

Global City Teams Challenge
Transportation SuperCluster (TSC)

Blueprint for Improving First and Last Mile Connections
For Transit and Freight



Transportation SuperCluster Co-Chairs:

<p>Wilfred Pinfold, urban.systems Inc. 2004 NW Irving St. Unit 3 Portland, OR 97209 (503)709-2975 wilfred.pinfold@urban.systems</p> 	<p>Skip Newberry, Technology Associates of Oregon 1221 SW Fourth Avenue, Room 340 Portland, OR 97204 (503)956-5192 skip.newberry@techoregon.org</p> 
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This document was prepared with the help and support of the following contributors and advisors.



Introduction	4
Pilot Programs for AV Technologies	5
Transit Station to Company Campus:	5
Transit Station to College Campus:	6
Transit Station to Public Place (e.g. shopping mall):	6
Residence to Transit Station:	6
Shared Mobility Vehicles	6
Freight	7
Mobility Hubs	8
Electric Vehicle Charging Infrastructure	8
Maintenance and System Operation	8
Right-of-way Management	8
Connected Vehicle	9
Transaction Platform	9
CityWeb	9
Interoperability	11
Autonomous Driving Systems Technology	11
Not All Autonomous Vehicles Are Driverless	12
Fully Autonomous Capabilities - Open Road and Controlled Environments	12
Autonomous Vendors	13
Sensor Technology	14
Mobile Device and Communications Networks	15
Business Models	15
Community Engagement	16
Urban Form	16
Modeling	17
Policies and Procedures	17
Questions and Answers	19
Contributors	22
Attachment A: EV-Ready Transit Hubs White Paper	24



Introduction

A SuperCluster is a multi-city, multi-stakeholder collaboration organized around common project objectives and shared solutions. Committed cities/communities and partners jointly tackle shared issues, develop and deploy shared solutions to create economies of scale.

The Transportation SuperCluster (TSC) was formed and is managed by forward looking municipalities interested in preparing their infrastructure for new technologies that look set to provide better, more equitable services at lower cost. It explores the opportunities provided by first and last mile vehicles including shared, low speed and autonomous. It explores the opportunities for building vibrant communities around transfer points and mobility hubs and it addresses how these vehicles and hubs can play a role in the last mile delivery of packages and other freight. To support these opportunities the supercluster works with teams developing new and advanced transportation models and environmental sensors that allow both the prediction of probable outcomes and the measurement of actual outcomes of introducing these technologies. Finally the supercluster works with teams implementing a smart CityWeb to ensure the portability and interchangeability of solutions and propose regulatory and policy changes that support the safe deployment of these technologies. This blueprint will address the range of opportunities offered by new mobility-related technologies. We will provide data about the readiness of these technologies and how we believe they will

influence city and community planning offering potential short and long term improvements in safety, equity, climate, employment and congestion.

We want to thank the National Institute of Standards and Technology (NIST) for their leadership in establishing the Global City Teams Challenge. By pulling together city, academic and industry leaders into action clusters and then combining synergistic action clusters into SuperClusters NIST has launched a wave of innovation that will bring lasting benefit to urban life in the US and abroad.

In this blueprint we will outline bold steps that can benefit mobility in our communities. We will not spend time reviewing the innovative work that is being done to improve highway safety or improve nationwide freight. We are aware of these innovations and will take advantage of them when appropriate.

We will focus our attention on improving first and last mile connections for transit users and last fifty feet for freight delivery. We will explore how a convenient clean shared electric vehicle fleet can drive up the use of mass transit, reduce the need for private vehicle ownership, reduce traffic congestion and improve air quality.

Pilot Programs for AV Technologies

In the last few years we have seen three significant shifts in urban mobility, (1) sharing, (2) electrification, and (3) autonomy. While this RFI is nominally focused on Autonomous Vehicles many of the desired community benefits can be gained by implementing first and last mile solutions with a shared electric fleet. Further, by running pilots of shared electric fleets that are autonomous ready or partially autonomous we will gain considerable insight into how to deploy autonomous vehicles when the technology is ready for full operation.

The first and last mile pilots proposed by the urban.systems team are intended to lead cities to a future vision of urban mobility. These pilots will provide considerable learning and inform the pilots that follow.

The first and last mile transportation system should provide:

- Safe pedestrian pathways
- Safe cycling paths
- Urban Speed Vehicles (12mph), busses, cars and specialty vehicles

and in this way

- Significantly reduce fatalities because of reduced speed
- Significantly reduced parking space requirements because of vehicle sharing
- Reduced rider cost because of autonomy

The team will start with simple demonstrations that evolve to more complex solutions as understanding is gained. A sample set of demonstrations to start the process could be:

Transit Station to Company Campus:

A number of large companies in the Portland area are served by TriMet stations that are somewhat distant from campus (such as Nike and Intel). This limits the use of transit unless the company supports a bus service to bridge the gap from transit station to campus (as is done by WeDriveU for Nike). We would propose this function be performed by a connected on demand electric bus transitioning to an autonomous bus which could transport employees from the transit station to the

industrial campus and may also be used on campus to deliver passengers to selected buildings. We have discussed the application with WeDriveU, they are quite interested.

Because all of the bus passengers work for the same employer we believe this demonstration can be done with less concern of how passengers react as strangers. The scope of the pilot could include access badge readers and/or other systems such as facial recognition. This would assure all riders had appropriate access to campus. Unidentified passengers could be identified and connected to the company security officer for access or denial of access to campus.

Transit Station to College Campus:

Like the previous pilot but with lower identification requirements due to the open nature of campuses, a similar transit station to campus pilot can be started with an electric bus fleet that will evolve over time into an autonomous electric fleet. If successful, the technology could have direct use for many locations in Oregon.

Transit Station to Public Place (e.g. shopping mall):

Unlike the more homogeneous employee and student pilots, a transit station to public place pilot is more like regular bus service and provides the opportunity to begin development of connected systems to assure passenger safety and reduce rider anxiety. Such topics as rider identification (including ID card, facial recognition technology, biometric ID, etc.) should be investigated. In-vehicle monitored cameras may be used.

Residence to Transit Station:

For this pilot we could use a bus or car. If the bus is relatively small and picks up only passengers in a local neighborhood they may feel safe. With a car which carries 2, 4, or 6 passengers and only collects passengers at one stop this issue is removed.

Shared Mobility Vehicles

We can and do share a wide range of vehicles in Portland. Most of these ride share options use conventional high speed gasoline vehicles. The use of traditional gasoline vehicles is driven by the expectation that the rides will use highways. For a last mile solution this capability is not necessary. Urban Speed Vehicles (USVs) are a federally-approved, street-legal vehicle classification under the Federal Motor Vehicle Safety Standard 500¹ ("FMVSS 500") passed in 1998. Their popularity has grown in niche markets with improvements in battery technology and a broader acceptance of electric vehicles. City leaders and transportation planners are now



¹ "TP-500-02 - NHTSA." 19 Apr. 2006,

<https://www.nhtsa.gov/DOT/NHTSA/Vehicle%20Safety/Test%20Procedures/Associated%20Files/TP-500-02.pdf>. Accessed 12 Aug. 2017.

incorporating USVs as a critical part of the mass transit solution. Urban speed electric vehicles are also the ideal starting point for autonomous vehicles because of their capital and operational cost, safety, and versatility. Urban Speed electric vehicles offer an environmentally friendly approach to first and last mile challenges, expanding the distance most people will travel without a car from ¼ miles to 2 miles. Adding autonomy makes them economical as a door to transit option in all neighborhoods.

One major advantage of the FMVSS 500 law is that it does not require the extensive crash testing mandated for high speed vehicles. The lower speed allows the vehicles to use lighter weight construction, modular assembly techniques, and fewer parts. The lower barrier to entrance created by FMVSS 500 law provides companies the ability for greater customization, faster innovation, and shorter time to market. The result is an affordable, practical and sustainable “link” in the transportation system that blends with walking, biking, and mass transit. Further the modularity makes local maintenance and repair possible. As reliable automation becomes available these vehicles will be able to charge themselves and arrive at a customer's door ready for a trip to a transit stop or local business.



