MOBILE Communications and TRANSPORTATION in Metropolitan Regions

Mitchell L. Moss, Josh Mandell, and Carson Qing

The Rudin Center for Transportation Policy and Management

New York University, NY

July 2011

ABSTRACT

This study examines the role of mobile communications in urban transportation systems and analyzes American metropolitan regions best positioned to capitalize on the growth of mobile technologies. This paper identifies three critical factors—data accessibility, mobile network strength, and mobile tech user/developer demographics—and uses data from several public resources in an analysis of major Metropolitan Statistical Areas (MSAs). The authors explore trends and public policy implications for furthering the use of mobile communications in the transportation systems of metropolitan regions.

The rankings revealed that metropolitan regions each have areas of strength and weakness. In fact, no MSA ranked in the top five for each category, suggesting that though several cities were very strong (top five) in two categories (San Jose, San Francisco, Washington DC, San Diego), every MSA has substantial room for improvement.

ACKNOWLEDGEMENTS

The writers appreciate the helpful comments and suggestions of their colleagues throughout the research and writing of this paper. Special thanks to Anthony Townsend, Andrew Mondschein, Sarah Kaufman, and Jordan Anderson for guiding the initial research plan. Thanks also to HopStop, especially CEO Joe Meyer, for insights on transportation software, transit data, and application development, as well as to CityGoRound/WalkScore for continued support. We are also indebted to Adam Greenfield, Managing Director at UrbanScale, for sharing ideas on the future of networked cities; to Dylan Goelz - Head of Marketing and Design at Roadify; to Shankar Prasad, Professor of Public Policy and Statistics at NYU Wagner, for statistical analysis support; and to John Robert Baker for mapping assistance.

CONTENTS

[1]

INTRODUCTION

Smartphone usage is increasingly pervasive in modern society. In the United States, according to the FCC, "data traffic on AT&T's mobile network, driven in part by iPhone usage, is up 5,000% over the past 3 years, a compound annual growth rate of 268%." In North America, "wireless networks carried approximately 17 petabytes per month in 2009, an amount of data equivalent to 1,700 Libraries of Congress."[2]

Transportation information is a major driver in this surge in data traffic, as Americans are using their phones to plan trips, navigate, and experience the world around them with the help of their handheld devices. According to the comScore 2010 Mobile Year in Review, over 60 million Americans accessed maps from their mobile device in December 2010, up 46% from December 2009.[3] Nielsen's "State of Apps" report indicates that on the major smartphones—Apple, Android, BlackBerry, and Windows—Google Maps was in the top four most used applications.[4]

The boom in smartphone adoption has coincided with an economic and political shift that puts more pressure on information dissemination tools. As public support for new roads, highways, and mass transit systems becomes more difficult to obtain, there will be increasing use of mobile communications by commuters, drivers, and passengers seeking to plan and arrange their trips to minimize delays, waiting time, and congestion. Simply put, information will play a larger role in the transportation arena, especially as consumers face a world of transportation characterized by limited new public investment. Within this context, cities have the option to be an active player, or a sideline spectator.

Providing open data is a major step towards truly unified, networked cities. The faster that transportation agencies release their data and build relationships with the developer and user communities, the sooner that the public and private sectors will be able to contribute to address key transportation and other urban challenges. These regions will also have more effective transportation applications for mobile phones and will be better positioned to integrate other data driven projects that make public systems more intelligent.

This study seeks to determine what metropolitan regions are best positioned to excel in this mobile-centric environment. The goal is to identify best practices and challenges, while initiating discussion on the relationship between mobile communications and transportation. To achieve this objective this study examines open data policies of metropolitan transportation authorities. It also considers key elements of data utilization, namely the smartphone user and software developer populations, as well as mobile wireless connectivity of metropolitan regions.

METHODOLOGY

The study ranks a large sample of 274 metropolitan statistical areas (MSAs) provided by the U.S. Census Bureau's 2009 American Community Survey, based on transportation mode use in commuting (equal combination of absolute and percent use). The study then aggregates the rankings for the eight major modes of transport, selecting the top 25 highest ranked MSAs for the sample. The sample is evenly distributed geographically across the US (Figure 1) and represents a large share of major metropolitan areas (Table 1).

Sample MSAs were then scored on the level of open data made available for both transit and motorist usage. Operating under the principle that motorist data is already being collected and utilized by private sector entities and that greater gains are to be made by achieving open transit data, the study weighted transit data accessibility twice as heavily as that of car-dependent modes. Utilizing data from the FCC's National Broadband Map, MSAs were also evaluated on wireless network strength, specifically mobile broadband and Wi-Fi coverage, as well as download speed and where applicable, underground Internet connectivity. Finally, the study examined Census and Bureau of Labor Statistics (BLS) data to estimate smartphone user and software developer populations.

DATA ACCESSIBILITY

The transportation sector experienced the power of open data in 1995, when the U.S. Department of Defense and National Oceanic and Atmospheric Administration greatly improved the Global Positioning System (GPS). Although GPS satellite data was public up until that point, the data quality was inadequate and as a result, was not highly commercialized. The result of the improved data policy, as highlighted by the Federal Communications Commission (FCC) in the recent U.S. National Broadband Plan, was the creation of the GPS and navigation industries.[5] GPS technology is near ubiquitous in modern consumer trip planning, as Americans use it in their mobile phones, cars, and other handheld navigation devices.

As in the case with GPS in the 1990s, the transportation sector is again experiencing improved mobility as a result of new, innovative location-based technology. Web based software and applications are providing consumers with new virtual tools to better plan trips, navigate, and interact with their environment. Although these applications will undergo much change in future years, the shift to an open, real-time data platform is setting the stage for improved public services and user experience. For this reason, metropolitan regions with open data will have an advantage in the pursuit of more intelligent, livable cities.

Open Data and Transportation Applications

The term "open data" refers to whether or not information is free to the public and available for private use, and/or commercial development. In the field of transportation, the term usually refers to the data possessed by transit and other transportation authorities and whether or not they are publicly available to software developers. In transit, the essential data includes schedules, routes, and stop locations, with real-time data being the most valuable. Schedules, routes, and stop locations are the minimum to be listed on Google's General Transit Feed Specification (GTFS) website, which serves as the primary data source for software developers.[6] GTFS is not the only transit data format and there are other important kinds of transportation data, including station GIS locations, traffic statistics, and/or parking space availability, among others. Many transit agencies provide an abundance of open data on their agency websites, ranging from mobility related data (transit, traffic, parking, etc.), to administrative, performance, and safety data. Given the early stages of the open data movement and the principal objective of transportation mobility, making routes, schedules, and stop locations available are the generally accepted determining criteria for labeling an agency "open data."

Private website and application (app) developers are now utilizing this data from GTFS and agency sites to create valuable applications for improving user experience. CityGoRound, a website dedicated to transit applications and open data, currently claims that of the 824 U.S. transit agencies listed on their site, 184 have open data (six of which are real-time) that have resulted in over 170 transit apps.[7] Google Maps, HopStop, and Mapquest produce well-known navigation tools, but there are also many small business developers utilizing this data as well. For example, the iTrans NYC App, which is produced by one individual, is among the top five highest grossing navigation applications sold in the Apple iTunes App Store.[8]

Beyond transit applications, countless other transportation services have been created across the U.S., including augmented reality 'wayfinding' apps, driver monitoring and reporting tools, and parking space maps. Augmented reality applications integrate location-based information (local businesses, subway/bus stations, etc) into a user's camera phone so that the application user can point his or her phone down a street and actually see information and advertisement signs layered on top of the existing camera view. Meanwhile, driver-monitoring applications can actually use motion technology to measure speed, breaking patterns, and other driving habits to relay information to yourself or a family member.

Several peer-to-peer data sharing applications have emerged to harness the potential of crowd-sourced data. Since such programs have not yet reached critical mass and are based on crowd-sourced data, they are beyond the parameters of this study. Although transportation apps derived from GTFS data have already been widely adopted in the app market and have been recognized for improving user experience, there are serious limits to the quality of these programs.

Applications that deal in real-time mobility—transit, traffic, and parking—are only as effective as the quality of data from which they are derived. The quality is usually determined by the data source, which can be broken down into three categories: “Application Programming Interface (API),” real-time API, or “scraped data.” An API is essentially a structure of code and web protocols that organizes information. As mentioned above, Google’s GTFS feed specification serves as the primary format for transportation APIs. The term “real-time API” refers to whether or not a given transit agency provides their data in real-time. In other words, a transportation authority may claim open data because they provide transit schedules, routes, and locations in the GTFS format on their website, but they may only update their data periodically, meaning that service outages, delays, etc. may not be fully integrated into trip-planning programs. Real-time data on the other hand, theoretically provides live data on vehicle location, schedule, etc. In the absence of an API, enterprising programmers can “scrape data” from other data formats on the website (a PDF of the train schedule for instance) to create a program. The problem with programs based on scraped data is that transit timing is so unpredictable and as such, real-time mobility requires the most real-time of data. Some applications have been developed without GTFS, but such examples are labor intensive and face the challenge of data accuracy. New York City’s Exit Strategy—an application that tells riders where to stand for optimal exit timing—functions well because station exits are relatively fixed, unlike train arrival times for instance.

