat waves, has increased since the middle of the 20th century, mostly owing to lack of data or studies in Africa and South America. However, it is likely that heat wave frequency has increased over this period in large parts of Europe, Asia and Australia.

Figure 3: Tokyo “guerrilla rain storm” during the summer of 2013 caused by the city’s heat-island effect.

Source: Japan Times, Jake Adelstein, July 13, 2013.

Extreme Rainfall Events

Extreme precipitation events over most of the mid-latitude land masses and over wet tropical regions are very likely to become more intense and more frequent by the end of this century as global mean surface temperature increases. Even so, there is high confidence that, as the climate warms, extreme precipitation rates (e.g., on daily time scales) will increase faster than the time average. Changes in local extremes on daily and sub-daily time scales are expected to increase by roughly 5 to 10 percent per degree Celsius of warming (medium confidence).7 As previously stated here, in North America and Europe there have been likely increases in either the frequency or intensity of heavy precipitation.

Extreme Wind Events

Wind extremes seem to be declining in mid-latitudes and increasing in high latitudes.10 However, confidence in trends in extreme winds is low, due to quality and consistency issues with analyzed data.

9 Global mean sea level has risen by 0.19 [0.17 to 0.21] meter, estimated from a linear trend over the period 1901–2010, based on tide gauge records and additionally from satellite data since 1993. It is very likely that the mean rate of sea level rise was 1.7 [1.5 to 1.9] mm yr–1 between 1901 and 2010. Between 1993 and 2010, the rate was very likely higher at 3.2 [2.8 to 3.6] mm yr–1, similarly high rates likely occurred between 1920 and 1950. The rate of GMSL rise has likely increased since the early 1900s, with estimates ranging from 0.000 [–0.002 to 0.002] to 0.013 [–0.007 to 0.019] mm yr–2. It is very likely that the rate of GMSL rise during the 21st century will exceed the rate observed during 1971–2010 for all Representative Concentration Pathway scenarios (four possible climate futures described in IPCC AR5) due to increases in ocean warming and loss of mass from glaciers and ice sheets. Projections of sea level rise in IPCC AR5 are larger than in the Fourth Assessment Report (IPCC AR4), primarily because of improved modeling of land-ice contributions (see Figure 4). For the period 2081–2100, compared to 1986–2005, GMSL rise is likely (medium confidence) to be in the 5 to 95 percent range of projections from process based models, which give 0.26 to 0.55 meter for RCP2.6, 0.32 to 0.63 meter for RCP4.5, 0.33 to 0.63 meter for RCP6.0, and 0.45 to 0.82 meter for RCP8.5. For RCP8.5, the rise by 2100 is 0.52 to 0.98 meter with a rate during 2081–2100 of 8 to 16 millimeter per year–1.

10 IPCC AR5
Extreme Storm Events - Hurricanes, Typhoons (Cyclonic Storms)

Scientists are almost certain that the frequency and intensity of storms in the North Atlantic have increased since the 1970s, although the reasons for this increase are debated. Climate model projections indicate that it is likely that the global frequency of tropical cyclones will either decrease or remain essentially unchanged, concurrent with a likely increase in both global mean tropical cyclone maximum wind speed and rainfall rates. There is lower confidence in region-specific projections of frequency and intensity. However, due to improvements in model resolution and downscaling techniques, it is more likely than not that the frequency of the most intense storms will increase substantially in some basins under projected 21st century warming.

Droughts

Drying in the Mediterranean, southwestern U.S. and southern African regions is consistent with projected changes in global wind circulation patterns. Confidence is low for a global-scale observed trend in drought or dryness (lack of rainfall) since the middle of the 20th century, owing to lack of direct observations, methodological uncertainties and geographical inconsistencies in the trends.  

Climate Trends and Projections in Case Cities

The weather and climate of any local area is highly particular to that site. Any given city experiences some climate variability and, at times, extremes that need to be managed for within the organization and operation of local urban systems. For the case study cities for which data were available, all experienced warming over the period of 1901-2012. The most warming was observed in Tokyo (1.3 degrees Celsius), with slightly lower amounts in London (1.2 degrees Celsius), Madrid (1.2 degrees Celsius), New York City (1.2 degrees Celsius) and Vienna (1.2 degrees Celsius). Los Angeles experienced the lowest amount of warming (0.8 degrees Celsius).  

Transit managers in these cities already recognize the new risks posed by climate change. This is especially true for flooding and heat stress events. All of the cities have experienced extreme events in the recent past that significantly disrupted the transit system. The case study cities are observing climate change now and will experience further change and accelerated change in the future. Table 2 presents some regional projections of temperature change and precipitation change.  

The case study cities have available to them detailed climate change assessments that provide finer spatial and temporal resolution data regarding possible future climate change. Several of the cities conducted extensive surveys of climate trends and projections that were used by transit managers, while others developed data on an ad hoc basis connected with national or global efforts to understand future climate dynamics.

Some of the most extensive work has been completed by London and New York. For London, defined administratively by the Greater London Authority, the primary source for climate information has been the national government’s data sets on climate conditions and climate change. The U.K. Climate Impacts Programme was established in 1997 and generated climate scenarios in 1998, 2002 and 2009. Using the UKCIP’s 2002 national climate scenarios, the London Climate Change Partnership produced regional scenarios and a report on London’s climate risks, London’s Warming. The City of New York, through its Office of the Mayor, created the New York City Panel on Climate Change in 2008. The NPCC provides comprehensive data on climate trends and future climate projections, including quantitative and qualitative information on the likelihood of extreme events. Similar science-policy working committees have been developed in many of the case study cities. In Vienna, for example, the local scientific community has worked closely with city administrators, including transit officials, via the Master Plan and Klimaschutzprogramm to bring cutting-edge climate science into planning processes.

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**Table 2: Regional Projections of Temperature and Precipitation Change with Reference to Case Study Cities (Min-Max)**

<table>
<thead>
<tr>
<th>Region</th>
<th>City</th>
<th>Temperature</th>
<th>Precipitation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2035</td>
<td>2065</td>
</tr>
<tr>
<td>Eastern North America</td>
<td>New York</td>
<td>0.4 - 1.9°C</td>
<td>1.0 - 3.5°C</td>
</tr>
<tr>
<td>Western North America</td>
<td>Los Angeles</td>
<td>0.3 - 1.9°C</td>
<td>0.9 - 3.4°C</td>
</tr>
<tr>
<td></td>
<td>Vienna &amp; London</td>
<td>1.0 - 2.7°C</td>
<td>-0.5 - 5.8°C</td>
</tr>
<tr>
<td>Central America</td>
<td>Mexico City</td>
<td>0.4 - 1.3°C</td>
<td>1.0 - 2.4°C</td>
</tr>
<tr>
<td>South America</td>
<td>Santiago</td>
<td>0.4 - 1.2°C</td>
<td>0.6 - 1.7°C</td>
</tr>
<tr>
<td>West Coast</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern Europe</td>
<td>Madrid</td>
<td>0.3 - 2.0°C</td>
<td>0.7 - 3.1°C</td>
</tr>
<tr>
<td>Eastern Asia</td>
<td>Tokyo</td>
<td>0.3 - 1.7°C</td>
<td>0.9 - 3.0°C</td>
</tr>
</tbody>
</table>

*For precipitation and temperature, (-) values correspond to a decrease in precipitation or temperature and (+) values correspond to an increase in precipitation or temperature. Source: IPCC AR5 2013.

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11 This does not mean that drought is unlikely to occur in the future. Based on updated studies, conclusions regarding global increasing trends in drought since the 1970s were probably overstated. However, this masks important regional changes: the frequency and intensity of drought have likely increased in the Mediterranean and likely decreased in central North America since 1950.  
12 Similar data were not available for Santiago or Mexico City.  
13 Derived from IPCC AR5  
14 The UKCIP was established with the aim of providing a framework for an integrated national assessment of climate change impacts, and subsequently to help organizations assess how they might be affected by climate change, so they can prepare.  
15 UKCIP
In most cases, the data developed for local contexts is of a finer spatial resolution than what is available at a national or continental spatial scale, but rarely do the data or model result in conflict in direction. For example, within New York City the projected rate of sea level rise developed by the NPCC is up to double the rate defined for North America within the IPCC efforts. This difference results from the fact that regional and local scale-modeling can incorporate a variety of site-specific factors that influence the rate of sea level rise. Several international efforts, including the Urban Climate Change Research Network and the Durban Adaptation Charter, have worked to develop fine-scale climate change data through collaborations between local scientists and local stakeholders.

Effects of Climate Variability and Dynamism on Urban Transit Systems

The cumulative effect of climate change, including system-level cascade effects, will vary significantly from city to city. While all transit systems experience climate risk, the intensity and extent of the effects are influenced by the level of risk (a measure of exposure and frequency of events) and the vulnerability and resiliency of the system.

Some cities have experienced frequent disruptive events while others have not. Within the case study cities, London, New York, Tokyo, and Vienna have experienced frequent disruptive events that have sharpened their focus on climate change. Other cities that historically have not experienced as many events or such defining events have still been affected by a broad variety of climate stresses, such as Santiago, Madrid and Los Angeles. Both sets of cities illustrate how urban transit systems respond to climate risks.

The connection between climate experience, current risks and potential future risk is well illustrated in Madrid, where a relatively resilient urban transit system has experienced significant climate events, and where future climate change is likely to impact various sectors. According to Madrid’s sustainability plan, Ayuntamiento de Madrid (2008), it is anticipated that Madrid temperatures will increase significantly 4 – 7 degrees Celsius in the summer and 2 – 4 degrees Celsius in the winter by 2100 (relative to the period of 1960-1990). Precipitation is generally expected to decrease, particularly during the spring and summer months, which tend to be historically dry.

With respect to extreme events, more frequent heatwaves and flooding events in areas close to the Manzanares River, which traverses Madrid and is close to residential housing, are likely. Intensification of the urban heat island effect is also likely. UHI over Madrid has raised surface temperatures by 5 – 6 degrees Celsius for some portions of the city. Severe droughts are highly likely to occur in the future, as the city is in a Mediterranean climate zone that is projected to become increasingly drier over time and experience more extensive droughts. For many portions of Spain, including Madrid, a drought during 2005 caused a 36 percent decrease in national hydroelectric power production. Development patterns are also leading to increasing flood risks. A lack of available land to build on has led to some river channels being encroached on by the outer limits of Madrid. Where the Manzanares River flows past Madrid, there is also likely to be a heightened risk for flooding. Flooding in this part of Madrid could negatively impact public drinking water resources and damage housing units.

Although Madrid’s climate is changing, Madrid’s transit system may not be very vulnerable to damages with respect to climate change when compared with other cities such as New York and London due to their lower elevations and location along major waterways. Despite this and the fact that Madrid has been increasing the energy efficiency level of its transportation fleets (metro and bus), there are still many climate risks that may be exacerbated by climate change. High temperatures can lead to problems with pavement durability, and roadways that buckle can cause car accidents, among other problems. Higher winter temperatures lessen the demand for snow clearing, but at the same time increase the need for de-icing when rain falls on cold road surfaces. Increased temperatures can lead to ruts or cracks in non-structural features, which could be of concern for older buildings in the city. Heavier storms around Madrid are likely to lead to the destabilization of slopes upon which infrastructure may be situated – including road-and-rail-based transport. Flash floods can cause erosion of slopes, and roadway or railway washouts around the city.

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16 Los Angeles, Santiago and Tokyo have a long history of earthquake risk and hazards that enhance their awareness of the potential for large scale system disruptions.
17 It is should be noted that London, New York, Tokyo and Vienna, given their temperate region locations, already have dynamic seasonal shifts in climate, temperature and precipitation. Los Angeles, Madrid and Santiago are located in Mediterranean climate regions associated with less violent climate shifts except for flash flooding in mountainous terrain and summer heat stress.
18 Salamanca et al.
19 Moreno
20 DG Environment
21 Ayuntamiento de Madrid
22 Moreno
23 Ayuntamiento de Madrid; Doll et al.
Around the world, transit system operations, management and policy will have to cope with the effects of climate change. For operations, the central questions regard disruption or delay of service as well as cascading failures that could significantly interrupt services for an extended period – weeks and months. In the case of New York’s MTA, Tropical Storm Irene in 2011 caused the washout of a commuter rail line that took three months to repair and re-open. In the management context, transit managers will need to use forward-looking information such as climate change projections instead of historical information to make decisions. Vienna has already learned this lesson: Vienna’s transit managers had to adjust and enhance their flood control policies after their system experienced frequent flooding from more severe storms, exceeding statistical expectations. For transit planners and decision-makers, the best policies and plans will be flexible and adaptable over time. Transit managers will have to recognize that with climate change their current policies might be insufficient.

Key Effects on Case Study Cities

All the transit systems in the case study cities recognize the importance of climate risks and have completed assessments of the potential impacts of enhanced climate variability and change. The key climate impacts included flooding and inundation and a variety of other extreme events, particularly heat stress. Several of the individuals interviewed recognized that recent weather and climate patterns illustrated greater variability. In many cities, extreme events and/or unusual seasonal patterns such as the intense flooding of the New York subways, flooding and warm winter temperatures in Vienna and extremely snowy winters in Tokyo alerted the interviewees to the need to investigate climate dynamics and systems operation. Increased temperatures were especially significant for transit systems that were pressing up against limits to effective system operation. For cities such as Vienna, where air conditioning was not traditionally put into public transit, warmer summers over the past two decades have led to the integration of cooling equipment in the system’s trams. In Los Angeles, passengers waiting for transit service or maintenance personnel working on equipment are already overheating. These conditions present a spectrum of significant adaptation challenges for cities, including how to respond to the cost and funding demands associated with the retrofitting of the existing systems to meet these emerging climate change requirements.

The interviewees recognized a variety of key immediate and long-term effects of climate variability and change:

- Immediate impacts included loss of revenue from train cancellations and expenses to restore damaged assets.
- Longer-term impacts were associated with increased capital expenditures for replacing and updating infrastructure, as well as increased expenses to train system operators on emergency response and new adaptive management practices.
- Several transit managers also noted the possible increase of emergency response services, including evacuation and sheltering.

In general, the case study city transit managers are largely focused on the effects of extreme events and climate variability that could disrupt or influence their systems in the short-term. This is largely because of the traditional 10-20 year planning horizon and a general lack of confidence in long-term climate projections. In most cases, the municipal transit systems had not yet performed the formal assessment of key climate risk impacts in the second half of this century. Where work of this type was done, the results indicate a potential for accelerated climate change. In the case of New York, the rate of sea level rise could increase five times above the 20th century rate of 2.5 cm (1 inch) per decade by mid-century; and increase to almost 10 times above by the year 2100.

All the cities maintain systems that collect information on climate risk in their transit system service shed, as well as data on service delivery during highly disruptive events. However, not all cities are able to collect high-quality and extensive data – typically, only the larger and wealthier cities do. Creating an integrated indicator and monitoring system which can build off of the existing weather and climate data-gathering equipment and protocols would assist in the development of climate resiliency and adaptation strategies. This is an activity that could be funded through current expenditures for such data gathering and could be expanded through forward-planned budgeting within the transit agencies.

In many cities, extreme weather events become focused moments for the transit system operators and managers to reassess risk and identify opportunities for coordinated resiliency and adaptation planning and response. The relative role of extreme events setting off a policy response is particularly evident in the case of New York (see Appendix B). While New York City includes agencies and organizations with extensive resources and has been presented as an outlier given its size and complexity, the New York City transit system has been confronted by several massive, system-wide shutdowns in recent years, including major weather events in 2007, 2011 and 2012, the Northeast Blackout in 2003, and the attacks on September 11, 2001. These extreme events have provided the impetus for advanced planning for...

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24 Events like Tropical Storm Irene, which followed a two month period of unusually heavy rains, are consistent with climate change predictions.
natural and man-made risks. Hazards and disasters research shows that especially after multiple harmful or disabling events, organizations and individuals will take action. Given that, it can be assumed that as other cities experience extreme climate events actions will follow. Clear evidence for similar advanced action in response to recent histories of extreme events also can be seen in Tokyo and Vienna.

Climate Adaptation and Urban Transit Systems

Transit systems have long had to manage the impacts of climate under the auspices of variety disaster risk reduction, hazard mitigation, and emergency response strategies. In many ways, climate change represents an extension or augmentation of known risks such as more flooding or more frequent intense heat events. In other cases, climate change will manifest itself as new risks or hazards or events historically seen as highly unusual or “freakish,” such as historically unprecedented long heatwaves or extended periods of precipitation.

In response to these threats, urban transit systems are now witnessing a blending of these earlier approaches with modern climate change adaptation strategies. A range of basic approaches to respond to climate risk has been defined for the urban transportation sector.25 Most of these approaches focus on “technological fixes.” Historically, infrastructure has been protected from floods by building or strengthening levees, elevating equipment or improving drainage or pumping capacity. The transit systems in all of the case study cities have adopted flood hazard mitigation strategies; Tokyo is particularly illustrative. East Japan Railway Company, Tokyo Metro, Toei Subway and to a lesser extent the other 22 railway operators in Tokyo,26 in concert with the local and national governments, have built and put into practice a wide variety of large, medium and small-scale infrastructure devices, including extensive levees and station specific water barriers to protect the systems from flooding and a range of other hazards.

Significant changes in the climate risk protection within cities and their transit systems have emerged in recent years. These focus on three general areas of advancement: 1) instrumentation, sensing, and smart systems; 2) integration of ecosystem services; and, 3) resiliency practice. Advanced instrumentation and sensing capacity, including the development of microsensors, now allow transit systems to monitor the shifts in risk and hazard conditions and alert managers to potential immediate threats. Most transit systems now accept flood detention strategies and passive cooling as part of risk and hazard mitigation.

The integration of resiliency into urban system operation has been equally important. Broadly defined as the capacity to “bounce back” after a shock or stress, resiliency practice has been expressed in a variety of ways, which for transit could include temporarily moving rolling stock in advance of storms to protected locations and diversifying transport modal choices.

It is critical that climate adaptation considerations be incorporated into transit plans, construction and management even while retrofitting existing transportation assets. Several factors have been associated with adaptation efforts in urban transit systems that could reduce their overall level of exposure and vulnerability and enhance their resiliency to climate change. The two key factors seen as most critical in the literature and by transit managers were access to resources (e.g., human, institutional and financial) and the capacity to put them into use.

Several additional factors were also identified in the research literature and include:

1. Flexibility, broad cross-disciplinary involvement and buy-in
2. Embedding climate change into work streams rather than developing a special system
3. Prioritizing “no-regrets” strategies to understand the consequences of inaction and meeting multiple goals
4. Planning for and executing effective communication with customers
5. Top level engagement with a central point of coordination
6. Coordination with other infrastructure and service providers within the system’s service-shed

Type of ownership (private, public or quasi-public) is not consistently associated with conditions of higher or lower response capacity. In case study cities, conditions of ownership and related structural conditions and constraints, including funding sources, revenue streams and executive decision-making, vary widely based on whether the transit organization is public or private. Despite these variations, in all cases close and interdependent relationships between private and public sectors are maintained.