Local partners Mobility Cubed, Inc. have design a family of Urban Speed Vehicles (USVs) based upon two simple chassis platforms. The modular design makes it possible to purpose design and build vehicles to meet fleet requirements. Utilizing standard high quality drive components, including lithium iron phosphate batteries and high end drive train components allows Mobility Cubed to build an affordable, reliable and sustainable electric vehicle. A low parts count combined with design modularity means the vehicle can be “kitted” for local assembly and shipped cost effectively all over the world.

Freight

Freight has many vehicle options including drones for dropping off packages and driverless delivery vehicles. These driverless delivery vehicles could ferry groceries and other packages to your front door on demand for a low cost per trip. Building out mixed, hub-and-spoke delivery systems, optimizing freight routes, and scheduling deliveries to minimize congestion can significantly reduce costs and improve quality of life. Reducing dwell time of freight vehicles at delivery points is a complex problem requiring close coordination of public and private concerns



--- zoning officials, parking authorities, freight services, and building/site managers.

Mobility Hubs

Any transit stop can be turned into a Mobility hub where the first and last mile vehicles are serviced, charged and stored when not in service. At these hubs passenger experience can be improved with digital information signs that respond to real-time conditions, improved lighting, improved pedestrian safety, bike racks, improved safety including CCTV cameras, and much more.

Using technology to increase safety and security at transportation hubs improves ridership and reduces cost. Transit hubs can become business hubs where people stop for food and coffee, to pick up and drop off packages, and to do some local shopping on their way to and from work. Attachment A of this document offers an “EV-Ready Transit Hubs White Paper” exploring this topic in more detail.

Electric Vehicle Charging Infrastructure

We plan to work with Forth Mobility on demonstration projects to advance electric, smart and shared transportation. We plan to work with Portland General Electric Company (PGE) and their efforts to accelerate transportation electrification.

Maintenance and System Operation

Urban Speed Electric Vehicles like Mobility Cubed’s World Bus are constructed with less than 300 major parts, compared to over 2,500 parts for a typical gasoline engine vehicle. In addition, these vehicle’s assembly techniques are significantly less complicated than typical gasoline engine vehicles. The small bill of materials coupled with streamlined assembly processes enable Mobility Cubed to deploy relatively small (5,000 unit) volume runs of vehicles. The vehicles can be assembled and maintained at facilities near their operation, thereby providing local jobs, supporting the local economy, reducing shipping and logistics costs.

Right-of-way Management

Urban Speed electric vehicles can interact with the current built environment in new ways. For example, rather than consider curb pick-up and drop-off these vehicles can come into building spaces without polluting the environment. Picking up directly from transit stops and dropping off in schools, hospitals, universities and offices protects passengers from the elements in ways that have not been possible before. Covered transfer facilitates better protection for patients and people with disabilities.

Similarly last mile freight carried by vehicles that can come into warehouses and factories offers many benefits including clearing the streets. These driverless delivery vehicles and small autonomous drones can ferry groceries and other packages to customer’s front doors on demand for a low cost. Building hub-and-spoke delivery systems, optimizing freight routes, and scheduling deliveries to minimize congestion can significantly reduce costs and improve convenience. Reducing dwell and idle time or getting vehicles off the street completely during delivery requires coordination with public and private concerns, zoning officials, parking authorities, freight services, and building/site managers.

One advantage of autonomous urban speed electric vehicles is that there is no reduction in efficiency, increase in cost or increase in pollution for a larger number of small vehicles. The vehicle can

therefore be sized for the appropriate purpose. For example picking people up or dropping packages at home can be done with a small vehicle whereas taking people or deliveries to a work campus like Intel or Nike can be done with a bus or delivery truck.

Connected Vehicle

Connected urban speed electric AVs can operate without traffic signals. They can synchronize their behavior through vehicle-to-vehicle communications at junctions and can operate at safe speeds that change by location and road conditions. Vehicle-to-infrastructure communications can be used to activate street lights, get updated route information, open doors, and receive scheduling information.

Transaction Platform

As a citizen moves through a city they interact with city services, transit, schools, parks, and shops. Each of these interactions contains information that can be used to deliver better services. In a smart city each interaction creates a digital transaction informing both the citizen and the city service providers. These transactions should be simple and secure. Ideally they should happen invisibly to the citizen while respecting a citizen's expectations of privacy. For example, as a commuter gets on light rail for the morning commute, there is an interaction between something the commuter carries and the train that completes the ticketing transaction. If the commuter chooses that this transaction be anonymous then the city will know that a passenger stepped onto light rail at one station, off at another and paid the appropriate fare. If the commuter chooses to share personal data with the city then the city will be able to track progress from home to work thus better understanding connections and opportunities to improve the overall commute.

urban.systems plans to test such a transactional platform that facilitates low friction data exchange and a personal policy engine that allows each citizen to manage and control how and if to share personal information. urban.systems will also test capabilities that allow a service provider to create incentives for citizens to share personal information ensuring the optimal balance between openness and privacy. The urban.systems transnational platform is scalable, open, distributed, and secure.

CityWeb

Technology becomes more pervasive everyday, and cheaper, faster and easier to use. We expect more from it with every new generation. Two significant technology trends, namely Internet of Things (IoT) and open data, are promising innovation and change at an even greater pace than the usual rapid-fire deployment and adoption of technology. Increased funding in the Smart Cities, Transportation, Grid and Energy sectors, which seek to exploit these trends, are driving the need for greater software development. So are Federal Government initiatives requiring compliance. With IoT and open data, it is becoming increasingly possible to build complex, interoperable software ecosystems that provide us with a richer, more time-efficient, cost-efficient, more energy-efficient and human-friendly digital quality of life.

However, the cost to develop, deploy and maintain these complex technology projects isn't getting correspondingly cheaper or easier. The burden of achieving these goals is still difficult for those in the public sector, academia, or even commercial organizations who might not have deep emerging technology skills. Writing "Smart City" applications can be hard. Often, the software and tooling environment is proprietary and the resulting applications fail to interoperate with applications

developed elsewhere. It can also be expensive due to a lack of in-house knowledge, skills and tools for such software.

There is an understandable hesitation in adopting closed, proprietary solutions or even APIs that are pushed forward by commercial vendors. Even if the API is open, the code supporting it often is not, and locks the consumer into the ecosystem of the commercial vendor, without the ability to interoperate with others. The vertical software stack supporting such alternatives only results in the use case or application sector getting siloed into fragmented ecosystems. There are significant cost and adoption advantages when APIs are not only open but backed by open source communities. Leveraging such available resources (or getting them to cooperate with each other) would be valuable. It would also align with the Federal initiative for a "City Web", which encourages the adoption of common and proven approaches to the Smart City mission.

The President's Council of Advisors on Science and Technology (PCAST) issued a report in 2016 on "Technology and the Future of Cities"², in which they identify the need for more effective approaches to data integration and sharing to solve problems in cities. They point out the:

- Lack of universally accepted platforms and standards.
- City incentives that drive a focus on local issues.
- Incomplete awareness of available solutions.
- Lengthy procurement processes that are unsuitable for agile, iterative, technology-based solutions.

and resulting:

- Uneven distribution of solutions.
- Idiosyncratic implementations.
- Rarely re-usable software for other cities.
- Expensive implementations.
- Disadvantages to smaller cities with fewer resources, less capacity for innovation who fall further behind in the digital quality of life offered to their residents.

"There are few private and no public mechanisms today to distribute the new knowledge and data associated with innovations comprehensively across the nation's cities. There is no "app store" specific to city applications..."

Hence they recommend the concept of a comprehensive information infrastructure for cities to use and share, the notion of a "City Web", an information-sharing platform benefiting all cities, especially those with fewer resources. This would include information on solutions, best practices which have been tried and tested, and had the benefit of experience. "The goal of the City Web is to allow the accumulation and replication of urban solutions and associated data and technologies in ways that benefit cities with different sizes, different technological know-how, and different financial capabilities."

We use the above concept of a "City Web" from the PCAST report to build upon and address these issues and more. To that end, we thus propose the implementation of "CityWeb", an open data platform and smart city solutions resource. CityWeb can be built and implemented for any locality or Smart City, supplemented by collaboration amongst participants and cities, domain experts and users, and strong open source development communities working in the Smart City technology fields.