Moreover, if there is data, an application can be created, but the relative frequency of updating that data is of critical importance. After all, an app that provides outdated schedules and does not reflect service changes can do more harm than good. Open real-time data is obviously the highest quality, because it (presumably) provides truly current information. In addition, the continuity, or fragmentation, of data across agencies in a given region is especially important. For example, if a consumer uses an app to plan a trip over multiple transit services, each mode is critical to the process. Only if the data from all agencies in the route is current and accurate does the app truly serve its purpose.

Methodology: Assessing Data Accessibility

To evaluate data accessibility—the quality and continuity of data in a given metropolitan region—this study cross-referenced information from multiple sources, including CityGoRound, Google Transit, Nextbus, and various agency websites, to create an aggregated score and ranking for transit and motorist data. Scores for mass transit were subject to ridership weights to calculate raw scores. After obtaining raw scores, the average raw score for each mode across 25 MSAs was calculated and the raw scores were subtracted from the averages to obtain an "adjusted raw score" for each MSA. The adjusted raw score was then subject to weights based on modal use relative to other MSAs (Table 2) to obtain a weighted score. The weighted scores were then ranked for each mode to obtain a ranked score for each transit mode (Table 3). This weighting system was employed to account for relative modal use in determining how relevant the data made accessible (or lack of data) is in a given metropolitan area's transportation system. The use of ranked scores, which will be used uniformly across the entire study, is necessary in order to compare very different types of metrics and combine these metrics fairly and appropriately in computing the composite rankings.

For car-dependent modes, data accessibility scores were assigned by a fixed point system based on the real-time parking and traffic data available to developers and users (Tables 4 and 5), meaning that scores were not ranked and weighted. Unlike transit, where several resources (GTFS, CityGoRound, Nextbus) exist to highlight which agencies provide open data, traffic data is released by state or local Departments of Transportation through their "511" real-time traffic services, while parking data is also released by similar institutions or public parking authorities. In most cases, public authorities do not provide open data for developers on parking and traffic information, thus some partial credit was given where an effort has been made to convey information directly to mobile users. These fixed raw scores for car-dependent modes were also subject to modal use weights to obtain weighted scores, which were then ranked to obtain "ranked scores" (Table 6).

Finally, the ranked scores for transit and motorist data accessibility were aggregated, with transit scores receiving twice as much weight as motorist scores (Table 7). This decision was based on two beliefs. One, public agencies have more responsibility to release data regarding public transportation. Motorist data has and will continue to be serviced by the private navigation, telecommunications, and car-share industries. Two, given the often complex nature of trip planning on multi-modal public transit, it is more important that agencies provide a platform for enhancing user experience on public transportation.

Results & Implications

DATA ACCESSIBILITY RANKINGS		
Rank	***Metropolitan Statistical Area***	***Score***

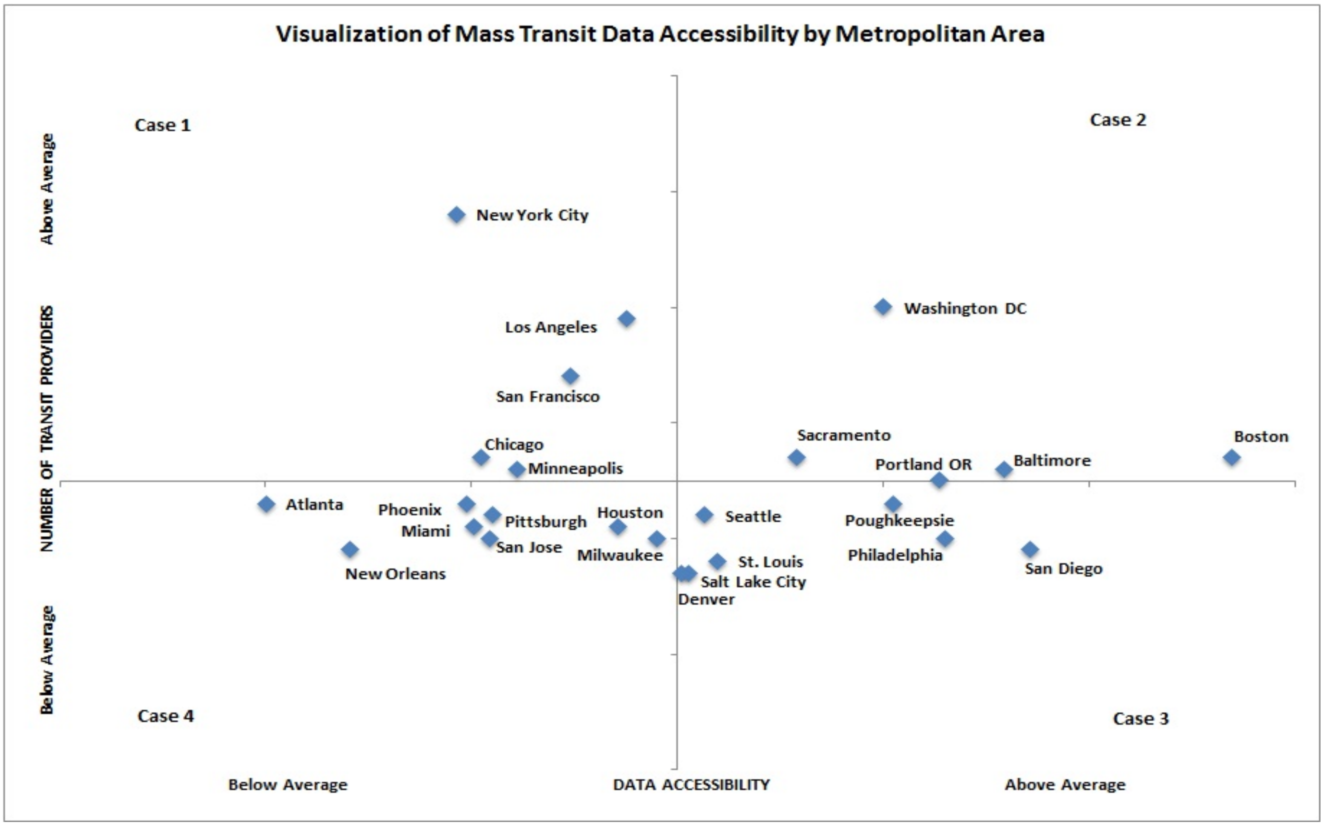
1	**Boston-Cambridge-Quincy, MA-NH**	**22.6**
2	**Poughkeepsie-Newburgh-Middletown, NY**	**15.7**
3	**Portland-Vancouver-Beaverton, OR-WA**	**8.1**
4	**Washington-Arlington-Alexandria, DC-VA-MD-WV**	**7.7**
5	**San Diego-Carlsbad-San Marcos, CA**	**6.8**
6	**Salt Lake City, UT**	**6.7**
7	**San Francisco-Oakland-Fremont, CA**	**6.5**
8	**Philadelphia-Camden-Wilmington, PA-NJ-DE-MD**	**6.3**
9	**Baltimore-Towson, MD**	**4.2**
10	**San Jose-Sunnyvale-Santa Clara, CA**	**3.9**
11	**Chicago-Naperville-Joliet- IL-IN-WI**	**3.3**
12	**New York City-Northern New Jersey-Long Island, NY-NJ-PA**	**1.5**
13	**Seattle-Tacoma-Bellevue, WA**	**0.9**
14	**Denver-Aurora-Broomfield, CO**	**0.1**
15	**Los Angeles-Long Beach-Santa Ana, CA**	**0.0**
16	**Pittsburgh, PA**	**-0.7**
17	**Sacramento-Arden-Arcade-Roseville, CA**	**-2.5**
18	**St. Louis, MO-IL**	**-3.4**
19	**Milwaukee-Waukesha-West Allis, WI**	**-6.3**
20	**Minneapolis-St. Paul-Bloomington, MN-WI**	**-8.2**
21	**Houston-Sugar Land-Baytown, TX**	**-10.6**
22	**Phoenix-Mesa-Scottsdale, AZ**	**-12.2**
23	**Atlanta-Sandy Springs-Marietta, GA**	**-13.3**
24	**Miami-Fort Lauderdale-Pompano Beach, FL**	**-17.6**
25	**New Orleans-Metairie-Kenner, LA**	**-17.9**

Boston, with its high public transit utilization and open data initiatives of the last two years was the clear leader in data accessibility. This standing reflects the policies of the Massachusetts Bay Transportation Authority (MBTA) to provide open data as early as August 2009 and now real-time open data for its highest utilized modes—bus, subway/light rail, and commuter rail. It also highlights the remarkable level of coordination among Boston's transit agencies that serve areas not covered by the MBTA to ensure continuous data sharing. Others with high utilization and open data—Poughkeepsie (Commuter Rail), Philadelphia

(Bus), Washington DC (Subway)—were also noteworthy. Although motorist data was weighted less than transit, metropolitan regions with high driving rates and open motorist data were rewarded as well. San Jose, San Francisco, Chicago, Poughkeepsie, and New York City motorists also benefited from open data initiatives from state and regional transportation authorities.

