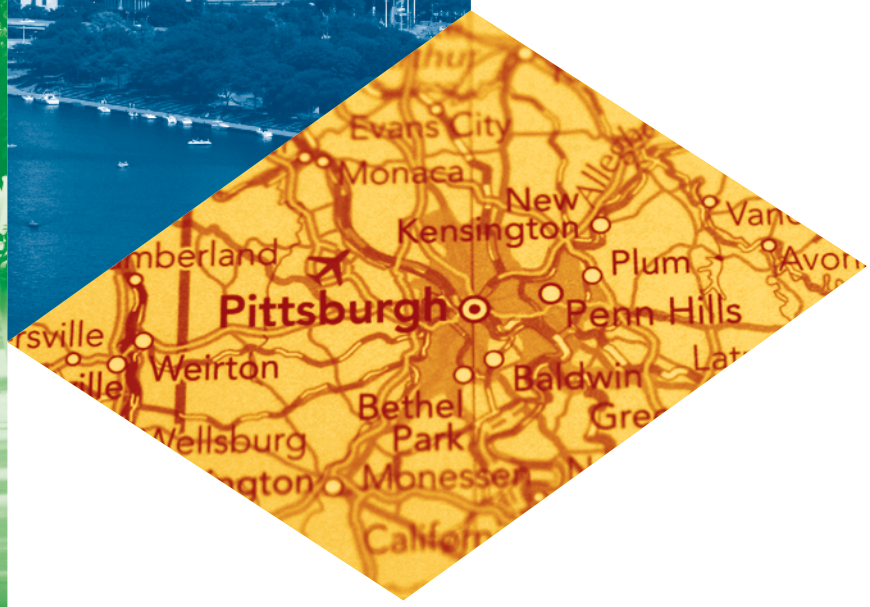
IBM's Smarter Cities Challenge

Pittsburgh

Report



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1. Executive summary

Introduction

The City of Pittsburgh has experienced a phenomenal resurgence from its historical role as an industrial city to a modern, diverse economy based upon education, healthcare, knowledge and financial services. After being named "Most Livable City[1]" in 2011 by the Economist Intelligence Unit, its visibility among American citizens has increased. Consistent with its ambition to accelerate economic development and improve quality of life to usher a renaissance, the City of Pittsburgh has embarked upon an ambitious program, known as PLANPGH[2], which will define the City's course for the next 25 years.

Urban transportation is core to the economic sustenance and development of cities like Pittsburgh. Active transportation options, such as biking or walking, high-quality transportation infrastructure, availability of parking and efficient public transit will empower citizens and visitors to contribute to the vibrancy of the economy.

MOVEPGH[3], Pittsburgh's transportation improvement plan, is a timely step that the City has taken to ensure it recognizes and addresses urban transportation as an important component in achieving its first-ever comprehensive plan, PLANPGH.

The IBM Smarter Cities® Challenge team noted these important strengths of the city:

- Passionate citizens who genuinely care about the betterment of the city
- Committed leaders, administrators and transportation stakeholders
- Access to education and research institutions willing to contribute through various pathbreaking initiatives
- A number of foundations that highly desire to fund innovative initiatives for the advancement of society and economic development of the region
- A strong presence of advocacy groups with very focused agendas that can increase citizen contribution and acceptance, while helping to drive change
- Socially responsible corporations serving as leading examples of community participation

Pittsburgh, however, faces challenges, some of which are unique and have the potential to impede the MOVEPGH initiative:

- Topographical complexities with hills and slopes
- A confluence of rivers that separates real estate, making Pittsburgh the "City of Bridges"
- Weather conditions that may restrict opportunities for alternate modes of commuting and inhibit changing commuter behavior
- Limited opportunities to expand roads due to a complex street network

The challenge

During a three-week period, from 24 September to 12 October 2012, a team of six IBM experts worked in the City of Pittsburgh to deliver recommendations around the key challenges defined by Mayor Luke Ravenstahl. The team was asked to identify innovative ways of optimizing current transportation systems and encourage more multimodal transportation options, especially for commuters from outside the city, to enable Pittsburgh to contribute to the economic vitality of the region.

The number of people in Pittsburgh's urban core doubles during each business day, with 52 percent of the people commuting into the city relying on public transportation. In March 2011, public transportation services were reduced by 15 percent. The threat of more transit service reductions requires the City to identify innovative ways of optimizing its current systems and encourage more multimodal transportation options, especially for workers commuting into Pittsburgh. This transportation situation is not unique among post-industrial Northeastern cities, but success in Pittsburgh could provide a model that can be replicated throughout the nation. Pittsburgh's successful renaissance into a technology-based, green community should not be stalled by a lack of transportation.

Throughout 2012, the City and its partners engaged citizens and a vast array of other stakeholders to develop MOVEPGH, the first-ever multimodal transportation plan for Pittsburgh. The IBM team was invited to help tackle this challenge in Pittsburgh's quest to be a Smarter City.

Recommendations

The IBM team studied the City's challenges, constraints and strengths to arrive at a tangible roadmap of near-term and long-term actions that the City can implement.

While developing the recommendations, the team considered these three fundamental elements:

- **Prosperity** – such as promotion of economic development, elimination of blight, reduction of crime and increased property value
- **Equality** – such as access for all citizens to transportation options, support for a diverse mix of modes, soliciting and seeking equitable contribution from all stakeholders
- **Health** – wellness benefits of human-powered transportation, public safety and air quality

The proposed recommendations include:

- Streamlining traffic flow by developing a distributed traffic management center
- Empowering travelers by creating an integrated transportation data and information services platform
- Promoting alternative modes of transportation to reduce the number of cars on the road
- Revealing transportation insights by leveraging data analysis
- Coordinating governance for data sharing to develop and deliver a shared transportation data vision and framework
- Expanding the scope of the ParkPGH program

Conclusion

The recommendations in this report endeavor to help Pittsburgh develop into a technologically empowered Smarter City. The short-term recommendations will allow the City and its stakeholders to take some actions to see immediate benefit, while medium- and long-term collaboration recommendations will support a transportation data vision and framework to enable and drive transformation. The combined effect will help move Pittsburgh's passenger transportation and planning to that of a top-tier city.

2. Introduction

A. The Smarter Cities Challenge

In 2010, IBM Corporate Citizenship launched the Smarter Cities Challenge to help 100 cities around the world over a three-year period become smarter through grants of IBM talent. The City of Pittsburgh, Pennsylvania, was selected, through a competitive process, as one of 33 cities to be awarded a Smarter Cities Challenge grant in 2012. Since the program's inception in 2010, more than 60 cities have received Smarter Cities Challenge grants, and many of these have already made great progress on the road to becoming more instrumented, interconnected and intelligent (additional information is available at www.smartercitieschallenge.org).

During a three-week period, from 24 September to 12 October 2012, a team of six IBM experts worked in the City of Pittsburgh to deliver recommendations around key issues for Mayor Luke Ravenstahl to:

Identify innovative ways of optimizing current transportation systems and encourage more multimodal transportation options, especially for commuters from outside the city, to enable Pittsburgh to contribute to the economic vitality of the region.

B. The challenge

As outlined in a vision statement of MOVEPGH – Pittsburgh's urban transportation improvement roadmap for the next 25 years – the City aspires to provide a transportation network that is safe and efficient while meeting its commercial, residential and recreational needs. MOVEPGH plans focus on the movement of people rather than vehicles in anticipation of an expected population increase during the next few decades, resulting from economic diversity, affordable housing, vibrant neighborhoods, world-class medical facilities, esteemed institutions of higher learning, breathtaking landscapes and recreational opportunities.

The City has ambitious plans for its economic prosperity and improving the quality of life for citizens. Its comprehensive PLANPGH initiative will lead to a comprehensive plan that incorporates components such as transportation, land use, open space and economic development

Various stakeholders have been working to make this vision a reality, to the best of their ability and within their scope of influence. These include the Port Authority of Allegheny County, Pennsylvania Department of Transportation, Pittsburgh Department of City Planning, Pittsburgh Parking Authority, Urban Redevelopment Authority of Pittsburgh, corporate and institutional citizens, community organizations, foundations and the general public. There is a substantial opportunity for these stakeholders to coordinate their actions toward a common purpose. Improved collaboration will help overcome impediments, such as limited resources.

Other obstacles to efficient transportation include increased road congestion, buses operating at full capacity during peak hours, residents' reluctance to use public transit or carpool, a perception that buses are only for low-income riders, suboptimal pedestrian and bicycle pathways, and the high availability of parking spaces at low cost. The IBM team felt one important area to address was the availability and effective use of existing data with an integrated view to make informed decisions.

C. Approach

The IBM Smarter Cities Challenge team used an organized approach to the challenge, conducting structured interviews with various stakeholders and process owners, testing public transport, walking through important neighborhoods, visiting economic development zones and participating in the demonstration of pilot solutions.

After collecting and collating the facts, the team developed an initial set of recommendations through systematic research, deliberative sessions and application of the team's collective experience with similar situations in other cities around the world. The recommendations were validated with other IBM global specialists in relevant areas and the feedback was incorporated.

D. Multimodal transportation maturity model assessment

The IBM team used a multimodal transportation maturity model that is used for assessing how well cities leverage available multimodal passenger transportation resources – including data, modeling and analysis, information services and traffic management – to deliver an integrated and optimized multimodal service to travelers.

In the assessment, five possible maturity levels were identified, ranging from a single-mode, isolated approach to one of integrated and optimized multimodal planning and operations, as illustrated in Figure 1.

The line of red dashes represents the current state of maturity in the City of Pittsburgh across the dimensions of data use, information services, traffic-flow management, coordinated governance and alternatives to single-occupancy vehicles (SOV). The line of blue dashes represents the expected future state after the successful implementation of the recommendations in this report. As is evident, the biggest shifts can be expected in the use of data-driven insights to guide transportation and land-use planning, as well as empowering travelers with information, which will also have a positive effect on streamlining traffic flow.

	Level 1 Single mode	Level 2 Coordinated mode	Level 3 Partially integrated	Level 4 Multimodal integration	Level 5 Multimodal optimized
Streamlining traffic flow	Limited traffic data collection and integration with ad hoc analysis by individual modes; manual incident response	Data collection for major routes; periodic data collection and analysis, with network and incident response mostly by individual modes	Real-time collection of multiple data sources, with high-level analysis and automated network and incident response systems	Real-time multimodal coverage for most corridors, with detailed real-time data analysis and multimodal incident response	System wide real-time multimodal data collection; integration and analysis with dynamic network optimization and incident response
Empowering travelers	Mostly limited, static traveler information collection	Static trip planning with limited real-time alerts (radio/tv channels)	Multichannel trip planning and customized alert subscription	Multimodal transport card with on-journey multimodal information services	Single customer transport account; location-based multimodal proactive trip advisory
Encouraging alternative modes	Minimal activities to improve alternatives to road transport in rush hours	Single-mode transit information; subsidized transit service; to attract SOV users to transit	Premium-class transit system on dedicated infrastructure; integrated information services	Multimodal mobility infrastructure and service integrated with main employers (CRS)	Optimized economic and loyalty incentives guaranteeing service levels
Revealing transportation insights	Decisions mostly based on experiences, established rule-of-thumb or best guess	Regional travel demand model for most relevant modes of transport on arterial routes	City and regional travel demand modeling and impact calculation (congestion, emission, safety)	All modes of transport – city and regional travel demand, impact and integrated CBA calculations	Real-time traffic monitoring, short-term forecast, activity simulation demand and economic modeling
Facilitating governance for data sharing	Single mode planning with little coordination between various transport providers	A transport vision is articulated with a single overarching regulator but with limited planning and management powers	Integrated multimodal transport authority with demand management measures	Integrated corridor-based multimodal planning with dynamic demand management schemes	Integrated regional multimodal planning and continous systemwide performance measures

Figure 1
Multimodal transportation maturity model assessment for the City of Pittsburgh (current state: red dashes; future state: blue dashes)

3. Context for recommendations

It is evident that the City of Pittsburgh wants to accelerate the improvement of its urban transportation planning through its new program, MOVEPGH. The City has stated that this blueprint will provide the basis for a transportation network to keep Pittsburgh moving toward livable communities and sustainable systems[4].

Smarter Cities are instrumented, interconnected and intelligent – collecting more frequent, high-quality data, sharing and integrating it in useful new ways, and performing a range of analysis to generate insightful forecasts using that data – progressing to a more efficient use of existing resources to deliver superior services to their citizens. This intelligent use of data holds the promise of transforming the urban transportation landscape for Pittsburgh, helping to ensure the future of the city is healthy, prosperous and open to all.

There is a wealth of transportation-related data already collected in the city and region, but the data is housed across multiple agencies that influence transportation. Only some of this data is being shared, though not in an integrated manner or in the most useful formats. There are gaps in data collection, which may require additional instrumentation or additional data sources.