City Case Study-Related Adaptation Strategies

All the case study transit agencies have recognized the importance of assessing the potential impacts of increased climate variability and change, yet only a few have dedicated climate adaptation planning and assessment processes and have also committed extensive resources to climate adaptation. Conversely, much greater attention has been focused on climate mitigation, greenhouse mitigation and energy savings that could result from urban transit use and system expansion. In general, urban transit is presented as a critical component of the case study cities’ attempts to define and meet greenhouse gas emission goals. This is especially true for Madrid, Santiago and Tokyo. With respect to climate adaptation, the London, Los Angeles and New York systems have been able to focus the greatest amount of resources on these issues. A similar level of variation exists with respect to the conditions of climate governance and decision-making framework for climate adaptation strategies.

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26 The Toei Subway is the other major metro operator, but is owned and directly operated by the Tokyo municipal government. In total there are 25 different railway operators in the Tokyo metropolitan area.
The Greater London Authority has created an extensive policy infrastructure to bring climate science information into a decision-making process and to define steps to enhance the resilience of its transit system to climate change. In most other places, the governance of climate risk takes place within the existing codes and regulations used to maintain the operation of the transit systems. Transit agencies are sensitive to the possibility of emergent climate change. Several agencies, but not all, say they have actively tried to draw attention to the ever-present signals of increased climate dynamics (e.g., more frequent weather-related delays, etc.).

In many cities, opportunities exist for day-to-day operators and upper level managers to discuss weather and climate-related risks. All city transit systems maintain basic metrics of weather and climate-related risks, but most have not yet developed metrics to assess the value or contribution of climate resiliency and adaptation strategies. One exception is the Los Angeles Metro, which has developed a set of metrics focused on sustainability and resiliency— including several climate change and adaptation measures.

Networks and international organizations have been quite valuable for transit organizations in understanding climate risk and developing and implementing adaptation strategies. Meaningful cooperation between cities was often cited; for example, New York’s MTA has worked extensively with Tokyo and London as well as other cities on both flooding and heat mitigation measures. Networks include transit-focused and climate-focused organizations such as The C40 Cities Climate Leadership Group. The prevailing approach has been to incorporate increased climate dynamism into everyday operations and life-cycle capital redevelopment. This integration and enhanced flexibility or adaptive management structure is seen as the most robust response to climate change impacts and effects.

Concluding Thoughts

It is clear that urban transit systems have been affected by climate change and that a wide variety of potential and emerging impacts have been identified. The costs and disruptions associated with recent climate events have been documented and studied. Every agency interviewed for this analysis has experienced increased climate variability, though many of them do not formally recognize this as part of a long-term trend and broad-scale climate change. It was stated that within many agencies a significant proportion of employees remain skeptical regarding the reality of long-term climate change, and in general the term “climate change” is not widely used in planning, management and operation.

Opportunities for Transit Agencies to Improve Resiliency and Adaptation Strategies

Several clear opportunities exist to enhance transit system response capacity, resiliency and adaptation in the face of climate risk. Many of these opportunities are illustrated by the city transit systems presented in this paper.

To build the response capacity of the transit systems, it is critical to increase the level of connection between the different constituencies with interests in urban transit systems operation and upper-level strategic management. Additionally, creating more and broader links between managers and operators could enhance the level of information and resource flow needed to implement effective climate resiliency strategies. Just as the connections between transit system representatives via national or international partnerships/networks have promoted local capacity, greater communication between the operational and managerial elements within transit agencies can also promote response capacity. Some of the case study cities have already informally begun integrating operational and managerial decision making around climate resiliency, which could eventually lead to more formal links over time.

Other possible actions to advance resiliency and adaptation include:

1. Create climate change science panels that produce updated and on-demand climate data and modeling results for transit officials and utilize the expertise of the local science community and local transit community.
2. Develop and implement robust indicator and monitoring systems that include among other sources of data the “local knowledge” of day-to-day operators.
3. Use extreme events as learning opportunities to review all aspects of the transit system’s operation and management, including an assessment of every individual’s responsibility during a system crisis.

Challenges to Implementing Climate Resiliency and Adaptation Strategies

A significant challenge for promoting resiliency and adaptation rests with the complex nature of cities and their extended metropolitan regions, including the administration of urban transit systems and other critical infrastructure. Within any large metropolitan region there may be several separate entities responsible for different components of the region’s public transit infrastructure—each entity with its own revenue stream and set of stakeholders. In addition, the operation of any one transit service is dependent on a variety of other urban systems such as energy supply, road and highway maintenance and communications. Coordination across these different organizations and associated constituencies is inherently difficult. In such a highly fragmented system, the capacity to develop and
implement integrative adaptation plans can be limited. Even in the case of New York City, quite advanced in climate adaptation, the post-Hurricane Sandy resiliency and adaptation planning did not include comprehensive and detailed strategies because the city’s transit system is operated by the State of New York – a distinct governmental entity which was to receive separate post-disaster federal aid.

Another significant challenge for urban transit system operations is defining climate action plans that include a diversity of strategies instead of ones that only focus on a single approach to adaptation. The research literature and empirical evidence illustrates that physical intervention, including hard risk and hazard mitigation infrastructure (e.g., walls and levees) by themselves have limited capacity for reducing vulnerability and improving resiliency. An integrated approach including hard and soft (ecosystem services) intervention on a variety of scales, coupled with management and policy reform are currently seen as leading to the most meaningful and robust adaptation approaches.

A crucial element in this integrated approach – or really any adaptation strategy – will be identifying funds to support these efforts. In general, transit authorities have limited ability to raise significant funds for large scale interventions and typically must do so with significant support from state or national government. Integrating adaptation planning and implementation into regular capital expenditure upgrades while also promoting resiliency actions (e.g., removing assets in harm’s way before a disaster), is seen as the most cost effective and financially realistic approach. This is especially true in our current era of increasing fiscal stress and lack of alternative revenue streams.

The potential connections between climate change mitigation and adaptation are especially important in the context of urban transit systems. Urban transit provides clear advantages for promoting greenhouse gas emission reduction strategies and goals. Although the numbers vary widely, transportation can be responsible for 20-50 percent or more of the greenhouse gas emissions of developed cities. The case study cities all highlight the benefits of urban transit systems as an effective low carbon mechanism for mobility. In Madrid, a recent survey found that road transportation was responsible for 46.9 percent of the greenhouse gas emissions, while other forms of transit contributed 5.8 percent.27 In New York City, automobiles emitted 20.6 percent of greenhouse gas and transit only 2.6 percent, with most of balance originating from buildings.28 The capacity to take further advantage of urban transit greenhouse gas emissions reductions benefits by increasing ridership are hampered by the significant investments required to expand infrastructure at a time when the existing infrastructure is increasingly at risk from increased climate dynamics and extreme events.29

As demands for climate mitigation and adaptation increase, it will be beneficial to identify cross connections between these two streams. Yet, while there are potential synergies, there are also conflicts. For example, some adaptation approaches might encourage air conditioning in response to increasing heat stress, which then could result in increasing greenhouse gas emissions. A central long-term synergy might arise in future low carbon scenarios in which cities could accrue financial benefits from transit-related greenhouse gas reduction via a carbon fee system. These benefits could be used to both expand the service to encourage more ridership and greenhouse gas reduction, as well as promote more rapid expansion of the adaptation strategies. This approach is well exemplified by the KLIP climate planning strategy that is now being implemented in Vienna. This effort is consciously attempting to incentivize the expansion of public transit and reduce auto use.

Final Thoughts, Longer-Term Reorientation

One of the greatest challenges is how “resiliency” is defined by these transit systems. In most cases, the term illustrates an engineering and safety perspective to enable a system to “bounce back” after a disaster. While this definition is logical and laudable, the challenge will be to embrace the broader and longer-term aspects of resiliency which, given the projections for future climate change, could require more profound adaptation of systems whose operation will become increasingly fragile in the face of even more dramatic climate shifts.

References


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27 Madrid
28 NYC
29 The costs of service expansion and extreme event damage vary widely from city to city and are based on the structure of the existing systems, opportunities for expansion (including settlement patterns), and the level and character of climate risk and hazard.


Appendix A: Climate Change Projections – Additional Details

Figure 2 illustrates the distribution of global temperature change, with higher amounts in more northerly and southerly latitudes as well as some areas of average number temperature increases. It is difficult to define global trends for specific weather and climate measures, but it is very likely that during the period of record, the number of cold days and nights has decreased and the number of warm days and nights have increased on the global scale between 1951 and 2010. A recent decrease of the warming rate increase has been the subject of intense scientific debate but has not altered the overall profile of a dramatically warming planet.

Global surface temperature change for the end of the 21st century is likely to exceed 1.5 degrees Celsius relative to 1850 to 1900 for all Representative Concentration Pathways scenarios except one. The global mean surface temperature change for the period 2016–2035 relative to 1986–2005 will likely be in the range of 0.3 degree Celsius to 0.7 degree Celsius (medium
Global mean sea level has risen by 0.19 [0.17 to 0.21] meter, estimated from a linear trend over the period 1901–2010, based on tide gauge records and (since 1993) satellite data. It is very likely that the mean rate of sea level rise over the period 1901–2010 was 1.7 [1.5 to 1.9] mm/yr–1. Between 1993 and 2010, the rate of sea level rise was likely higher at 3.2 [2.8 to 3.6] mm/yr–1. Similarly high rates occurred between 1920 and 1950. The rate of GMSL rise has likely increased since the early 1900s, with estimates ranging from 0.000 [−0.002 to 0.002] to 0.013 [−0.007 to 0.019] mm/yr–1. It is very likely that the rate of GMSL rise during the 21st century will exceed the rate observed during 1971–2010 for all RCP scenarios due to increases in ocean warming and loss of mass from glaciers and ice sheets.

Projections of sea level rise in the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (see Figure 4) are larger than in the Fourth Assessment Report, primarily because of improved modeling of land-ice contributions. For the period 2081–2100, compared to 1986–2005, global mean sea level rise is likely (medium confidence) to be in the 5 to 95 percent range of projections from process based models, which give 0.26 to 0.55 meter for RCP2.6, 0.32 to 0.63 meter for RCP4.5, 0.33 to 0.63 meter for RCP6.0, and 0.45 to 0.82 meter for RCP8.5. For RCP8.5, the rise by 2100 is 0.52 to 0.98 meter with a rate during 2081–2100 of 8 to 16 mm/yr–1.

### Appendix B: City of New York Case Study

The connections between hazard mitigation, climate change adaptation, and the evolution of adaptation and resiliency strategies are well illustrated by the climate change action in New York City, where the Metropolitan Transit Authority (MTA) became a policy window for the initiation of climate change adaptation planning and action. The event of a highly vulnerable community in the city’s central business districts. Suddenly the prospect of climate change impacts seemed more immediate and relevant. The event became a policy window for the initiation of climate change adaptation policy in New York City, and marks a transition in the city’s climate action.

In the immediate aftermath of the 2007 storm, the New York State Governor directed the MTA to conduct an assessment of the system’s vulnerability to future storms. Specific recommendations for improving the MTA’s operations, communications, engineering and regional interagency issues were put forth, including the creation of an Emergency Response Center and Inter/Intra-Agency Flooding Task Force. These adaptation measures, developed in response to crisis, increased the capacity of the MTA in the face of future storm events.

Several years later, two other storms presented additional opportunities and policy windows to catalyze new and larger scale climate action. Hurricane Irene struck the metropolitan region in late August 2011. Local officials and other stakeholders...
broadly described it as another focusing event for putting extreme event resiliency planning proposals into practice. Hurricane Irene resulted in extensive flooding in distant suburban and exurban areas north and west of the city, and resulted in only slight storm surge flooding in the city itself. It caused approximately $65 million of damage for the MTA and, most important, the loss of a section of commuter train to rain-induced railway bed washout.\textsuperscript{30} Fourteen months after Irene, Hurricane Sandy hit the metropolitan region, causing catastrophic damage, the most significant of which came from record storm surge and coastal flooding. In the aftermath of Hurricane Sandy, former Mayor Bloomberg created the Special Initiative for Rebuilding and Resilience (SIRR) and reconvened the New York City Climate Change Adaptation Taskforce.

Hurricane Sandy dealt New York’s transit system a massive blow, resulting in approximately $4.75 billion of damage.\textsuperscript{31} As projected in earlier assessment reports, almost all of the major subway tunnels flooded because of the record storm surge. Other disruptions were present in the above-ground components of the system. Sandy made landfall on a Monday evening, and the majority of systems were shut down for the remainder of the workweek (see Figure 6). The recovery process included pumping storm surge out of the tunnels and checking all the equipment. Loss and damage were significantly less than they could have been because the entire transit system was closed well in advance of the storm’s full impact, and mobile assets such as subway cars and buses were relocated to higher elevation sites away from storm surge zones.

The SIRR focused on assessing the damage from Sandy, understanding how future climate change might influence the level of coastal risk, and promoting resiliency efforts in neighborhoods most at risk of current and future flooding. The SIRR released its report in June 2013, and the NPCC released its climate projection updates at the same time. Similar to the two previous PlaNYC documents, the SIRR report highlighted dozens of new initiatives and actions designed to reduce vulnerabilities, aid in rebuilding, and institutionalize resiliency practice. The SIRR only focused indirectly on the Metropolitan Transit Authority infrastructure and systems because of how the federal recovery money was to be allocated. Funding would be provided to the City of New York and the State of New York, as well as other states. SIRR was directed at wholly city-owned/housed infrastructure, of which the MTA is not included. In the months that followed Hurricane Sandy, the MTA created its own climate change taskforce to address the broader management, planning and operational issues associated with climate risk and resiliency.

\textsuperscript{30} MTA 2012
\textsuperscript{31} MTA 2013
It is self-evident: the more paying customers use a transit system, the better the return on investment for the transit provider. Yet exploiting this simple formula is anything but simple: adapting a transit system to a growing population spread over a growing geographic area while keeping costs in line with revenue is a major challenge for transit providers.

One way to increase the customer base is to extend the network, as long as there is a concentration of population and employment at the new stations. But this may not be enough, as the case of Singapore illustrates: As a result of Singapore’s ongoing commitment to link land use and transportation, 80 percent of the population is within 400 meters (about a quarter of a mile) of a bus or metro line. Over the last decade, the Land Transport Authority has been steadily expanding its network and increasing service. Even so, as a result of rapid growth in wealth and population over the last decade (from 3.8 to 4.8 million persons), car ownership jumped from 26 percent to 47 percent, and the modal share captured by public transit actually decreased from 63 percent in 1997 to 58 percent in 2004.

The growing number of passenger servicing trips [car trips to mass transit stops] should raise a red flag to transport planners as they are usually first-and-last mile trips that could have been completed on the public transport network and thus avoided entirely... Commuters need to be persuaded to use alternative modes of transport such as public transit or cycling or walking, for short trips.¹

— Singapore Land Transport Authority

Thus, even in situations where the line-haul network can be expanded, transit providers need to focus on the first-and-last leg challenge if they hope to fully capitalize on their investments.

¹ Household Interview Surveys from 1997 to 2008 – A Decade of Changing Travel Behaviors, LTA, May 2010
“Combined mobility” – the addition of individual modes of transport to supplement mass transit systems – is a promising solution.

In many metropolitan areas, extending the transit network is becoming more expensive as capital and labor costs increase, and as it gets harder to secure the space for rights-of-way. In many developed economies such as Europe and the U.S., spending on infrastructure is predominantly directed at asset maintenance and repair, with few opportunities for new rail lines. Momentum behind infrastructure funding has dissipated in most European countries - at least for the time being - as the region copes with severe government debt by slashing budgets and postponing many infrastructure projects.

All of this points to the importance of using as many modes as possible to “irrigate” transit access from the line-haul system into a larger geography where there is a huge reservoir of potential riders who would use the transit network if they did not live beyond walking or cycling distance, or if they had ready access to a connecting service or an alternative mode. While it is difficult to quantify the increases in ridership that might accrue by fixing the last-mile problem, there is nevertheless a convincing proxy for this in the well-established research linking transit use to distance from the service. Not surprisingly, the distance to the nearest transit stop and the number of transit stops near home are strongly related to transit travel. To the extent that transit trips offset vehicle trips, transit travel reduces vehicle miles traveled and increases walking to transit; the greatest effect is within one-quarter mile or less of a stop, declining by half between one-quarter and one-half miles, and becoming very small beyond that. This is supported by a Singapore Land Transport Authority study that found transit use declined by 1.6 percent for every 100 meters (about 330 feet) from the station, and explains LTA’s commitment to building a network of integrated transport hubs with seamless intermodal connections as well as a more extensive network of covered passageways to make walking more attractive.

Similarly, a 2011 study by the European Commission concludes that public transport quality and connections need to be greatly improved to reach the 71 percent of car users who feel that public transport is less convenient than the car. A similar proportion (72 percent) say they don’t use public transport because of a lack of connections (49 percent of “very important” responses). Sixty-four percent blame too few services.

The objective is clear: by increasing access to transit services, by whatever means, ridership and revenues will increase.

The Context for Combined Mobility

Policies to increase non-auto mobility will need to confront several realities about the changing metropolitan landscape – realities that challenge established transportation planning practices and standard models for transit provision.

Sprawl continues. Despite the often stated reality that a greater proportion of people will be living in cities, these urbanizing areas are not necessarily configured in ways that make line-haul access (between terminals) possible. Although efforts to curtail sprawl and promote more centered development have taken hold over the last several decades, many mature metropolitan regions are permanently settled in ways that do not meet the density thresholds to support conventional rail and bus services. While sprawl is typically associated with American urbanization, it is regarded as one of the major challenges in Europe as well, particularly in the southern, eastern and central areas that saw rapid growth from EU regional policies. These places have seen a lot of auto-dependent suburban development; over the past 20 years, built-up areas in many western and eastern European countries have increased by 20 percent while the population has increased by only 6 percent. In Madrid, the Consorcio Transporta Madrid describes the settlement pattern in terms of Madrid City, the metropolitan ring of established satellite cities, and the “rest of the region.” Although the trend has slowed since the mid-1990s, growth in the metropolitan ring and the rest of the region has been at the expense of the center city, “giving rise to radical changes in mobility in the region, with a significant increase in metropolitan journeys.” In fact, mobility between municipalities that are not in the metropolitan ring has been increasing, with more than two-thirds of these journeys made by private vehicle (69.4 percent).