In the cases of large metropolitan areas such as the New York metropolitan region and Los Angeles Region, for example, fragmentation across bus agencies at the metropolitan level led to below average data accessibility scores. Considering the high modal use for bus services in these two areas, their overall ranking suffered considerably.

In the New York region, large transit agencies such as Metropolitan Transportation Authority (MTA), Port Authority of New York and New Jersey (PATH), and NJ Transit provide open and in some cases real-time data for software developers. However, a large number of popular regional commuter bus companies, which are mostly private, independently operated entities, provide transportation services for many suburban residents to New York City on a daily basis. Only a few of these providers release open data. Furthermore, while large transit agencies in the New York region may indeed release a great deal of data across a variety of subjects, the fact remains that developers in the city are working with fragmented data across a large metropolitan area and as a result, consumers are more likely to receive imperfect software applications.



Moreover, as the above scatter plot illustrates, metropolitan areas in the upper-left quadrant (New York, Los Angeles, San Francisco, and to a lesser extent Chicago and Minneapolis) encompass numerous transit agencies and thus face greater challenges in terms of coordination and management. For these MSAs, the relatively low transit scores are understandable, given the early stages of the open data movement in these larger, more complex regions.

MSAs found on the right side quadrants represent metropolitan regions that provide above average transit data-based on ridership. They vary in the number of transit agencies covered, with Washington D.C. representing the most (24) agencies and Denver/Salt Lake City representing only one each (though they see large ridership). That Washington, D.C. is still on the right side of graph illustrates the region's pattern of strong cooperation on open data policy, where more than half of the 24 agencies provide open data. Case 3 regions release more data proportionately than Case 1, but it should be noted that these regions have fewer agencies and thus face fewer constraints with regard to coordination, institutional barriers, and sheer scale.

Lastly, MSAs in the bottom left region of the transit scatter plot were the weakest in transit data availability and with the exception of San Jose, were also at the bottom of motorist data open data. Among the eight metropolitan regions found in the lower left quadrant, most regions had only a few transit services that provided open data, and in some cases, no transit data was available at all.

MOBILE NETWORK STRENGTH

Transportation applications that rely on mobile communications and access to information offer the potential to save transit users and driver's time and substantially improve the overall transportation experience. However, as almost everyone with a smartphone knows, wireless connectivity is of utmost importance when trying to connect to the Internet or use a web-based application. After all, applications that address real-time issues such as transit, traffic, and parking, demand continuous connectivity. Although programs such as the aforementioned Exit Strategy or the popular iTrans trip-planning application do not require Internet connection, these applications naturally suffer from potential information gaps. The desire for optimal wireless connection is likely a major reason that in Pew's 2010 Mobile in Review survey, respondents listed "network quality" as the most important factor in phone and service selection.[9]

In the larger context, network quality is increasingly important in the transportation sector. Most "smart city" programs that rely on sensors and real-time data are relayed by mobile broadband. Similarly, mobile GPS navigation, other location-based services rely on mobile broadband. And, as location becomes another layer in the personalization of consumer experience, mobile wireless connectivity is only going to grow in value.

Methodology

To determine which MSA's mobile phone users currently have the best wireless connectivity the study examined four metrics. For the three mobile network statistics, the study used the National Broadband Map (NBM), to analyze "Terrestrial Fixed Wireless – Unlicensed," "Terrestrial Mobile Wireless – Licensed," and median mobile download speeds across MSAs. Fixed base points were also awarded to agencies that provided Wi-Fi access to underground subway systems.

Terrestrial Mobile Wireless—the measure of mobile broadband offered in a given area—is defined by the NBM as a service "generally offered by cellular phone providers, and includes technologies such as LTE, mobile WiMAX, CDMA2000 (EVDO), and UMTS (HSPA)." [10] This service was given a 50% weighting because mobile broadband is the most important provider of network access to smartphone users.

Terrestrial Fixed Wireless—the service that covers general Wi-Fi—is defined as "Wi-Fi and other similar technologies (e.g., WiMAX and other proprietary wireless systems)" and received 20% for serving as a partial provider of Internet access for smartphones. Underground Wi-Fi provided by transit agencies received 20% weighting, because of the heavy ridership of subway passengers and the numerous gains (or losses) for having underground web access. Download speed was considered important for web navigation and app utilization, but was greatly overshadowed by the prerequisite of network connectivity: hence it was given 10% weighting.

Results & Implications

In view of the relative importance of mobile broadband, the metropolitan regions with greatest Terrestrial Mobile Wireless numbers came out on top. San Jose, Philadelphia, and Milwaukee were the top performers and as a result landed in the top three for Mobile Network Connectivity. Salt Lake City, Phoenix, and

Baltimore were other notable regions with strong mobile broadband coverage and ranked fourth, fifth, and seventh respectively.

MOBILE NETWORK RANKINGS						
Rank	***Metropolitan Area***	***Mobile***	***Wi-Fi***	***Speed***	***Subway Wi-Fi***	***Score****
1	**San Jose**	10	11	8	0	**8.0**
2	**Philadelphia**	11	2	-1	6	**7.0**
3	**Milwaukee**	12	-2	11	0	**6.7**
4	**Salt Lake City**	9	12	-11	0	**5.8**
5	**Phoenix**	8	9	-9	0	**4.9**
6	**San Francisco**	-2	6	10	12	**3.6**
7	**Baltimore**	7	-1	7	-3	**3.4**
8	**Minneapolis**	4	1	6	0	**2.8**
9	**New York**	3	-3	0	9	**2.7**
10	**Houston**	6	0	-6	0	**2.4**
11	**Chicago**	5	5	-2	-6	**2.1**
12	**Sacramento**	-1	8	-8	0	**0.3**
13	**Los Angeles**	2	-8	-7	3	**-0.7**
14	**Poughkeepsie**	1	-4	-10	0	**-1.3**
15	**Denver**	-6	7	2	0	**-1.4**
T-16	**Boston**	0	-10	12	-9	**-2.6**
T-16	**Pittsburgh**	-5	-5	9	0	**-2.6**
18	**Seattle**	-4	-6	4	0	**-2.8**
19	**St Louis**	-10	4	3	0	**-3.9**
20	**Portland OR**	-12	10	-3	0	**-4.3**
21	**New Orleans**	-3	-12	-12	0	**-5.1**
22	**Atlanta**	-7	-7	-5	0	**-5.4**

23	**Miami**	-9	-9	5	0	**-5.8**
24	**San Diego**	-8	-11	-4	0	**-6.6**
25	**Washington D.C.**	-11	3	1	-12	**-7.2**

The ranking for Terrestrial Fixed Wireless (Wi-Fi) was more sporadic, with Salt Lake City (overall 4th), San Jose (overall 1st), and Portland (overall 20th) leading the category. Mobile download speed was also mixed relative to the overall rankings, with Boston (overall 16th) leading the category and Milwaukee (overall 2nd) and San Francisco (overall 6th) at second and third respectively. New York (PATH) and Philadelphia (Southeast Pennsylvania Transportation Authority) received partial points for providing at least partial Wi-Fi on subway platforms, and San Francisco's Bay Area Rapid Transit (BART) received a full point for Wi-Fi throughout the entire system. Washington D.C., Boston, Chicago, and Baltimore were penalized for not providing Wi-Fi in their subway systems, after accounting for high modal use in those regions.

Comparing Mobile Network Strength with the Data Accessibility rankings, it is surprising to see that no metropolitan region was in the top five for both categories. Salt Lake City and San Francisco were the most consistent, suggesting that these regions are better positioned to employ transportation relation mobile apps, as well as wireless transportation infrastructure. This is especially good news for San Francisco, where the city has invested $20 million in SF Park, a sensor and data driven intelligent parking system.

In addition to Salt Lake City and San Francisco, the network rankings should be of special interest to jurisdictions that have already made the move to open real-time data and rely more heavily on wireless connectivity. These public agencies include San Francisco's Municipal Railway (SF Muni) and BART, Chicago's Transit Authority, Seattle's King County DOT Transit, Portland's Tri-County Metro, and Washington DC's Circulator. As noted above, San Francisco placed sixth in Mobile Network Strength, but the rest of the real-time MSAs actually placed in the bottom ten. These rankings do not reduce the importance of open data programs, but they do underscore the importance of other pieces in the mobile ecosystem. Open data can be incredibly useful, but it is not an end in and of itself.

Moreover, just like open data or smartphone demographics, network connectivity alone is not a panacea for solving transportation problems. As noted above, some of the best cities for open data are actually some of the worst for network connectivity. Boston, although excellent in open data, ranks 16th for network strength, while Portland (third in data accessibility) ranked 20th. Similarly, Washington D.C., which ranked 4th for data accessibility, ranked 25th for network strength. When embarking on open data programs and wireless infrastructure, regions should also consider the networks over which the massive amounts of new data are going to flow.