The City of Pittsburgh has all the necessary ingredients to become a global leader in public transportation, in which data-driven information analysis is applied to regional resources to make wise decisions about where to utilize its limited funding, what projects are critical to the region and what affect these decisions will have on the transportation infrastructure. It is time for the City to act upon making intelligent use of data to help realize the goals of PLANPGH.

The recommendations in this report are concrete and impactful but will require collaboration among stakeholders. The recommendations are also interconnected and work together as a package, covering five core areas connected by the common thread of a more integrated and intelligent use of data.

The IBM team identified a sixth recommendation focused on parking. Because of the tactical nature of this recommendation, it was not included in the five strategic core areas of recommendations.

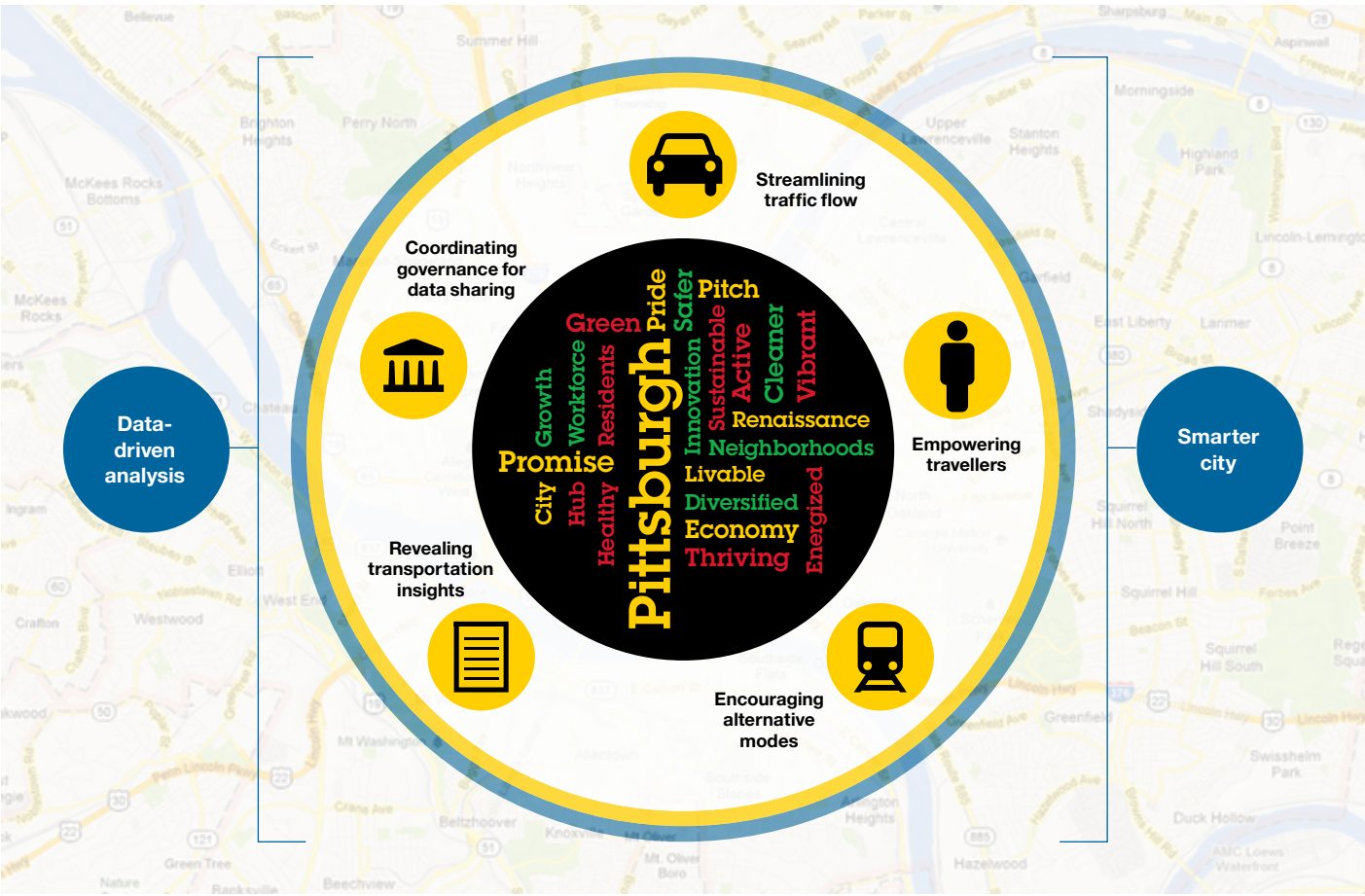

Figure 2
The recommendations cover five core areas and aid data-driven analysis

4. Recommendations

Recommendation 1: Develop a distributed traffic management center

The City should develop a distributed traffic management center to streamline the flow of traffic and reduce congestion.

Scope and expected outcomes

Traffic management centers are primarily designed to facilitate the smooth flow of traffic through a city. They rely on data received from a variety of monitoring and data-collection devices, and make decisions to help relieve congestion and bottlenecks, such as "extend traffic signal at this intersection by an extra 15 seconds" or "send a field dispatch team to fix that light." For the City of Pittsburgh, having a fully staffed and equipped state-of-the-art traffic management center would be a strain on scarce resources, and the benefits from such a center may be obtained through another mechanism – a form of distributed traffic management center. A virtual traffic management center combines selected capabilities at a central traffic management center with self-regulated traveler behavior driven by rich traveler information resources.

For the City of Pittsburgh, there are two key elements necessary to realize that goal:

1. Bring the entire traffic signal infrastructure under central management, improving the ability to remotely manage traffic signal patterns and respond to issues.
2. Develop a real-time journey planning and advisory web-based application that allows travelers to self-regulate their travel behavior and make informed decisions.

Traffic signals are a significant control point in the flow of traffic, and the City's ability to remotely monitor, manage and modify signal patterns is a significant capability that will help improve the flow of vehicular and pedestrian traffic, while reducing the resources needed to make desired changes. Traffic signals are a primary responsibility of the Pittsburgh Department of Public Works, specifically the Bureau of Transportation and Engineering. Currently, the City has approximately 130 traffic signals on the central system and approximately 480 connected via radio, which prevents maintenance alerts from reaching the Bureau of Transportation and Engineering directly. For some intersections, a worker must physically drive to the intersection to fix problems or change signal patterns. Centralized, remote management of all traffic signals will reduce the burden on available resources while improving the center's ability to manage congestion.

In addition to centralized traffic signal control, a recent, successful pilot by Carnegie Mellon University (CMU) of its adaptive traffic control system in Pittsburgh's East Liberty neighborhood demonstrated an approximately 30 percent improvement in traffic flow. The system holds promise for improving other similar intersections. The City should expand testing to other sites where signals are already optimized for traffic and pedestrian flow to validate the improvements achieved at the East Liberty neighborhood in preparation for broad deployment. The City should add variables, such as optimization for pedestrians, to help establish the full impact of the technology. The project is promising and should receive continued support from the City, university and philanthropic foundations, and additional results should be gathered to help highlight the types of intersections across the City that will benefit from its deployment.

Beyond traffic signal control, empowering travelers to save time, money and streamline their journey through rich information sources is the second major element that will contribute to improvements in traffic congestion, carbon emissions and use of other modes of transportation. Of the several rich applications that could fulfill this purpose, wide access to a state-of-the-art, real-time journey planning and advisory application would have the most impact and allow travelers to self-regulate their own travel plans and behavior.

The City should sponsor the development of a real-time journey planning and advisory tool that is widely available and accessible through multiple channels. It should be available via web browsers, mobile devices, vehicle navigation systems and, eventually, in transit stops, cabs, parking locations, bike stations and other transportation-related locations.

An expected outcome will be reduced long-term operational costs for signal-related issues (failback "flashing signal" mode, signal stops working, etc.), and an established foundation for automated decision control in future. The combined effect of the recommended actions is expected to reduce congestion levels by 5-10 percent, with a greater reduction at certain intersections and corridors.

Proposed owners and stakeholders	Suggested resources needed
The project should be owned by the Bureau of Transportation and Engineering, working in collaboration with CMU for expanding the adaptive signal tests and to potentially initiate the development of a state-of-the-art, real-time, journey-planning application.	It is a medium-cost project overall and a significantly lower-cost alternative to the development and operation of a first-class, state-of-the-art traffic management center.
Dependencies	**Key milestones, activities and timeframes**
This recommendation is largely independent; however, the development of a real-time, journey-planning application requires access to data, some of which could be obtained through a combination of third-party data providers, and the remaining data could be accessed in the transportation data platform (Recommendation 2).	• The project should progress with increasing scope and benefits over a period of 6-24 months. • Acquire the needed software and infrastructure to bring all traffic signals onto the central system. • Work with CMU to develop an appropriate model for expanding the test to other parts of the city. • Work with CMU to take advantage of the "ambient intelligence" project and other data sources based in Recommendation 2 and kick-start the development of a real-time, journey-planning application. To reduce the time required to develop the application, third-party data sources can be leveraged.
Priority status	
High – provides immediate benefits to traffic flow and information services	

Recommendation 2: Create an integrated transportation data and information services platform

The City should create an integrated transportation data and information services platform to foster the development of traveler information services, and drive transportation data modeling and analysis to guide planning and decision making.

Scope and expected outcomes

Transportation in Pittsburgh is managed through multiple agencies, each of which collects and uses valuable data related to traffic and transportation, driven by the specific needs of each agency. This collective data provides a holistic view of transportation in the City and, if further broken out of its current silos, holds the power to transform the life of citizens, businesses and visitors.

The set of actions in this recommendation encourages the various agencies that are stakeholders in city transportation to progressively open more of their data for use by travelers, other agencies and third parties, such as private enterprises, so that value-added services could be provided to travelers.

A second, equally significant use of this data is in driving various types of transportation-related models to guide planning and decision making. Examples include simulation and analysis of multimodal transportation within a neighborhood and evaluating transit level services for specific times.

The faculty and students at Carnegie Mellon University's CyLab are driving a project called "Ambient Intelligence," designed to collect a variety of data related to a city onto a common platform. This could act as a bootstrapping mechanism to build a transportation data and information services platform for the City of Pittsburgh.

Over the longer term, it would be useful to leverage a technology platform that uses data to provide visualization of operations along various key performance indicators across multiple agencies in the City. It also facilitates coordination of cross-agency operations with business and citizen participation with a common goal of enhancing citizen services. The transportation data and information services platform provides the necessary foundation to leverage these technologies.

The City should build a transportation data and information services platform that makes current information available in a variety of standard formats, including as web services and application programming interfaces (APIs). Related data is available from a variety of sources, including, but not limited to:

- Pennsylvania Department of Transportation (PennDOT)
- Southwestern Pennsylvania Commission
- Port Authority of Allegheny County
- City of Pittsburgh Traffic and Operations
- Pittsburgh Bureau of Police
- Pittsburgh City Planning
- Pittsburgh Parking Authority and private parking businesses
- Cab operators

Some of this data is already publicly available and needs only to be sourced and made available in additional standard data formats, such as XML, RSS, web services and comma-separated values (CSV). In other cases, data may need to be made available by the respective agencies.

As gaps in data are identified and additional real-time data is gathered over time, these also should be made available through the transportation data platform. A relationship with data providers, such as Navteq and TomTom, should be established to get detailed real-time traffic flow information and be made available through this data platform. These data providers will help the City leap-frog a few years of data collection efforts and have a significant impact on data availability.

A transportation data and information services platform will provide citizens, visitors and other stakeholders with immediate access to relevant transportation- and traffic-related data. It will also encourage the development of new, rich, value-add applications that will enhance the traveler experience, such as real-time multimodal journey planners, real-time traffic applications, traffic re-routing alerts and safety alerts. Equipping travelers with rich, useful information has been found to have an impact on traveler behavior leading to better traffic flow, greater utilization of all available modes of transport and long-term economic benefits[5].