In some emerging market cities, such as Santiago de Chile, transit planning cannot keep up with rapid metropolitan expansion. For reasons of both equity and environment, combined mobility can help extend transit access to these sprawling landscapes.
The foundation of most transit networks is still the “solar” model of transportation and land use, in which the majority of transit trips are on commuter lines that emanate in a radial pattern from a single central business district. But as concentrations of employment and housing in the larger region start to become true centers in their own right, a much more complex “constellation” of destinations emerges, generating an equally complex pattern of transit trips not served by existing transit networks. In Europe, the emerging urban agglomerations are called “Functional Urban Areas,” and are considered the building blocks of a successful polycentric region. The concept of polycentric development supports the idea that there are specialized regional competencies—networks of specialists, resources, supplies and workforce—that are difficult to reproduce elsewhere. Improving the economic performance of an urban region depends on creating linkages—physical as well as economic—between centers with complementary strengths.9

Vienna has witnessed this same phenomenon, where more and more smaller centers are emerging within a distance of about 50 kilometers (30 miles) from each other, often focused on a particular industry or service economy sector. In 2007, White Plains, one of the regional centers north of New York City, had nearly as many reverse commuters (2,600) as those destined for work in Manhattan (3,460), and 23 percent of the total reverse commuters for the entire Metro North rail system. More than half of New York City’s jobs are located outside of Manhattan’s central business district. Approximately half of the workers living in each of the city’s four other boroughs also work in their own borough. Regional mobility depends on finding ways to accommodate these more complex movement patterns within and among these multiple centers. Combined mobility is an essential part of this strategy.

Patterns of urban activity are becoming more complex. The emergence of the “24/7 city” has generated demand for more trips of different kinds throughout the day.10 While weekday morning and evening peak periods continue to exist, rush hour durations are expanding, and demand on weekends and non-work hours is increasing. A 2010 study by Singapore’s LTA found that individuals were making more discretionary trips for social and leisure activities. The same study found that a combination of flexible work arrangements and road pricing strategies had shifted the morning rush period earlier, and made it longer. In the New York region, ridership in the off-peak and overnight periods, in particular, is where the majority of the increased ridership has occurred in recent years. From 2007 to 2011, average weekday off-peak and overnight ridership increased by 7.4 percent while peak ridership increased by 2.2 percent. Average weekend ridership increased by 7.2 percent from 2007 to 2011 compared to 4.8 percent on an average weekday.

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9 Potentials for Polycentric Development in Europe, ESPON 111, European Commission
10 Madrid, A World Reference, Consorcio Transporta Madrid, November 2013
In the Madrid region, non-mandatory travel accounts for almost 43 percent of the total, suggesting purposes for making journeys are increasingly varied. “The issue of mobility is, therefore, gradually becoming more complex.”

City dwellers now make more frequent, unpredictable and varied trips that cannot be served efficiently by conventional transport, driving the demand for complementary services and demand-responsive modes. Meanwhile, heightened expectations surrounding information technology put pressure on transit providers to make real-time information available to riders, and to offer unified fare collections using open payment technologies to pay for any mode with a swipe of a contactless credit card or cell phone.

The idea of intermodal connectivity is not new. What has changed are the diversity of modes that are now considered part of this extended network and the role played by both technology and new institutional arrangements and partnerships in facilitating these connections. A new set of practices is now referred to as “combined mobility” or “integrated mobility services.”

Car sharing, taxis and shared taxis, bicycle and bike sharing, carpooling, demand-responsive transport, car rental, etc. are services that can complement the classic fixed line, timetable-bound public transport services, and, together with walking, they form a complete and coherent mobility solution. The combined mobility framework considers the complete trip, from door to desk, and from first mile to last mile.

This paper discusses several major dimensions of this phenomenon:

- **New methods**, including new institutional arrangements and new levels of cooperation between the transit agencies and the providers of other modes.
- **New modes**, including especially shared cars and bicycles, but also new models for taxi service and shuttle buses.
- **New spaces**, including the kinds of physical accommodations needed to facilitate intermodal connections and to store different kinds of vehicles.

### New Methods, New Modes, New Spaces

#### New Methods

At the center of combined mobility is coordination among transit agencies and providers of other modes. The degree of integration varies: it may be primarily information-sharing about timetables and the availability of other modes, such as bicycles and cars, or it can extend to actual shared control or public ownership of the alternative mode. For example, some transit providers have decided to launch their own car sharing programs, including Bologna, Munich, Wuppertal and Dresden: German Rail has launched its own program - DBCarsharing. In some cities, bike share programs are privately initiated and operated, such as New York City’s Citibike, but several of the established bicycle sharing programs were started by and continue to be owned by transit agencies, including Call A Bike, owned by Deutsche Bahn, and Barclays Cycle Hire, owned by Transport for London.

On the motorized front, Japan is a case study in the role that feeder buses can serve in supporting the transit system. Thirty percent of ridership there arrives by feeder bus, much of it on Japan’s Green Mini Bus service, which carries 1,526,000 passengers a day. Some of these services are free. Others have significant discounts through prepaid IC12 cards.

While service integration can take many forms, there are several strategies that most programs share:

- Unified payment systems
- Media and information sharing
- Institutional integration

#### Unified payment systems

Unified payment systems, which enable the use of the same ticket or monthly pass for multiple services, are an essential first step toward a more comprehensive system integration. For example, even though Santiago’s transit authority, Transantiago, is only a decade old and is just starting to think about combined mobility, one of its first steps was to create a unified fare structure and payment system for the buses and metro. This move has had the positive effects of rationalizing and making more efficient Santiago’s transit service, and establishes a solid foundation for Transantiago to build on. For cities that are further along in implementing combined mobility, riders may use a single ticket or monthly pass not just for buses and subways, but for car share, bike share and even taxi services as well. Many cities have introduced single card payment systems and flexible options for purchasing and adding value to the cards. Examples include the Bremer Karte plus Autocard in Bremen, which is a combined transit and car share ticket, and the Zurimobil chip card in Zurich, which provides access to cars, taxis and public transport.

One of the most ambitious initiatives is Hannover’s HANNOVERmobil, a joint ticket that integrates public transport, car-sharing, taxis, German rail services, bicycle and other services. HANNOVERmobil provides customers hassle-free, one-stop mobility. Instead of spending time on choosing the right solution and signing up with a multitude of providers, the customer has instant access to a comprehensive “mobility menu” from which he can choose the most appropriate service at any time by using his “all-in-one” access card. In this case, the public transit provider has become a comprehensive mobility provider, improving transit customer service, increasing the number of customers and building customer loyalty.

This program integrates four services: Public transport, public car, taxi and long distance rail. The integration of public transit and car sharing forms the core of HANNOVERmobil. Residents can pick up one of the cars in their neighborhood and pay by the

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11 Ibid.

12 Integrated circuit
hour and mile. More than 2,000 customers are using car sharing in Hanover today, with more than 110 cars and vans located in 70 spots all over the city and in parts of the surrounding area.

**Figure 4: Mobile devices with HANNOVERmobil.**

![Image of mobile devices](image)


Finally, a significant advantage of unified payment systems is the possibility for the transit authority to monitor the entire network, and thus to influence travel patterns through measures such as congestion pricing. Singapore, which was one of the earliest adopters of a single card payment system, uses differential pricing, as well as cash awards and discounts, to distribute trips outside of peak hours, in particular the morning peak.

The flexibility of the unified payment system allows for this dynamic pricing structure, which would have been prohibitively cumbersome without this technology.

Open payment systems can take this flexibility a step further by changing the role of the transit provider to a vendor – similar to a local convenience store. The rider no longer purchases fare media from the provider’s ticket machine or station clerk to access the system, but instead, “purchases” access directly at the turnstile using a contactless credit card or near field communication-enabled mobile phone. The benefits of this are numerous:

- Passenger convenience and throughput are increased.
- Differentiated fare structures, such as congestion pricing, are easier to implement.
- Capital and operational costs are reduced because ticket vending media and infrastructure do not have to be installed or maintained.
- Data collection enables both real-time intelligence and longer term management benefits.

**Media and information sharing**

Combined mobility initiatives rely on the near-ubiquitous access to cell phones, the internet and forms of social media. These initiatives include everything from using a computer, cell phone or other mobile device to get real-time information about schedules, service and bike share/car share availability; to making reservations for rentals, taxis and transit; to arranging in real time passenger rides with drivers in exchange for payment, using apps like Lyft, Uber and Sidecar.

The Deutsche Bahn Call A Bike system uses electronic locks controlled by embedded microcontrollers activated from one’s cell phone. In Zurich, the “urban mobility information system” Mobil includes a map at all transit stops that has status information not only about all of the transit lines, but about pedestrian areas, bicycle paths and car parks.

In Vienna, the Wiener Modellregion’s “e-mobility on demand” research project aims to integrate various e-mobility options – electric vehicles, the charging infrastructure, the optimal combination of types of transport and access to them by means of a multi-modal mobility ticket for users – into a new paradigm of intermodal urban mobility. These alternatives aim to extend mobility when walking, cycling or public transport is not practical. In May 2009 the City of Vienna launched its Intelligent Transport System with the goals of improving traffic management and providing regional travelers an accessible trip- or route-planning tool. More recently, as a next generation effort for ITS, the City of Vienna, with funding from the Climate and Energy Fund, released its project SMILE (Smart Mobility Information and ticketing system Leading the way for Effective e-mobility services). This personal mobility assistance app represents a prototype of a comprehensive multimodal mobility platform for all of Austria. Through the SMILE app on their smartphone, travelers will be able to view real-time travel alternatives for getting to their destinations, and can reserve and pay for their trips as well. SMILE is currently working with 20 vendors and providers ranging from local and long distance train operators to car sharing and taxi companies. The research project is in testing phases and will run until March 2015.

**Institutional Integration**

The combined mobility paradigm depends on close coordination among the providers of the different modes, and between public and private actors. Santiago offers a case study in how institutional integration was a necessary although not sufficient condition for creating a rational transit system. Transantiago emerged in reaction to the chaos that ensued after embracing the principle of “freedom to work,” which allowed private providers within the city to operate independently and without coordination. The system remains somewhat hindered by an incoherent, suboptimal pattern of urban development, the result of a fragmented governance structure in the city. However, when considering incremental, manageable steps an institution can take towards greater service integration, Transantiago is a success story.

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13 Perrotta, Zupan, Barone et al, Transit Leadership Summit white paper, March 2013
14 Arthur D. Little 2014, 20
Consolidation of administrative power would seem to be the antidote to the balkanization that handicaps coordinated transportation planning in many U.S. cities. In Singapore, coordinated planning of land use and transport is achieved not through administrative and legal consolidation of institutions and governance, but instead through the use of interagency committees that ensure the “integration of planning and implementation.” These committees serve to link various city functions and enable the city to manage a hierarchy of integrated short, medium and long term plans.

This model of close coordination and cooperation is one that other cities have followed to successfully expand regional mobility. Vienna has long enjoyed an integrated transport master-planning process that covers all modes plus parking policy, pedestrians, and cycling as well as safety.15 Vienna’s consensus-based, integrated planning relies heavily on the “Social Partnership,” a voluntary co-operation among employers, employees and the city to promote public transport access and parking policies that restrict car use in the city. At the core of shaping this process, starting in the late 1960s, was the Integrated Traffic Management Team, a group that included independent experts, academics and public officials who set out to perform key policy evaluation studies and help determine an integrated holistic plan for the Vienna urban area.

Successful institutional integration commonly operates at the regional level rather than being limited to the metropolitan. In Vienna, for example, the regional transit authority called VOR (Eastern Austria region) coordinates service and fares and distributes all subsidies based on local and regional policies. All of the stakeholders work together based on a regional master plan.

In Madrid, the transit authority CRTM is responsible for coordinating transit throughout the region, both private and public operators. CRTM is responsible for uniform fare collection across the modes, coordination and approval of service plans (timings of transfers, coverage, hours of operation, etc.), and central monitoring of all services. CRTM’s new operations center gives the agency an overview in real time of all of the modes, public and private, which allows it to adjust services between different providers during incidents, provide customers with real-time information, and use centralized data collection for service analysis and planning. Coordination and integrated planning is facilitated by the CRTM board, made up of regional transit stakeholders, including municipalities, private and public operators, unions, consumer associations and the central government.

New Modes

Changing technology and changing attitudes are enabling an expanded range of modes for cities when they consider combined mobility. The still evolving list already includes taxis, car shares, short-term car rental, bicycles, bicycle shares, bicycles on transit and shuttle buses. Southern California Association of Governments even includes what they call “Casual Carpool,” where ride-sharing is coordinated on the spot at pre-designated locations, often near transit or dense places.

Rethinking the car

Perhaps most surprising is the degree to which the automobile, generally considered the antithesis of transit, is being reconsidered. TLS Participants agreed that the car will continue to be an important part of mobility planning, but in new ways. Park-and-ride facilities have always played a role in bringing riders to the system, although two of the cities at this summit, Singapore and Montreal, acknowledged difficulty making the park-and-ride model effective. For this reason, the design and integration of these facilities is getting increased attention. In Tokyo, the design and location of park-and-ride facilities is carefully considered. Tokyo’s prepaid IC card can be used not just for transfers and discounts between the metro and the feeder bus network, but for payments and discounts at parking facilities. The parking fee structure is carefully calibrated to different kinds of users. Some of this is being driven by technology, such as the emergence of compact electric vehicles of different kinds. Still at the frontier, but now taken seriously, are self-driving automobiles.

At the center of this movement is car sharing, in which users forego owning their own car and instead have access to a shared pool of vehicles, either as members of car clubs or as retail customers. In recent years, car sharing has expanded hugely, with operations in 27 countries across five continents, counting almost 1.8 million members and more than 43,550 vehicles, with near term expansion into seven additional countries around the world. This expansion is due to a softening in the demand for car ownership among affluent urban professionals who are increasingly cost- and environment-conscious. It is also spurred by the technological innovations that make transactions fast and easy. Car sharing recently has begun to integrate with public transit offerings to provide travelers a seamless door-to-door trip. The heightened accessibility and popularization of car sharing also has led to the development of alternative formats, most notably in personal vehicle sharing (also referred to as peer-to-peer car sharing), as well as station car programs—in which dedicated vehicles stand at transit stations for the express purpose of last mile mobility to riders’ final destinations—and vehicle and corporate innovations, for example, branding cars with third-party advertising. Similarly, car sharing fleets are an ideal platform for experimentation with specialized technologies.
such as electric-powered and autonomous self-driving cars. Car sharing organizations may be private, for-profit companies or they may organize as a nonprofit organization, a member-owned cooperative, a subsidiary of a transit agency, or an experimental or research based effort. An example of the next generation of car sharing formats would be the autonomous vehicle – e.g., BMW’s DriveNow electric vehicles, and a test program in Australia between the University of New South Wales and car sharing company GoGet to build the first fleet of autonomous vehicles in the country. One element of the e-mobility project of Wiener Modellregion, described above, proposes the adoption of shared electric vehicles.

All of the successful car share arrangements rely on information technology to facilitate transactions.

- In Zurich, through the ZVV Annual Travelcard + Mobility, the Swiss rail operator offers travelers access to the car sharing company Mobility Switzerland’s 2,600 vehicles in 435 locations across the country, 24 hours a day, seven days a week. For travelers who use a Mobility Switzerland vehicle more than three hours a week or 165 hours a year, an enhanced card allows savings over Mobility’s standard hourly rate. Users can purchase a P+Rail Pass that enables them to pick up a car at any one of 550 P+Rail stations and then get on a train, or travel by bicycle to the station and leave it at a staffed cycle park.

- In Germany, holders of the Deutsche Bahn Card receive special incentives when they use Flinkster, their car-sharing service. DB both owns its own fleet and has agreements with private car-sharing companies to allow access to additional cars, an arrangement that is invisible to holders of the DB card. Flinkster has started rolling out electric cars at the same rate as conventional vehicles. Flinkster is also starting to experiment with tiny, folding electric vehicles to cover the final legs of trips: the “Hiriko” is more compact than a Smart Car, can be charged in 15 to 20 minutes, and, using an app, can be located instantly.

- Paris has launched Autolib’ Bluecars, the car share equivalent of its successful bike share program Velib’. This program allows point-to-point car sharing of small electric vehicles. There are currently 33 stations, but by next year there will 1,120 rental and recharging stations for a fleet of 2,000 electric cars. The stations will have their own distinctive architecture.

- Madrid is in the process of concluding agreements with two private car sharing companies that will offer discounts to transit users.

- The Uber smart device application enables the traveler to arrange for a driver of almost any kind, from taxis to limousines to private drivers. Uber is now available in over 70 cities around the world.

A variety of configurations have emerged for the integration of car sharing with transit. In Brussels, Taxistop-Cambio (founded in 1975) is a nonprofit organization with the mission of advancing projects that “do more with less” by leveraging existing goods and means. It now encompasses functions such as its carpool service that facilitates individuals and businesses organizing the sharing of rides to work; Schoolpool, which provides the same service for pupils and their families; and, most relevantly, Cambio, a partnership with a German car sharing company to provide Taxistop customers access to their fleet.

Taking mobility integration still further, Dutch company Mobility Mixx expanded from a car sharing provider to a full-range mobility service provider, including rental cars, public transport reservations, park-and-ride, trip scheduling and payment. In addition, Mobility Mixx incorporated a package of business travel options; besides the car pool and train at the location, it offers access to Mobility Mixx OV-bicycle taxi, park-and-ride parking lots, rental cars, the electronic processing of mileage claims and the management of personal mobility budgets. Travel advice from door to door - via Internet and call center - allows employees to choose and combine.
Bike and ride

The bicycle is increasingly seen as mode of choice for first-mile/last mile connections. There has been a huge proliferation of bicycle sharing programs across the globe. In May 2011 there were around 375 schemes comprising 236,000 bicycles. As of April 2013 there were around 535 bike-sharing programs around the world, making up an estimated fleet of 517,000 bicycles, a doubling of bicycle sharing programs in two years. Madrid is in the process of instituting an electric bike rental program that will offer discounts to transit users. Singapore is in the process of developing entire “bicycle towns,” where bicycle mobility is an organizing principle. In some cities, bicycle transit has become so popular that automated structures are being built (see discussion below). In Vienna, for example, Citybike Wien has 111 bicycle stations holding 1,300 bicycles around the city. Vienna’s Transport Master Plan notes that cycling has shifted from a “purely leisure and sporting activity to an everyday mode of transport. It is an alternative to motorized forms of transport, particularly in densely built-up urban areas for journeys of up to 5 km.” In Singapore, the Transport Plan promotes intra-town cycling by connecting cyclists from their homes to major transport hubs, such as MRT stations and bus interchanges, where they can continue their journeys on public transport.

As with the car sharing programs described above, bike sharing increasingly is seen as an essential aspect of combined mobility, and transit providers are creating the same kinds of cooperative arrangements as they have with car sharing initiatives. In Wallonia (Belgium), C-TEC folding bicycles are offered as part of a combined season ticket from the public transport operator TEC to expand the catchment area for bus service. Wuppertal (Germany) is host to Mo-bility, an innovative joint project of three organizations: the design firm LUNAR Europe, the environmental organization Green City e.V., and the University of Wuppertal. Mo subscribers can rent bicycles, cargo bicycles, e-bikes and cars or use public transportation with just one card. The program set bicycle usage fees and annual membership prices very low to encourage initial adoption and use of the bicycles as a public transit alternative; today, a one-day ticket costs only 1.70 euro (or 2.19 dollars). Then Mayor of Paris Bertrand Delanoë reported his main motivation was to reduce traffic and pollution, and a spokesman explained, “We think it could change Paris’ image – make it quieter, less polluted, with a nicer atmosphere, a better way of life.” Today Velib’ boasts it is the world’s largest bike sharing program. It has over 20,000 bicycles available 24 hours per day in 1,800 stations spread about every 300 meters (328 yards) around the city.