² "Technology and the Future of Cities - The White House."

https://www.whitehouse.gov/sites/whitehouse.gov/files/images/Blog/PCAST%20Cities%20Report%20_%20FINAL.pdf.

Accessed 16 Aug. 2017.

urban.systems is working with NIST and US Ignite to establish a "CityWeb" project, which has as its goal the implementation and definition of an integrated data management portal and information-sharing platform for Smart City solutions. It is both a resource for Smart City technology solutions as well as a locality-specific portal with links and archives of information that are relevant to the community. A CityWeb instance can be implemented for each Smart City, with city-specific information. These CityWeb instances are intended to be bolstered by additional resources in the form of an open source software development community contributing to a Software Development Kit (a "CitySDK") for Smart City technologies. Below are some key principles of a CityWeb as we envision it, namely:

- Information Sharing and Community
 - Leveraging the experience and knowledge of previous projects and work done in this space as noted previously to benefit all.
- Open Data Portal
 - Having data generated by Smart City infrastructure and participants be open and available to users and 3rd party developers.
- Privacy and Control
 - Adhering to "MyData" principles, giving users control over and information about the information that is collected about them, whom it is shared with, and how it is used, and being transparent about such activity.
- Smart Technology Solutions and Resources
 - Sensors and IoT solutions.
 - A Software Development Kit for Smart City Solutions (CitySDK) and an Open Source project for its development.
- Interoperability
 - Standards and APIs.

There is a complete description of CityWeb - A Smart City Information-Sharing Platform and Urban Solutions Resource on the GCTC wiki³

Interoperability

Development and adoption of commonly-used Standards and APIs to ensure applications and services can work together to provide more powerful features and convenience to all users, whether public sector or private, academia or nonprofit.

Autonomous Driving Systems Technology

In the last few years, there has been a major shift in the outlook for autonomous vehicles, not just in the headlines, but with investment and a serious development effort from almost every player in the auto and industrial technology industries. It has become clear that a significant trend has now made its way into a full commitment from participants. Predictions on the future size of the autonomous industry have ranged from the billions to the hundreds of billions of dollars. Contributing technologies such as sensors, navigation, location services and positioning software have all matured just enough to have autonomous vehicles reach road testing stage with success.

³ "CityWeb - Modelado Foundation Wiki." 5 May. 2017, <https://wiki.modelado.org/CityWeb>. Accessed 16 Aug. 2017.



Autonomous vehicles are a key component of the “transportation as a service” vision of the future. Its advantages in providing greater safety, efficiency, cost-effectiveness and flexibility drive its development. It will be easier to provide more economically viable transportation solutions and products while being more sensitive to environmental concerns and complying with or exceeding existing green laws. In addition to those factors, its potential enabling of a large eco-system built around connected technologies to improve user experience, reduce congestion and environmental impact, build on lucrative software, media and infotainment market spaces contribute to the perfect storm of motivating drivers behind autonomous vehicles.

Urban areas wanting to transform into smart cities see the potential of urban speed electric transport as the energy-responsible, efficient and connected public transport vehicle of the future.

Not All Autonomous Vehicles Are Driverless

Although the term “Autonomous” has become synonymous with “driver-less”, it is only the last category, Level 5 Autonomous, that can do away with the driver altogether. As defined by the SAE International standard⁴, adopted by the USDOT, there are six levels of Automation for Driving:

- Level 0 the human driver does everything
- Level 1 an automated system on the vehicle can sometimes assist the human driver conduct some parts of the driving task
- Level 2 an automated system on the vehicle can actually conduct some parts of the driving task, while the human continues to monitor the driving environment and performs the rest of the driving task
- Level 3 an automated system can both actually conduct some parts of the driving task and monitor the driving environment in some instances, but the human driver must be ready to take back control when the automated system requests
- Level 4 an automated system can conduct the driving task and monitor the driving environment, and the human need not take back control, but the automated system can operate only in certain environments and under certain conditions
- Level 5 the automated system can perform all driving tasks, under all conditions that a human driver could perform them.

Autonomous operations are being developed for all vehicle form-factors from passenger vehicles to buses, shuttles, freight carriers, long-haul trucks, industrial equipment and cargo movers. They include high-speed as well as urban speed vehicles.

Most modern cars have some level of driver assistance such as sensor information, ABS brakes, collision detection, vehicle vicinity mapping, and even collision avoidance (the vehicle automatically brakes to avoid a collision without requiring the driver). Cruise control has been available on many cars and trucks for a long time. With a tremendous increase in the capabilities of the software stack present in modern cars, greater automation and sophisticated control and monitoring are becoming easier and cheaper.

⁴ "automated driving - SAE International." https://www.sae.org/misc/pdfs/automated_driving.pdf. Accessed 12 Aug. 2017.

Fully Autonomous Capabilities - Open Road and Controlled Environments

Autonomous vehicles operating without a driver (Level 4 and Level 5) require at least the ability to determine the location of the vehicle, determine and follow a route to a destination, determine immediate obstacles and potential collisions in the vicinity of the vehicle and take steps to safely move forward or stop as needed. They also require the ability to navigate on open roads, follow routes, obey street signs and traffic signals, coexist with other vehicles on the road, perform operations such as turns and lane changes, and comply with all traffic laws. The level of redundancy, safety, performance and data handling required to deliver these capabilities means complex and software and advanced hardware and sensors. These technologies are still in the early stages of development and maturity.

When fully autonomous vehicles are operated in strictly controlled environments (Level 4) such as on special lanes and on private campuses the software and hardware required is simpler, cheaper and easier to test and produce. Manufacturers can use simpler location technologies and do not need the complexity and risk management of street navigation, with its high liability and complex performance requirements. Such use cases are more likely to be deployed much earlier than with full Level 5 autonomy.

Autonomous Vendors

There are several categories of providers of autonomous vehicles and components. At a high-level, we observe three distinct types of vendors:

Full solution vendors:	Vehicle + all the software and other hardware necessary (integrated solution).
Autonomous software stack only:	Vendors who provide an autonomous software stack to hardware (vehicle) manufacturers (these include closed, proprietary solution providers as well as open source solution providers).
Component providers:	Vendors who provide only autonomous components (whether software or hardware).
A survey of the industry shows that the above are made up of:	
Traditional auto manufacturers:	Almost every automaker is performing research and development into autonomous vehicles, and is converting their current offerings into autonomous-capable versions. Most expect to have an autonomous vehicle on the road by 2020-2025.
Traditional Suppliers:	Quite a few have transitioned into providing or planning to provide autonomous versions of their components. These include hardware and software, ECU suppliers, by-wire programmable units such as by-wire-brake controllers, etc.
Autonomous Software Suppliers:	Companies who provide a full autonomous software solution to deploy on any vehicle (with certain hardware requirements).
Autonomous Component Suppliers:	New companies like Mobileye who are industry leaders in deploying sensors for localization and positioning, Quanergy, a LIDAR (Laser RADAR) supplier, etc.

Related industries and tech companies moving into the autonomous vehicle provider business:

Companies such as Google, Uber, Lyft have entered the autonomous vehicle provider market. Ride-sharing companies like Uber and Lyft need such vehicles for their future fleet. Tech companies such as Google and Apple have entered the market because of their software skills. Google is road-testing their own autonomous vehicles while Apple has said they will be providing a full autonomous software solution to their partner manufacturer companies.

Two important points should be understood from this list: (i) There are many options for deploying robust commercial last mile solutions today. These solutions can address city objectives on sustainability, safety and equity without any new innovations. (ii) Any legislation should recognize that these technologies exist and all efforts should be made to deploy them rather than constructing legislation that would delay this deployment.

Now let's look at the promise of full autonomy, or National Highway Traffic Safety Administration (NHTSA) level 5 autonomy. NHTSA considers this to be complete driver replacement in all situations including off road. Many in the general public believe this technology is just around the corner. It is not. There are many technical challenges to achieving full autonomy and since we have limited our discussion to last mile solutions, level 5 is outside our scope.