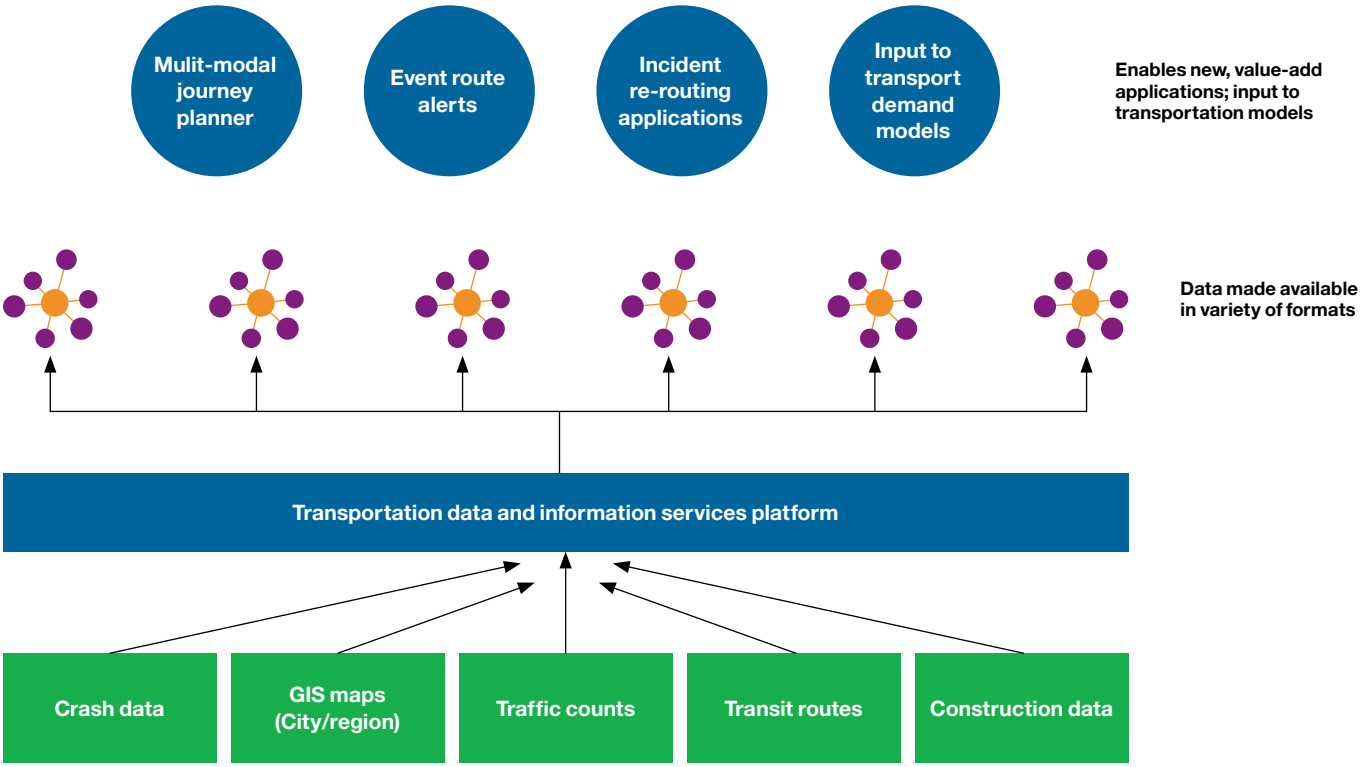

Figure 3
Transportation data and information services platform

Availability of data will also simplify implementation of the transportation data modeling and analysis tools. As highlighted in Recommendation 4, access to the right type of data for modeling and analysis is crucial, and this platform will help ease that accessibility. Not all data that is required for data modeling and analysis is expected to be made available through this platform, but there will be substantial overlap between the needs of the modeling and analysis tools and data available through this platform.

Proposed owners and stakeholders	Suggested resources needed
This is a project of high significance to the long-term vitality of transportation and the application of modeling and analysis to several aspects of development in Pittsburgh, and the IBM team proposes that the Director of City Planning should have ownership of this initiative. Also, to bootstrap the project, it may be best to build on the initiatives at Carnegie Mellon University, in collaboration with the philanthropic foundations. All the regional agencies that operate in the City are critical stakeholders in the success of this recommendation, including: • Pennsylvania Department of Transportation • Southwestern Pennsylvania Commission • Port Authority of Allegheny County • City of Pittsburgh Traffic and Operations • Pittsburgh Bureau of Police • Pittsburgh City Planning • Parking Authority	Once all stakeholders are on board, this effort will require a small staff skilled in IT to bring this data together in appropriate formats and create a few sample applications and tutorials for training IT developers. The transportation data and information services platform will need to be hosted on a server, with appropriate web-hosting and data-streaming software. As usage increases, additional servers could be added to manage the load. This would be a medium-sized project from a cost perspective.
Dependencies	**Key milestones, activities and timeframes**
This recommendation does not depend on other recommendations. On the other hand, this is a core qualifying recommendation that lays the foundation for better data-driven outcomes.	The project should unfold with increasing scope and benefits over a period of 6-24 months. • **Data identification:** Working across stakeholders, identify key data elements being captured regarding road and traffic conditions by all stakeholders. Note the data elements that are already electronically available as a stream and ready for sourcing, and work with stakeholders to identify additional useful elements that could be made available. • **Pilot:** Establish a pilot scope, identifying the most interesting traffic- and road-related data, and create a data platform around this comprehensive data. Make the data available as a set of services or data streams for application developers to leverage, showcasing a sample application on the site as a tutorial. • **Validate and expand:** Market the comprehensive information portal to the public, track success of the pilot, expand the scope to include additional data elements and make them progressively available for use.

Priority Status
High – this is a key recommendation for the City to leverage data both for delivering improved citizen travel services, as well as driving modeling and analytical tools to assist in transportation planning that will provide immediate benefits to the City's traffic flow and information services issues

Recommendation 3: Promote modal shift to reduce the number of cars on the road

The City should provide improved alternatives to single-occupancy vehicles (SOV) in order to reduce traffic, increase public transit ridership by 10 percent, and significantly increase walking and biking during appropriate months.

Scope and expected outcomes

The use of technology can help reduce traffic congestion, but there is a limit to what technology can achieve. Eventually, new infrastructure must be built or the number of single-occupancy vehicles on the roads will have to diminish.

In order for people to consider alternative transportation modes, something must trigger a change in behavior, such as:

- Availability of better alternatives
- The cost of using a car becomes too expensive
- Changes are made to the city to discourage the use of cars

The IBM team did not see from interviews that much support exists for policies that would reduce access to congested areas of Pittsburgh, either through a cordon pricing scheme (similar to London, Stockholm and Singapore) or by making access difficult for cars by reducing parking space and closing streets to car traffic. Therefore, the team chose to focus recommendations on providing better alternatives to SOVs.

There are six basic alternatives to using SOVs:

- Walking
- Biking
- Public transit
- Cabs
- Carpooling
- Car sharing

Walking

Walking is not always a feasible alternative to using a car, but it plays a significant role in improving the wellness of people, as many medical studies have demonstrated. Also, increasing foot traffic on the streets makes a neighborhood more vibrant. As a result, many reports that focus on city livability measure how easy it is for pedestrians to walk around town. The IBM team learned through interviews that parents would, in general, prefer to have their kids walk to school, since it increases exercise, as long as they feel it is safe.

Pittsburgh is, by American standards, already a very walkable city, but there is always room for improvement. Most of the current complaints are centered on the lack of sidewalks in certain areas or existing sidewalks that are too narrow to accommodate pedestrians, joggers, bicycles and bus stops. The City understands the problem well, and is working on the issue as part of the MOVEPGH initiative. Several local transportation management associations have studied the issue in depth, so the IBM team has limited discussion of the issue in this report.

Biking

While many people own a bicycle, not everyone uses it the same way. For some, the bike is a way to perform physical exercise, often during the weekend. Others use it only for short distances. Finally, a third group uses the bike as their primary mode of transportation. The needs of these various groups must be catered to in different ways.

Those who desire occasional exercise need a safe circuit to cycle without feeling threatened by cars, such as through a large park, which could include separate tracks for bikers, joggers and walkers. This could transform the park into a popular destination for health-conscious people and spur economic opportunities for cafés and restaurants surrounding the venue. The existing bicycle trails in some of the city's largest parks could be improved. The number of occasional bikers also could significantly increase if the City developed a bike-share program, as found in many other cities.

This kind of initiative generally does not require large capital investments and is well received by the both citizens and tourists, so it could be sponsored by the private sector. For example, last August, the New York City Department of Transportation announced a partnership with Citi to launch the Citi Bike system in early 2013. Citi will provide $41 million to fund 7,000 bikes and 420 bike stations. In a public statement, DOT Commissioner Janette Sadik-Khan said, "The enthusiasm for this program continues to grow, and we look forward to bringing this affordable new transportation option to New Yorkers without cost to taxpayers."

The second group is comprised of those who use their bikes primarily for short distances near their home. These users primarily require secure bike racks at their destination and, in particular, at bus stops. In some areas that are not served by the public transit system, many homes are a significant distance from a bus stop. For those residents, it is imperative to find a convenient solution to get to the station and back home, known as the first- or last-mile problem. There are several solutions, including bikes, shuttles, Segways and electric cars. This is especially true in the suburbs. The City of Pittsburgh and the Bike Pittsburgh organization have partnered to provide free bicycle racks to eligible small businesses.

The final group is composed of hardcore bikers who want to move safely around the entire city throughout the year. This is the group that has, justifiably, the most complaints of the current situation. Solving their problems, however, will most likely prove to be expensive and difficult.

The main problem is that, while the number of bike lanes has increased significantly over the past years, most of the growth has occurred based on opportunity. The City would build bike lanes when a sufficiently lengthy section of a road is deemed wide enough to house one. Better planning is needed to build continuous bike lanes between popular destinations. Such a plan is under development and will be presented next year – the City should properly prioritize the construction of longer and more secure bike lanes.

In addition, the City should enter discussions with the region's largest employers to make it easier for their employees to get to work on their bikes. This means planning for showers, lockers and changing facilities.

The IBM team was unable to find objective data about the percentage of bikers in each group. Obtaining that information is required to better serve each category and justify investments.

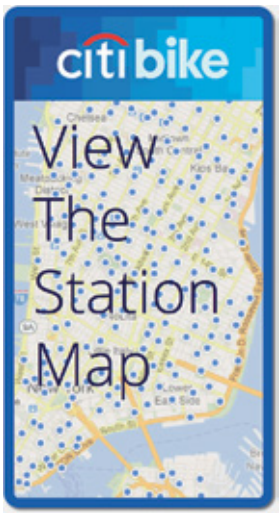

Figure 4
New York announced Citi Bike, an ambitious bike-sharing initiative in 2011[6]

Figure 5
A smart card-operated bicycle rack[7]

Public transit

In the Pittsburgh metropolitan area, the Port Authority of Allegheny County manages 95 percent of the public transit. Currently, the cost of a ticket only covers about 25 percent of the real cost of the service, and the Port Authority faces financial problems. However, with the current routes and infrastructure, it could handle a 10 percent increase in passengers without requiring additional investments. This would represent nearly 6 million additional passengers and more than $8 million in revenue increases that could be reinvested in the system. This would reduce traffic significantly, as 95 percent of those new users currently drive cars[8].

What is required to attract new users to the public transit system? Currently, most bus users seem to be young or low-income residents – the population segment with few options beyond public transportation. In order to attract new users, the system must be attractive to new segments of the population. In the team's discussions with local residents, it found that a lack of information is a major roadblock for many potential users, accompanied by a lack of routes and low frequency of bus stops. The problems mentioned were:

- Lack of clear route information
- Lack of clear schedule information
- Uninviting bus stops
- Exact change is required
- A poor overall public-transit experience

Lack of clear route and schedule information

The lack of maps and route information is a liability to the City that is difficult to understate. First-time visitors, such as tourists or new students, find it difficult to move around since there are no indicators related to landmarks. Foreigners visiting the city are unlikely to access the information published on the Internet due to unaffordable cellular data roaming charges. They need clear information at the bus stop.

Residents also face difficulties. Published information is incomplete and hard to find. The route information provided by the Port Authority website is only useful if the user knows the bus stop names, an assumption that should not be relied upon. There is no complete regional map available for download.

The information published on Google Transit is minimally useful since the service is still in beta testing and has bugs. Anecdotal evidence showed the service was unable to provide optimal routes, and the travel time estimation was highly inaccurate.

The Tiramisu application (Figure 6), developed by CMU, is a great first step in the right direction. The IBM team used the application multiple times on bus trips around the City. Currently a university project, it relies on crowd sourcing and schedules to provide arrival information. The quality of the information is dependent upon the data collected from the crowds using the application. If no data is available, the application is reliant upon published schedules. The City should have a Port Authority of Allegheny County-branded application for all popular smartphones that relies on real-time information from the buses.

In the wake of recent frequency reduction, people now have a stronger need for schedules and service frequency information. Today, people simply do not know when the next bus will come. This information is vital during the winter when bus stops are bitterly cold. If people had exact arrival information, they would spend less time at the bus stop, clearly improving the user experience.

Publishing real-time bus arrival information has been made possible through a technology called Automatic Vehicle Location (AVL) that has been available for several years.

For transit, the actual real-time position of each vehicle is obtained from the on-board GPS (which could be complemented with additional data from the National Differential GPS, also known as NDGPS, for better accuracy) and its location is relayed to a control center. Actual position determination and relay techniques vary, depending on the needs of the transit system and the technology (or technologies) chosen. Typically, vehicle position information is stored on the vehicle for a time, which can be as short as a few seconds or as long as several minutes. There must be a balance between the accuracy of the information (which requires transmitting the information as often as possible) and the cost of data transmission (which can be minimized by sending fewer updates). Position information can be relayed to the control center in raw form or processed onboard the vehicle before its transmission. The information is then processed at the control center, before sending the relevant information to each of the bus stops to display it.