Combined mobility can be accomplished also by linking bicycles and cars. If downtowns are configured effectively for cycling and a city can offer strategically-located parking with a calculated fee structure, then it might have a formula for reducing downtown car traffic. The city of Calgary used exactly this approach, providing free parking about five miles from downtown, along a bicycle trail leading into the downtown.

Finally, when evaluating the feasibility of combined mobility strategies, it is important to consider the physical space required on line-haul vehicles for transporting alternative vehicles. More attention is being paid to bicycle racks on buses, both in terms of their capacity and ease of use. Light rail vehicles in Portland and elsewhere provide hangers for bicycles inside the cars. In more ambitious examples like the GO Train Bike Car in Niagara Falls, Ontario, entire rail carriages are dedicated for bicycle transport. In the U.K., on some tram lines, bicycle trailers are hitched to the back of the light rail vehicles.

Figure 7: New York City bike share docking station.

Source: Citibike.

Taxi as transit

Though taxis are a form of transportation, traditionally they have not been considered a mode of transit. The utility of on-demand service is outweighed by higher cost and the uncertainty of availability in more sparsely populated places. Combined mobility, however, makes taxi service more affordable for the user by promoting shared taxis, and makes taxi service more efficient for the provider by using information technology to rationalize trip requests. This rationalization may start out informally and then, by degrees, become more of a standardized approach. For example, in Santiago, shared taxis contribute to mobility by working certain routes at certain frequencies in a framework regulated by the city. The vehicles have distinctive signage and

17 Vienna 2003, 24
18 Kate Betts, TIME, October 1, 2007
19 Arthur D. Little, 17
travel between set destinations at each end of a route. Along the way, passengers may board or disembark at will. The transit authority coordinates with the agency that licenses the cabs, and the pickup and drop-off locations are often at metro stops or bus stops. At present, direct integration in terms of schedules, payment or information sharing by way of maps or online schedules does not exist, but this is easy to envision as a next step.

One of the best examples of taxi-as-transit comes from the Brussels region. Public transport operator STIB collaborated with a private taxi company, Taxis Verts, to create Collecto, a demand-responsive transport service offered at an affordable flat rate. Users request taxi service by phone from among 210 office pickup points to any destination in Brussels. Collecto departure points usually correspond with the STIB stops, which are marked with the Collecto logo. In other cases, the collection point just requires space for signage, indicating the logo and a waiting area for users. This point usually can be accommodated on street sidewalks or along the edge of pedestrian plazas, for example. The STIB-Taxis Verts public-private collaboration also worked to redesign the Brussels night bus service through optimizing schedules and enhancing cost efficiency of existing night bus lines.

Another prime example of taxi transit is Vienna’s development of the ASTAX (Anruf sammeln) system, which was started in 1999 as a pilot project and currently runs seven routes in the city. ASTAX taxis use public bus stops marked with an additional ASTAX logo sticker, and the taxis drive like the bus, from stop to stop. However the ASTAX taxis serve areas of little demand – less densely populated areas—and riders call for the taxi by phone in advance to cover their trip. Public transit operator Wiener Linien contracted this service out to a private operator that is able, when feasible, to match requests and facilitate a many-to-one routing, while still recognizing passengers’ needs for a seamless trip. Two years ago, Wiener Linien replaced a major night bus line with the ASTAX in order to avoid empty or nearly empty buses circulating through residential areas. Because the ASTAX drives only when it is called, it has reduced line operating costs and thus increased the mobility needs of the Viennese in-line network in a highly efficient fashion.

Figure 8: An example of taxi-as-transit in Brussels. Collecto operates seven days a week for 23 hours and covers the entire Region of Brussels-Capital.

New Spaces

The picture that emerges from these many combined mobility approaches is one of a multiplicity of fine-grained and dispersed connections among modes taking place across the region. However, the connection to the core network remains paramount in urban mobility, and so it is still within the larger central station areas that the best practices in station area design and the combined mobility paradigm intersect. The success of this station redevelopment strategy centers on making these intermodal connections as seamless as possible—overcoming the “disutility of transfers.” Beyond coordinated schedules and fare collection, physical space has to be provided for the vehicles, and—just as important—designed so as to make each transfer a convenient and pleasant part of the overall trip.

In Madrid, intermodal connections are a major design consideration, and over the last decade the city has engaged in a large-scale effort to rebuild outdated stations to improve transfers, at times even realigning rights-of-way to make the connections. Whenever possible, transit is brought closer to grade, where it is easier for riders to get their bearings. To further facilitate easy transfers, new stations stack intersecting services vertically and typically perpendicular to one another. In Vienna, where most metro stations already have connections to multiple tram and bus routes, bright, often natural light combines with well-designed, colorful wayfaring signage to facilitate movement through and around the station. Well-designed public spaces are the heart of Madrid’s and Vienna’s new station areas, creating the space for passengers to move pleasantly between modes and to stay oriented. In both cities, several large, at-grade pedestrian plazas support dense development around the central station, further extending and integrating the travel experience into the urban fabric.

These anecdotes comport with a familiar and broadly accepted set of best-practice design and planning strategies, often collected under the banner of Transit Oriented Development. In the lower density environments where combined mobility strategies are filling the accessibility gap, some TOD practices are less in play, for example, that the station area should accommodate a diverse range of activities, including civic uses; or that development should favor uses that support transit ridership, particularly higher density residential uses. However, many TOD best practices apply regardless of the surrounding land-use mixes and densities. For example, it is always essential to create good pedestrian and bicycle connections from the station to the surrounding area to capture as many riders as possible, and to leverage the land development benefits of transit access.

Effective points of intermodal activity balance competing needs for space and access among modes – connecting transit services, taxis, car parking – but also favor pedestrians and bicycle connections to the surrounding neighborhoods. Singapore transit stations designate ample space for bus transfers and for taxi lines, ensuring that these functions do not prohibit traffic flow and movement of the other modes present. At the Bukit Panjang node, for example, the bus interchange takes place as part of an intermodal complex that includes metro and light rail stations as

21 Interview, Robert Cervero
well as car parking, bike parking and taxi pickup and drop-off. The intermodal facility is the base of a larger mixed-use development that includes residential towers.

Several Madrid stations demonstrate the role that well designed public spaces at the point of transfer play, not only creating the physical space needed, but orienting travelers and creating an identity for the station area. The public spaces are well appointed in terms of materials, landscaping, lighting and directional signage, and maximize passive surveillance with uninterrupted sight lines through the space. The Moncloa interchange is a good example. With a direct connection to a Bus/ HOV lane on the A-6 highway corridor, it brings together two metro lines and 20 suburban bus routes. In terms of urban design, it also integrates the design of the Plaza del Arco de la Victoria above. Vienna, likewise, has invested a great deal in the design of maps and way-finding signage, as well as real-time information displays to provide orientation, especially as one moves between modes.

Room for the Car

Because driving continues to represent the primary method for getting from home to transit, parking is an essential aspect of successful station design. Many of the combined mobility strategies discussed here create the opportunity to reduce the total amount of land devoted to the automobile, because they substitute other modes for trips that traditionally were made by car. In addition, smaller vehicles help relieve some of the pressure on finding space. The Hiriko electric vehicle has set the bar in this arena because of its groundbreaking capability to fold up into a very compact configuration. But even as cars get more compact and combined mobility takes hold, there remains ongoing need, especially in the less central areas where combined mobility is most in play, to provide parking for rental cars and car sharing services. This necessity presents a design challenge in providing parking close enough to the station to facilitate smooth transfers, without allowing the parking to dominate and deaden the station area.

In many places, parking will have to be in surface lots. But well established strategies exist for managing and designing these lots in ways that do not impede mobility of pedestrians or the creation of inviting spaces. In terms of location, lots should not be sited along the edges of important connecting corridors or public spaces, but should be placed behind the buildings defining these public spaces. Lots should be broken up into sections to avoid a large and undifferentiated sea of parking. In terms of aesthetics, surface lots can be made attractive through careful selection of materials, landscaping and lighting; well-defined pedestrian paths make walking to the station or other modes clear and safe. To facilitate intermodal connections, dedicated spaces for rental cars or car shares should reside in the most visible and easy to access parts of parking lots.

Where economically feasible, parking structures, especially automated facilities, can be a very space efficient way to house large numbers of vehicles. Parking structures can be exciting pieces of architecture and can incorporate mixed use buildings, thereby contributing to the character of the station area. Regardless of how ambitious the building is, if structured parking is provided, the ground floor should be lined with pedestrian oriented activities that relate to those outside, and as with surface parking lots, the dedicated spaces for rental cars or car shares should be in the most visible and easy to access locations. In Vienna, large park-and-ride garages stand at several outlying metro stations (mostly terminals), and they are designed with good connections to the platforms.

Figure 9: This model of the Hiriko electric car is capable of folding into a more compact form, runs off a 20 horsepower electric motor, and can reach a maximum speed of 50 kph (31 mph).

Figure 10: Santa Monica, California Civic Center parking garage is the first LEED-certified parking structure in the world.

It is not as difficult to make space for “demand responsive” services such as taxi services or some of the more flexible “concierge” models for car sharing. Even so, taxis compete for space where they wait, and their movements through the station area need to be carefully designed so as not to interfere with pedestrians, bicyclists and buses. Vienna has several car sharing services, and some reserve curb space around stations next to the taxi stands. In Hannover, shared parking is either integrated within the existing large parking lots or assigned dedicated street parking spots. In other cases, parking space is allocated to accommodate 10 to 15 cars. In existing parking lots, few spots are reserved for these cars.

22 Madrid, A World Reference, Consorcio Transporta Madrid, November 2013
Room for the Bike

Bicycles may be low impact, but as biking achieves scale as a transit mode, cities need to account for the spatial demands of bicycle infrastructure: bicycle share stations, bicycle parking facilities and bicycle lanes all compete for space in the transit landscape. Bicycle facilities, especially in some very dense urban environments, may not be stand-alone facilities, instead built into buildings within the station area or within the stations themselves. In Vienna, for example, S-bahn stations have bicycle parking of various kinds, many with bicycle share stations. The new multimodal central station in Vienna will have underground bicycle parking with spaces for over 1,000 bicycles.

Figure 11: Located in the Netherlands, the Bicycle Apple is a bike parking structure that can hold up to 970 bikes at a time.

In the Netherlands, where an estimated 27 percent of daily trips are made on bicycle, the outsized success of biking has gotten a lot of attention because of the overcrowded conditions at bicycle parking stations. The crowding exists despite generous provision of facilities: vast bicycle parking structures sit outside of or underneath Dutch railway stations in the major cities. In fact, parking is so readily available that many riders keep a bicycle at their origin and destination stations. In some areas, bicycle use has become so intense that cities have devised ambitious dedicated-structure parking solutions. Outside of Amsterdam’s Central Station, a three-story structure holds about 9,000 bicycles, and in Groningen, a massive, covered and guarded facility holds 4,500 bicycles. In Tokyo, the Kasai Station houses a series of underground parking structures, capable of housing up to 9,000 bicycles that can be quickly retrieved through an automated system. In Zaragoza and several other Spanish cities, the “Biceberg” pavilion stores up to 92 bicycles in the space that four cars would take up.

Figure 12: “Biceberg” bike storage in Spain.

Biking facilities need to be secure, protected from the weather and able to accommodate different user needs. The combined mobility objective presents several urban design considerations: from the connecting mode, bicycle facilities should be either visible by direct line-of-sight, or easy to find because of well-designed signage. They should also be an attractive and integral part of the overall design of the place, contributing to the overall liveliness of the urban space and benefiting from the passive security and visibility that result from successful place-making. Adequate space around racks, and routes that provide cyclists room to maneuver but that prevent conflicts with pedestrians or parked cars also contribute to successful facilities. Racks should not block access to building entrances or fire hydrants. Charging stations should be provided for electric or battery assisted bicycles.

Particularly successful programs to accommodate bicycling as a transit mode go a step beyond merely creating the space to park bicycles. Many cities have begun to also incorporate supporting services, including maintenance and repair, sales and education. “Radstation” in Münster (Germany) provides a bikewash. In the U.S., a company called Bikestation has developed “bike transit centers” in California and Washington, D.C. where cyclists not only get secure parking, but air for tires, Wi-Fi, showers and trip-planning information. Employers who provide a place to shower, change and store clothes can encourage bicycle commuting, and these facilities can also be used by those who are not necessarily bicycle commuters, but who want to exercise during the day. Where it is not possible for employers to provide these amenities in their own buildings, cooperative arrangements can be made with nearby facilities. Employers and other destinations should provide those amenities, as well as electric power supply to recharge bicycle batteries.
From “intermodal transit facilities” to “active mobility districts”

The idea of a single facility where the full range of intermodal transfers takes place seamlessly and under one roof is compelling, and in the densest urban environments, the high cost and low supply of land can encourage such functional solutions. Where conditions are less optimal, however, the “mobility district” represents an alternative design model. In the mobility district, the various modes are not within one structure, but rather constitute a single relatively compact and walkable neighborhood. In this model, the movement between modes is itself a part of the urban experience, and the development of an activated and attractive district centered around transit becomes a form of urban regeneration.

The mobility district concept has several advantages: it can be less expensive and more straightforward to plan and build than a single structure; it can be implemented incrementally in response to market forces; and, because of its smaller scale, it can be calibrated to the existing context rather than imposing itself onto and dominating the surrounding fabric.

Denver’s Union Station redevelopment project, now under construction, is based on this same approach. A series of urban spaces connect a variety of transit modes to a new neighborhood hosting eight tracks of commuter rail (with room for expansion), Amtrak corridor, a three-track corridor for light rail transit, and a 22-bay regional bus facility (16 regional, four downtown circulator, two commercial buses), in addition to bicycle share and car share facilities. The new neighborhood comprises an easily navigated grid of streets and blocks. The different transit services are separate, but all within walking distance by way of the grid, interspersed public spaces and an underground concourse providing access to the bus bays. The mobility district design focuses not just on getting to and from this neighborhood, but equally on the act of moving through it.

Financial Implications

For a transit provider, quantifying the net financial costs and benefits of a capital project is not a trivial exercise. With combined mobility strategies, the same valuation challenges apply. While the cost side of the equation can be broadly obvious—it will be less resource intensive to implement combined mobility than to build more fixed guideways—the benefit side of the equation is more complex. One might measure increased ridership and fare box revenue that results from bringing more people to the system, although as the findings from this summit suggest, fare box recovery is itself a complex metric which does not necessarily internalize a wide variety of hidden costs or subsidies. Beyond that, many of the benefits that combined mobility sets out to generate are indirect and difficult to measure. Participants at this summit suggested that social media could be used more to understand how riders value expanded mobility options.

Ideally, when cities are making a comprehensive analysis of their transport investment alternatives, they find ways to monetize the following outcomes of investment in more sustainable mobility:23

- Improved safety and security
- Reduced air and noise pollution, greenhouse gas emissions and energy consumption
- Improved efficiency and cost-effectiveness of the transportation of persons and goods
- Contributions to enhancing the attractiveness and quality of the urban environment and urban design

If traditional economic evaluation tends to undervalue non-motorized transport benefits, a more comprehensive evaluation of these positive impacts would result in greater investment.

23 Eltis, a research organization
in these modes: “Many planning decisions affect walking and cycling decisions, and therefore the amount of active travel that occurs in a community. To the degree that a planning process undervalues active transport it will underinvest in these modes, reducing overall transport system diversity and efficiency.”

This is supported by the European Commission’s findings that most of the external costs of transport are not internalized, and the methodologies are consistent among member states. While this suggests a strong case for combined mobility, at the moment there is little research that examines specifically the net impacts of one type of strategy compared to another.

Nevertheless, interest in quantifying the benefits of combined mobility and in capturing these planning objectives in transport investment analysis has grown in tandem with the popularity of these new approaches. In 2003, the U.K. Treasury adopted measures to appraise and evaluate projects that establish a much wider concept of measured benefits, namely that they incorporate economic, environmental, social and distributional parameters, along with the more conventional focus on reductions in travel time. They found outsized cost-benefit ratios for investments related to biking and walking. The U.K. studies show that within transport, investment in walking and cycling are likely to provide low cost, high-value options for many local communities. Their study underscores how much value had been missed by traditional evaluation metrics.

The City of Vienna considers the collateral benefits of the investments in its world class cycling network and justifies its investments in those terms:

- Safe and comfortable cycling infrastructure enables young and elderly people to be mobile by using a healthy and environmentally friendly mode of transport.
- Cycling comes at much lower costs to society than individual motorized transport, largely due to reduced costs for healthcare and externalized factors such as pollution, noise and congestion.
- Integral cost calculations - including the health, environmental, social and economic costs and benefits - show a high return on investment for cycling infrastructure.

Madrid, similarly, is undertaking intermodal station improvements with the expectation of a return on investment that more fully incorporates planning objectives.

Scholars have endeavored to monetize cities’ combined mobility investments in somewhat of a piecemeal fashion, but results are solidly positive. Kjartan Sælensminde at Oslo’s Institute of Transport Economics presents cost-benefit analyses of non-motorized transport investments in three Norwegian cities, and estimates that the benefits of investments in cycle networks outweigh the costs by a magnitude of four to five times.

A number of other similar studies, such as one from the U.K., find an integrated program that increases walking in British towns provides benefits worth £2.59 for each £1.00 spent, considering just reduced mortality. Including other benefits (reduced morbidity, congestion and pollution) would increase this value. Another study estimated that in Portland, Oregon, investments in bicycle facilities over 40 years in the range of $138 million to $605 million will provide healthcare savings in the range of $388 million to $594 million, $143 million to $218 million in fuel savings, and $7 billion to $12 billion in longevity value, resulting in positive net benefits. This suggests that in North America, basic mobility is worth at least 30 cents per passenger-mile to society.

A study conducted hedonic price method testing to determine whether a market premium exists for real estate within pedestrian-and transit designed development, and found that people indeed are willing to pay for this way of life. This finding suggests that transit providers should be able to capture the induced increases in real estate value from combined mobility.

In a similar vein, the City of Copenhagen’s Bicycle Strategy 2011-2025 compares the total costs of different kinds of trips: taking a bicycle trip results in a societal gain of €0.49 (63 cents), while a using a car for the same trip results in a societal net loss of €0.89 ($1.14). The firm also finds annual health benefits of cycling in Copenhagen to be €228 million ($293 million).

Pedestrian improvements have similar outcomes: one meta analysis of studies finds net benefits to these investments, including two U.K. studies that take a comparative approach to other transport infrastructure. The return on investment in the walking environment is likely as high as and even higher than investments in other transport projects. As comparative research in this vein develops and includes larger sample sizes, certainty will develop surrounding results, but early research appears to support combined mobility as a sound financial investment choice for cities.

As far as the question of whether combined mobility has any implications for “value capture,” the research and discussion at the Transit Leadership Summit include the fact that points of intermodal connection create value. But as the research into value capture illustrates, these impacts may be difficult to quantify.