DEMOGRAPHICS OF SMARTPHONE USERS AND SOFTWARE DEVELOPERS

A city may release a great amount of data and/or possess excellent mobile connectivity, but if there is a shortage of developers to create new applications, or a lack of consumer usage, data and connectivity lose their significance. On the user side, various comScore and Nielsen industry studies have shown that particular demographic groups are higher adopters of smartphones. Although such studies do not cover geographic location, they do note that urban and suburban residents are twice as likely as rural peers to own a smartphone.[11] Our review of such industry studies found that they do provide valuable demographic data, which can be used to identify which regions should have the highest rate of adopters.

Regarding developers, there is a substantial body of research that has found that higher concentrations of industry clusters in a given region can yield positive industry growth and spillover effects. Applying this logic to the software developers, it is possible to see which metropolitan regions have the greatest agglomerations, and thus enjoy the greatest development of web-based programs and mobile apps.

Demographics of Higher Smartphone Adoption

The Pew Research Center's Internet and American Life Project is one of the leading sources of reliable and timely data on smartphone demographics. Pew's most recent study in July 2011 identifies several demographic characteristics that are associated with smartphone adoption. It revealed that the strongest positive indicator of smartphone ownership was income, with 59% ownership among those earning $75,000 or greater, compared to just 22% among those earning $30,000 or less. Positive correlation was evident for educational attainment as well, where adoption rates were 18% for no high school diploma, but up to 48% for those with at least a college degree. Conversely, Pew's study confirmed negative correlation with age, where 52% of 18-29 year olds, 45% of 30-49 year olds, 24% of 50-64 year olds, and 11% of individuals 65 and older owned smartphones. Lastly, Pew and Nielsen research have shown that about 30% of whites (non-Hispanic) owned smartphones, while 44% of African Americans and Hispanics did so.[12] Nielsen's Quarter 1 analysis reflected similar findings and reported 44% ownership by Asian/Pacific Islanders.[13] [14]

In addition to ownership is the issue of online access via smartphone. Pew found that age was the greatest differentiator in demographics for using smartphones for online access.[15] Young people use their smartphones to get online more than their elders and they do so more frequently. Additionally, Pew found that when it comes to accessing the Internet from a smartphone *as the primary means*, the correlation between income and usage was negative. Those making $30,000 or less actually used smartphones the most, while those with highest incomes did so the least. This trend presumably reflects the ability of higher income earners to possess other computer devices, such as desktops, laptops, and tablets.

Lastly, Pew studies have found non-whites to be more than twice as likely as their white peers to use their phone as their primary Internet access device.[16]

With the exception of income, the pattern of smartphone ownership and the smartphone as the primary online mechanism were the same. Although it is tempting to consider the discrepancy in income correlation a contradiction, it is not. The fact that low-income groups use their smartphones as their primary access device does not mean that high-income users are not using their smartphones equally, if not more frequently. Moreover, with increasing wireless spectrum shortages and increased smartphone adoption, service providers have already begun phasing out their unlimited data plans. This supply-driven shifting of costs to consumers will likely reinforce the importance of income as an indicator of smartphone ownership in the future.

Software and Application Developers

A March 2011 study from Delgado, Porter, and Stern demonstrates that industry clustering correlates with higher employment, higher wages, and more patenting.[17] Applying this logic to software, MSAs can be compared to see which metropolitan areas enjoy the highest proportions and real numbers of developers. The Bureau of Labor Statistics (BLS) annual Occupational Employment report provides useful geographic statistics that can be used to map such clusters. Taken together, the user and developer data can paint a picture of which metropolitan regions possess the right balance of human capital for smartphone development and integration in the future.

Methodology

To identify metropolitan regions where smartphone adoption and software development were greatest, a ranking of the 25 MSAs by five demographic characteristics was necessary. The study used the 2009 American Community Survey provided by the US Census Bureau to extract statistics on individual income level, educational attainment, race, and age for the populations of all 25 sample MSAs. In accordance with the findings of Pew and Nielsen, MSAs were ranked for an overall user score based on age (30%), income (30%), racial diversity (20%), and educational attainment (20%).

After obtaining the user score (Table 10), the developer score was calculated based on a combination of the percent concentration and real number of software developers in each MSA workforce (Table 11). To measure software/app developer concentrations, the study used the Bureau of Labor Statistics "Location Quotient" index that measures concentrations of specific industries and occupations in large geographic areas, including MSAs. These numbers represent the proportion of software developers in a metropolitan area's workforce divided by the proportion of such occupations in the national workforce and account for 2/3 of the MSA score. MSAs were also ranked on total number of developers, to provide credit to larger cities with larger developer workforce that might be overshadowed by the MSA total population. The rankings are summarized in Table 11. (Note: BLS Occupational Employment Statistics do include part-time workers, but do not include the self-employed.)[18]

Moreover, demographics were evaluated based on a combination of smartphone users and software/app producers. In computing the composite scores for Smartphone Adoption and Software Development, the user ranked scores received twice as much weight as the producer ranked scores. The rankings of Demographics are summarized in Table 12, and a more detailed methodology summary can be found in the Appendix.

SMARTPHONE ADOPTION AND SOFTWARE DEVELOPMENT RANKINGS		
Rank	***Metropolitan Statistical Area***	***Score****

1	**San Jose-Sunnyvale-Santa Clara, CA**	**12.0**
2	**Washington-Arlington-Alexandria, DC-VA-MD-WV**	**11.0**
3	**San Francisco-Oakland-Fremont, CA**	**9.3**
4	**San Diego-Carlsbad-San Marcos, CA**	**7.0**
5	**Atlanta-Sandy Springs-Marietta, GA**	**6.3**
6	**Seattle-Tacoma-Bellevue, WA**	**6.0**
T-7	**Denver-Aurora-Broomfield, CO**	**5.7**
T-7	**Los Angeles-Long Beach-Santa Ana, CA**	**5.7**
9	**New York-Northern New Jersey-Long Island, NY-NJ-PA**	**4.3**
10	**Baltimore-Towson, MD**	**3.0**
11	**Boston-Cambridge-Quincy, MA-NH**	**2.3**
12	**Minneapolis-St. Paul-Bloomington, MN-WI**	**2.0**
13	**Chicago-Naperville-Joliet, IL-IN-WI**	**0.3**
T-14	**Philadelphia-Camden-Wilmington, PA-NJ-DE-MD**	**-0.7**
T-14	**Sacramento--Arden-Arcade--Roseville, CA**	**-0.7**
16	**Houston-Sugar Land-Baytown, TX**	**-1.3**
17	**Salt Lake City, UT**	**-4.3**
18	**Portland-Vancouver-Beaverton, OR-WA**	**-5.3**
19	**Phoenix-Mesa-Scottsdale, AZ**	**-6.0**
20	**Milwaukee-Waukesha-West Allis, WI**	**-7.7**
T-21	**Poughkeepsie-Newburgh-Middletown, NY**	**-8.0**
T-21	**St. Louis, MO-IL**	**-8.0**
23	**New Orleans-Metairie-Kenner, LA**	**-9.7**
24	**Miami-Fort Lauderdale-Pompano Beach, FL**	**-10.3**
25	**Pittsburgh, PA**	**-11.3**

Results & Implications

Clearly San Jose (Silicon Valley) has a distinct advantage from a demographics perspective: it has a diverse, high-income, young workforce, and highly educated from the user point of view. Even further, it is the hub of technological innovation, research and development for new communications services and systems. When new ideas and services emerge in the mobile and software industry, they are either generated in Silicon Valley, or firms located there are adept at deploying them in new and pioneering ways. For such reasons, the Bay Area and Silicon Valley are at a distinct demographic advantage in developing mobile software and applications for transportation purposes. Meanwhile, Washington D.C., San Diego, who were in the top five for both data accessibility and demographics, are positioned well when it comes to the production and adoption of mobile technologies.

COMPOSITE RANKING

To calculate a composite ranking of the metropolitan regions, the study combined the three category rankings—data accessibility, wireless network strength, and user/developer demographics—to identify which regions had the "best mix" of these factors. Due to the high importance of data accessibility in the software development process and the broader necessity of open data for achieving more intelligent transportation systems, the data accessibility score counted as 50%, while mobile wireless connectivity and demographics accounted for the balance, receiving 25% each.