Currently for ride services such as Uber and Lyft approximately 80% of the operating cost is for the driver. This cost puts these services out of reach of many low income families. For first mile last mile solution to be equitable we must reduce the cost per ride. We believe Level 4 autonomous (driverless) operation in controlled environments will meet the needs of first mile last mile transit without the risk, time and cost required to develop level 5.

urban.systems intends to conduct trials of these technologies to assess readiness for addressing selected sustainable, vision zero and equity goals and intends to conduct a set of trials in districts that introduce the public to these vehicles and learn how people respond.

Sensor Technology

We define a smart city as one that has purpose (sustainability, equity, traffic safety) to its planning and measures results of its actions towards achieving that purpose. For this reason we consider three elements fundamental to a smart city: (1) A planning process based on a deep understanding of the needs of the community, (2) A set of metrics to measure progress, and (3) A data platform to enable data collection and measurement against metrics. A smart city is therefore a dynamic city that makes living in a dense urban environment more civil and more rewarding. A smart city is not only attractive to people who live there, but to people who visit and companies doing business there.

As already explained, we consider a data platform to enable data collection and measurement against planning metrics to be fundamental to a smart city. The goal is to make decisions based on data. Such a platform would enable a real time response to demand, events and emergencies. It would allow planners to make sure the city's budget is used as effectively and efficiently as possible to meet the city's goals. This represents one way that cities can break down silos and use data intelligently so that government operates as a true enterprise, rather than as a series of loosely linked departments and agencies.

Through greater data availability citizens can be better engaged, and system managers can see further and more holistically.

Mobile Device and Communications Networks

We propose working with partners to build out the necessary communication networks and mobile device applications. We have had discussions with US Ignite about joining their Smart Gigabit Communities (SGC) program. This program seeks to enable communities to accelerate the development and deployment of next-generation gigabit applications and services. We have worked with FIWARE in developing the FIWARE GCTC Challenge⁵ which aims to make forward-looking partnerships between cities and communities in North America with organizations currently providing solutions in Europe and create Smart City pilot trials designed to be replicable and scalable at global scale.

Both these activities have received significant support from PSU and OHSU and we look forward to working with all these organizations to build the necessary Mobile device and communications networks.

Business Models

In October of 2016, Citigroup released a report (Infrastructure: The \$59 Trillion Opportunity to Kickstart Global Growth⁶) estimating that the global market for infrastructure investments will reach \$59 trillion within the next fifteen years. The report observed that transportation infrastructure would account for a large portion of this market. Cities that are able to establish themselves as viable “living laboratories” where new infrastructure and technologies can be deployed and tested will capture a larger portion of this economic pie.

Open architectures and interoperability among different technologies will be essential to ensuring this economic opportunity is accessible to companies at a variety of stages and sizes. Similarly, enabling open access to certain data will enable companies to develop technology solutions that utilize and deliver this data to constituents and other companies in engaging and innovative ways.

Aside from access to a large global market and open technology infrastructure, creating opportunities for talent development will be important to ensure economic opportunity is broadly distributed within the Portland region. Hack Oregon⁷ is a local nonprofit that provides training opportunities for people interested in learning how to develop software and work with data to address civic challenges. Hack Oregon has already successfully worked with the City of Portland on open data projects and will be a key partner in developing transportation-related data solutions while training local talent.

The realization of the potential benefits of AVs, in terms of the impact on transportation access, equity, congestion and pollution reduction and safety is likely to hinge directly on important public policies set or controlled by local and state governments. In particular, how vehicles are licensed and

⁵ "FIWARE GCTC Challenge 2017: cross-border cooperation USA" 13 Jul. 2017, <https://www.fiware.org/2017/07/13/fiware-gctc-challenge-2017-cross-border-cooperation-usa-europe/>. Accessed 16 Aug. 2017.

⁶ "New Citi Report: Infrastructure – The \$59 Trillion Opportunity to" 20 Oct. 2016, <http://www.citigroup.com/citi/news/2016/161020a.htm>. Accessed 12 Aug. 2017.

⁷ "Hack Oregon." <http://www.hackoregon.org/>. Accessed 16 Aug. 2017.



taxed and how roads are financed will be critical. It is clear that the existing fuel tax and vehicle registration fees will not provide sufficient funding or the correct incentives for optimal deployment of AVs.

In addition, city parking policy can play a key role in encouraging the development and use of AV fleets. Pricing strategies for parking can encourage households to reduce or eliminate the number of cars they own, and to rely more heavily on other modes of transportation, including transit, bikes, walking and ride-hailed vehicles. Smart parking policies that adjust parking rates in real time can be an important complement to AVs.

Impresa and City Observatory⁸ have extensively explored urban transportation policy and the role of AVs. We have also written about the economics of AVs and how public policy, especially road pricing and parking policies, is likely to influence AV adoption. Impresa regularly communicates with colleagues at the Brookings Institution, major providers of parking and traffic data, leading ride-hailing firms, and other institutions studying AV deployment.

City Observatory is a virtual think tank on urban policy founded with support from the John S. and James L. Knight Foundation. Impresa is an economic consulting firm based in Portland, specializing in economic development, transportation and housing policy.

Community Engagement

The RFI states the policy outcomes that are most important to the City of Portland as being safety, equity, climate impacts, job creation and congestion relief. Moreover, the City has expressed that the Smart Autonomous Vehicles Initiative (SAVI) initiative⁹ must spur innovation and guide the Smart Autonomous emerging technology to serve community goals and, in particular to benefit low and moderate income Portlanders. This emphasis on equity and inclusion is what makes Portland unique as a City.

Toward these ends SERA/Civic Ecology Institute¹⁰ proposes to conduct a series of Civic Ecology workshops in target communities that will enable technology experts and citizens to engage in designing future smart autonomous systems that are accessible to a variety of income levels in these target communities. These systems could include such ideas as accessible deployment technologies through training on mobile device and communication networks, small business entrepreneurial opportunities, integration of charging stations into community fabric, integration with bicycle, transit and other existing mobility systems and a host of other equity building ideas.

These systems and relationships will then be broken down into specific project and policy initiatives that can be undertaken in collaboration with the community, the City and technology vendors through a Civic Public-Private partnership (CP3). The process will yield a co-created vision for deployment that is shared by the community, the City and vendors, a statement of shared values, systems conceived to achieve the vision, specific projects and metrics by which to measure successful deployment.

⁸ "About | City Observatory." <http://cityobservatory.org/about/>. Accessed 16 Aug. 2017.

⁹ "Smart Autonomous Vehicles Initiative (SAVI) | The City of Portland" <https://www.portlandoregon.gov/transportation/73493>. Accessed 16 Aug. 2017.

¹⁰ "SERA launches the Institute for Civic Ecology - SERA ArchitectsSERA" 6 Jan. 2017, <http://seradesign.com/2017/01/sera-launches-institute-civic-ecology/>. Accessed 16 Aug. 2017.