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As far as the question of whether combined mobility has any implications for “value capture,” the research and discussion at the Transit Leadership Summit include the fact that points of intermodal connection create value. But as the research into value capture illustrates, these impacts may be difficult to quantify.

Location-based value capture makes sense when it is clear that transit will improve an area that is well-defined. Value capture is difficult to implement because it is difficult to separate the pure value of location from the value that is created by the efforts of the developer or property owner. It is also hard to disentangle the value added by one piece of infrastructure, such as a transit line, from the value of other intrinsic elements of a location. These challenges to implementing value capture are exacerbated when applied to the combined mobility paradigm, which by definition is about extending the benefits of transit access into a larger and less defined geography that may even change by time of day.
If it is difficult to quantify the sphere of influence of a transit investment even when talking about conventional fixed-guideway improvements, it will be even more difficult when talking about the kinds of flexible and multifaceted improvements that are the hallmark of combined mobility, even though these initiatives clearly create added property value.

Image 15: Value of time saved in travel.

Source: Regional Plan Association.

Conclusions

Combined mobility has an important role to play in extending mobility to larger geographies, and in providing more choice for more people. But it is important to note that early anecdotal evidence suggests that purchasers of “mobility packages” tend to be younger, well-educated and environmentally conscious urban workers for whom car ownership does not have high emotional value. That is a challenge to the equity objective of reaching less well-off populations in places that are poorly connected to the rest of the metropolis.

Institutional integration is essential

By definition, combined mobility depends on cooperation among the providers of the different modes. Close communication enables comprehensive planning, as in Vienna, so that capital investments can be prioritized and reinforce shared objectives rather than creating unwanted competition. Part of Transantiago’s agenda in managing their bus network is to insure that competing routes do not cannibalize one another. The efficiency and efficacy of the combined network depends on coordinated service plans. And unified fare collection, one of the central components of all combined mobility programs, depends on an integrated approach. Unified fare collection also creates the ability to incentivize ridership across the network by differential pricing.

While institutional integration is essential, the case of Singapore illustrates that it is not necessary to create a single consolidated entity, but rather, close coordination through inter-agency committees. Vienna’s integrated transport planning process covers all modes and relies heavily on its consensus-based “social partnership” – voluntary cooperation among employers, employees and the city to promote public transport access and parking policies that restrict car use in the city. In the U.S., where resistance to centralized planning is so entrenched, this kind of “civic infrastructure” may provide the way toward more coordinated planning.

The Madrid Consorcio suggests several threshold questions which should be considered when talking about regional integration of transport services: What modes should the authority take responsibility for? Over what geography? Over which infrastructure elements? And what responsibilities should the authority take on regarding complementary policies and investments that may not be part of their core competence?

Design matters

Best-practice design strategies from conventional Transit Oriented Development experience apply for the places where the new expanded range of intermodal transfers take place. Mitigating the “disutility of the transfer” depends on making the connection experience as comfortable and as seamless as possible. The Madrid and Vienna case studies illustrate the importance of design: aligning connecting services; making the transfers as close to the surface as possible for easier orientation; appointing the intermodal facilities with attractive materials that reinforce the identity of different spaces; and clear wayfinding signage and lighting. These same strategies apply in Singapore, which is a leader in building compact facilities that bring together multiple modes.

Flexibility will be needed

The experiences with combined mobility described above demonstrate the speed with which the transit landscape is changing. In this context, it is important for transit providers to be flexible. In part, this concerns the fare collection and communications technology: hardware components should be modular and enable the ready switching in and out of new components. Even more important, despite the fact that off-the-shelf technology is attractive, transit providers should be cautious about proprietary arrangements, which can inhibit flexibility and innovation.36 As important, flexibility will be needed in the design of the station areas and the points of transfer. Best-practice station area design should anticipate that more space will be needed for car sharing, bicycle sharing, taxis and other connecting services.

36 Perrotta, Zupan, Barone et al, TLS white paper, March 2013
Density and land use still matter

Combined mobility does increase the reach of transit systems into less dense places. But it is still true that “integrated mobility services” work best where there are agglomerations of activity and transit options; in other words, the implementation of integrated mobility is not immune from the density/transit paradigm. Even in cities such as Vienna that have comprehensive and multi-modal approaches to transit, the options for combined mobility are more robust where concentrations of employment and housing are greatest. And in Tokyo and Singapore, closely managing land uses and densities at transit stops has enabled line-haul networks to be extended.

Defining combined mobility

Combined mobility is a broad term for a relatively new, evolving and disparate set of practices. This paper describes many of the new modes and practices that seem to fall under this new term, as well as the changing spatial requirements for these new modes. But itemizing the characteristics of combined mobility is not the same thing as having a definition that is accepted across the industry; simply putting bike racks on buses is not the same thing as integrating fares and providing real-time information sharing so that new kinds of multi-modal trips are enabled. The reason this is important is because it will be difficult to agree upon and then to evaluate policies and investments if there is not a shared set of objectives and performance standards that would be part of this definition.

Implementing combined mobility

Private sector actors have overwhelmingly been responsible for developing the new modes discussed in this paper, particularly as regards bicycle sharing and car sharing, as well as rethinking taxi services as an accessible mode of transit. Even information platforms have been privately developed once public data became available. In most cases, the public sector has been as much the responder as the instigator of combined mobility innovations.

That said, the transit provider has the essential role in coordinating all of these efforts into an integrated network designed to serve the public interest. And it is the transit provider who has the resources to leverage these kinds of initiatives. For example, the transit provider can use its considerable purchasing power to incentivize cooperative agreements with other providers, initiate pilot demonstration projects and to insist on design excellence for intermodal facilities. The transit provider can support collateral investments and initiatives such as pedestrian and bike improvements, traffic-calming, and parking policies that discourage auto use.

The transit provider can also eliminate regulatory and operational barriers to experimentation, and can share data with other mobility entrepreneurs. The public transit provider is the only entity that can act as the convener for the disparate providers of alternative modes.

Finally, one of the striking aspects of the combined mobility phenomenon is the large role that changing attitudes have played in its acceptance. For example, car ownership, long considered an essential part of every lifestyle, even among city dwellers, is now seen by many as a discretionary investment. Users are willing to share access. Increased awareness of the environmental impacts of the automobile, as well as an increased appreciation of the health benefits of walking and biking, has also helped fuel this movement. The transit provider has an important role to play here in marketing and awareness campaigns, and in disseminating information about best practices.
PARTICIPANTS
We already know that we share common issues and problem with our colleagues from other large metropolitan areas...getting a good understanding of perspectives from each attending transit agency on shared issues was quite valuable. The white paper preparation was very interesting...it gave us ideas for good practices, and the peer review and the discussion that followed gave us clear examples of how it applied in reality for each of those topics.

— Montreal, Daniel Bergeron

It was interesting to see what the improvements were from all over the world, what the preoccupations were of the companies all over the world.

— Paris, Philip Martin

JR East’s initiatives in Tokyo with mega transit volume and surrounded by severe natural disasters can be paid attention to in the world but are not always the best solutions. Challenges, experiences, and method of thinking of the leaders in the cities worldwide are very much useful for me to lead my company’s globalization.

— Tokyo, Masaki Ogata

What’s important is that events like the Summit bring executives from individual organizations into contact with new perspectives and modes of operation. Many executives can be ”creatures of their environment” in that they work their way up the hierarchy of their organization and do not have the chance to explore other organizations or networks/systems. Events bringing together different operators and etc. encourage sharing, challenging discussions, and furthermore inspire some evolution of perspectives. Like a ”cross-cultural” exchange.

— New York, Michael Horodniceanu

TLS looks outside just operations and studies other challenging topics like climate change/first last leg connections/design.

— Vienna, Karl Bergner
Rohit AGGARWALA
Principal, Bloomberg Associates
Rohit “Rit” Aggarwala leads the sustainability practice at Bloomberg Associates, a philanthropic consulting firm that serves city governments. He also advises former New York City mayor Michael R. Bloomberg in his role as the special envoy for cities and climate change of the United Nations secretary general; and is a professor of professional practice in international and public affairs at Columbia University. He also co-chairs the Regional Plan Association’s Fourth Regional Plan for the New York metropolitan area.

Aggarwala served as special advisor to the chair of the C40 Cities Climate Leadership Group from 2010 to 2013, guiding the organization’s strategic transformation into a global leader. During that period, he also developed the environment program at Bloomberg Philanthropies, which grew to a total of $145 million in grants under his management.

Aggarwala served as Director of New York City’s Office of Long-Term Planning and Sustainability from 2006 to 2010, and led the creation and implementation of “PlaNYC: A Greener, Greater New York.” PlaNYC has been hailed as one of the world’s best urban sustainability plans, leading New York City to a 19 percent reduction in its carbon footprint since 2005. Prior to joining City Hall, he was a management consultant at McKinsey & Company from 2002 to 2006.

Aggarwala holds a B.A., MBA, and Ph.D. from Columbia University, and an M.A. from Queen’s University in Ontario. He was born in New York City, where he now lives with his wife and daughter.

Heather ALLEN
Programme Director of Sustainable Transport, Transport Research Laboratory
Heather Allen has worked internationally in urban passenger transport for more than 20 years. In August 2011 she joined TRL, where she is the lead on deepening knowledge and skills in rail and public transport, especially in the areas of climate change and land transport (mitigation and adaptation), low carbon mobility strategies, and sustainable transport policy development. She has wide international experience in all aspects of urban transport and sustainable cities, and is involved in a variety of U.K.-based, European and international projects. This includes work on electric mobility and its charging infrastructure in Europe, sustainable transport (BRT and NMT) development in Addis Ababa, alternative fuel (CNG) for buses in Indonesia, providing input on public transport for an international research study on low carbon transport by 2050 in seven countries in Asia, and developing a sustainable transport forum for Africa for the SSATP (Transport Policy Programme) with the World Bank. She is on a number of committees and boards such as the National Academy of Sciences Transportation Research Board’s Committee for Developing Countries, the Transport Committee for Green Climate Bonds and the Association of European Transport Climate Change committee. She authored a number of papers and has given input to many technical reports, including papers on the UNFCCC Climate Change Conferences (climate change and transport 2009 to 2013), a background paper on financing in urban transport (UNCRD – 2011), WRI Readiness for Climate Finance (2013), GIZ Climate Finance and Transport (2012), ITDP Bus Rapid Transit Planning Guide (2007), TEEMP methodology for calculating GHG emissions from transport. She is a founding member of the SLOCAT partnership (a type II U.N. partnership between 80 international organizations promoting low carbon, sustainable transport) and a founding member of the international multi-stakeholder initiative on land transport and climate change called Bridging the Gap. Previous to this, she developed and managed the Sustainable Development Charter at the International Association of Public Transport. She is also an experienced trainer on sustainability and transport.

David ARMOUR
Chief City Executive, New York City Center of Competence Americas, Siemens Infrastructure & Cities
Appointed by the Siemens Cities Center of Competence as chief city executive for New York City in October 2012, David Armour is responsible for establishing Siemens’ strategy for the metropolitan New York region. As the lead city executive, Armour will build the regional Siemens teams, establish relationships with key city and regional decision makers, and drive Siemens’ solutions into the respective markets.

The Cities Center of Competence is dedicated to understanding the key challenges facing cities as they strive for economic growth and long-term prosperity. The CoC strives to leverage the company’s global experience and deep portfolio of infrastructure solutions to help cities create and implement plans for the future.

Armour serves on the Executive Committee of the board of directors for the Regional Plan Association. He holds a bachelor’s degree in biology from Washington University, St. Louis, and a bachelor’s degree in electrical engineering and a master’s degree in biomedical engineering from the University of California.

Hiro ASO
Director of Major Projects, John McAslan + Partners
Hiro Aso joined John McAslan + Partners in 1994, and was appointed a director of JMP’s Urban Infrastructure unit in 2005. Now, as director with responsibility for major projects in Transport + Infrastructure, he is leading the practice’s Crossrail team. He has over 10 years’ experience with major transportation projects, and is well known to key planning and transportation stakeholders. Aso led the design team for the King’s Cross Station redevelopment. He manages design coordination across urban infrastructure projects, and oversees project and design management of key commissions.

His skills have also been targeted in other kinds of projects, such as the 22,000 square foot John Lewis commercial development at Liverpool One, and in consultancy roles involving the Heathrow Express scheme at Paddington, Heathrow Terminal 5, and London Underground.

Aso is a Fellow of the Chartered Institute of Highways and Transport.

Richard BARONE
Director of Transportation Programs, Regional Plan Association
In his role as director of RPA’s transportation programs, Richard Barone is responsible for the organization’s transportation portfolio in the areas of finance, policy and planning. He is RPA’s subject matter expert on freight/logistics, technology and urban transportation systems, and aviation.

Barone is leading RPA’s transportation effort for the Fourth Regional Plan, a once-in-a-generation planning exercise to prepare the New York Region for the next three decades of growth. In addition, he has led or served as a primary researcher on several of RPA’s major studies, including Moving Blocks: A Plan to Upgrade New York’s Subway, How the Long Island Rail Road Could Shape the Next Economy, The Future of the New York Region’s
Airports, Tomorrow’s Transit: New Mobility for the Region’s Urban Core. Barone is also a member of the Transportation Research Board Committee on Intergovernmental Relations in Aviation, a division of the National Research Council. He was also a participant in the I-95 Corridor Coalition’s 2008 Freight Academy and the 2006 recipient of the September 11th Memorial Program for Regional Transportation Planning. Barone received a master’s degree in urban planning from Columbia University and a bachelor’s degree in labor and industrial relations from the Pennsylvania State University.

**Daniel BERGERON**

Vice President of Strategic Information & Metropolitan Affairs, Montréal Agence Métropolitaine de Transport

Daniel Bergeron is vice president of strategic information and metropolitan affairs at the Agence métropolitaine de transport. He began his career working as a transportation researcher, and then acted as project manager for a major consulting group in transportation planning.

In 1997, Bergeron joined the newly founded AMT, where he now manages the regional framework for transportation surveys, network modeling, integrated public transportation fare systems and the financial framework linking together all the public transportation operators and municipalities of the Montreal region.

The AMT was created by the Quebec government in 1996 to strategically plan and efficiently coordinate public transportation in the Greater Montreal area. The AMT also includes express bus and commuter rail networks, and is the sixth largest passenger rail transport system in North America. The AMT territory is comprised of 83 municipalities, 12 public transportation and 13 paratransit operators, to name only the principals.

Bergeron is often identified by partners as a reliable and credible reference for technical, financial and institutional issues on urban public transportation.

**Karl BERGNER**

Division Manager & Operation Manager Tram and Metro, Wiener Linien GmbH & CoKG, Vienna

Karl Bergner was appointed division manager of Wiener Linien in June 2002, and operation manager tram and metro in September 2005.

He has more than 37 years of experience in public transport technology and operation. His background is in the metro construction business, and he was responsible for introduction of ATO signaling systems and communication engineering equipment.

Bergner was appointed as manager of tram and bus depot operation in May 1984, and vice department manager of bus operation in Vienna in July 1991. In this function he developed the first night bus service in the capital of Austria. Since June 2002, he has been responsible for the metro system of Wiener Linien. He is involved in the extension of the metro network and the development of new train fleet and station design. In September 2006, after three years of development and introduction, he opened the new OCC for the whole Viennese metro network, which is one of the most up-to-date control centers in world. Currently he is working on automatic operation of the prospective sixth metro line in Vienna.

He is a member of the metro operations committee of VDV (Association of German PT Operators) and member of the UITP Operation Division, Subcommittee Metro Operation. He was a member of the UITP Security Commission.

**Anders BRÄNNSTRÖM**

Chairman of the Board, Volvo Research and Educational Foundations

Anders Brännström holds a Ph.D. in Industrial Management from Chalmers University of Technology, and an MBA from Gothenburg University. He spent his early years as an assistant professor at Chalmers. In the early 1980s, he left academia for an assignment as director for corporate development in the Sweedayards Group. He was later appointed president of Götaverken Energy, within that group. Götaverken Energy; later acquired by a competitor, was a manufacturing company specializing in large-scale boilers, specifically black liquor recovery boilers, doing business on several continents.

After leaving Götaverken, he served two years as president of a small high tech company in robotics before joining management at SKF, a world leading manufacturer of bearings, with headquarters in Sweden. At SKF, he was director for business development, executive director of industrial sales and executive director for sales, company division. In these roles he was active on all continents.

In 1999, he joined the Volvo Group to become president of Volvo Technology Transfer AB, a corporate venture capital entity within the Volvo Group. The assignment was to invest in small companies of interest for the Volvo Group, where a minority shareholding was at least initially preferred, and help them to develop.

He retired in 2010 from this position, and is now active as an ordinary member or chairman in a number of different boards. Among other assignments, he was appointed chairman of the board for Volvo Research and Educational Foundations in January 2011.

**Peter CAFIERO**

Chief of Operations Planning, New York Metropolitan Transportation Authority, New York City Transit Authority

Peter Cafiero is chief of operations planning at MTA New York City Transit, where he manages a department responsible for providing a full spectrum of planning services for the New York City subways, buses and the Staten Island Railway, including schedules; passenger counts; data analysis and reporting; service and performance indicators; international benchmarking; service diversion and special events planning; service planning; ridership modeling and operations analysis.

The highlights of his 25 years at NYC Transit include leading the planning effort and producing the environmental impact statement for the Second Avenue Subway project, developing service plans for the restoration of full subway operation over the Manhattan Bridge and the introduction of service through the 63rd Street Connection, and successfully introducing NYC’s first Bus Rapid Transit routes. He is a past president of both the CoMet international metro benchmarking group and the International Bus Benchmarking Group.

Cafiero graduated from The Cooper Union (Civil Engineering, 1983) in New York City, where his interest in transportation issues developed, in part, from his daily commute from New Jersey. He then attended Northwestern University in Evanston, Illinois, receiving a master’s degree in civil engineering/transportation planning before returning to New York, where he was a planner at Metro North Railroad before moving to NYC Transit. He currently lives in Brooklyn with his wife, Karyl, and twin daughters Paula and Louise.

**Morris CHEUNG**

Human Resources Director, Hong Kong MTR

Morris Cheung has been working with MTR for 29 years. Cheung started his career as an engineer and for 10 years he was responsible for the safe, reliable and quality customer service performance of the entire MTR train fleet. He spent two years as the managing director of the cable car subsidiary company of MTR before he was named chief of operations in 2009. He was
responsible for the operations of all transport business of MTR in Hong Kong, including the metro network, cross-boundary and intercity services, light rail and feeder buses. Cheung then became chief of operations engineering, overseeing all maintenance and technical functions for railway. In 2012, he was appointed as the human resources director.

**Cheew Hock Yong**  
Chief Executive, Singapore Land Transport Authority  
Cheew Hock Yong was appointed chief executive of the Land Transport Authority in September 2010. Cheew is a board member of the Land Transport Authority, International Enterprise Singapore and the Singapore Indoor Stadium Ticketing Company. He is also chairman of MSI Global Ltd. and a member of the National Council Against Drug Abuse.