COMPOSITE RANKINGS

Rank	*Metropolitan Statistical Area*	*Data*	*Network*	*People*	*Overall Score**
1	**San Jose-Sunnyvale-Santa Clara, CA**	3	12	12	**30**
2	**San Francisco-Oakland-Fremont, CA**	6	7	10	**29**
3	**Boston-Cambridge-Quincy, MA-NH**	12	-3	2	**23**
4	**Philadelphia-Camden-Wilmington, PA-NJ-DE-MD**	5	11	-1	**20**
5	**Salt Lake City, UT**	7	9	-4	**19**

T-6	**Baltimore-Towson, MD**	4	6	3	**17**
T-6	**Washington-Arlington-Alexandria, DC-VA-MD-WV**	9	-12	11	**17**
8	**San Diego-Carlsbad-San Marcos, CA**	8	-11	9	**14**
9	**Poughkeepsie-Newburgh-Middletown, NY**	11	-1	-8	**13**
10	**New York City-Northern NJ-Long Island, NY-NJ-PA**	1	4	4	**10**
11	**Portland-Vancouver-Beaverton, OR-WA**	10	-7	-5	**8**
12	**Chicago-Naperville-Joliet, IL-IN-WI**	2	2	0	**6**
T-13	**Seattle-Tacoma-Bellevue, WA**	0	-5	7	**2**
T-13	**Denver-Aurora-Broomfield, CO**	-1	-2	6	**2**
T-13	**Los Angeles-Long Beach-Santa Ana, CA**	-2	0	6	**2**
T-16	**Sacramento-Arden-Arcade-Roseville, CA**	-4	1	-1	**-8**
T-16	**Minneapolis-St. Paul-Bloomington, MN-WI**	-7	5	1	**-8**
18	**Milwaukee-Waukesha-West Allis, WI**	-6	10	-7	**-9**
T-19	**Houston-Sugar Land-Baytown, TX**	-8	3	-3	**-16**
T-19	**Phoenix-Mesa-Scottsdale, AZ**	-9	8	-6	**-16**
T-21	**Pittsburgh, PA**	-3	-3	-12	**-21**
T-21	**Atlanta-Sandy Springs-Marietta, GA**	-10	-9	8	**-21**
23	**St. Louis, MO-IL**	-5	-6	-8	**-24**
24	**New Orleans-Metairie-Kenner, LA**	-12	-8	-10	**-42**
25	**Miami-Fort Lauderdale-Pompano Beach, FL**	-11	-10	-11	**-43**

Once again, the Bay Area's user and industry demographics combined with strong connectivity and better than average data accessibility make them clear leaders in the potential for mobile technology adoption and creation. There exists room for improvement in data accessibility: while large agencies such as BART and SF Muni are unmatched in the quality and practicality of the data that they make available for developers, greater coordination is needed at the metropolitan level in this region. Also, San Francisco is the only metropolitan area within the sample that provides open data for real-time parking availability and also provides Wi-Fi coverage throughout the subway system. With the high-tech hubs in Palo Alto and San Jose located nearby, the Northern California "mega-region" appears to be at a significant advantage when evaluating the potential for mobile technology to support and improve regional transportation systems.

Washington D.C. (2nd composite ranking) and San Diego (4th composite ranking) share comparable traits in that both were top four for data accessibility and demographics, but were the worst two regions for wireless network strength. These standings reflect a clear need to explore greater regional coverage in concert with continued open data policies. Similarly, regions like Boston (composite ranking 3rd) Portland (composite ranking 11th), and Poughkeepsie (composite ranking 9th) were among the best in data accessibility, but did not place in the top ten for either of the other categories, suggesting that they are ahead of the game in terms of open data, but could invest more in wireless network quality to better position themselves for future mobile developments.

Philadelphia (4th composite ranking) and Salt Lake City (5th composite ranking) were consistent across the board, scoring above average for data accessibility and network strength, but below average on demographics. Since there is much less a region can do to improve demographics, these two cities should build on their strengths in open data and strong wireless networks.

The country's most populous regions—New York, Los Angeles, and Chicago—were in the middle of the rankings in each category. These metropolitan regions, especially New York in recent months, have embarked on high profile open data and smart city programs. The problem for New York is that there is massive demand for public transit, leading to coordination problems on the metropolitan level with the considerable number of both public and private transit operators. The rankings reflect that not enough data is provided with respect to the number of agencies and riders on a regional level. In Los Angeles, the coordination challenge derives from the exorbitant number of municipalities that offer bus services. On the other end, Chicago is more consolidated at the regional level, but suffers from lack of open data on its highly used commuter rails.

CONCLUSIONS & POLICY IMPLICATIONS

With smartphone penetration projected to reach 50% by August 2012, public sector transportation agencies should actively develop strategies to harness mobile communications to serve the users of their services and systems. Trends in mobile communication, combined with limited public investment in new transportation infrastructure will make it even more important to improve the capacity of existing systems. The rapid growth of Near Field Communication (NFC) technology and the boom in mobile payments will accelerate this process. Simply put, information systems, often design by users and free-lance application developers, will play a growing role in transportation innovation in the coming decades.

To understand the terrain of metropolitan regions, this study examined open data accessibility, wireless network strength, and user and developer demographics across American metropolitan regions. The results indicate that the Bay Area region, encompassing San Francisco and San Jose, currently leads the country in readiness to create, adopt, and integrate new mobile technologies. Several other regions scored well in one or even two categories, but no metropolitan region ranked in the top five for each category.

The diversity in ranking across the three variables illustrates the need for greater coordination and attention on this topic. Metropolitan regions with a high number of transportation agencies need to create a synchronized data policy, while regions with more consolidated systems need to start by releasing data for the modes with greatest ridership.

At the same time, all metropolitan regions need to reassess mobile broadband and Wi-Fi networks to ensure that sufficient infrastructure exists to accommodate the coming surge in mobile traffic. If government plans to make mobility a priority and indeed does move towards a government as a platform model, then affordability of service plans is equally essential. The issue of cost and access is especially critical to regions with below average educational attainment and income levels, where smartphone adoption is less common. Although governments can or should do little to affect the pricing of smartphones and service plans, they can communicate with phone producers and service providers on their policy objectives for information dissemination, so that more high-power, less feature phones may be produced.

Throughout this process, public agencies should also engage with local communities to get users and developers more involved. Specifically, developers responsible for creating these programs must be mindful of user demographic transportation patterns. Loukaitou-Sideris and Gilbert found that, for example, Latinos were more aware of street-level landmarks such as vendors, while Anglos were more focused on large-scale landmarks such as buildings.[19] Similarly, Mondschein et. al. even find that travel mode influences how we navigate, so transit users will rely on different information and aspects of the built environment than drivers, for example.[20] If a city wants to target specific audiences, or simply shape the overall design of services with user preferences in mind, this kind of research is crucial.

Moreover, new mobile communications systems offer the greatest opportunity to improve the capacity of users to make decisions that lead to more productive responsive transportation services. Although it is not government's role to dictate smartphone adoption and usage, public transportation agencies can play an active role by releasing high quality data, thoughtfully engaging with users and developers, and advocating for high quality, affordable mobile service options.

APPENDIX

DATA ACCESSIBILITY SCORING METHODOLOGY

For evaluating transit data accessibility, the study cross-referenced information from multiple sources:

1) **CityGoRound** (www.citygoround.org) has a comprehensive listing of major transit agencies in major metropolitan areas and whether they provide open data on schedules, stops, and routes and real-time departure and arrival data for mobile technology developers.

2) **Google Transit** (http://www.google.com/intl/en/landing/transit/) has a list of transit agencies that have agreed to share their raw data on schedules, stops, and routes on the General Transit Feed Specification that can be used to develop mobile applications

3) **Nextbus** (www.nextbus.com) is an online/mobile service that provides GPS tracking capabilities for transit agencies with bus and streetcar services. They have partnered with many transit agencies that have agreed for Nextbus to provide real-time tracking and arrival information for riders and mobile users through web access. They provide an open API for such real-time information that can be used for development of mobile applications[21].

4) **Transit agency websites**, to confirm whether they provide open and real-time data for mobile application developers.

Information from these sources were used to calculate the raw data accessibility scores, which were subject to weights based on the annual number of trips taken on each transit service, independent of agencies. For agencies that offer services for multiple modes, such services were treated independently.

For each transit mode (bus, subway/light rail/elevated, and commuter rail) the raw scores, subject to ridership weights, were aggregated and divided by the number of agencies that provided the service. The formula for calculating the raw score of a given transit mode in an individual MSA is provided below.

essibility score of individual mode of transit for a metropolitan area

After obtaining the raw scores, the raw scores were subtracted from the mean raw score for each mode across all MSAs that have transit services for that particular mode. These were the "adjusted raw scores," which where then subject to modal use weights (summarized in Table 2) to obtain the weighted scores. Calculation of the weighted scores was based on the following formula:

10	25	107	4	25	**49.88**					
13	**Minneapolis**	72	96	10	33	41	66	26	60	**50.50**
14	**Atlanta**	76	23	20	9	30	6	122	127	**51.63**
15	**Phoenix**	94	5	34	46	42	82	19	97	**52.38**
16	**San Diego**	109	52	24	23	22	111	47	37	**53.13**
17	**San Jose**	125	16	48	19	10	123	9	87	**54.63**
18	**Houston**	57	3	28	39	55	46	92	118	**54.75**
19	**Milwaukee**	62	83	16	96	47	42	74	41	**57.63**
20	**St. Louis**	7	88	36	13	48	61	99	117	**58.63**
21	**Salt Lake City**	128	15	39	17	32	122	36	92	**60.13**
22	**Pittsburgh**	91	76	8	15	77	86	126	10	**61.13**
23	**Denver**	113	70	14	11	19	144	41	79	**61.38**
24	**New Orleans**	96	22	44	22	222	12	29	58	**63.13**
25	**Poughkeepsie**	176	41	73	30	7	1	163	17	**63.50**

Source: US Census Bureau

<u>Explanation of Column Headings</u>

Overall, 8 modes of transportation were selected for the study. A rank of MSAs by ferryboat commuting was deliberately excluded so that the sample would not favor coastal cities. The column headings represent the rank of the MSA for each mode out of the 274 MSAs included in the 2009 American Community Survey.