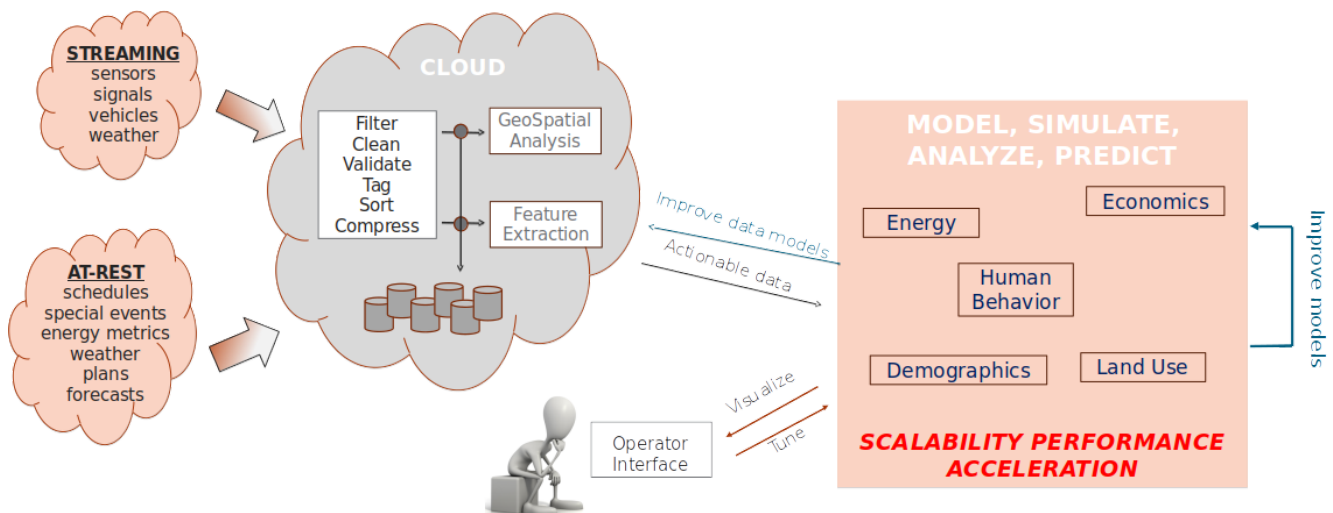
Urban Form

As part of the above process, SERA/Civic Ecology institute will advise on the impacts of deploying this emerging technology on future urban form in these target communities. Such questions as how do we re-think transportation corridors, intersections, vehicle pick-ups/drop-offs, the interaction with existing and future transit stations, stops and lines, and other aspects of the public environment to ensure equitable pedestrian access and comfort? Longer term, what might be the impact on community form if there is less of a need for parking facilities? How to redevelop surface parking lots? How to repurpose existing structured parking in a sustainable way? Do these redevelopment opportunities offer possibilities for neighborhood densification of housing and employment, thus reducing pressure to expand the urban growth boundary? Any of these issues are central to the mission of Prosper Portland and its Neighborhood Prosperity Initiative suggesting that target deployment areas should coincide with these Prosper Portland neighborhoods.

SERA/Civic Ecology Institute will address these issues in the above described workshops in order to provide a coherent understanding of all of these issues which the City has expressed are of great concern if the emerging technology is going to contribute to a prosperous, equitable City.

Modeling

Predictive modeling software provides the tools needed to manage the city as events unfold, from unexpected traffic jams and sudden rainstorms. Improving parking and traffic; effectively managing energy in schools, buildings and streetlights; increasing the efficiency of waste collection and water management; as well as improving citizen services, such as information about public transit and shopping.



Transit oriented design can help by reducing private cars as much as possible and encouraging the use of public transport and bicycles. The platforms time horizons are limited to real-time, near-term, or long-term leaving operators and city planners blind to the consequences of their actions at different time-scale with devastating consequences given the cost of mis-directed transportation decisions.

Policies and Procedures

In 2016, the National Highway Traffic Safety Administration (NHTSA) developed its Federal Automated Vehicles Policy, the first step in creating a federal AV policy. In July of this year the Subcommittee on Digital Commerce and Consumer Protection met in open markup session to provide the NHTSA with authority over highly automated vehicles, to provide safety measures for such vehicles, and for other purposes.

Twenty-two states have either passed legislation related to autonomous vehicles or adopted regulations through a governor's executive order. This patchwork of legislation ranges from the simple, such as authorizing a study on autonomous vehicles¹, to robust requirements for automated vehicles.^[3] The Auto Industry has been advocating for federal (rather than state-by-state) regulation of autonomous vehicles, hoping to bring more consistency and to encourage innovation. On July 28th, the House Energy and Commerce Committee stepped into the mix by voting 54 – 0 to advance to the full House a bill known as the “Safely Ensuring Lives Future Deployment and Research In Vehicle Evolution Act” (“SELF DRIVE Act”), H.R. 3388. The SELF DRIVE Act would be the first major federal effort to regulate autonomous vehicles beyond the previously adopted “voluntary” guidelines established by NHTSA.

The SELF DRIVE Act would clarify and expand the National Highway Traffic Safety Administration's authority with respect to highly automated vehicles. Foremost in the draft bill is its express preemption of state laws governing the design, construction, or performance of highly automated vehicles. Under the bill, states may continue to regulate licensing, registration, liability, safety inspections and certain other aspects of vehicles and their operation, but they would be preempted from regulating the design, construction or performance of highly automated vehicles, automated driving systems, or components of automated driving systems unless the state law is identical to a standard prescribed under the Federal law. However, this does not preclude the United States Government, a State, or a political subdivision of a State from prescribing a higher performance requirement for its own use. The preemption language should begin pushing toward a regulatory regime that avoids a patchwork of differing requirements that could stifle the rollout of automated vehicles.

The SELF DRIVE Act would create a fifth exemption category under 49 U.S.C. § 30113, authorizing NHTSA to exempt a manufacturer from meeting one or more Federal motor vehicle safety standards (FMVSSs) to facilitate the development and field testing of highly automated vehicles, features or systems. To qualify for an exemption, the petitioning manufacturer must demonstrate that the safety level of the system or feature at least equals the safety level of the standard for which exemption is sought or that the vehicle provides an overall safety level at least equal to the overall safety level of nonexempt vehicles.

Under this provision, NHTSA would have authority to exempt up to 25,000 vehicles manufactured in the first 12-month period, 50,000 vehicles manufactured in the second 12-month period, 100,000 vehicles manufactured in the third 12-month period, and 100,000 vehicles manufactured in the fourth 12-month period. Manufacturers would be required to provide information about all crashes involving exempted vehicles of which the manufacturer becomes aware. The bill would also require NHTSA to create a searchable public database of exempted vehicles.

The SELF DRIVE Act also seeks to tackle the challenge of public perception by requiring reports to Congress and eventually initiating rulemaking to require manufacturers to disclose features to consumers. These disclosures would likely include a standardized or semi-standardized description of the features and limitations of the vehicle's driving automation system or feature.

Questions and Answers

Answers to these questions are based on best current understanding. However, much is unknown and we expect answers to change as we progress towards operational systems. We recommend the City of Portland establish an Advisory Working Group to review the Connected and Autonomous Vehicles Policy, the current Interim Administrative Rule and be ready to guide future questions and opportunities as they arrive.

Q: What are you proposing to test?

- A:
- (1) Community engagement: SERA/Civic Ecology Institute proposes to conduct a series of Civic Ecology workshops in target communities that will enable technology experts and citizens to engage in designing future smart autonomous systems that are accessible to a variety of income levels in these target communities.
 - (2) Technology: urban.systems intends to conduct trials of connected urban speed electric vehicles and autonomous technologies to assess readiness for addressing selected sustainable, vision zero and equity goals.
 - (3) Operations: urban.systems intends to conduct pilots to introduce the public to connected urban speed electric vehicles and autonomous vehicles and learn how people respond.

Q: Will your tests require any hardware, connectivity or other infrastructure upgrades or investment?

- A:
- (1) High Bandwidth short range and low bandwidth long range connectivity possibly 5G and LoRa respectively. We will work with organizations like US Ignite and FIWARE to ensure we are delivering well tested hardware and software infrastructure.
 - (2) High accuracy geolocation either through either:
 - Real Time Kinematic (RTK) satellite navigation: a technique used to enhance the precision of position data derived from satellite-based positioning systems such as GPS. It relies on a reference stations to provide real-time corrections, providing up to centimetre-level accuracy.
 - Ultra-Wideband (UWB). ultra-wideband technology is several times better than traditional positioning systems based on WiFi or GPS. Furthermore, the signals can penetrate walls and make it suitable for indoor environments or urban canyons.

Q: In what type of terrain/environment do you hope to test ?

A: We are interested in first mile last mile challenges, testing in urban retail, industrial and residential and in all seasons.

Q: What streets or blocks in Portland do you propose testing?

A: We are looking for a variety of environments that meet the city planning goals. We are particularly interested in Neighborhood Prosperity Initiative Districts like 42nd Ave, Cully Blvd Alliance, Rosewood, Division-Midway Alliance, Jade District, Historic Parkrose and Main Street Districts like St. John's Center for Opportunity, Alberta Main Street. While we intend to step

through Tests (1), (2), (3) in that order we believe the Neighborhood Prosperity Initiative Districts will be particularly valuable in understanding ways to address equity and prosperity with Community engagement while the main street districts will be ideal Technology testbeds.