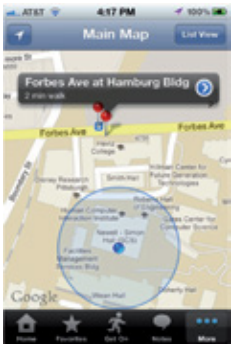

Figure 6
The Tiramisu application, developed by Carnegie Mellon University[9]

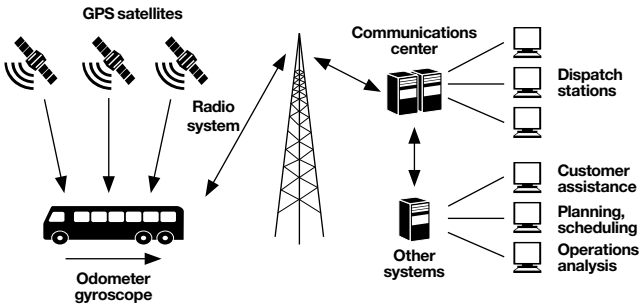

Figure 7
Diagram depicting how a typical AVL system works[10]

Figure 8
A bus stop displaying arrival times based on an AVL system

While it is true that GPS would not work inside Pittsburgh's many tunnels, it could be complemented by other, simpler technologies that can infer current position based on the last GPS reading, with vehicle speed and direction (using a digital compass).

In general, AVL systems also integrate:
- Automatic passenger counting
- Emergency alarm
- Digital communications

Currently, AVLs are used by transit agencies throughout the world to assist them in many ways:
- Operations
  - Provide customers with real-time service information.
  - Improve schedule adherence.
  - Improve service efficiency.
  - Achieve better command and control of the system.
  - Improve bus schedules.
  - Improve information accuracy and availability.
  - Provide better operations support.
  - Reduce the number of street supervisors.
  - Simplify operation of vehicle for the operator.
  - Provide engine telemetry for real-time on-board diagnostic port monitoring.
- Communications
  - Replace aging radio system.
  - Reduce lost calls from operators.
- Safety
  - Improve response times to incidents and emergencies.
  - Reduce voice communications through mobile data terminals.
  - Reduce assaults on bus drivers and passengers.

In general, a good AVL system also provides the public transit authority with abundant and good-quality data that can be acted upon. For example, automatic passenger counting data analysis can be used to decide on the convenience of combining routes, balance service with demand and reduce vehicle turnover – effectively achieving the same or better service with fewer resources.

Integration opportunities
Having AVL-equipped buses offers many possibilities for transit interface with highway and traffic organizations or transportation management centers. Opportunities include:
- Providing transit buses with traffic signal priority through intelligent transportation systems (ITS) integration
- Obtaining traffic congestion data at the dispatch center to allow rerouting of buses or informing customers of delay
- Publishing real-time transit information freely available to a content aggregator, such as Google, traffic.com or GPS manufacturers
- Using buses to automatically communicate traffic speed and reporting of roadway incidents by transit vehicle operators

Traffic signal priority on arteries and freeway on-ramps can substantially improve the schedule adherence of transit vehicles and reduce run times. This effort requires cooperation between transit (Port Authority of Allegheny County), highway departments (PennDOT) and municipalities, because traffic signals are normally the responsibility of the latter two, and because giving transit vehicles priority affects other vehicle movements.

AVL-equipped buses can be used as probes for determining travel speeds on freeways and arterial roadways – a valuable information resource for a transportation management center, especially one with limited traffic detection or observation capabilities, particularly on arteries. This valuable data could complement the visual information provided by the cameras already distributed throughout the city.

Bus operators also can be useful in reporting incidents they see during their trips. Using the known location of the bus at the time of an incident report, the response of arterial, freeway and incident management systems and emergency services can be provided more quickly.

Transit information should be an important element of any regional traveler information system. Adding real-time transit information to available highway information can be helpful to travelers in making mode-choice decisions and would be expected to increase transit ridership.

While it is true that the Port Authority of Allegheny County buses are already equipped with GPS devices, significant investments are still required to create a comprehensive communications network, upgrade the buses and bus stops, and implement the software. Operational costs can be reduced by using solar-powered displays and commercial partnerships with private wireless Internet service providers (ISPs).

Uninviting bus stops

Most bus stops in Pittsburgh offer a Spartan experience, with no seats, shelter or route information – just the numbers of the bus lines stopping at the location.

This is a problem, especially for older people who traditionally are heavy users of public transit, yet who seem under-represented in Pittsburgh's public transportation system. It is also a problem for tourists, who lack information about how to move around in an unfamiliar city. Increasing ridership by tourists and occasional users should be a priority since they are most likely to pay the full fare, as opposed to daily riders who pay discounted fares.

The Airport Corridor Transportation Alliance (ACTA), a Transport Management Association (TMA) organization that the IBM team interviewed, recognizes this situation and has proposed an appealing new design for the suburban bus stop, although its size and cost may limit installation to a small number of locations.

Other organizations, such as SENSEable City Lab at the Massachusetts Institute of Technology (MIT), also have produced interesting design concepts that make use of current technology to deliver a first-class experience. In their design, called "EyeStop," a touchscreen allows passengers to get a variety of travel information. Power is provided by a solar rooftop and waiting passengers can access the Internet. The solution is futuristic and expensive, but illustrates a good example of what the City should strive to provide.

Besides shelter and seats, bus stops need a solution to the first- or last-mile problem, namely how people get to the bus stop. This is especially true in the suburbs, where bus stops can be relatively far from users. Available bicycle racks are a requirement in these situations.

Once smart cards are common in all buses, data will be available about which bus stops are most used by the elderly, which could be used to prioritize upgrades.

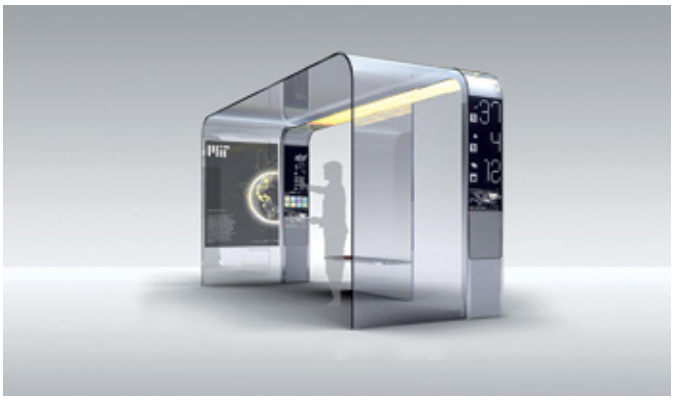

Figure 9
The futuristic 'EyeStop' bus stop designed at MIT[11]

Figure 10
An NFC reader inside a bus in Austria to simplify fare collection[12]

Exact change required

In several interviews, people mentioned the exact-change requirement as a reason for not taking the bus for an unscheduled trip. Smart cards, which are currently being deployed by the Port Authority of Allegheny County, and near-field communication (NFC) solutions will provide a simple means to pay for bus fares and spend less time at the bus stop. Since many passengers drive to the bus stop, it would increase convenience if the smart card could also be used to pay for parking (at both public and private lots), shared bikes and bike racks.

NFC is an emerging payment technology, supported both by VISA and MasterCard, in which payment is made by swiping the phone in front of an NFC reader. Because the technology is expected to be widely available on smart phones by 2014, planning for quick adoption should begin soon. NFC is already available on a limited number of Android and Blackberry smart phones, so testing could start immediately.

Automated Fare Collection (AFC) systems are generally a sound investment because they provide good returns on investment. For example, New Jersey Transit's revenue increased by 12 percent after AFC was deployed. The system also saves millions of dollars per year in fare-media handling costs. In New York City, tens of millions of dollars in fare evasion are recovered each year by its AFC.

While NFC and smart cards are effective technological solutions, a large segment of public-transit passengers may not have access to credit, such as children, international tourists and low-income citizens. Therefore, pre-paid options, such as cash-based, rechargeable smart cards need to remain available. A critical success factor in eliminating legacy fare-payment systems and creating a smart card payment infrastructure is to build a successful retail sales network that helps build public acceptance of smart cards and comfort among policy boards.

One of the main advantages of using a centralized electronic system for multimodal transit systems is that a large amount of information can be collected about user behavior. This is anonymous information that cannot be used to track an individual, but which can be very useful to understand patterns of behavior. Currently, the Port Authority of Allegheny County collects information from their buses daily, including passenger counts and fares paid, but the information is incomplete. There is no visibility to how people get to the bus stop (walking, biking or by car), nor is data available about a passenger's complete journey when using multiple bus lines or a combination of bus and rail. This information is crucial to planning a better public transit system, since it can be used to build models that run simulations with what-if scenarios. With the results, Port Authority of Allegheny County planners could give proper answers, with a high level of certainty, to difficult questions, such as which new lines are required or where to place the bus stops. Good planning must be based on hard data. This makes discussions with the community much easier.

Additional ideas for improving the user experience

To provide a better user experience, Internet access could be provided to passengers using public transit to create a compelling advantage over car use, especially during off-peak hours. Such an initiative would help drive a new kind of passenger – one that is younger, more educated and more affluent. In the past, providing good Internet speeds to a large number of users in a bus or a train proved difficult, but new 4G wireless technologies, such as Wi-Max or LTE (recently launched in Pittsburgh by AT&T), would provide better service at a much lower cost.

Wi-Fi aboard transit is a popular idea, confirmed by statistics from major cities. The Massachusetts Bay Transportation Authority reports 10,000 riders connect to its transportation system daily[13]. The Santa Clara Valley Transit Authority (VTA) reports that 15,989 of its passengers used the free Wi-Fi service this past July, accessing the system 75,510 separate times, with an average online time of 24 minutes and 58 seconds, and with average downloads of 13.2 megabytes of data.[14] The VTA system, which, according to SinglePoint, is the first 4G transit operation, uses the Clearwire WiMAX network as its 4G connection.[15]

Internet access does not need to be funded by the Port Authority of Allegheny County. There are many cities, such as Madrid, Spain, and New York City, which provide this service in partnership with private companies that fund it.

Finally, while it may seem unimportant, clarity about the appropriate time to pay a bus fare is important to the efficient flow of passengers. There is confusion because sometimes payment is required when exiting the vehicle (when the bus is heading away from the downtown area) and when entering the vehicle (when the bus is heading toward the downtown area). Confusion occurs in the bus, which results in the bus spending more time at stops than necessary, lengthening travel times and impacting customer service and satisfaction.

Financing the upgrades

It is clear that increasing usage of the public transit system will require additional investments to make the system more appealing to the general public, beyond those who have no other transportation option. This can be funded without requiring additional public funding or increasing the average ticket price, which is already relatively expensive.

Advertising

It appears that the Port Authority of Allegheny County obtains little advertising revenue, either outside or inside the bus, through digital signage systems – despite being a top-25 market and having signed a 2010 agreement with Titan to sell national media on its behalf. In 2011, advertising revenue was $1.38 million, which is relatively low for the amount of passengers transported. Currently, most bus advertising seems to be public-interest messages, and there is significant inventory (unused ad space) available. Negotiating a single, exclusive advertising contract for both national and local advertising should bring in additional revenue.

Increasing advertising revenue could pay for upgrades or part of the system's operating costs. Digital signage provides silent video information to avoid disturbing passengers. Besides allowing the transmission of public-interest messages, such as information about upcoming cultural events or general city information (such as tax payment reminders), the system can be used to sell advertising space and promote local businesses. The system can also use real-time GPS information from the vehicle to provide tourist information when in proximity to local attractions.

The IBM team recommends the City use digital signage on the Pittsburgh Light Rail (The T) and its main stations in order to provide the best return on investment and then continue later with the main-corridor bus lines.

Advertising on public transit is a good alternative to billboards, which many citizens dislike. Four US states – Hawaii, Maine, Alaska and Vermont – have already banned billboards. Scenic America estimates that 1,500 cities and communities nationwide prohibit or restrict the construction of new billboards[15]. By promoting the use of buses as an effective advertising medium, Pittsburgh can fight the proliferation of billboards and preserve its attractiveness to tourists.

Figure 11
A digital signage system inside a bus[16]

Figure 12
A bus carrying advertising

Naming rights
Naming rights are another possible source of funding. In 2010, the Southeastern Pennsylvania Transportation Authority (SEPTA) approved a resolution to allow Pattison Station to be renamed AT&T Station under a naming-rights agreement that brought in much-needed revenue for transit operations. The new name is part of a five-year contract valued at more than $5 million. AT&T Station also builds on SEPTA's relationship with AT&T, which is currently the only wireless carrier providing coverage underground along the Broad Street and Market-Frankford lines.

Concessions
Transportation system assets provide many opportunities for leasing real estate to private-sector concession businesses. This should be especially true at the The T stations in downtown Pittsburgh.