In his public service career in Singapore, Cheew has held appointments in the Ministry of Defense, the Ministry of Communications, the Ministry of Home Affairs, the Ministry of Finance, and the Ministry of Community Development, Youth & Sports.

He was a key member of the Bid Committee that won the right for Singapore to host the inaugural Youth Olympic Games in 2010. He also played a key role in Singapore’s successful hosting of the games.

Cheew graduated from the University of Tokyo, Japan with a bachelor’s degree in engineering (naval architecture) in 1990. He was awarded the Miyoshi Award for Academic Excellence (Tokyo University) in 1990. He also received a master’s degree in management from the Graduate School of Business at Stanford University in 2001.

Cheew was awarded the Public Administration (Silver) medal in 2004.

Cheew is married with two daughters, aged 13 and 17.

**Jonguk Chon**  
Director of Transportation Policy, Seoul Metropolitan Government  
Jonguk Chon is in charge of overseeing municipal transportation in Seoul, a city of more than 10 million people. He formulated policies aimed at facilitating mobility following his designation as director of taxis and logistics at City Transportation Headquarters in 2012.

He began his career as a public official in Seoul Metropolitan Government, and assumed the following positions after passing the exam for high-ranking public officials in 1992: director of parks and recreation, deputy director of urban safety, environment and finance.

After finishing his master’s degree in public administration at Carnegie Mellon University in December 2002, he returned to Seoul Metropolitan Government and served as director of economy and industry, and human resource development. In 2011, as director of taxis and logistics, he assumed responsibility for taxi-related matters, including the establishment of a Seoul taxi model, managing more than 70,000 taxi cabs in Seoul, improvement of the taxi service, as well as implementing logistics policy.

He was appointed director of transportation policy in January 2013. He is responsible for formulating transportation visions and policies in Seoul, management of budget for transportation projects, management/supervision of the metro operator, introduction of new transportation means such as a light rail transit system, transportation demand management, transportation fare policy, the Intelligent Transportation System plan, and operation of the smart transportation card.

**Luiz Antonio CORTEZ FERREIRA**  
Senior Environmental and Sustainability Specialist, São Paulo Metrô  
luizcortez@metrosp.com.br

Luiz Cortez is a senior environment and sustainability specialist at São Paulo Metrô, a publicly owned company under SP State’s Metropolitan Transportation Authority. He has been working with SP Metrô for 25 years and recently served as institutional relations coordinator and as advisor to the state secretary of metropolitan transportation.

Ferreira received his degree in architecture and urban planning (M.Arch. + M.U.P. equivalent) from São Paulo University. In 2000, he lived in Tokyo, Japan, where he received a master’s degree in urban transportation planning. Back in Japan, in 2006, he got a post-graduation specialization in environmental management in Osaka. Ferreira is the environment and sustainable mobility director of AEAMESP, a nonprofit advocacy association devoted to promoting efficient, environmentally sound, inclusive, and affordable transportation systems. He is also a member of the State Environmental Council and the State Climate Change Policy Steering Committee.

He was born and lives in São Paulo, Brazil.

**Paul COTÉ**  
Previously: Special Advisor – Executive Management, Montreal Agence Métropolitaine de Transport  
Paul Côté was a special advisor to the AMT’s executive management. As such, he headed the West Island Mobility Plan Committee, chaired the Train de l’Est project management committee and led the entry into service of the dual-mode locomotives.

He joined the AMT in October 2011 as vice-president of Operations and served as interim president and CEO from February to October 2012. Côté previously worked at Via Rail Canada where he devoted over 32 years of service. At Via Rail, he served as president and CEO from 2004 to 2010, after acting as chief operating officer, head of customer service and transport, maintenance, labor relations and security, and head of the marketing department.

In the 1990s, Côté made a major contribution to the renaissance of the passenger railway in Canada by redefining staff roles and helping to develop a management philosophy that makes customer satisfaction the top priority.
On December 11, 2012, Côté was inducted into the Canadian Railway Hall of Fame for his significant contribution to the railway industry over 38 years. He is recognized for his integrity and his management philosophy, which put a clear emphasis on customer service and teamwork.

Côté is president of the committee to host the 2018 FEI World Equestrian Games, president and member of the board of directors of the Fédération équestre du Québec and member of the board of directors of the Société d’agriculture du comté de Shefford. He is also governor of Portage, a nonprofit organization helping people affected by substance abuse.

The AMT was formed in 1996 by the Government of Québec to strategically plan and efficiently coordinate the travel of people in the greater Montreal area. It plans, coordinates, integrates and promotes public transit services. It also operates the commuter train and metropolitan bus transit networks.

Isabel DEDRING
Deputy Mayor for Transport, Greater London Authority

Isabel Dedring is London’s deputy mayor for transport. In this capacity she is responsible for setting policy and ensuring program delivery across the mayor’s transport portfolio. Key projects in this role have included the Tube Reliability Programme, targeting a 30 percent reduction in delays, developing the mayor’s recent Cycling Vision, and leading the development of London’s first-in-a-generation new roads strategy through the Roads Task Force.

Prior to being appointed to this role in 2010, she was the mayor’s environment advisor, responsible for delivering, among other things, the mayor’s large-scale building retrofit programs and launching the £100m London Green Fund.

A graduate of Harvard Law School, Dedring received her undergraduate degree from Harvard University in political science and Russian. Her previous roles include work for the U.S. Agency for International Development, advising inbound investors at Ernst & Young Kazakhstan, and a focus on regulated industries at McKinsey & Company.

A member of the New York bar, Dedring has been a guest lecturer at a number of universities. She is a board member of the Institute for Sustainability and deputy chair of the Transport for London board.

Michèle DIX
Managing Director of Planning, Transport for London

Michèle Dix is the managing director of planning at Transport for London (TfL). Dix started her career at the Greater London Council after completing her Ph.D. in transport and land use planning and became a chartered civil engineer through the GLC’s transport planning graduate scheme. After six years of policy work, Dix joined Halcrow Fox in the private sector, where she became the board director of urban transport planning. After 15 years working on a range of studies, Dix joined TfL as director of congestion charging; implementing, running and expanding the scheme with co-director Malcolm Murray-Clark. She was also responsible for developing the Low Emission Zone. Since, June 2007, Dix has been the managing director of planning, and leads TfL’s strategic thinking on the future transport needs of London, testing and challenging policies and providing clear direction on appropriate transport solutions for the future. Current studies include air quality, growth, health, and accessibility policies and major schemes such as the Northern Line Extension, Crossrail 2, New River Crossing and Translinks, and leading on the TfL’s aviation work for the mayor. She is responsible for the TfL’s work on ensuring that it is integrated within London.

Mortimer DOWNEY
Senior Advisor, Parsons Brinckerhoff

Mort Downey has spent five decades in the transportation profession, both public and private. During the Carter administration he was an assistant secretary of transportation, and during the Clinton administration he served for eight years as deputy secretary of transportation. Since then he has been associated with Parsons Brinckerhoff, as well as operating his own consulting business. He served on President Obama’s campaign transportation policy committee and was appointed as head of the Department of Transportation transition team.

In the public transportation area, he held various positions, including executive director, at the New York Metropolitan Transportation Authority from 1981 to 1993. More recently, he has been appointed as a federal member of the Washington Metropolitan Area Transit Authority, where he serves as second vice chairman and chairs the board safety and security committee. As a consultant, he has advised a number of transit authorities, including Transport for London, New Jersey Transit, the Port Authority of New York and New Jersey, Chicago’s CTA and RTA, and the Metropolitan Transportation Commission in the San Francisco Bay Area.

Jessie Feller
Former Senior Planner for the Energy Policy Program, Regional Plan Association

Jessie Feller came to RPA to launch and run the energy policy program. She specializes in urban-regional policy and planning, with a particular focus on sustainability and energy policy. Before joining RPA, she worked as a cluster specialist at Economic Competitiveness Group, working on competitiveness strategies for global city-regions, particularly the clean-tech sector. Clients included the Inter-American Development Bank (project in Mendoza, Argentina), United Nations Development Programme (project in Southeastern Anatolia, Turkey), Marin County Supervisors, and The Oakland Partnership. Prior to ECG, Feller was selected as a sustainability fellow to work at Oregon’s Portland Development Commission, reporting to PDC’s first sustainability manager.
Originally from San Rafael, California, she graduated Phi Beta Kappa from Vassar College with a bachelor’s degree in urban studies and hispanic studies and graduated with a master’s degree in environment and development studies with honors from the London School of Economics and Political Science.

Alain FLAUSCH
Secretary General, International Association of Public Transport (UITP)

Flausch was selected as secretary general of the International Association of Public Transport in September 2011 by the UITP executive board.

This appointment acknowledges Flausch’s longstanding commitment to public transport on the international stage. He was previously chairman of the Finance & Commerce sub-committee of the UITP Metro Committee (2001 to 2009); he has also been a member of the UITP Executive and Policy Boards (2004 to 2009), an executive member of the UITP International Metro Committee (2001 to 2009), a member of the Transport Management Committee (UITP) and chairman of the Design & Culture Platform. Flausch was elected president of UITP during the Association’s 58th World Congress in Vienna in June 2009. He is also the president of the Belgian Union of Urban and Regional Public Transport (UBTCUR), which gathers together the three national public transport companies.

Barbara GANNON
Principal, GannonConsult

GannonConsult is well-respected by the transportation industry for its dedication to the development of transportation leaders. Barbara Gannon was an instructor in Northeastern University’s national transit management seminars until 1995, and established the Center for Transportation Leadership at the Eno Transportation Foundation, training over 1,200 global transit leaders in the highway, tolling and transit sectors. Gannon served as Eno’s executive vice president until 2012.

In addition to experience as an educator and trainer, Gannon’s practical transit experience includes forging the start-up of a five-county rural/regional transit system, and managing an operating transit division for the Port Authority of Allegheny County in Pittsburgh, PA. This practical industry perspective was valuable as Gannon moved to the private sector to strategically guide a technology company’s investment in the future technology needs of the transportation sectors.

Gannon was awarded a doctoral degree in clinical psychology in 1998, held a clinical appointment at Harvard Medical School, and was a staff psychologist at Dana Farber Cancer Institute in Boston.

Gannon’s experience as an operating transit manager and a clinical psychologist with a background in business provide a unique perspective on her current work as a facilitator of forums and partnering events, and as an executive coach and trusted consultant to senior leaders, teams and boards of directors across the transport sector.

Antonio GARCIA PASTOR
Director of Planning, Consorcio Regional de Transportes de Madrid

Antonio García Pastor has developed his professional career in the field of transportation, both in the public sector as well as in private companies.

In public bodies, he has worked in the studies and planning department of the Consorcio de Transportes de Madrid, taking part in several phases of the Madrid Metro Extension Plan, European projects, etc.

He has been technical director and responsible for quality in FCC-Connex group (Veolia), working in different activities involving follow up and monitoring of existing tramway and bus operations in Spain, and preparation of bids for the operation of public transport systems. He is a member of the boards of some of the companies in the group, and is the liaison with Veolia-Connex headquarters in France.

He also worked as an associate at Steer Davies Gleave in its Madrid office, responsible for branches in Spain and Portugal. During this time, he worked on several national and international projects, preparing proposals for institutions such as the World Bank, the EBRD, international infrastructure concessionaires, etc., working in different fields such as business plans, transport companies acquisitions, demand forecasts, high speed railway projects, etc.

Presently he is the head of the planning and projects department at Consorcio Regional de Transportes de Madrid (Madrid Public Transport Authority). He leads the different planning actions of the organization, including strategic and tactical planning, coordinating with other national local, regional and national bodies. He also represents CRTM in different international associations such as UITP.

Stephen GLAISTER
Director, RAC Foundation; Emeritus Professor of Transport & Infrastructure, Imperial College London

Stephen Glaister, CBE Ph.D. FICE FTRF FCGI, is director of the RAC Foundation andemeritus professor of transport and infrastructure at Imperial College London.

Currently he is also a member of the expert advisory panel of the Office of Rail Regulation.

He has been a member of the analytical challenge panel at HS2 Ltd. and was partnership director at Tube Lines. For eight years prior to this he sat on the board of Transport for London.

He has also been: a non-executive director of London Regional Transport; a specialist advisor to the Transport Select Committee in Parliament; an advisor to the 2006 Eddington Transport Study; an advisor to the Commission for Integrated Transport; and a member of the steering group for the Department for Transport’s 2004 National Road Pricing Feasibility Study.

Glaister has published widely on transport policy and also on regulation in the telecommunications, water and gas industries.

Sir Peter HENDY
Commissioner, Transport for London

When he was knighted in 2013, the citation for Sir Peter Hendy CBE noted he has provided inspiring leadership since becoming Commissioner of Transport for London (TfL) six years ago. He has made London a world leader in integrated and innovative transport delivery, and has overseen record breaking operational performance, passenger numbers and the largest ever investment program. He led, and played a key role in preparing for, the successful operation of London’s transport for the 2012 Olympic and Paralympic Games.

Hendy joined the then London Transport as a graduate trainee in 1975 and gained experience of all aspects of bus operations before being appointed managing director of CentreWest London Buses Ltd. in 1989. He led the successful buyout of CentreWest by its management and staff with venture capital backing in 1994. He expanded the business, and, after its sale to FirstGroup PLC in 1997, he became divisional director, London and South East. Immediately prior to joining TfL, Hendy was deputy director – U.K. Bus, responsible for FirstGroup bus operations in London.
and southern England, starting operation of Croydon Tramlink, and a director of New World First Bus in Hong Kong.

In January 2001, Hendy rejoined the public sector, becoming TfL’s managing director of surface transport, and oversaw the revitalization of London’s bus service, resulting in an increase in passengers of over 60 percent.

As transport commissioner, Hendy has led the largest long-term investment program in London’s transport networks in generations, vital to supporting economic development and growth not only in London but across the U.K. This has resulted in faster, more frequent Tube services operating more reliably than at any point in history, an extended and expanded Docklands Light Railway, the creation of the London Overground orbital rail network, the start of Crossrail construction, the launch of Barclays Cycle Hire, contributing to a revolution in cycling growth in the capital of over 100 percent since 2000, and the construction of the U.K.’s first urban cable car, the Emirates Air Line. In 2011 to 2012, over 3.7 billion journeys were made on the TfL networks.

T. R. “Tom” Hickey, AICP
Former Manager of Special Projects Rail & Transit, Parsons Brinckerhoff

Tom Hickey is a Philadelphia-based transport strategist with 35 years of experience delivering quality bus and rail services. He spent two decades with public agencies, serving as general manager of the Port Authority Transit Corporation, railroad administrator for the State of Delaware, and in various operations and planning roles at Houston METRO, the Southeastern Pennsylvania Authority, the Bi-State Development Corporation (in St. Louis) and the New York City Transit Authority. As a consultant, he has contributed to transportation improvements in 34 states, Canada, Asia and the Middle East.

Hickey presently holds a number of committee leadership roles on the American Public Transportation Association and the Transportation Research Board. A graduate of Villanova University and an AICP certified planner, he is presently manager of special transit and rail projects with Parsons Brinckerhoff, Inc. He just returned from managing the design of a possible high-speed regional rail system for the United Arab Emirates.

Michael Horodniceanu
President of Capital Construction, Metropolitan Transportation Authority

Michael Horodniceanu is the president of MTA Capital Construction. Appointed in August 2008, he is responsible for building some of the largest and most complex transportation public works projects in the United States. With a budget of more than $20 billion, the MTACC portfolio includes East Side Access, Second Avenue Subway, the 7 Line Extension, Fulton Center, the completed South Ferry Terminal and the MTA Capital Security program.

Prior to joining MTACC, he was chairman and chief executive officer of the Urbitran Group, a New York City-based engineering and architectural firm. He served as New York City’s traffic commissioner from 1986 to 1990. Horodniceanu has also been a full-time professor in both the undergraduate and graduate schools of Polytechnic Institute of New York University and Manhattan College.

Horodniceanu earned a Ph.D. in transportation planning and engineering from Polytechnic Institute of New York University, a master’s degree in engineering management from Columbia University and a bachelor’s degree in civil engineering from the Technion-Israel Institute of Technology. He is the chairman of the advisory board of POLY-NYU Dept. of Civil Engineering and serves on the board of the Community Service Society of New York and on the board of the Transit Museum.

Christine Hsu
Executive Assistant, Regional Plan Association

Christine Hsu is the assistant to the executive director at RPA. Prior to this role, she was a research analyst at RPA, focusing primarily on urban parks and working landscapes. She has supported RPA’s open space projects such as Governors Island Alliance, and has contributed to a number of reports on the economic impact of urban park space on local and national economies.

Hsu is originally from Atlanta, Georgia, and graduated from Barnard College in New York City during the spring of 2013. She holds a B.A. in urban studies with a concentration in environmental science.

Eric-Mark Huitema
Member of the Worldwide ITS Board and Director Smarter Transportation Europe, IBM

Eric-Mark Huitema is responsible for intelligent transportation solutions and smarter cities initiatives in Europe. He is also a member of the IBM Global ITS board, as well as the ERTICO (ITS Europe) supervisory board.

He led the international business process management sales organization in Europe, responsible for the implementation of road usage charging implementations in London and Stockholm. He brings with him strong technology and management skills, developed in global operating internet, e-business and technological companies.

Huitema joined IBM in 2001 from internet provider Chello / Liberty Global, where he was co-founder and global vice president. Before he worked at EDS International, he started his career at Philips Electronics.

Huitema studied technical chemistry at the Technical University of Delft and at INSEAD in Fontainebleau where he received his master’s degree in deal making. He is fluent in Dutch, German and English.

Huitema is married and has four children, plays hockey and practices kite surfing. He also is a member of the Lions Club Bollenstreek and the Nieuwe of Littérare Société De Witte.

Carol Dillon Kissal
Former Deputy General Manager of Administration & CFO, Washington Metropolitan Area Transit Authority

Carol Dillon Kissal was the deputy general manager of administration and chief financial officer for the Washington Metropolitan Area Transit Authority from 2009 to 2014. At WMATA, Kissal oversaw its $2.5 billion budget and all associated financial functions, including revenue and fare collections, risk management, procurement, parking operations, accounting, and managing Metro’s real estate assets and joint development initiatives. Kissal also oversaw the departments of metro access and information technology, as well as the New Electronic Payments Program, the development of Metro’s new fare payment platform. Prior to joining Metro, she was
nominated by the president of the United States to serve as inspector general of the Small Business Administration. Kissal also served as deputy director of the District of Columbia Department of Transportation, and in six years as Amtrak’s corporate treasurer, she was responsible for $1 billion in financing for the nation’s first high speed rail. Kissal also spent seven years at IBM in the service organization, pricing data system outsourcing contracts for global customers. Kissal received a master’s degree in business administration from the Lubin School at Pace University and a bachelor’s degree in business management from Dominican College. In addition to being a registered member of the National Association of State Boards of Accountancy, a sponsor of continuing professional education, Kissal serves as a vice chair of Transit Finance Learning Exchange, a consortium that promotes finance professionals in transit.