Q: If you plan to use AVs, how many will be in use for your pilot? What is the maximum number of AVs that would be operating in the pilot program simultaneously?

A: Mobility Cubed is capable of deploying 1-2 vehicles now for tests and has developed an alliance with Gunderson LLC to build the assembly line. With this assembly line the supply of AVs is essentially unlimited. Gunderson is member of the Greenbrier Companies headquartered in Lake Oswego, Oregon and is a leading international supplier of equipment and services to the freight rail transportation markets. They are currently providing space and purchasing power, giving Mobility Cubed the ability to scale very rapidly as orders grow. urban.systems works closely with a number of electric vehicle companies including Easy Mile, Navya, Local Motors, Innova, and others

Q: How is success measured for your pilot program?

A: As we explore community needs with civic engagement we will develop a plan for data collection and use this data to measure progress against the City's Comprehensive Plan, Vision Zero Action Plan, and Climate Action Plan

Q: What data will be produced by the test(s)? Could such data be collected and shared on the following outputs during the program and at full deployment origin, destination, route, and VMT; speeds; emissions, etc.? If not, why?

A: In line with the PCAST report we recommend the concept of a comprehensive information infrastructure for Portland. This "City Web", would provide an information-sharing platform between many cities. We would use our strong relationship with NIST and the Global City Teams Challenge to engage other cities in this data sharing information on solutions, best practices and experience. Although there may be exceptions for reasons of security or privacy, the default position is that transportation data should be open to encourage the widest possible range of potential innovation.

Q: How would your service(s)/product(s) address Portland's goals, which are outlined in Chapter 9 of the City's Comprehensive Plan?

A: Safety and specifically Vision Zero : AV ready urban speed electric vehicles will have advanced crash avoidance technologies, this combined with the urban appropriate speed would play a significant role in achieving the Vision Zero goals. Note that a 12 mph vehicle can be brought to a full stop in 6 feet.
Ensuring equity : Addressing the last mile will go a long way to eliminating transportation deserts. Further removing cars and freeing up parking space will open streets to people and social spaces. Civic Engagement workshops will ensure

	community participation addressing concerns for equitable access and benefit.
Congestion reduction :	Shared vehicles will remove parked cars from streets and eliminate the need for cars to spend time looking for parking. Increased use of transit will take many cars off the road. Making streets safer for walking will mean more trips are taken by foot and bike.
Reducing climate pollution :	This will be potentially eliminating thousands of gasoline burning vehicles from Portland streets.
Creating great places :	Freeing up parking spaces and making streets safer for walking will greatly increase public space for community building.
Generating economic prosperity :	By leading this new era of urban transportation the City of Portland will bring an enlarged share of a \$59 trillion over the next fifteen years transportation infrastructure business to the region.

Q: What do you need for the pilot program to be successful? Specifically, what do you need from the City of Portland?

A: We will need coordination and cooperation among City of Portland, TriMet and pilot site owners.

Q: Is a partnership with the City of Portland contemplated for your pilot program?

A: Yes we believe the City of Portland should establish an Advisory Working Group to ensure support from the city for projects that use city infrastructure whenever possible and that reviews Connected and Autonomous Vehicles Policy prior to their being adopted to weigh factors that impact sustainability, equity, safety, prosperity, and innovation.

Q: If so, would such a partnership require a financial investment by the City?

A: We expect providing the above level of partnership on pilot programs, but we do not anticipate any major city funding.

Q: Has the technology been previously tested? If so, when and where did those tests take place?

A: The driver versions of the Mobility Cubed vehicles have been in operation for three years with several hundred thousand hours of operation. Drive-by-wire operation of the bus has been tested at the Gunderson facility on 4350 NW Front Ave since July 2017 and a preliminary demonstration has been shown to Portland's TriMet and Columbus OH US DOT winning team.

Q: What were the results of these tests?

A: (1) The transportation priorities of key neighborhoods around Portland.
(2) The readiness of key technologies to improving safety, etc.
(3) The social acceptance of these technologies in key neighborhoods around Portland.

Contributors

Wilfred Pinfold, urban.systems Inc.
2004 NW Irving St. Unit 3
Portland, OR 7209
(503)709-2975
wilfred.pinfold@urban.systems

urban.systems builds vibrant smart communities using technology to facilitate civic engagement, deliver services and share resources.

urban.systems considers three elements fundamental to a smart community: (1) A planning process based on a deep understanding of the needs of the community, (2) A set of metrics against which to measure progress, and (3) A data platform to enable data collection and measurement against metrics.

Skip Newberry, Technology
Association of Oregon
123 NE 3rd Ave #210
Portland, OR 97232
(503) 228-5416
skip.newberry@techoregon.org

Technology Association of Oregon is a local nonprofit working to build opportunities, better our economy and unify a voice for innovation in Oregon and beyond. A recognized leader in shaping and growing technology and business communities, TAO empowers businesses and entrepreneurs through networks, events, advocacy, resources and more. With over 400 member-companies, TAO's network brings together some of the largest companies in the world, small startups, and tech-enabled companies that are using technology to drive growth and innovation.

Jeff Allen, Forth
1600 SW 4th Ave, Suite 620
Portland, OR 97201
(503)724-8670
jeffa@forthmobility.org

Forth's mission is to advance electric, smart and shared transportation and eventually autonomous mobility solutions in the Pacific Northwest and beyond through innovation, demonstration projects, advocacy, and engagement. Forth has over 120 members representing automakers, EVSE suppliers, industry partners, utilities, local governments, and nonprofits and many other stakeholders within the transportation "ecosystem".

Ken Montler, Mobility Cubed Inc.
The "Q" Hut
Gunderson, LLC
4350 NW Front Ave,
Portland, OR 97210
(971) 404 -5308
ken.montler@mobilitycubed.com

Mobility Cubed builds electric vehicles relying on a common set of chassis frame and subcomponent parts. From these common parts, we build a range of vehicles from a sixteen seat bus to a two person car. Vehicle types include light delivery vehicles and industrial specialty vehicles. The Mobility Cubed buses have been in operation in the Philippines with an estimated 200,000 hrs. of operation.

Tim Smith, Civic Ecology Institute
Sera Architects
338 NW 5th Ave
Portland, OR 97209

SERA is a 100% employee-owned Architecture, Interior Design and Urban Design & Planning firm specializing in sustainable placemaking at all scales. Founded in 1968, SERA holds a key role in the development of the city's national reputation for



(503) 445-7385
tims@serapdx.com

Joe Cortright, Impresa
1424 NE Knott St,
Portland, OR 97212
(503) 213-4443
jcortright@impresaconsulting.com

Greta Knappenberger,
iSoftStone North America
5808 Lake Washington Blvd. #400
Kirkland, WA 98033
(425) 216-6300
gretak@isoftstone.com

Jill Sorensen, Baltimore Electric
Vehicle Initiative
111 S. Calvert Street
Suite 2310
Baltimore, Maryland 21202
(443) 514-7122
jats@bilyan.com

John Feo, Pacific Northwest
National Laboratory
902 Battelle Blvd.
Richland, WA 99354
(509) 375-3768
john.feo@pnnl.gov

Corey Marshall, Splunk
270 Brannan St,
San Francisco, CA 94107
(415) 968-9005
cmarshall@splunk.com

Jose Gonzalez, FIWARE
16 rue Paul Bourget
92160 Antony - France
+34 644 297 507
jgonzalez@interinnov.eu

livability. Tim and SERA founded the Civic Ecology Institute to address community resilience by empowering citizens to create strongly democratic and systemic solutions to neighborhood, city and regional resource allocation issues.

Impresa is a Portland based consulting firm specializing in metropolitan economies and knowledge-based industries, and education policy. Founded in 1995, Impresa has a two-decade track record of providing solid analysis and policy advice that addresses the key challenges confronting communities around the nation.

iSoftStone North America is a technology consulting firm partnering with our clients to bring best in class digital transformation services and create innovative solutions that improve business process and performance

Baltimore-Washington Electric Vehicle Initiative, is a non-profit focused on electric vehicle education and outreach.