Charge a nominal fee at Park & Ride lots that are still free
Allegheny County Controller Chelsa Wagner has suggested charging a nominal fee at the Park & Ride lots that are currently free. Charging a mere $1 per day could bring in an additional $2 million per year[17]. The IBM team supports this idea, as long as the revenue is reinvested in improving the public transit system to reach the goal of a 10 percent increase in ridership.

Increased ridership
A 10 percent increase in the annual number of passengers would have a significant positive impact on the profitability of the Port Authority of Allegheny County. The current number of buses and light trains could support this increase in ridership. If ridership increases more than 10 percent, the City would need to invest in additional capital expenditures, which the Port Authority of Allegheny County cannot afford.

Cabs
Three cab companies serve Pittsburgh –Yellow Cab, Classy Cab (a premium service) and Veterans' Taxi. Until last year, however, Yellow Cab held a virtual monopoly in Pittsburgh. Veterans' Taxi was recently allowed to enter the market, but it is a much smaller competitor, so the expected results of better service and price competition have yet to be seen.

Hailing a cab in the city seems nearly impossible because of local cab regulations. In addition, taxi stops are not well advertised. This impacts businesses because visitors hesitate to move around. Additionally, more taxi stops are needed outside the downtown area and in active business and shopping areas.

Cab companies should contribute to reducing vehicle emissions by using exclusively clean technologies, such as hybrid or electric engines.

Carpooling
In the 2000 US census, 75.6 percent of all commuters said they drive alone. During the last two decades, the number of commuters who drive has climbed steadily, from 81 million in 1980 to 113 million in 2000. During the same period, the number of carpoolers dropped from 19 million to 15.6 million. Drivers mention several reasons they avoid carpooling:

- Traffic and work patterns do not mesh.
- People work longer, irregular hours.
- Drivers enjoy the flexibility to come and go as they please.

In Pittsburgh, the high-occupancy vehicle (HOV) lanes on Parkway North (I-279) were opened in 1989 with a three-rider requirement. This was lowered to two riders in 1992 after complaints that virtually no vehicles were using the lanes. Despite this, the lanes remain underutilized, according to Dan Cessna, the current district executive for the Pennsylvania Department of Transportation. PennDOT data shows about 4 percent of drivers use the HOV lanes on I-279. Although there are many websites, such as carpoolworld.com, that can help find carpool participants, the trend has not reversed. Because of this, it does not seem the best use of taxpayers' dollars to spend more on advertising carpooling or investing in new HOV lanes.

As a result, HOV lanes will probably not change over the next few years. There should be some debate within the City about the future of those underutilized lanes. There have been some US-based experiments in which HOV lanes were used by SOVs for a fee. If PennDOT chose to implement such a strategy on the HOV lanes around Pittsburgh, this would be a good test bed for congestion-based pricing.

Car sharing

No matter how good the public transportation system, most people occasionally need the use of a car. When that happens, if they purchase a car, they become more likely to use it for their daily commute. As a result, car-sharing services, such as Zipcar, help to limit the growth of car ownership and keep people using more efficient transportation systems for a longer time. As a result, car sharing must be seen as a tool to complement public transit and limit congestion. For this reason, the IBM team recommends that the City work closely with car-sharing companies to understand their needs and customers' usage patterns. If the City provides car-sharing companies with quality information about demographics and public transit use, this could help them make good decisions on where to install new lots.

This recommendation, when implemented, will produce a wealth of information that will be extremely valuable in developing high-quality models that can be used to make decisions to improve traffic conditions.

Proposed owners and stakeholders	Suggested resources needed
This project will require collaboration between the City of Pittsburgh, the Port Authority of Allegheny County and PennDOT.	Expand the use of the Port Authority smart card to cover public parking (both ParkPGH and Park & Ride lots). Bike racks will require close collaboration between the City of Pittsburgh, the Port Authority of Allegheny County and ParkPGH. Many of the recommendations related to public transit will require significant investments. The team has proposed several alternatives to fund these recommendations, and those should be executed first, since increasing the price of a ticket or issuing more debt are not recommended options.
Dependencies	**Key milestones, activities and timeframes**
This recommendation does not depend on other recommendations, although Recommendation 5 will help accelerate deployment.	1. Complete the deployment of the smart card to all buses. 2. Implement measures to obtain new revenue for the Port Authority of Allegheny County. 3. Invest in an AVL system. 4. Use the generated data to feed the model and execute simulations.
Priority Status	
High	

Recommendation 4: Leverage data analysis to reveal transportation insights

The City should utilize data analysis to reveal insights about transportation to improve the quality of decision support for planning and development of transportation services.

Scope and expected outcomes

Cities are complex organisms, and transportation is deeply integrated with nearly all of the processes that affect the social and economic lives of each citizen. With such complexity, it is challenging to measure all of transportation's impacts and ensure that wise decisions are made to advance the health, prosperity and openness of the city.

Modeling is one proven approach to understanding citizens' preferences and potential behavior, helping cities gain increased insight to improve the quality of decision support. By using advanced modeling techniques, the City can more easily:

- Design safer, more reliable and efficient transport systems in which multiple modes of transport are available to each citizen.
- More efficiently and effectively communicate with citizens, surrounding communities, the State of Pennsylvania and other stakeholders, since the City's decisions will be supported by understandable data analysis with the impact of investments and operational changes clearly visualized.
- Calculate impacts, benefits and other variables as a basis for estimation of city revenues from parking, commuting and property values.

The implementation should be organized in close collaboration with key stakeholders, including Southwestern Pennsylvania Commission (SPC), PennDOT, Carnegie Mellon University, the University of Pittsburgh, and others with interest and capability in gathering and analyzing data.

There are a bewildering number of models used by the City's transportation planners to attempt to manage the process and outcomes of projects and initiatives. None of these models are specific to the needs of Pittsburgh, and some that have been forced on the City by other governance organizations have led to design decisions that are clearly suboptimal, mostly through an over-focus on the needs of SOVs. In addition, none of these existing models provide the insights for policymakers to make informed decisions on allocation of resources between transportation and competing project alternatives.

Few city governments possess the resources to create and execute complex modeling. Fortunately, Pittsburgh possesses an unusual wealth of capabilities, including global universities, strong regional planning organizations and philanthropic foundations that understand the criticality of transportation to a city's success. The City has an opportunity to assume an important role in coordinating activities among these stakeholders, who together possess the needed resources to realize the potential of Pittsburgh and the surrounding region to become a global leader in transportation.

The IBM team recommends leveraging the capabilities available to Pittsburgh through the data already collected by various organizations, combined with the analytics capabilities of Pittsburgh's institutions, to create, implement and maintain Pittsburgh-specific transportation models.

The City should incorporate lessons learned from external best-practice environments. Working with partner stakeholders, all should jointly agree on the requirements for the models' functionalities. The City should coordinate a project to set regional standards for modeling tools, methodologies and data collection.

The Southwestern Pennsylvania Commission has started testing VISSIM and VISUM, state-of-the-art transportation modeling tools from Planung Transport Verkehr AG. As a key regional stakeholder, the City should work with the SPC to ensure Pittsburgh's requirements are taken into account because the City and SPC will be more effective together than each working separately. A recommended starting point is to increase the general skill and understanding of the area by appointing a subject-matter expert for transport and land-use modeling.

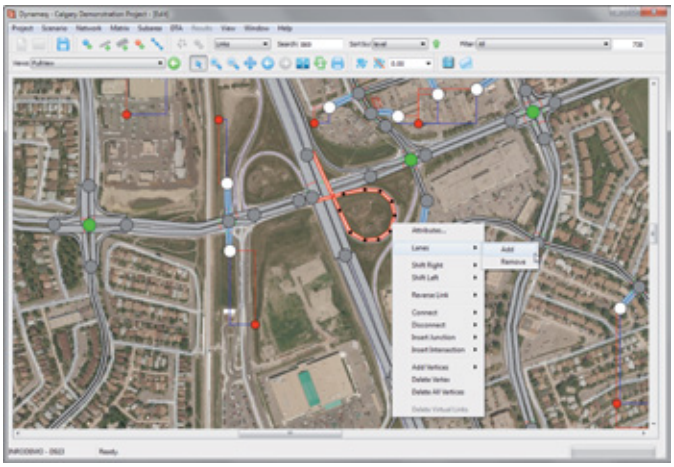

Figure 13
An example of traffic-flow modeling

Figure 14
An example of simulation visualization

The City and stakeholders should develop models for the parking market and property values in partnership with relevant research groups. These models normally are not included in standard transport-demand model tools. Such models can generate value for strategic planning and value-capture initiatives within a short time.

To use the developed models, the City and stakeholders should execute an end-to-end pilot project and develop a multiyear development and implementation plan. They should adopt best-practice policies to ensure that the models in use accurately reflect the role of transportation in promoting health, prosperity and equality:

- Ensure that traffic models incorporate all modes of transport in streetscapes and intersections, including pedestrian, bicycle, public transit, commercial transit (buses and vans), carpool, single-occupancy vehicle and freight.
- Include impacts of route choices for travelers using each mode, including costs (both direct to the traveler and indirect to the community and environment) and time (including congestion effects).
- Ensure that models consider both peak and median demand.
- Include entire trip chains, incorporating mode and destination choices, as well as connections between subsequent voyages.
- Include a full picture of economic impacts. Note that vehicles at rest incur costs, not just vehicles in motion. Include indirect costs, such as energy consumption, environmental footprint and public safety.
- Ensure models can be applied at multiple granularities, including neighborhoods, sections, transit sheds, municipalities, counties and regions.
- Use data standards to enable connections and multivariate analyses with other organizations' models, plus application to GIS and other modeling and simulation tools.
- Validate what inter-correlations must be secured between different models, such as economic development, long-distance trips, freight, regional transport demand model, simulation tool for local areas, parking-market modeling and property-value modeling.
- Establish access to all relevant types of data needed for the model, including network, socioeconomic, demography and traffic data for all modes of transport. Data should be freely accessible using open data standards. Examine new types of data sources from telecommunications operators, public and private traffic cameras, embedded road sensors, smart card data, transit passenger counters and others. Analyze existing gaps that might need to be filled.
- Include adjacent research programs, including environmental, sustainable economic development, tourist, land development and redevelopment, and other data analysis programs.
- Develop and maintain the skills of the local and regional modeling community. Modeling is a growing discipline, and this initiative could provide a new opportunity for Pittsburgh to become a global center for modeling and simulation.

The City and stakeholders should create a dataset for Pittsburgh travel modalities that is both Pittsburgh-centric and neighborhood-specific. Development projects need to be aligned with an accurate projection for travel modes, including walking, cycling, public transportation, carpool, single-occupancy vehicles and freight vehicles. Current models in use reflect Pennsylvania averages that include many rural and suburban datasets that do not accurately reflect the realities of Pittsburgh.

Data sources:

1. Traveler counts and categorization – can be provided through streaming camera data, using existing cameras at PennDOT and other organizations
2. Bus schedules and passenger counts – can be provided through Port Authority schedules and deployed APC technologies

Data analysis:

- Camera data can be analyzed by the CMU Ambient Intelligence Lab, which can interpret streaming data to count vehicles by type, such as pedestrian, car, bicycle, bus and truck.
- Data sources must be aggregated and visualized to provide combined modality information.

With sufficient data inputs, stochastic models can be created across Pittsburgh, specific to each neighborhood or, if desired, each property tract.

As a longer-term project, the City and stakeholders should consider the development of a systems dynamics model for Pittsburgh policy analysis. Policymakers must be able to understand the impacts of decisions on transportation and other areas, including energy, telecommunications, health, education, public safety and government services.

Systems dynamics are built with collections of causal loop diagrams, indicating positive and negative feedback loops. Loop connections represent actual causal relationships, not correlations – connecting two variables in the diagram means that a change in the preceding variable directly causes a change in the subsequent variable.

Building a systems dynamics model can be complex because it requires the identification of many data points specific to the City and region.