TABLE 2

<u>DESIGNATED WEIGHTS (APPROXIMATE) BASED ON MODAL USE FOR 25 MSAs BY COMMUTING MODE</u>

Metropolitan Area	***Drive Alone***	***Carpool***	***Bus***	***Subway Light Rail***	***Commuter Rail***	***Taxi***
Atlanta	0.80	0.64	0.40	0.72	0.36	0.88
Baltimore	0.72	0.32	0.56	0.76	0.76	0.80
Boston	0.28	0.12	0.60	0.92	0.88	0.84
Chicago	0.32	0.28	0.76	0.88	0.96	0.92
Denver	0.56	0.40	0.52	0.64	0.56	0.04

Houston	0.96	1.00	0.32	0.16	0.12	0.52
Los Angeles	0.52	0.84	0.88	0.60	0.60	0.36
Miami	0.88	0.60	0.48	0.36	0.40	0.64
Milwaukee	0.92	0.24	0.44	0.04	0.20	0.60
Minneapolis	0.84	0.16	0.68	0.20	0.28	0.44
New Orleans	0.64	0.68	0.16	0.32	0.04	0.76
New York	0.20	0.04	1.00	1.00	1.00	0.96
Philadelphia	0.48	0.08	0.84	0.80	0.92	0.68
Phoenix	0.68	0.96	0.28	0.08	0.24	0.28
Pittsburgh	0.76	0.36	0.72	0.52	0.08	0.24
Portland OR	0.12	0.44	0.64	0.68	0.44	0.20
Poughkeepsie	0.04	0.52	0.04	0.24	0.84	1.00
Sacramento	0.44	0.92	0.12	0.48	0.52	0.32
Salt Lake City	0.36	0.80	0.2	0.44	0.32	0.12
San Diego	0.60	0.48	0.36	0.28	0.48	0.16
San Francisco	0.08	0.56	0.96	0.84	0.80	0.56
San Jose	0.40	0.76	0.08	0.40	0.72	0.08
Seattle	0.24	0.88	0.92	0.12	0.64	0.40
St. Louis	1.00	0.20	0.24	0.56	0.16	0.48
Washington DC	0.16	0.72	0.8	0.96	0.68	0.72

TABLE 3

MASS TRANSIT DATA ACCESSIBILITY RANKINGS					
Rank	***Metropolitan Area***	***Bus***	***Subway Light Rail***	***Commuter Rail***	***Score***
1	**Boston**	4	10.9	12	**26.90**
2	**San Diego**	11	7.63	-1.5	**17.13**
3	**Baltimore**	7	4.36	4.5	**15.86**
4	**Philadelphia**	12	-6.54	7.5	**12.96**
5	**Portland OR**	-2	8.72	6	**12.72**
6	**Poughkeepsie**	0	0	10.5	**10.50**
7	**Washington DC**	4	11.99	-6	**9.99**

8	**Sacramento**	1	3.27	1.5	**5.77**
9	**St. Louis**	3	-1.09	0	**1.91**
10	**Seattle**	8	-2.18	-4.5	**1.32**
11	**Salt Lake City**	9	-5.45	-3	**0.55**
12	**Denver**	10	-9.81	0	**0.19**
13	**Milwaukee**	-1	0	0	**-1.00**
14	**Los Angeles**	-12	6.54	3	**-2.46**
15	**Houston**	-4	1.09	0	**-2.91**
16	**San Francisco**	-6	9.81	-9	**-5.19**
17	**Minneapolis**	-10	2.18	0	**-7.82**
18	**Pittsburgh**	-9	0	0	**-9.00**
19	**San Jose**	6	-7.63	-7.5	**-9.13**
20	**Chicago**	-3	5.45	-12	**-9.55**
21	**Miami**	5	-4.36	-10.5	**-9.86**
22	**Phoenix**	-7	-3.27	0	**-10.27**
23	**New York City**	-11	-8.72	9	**-10.72**
24	**New Orleans**	-5	-10.9	0	**-15.90**
25	**Atlanta**	-8	-11.99	0	**-19.99**

TABLE 4

SCORING REAL-TIME TRAFFIC DATA AND INFORMATION ACCESSIBILITY		
Metropolitan Area	***Base Points for Each Mode***	***Data & Information Availability***
Chicago	**1.00**	Open Data[22]
New York City	**1.00**	Open Data[23]
San Francisco	**1.00**	Open Data[24]
San Jose	**1.00**	Open Data[25]
Poughkeepsie	**1.00**	Open Data[26]
Boston	**0.50**	Open Data (Road Conditions)[27]
Atlanta	**0.25**	Mobile App[28]
Seattle	**0.25**	Mobile App[29]
Baltimore	**0.10**	Mobile Web Access[30]
Denver	**0.10**	Mobile Web Access[31]
Houston	**0.10**	Mobile Web Access[32]
Milwaukee	**0.10**	Mobile Web Access[33]
New Orleans	**0.10**	Mobile Web Access[34]
Philadelphia	**0.10**	Mobile Web Access[35]
Phoenix	**0.10**	Mobile Web Access[36]
Pittsburgh	**0.10**	Mobile Web Access[37]
Portland OR	**0.10**	Mobile Web Access[38]
Salt Lake City	**0.10**	Mobile Web Access[39]
St. Louis	**0.10**	Mobile Web Access[40]
Washington DC	**0.10**	Mobile Web Access[41]

TABLE 5

SCORING DATA ACCESSIBILITY FOR REAL-TIME PARKING AVAILABILITY

Metropolitan Area	***Base Points for Each Mode***	***Real-Time Parking Data Accessibility***
San Francisco	**1.00**	Open API [42]
Pittsburgh	**0.50**	Open Data for Partner Developers[43]
New York City	**0.50**	Open Data for Partner Developers [44]
Washington DC	**0.50**	Open Data for Partner Developers [45]
Los Angeles	**0.50**	Open Data for Partner Developers [46]
Salt Lake City	**0.50**	Open Data for Partner Developers [47]

TABLE 6

MOTORIST DATA ACCESSIBILITY RANKINGS					
Rank	*Metropolitan Area*	*Drive Alone*	*Carpool*	*Taxi*	*Score*
1	**San Jose**	12	11	7	**30**
T-2	**San Francisco**	8	12	9	**29**
T-2	**Chicago**	10	9	10	**29**
T-4	**Poughkeepsie**	4	10	12	**26**
T-4	**New York City**	11	4	11	**26**
6	**Salt Lake City**	7	8	4	**19**
7	**Pittsburgh**	9	6	1	**16**
8	**Boston**	3	3	8	**14**
9	**Los Angeles**	6	5	-6	**5**
10	**Washington DC**	5	7	-9	**3**
T-11	**Seattle**	1	-6	5	**0**
T-11	**Denver**	-2	-4	6	**0**
T-11	**Atlanta**	0	-3	3	**0**
14	**Portland OR**	2	-5	2	**-1**
15	**Philadelphia**	-1	2	-8	**-7**
16	**Minneapolis**	-8	1	-2	**-9**
T-17	**San Diego**	-7	-7	0	**-14**
T-17	**St. Louis**	-11	0	-3	**-14**
19	**Phoenix**	-5	-10	-1	**-16**
20	**Milwaukee**	-9	-1	-7	**-17**
T-21	**Baltimore**	-6	-2	-11	**-19**
T-21	**Sacramento**	-3	-12	-4	**-19**
23	**New Orleans**	-4	-8	-10	**-22**
24	**Houston**	-10	-11	-5	**-26**
25	**Miami**	-12	-9	-12	**-33**

TABLE 7

DATA ACCESSIBILITY RANKINGS		
Rank	*Metropolitan Statistical Area*	*Score*
1	**Boston-Cambridge-Quincy, MA-NH**	**22.6**
2	**Poughkeepsie-Newburgh-Middletown, NY**	**15.7**
3	**Portland-Vancouver-Beaverton, OR-WA**	**8.1**
4	**Washington-Arlington-Alexandria, DC-VA-MD-WV**	**7.7**
5	**San Diego-Carlsbad-San Marcos, CA**	**6.8**
6	**Salt Lake City, UT**	**6.7**
7	**San Francisco-Oakland-Fremont, CA**	**6.5**
8	**Philadelphia-Camden-Wilmington, PA-NJ-DE-MD**	**6.3**
9	**Baltimore-Towson, MD**	**4.2**
10	**San Jose-Sunnyvale-Santa Clara, CA**	**3.9**
11	**Chicago-Naperville-Joliet- IL-IN-WI**	**3.3**
12	**New York City-Northern New Jersey-Long Island, NY-NJ-PA**	**1.5**
13	**Seattle-Tacoma-Bellevue, WA**	**0.9**
14	**Denver-Aurora-Broomfield, CO**	**0.1**
15	**Los Angeles-Long Beach-Santa Ana, CA**	**0.0**
16	**Pittsburgh, PA**	**-0.7**
17	**Sacramento-Arden-Arcade-Roseville, CA**	**-2.5**
18	**St. Louis, MO-IL**	**-3.4**
19	**Milwaukee-Waukesha-West Allis, WI**	**-6.3**
20	**Minneapolis-St. Paul-Bloomington, MN-WI**	**-8.2**
21	**Houston-Sugar Land-Baytown, TX**	**-10.6**
22	**Phoenix-Mesa-Scottsdale, AZ**	**-12.2**
23	**Atlanta-Sandy Springs-Marietta, GA**	**-13.3**
24	**Miami-Fort Lauderdale-Pompano Beach, FL**	**-17.6**
25	**New Orleans-Metairie-Kenner, LA**	**-17.9**