Young-in KWON
Research Fellow, Department of International Cooperation and Northeast Asia Studies, The Korea Transport Institute
Young-in Kwon has more than 25 years of experience in transport research with KOTI, a national research agency for the government of the Republic of Korea.

He received his bachelor’s and master’s degrees in civil engineering at Hanyang University in Seoul. He studied transportation planning at the Department of Civil Engineering, Tokyo Institute of Technology in Japan from 1994 to 1997. His research interests cover public transport, road planning, parking and non-motorized transportation. He has done major projects on sustainable transport planning and master plans for transport infrastructure in Korea. His international research projects include the ASEAN road network master plan, Sumatra islands road network master plan, ground access for Clark & Cebu airport in the Philippines and strategies for Mongolia’s green public transport.

Kwon served as a visiting researcher at the Transportation Research Group of the University of Southampton in 2008 and at the Institution for Transport Policy Studies in Japan in 2009. Recently, he has been working for international cooperation on transportation projects for the Korean government office in Abu Dhabi in the United Arab Emirates. He was involved with several international research activities of the East Asian Society of Transportation Studies, World Road Congress and Transportation Research Board.

Robert LANE
Senior Fellow for Urban Design, Regional Plan Association
Rob Lane, an architect and urban designer, is a senior fellow for urban design at RPA. He directs the regional design program, which is devoted to improving the metropolitan landscape through research and place-based planning and design interventions. Lane’s current and recent work focuses on the relationship between transit, land use and urban design and emphasizes public participation and communication through visual techniques. Projects include the Newark Vision Plan, the Far West Side Redevelopment Alternatives Study and the Civic Alliance community design workshop for the rebuilding of Lower Manhattan after the 9/11 attacks. Currently, he is co-managing RPA’s participation in the Rebuild by Design initiative, in partnership with the Institute for Public Knowledge, the Municipal Art Society and Van Alen Institute.

Before coming to RPA, Lane was an associate at Kohn Pedersen Fox Architects, PC. Lane received his bachelor’s degree from Cornell University and a master’s degree in architecture from Columbia University.

Adi LAU
Deputy Director of Operating, MTR Corporation
Adi Lau is the deputy director of operations for MTR Corporation Limited, responsible for managing the operations of all transport business of the mass transit railway network in Hong Kong, including cross-boundary and intercity services, light rail and feeder buses.

He is the president of the China Hong Kong Railway Society and is a council member of the China Railway Society. He is also an advisor to the World Railway Development and Research Society.

He joined MTR Corporation in 1982. He held various management positions in design, construction, operations and maintenance of the metro system in Hong Kong. From 2004 to 2007, he was the general manager for the merger integration of MTR Corporation and KCR Corporation.

From December 2007 to October 2011, Lau was the general manager of MTR Corporation (Shenzhen) Limited and was the chairman and general manager of MTR Consulting (Shenzhen) Company, created to design and construct Shenzhen Metro Line 4 – Phase 2 and to subsequently operate and maintain all of Line 4 for 30 years.

Lau is a chartered engineer with a bachelor’s degree in civil engineering from the University of Hong Kong. He holds an MBA from the University of Michigan, and is a graduate of the Advanced Management Program of INSEAD. He is also a senior member of the China Railway Society.

Arthur T. LEAHY
CEO, Los Angeles Metropolitan Transportation Authority (Metro)
Arthur T. Leahy, one of the nation’s leading transportation executives, started out as a bus driver in Los Angeles 39 years ago, and is now the chief executive officer of the Los Angeles County Metropolitan Transportation Authority. Metro is the lead transportation planning and programming agency for the county, and funds construction of numerous street, highway and transit improvements. He has served in the position since April 2009.

Prior to Metro, Leahy headed the Orange County Transportation Authority from 2001 to 2009, where he oversaw the planning, financing and coordination for Orange County’s freeway, street and transit development. Prior to OCTA, Leahy served as general manager of the transit agency in Minneapolis-St. Paul between 1997 and 2001.

Leahy began his transit career in 1971 driving a bus for the Southern California Rapid Transit District, a predecessor of Metro, while attending college. He worked his way up through the ranks to head operations for Metro, overseeing bus operations and activation of the Metro Blue Line and Metro Red/Purple Line, before taking the Minneapolis chief executive job.

Leahy earned a bachelor’s degree in political science from California State University, Los Angeles and a master’s degree in public administration from USC.

LEW Yei Der
Group Director of Corporate Planning & Research, Singapore Land Transport Authority
Lew Yei Der is the group director of the Corporate Planning and Research Group in the Land Transport Authority, Singapore.

His current portfolio includes spearheading corporate development and strategic research, and expanding the research and training capacity of the LTA Academy. Lew has been with the LTA since its formation in 1995, holding various management positions. He holds a first class honors degree in civil
Joseph J. LHOTA  
Former Chairman and CEO, New York Metropolitan Transportation Authority  
Joe Lhota was nominated by Governor Andrew Cuomo and confirmed by the New York State Senate as the chairman and chief executive officer of the Metropolitan Transportation Authority (“MTA”) in January 2012, and held the position until December 2012.

Lhota has extensive experience in both the private and public sectors. Before he joined the MTA, he served as executive vice president for The Madison Square Garden Company, where he was responsible for the development and execution of company-wide human resources strategies, government affairs, information technology, facilities and real estate, and an array of corporate services.

Prior to MSG, Lhota was an executive vice president of Cablevision Systems Corporation. He was deputy mayor for operations in the administration of Mayor Rudolph W. Giuliani. Before being appointed deputy mayor, Lhota was the city’s budget director, managing the city’s $36 billion operating budget and $45 billion capital budget.

Lhota is a resident of Brooklyn Heights. He is a cum laude graduate of Georgetown University and received his MBA from the Harvard Business School.

LIU Thai Ker  
Director, RSP Architects Planners & Engineers  
Liu Thai Ker is an architect-planner. Since 1992, he has been director of RSP Architects Planners & Engineers (Pte) Ltd., a consulting firm with projects in Singapore and a dozen countries.

Liu has served as an adjunct professor at the School of Design and Environment and the Lee Kuan Yew School of Public Policy, National University of Singapore. He is also an adjunct professor at the College of Humanities, Arts & Social Sciences, Nanyang Technological University. He is a member of several governmental bodies in Singapore, and planning advisor to over 20 cities in China.

As architect-planner and chief executive officer of the Singapore Housing & Development Board, 1969 to 1989, Liu oversaw the completion of over half a million dwelling units. In 1989, he became the chief executive officer and chief planner of Urban Redevelopment Authority, for which he spearheaded the major revision of the Singapore Concept Plan in 1991.

In the cultural arena, he served as chairman of the National Arts Council from 1996 to 2005, and of the Singapore Tyler Print Institute from 2000 to 2009.

He is also a recipient of several awards, including the Gold Medal of the Singapore Institute of Architects in 2001, and the Medal of the City of Paris, France in 2001.

Måns LONNRoth  
Board Member, Volvo Research and Educational Foundations  
Måns Lonnroth was until 2012 a member of the board of the VREF, Volvo Research and Educational Foundations, as well as of the International Institute for Sustainable Development, Winnipeg, Manitoba, Canada. He has been managing director of Mistra, a Swedish foundation for strategic environment research, and international vice chairman of the China Council for International Cooperation on Environment and Development.

Lonnroth has also been state secretary at the Swedish ministry of environment from 1994 to 1999 and a political advisor to the prime minister’s office from 1985 to 1991.

He has served on the boards of various research councils and was for 15 years an elected member of the Stockholm County Council.

The common element in all his pursuits is his interest in the meeting point between politics, policy and science. He was trained in applied mathematics and graduated from KTH in 1967.

Teik-Soon LOOI  
Director of Policy, Singapore Land Transport Authority  
Teik-Soon Looi is a director of policy in the policy division of the Land Transport Authority. His present portfolio is on public transport policies related to fares, ticketing payment services, bus and rail services, industry structure, bus financing, regulatory and licensing models, etc. He has more than 12 years of in-depth experience in fare policy development and implementation.

Anders LINDSTRÖM  
Managing Director, Storstokholms Lokaltrafik  
Anders Lindström served in the Swedish Armed Forces and finished as Lieutenant General. Lindström served as the first Swedish liaison officer at Central Command Florida during the war in Afghanistan and ISAF’s establishment.

Lindström has also been head of Sweden’s international force and has regularly visited Sweden’s priority areas in the Balkans, Middle East, Africa, Asia, and Afghanistan.

Over the past decade Lindström has been engaged and partly responsible for great transformations in Sweden’s Armed Forces.

As of January 2014, Lindström is the president of the organization responsible for public transport on land and at sea in Stockholm County, as well as public communications. Specifically, he was the lead officer in the major fare-related review in 2005 and the on-going review slated for completion in 2013. His previous appointment was the secretary to the Public Transport Council. He also has experience in road and rail planning and design, road operations and management, competitive tendering and regulation of transit operation. A civil engineer with an MBA, Looi also holds a master’s degree in public management from the Lee Kuan Yew School of Public Policy, National University of Singapore.

Philippe MARTIN  
Director General of Transport Operations & Maintenance, Régie Autonome des Transports Parisiens  
A graduate of the Ecole Centrale de Paris and Auditor IHEDN of the 53rd session (2000 to 2001), Philippe Martin has been the director general in charge of transport operations and maintenance within the RATP Group since October 2009. He also acts as executive vice president in charge of Services and Solutions, and has held various positions in both operational (director of the RER line A, director of the central maintenance workshop bus and others) and in engineering.

He is a knight of the National Order of Merit and knight of the National Order of the Legion of Honor.

Sergio Aníbal MARTINEZ SANCHEZ  
Former Director  
General of Planning and Transport, Mexico City  
Sergio Martinez Sanchez has been the transport and thoroughfare secretary of the Main Directorate of Planning and Roads since 2006.

Previously, he was the general director of building, services and urban development (2003 to 2006) for the Iztacalco District, and sub delegate of building and urban growth for Coyocan and Tláhuac Districts. In the private
sector, he acted as architect-director at SAMS, and consulted on diverse projects involving architectural design, construction, building supervision and technical studies.

He attended UNAM, where he studied architecture.

**Juliette Michaelson**  
**Vice President for Strategy, Regional Plan Association**  
As vice president of Strategy, Juliette Michaelson is involved in a wide range of critical projects. She is currently focused on an initiative to bring together the chief executives of the world’s most dynamic and innovative transit agencies to discuss shared challenges and opportunities.

Michaelson is the author of a landmark RPA report that used statistical modeling to estimate the positive impact that improved transit service has on adjacent property values. The report is still quoted to make the case for building dense nodes of development around train stations. Also part of Michaelson’s portfolio is RPA’s advocacy efforts on the Far West Side of Manhattan, including Moynihan Station, Javits Convention Center and the Hudson Railyards.

**Ricardo Montecino**  
**Technical Director, Directorio de Transporte Público Metropolitano, Santiago**  
Ricardo Montecino is the technical director of the executive secretary of the Directorio de Transporte Público Metropolitano, where he is responsible for the development of technical and transversal initiatives, which also include organizational development.

He joined DTPM in 2012. His first task was to study and develop a new organizational and institutional framework for the DTPM, including the necessary legal changes.

Before joining DTPM, Ricardo was an associate at Steer Davies Gleave, an international transport consultancy. He started there in 1999, mainly in the office in Santiago, where he worked for different markets, countries and clients. He was in charge of the office from 2007 to 2010, and since 2011 has been the commercial manager for the Latin American market.

Montecino has a degree in civil engineering from the Catholic University of Chile. He also holds a master’s degree in engineering and transport planning from the University of Leeds.

**Takao Nishiyama**  
**Executive Officer and Director of International Department, East Japan Railway Company**  
Takao Nishiyama joined Japanese National Railways in 1981 and was assigned to the East Japan Railway Company when JNR was divided and privatized in 1987.

In JR East he held various management positions, mainly in the transport and rolling stock field, such as chief of an electric railcar depot, manager of the car and crew utilization division of a regional office, and general manager of the transport department of the regional office. From 2007 to 2008 he was responsible for overall customer service in the company as general manager of the customer service department at headquarters, and he served as executive director of the New York office for four years starting in 2008.

As of June 2012, he has been in charge of the overall international affairs of the company as director of the international department.

**Guy Nordenson**  
**Partner, Guy Nordenson & Associates, and Professor, Princeton University**  
Guy Nordenson is a structural engineer and professor of architecture and structural engineering at Princeton University. Nordenson was the structural engineer for the Museum of Modern Art expansion in New York, the Jubilee Church in Rome, the Simmons Residence Hall at MIT in Massachusetts, the Santa Fe Opera House, and over 100 other projects. Recently completed projects include two pedestrian bridges for Yale University and the New Museum of Contemporary Art in New York. Current projects include the expansion of the Kimbell Art Museum in Fort Worth and the National Museum of African American History and Culture in Washington, D.C. He is the author of *On the Water | Palisade Bay* (Hatje Cantz Verlang / MoMA 2010) and *Patterns and Structure* (Lars Müller Publishers 2010). Nordenson is also active in earthquake engineering, including code development, technology transfer, long-range planning for FEMA and the USGS, and research. He initiated and led the development of the New York City Seismic Code from 1984 to its enactment into law in 1995.

**Henrik Normark**  
**Head of Business Development, Storstockholms Lokaltrafik**  
Henrik Normark has a bachelor’s degree in business administration from the University of Uppsala in Sweden. Normark started his career in the healthcare industry as a management trainee, and served several years in different management positions, on an operational as well as strategic level, in charge of excellence in strategy and process development and implementation, as well as business integration after mergers and acquisitions.

Normark is now head of business development at Stockholm Public Transport, responsible for strategic development of SL’s business model, business strategies as well as brand and sales strategies.

**Nadiah Loh**  
**Senior Researcher, Knowledge Management, Singapore Land Transport Authority**  
Nadiah Loh is a senior researcher in the knowledge management division of the Land Transport Authority, Singapore. She graduated with an honors degree in economics from the National University of Singapore, and joined LTA in 2012. Prior to joining LTA, Nadiah was a policy analyst with the Public Service Division, Prime Minister’s Office.

**Masaki Ogata**  
**Vice-Chairman, East Japan Railway Company**  
Masaki Ogata joined Japanese National Railways in 1974, and then JR East when JNR was divided and privatized in 1987. He became the manager of the customer service division of the marketing department, general manager of the transport safety department, and director and general manager of the transport and rolling stock department. There he was engaged in drafting the safety middle term plan, and now he is considered a leader in the field of safety within the company.

He was appointed as executive vice president and head of railway operations for headquarters in 2008. He was in charge of the daily operation of the railway, which 1.7 million passengers use daily, and led the preparations for the opening of the Tohoku Shinkansen extension between Hachinohe and Shin-Aomori in December 2010, and the increase in its operating speed to 300 km per hour in March 2011.
Since June 2011, he has been vice-chairman of JR East, in charge of introduction of ICT to railways, further improvement of customer safety and transport service reliability, and making advanced Japanese railway technology and environmental awareness known to railway systems overseas.

Sotiris A. PAGDADIS
Principal, PricewaterhouseCoopers LLP

Sotiris Pagdasis leads the state and local government initiatives for PricewaterhouseCoopers’ capital projects and infrastructure practice nationally. He has over 25 years of experience consulting with top executives in public and private sector infrastructure management. Sotiris has helped clients manage the complexities associated with megaprojects, involving capital development, capital improvement and rehabilitation, public-private partnerships, project financing, and real estate optimization and development.

His advisory expertise includes strategic planning, capital project planning, infrastructure assessment, capital project financing, value analysis, risk management, productivity benchmarking, operations planning and technology assessment. He has advised across the United States and Canada, France, Spain, Portugal, Italy, Greece, Cyprus, the Netherlands, Germany, China, Hong Kong, Singapore, Malaysia, India, Brazil, Argentina, Mexico, Colombia, the UAE, South Africa, Ghana, Uganda and elsewhere.

Patricio PEREZ
Head, Transantiago

Currently, Patricio Pérez is the head of the Santiago public transport system Transantiago, which is responsible for the regulation and supervision of bus operators and the coordination of the service provided by their 6,000 buses, jointly with the 103-kilometer metro network in an integrated system with nearly four million passenger trips per day. Perez is an industrial engineer. He has a master’s degree in transport engineering from the Catholic University and holds an MBA from Adolfo Ibañez, both in Chile. His began his current position in October 2011 after being in charge of the negotiation process regarding contracts between the government and private bus operators of Transantiago in February 2011. His previous positions include chief of staff and advisor to the minister of transport and telecommunications (Santiago, Chile, 2010), senior manager for business consulting at Everis (Santiago, 2009) and principal consultant at Steer Davies Gleave (Santiago, 2001 to 2009 and London, 2000 to 2001). He brings with him fifteen years’ experience in business development, business strategy and project analysis in Latin America, North America and Europe.

Howard R. PERMUT
Former President, New York Metropolitan Transportation Authority

Howard Permut was President of MTA Metro-North Railroad from July 2008 to January 2014. He was the fourth president in the railroad's history and was part of the original team that created Metro-North out of the Conrail commuter operations in New York and Connecticut in 1983. During his tenure, Metro-North had numerous achievements including historic levels of service reliability, increased ridership (which made Metro-North the largest commuter railroad in North America), and record levels of safety. He overhauled its financial performance to increase efficiency and successfully commissioned a number of facilities.

Prior to his current role as president, Permut had a series of positions of increasing responsibility at Metro-North: senior vice president of planning, procurement and business development; vice president of planning and director of planning. Before working for MTA/Metro-North, he worked at the Northeastern Illinois RTA during its formative years, and at the CTA.

He is also a visiting scholar at New York University and has completed consulting assignments for major transit agencies in London, Santo Domingo, Philadelphia, San Francisco and Los Angeles. He has served on various TCRP Research and APTA panels. He has taught the NTI Senior Leadership Course, and has lectured at Yale, University of Pennsylvania, NYU, Northwestern, Simon Fraser University, CUNY and Brooklyn Polytechnic Institute.

Jerome POURBAIX
Head of Policy, International Association of Public Transport (UITP)

Jerome Pourbaix is head of policy at the International Association of Public Transport. Recently he led the development of a toolbox on public transport funding and established scenarios for urban transport by 2025, Pourbaix is currently coordinating UITP international advocacy activities. He studied sociology in Belgium and the U.K.

John “Jack” M. REILLY
Professor of Practice, Rensselaer Polytechnic Institute, and Advisor, World Bank

Jack Reilly is a professor of practice in the Civil and Environmental Engineering Department at Rensselaer Polytechnic Institute, where he teaches a number of transportation and engineering courses. Prior to his current position, he was on the staff of the Capital District Transportation Authority in Albany, New York, where he was deputy executive director, with responsibility for planning, capital project development and information technology. He has also served as a consultant to the World Bank (India and China) and several U.S. transit systems of varying sizes. He recently completed a manual on transit capacity analysis for cities in developing countries. He is a member of the Transit Research Advisory Committee, which advises the Federal Transit Administration on the direction of transit research, and has chaired a number of panels for the Transportation Research Board of the National Academies in areas such as bus rapid transit, transit capacity and transit innovation.