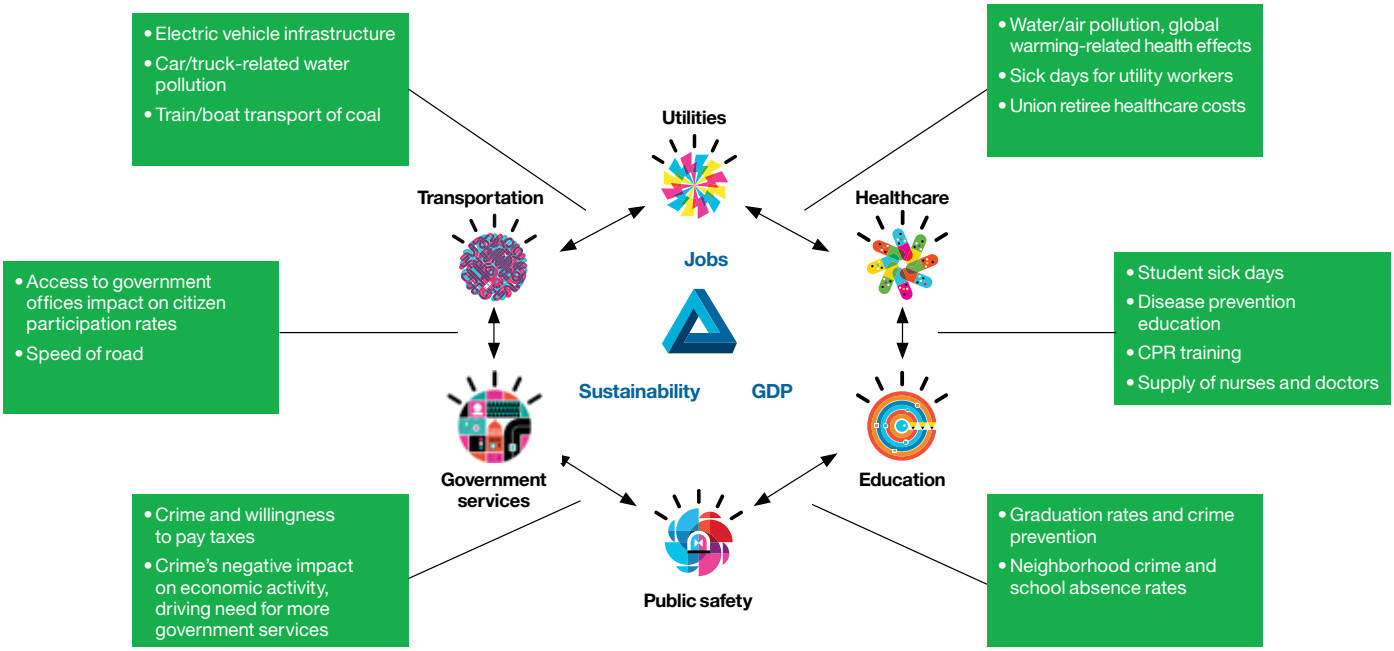

Figure 15
Systems dynamics for government analysis include a range of connected domains

Proposed owners and stakeholders	Suggested resources needed
Owner: Pittsburgh City Planning **Stakeholders:** • Southwestern Pennsylvania Commission • Pennsylvania Department of Transportation • Academic institutions • Philanthropic foundations • Planning teams in regional, county and municipal governments • Advocacy organizations	• Active participation across the stakeholder community • Funding for development and community coordination
Dependencies	**Key milestones, activities and timeframes**
• Willingness of stakeholders to participate and cooperate • Additional sources of data collection from a wide range of stakeholders and partners	**Short term:** • Initiate a local/regional community of modeling practice that includes all stakeholders. • Decide on what modeling packages the City and partners will choose as common standards. • Establish a common open-data repository. • Develop a pilot modeling project to correlate the impacts of parking options. • Develop a pilot for a Pittsburgh-centric and neighborhood-specific travel modality analysis. **Medium and long term:** • Evaluate the effectiveness of pilots. • Institute regular use and continuous improvement of the modeling practice. • Explore development of a dynamic systems model for Pittsburgh. • Maintain and develop the regional modeling community's reach skills.
Priority Status	
High – this is a high-priority recommendation that will take several years to fully implement but will add significant value for the City.	

Recommendation 5: Initiate a collaborative effort to develop and deliver a shared transportation data vision and framework

The City should initiate a collaborative effort to develop and deliver a shared transportation data vision and framework to support data-driven transportation decisions.

Scope and expected outcomes

Because there are many stakeholders involved in transportation within Pittsburgh and the surrounding region, and because there is no sole owner of the transportation infrastructure, there is limited decision making that uses common data sets. Organizations are working with data from their own silo, minimally sharing data with each other, making decisions based on instinct, or manually incorporating data from elsewhere into their own data systems. Shared databases for transportation and related decision making between the City and the stakeholders are limited or non-existent. Sub-optimal decisions are being made.

The IBM team observed numerous examples of rich data sources:

- Master plans (PLANPGH, MOVEPGH, SPC, Allegheny Places)
- Studies on development, transportation, land use and economics (Pittsburgh Community Reinvestment Group (PCRG), Urban Redevelopment Authority of Pittsburgh (URA), foundations, advocacy groups)
- Traffic21 research pilots focused on transportation (CMU)
- Operational data from key transportation elements (City of Pittsburgh, Port Authority of Allegheny County, Pittsburgh Parking Authority, Pittsburgh Cultural Trust)
- Investment, spatial, financial and statistical data (SPC, PennDOT, advocacy groups, developers)
- Traffic and transportation data (SPC, PennDOT)

Data in these organizations are housed in a variety of formats, including PDF files (reports and studies), spreadsheets, word-processing documents, GIS systems and operational databases. Each organization leverages the data for its own mission and strategies. The City and regional stakeholders all are governed by their own rules of operation. Each organization has its own regulatory framework for operation and decision making.

Interactive access to data and analyses is starting to happen. The City is taking steps to make its data available online to share with interested parties through their recently launched PGHSNAP website, as well as the City's web portal. ParkPGH shows real-time data on its website and through phone apps for use by citizens.

While all transportation-related organizations in the City and region are gathering and using data, there needs to be a formal commitment to making this data available through a common platform and data-sharing mechanism. This will lay the groundwork for creating services, such as traveler information services to empower citizens, and for generating data-driven insights using transportation and land-use modeling and analysis.

The City should create a common transportation data vision and framework for coordination to support data-driven transportation decisions across all City and regional organizations with:

- A charter
- A mission
- Committed staff with the appropriate skill requirements
- Required funding and resources
- Identified data sources

It should establish a collaborative digital space for open transportation data, and leverage collaboration tools to store and share data with all stakeholders. The City of Pittsburgh should actively engage citizens and stakeholders to educate, build awareness of the initiative, communicate ideas, and propose new data sources and updated information.

An example of a shared data vision and framework can be seen in the Virginia Economic Development Partnership[18]. While this is a formal partnership focused on economic development, it led to collaboration between state and local government organizations, developers, real estate and management firms, and other private-sector organizations to develop a shared economic vision. The overall vision led to a shared data vision and the framework required to use the data and information for success. Decisions were made about what data was important, who owned the best-quality data, who could provide it, and who would be responsible for providing the most current data. This economic development data vision included the integration of data around transportation, utilities, employment, quality of life and business demographics.

A coordinated and shared data vision and framework would support enhanced data-driven decision making in the City of Pittsburgh and region on transportation and related areas of concern. The investment in plans, studies and other data collection would be used to its fullest extent and leveraged by all interested parties.

Eventually, the City of Pittsburgh and key regional stakeholders would be able to make data-driven decisions on transportation funding initiatives, with a mechanism to prioritize requirements and fund projects based on an understanding of the impact they would make on all modes of transportation, land use and development, and overall economic growth in the region. This approach expands the capabilities to explore various transportation options and their impact across the city and regional boundaries, as well as make better use of fiscally constrained budgets.

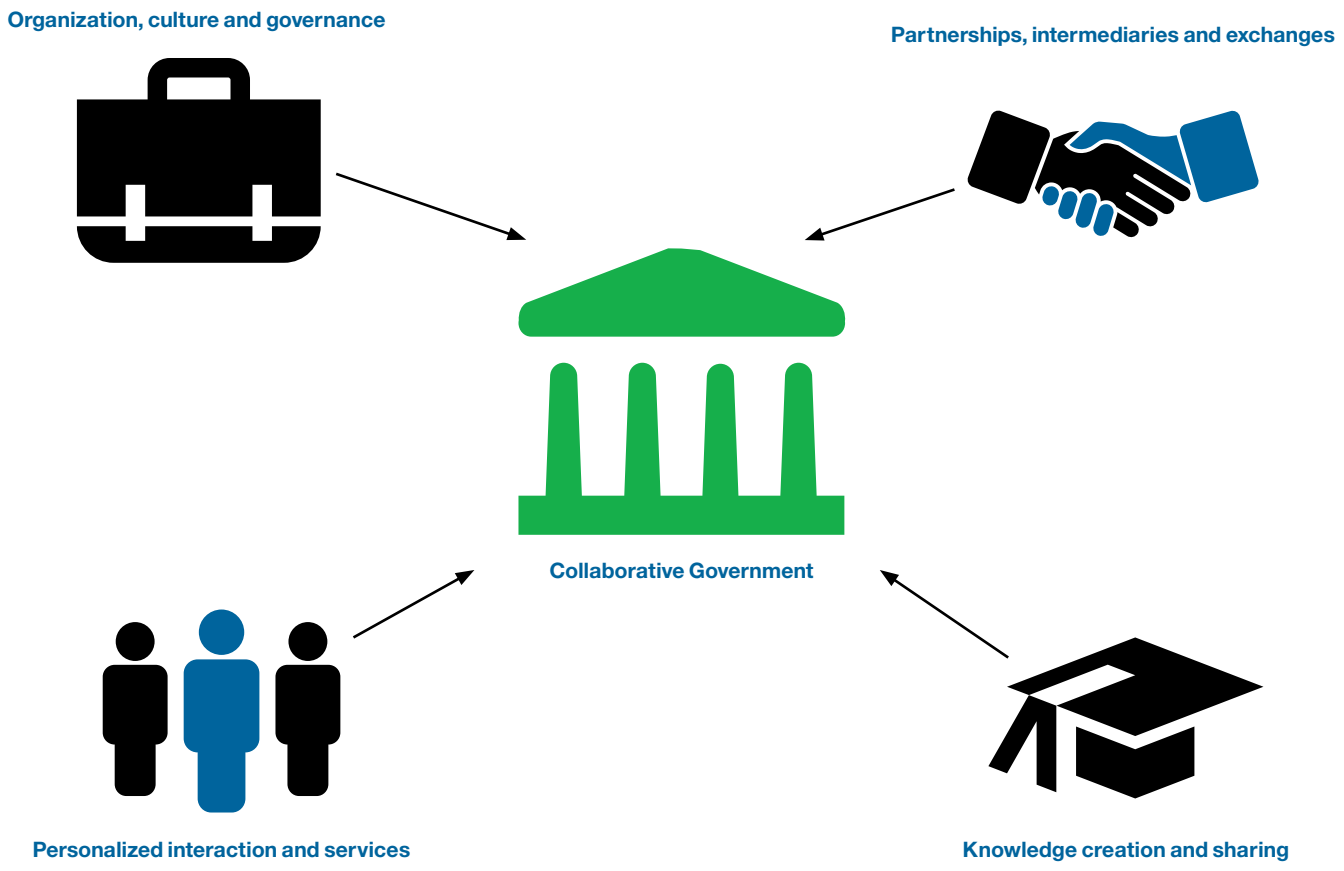

Figure 16
A framework for collaboration[19]

Proposed owners and stakeholders	Suggested resources needed
The City should take the lead in bringing stakeholders together to create the charter, mission, governance, approach and coordinated framework. All major transportation organizations that affect traffic in Pittsburgh should be involved, along with key City organizations: • Mayor of Pittsburgh • City of Pittsburgh (transportation, planning and police) • Southwestern Pennsylvania Commission • Pennsylvania Department of Transportation • Port Authority of Allegheny County • Pittsburgh Parking Authority • Private parking businesses • Taxi cab companies • Developers • Advocacy groups • Foundations	This shared data vision and framework coordination will require strong leadership and commitment to assure that it will support a transportation vision for the City and region.
Dependencies	**Key milestones, activities and timeframes**
This recommendation is dependent upon the City and other key stakeholders agreeing that a shared data vision and framework is a way to make a better Pittsburgh and support prosperity for the City and the region.	• The Mayor should take the lead in reaching out to key stakeholders to explore a shared data vision and coordinated framework. • The key stakeholders should develop a charter, identify and assign committed personnel, identify measurable goals, and identify and secure other resources, as needed. • The key stakeholders should create a governance action plan that includes: – Strategic data that is prioritized and tracked – Stakeholder engagement – Milestones and performance metrics • To turn the electronic sharing between organizations into a success, these steps may be required: – Clearance from legislative bodies and other authorities – A review of liability issues and other concerns – Definitions about who owns the data and any intellectual property – Contracts to be signed before electronic data sharing can occur
Priority Status	
High – this is a high-priority recommendation for the City of Pittsburgh and its key stakeholders to do more with less, be effective and efficient in the use of its resources, allow growth of the city and enhance the economic vitality of the area.	

Recommendation 6: Expand the scope of the ParkPGH program

The City should expand the scope and reach of the ParkPGH program to improve visibility and improve utilization of available parking.

Scope and expected outcomes

Availability of parking is a significant determinant of the flow of traffic in Pittsburgh – with price, proximity and perception of safety contributing to choice in mode of travel and traffic patterns.