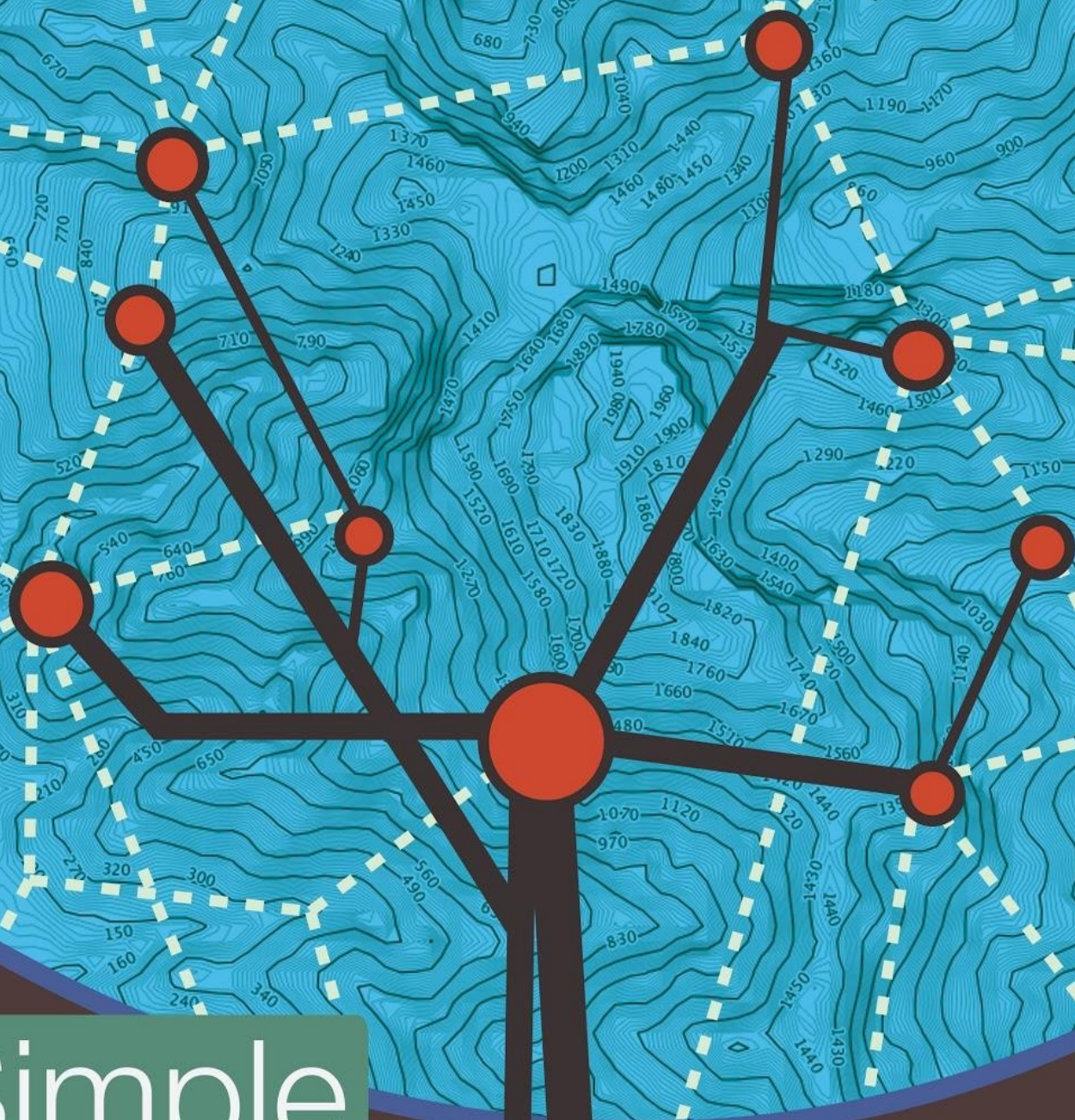
Pacific Northwest National Laboratory is one of the United States Department of Energy national laboratories, managed by the Department of Energy's Office of Science.

Splunk takes your machine data and make sense of it. IT sense. Security sense. Business sense. Common sense. Splunk products deliver visibility and insights for IT and the business. Splunk was founded to pursue a disruptive new vision: make machine data accessible, usable and valuable to everyone

The FIWARE Community is an independent open community whose members are committed to materialise the FIWARE mission, that is: "to build an open sustainable ecosystem around public, royalty-free and implementation-driven software platform standards that will ease the development of new Smart Applications in multiple sectors".



Hub to Hub



Simple

Transit for All



EV-Ready Transit Hubs

White Paper

11 August 2017

Baltimore-Washington Electric Vehicle Initiative (BEVI)
111 S. Calvert Street
Suite 2310
Baltimore, Maryland 21202
www.marylandEV.org

(cover Hub-to-Hub artwork by 2015 summer EV intern
and MICA art student, Sara Klementovic)

INTRODUCTION – Mobility Hubs in Baltimore

In 2015, BEVI published a Whitepaper advocating for the siting of EV-ready transit hubs throughout Maryland, starting in Baltimore City. We worked with key stakeholders to study, socialize and implement this concept, combining it with smart city initiatives and infrastructure development. The work became known as the Baltimore Smart City initiative or “B’Smart” Project, a smart city planning construct that addresses the inter-disciplinary nature of this infrastructure development work, crossing clean energy, clean transportation and Internet of Things applications. Community safety, public WiFi, health, wellness and economic opportunity are included in the smart city planning mix.

B’Smart stakeholders include City and State units of government, our local utility, area nonprofits, university researchers and smart city industry partners. The B’Smart consensus is to focus our efforts on low-income communities in the City hardest hit with transportation access challenges, such as West Baltimore. This meant we needed the input and cooperation of the community.

B’Smart has become a call to action for mobility. Our Maryland Transit Administration (MTA) has been leading the charge with its [BaltimoreLink](#) plan. First announced in October of 2015, the BaltimoreLink plan embraces the concept of transit hubs. Actually creating the hubs in a way that embraces clean energy and smart city planning challenges boundaries of agency jurisdiction, policy, politics, practice. Still, MTA and the Baltimore City Department of Transportation are making progress. Under the leadership of Mayor Catherine Pugh, and in close cooperation with State Governor Larry Hogan and his administration, the first of the new transit hubs is emerging as the [new West Baltimore MARC Station](#). A new Smart City Council for Baltimore City has been announced, and will continue to advance the multi-modal transportation options such as bike-sharing, car sharing and electric vehicle charging to be available at each one of these locations to support commuters. Favoring zero emission vehicles will help reduce pollution from the transportation sector, improve City health, wellness and mobility.



Phase I Transit Hub Development started in Baltimore City by MTA
(<https://www.youtube.com/watch?v=wmc555vTMDw>)

TRANSIT HUB PRINCIPLE

A Transit Hub is a location that coordinates existing public transportation options like bus or rail with multi-modal transportation resources like safe walking, cycling, bike-share and car-share. More than just a rail station or a bus stop, a Transit Hub enables someone to get to and from public transportation using a connecting bus, shuttle, bike or car-share service, thus eliminating the need to own a car in order to get to and from work, school or around town.

Transit facilities and services are an essential element of the social, economic, and cultural fabric of every city and region in Maryland. Presently, Maryland's transit resources are distributed, overlapping, and inefficient. Greater coordination would save operating and capital expenses, reduce energy consumption, pollution and traffic congestion. Too many citizens continue to drive. We need to improve our transit culture and transit options as a compelling complement and preferred option to cars, especially for urban transportation. A high quality transit system will bring communities together, enhance public safety, provide local business opportunities and improve quality of life. A Maryland Transit Hub system would achieve the following objectives:

- Streamline transit planning, land use patterns and infrastructure by defining strategic Transit Hub locations across the State
- Facilitate the development of Greenway routes between Transit Hubs for faster, safer and more efficiently transportation, especially from Hub to Hub
- Reduce traffic congestion management
- Improve air quality by promoting electric vehicles (zero emission) and active transportation (cycling and walking) to Hubs
- Reduce energy consumption and, therefore, produce transportation-related energy savings
- Form the backbone for managing travel demand
- Provide essential mobility for those who do not operate a private vehicle
- Build community space
- Design and operate each Hub as a microgrid capable of operating in power outages, fortifying the grid with back-up power
- Promote Smart City design by incorporating broadband conduit and free wireless internet access as part of each Transit Hub and Greenway.