Xavier ROSELLO
Deputy Technical Director, Barcelona Autoritat del Transport Metropolità

Xavier Rosello has a doctorate in industrial engineering and a degree in economic sciences. In 2000, he was named assistant technical director at ATM (Barcelona Autoritat del Transport Metropolità). ATM is a public consortium of public administrations whose main mission is the coordination of public transport in the metropolitan area of Barcelona. He has been responsible for institutional representation, participation in European projects, transportation planning and supervision of mobility surveys.

From 1975 to 1985 and from 1998 to 2000, he was the general director for transport and mobility of the Catalan Government, participating in projects such as the Metro Plan in 1984, station design studies and design and supervision of the Journey to Work survey. From 1989 to 1993 he was a project leader in AIS, a private company devoted to Artificial Intelligence. He oversaw the development of projects based on neural networks and genetic algorithms.

From 1985 to 1989, he was the software development project leader at the Informatics Centre of the Generalitat de Catalunya. He taught operations research from 1978 to 1985, computational linguistics from 1986 to 1992,
Richard R. SARLES
General Manager and CEO, Washington Metropolitan Area Transit Authority (Metro)

Richard Sarles was appointed general manager and chief executive officer by the Metro Board of Directors in January 2011. Sarles has more than 40 years of experience in the transit industry with WMATA, NJ TRANSIT, Amtrak, and the Port Authority of New York and New Jersey.

He was appointed interim general manager of Metro in April 2010, and in his short tenure at the helm, Sarles has set the agency on a course to improve safety, reliability and financial stability. He has led dozens of actions on a course to improve safety, including strengthening the safety department, expanding training agencywide, establishing a new roadway worker protection program, creating a safety hotline, enhancing a whistleblower protection policy, as well as establishing a new employee safety recognition program. He has spearheaded the replacement of buses and MetroAccess vehicles, and the acquisition of new rolling stock – 7000 series rail cars equipped with advanced crashworthiness technology. Under his leadership, Metro has a $5 billion six-year capital improvement program dedicated to improving safety, customer reliability and adhering to the State of Good Repair initiative. To enhance transparency and public accountability, Sarles also established a new online Vital Signs performance measurement system.

Michael SCHABAS
Associate, First Class Partnerships Rail Consultants

Michael Schabas has experience planning, financing, building and operating metros and passenger railways. He has worked in more than 20 countries, and been a board member of train operating companies in the U.K., Germany, Australia and Nigeria. Trained originally as an architect, city planner and transport economist, in his early career he helped design the Vancouver Skytrain, Canada’s first automated metro. He came to London in 1988 to conceive and promote the Jubilee Line Extension, and to upgrade the Docklands light railway, working on behalf of the Canary Wharf developers who contributed over £500 million. When British Rail was privatized, he formed GB Railways, which acquired Anglia Railways, doubling passenger numbers and revenues while reducing average fares over the seven year franchise term. Currently he is working with local investors developing Nigeria’s first metro system, under a 25 year public-private partnership concession. For further details visit www.schabas.net

Elliott SCLAR
Professor & Director, Center for Sustainable Urban Development, Urban Planning & International Affairs, Columbia University

Elliott Sclar is the director of the Center for Sustainable Urban Development at the Columbia University Earth Institute and professor of urban planning at the university’s Graduate School of Architecture, Planning and Preservation. CSUD is one of the eight centers of excellence in future urban transport supported by the Volvo Research and Education Foundations.

His latest volume, Urban Access for the 21st Century: Finance and governance models for transport infrastructure, was published in March by Routledge. It sets out a road map for reforming our approaches to urban transport finance. Through a series of chapters from international contributors, the volume demonstrates how small changes in the incentive structures built into current transport finance models can have large positive future impacts on service quality and efficiency. Sclar contributed the chapter on the economics of sustainable urban transport to UN-HABITAT’s 2013 Global Report on Human Settlements, Planning and Design for Sustainable Urban Mobility, published in October 2013. He was lead editor on The Urban Transformation: Health, shelter and climate change, published in January 2013.

Sclar has written extensively about the strengths and limitations of markets as mechanisms for effective public service delivery. His book You Don’t Always Get What You Pay For: The Economics of Privatization won two major academic prizes: the Louis Brownlow Award for the Best Book of 2000 from the National Academy of Public Administration, and the 2001 Charles Levine Prize from the International Political Science Association for a major contribution to public policy literature.
Elaine Seagriff
Head of London Wide Policy and Strategy, Transport for London

Elaine Seagriff is head of London-wide policy and strategy for Transport for London (TfL). Apart from a brief spell in California working on light rail and strategy, she has worked in the planning and provision of transport in London for around 20 years – covering major urban development, evaluation and monitoring of major investment projects, area-wide strategies for central, inner and outer London, integration of transport and land use planning policies and the development of all aspects of strategic policy. More recently she has focused on the development and execution of the mayor’s transport strategy, and the transport elements of the mayor’s spatial development strategy, which set out long-term challenges, agreed-upon goals and sets policy priorities and the vision for the transport system for the next 20 years. She leads the implementation of the mayor’s transport strategy for TfL through strategic policy development, working across TfL’s range of modes, and with key stakeholders, with a focus on policies to support the continued sustainable development of London.

Mohinder Singh
Dean, Singapore Land Transport Authority Academy

Mohinder Singh is the dean of the LTA Academy in the Land Transport Authority of Singapore. The Academy conducts research and training and exchange of knowledge on land transport policy and planning. He was the director of planning of the Land Transport Authority from 1996 to 2007 before assuming his current appointment as Dean of the LTA Academy. Before joining the Land Transport Authority in 1996, he served in various senior positions in the Ministry of National Development, overseeing urban and transport planning in Singapore. He holds a first class honors degree in civil engineering from Queen’s University, Canada and a master’s degree in transportation from the University of Birmingham, U.K.

William Solecki
Director & Professor, Institute for Sustainable Cities, City University of New York, Hunter College

William Solecki’s research focuses on urban environmental change and urban spatial development. He is the director of the CUNY Institute for Sustainable Cities and has served on several U.S. National Research Council committees including the Special Committee on Problems in the Environment. He currently is a member of the International Geographical Union’s Megacity Study Group and the International Human Dimensions Programme, Urbanization and Global Environmental Change Scientific Steering Committee. He also serves as the co-leader of several climate impact groups in the greater New York and New Jersey region.

Solecki’s teaching interests include courses on urban environmental change, urban spatial development and research methods. In the past couple of years, he has developed course material on climate change and cities. He also has taught classes in environmental policy and management, world geography/human geography, GIS, and resource conservation.

Julian WARE
Senior Principal, Commercial Finance, Transport for London

Julian Ware joined TfL in 2007, and has worked since on innovative funding and finance for transport projects in London – including Crossrail 1 and the Northern Line extension, as well as the plans for Crossrail 2. He is now a senior principal in the commercial finance team. Prior to joining TfL, he worked for KPMG on U.K. and international public-private partnerships. Before that he worked for the U.K. Strategic Rail Authority and the Department of Transport.

Thomas Wright
Executive Director, Regional Plan Association

Tom Wright is executive director of Regional Plan Association. He has steered many of the organization’s key initiatives, including the Draft Vision Plan for the City of Newark (2006) and A Region at Risk: The Third Regional Plan for the New York-New Jersey-Connecticut Metropolitan Area (1996).

Wright lectures widely on growth management and regional planning. He is a visiting lecturer in public policy at Princeton University’s Woodrow Wilson School of Public and International Affairs. Previously, he was deputy executive director of the New Jersey Office of State Planning, where he coordinated adoption of the New Jersey State Development

William Wheeler
Director of Special Project Development & Planning, New York Metropolitan Transportation Authority

William Wheeler has over 30 years of experience in transportation planning in both highway and public transportation at the local, county and regional levels. He is currently the MTA’s director of special project development and planning. Bill has overseen the MTA Long Range Planning Framework, the planning basis for the MTA megaprojects including East Side Access, the Second Avenue Subway and the Fulton Street Transit Center; and has spearheaded the MTA’s Regional Strategic Review, the foundation for new network initiatives in the MTA Twenty Year Capital Needs Assessment. Most recently, he is leading a comprehensive inter-railroad capacity evaluation of Penn Station and its surrounding network. Mr. Wheeler has training in urban planning and transportation engineering with a bachelor’s degree from Marietta College, an M.P.A. from American University and an M.S. from Manhattan College.

Terri Wills
Director of Global Programs, C40-Clinton Climate Initiative

Terri Wills is the Director of Global Programs for the C40, in partnership with the Clinton Climate Initiative. Before taking on this role, Terri served as the London city director for C40-CCI, working closely with the mayor of London’s office and agencies, the private sector and other partners to develop and implement climate change mitigation programs and projects.

Before joining C40-CCI, Wills was a senior policy advisor for the Ontario government in Canada, supporting the administration of a large-scale cleantech demonstration fund. Wills also spent several years as a consultant in Canada advising on economic development of the creative industries. Prior to these roles, Wills lived in the U.K. and worked for the BBC, first as a strategy manager – where she led the development of partnership plans for what is now Salford MediaCityUK – and subsequently as a head of strategy. Wills holds a master’s degree from the London School of Economics and a B.A.H. in political studies from Queen’s University, Canada.
and Redevelopment Plan (2001). From 1991 to 1993, he was coordinator of the award-winning Mayors’ Institute on City Design, sponsored by the National Endowment for the Arts.

Wright received a bachelor’s degree in history and a certificate in American Studies from Princeton University, and an master’s in urban planning from Columbia University.

David YALE
Deputy Executive Officer for Countywide Planning and Development, Los Angeles Metropolitan Transportation Authority (Metro)

David Yale is the deputy executive officer of regional programming for the Countywide Planning Department of the Los Angeles County Metropolitan Transportation Authority. He is responsible for transportation programming and long range financial forecasting for the regional transportation system in Los Angeles County. Yale’s focus has been local solutions to diminishing state and federal transportation funds, including the development of the Expenditure Plan for Measure R, Metro’s one-half cent sales tax proposal recently approved by over two-thirds of L.A. County voters. He is responsible for development of the multi-billion dollar Los Angeles County Transportation Improvement Program and the financial planning used for Metro’s $150 billion Long Range Transportation Plan.

Yale has a master’s in urban planning from the UCLA Graduate School of Architecture and Urban Planning and a bachelor’s in political and environmental studies from Pitzer College in Claremont, California.

YAP Kheng Guan
Former Senior Consultant, Public Utilities Board, Singapore

Yap Kheng Guan was a senior consultant and senior director at PUB, Singapore’s National Water Agency until his retirement in 2012. He was involved in the development of Singapore’s drainage infrastructure over a period of 30 years. He played a major role in formulating drainage policies and technical measures, and was responsible for several major flood control and drainage projects such as the Bukit Timah Flood Alleviation Scheme, the Singapore River cleanup and was the project director for the Marina Barrage project. The Marina Barrage, completed in 2008, creates a unique reservoir in the city for the country and brings about the three benefits of a new water supply, a flood control facility and a public space for people to enjoy.

Yap was also involved in Singapore’s latest initiative to transform its waterways into active, beautiful and clean water bodies. The ABC Waters program is aimed at turning Singapore’s network of utilitarian canals, rivers and reservoirs into attractive lifestyle venues for the community to enjoy and to value their water resources.

Yap strives to cultivate in Singaporeans a closer relationship with water and a sense of ownership towards their water resources. He started the 3P Network department in PUB in 2004, and was instrumental in transforming the organization’s approach to public communication and outreach. He was in charge of PUB’s corporate communication and community relations divisions, both strategic in bringing about a sustainable water management for Singapore. Yap was PUB’s spokesman on Singapore’s water management and projects for several local and international press and broadcasting reports.

Though Yap retired in July 2012, he remains active in both professional and voluntary works. He assisted PUB by organizing and teaching at a course on drainage for PUB engineers.

He has also been appointed to the Panel of Experts, Centre for Liveable Cities, under the Ministry of National Development (2012 To 2014).

He is also an adjunct professor at NTU, Singapore.

Robert YARO
President, Regional Plan Association

Robert D. Yaro is the president of Regional Plan Association, America’s oldest independent metropolitan policy, research and advocacy group. Based in Manhattan, RPA promotes plans, policies and investments needed to improve the quality of life and competitiveness of the New York Metropolitan Region, America’s largest urban area. Yaro co-chairs the Empire State Transportation Alliance and the Friends of Moynihan Station, and is vice president of the Forum for Urban Design. He serves on Mayor Bloomberg’s Sustainability Advisory Board, which helped prepare PlaNYC 2030, New York City’s new long-range sustainability plan.

Since 2001 Yaro has been the professor of practice in city and regional planning at the University of Pennsylvania. He also taught at Harvard University and the University of Massachusetts. He holds a master’s degree in city and regional planning from Harvard University and a bachelor’s degree in urban studies from Wesleyan University.

Markus ZACHMEIER
Senior Vice President, Siemens Mobility and Logistics

Markus Zachmeier is the senior vice president of Siemens Mobility and Logistics and the division cluster lead for the ASEAN-Pacific region. He is responsible for leading Siemens’ business as a leading international provider of integrated technologies for complete transportation and logistics solutions.

With more than 20 years of experience in the railway business, Zachmeier is widely recognized as a leading expert in the rail industry. He was involved in various functions in the major rail projects awarded to Siemens in the Asia region. These projects include the implementation of the BTS and MRTA Bangkok, ERL Kuala Lumpur, Metro Kaoshiung, ARL Bangkok, High Speed Line Beijing–Tianjin and the Delhi Airport Link.

In addition, Zachmeier spearheads Siemens’ activities in the promotion of urban mobility solutions in ASEAN cities. He is on the city consultation committees including Bangkok 21, Jakarta 21 and Ho Chi Minh 21 that support city planning for urban sustainability.

Fiona ZHU
Former Senior Planner and GIS Manager, Regional Plan Association

Fiona Zhu was responsible for RPA’s data warehouse and quantitative protocols. She teamed up with research staff on a wide range of topics at various geographic levels, specialized in geospatial analysis, map design and statistical modeling. Some of her work included a quantitative assessment of fair housing issues in the New York – Connecticut region, a comprehensive inventory of conservation context in the Northeast megaregion, and a comparison study of governance structures in global metropolitan areas. Before she joined RPA, Zhu studied at University of Pennsylvania, where she led a group studio project that studied the potential economic impact of a proposed high speed rail line to the central Florida region. She graduated with a master’s degree in urban planning and a Certificate of Spatial Analysis in 2010.

She grew up with her family in Southwestern China and received her bachelor’s degree from Peking University in Beijing.
Jeffrey M. ZUPAN
Senior Transportation Fellow, Regional Plan Association

Jeffrey Zupan serves as the senior fellow for transportation for Regional Plan Association. He has led RPA’s work in all facets of transportation planning and policy.

Mr. Zupan also has a consulting practice that has brought him a wide range of assignments involving transportation planning with a strong focus on transit, travel demand, urban design and policy formulation. Prior to initiating his consulting practice in 1990, for ten years Zupan was Director of Planning for NJ TRANSIT, where he directed the formulation and evaluation of that agency’s “new initiatives” program, which directly led to over $2 billion of transit investments.

Zupan is co-author of three major books, Urban Rail in America, Public Transportation and Land Use Policy, and Urban Space for Pedestrians, and is the author of many reports and technical papers on a wide variety of transportation matters. He also is co-author of RPA’s recent report, Upgrading to World Class: The Future of the Airports in the New York Region.
### Transit System Map Sources

<table>
<thead>
<tr>
<th>Country</th>
<th>Transit Authority/Operator</th>
<th>Data Source Year(s)</th>
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<td>Barcelona</td>
<td>ATM, 2012</td>
<td>ATM, 2012</td>
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<tr>
<td>Hong Kong</td>
<td>OSM, 2012, n/a</td>
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<td>Sao Paulo</td>
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<td>Seoul</td>
<td>RPA, 2013, n/a</td>
<td>RPA, 2013, OSM, 2014</td>
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Notes: Most OpenStreetMap (OSM) files were modified by RPA; Some files also contain lines drawn by RPA; All shapefile features are labeled with their appropriate source in the attribute table (available on transitleadership.org); Basemap files were provided by the respective city agency or downloaded via open source websites.

### City Metric Sources

- **Barcelona**: Autoritat del Transport Metropolità (ATM), Ajuntament de Barcelona, TRAM, Transports Metropolitanos de Barcelona (TMB)
- **Hong Kong**: Mass Transit Railway (MTR), The Government of the Hong Kong Special Administrative Region
- **London**: Transport for London (TfL), Greater London Authority, Office for National Statistics, VisitBritain
- **Los Angeles**: Los Angeles County Metropolitan Transportation Authority (LACMTA), Metrolink, National Transit Database (NTD), U.S. Census, Discover Los Angeles
- **Madrid**: Consorcio Regional de Transportes Madrid (CRTM), Eurostat
- **Mexico City**: Ciudad de Mexico Secretaria de Movilidad, Servicio de Transportes Eléctricos (STE)
- **Montreal**: Agence métropolitaine de transport (AMT), Société de transport de Montréal (STM)
- **New York City**: Metropolitan Transportation Authority (MTA), Port Authority of New York & New Jersey (PANYNJ), New Jersey Transit (NJT), National Transit Database (NTD), U.S. Census, New York State Department of Motor Vehicles (NYS DMV)
- **Paris**: Régie Autonome des Transports Parisiens (RATP), Syndicat des Transports en Île-de-France (STIF), Observatoire de la mobilité en Île-de-France (OMM), National Institute of Statistics and Economic Studies (INSEE), Eurostat
- **Santiago**: Directorio de Transporte Público Metropolitano (DTPM), Instituto Nacional de Estadísticas Chile (INE)
- **Sao Paulo**: São Paulo Metrô (SPM), Empresa Metropolitana de Transportes Urbanos de São Paulo, World Population Statistics, Prefeitura de São Paulo
- **Seoul**: Seoul Metropolitan Government (SMG), World Population Statistics, Korea Tourism Organization (KTO)
- **Singapore**: Singapore Land Transport Authority (LTA), SMRT Corporation
- **Stockholm**: Storstockholms Lokaltrafik (SL), Statistics Sweden
- **Tokyo**: East Japan Railway Company (JR East), Tokyo Metro, Tokyo Metropolitan Government
- **Vienna**: Wiener Linien (WL), City of Vienna, Eurostat

**Notes on Ridership Data**

Current ridership numbers reflect the most recent available, 2012-2014

**Notes on Financial Data**

For the most part, the financial statistics in the table represent the entire metro system in each city. However, there are a few cases where only a part of the metro system or more than the metro are included:

- **Seoul**: Includes Seoul Metro, one of the 4 main metro operators in the city. This represents 4 out of 18 metro lines.
- **Los Angeles & Singapore**: Include both the heavy rail and light rail because the light rail systems in these cities are closely integrated with the heavy rail metro.
- **Montreal, New York City & Santiago**: Include both the metro and bus systems because they are overseen by the same umbrella agency and it is difficult to separate the data.

**GDP for all cities**: Brookings Institute
ACKNOWLEDGEMENTS

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