TABLE 8

SUBWAY WI-FI POINTS			
Metropolitan Area	***Subway System***	***Base Points***	***Notes***
San Francisco	BART	**1.00**	Wi-Fi access on train and stations[48]
New York City	PATH	**0.50**	Wi-Fi access on few stations[49]
Philadelphia	SEPTA	**0.50**	Wi-Fi access on few stations[50]
Washington DC	WMATA	**0.00**	Plans for wireless infrastructure expansion[51]
Baltimore	MTA	**0.00**	Wi-Fi on Buses, not Subways[52]
Los Angeles	MTA	**0.00**	Wi-Fi on Subways Possible in Future[53]
Chicago	CTA	**0.00**	Wi-Fi Available only for Maintenance Mgmt[54]
Boston	MBTA	**0.00**	Wi-Fi on Commuter Rail, not Subways[55]
Atlanta	MARTA	**0.00**	None

TABLE 9

NETWORK STRENGTH RANKINGS						
Rank	***Metropolitan Area***	***Mobile***	***Wi-Fi***	***Speed***	***Subway Wi-Fi***	***Score****
1	**San Jose**	10	11	8	0	**8.0**
2	**Philadelphia**	11	2	-1	6	**7.0**
3	**Milwaukee**	12	-2	11	0	**6.7**
4	**Salt Lake City**	9	12	-11	0	**5.8**
5	**Phoenix**	8	9	-9	0	**4.9**
6	**San Francisco**	-2	6	10	12	**3.6**
7	**Baltimore**	7	-1	7	-3	**3.4**
8	**Minneapolis**	4	1	6	0	**2.8**
9	**New York**	3	-3	0	9	**2.7**
10	**Houston**	6	0	-6	0	**2.4**
11	**Chicago**	5	5	-2	-6	**2.1**
12	**Sacramento**	-1	8	-8	0	**0.3**
13	**Los Angeles**	2	-8	-7	3	**-0.7**
14	**Poughkeepsie**	1	-4	-10	0	**-1.3**
15	**Denver**	-6	7	2	0	**-1.4**
16	**Boston**	0	-10	12	-9	**-2.6**
16	**Pittsburgh**	-5	-5	9	0	**-2.6**
18	**Seattle**	-4	-6	4	0	**-2.8**
19	**St Louis**	-10	4	3	0	**-3.9**
20	**Portland OR**	-12	10	-3	0	**-4.3**
21	**New Orleans**	-3	-12	-12	0	**-5.1**
22	**Atlanta**	-7	-7	-5	0	**-5.4**
23	**Miami**	-9	-9	5	0	**-5.8**
24	**San Diego**	-8	-11	-4	0	**-6.6**
25	**Washington DC**	-11	3	1	-12	**-7.2**

Source: National Broadband Map (2011)
*Total score for Network Strength calculated based on weights: 50% Mobile Wireless Broadband availability, 20% Wi-Fi availability, 20% Underground Metro Wi-Fi availability, 10% Mobile Download Speed

Explanation of Column Headings

(**Mobile**) *Ranked points based on data defined by National Broadband Map as "Terrestrial Mobile Licensed Wireless" availability, or mobile wireless broadband availability, expressed as a percent of MSA population.*
(**Wi-Fi)** *Ranked points based on data defined by National Broadband Map as "Terrestrial Fixed Unlicensed Wireless" availability, or mobile wireless broadband availability, expressed as a percent of MSA population.*
(**Subway Wi-Fi**) *Ranked points based on the availability of Wi-Fi in city subway systems. Partial credit was awarded to MSAs with subway systems that offer limited Wi-Fi in specific stations and platforms. Fixed points were weighted by subway use and converted into ranked points.*
(**Speed**) *Ranked points based on data defined by National Broadband Map as the median download speed on a wireless mobile device.*

TABLE 10

USER RANKINGS		
Rank	*Metropolitan Statistical Area*	*User Score**
1	**San Jose-Sunnyvale-Santa Clara, CA**	**8.9**
2	**Washington-Arlington-Alexandria, DC-VA-MD-WV**	**8.1**
3	**San Francisco-Oakland-Fremont, CA**	**4.5**
4	**Atlanta-Sandy Springs-Marietta, GA**	**3.5**
T-5	**Los Angeles-Long Beach-Santa Ana, CA**	**3.4**
T-5	**San Diego-Carlsbad-San Marcos, CA**	**3.4**
7	**New York City-Northern New Jersey-Long Island, NY-NJ-PA**	**3.1**
8	**Denver-Aurora-Broomfield, CO**	**2.7**
9	**Seattle-Tacoma-Bellevue, WA**	**2.6**
10	**Baltimore-Towson, MD**	**2.4**
11	**Chicago-Naperville-Joliet, IL-IN-WI**	**2.3**
12	**Houston-Sugar Land-Baytown, TX**	**1.4**
13	**Minneapolis-St. Paul-Bloomington, MN-WI**	**0.6**
14	**Boston-Cambridge-Quincy, MA-NH**	**0.3**
15	**Sacramento-Arden-Arcade-Roseville, CA**	**0.1**
16	**Philadelphia-Camden-Wilmington, PA-NJ-DE-MD**	**-1.8**
17	**Salt Lake City, UT**	**-2.0**
18	**Phoenix-Mesa-Scottsdale, AZ**	**-2.7**
19	**Poughkeepsie-Newburgh-Middletown, NY**	**-2.7**
20	**Portland-Vancouver-Beaverton, OR-WA**	**-3.1**
21	**Milwaukee-Waukesha-West Allis, WI**	**-4.3**
22	**New Orleans-Metairie-Kenner, LA**	**-4.9**
23	**St. Louis, MO-IL**	**-5.8**
24	**Miami-Fort Lauderdale-Pompano Beach, FL**	**-8.6**
25	**Pittsburgh, PA**	**-11.4**

*Score was calculated by ranking MSAs based on Median Age, Percent Non-White, Percent Earning $75,000 or more annually, Percent with College Degree or Higher Education, with data obtained from the US Census Bureau, and then averaging the four ranked scores based on the following weights: 30% Age, 30% Income, 20% Education, 20% Race.

TABLE 11

DEVELOPER RANKINGS

Rank	*Metropolitan Statistical Area*	*Cluster*	*Total*	*Developer Score**
1	**San Jose**	12	9	11.0
2	**Washington DC**	10	12	10.7
3	**Seattle**	11	8	10.0
4	**Boston**	9	10	9.3
5	**San Francisco**	7	6	6.7
6	**Denver**	8	3	6.3
7	**Minneapolis**	6	2	4.7
8	**San Diego**	4	-1	2.3
9	**Philadelphia**	1	4	2.0
10	**Baltimore**	3	-2	1.3
11	**Sacramento**	5	-7	1.0
T-12	**Atlanta**	0	1	0.3
T-12	**Los Angeles**	-3	7	0.3
14	**New York City**	-5	11	-0.3
15	**Portland OR**	2	-6	-0.7
16	**Chicago**	-6	5	-2.3
17	**St. Louis**	-2	-4	-2.7
18	**Salt Lake City**	-1	-10	-4.0
T-19	**Houston**	-8	0	-5.3
T-19	**Milwaukee**	-4	-8	-5.3
21	**Phoenix**	-7	-3	-5.7
22	**Miami**	-10	-5	-8.3
23	**Pittsburgh**	-9	-9	-9.0
24	**New Orleans**	-11	-11	-11.0
25	**Poughkeepsie**	-12	-12	-12.0

Source: Bureau of Labor Statistics Occupational Employment Statistics (2011)

*Total score for mobile technology producers was calculated by aggregating the ranked scores measuring occupational clusters of software developers and absolute number of software developers in a metropolitan area, with the ranked scores for clustering receiving twice as much weight as those for the absolute numbers.

Explanation of Column Headings

(**Cluster**) indicates the ranked score for 25 metropolitan areas based on occupational concentration of software developers, measured by the Bureau of Labor Statistics' Location Quotient index.
(**Total**) indicates the ranked score for 25 metropolitan areas based on the total number of software developers employed in each region.