THE NEW TRANSIT VISION FOR MARYLAND, starting with BaltimoreLink

The new transit vision for Maryland creates a more user friendly, attractive, efficient and reliable transit system for the State. The keys to this new transit vision are these:

- Site design and active transportation improvements, pedestrian and cycling in particular, are critical to supporting transit use
 - Enhancing existing services can offer large benefits, particularly smart phone and related digital support
 - Defining EV-ready Transit Hubs as strategic transit assets across the State, connected by express routes for electric buses, cycling and walking to promote active, clean transportation from Hub to Hub
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- Connecting Transit Hubs by express electric buses and promoting cycling and walking
 - Broad regional support
 - Increasing transit ridership and revenue by improving the quality of all transit services
 - Aligning transit services with demand
 - Improving existing and develop new partnerships with public and private stakeholders
 - Re-emphasizing the need for transit supportive built environments (TOD – transit-oriented development) which can be achieved through design guideline development
 - Continued performance monitoring to guide service development

This new transit vision for Maryland has two primary components:

Bus Rapid Transit (BRT) service designed around current critical transit connection sites to be re-defined as Transit Hubs

This component emphasizes the use of transit as a key transportation mode complemented by transit oriented development. Bus Rapid Transit (BRT), preferably electric, is a high performance transit service that functions more like light rail than a local bus. In the preferred Transit Hub matrix for Maryland, Hub to Hub BRTs run express on dedicated “greenway” routes from Hub to Hub, incorporating elements such as priority treatment at traffic signals, reduced, restricted or eliminated car access, station amenities such as real time arrival/departure information, attractive shelters, free wifi, park-and-ride lots, benches and in some cases restrooms and other services. BRT systems are complemented by local buses, sometimes referred to as feeders, to bring passengers to the high performance BRT routes.

To further encourage transit use, Transit Oriented Development (TOD) is encouraged at BRT or other transit service stations. Transit Oriented Development is generally defined as mixed-use development (development that mixes residential, retail, office, open space, and public uses) within walking distance of a transit stop that encourages travel on foot or by public transportation instead of by car.

Greenways Corridors to allow express, active transportation from Transit Hub to Transit Hub

Greenways would be dedicated routes from Hub to Hub that provide for express buses, preferably electric, cycling and pedestrian movement. Greenways, in combination with Transit Oriented Development (TOD), will create communities that on a regional scale preserve open space and reduce the need for travel by car, thus reducing congestion and vehicle emissions. Transit Oriented Development is generally defined as mixed-use development (mixing residential, retail, office, open space, and public uses) within walking distance of a transit stop that encourages travel on foot or by public transportation instead of by car. The “permanent” nature of Greenways contributes to greater development along a corridor than that stimulated by local bus service in mixed traffic.

MARYLAND NEW TRANSIT VISION COMPONENTS

- Bus-only travel lane (<http://baltimorelink.com/baltimorelink-basics/infrastructure>)
 - Greenways, including pedestrian and bike paths
 - Bike-share and Car-share at every Transit Hub location
 - Greenway transit signal priority, energy saving LED streetlights and accompanying digital signage
 - ADA compliant Transit Hub shelters,
 - EV-ready Park and Ride lots with Level 1 and Level 2 charging
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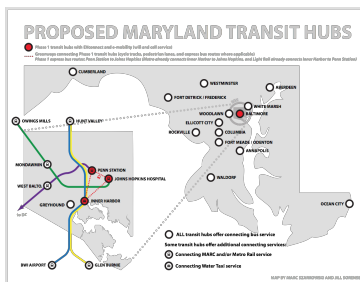
- Smart Card and mobile application transportation mode interoperability
- Free wifi at all Transit Hubs
- Transit Hubs as microgrids

RECOMMENDATIONS (next 5 years)

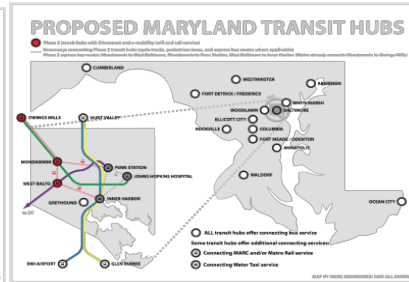
1. Continue to support MTA in implementing its 2015 Transit Development Plan and BaltimoreLink
 - a. Expand BRT around a Transit Hub Master Plan
 - b. Strengthen the system beginning with express routes from Hub to Hub, preferably on defined Greenway Corridors, and local routes.
 - c. Improve the fleet by reintroducing electric buses on BRT routes, providing commuter coaches on all express routes, and installed Intelligent Transportation System components on all vehicles.
 - d. Plan for and begin to construct Transit Hubs starting with key strategic locations.
 - e. Improve transit infrastructure by implementing BRT infrastructure throughout the MTA system, bus only lanes, pedestrian access, more shelters, universal Smart Card and Smart Phone access, a new Computer Aided Dispatch and Automatic Vehicle Location systems, and a new fare collection system.
 - f. Better integrate pedestrian, transit, and bicycle infrastructure using Greenways.
 2. Investigate new funding mechanisms to support MTA, Baltimore and regional transit operations
 - a. Energy and monetary savings by converting to electric buses and LED street lights.
 - b. Appropriate level of fare increase for base fare on fixed route services to increase the share of revenue provided by transit customers.
 - c. New and expanded transit access agreements for Smart Card or device users, service personnel (military, police, firemen, educators and students, non- profit sectors).
 3. Revise the Transportation Improvement Program project evaluation process to ensure that transit is being considered in the benefit/cost ratio developed for all projects. Support the State's goals to reduce greenhouse gas emission impacts during project selection and development.
 4. Explore the potential for bus/transit only travel lanes, beyond those planned for the BRT routes, in various locations throughout the region.
 5. Use established national criteria to identify transit corridors that may have the potential to support streetcar or light rail transit.
 6. Coordinate with municipalities, the counties and the state in the development of Complete Street design guidelines, standards and/or ordinances that incorporate the needs of the regional transit system (including articulated buses). Encourage inclusion of transit access for pedestrians in state and municipal ADA conformance plans (universal design elements such as sidewalks in good condition, curb ramps, etc.).
 7. Ensure that ADA (Americans with Disabilities Act) requirements are being met adjacent to all transit routes, on regular route vehicles and on paratransit vehicles through the implementation of universal design techniques (those that accommodate the widest range of users). Explore further
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use of audio and video based technologies on buses.

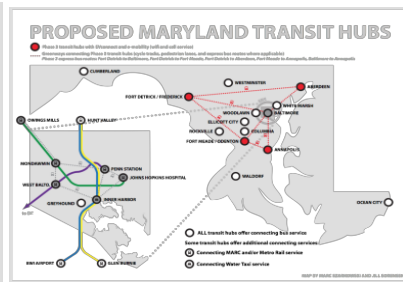
8. Continue to work with and promote integrated land use and transportation planning that supports transit oriented development and land use projects that encourage transit use (especially for seniors and lower income housing). Improve local understanding of development finance in real estate markets for transit oriented development.
9. Encourage improved intermodal connections among transit providers including Amtrak, intercity, county, university and independent bus carriers, and the Baltimore-Washington International Airport as well as walking, bicycling, and driving. Work with MTA and regional transit carriers, including Amtrak, on the development of shared intermodal stations.
10. Continue to engage major public and private stakeholders in transportation demand management initiatives and monitor significant new development in order to structure future transit service, transit access agreements (employer/institution financial partnerships with MTA), and opportunities to influence development in transit supportive ways.
11. Develop marketing or education materials targeted to elected officials, developers, financiers, etc. about the benefits of transit and the cost to provide transit service.
12. Continue to encourage open communication between State agencies and non-State transit providers.



Phase II Transit Hub



Phase I Transit Hub Dev



Phase III Transit Hub Dev