There is sufficient parking availability from the perspective of overall available spots; however, many may not be close to the desired destination and generally require payment (although several free spots are available). This contributes to a misperception of insufficient parking availability.

Parking at the Pittsburgh Parking Authority garages is usually available at a lower cost than privately controlled parking garages. This price differential, coupled with the fact that most drivers park for a full day, means that the Parking Authority garages fill first and do not turnover during the day. This results in lower net revenue than might be gained otherwise. Furthermore, downtown Pittsburgh is eminently walkable, making it a "park once" type of space.

Economic incentives can be used to modify behavior that will balance utilization of parking spaces, perhaps leading vehicle owners to choose garages farther out rather than parking closer to the main job centers, including downtown. Straight raising of parking prices is usually not a workable strategy. A better technique is to use variable pricing at different lots, coupled with dynamic pricing strategies (based on season and time of day) can be adopted. Time-limited parking has found limited value in other cities but could be considered. To account for the multiple factors involved, it is best to use a parking model that can help with the planning and decision making of these schemes.

Also, certain parking lots and garages do not fill because of a perception of lack of safety or absence of line-of-sight (where the destination is not directly visible from the parking location). Integration of public transit is available at select locations but is not a universal design element.

ParkPGH (parkpgh.org) is a real-time parking availability system for the Pittsburgh cultural district, pioneered by the Pittsburgh Cultural Trust, which brings current and forecasted availability to travelers through an online application. ParkPGH has found widespread use, but an expanded scope would deliver on its potential to provide services across the entire city and help to balance utilization rates.

The City should expand the scope of the ParkPGH system to:

- Include all public and private parking garages
- Include surface lot and street spaces
- Add sensor-based detection to improve the accuracy of availability counts
- Transfer long-term ownership to either the Pittsburgh Parking Authority or a private entity focused primarily on parking

Figure 17
Public Parking Authority garage[20]

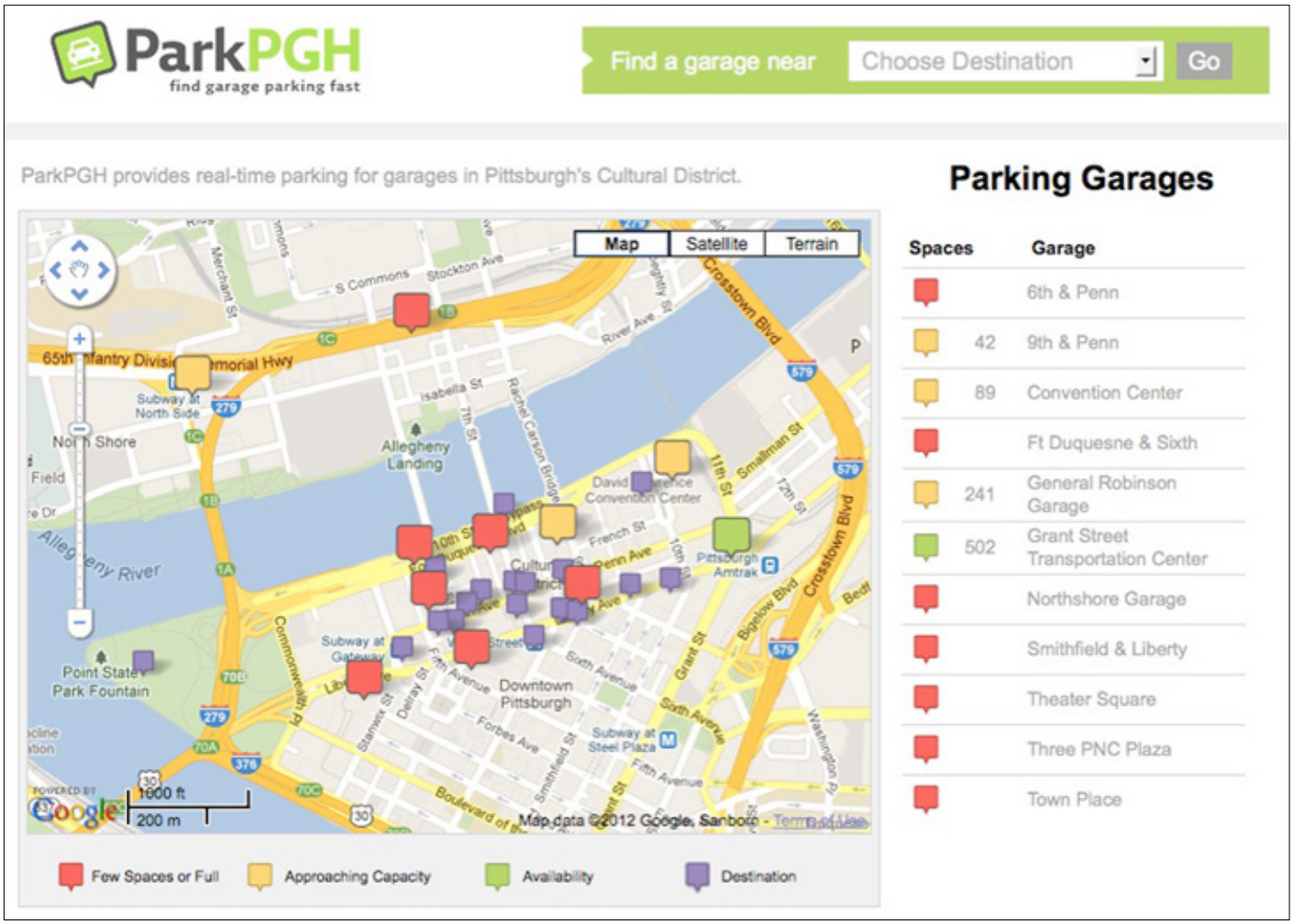

Figure 18
ParkPGH offers real-time parking availability information[21]

Additional capabilities should be added to ParkPGH, including:

- Information regarding safety features – lighting, guard availability and crime incidents
- Information regarding convenience – walking and biking paths to nearby destinations and connectivity to transit options
- Incorporate the capabilities of the current Facilities Locator services beyond the Pittsburgh Parking Authority garages

The City should improve visibility through street-level, smart parking signs that show availability without having to use smartphones, such as in the vision laid out by the Oakland Business Improvement District plan.

Further, the core model of ParkPGH should be expanded to help with forecasts for dynamic and variable pricing usage and its effect on utilization rates, revenue and parking patterns. The model should leverage, among other things:

- Data from all public and private parking garages, as well as street spaces and lots regarding utilization rates and availability
- Pricing (hourly and daily)
- Leased lots
- Current distribution pattern and utilization, including daily and seasonal variations

The model should seek to forecast changes in utilization, parking patterns and revenue with respect to variable and dynamic pricing schemes, and help guide decision making regarding the value and applicability of such schemes.

Increasing visibility of parking availability across the city will improve traffic flow, balance utilization of parking spots, and, with better information for connectivity to transit, biking and walking pathways, increase multimodal utilization. Expansion of the model to include variable and dynamic pricing schemes will help generate insights regarding use of these methods to further optimize utilization, parking patterns and revenue.

Proposed owners and stakeholders	Suggested resources needed
This project will require collaboration between the Pittsburgh Cultural Trust, Pittsburgh Parking Authority and the private entities managing other parking spots across the city. While ParkPGH is currently owned and managed by the Pittsburgh Cultural Trust, discussions regarding long-term ownership should be initiated as soon as possible. Carnegie Mellon University is a crucial addition to help extend the model to generate insights around variable and dynamic pricing and its impact utilization, revenue and parking patterns.	Resolving the long-term ownership of ParkPGH would require collaboration between Pittsburgh Cultural Trust, Pittsburgh Parking Authority and private operators. Adding capabilities to ParkPGH would require a 2-3 person IT staff for a period of 12-18 months. Expanding the core model to help with variable and dynamic pricing strategies would require collaboration with CMU. The cost would be medium.
Dependencies	**Key milestones, activities and timeframes**
This recommendation does not depend on other recommendations, though implementing Recommendation 4 will help accelerate its deployment.	1. Support current plans for ParkPGH downtown expansion and selected street spaces and parking lots 2. Resolve long-term ownership and maintenance of ParkPGH 3. Expand to cover other areas of the city 4. Add identified functionality to increase the value of ParkPGH and market widely to citizens and visitors 5. Expand core model capabilities to include insights regarding use of variable and dynamic pricing schemes to help guide decision making
Priority Status	
Medium	

Roadmap of recommendations

The IBM team's recommendations come together in the form of a package of recommendations that build on and complement each other:

- Streamlining traffic flow
- Empowering travelers
- Encouraging alternative modes of transportation
- Revealing transportation insights
- Coordinating governance for data sharing

Short-term recommendations

In the short term, the City of Pittsburgh and its stakeholders could take some short-term actions that would allow the City and citizens to experience immediate benefits. These recommendations are summarized in Figure 19.

	Short term <6 months
Streamlining traffic flow	• Centralized signal management
Empowering travelers	• Multi-use Smart Card • Regionwide parking information • Pay-to-play HOV
Encouraging alternative modes	• Bikeshare • Better bus stops • Sidewalks required elements of new road construction
Revealing transportation insights	• Pittsburgh-centric, neighborhood-specific multimodal traffic dataset • Pittsburgh parking analytics • Neighborhood transportation measurement and analysis
Facilitating governance for data sharing	• Initiate collaborative effort across stakeholders • Define charter, skill requirements, identify initial data sources

Figure 19
Quick wins for the City of Pittsburgh to implement in six months

The longer-term recommendations, outlined in Figure 20, will allow the City of Pittsburgh to realize the benefits of making better use of its infrastructure and develop a higher degree of maturity in coordinating all modes of transportation across Pittsburgh and the surrounding region.

	Medium term 7-24 months	**Long term** >24 months
Streamlining traffic flow	• Expand adaptive grid • Real-time traveler advisor • Implement Integrated Operations Center	• Citywide adaptive grid • Regionwide Integrated Operations Center with expanded scope
Empowering travelers	• Citywide traveler information services	• Regional traveler information services
Encouraging alternative modes	• Implement common technology platform on public transit, enabling AVL, safety, new advertising, public information	• Safe, off-road bicycle routes connecting neighborhoods
Revealing transportation insights	• Pittsburgh-centric, neighborhood-specific multimodal traffic dataset • Pittsburgh parking analytics • Neighborhood transportation measurement and analysis	• Pittsburgh Dynamic Systems Modeling
Facilitating governance for data sharing	• Initiate collaborative effort across stakeholders • Define charter, skill requirements, identify initial data sources	• Maintain, update and continuously improve quality, quantity, and usefulness of shared data and information analysis

Figure 20
Recommendations to allow the City of Pittsburgh and its stakeholders to drive its desired target state

5. Conclusion

Pittsburgh is in the midst of transformation to a vibrant, new-generation economy. Transportation touches on nearly every aspect of the "system of systems" that makes up the City. Land use, economic development, and the health and wellbeing of the citizens are affected. It is key to the City's success.

Pittsburgh has all of the key elements of a Smarter City, including global universities, philanthropic foundations, regional planning organizations, passionate neighborhood and advocacy groups, engaged employers and passionate citizens. Since all of the organizational and technical ingredients for smarter transportation are already present, the City needs only to improve coordination to realize its benefits.

Data and data-driven analysis hold the power to transform the transportation landscape of Pittsburgh. Managing transportation, however, is challenging because it is managed through multiple organizations, each of which collects and uses valuable data driven by its own specific needs. Collectively, the data provides a holistic view of transportation, and, if broken out of its current silos, can transform the life of citizens, businesses and visitors.

Because Pittsburgh is an economic driver of the region, its transportation decisions also affect the surrounding area. The City of Pittsburgh can build upon its strengths and work around its limitations by finding new ways to collaborate and work with public and private stakeholders to ensure that everyone is positively contributing to the overall transportation objectives of the City and the region. With growing budget and infrastructure issues, the City cannot continue to spend its way out of its challenges.

The recommendations in this report endeavor to help Pittsburgh develop into a technologically empowered Smarter City. The short-term recommendations will allow the City and its stakeholders to take some actions to see immediate benefit, while medium- and long-term collaboration recommendations will drive a transportation data vision and framework to enable and drive transformation. The combined effect will help move Pittsburgh's passenger transportation and planning to that of a top-tier city.