TABLE 12

DEMOGRAPHICS RANKINGS		
Rank	*Metropolitan Statistical Area*	*Score**
1	**San Jose-Sunnyvale-Santa Clara, CA**	**12.0**
2	**Washington-Arlington-Alexandria, DC-VA-MD-WV**	**11.0**
3	**San Francisco-Oakland-Fremont, CA**	**9.3**
4	**San Diego-Carlsbad-San Marcos, CA**	**7.0**
5	**Atlanta-Sandy Springs-Marietta, GA**	**6.3**
6	**Seattle-Tacoma-Bellevue, WA**	**6.0**
T-7	**Denver-Aurora-Broomfield, CO**	**5.7**
T-7	**Los Angeles-Long Beach-Santa Ana, CA**	**5.7**
9	**New York-Northern New Jersey-Long Island, NY-NJ-PA**	**4.3**
10	**Baltimore-Towson, MD**	**3.0**
11	**Boston-Cambridge-Quincy, MA-NH**	**2.3**
12	**Minneapolis-St. Paul-Bloomington, MN-WI**	**2.0**
13	**Chicago-Naperville-Joliet, IL-IN-WI**	**0.3**
T-14	**Philadelphia-Camden-Wilmington, PA-NJ-DE-MD**	**-0.7**
T-14	**Sacramento--Arden-Arcade--Roseville, CA**	**-0.7**
16	**Houston-Sugar Land-Baytown, TX**	**-1.3**
17	**Salt Lake City, UT**	**-4.3**
18	**Portland-Vancouver-Beaverton, OR-WA**	**-5.3**
19	**Phoenix-Mesa-Scottsdale, AZ**	**-6.0**
20	**Milwaukee-Waukesha-West Allis, WI**	**-7.7**
T-21	**Poughkeepsie-Newburgh-Middletown, NY**	**-8.0**
T-21	**St. Louis, MO-IL**	**-8.0**
23	**New Orleans-Metairie-Kenner, LA**	**-9.7**
24	**Miami-Fort Lauderdale-Pompano Beach, FL**	**-10.3**
25	**Pittsburgh, PA**	**-11.3**

*Score was calculated based on a combination of Mobile Technology User and Mobile Technology Producer ranked scores, with Mobile Technology User ranked scores receiving twice as much weight as Producer ranked scores.

TABLE 13

COMPOSITE RANKINGS

Rank	*Metropolitan Statistical Area*	*Data*	*Network*	*People*	*Overall Score**
1	**San Jose-Sunnyvale-Santa Clara, CA**	3	12	12	**30**
2	**San Francisco-Oakland-Fremont, CA**	6	7	10	**29**
3	**Boston-Cambridge-Quincy, MA-NH**	12	-3	2	**23**
4	**Philadelphia-Camden-Wilmington, PA-NJ-DE-MD**	5	11	-1	**20**
5	**Salt Lake City, UT**	7	9	-4	**19**
T-6	**Baltimore-Towson, MD**	4	6	3	**17**
T-6	**Washington-Arlington-Alexandria, DC-VA-MD-WV**	9	-12	11	**17**
8	**San Diego-Carlsbad-San Marcos, CA**	8	-11	9	**14**
9	**Poughkeepsie-Newburgh-Middletown, NY**	11	-1	-8	**13**
10	**New York City-Northern NJ-Long Island, NY-NJ-PA**	1	4	4	**10**
11	**Portland-Vancouver-Beaverton, OR-WA**	10	-7	-5	**8**
12	**Chicago-Naperville-Joliet, IL-IN-WI**	2	2	0	**6**
T-13	**Seattle-Tacoma-Bellevue, WA**	0	-5	7	**2**
T-13	**Denver-Aurora-Broomfield, CO**	-1	-2	6	**2**
T-13	**Los Angeles-Long Beach-Santa Ana, CA**	-2	0	6	**2**
T-16	**Sacramento-Arden-Arcade-Roseville, CA**	-4	1	-1	**-8**
T-16	**Minneapolis-St. Paul-Bloomington, MN-WI**	-7	5	1	**-8**
18	**Milwaukee-Waukesha-West Allis, WI**	-6	10	-7	**-9**
T-19	**Houston-Sugar Land-Baytown, TX**	-8	3	-3	**-16**
T-19	**Phoenix-Mesa-Scottsdale, AZ**	-9	8	-6	**-16**
T-21	**Pittsburgh, PA**	-3	-3	-12	**-21**
T-21	**Atlanta-Sandy Springs-Marietta, GA**	-10	-9	8	**-21**
23	**St. Louis, MO-IL**	-5	-6	-8	**-24**
24	**New Orleans-Metairie-Kenner, LA**	-12	-8	-10	**-42**
25	**Miami-Fort Lauderdale-Pompano Beach, FL**	-11	-10	-11	**-43**

*Overall score was computed by aggregating the ranked scores for Data Accessibility, Network Strength, and Demographics based on the following weighting system: 50% Data Accessibility, 25% Network Strength, 25% Demographics

Explanation of Column Headings
(**Data**) *Ranked scores for Transportation Data Accessibility*
(**Network**) *Ranked scores for Network Strength*
(**People**) *Ranked scores for Demographics*

REFERENCES

[1]

[2] "National Broadband Plan," Federal Communications Commission (FCC). http://www.broadband.gov/plan/5-spectrum/#s5-1

[3] "2010 Mobile Year in Review," comScore, February 2011. 18.

[4] State of Apps," Nielsen. June 2010. 3.

[5] "National Broadband Plan," Federal Communication Commission (FCC). http://www.broadband.gov/plan/1-introduction/

[6] General Transit Feed Specification. http://code.google.com/transit/spec/transit_feed_specification.html

[7] CityGoRound. All US Transit Agencies. July 23, 2011. http://www.citygoround.org/agencies/us/?public=all

[8] http://www.appstoreapps.com/top-50-paid-navigation-apps/

[9] "2010 Mobile Year in Review," comScore, February 2011. Page 10.

[10] http://www.broadbandmap.gov/classroom/technology#terrestrial-fixed-wireless-unlicensed

[11] Smith, Aaron. "35% of American adults own a smartphone," Pew Research Center. July 11, 2011. 6.

[12] Ibid, 6.

[13] Quick, Chris. "With Smartphone Adoption on the Rise, Opportunity for Marketers is Calling," Nielsen Wire. September 15, 2009. http://blog.nielsen.com/nielsenwire/online_mobile/with-smartphone-adoption-on-the-rise-opportunity-for-marketers-is-calling/

[14] Sage, Simon. U.S. Smartphone Penetration Highest Among Asian/Pacific Islanders, IntoMobile. February 21, 2011. http://www.intomobile.com/2011/02/01/amaerican-asians-hispanics-most-likely-to-own-smartphone/

[15] Smith,13.

[16] Smith,15.

[17] http://www.isc.hbs.edu/pdf/DPS_Clusters_Performance_2011-0311.pdf

[18] http://www.bls.gov/oes/

[19] Loukaitou-Sideris, A. and L. Gilbert (2000). "Shades of Duality: Perceptions and Images of Downtown Workers in Los Angeles." Journal of Architectural and Planning Research 17(1): 16-33.

[20] Mondschein, A., E. Blumenberg, et al. (2010). "Accessibility and Cognition: The Effect of Transport Mode on Spatial Knowledge." Urban Studies 47(4): 845-866.

APPENDIX

[21] http://www.nextbus.com/xmlFeedDocs/NextBusXMLFeed.pdf

[22] http://www.travelmidwest.com/lmiga/policies.jsp

[23] http://www.511ny.org/developer.aspx

[24] http://www.511.org/developer-resources.asp

[25] http://www.511.org/developer-resources.asp
[26] http://www.511ny.org/developer.aspx
[27] http://www.eot.state.ma.us/developers/
[28] http://www.511ga.org/
[29] http://www.wsdot.wa.gov/traffic/seattle/
[30] http://m.chart.maryland.gov/home/
[31] http://www.cotrip.org/m/home.xhtml
[32] http://traffic.houstontranstar.org/mobile/
[33] http://www.511wi.gov/mobile/
[34] http://hb.511la.org/main.jsf
[35] http://www.511pa.mobi./EventList.aspx?PageMode=Traffic
[36] http://www.az511.com/pda/Speed/
[37] http://www.511pa.mobi./EventList.aspx?PageMode=Traffic
[38] http://www.tripcheck.com/Mobile/pages/Default.aspx
[39] http://commuterlink.utah.gov/mobile.aspx
[40] http://mobile.gatewayguide.com/
[41] http://m.chart.maryland.gov/home/
[42] http://sfpark.org/how-it-works/developerresources/
[43] http://www.bizjournals.com/pittsburgh/news/2010/12/14/parkpgh-real-time-parking-app.html
[44] http://money.cnn.com/2011/04/29/technology/streetline/index.htm
[45] http://money.cnn.com/2011/04/29/technology/streetline/index.htm
[46] http://money.cnn.com/2011/04/29/technology/streetline/index.htm
[47] http://money.cnn.com/2011/04/29/technology/streetline/index.htm
[48] http://www.wifirail.net/
[49] http://www.nj.com/hudson/index.ssf/2010/08/path_getting_some_cell_service.html
[50] http://www.septa.org/events/wifi.html
[51] http://wmata.com/about_metro/news/PressReleaseDetail.cfm?ReleaseID=2479
[52] http://www.businesswire.com/news/home/20110323005545/en/Maryland-Transit-Administration-MTA-Rolls-Motion-Technology
[53] http://secondavenuesagas.com/2010/07/27/mta-vows-to-bring-cell-wifi-service-underground-again/
[54] http://www.digitalcommunities.com/articles/Chicago-Transit-Authority-Deploys-Wi-Fi-for.html
[55] http://www.mbta.com/riding_the_t/wifi/