6. Appendix

A. Acknowledgements

Name & Title	Organization
Noor Ismail, Planning Director	Pittsburgh City Planning
Joy Abbott, Assistant Planning Director	Pittsburgh City Planning
Patrick Roberts, Principal Planner	Pittsburgh City Planning
Justin Miller, Planner II	Pittsburgh City Planning
Mike Homa, GIS Manager	Pittsburgh City Geographic Information Systems
Chuck DiPietro, Vice President	Southwestern Pennsylvania Commission
Tajuana Stephenson, Acting Director and Chief Information Officer	Pittsburgh City Information Systems
Kate DeSimone, Senior Counsel of Information Technology	Pittsburgh City Information Systems
Sylvia D Harris, Information Security and Network Manager	Pittsburgh City Information Systems
Stan Caldwell, Deputy Director, T-SET University Transportation Center	Carnegie Mellon University
Dr. Jim Garrett, Thomas Lord Professor and Head, Civil and Environmental Engineer and Co-Director, Pennsylvania Smarter Infrastructure Incubator	Carnegie Mellon University
Al Biehler, Distinguished Service Professor of Transportation Systems and Policy	Carnegie Mellon University
Rick Stafford, Distinguished Service Professor of Public Policy	Carnegie Mellon University
Marc Flemming, VP Marketing and Communications	Pittsburgh Cultural Trust
Eric Stoller, Program Officer	Heinz Endowments
David Roger, President	Hillman Family Foundations
Steve Bland, CEO	Port Authority of Allegheny County
Thomas Link, Director, Center for Innovation and Entrepreneurship	Urban Redevelopment Authority of Pittsburgh
Georgia Petropoulos Muir, Executive Director	Oakland Business Improvement District
David Wohlwill, Program Manager, Longer Range Planning	Port Authority of Allegheny County
Chuck Rompala, Assistant Manager of Road Operations	Port Authority of Allegheny County
Scott Vetere, Director of Service Planning and Schedules	Port Authority of Allegheny County
David Onorato, Executive Director	Pittsburgh Parking Authority
Chuck Imbrogno, Models/Data Analysis Manager	Southwestern Pennsylvania Commission
Doug Smith, Transportation Planner	Southwestern Pennsylvania Commission
Ryan Gordon, Transportation Planner	Southwestern Pennsylvania Commission
Domenic D'Andrea, Project Manager, Regional Traffic Signal Program	Southwestern Pennsylvania Commission
Sara Walfoort, Transportation Planning Manager	Southwestern Pennsylvania Commission
Tom Klevan, Transportation Planner	Southwestern Pennsylvania Commission
David Totten, Transit Planner	Southwestern Pennsylvania Commission
Cindy Jampole, Principal, Transportation Planning and Parking Services	Trans Associates

Name & Title	Organization
Todd Reidbord, President	Walnut Capital Management (Bakery Square)
Dan Cessna, District Executive	Pennsylvania Department of Transportation
Wanda Wilson, Executive Director	Oakland Planning and Development Corporation
Chuck Half, City Innovation and Performance Manager (PittMAPS)	City of Pittsburgh
Scott Bricker, Executive Director	Bike Pittsburgh
Chris Sandvig, Regional Policy Director	Pittsburgh Community Reinvestment Group
Pat Hassett, Roadway and Bridge Programming	Pittsburgh City Department of Public Works
Dr. John Zimmerman, Human Computer Interaction Institute	Carnegie Mellon University
Christoph Mertz, Senior Project Scientist, Robotics Institute	Carnegie Mellon University
Matt Sanfilippo, Executive Director CenSCIR	Carnegie Mellon University
Dr. Alan W Black, Associate Professor, Language Technologies Institute	Carnegie Mellon University
Dr. Norman M Sadeh, Director Mobile Commerce Lab	Carnegie Mellon University
Dr. Gregory J Barlow, Fellow, Robotics Institute	Carnegie Mellon University
Dr. Ramayya Krishnan, Dean William W and Ruth F Cooper Professor of Management Science and Information Systems	Carnegie Mellon University
Ken Zapinski, Staff Director for Regional Air Service Partnership	Allegheny Conference of Regional Development
Anthony Boule, Director of Administration and Pittsburgh Parking Court	Pittsburgh Parking Authority
Mavis Rainey, Executive Director	Oakland Transportation Management Association
Lynn Manion, Executive Director	Airport Corridor Transportation Association
Court Gould, Executive Director	Sustainable Pittsburgh
Jason Previte, Senior Civil Engineer Supervisor	Pennsylvania Department of Transportation
Rebecca Schenck, Project Development Specialist	Urban Redevelopment Authority of Pittsburgh
Susheela Nemani-Stanger, Manager, Economic Development Department	Urban Redevelopment Authority of Pittsburgh
Jessica Smith-Perry, Assistant Director, Department of Housing	Urban Redevelopment Authority of Pittsburgh
Paul Moore, Principal	Nelson-Nygaard Consulting Associates, Inc.
Phil Goff, LEED AP, Senior Planner	ALTA Planning and Design
Allison Crnic, Associate Planner	AECOM
Rich Krajcovic, Assistant Engineering Manager	GAI Consultants, Inc. (ALMONO Project)
Eric Cartwright, Vice President Corporate Construction and Real Estate	University of Pittsburgh Medical Center
Donald Charley, Executive Director Parking and Security	University of Pittsburgh Medical Center
Darren Belajac, Director of Planning	East Liberty Development, Inc.
Loralyn Fabian, Program Manager	East Liberty Development, Inc.
Nate Cunningham, Director of Real Estate Development	East Liberty Development, Inc.

Name & Title	Organization
Shelly Majcen, Neighborhood Planner	Pittsburgh City Planning
Darija Wiswell, RD, LDN	Allegheny County Health Department
Tom Stulginski, Program Manager	Allegheny County Health Department
Jen Jeffers, Permitting and Licensing Manager	Pittsburgh City Planning
Tobin Stuff, Student/Intern	Pittsburgh City Planning
Amanda Purcell, Traffic Engineer	Pittsburgh City Public Works
Richard Snipe, Housing Portfolio Manager	Urban Redevelopment Authority of Pittsburgh
Kathleen Colbert-Gibson, Data Analyst	Southwestern Pennsylvania Commission
Dr. Yang Cai, Professor, Director of Ambient Intelligence Lab, CyLAB	Carnegie Mellon Institute
Dr. Howard Lipson, Senior Research Fellow of the Lab and Group Manager of CERT/SEI	Carnegie Mellon Institute
Dr. Kun Zhang, Post-doctorate Researcher and Visiting Scholar from China	Carnegie Mellon Institute
Brian Zeleznik, Senior Research Fellow	Carnegie Mellon Institute
Tania Ros Codina, Research Assistant	Carnegie Mellon Institute
Matt Sebek, Research Assistant and Intern	Carnegie Mellon Institute
Aravind Subramanian, Research Assistant	Carnegie Mellon Institute
Madelyn Roehrig, Director of Adult Education Division	Carnegie Museum of Art
Reed McManigle, Senior Manager, Center for Technology Transfer and Enterprise Creation (CTTEC)	Carnegie Mellon Institute
Dr. Irving Oppenheim, Professor Civil and Environmental Engineering & Architecture	Carnegie Mellon University
Dr. Xuesong (Pine) Liu, Asset Preservation Manager	Carnegie Mellon University

B. Team biographies

Huibert Aalbers

SWG Technical Manager,
IBM SWG Mexico
Mexico City, Mexico

Huibert Aalbers has run IBM's Software Group technical team at IBM México since 2006. He earned a Bachelor of Business Administration from Madrid's Complutense University and a Master of Business Administration from IPADE Business School. His passion for personal computing led him to software development at a very young age. At 18, he published his first software title in Spain, and later published three additional titles in the US while still a student. A native of The Netherlands, he completed an internship in Canada, then moved to México, where he built the ISP business at Grupo ASAE-PROESA and worked with customers such as Bital (now HSBC) to help define and implement their intranet and Internet strategies. At Informix Software, Aalbers served as Latin America's Internet Competency Center Director. After IBM acquired the company, he became a Software IT Architect, achieving Senior Certification four years later.

Darin Briskman

IBM Client Technical Architect
Pacific Distribution Sector
Beaverton, Oregon

Darin Briskman is the IBM Client Technical Advisor for Pacific Distribution. His interest is in leveraging analytics to improve outcomes in areas where the impact of information technology is still in its early stages, such as health, education and government. Briskman has been involved in the analysis, design, architecture, articulation, implementation and management of IT systems since 1989. He also has been a leader in IBM's Smarter Cities initiatives, working with local and municipal governments in North America, Europe and Asia. Prior to joining IBM in 1999, Briskman helped manage Knowledge Management at Sequent Computer Systems, after working for 3Com, Lotus Corporation, NASA, the US Congress and certain US government agencies. Briskman attended the Georgia Institute of Technology, Northwestern University and the University of Tel Aviv for his bachelor, master and doctoral studies in physics. He is a Master Certified Information Technology Architect by both IBM and the Open Group.

Cindy Dalton
Briefing Manager, IBM Institute for Electronic Government
Washington, D.C.

After working in the energy industry for more than 10 years, Cindy Dalton joined IBM in 1987 supporting US energy and environmental clients. In 2001, she moved to the IBM Institute for Electronic Government (IEG) Briefing Center in Washington, D.C. Focused on global public sector clients, the IEG delivers special programs for government, education and healthcare senior-level executives. Dalton manages the daily operations of the briefing center and also designs and delivers customized briefings on public-sector solutions for IBM clients. Dalton was selected to work on a special citizen Transportation Committee in her town of Gaithersburg, MD, where she worked on updating the city's Master Transportation Plan and made a number of recommendations on reducing traffic congestion, environmental considerations related to roadways, and the integration of pedestrian and bike paths into the transportation system. Originally from Ohio, Dalton earned her bachelor's degree from Mount Union and a Master of Business Administration from Kent State. In her spare time, she enjoys reading, photography, biking, walking and volunteering.

Gunnar Johansson
Public Sector Executive, IBM Nordic
Oslo, Norway

Gunnar Johansson is a Transport Economist and has been a professional consultant for more than 20 years. His background with Transek, Price Waterhouse Coopers Consulting and IBM has focused on policy evolution and the implementation of large-scale programmes for state enterprises and public companies in the transportation industry. Johansson has deep skill in transport policies, including pricing strategy for road and public services, and has been involved in a large number of full-scale projects (including RUC and toll roads), as well as national and international research projects. He left Transek as General Manager in 2001 to join IBM as a transportation industry leader within the Nordics. For the past year, Johansson has been responsible for the solution design for the Stockholm city congestion charging scheme. In 2009, he was appointed as Business Development Executive for the IBM Smarter City initiative for IBM Nordic. Johansson is member of the Norwegian National ITS Board of Directors and an advisor for the Volvo Research and Educational Foundations.

Viswanath Srikanth
Software Architect – Industry Solutions
Raleigh, North Carolina

Viswanath Srikanth is a Senior Software Engineer at the IBM Software Group Architecture & Technology, focused on IBM Open Standards and Open Source initiatives. His current assignment is directed toward helping IBM clients work through issues surrounding "Commercial Use of Consumer Data" – a topic of intense focus at US and European Union government institutions, as well as data privacy advocates. The goal of the effort is to provide consumers with understandable and reasonable options regarding use of their personal data, increase transparency regarding its use and significantly enhance governance of it. Prior to this assignment, Srikanth led IBM's focus on Intelligent Transportation data standards, working on leveraging public transit and private-vehicle transportation standards to help drive better coordination of city traffic patterns, improve travel planning and encourage greater use of public transit by the citizens of the city. An IBM Master Inventor, Srikanth earned a Master of Computer Science and has worked for 17 years in the IT industry. He hails from New Delhi, India, and presently lives in Chapel Hill, North Carolina, with his wife and son.

Prashant Washimkar
Industry Executive,
Travel and Transportation
IBM Global Business Services, India
Pune, India

Prashant Washimkar leads the Travel and Transportation industry for IBM Global Business Services India. In this role, he covers global engagements in industry sectors such as airlines and Airports, travel and related services, rail, and freight and logistics. Washimkar has 22 years of experience in consulting and the IT industry. He joined IBM as part of the PwC Consulting acquisition and has been with IBM for 12 years. His specific areas of interest are delivering business value through business transformation and strategy, developing win-win relationships with his clients, and inspiring young minds to be leaders in their chosen areas. Washimkar earned a post-graduate degree in management, specializing in IT, in Pune, India, and a diploma in computer studies from NCC UK. He is a Certified IS Auditor (CISA) and holds a Certificate in Executive Leadership from Cornell, as well as a PMP certification. In his spare time, he enjoys reading books, backpacking and teaching yoga.

Marian Lawlor
Manager, IBM Corporate Citizenship and Corporate Affairs
Vermont

Marian Lawlor manages IBM's philanthropic initiatives for Vermont and Michigan, as well as the IBM Smarter Cities Challenge for Pittsburgh. She joined IBM in the 1970s at IBM Burlington, where she has held technical and management jobs in areas as diverse as product engineering, data processing, product planning, technical vitality and community relations. Lawlor chairs the regional Workforce Investment Board and serves on a number of education-related boards. She received her bachelor's degree from Emory University and her master's degree from the University of New Hampshire. In her spare time, Lawlor enjoys traveling or relaxing at her seasonal camp on Lake Champlain.

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Alliance
Palestine
Beaver Falls
Lisbon
Evans City
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East Liverpool
Carrollton
New Cumberland
Pittsburgh
Wintersville
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