City of Toledo, Ohio

INTEGRATED PERSONAL MOBILITY MANAGEMENT SYSTEM – Monitor, Optimize, Analyze, Communicate

– Part 1 –

Vision Narrative

Prepared for

USDOT's Beyond Traffic: Smart City Challenge

February 4, 2016

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1. Define the Vision of Smart City Toledo

1.1 Overview

No one intentionally drives into a major traffic jam that will cost them hours to make what is normally a 20 minute trip. They do so from a lack of real time information on performance of the system or a lack of information on options to complete their daily travel. A smart city monitors overall transportation system performance on both arterial streets and freeways and bus routes in real time and analyzes changes in system conditions and performance. Based on this information the smart city makes real time adjustments in traffic control to optimize system performance, and to divert transit routing and optimize paratransit operations. The information can also be made readily available to area residents to recommend alternate highway routing to other paths to avoid and reduce problems where existing infrastructure capacity on those other routes allows. Finally the smart city translates this operations data into real time travel information and presents it in a readily accessible, easy-to-use format to inform users of the system. System users experience an optimized system and can make informed decisions on mode and routing to travel in the most efficient manner. They may not take their typical mode or route and will choose a different mode or route based on existing conditions. This results in less travel delay and improved safety (as crashes are correlated to congestion) for individuals and for the system overall. This is a smart city - This is integrated personal mobility management (mobility system).

The City of Toledo and its partners propose developing and demonstrating this type of holistic integrated mobility management system. It requires a new comprehensive approach to the use of the urban transportation system but for the most part can use newer but existing and proven technologies. We propose upgrading and integrating existing sensor (primarily video based), control and information technologies in a new and innovative way. Rather than providing for an adaptive traffic control system (ATCS) on separate isolated highway corridors this technology will be applied in a holistic manner to link and integrate signals for the entire arterial street system in the region. Sensors and control technology will be deployed at every signalized intersection and every signalized intersection becomes a real time traffic monitoring sensor. Signal pre-emption for transit and emergency response vehicles can be incorporated into traffic control to increase safety and efficiency of these services. Information from the existing Freeway ITS management system will be integrated with arterial traffic information (developed with the ATCS) to monitor overall system performance holistically rather than as a separate Freeway ITS monitoring and message system. This overall data can then be analyzed and input into a comprehensive system to adjust traffic control region wide to optimize performance and

guide transportation system users to the most efficient mode or routing available at the time of travel. If an unexpected disruption to the highway system occurs (crash, etc.) the ATCS and/or freeway sensors will detect its impact, determine the most efficient routes and communicate changes in traffic control to optimize performance. The data will also feed into a user notification function to alert system users. It will also be input into a route information system to assist users as they request travel information for designated origin and destination pairs. The real time information can also be integrated into transit scheduling services to optimize transit services particularly paratransit flexible routing. Information on alternatives (both route and modal) will be provided to users earlier in the trip making process.

This type of integrated information system approach can also be applied to rubber tire freight and logistics transportation into the Toledo-Lucas County Port Authority (Port) international docks, the NS Intermodal Terminal and major manufacturing and distribution hubs in the region (Fiat/Jeep's newest major assembly plant in Toledo, GM's Toledo transmission plant, and Norfolk Southern's Intermodal Terminal, among others). In addition to real time information on system performance described above information on hub operations, dock availability and access can be included and trucking companies and drayage operators can access the system to schedule real time minute by minute delivery of goods.

1.2 Why This Approach?

We believe this approach addresses the primary location and causes of system inefficiency and crashes in many urban areas in the United States. The primary mode for transportation of passengers and freight now and into at least the medium term future is overwhelmingly rubber tire private vehicles (most with one occupant). According to the 2010 American Community Survey over 76% of work commuters drove alone and another 9% drove in carpools in the United States as a whole. In Ohio commuters driving alone or in car pools accounted for over 90% of work trips. Most of the delays for vehicular travel occur on arterial and collector streets. The metropolitan planning organization (MPO) for our area, the Toledo Metropolitan Area Council of Governments (TMACOG) in its Congestion Management Process report (August 2013), states ". . . the vast majority of congestion in the Toledo metropolitan area occurs on arterials and collectors." They estimate that over 97% of daily vehicle delay hours occur on the arterial system. Future projections increase this to over 98%.

Further the real time, adaptive and integrated approach proposes a solution tailored to efficiently utilizing existing infrastructure capacity to address the main causes of congestion and related safety problems. Later in the Congestion Management Process report it states that "According to research by FHWA, 55% of roadway congestion (and related safety problems) can

be attributed to non-recurring events: traffic incidents, inclement weather, work zones or special events." A comprehensive traffic control and information system allows real time detection, notification, and optimization of system resources to address non-recurring incidents and events. Without expensive and oft-times politically impractical infrastructure expansion the best solution available to address congestion and related safety problems is to utilize excess capacity in the transportation system to address mobility needs by using slightly less desirable but still acceptable alternative routes or modes. Most users would accept a trip 5 to 10 minutes longer than their free flow option to avoid a 45 minute or longer delay.

Moreover, we believe this type of system, utilizing existing technologies with innovative refinements to apply them holistically to the urban environment, can be accomplished within the resource and schedule constraints of the USDOT Smart City Challenge. This is a practical yet innovative solution to actually implementing a response to the challenges of improving mobility for urban residents NOW. Many promising new technologies to make urban transportation more efficient and effective still require testing and development and many will require major changes to infrastructure in order to be practical. The personal integrated approach allows a demonstration of more efficient utilization of existing urban infrastructure capacity that holds the promise to greatly reduce user delay and frustration with using the system. This system will improve the safety, efficiency, and sustainability of movement of people and goods in our system within the project time frame.

Our vision includes utilizing the existing Toledo fiber optic signal communication backbone throughout the city (see Figure 1) to link the City's 498 signalized intersections (see Figure 2). This network will be improved as needed and extended into participating surrounding suburban communities. In this way all regional signals can be connected into this region-wide ATCS. The system will link and integrate existing signals to an existing central control location in downtown Toledo (Government Center on Jackson Boulevard). The City's existing central processing capability at this location can be expanded and upgraded per the requirements of this approach. An automated system to analyze and interpret data from intersection and freeway sensors will be developed. This information will be input into signal optimization software systems to update signal timing to maximize efficiency and reduce overall delay and maintain smooth flow and speed of movement. This information can also be input into transit routing software, especially flexible, on-demand systems such as paratransit to optimize routing efficiency real time. In addition this data will be input to routing software to address, in real time, requests from users about alternative ways to satisfy travel demand. Information on "events" and their affect on the system can be directly relayed to system users and can be made available using the internet and mobile applications.

Figure 1: Signal Connection Cable Network – City of Toledo

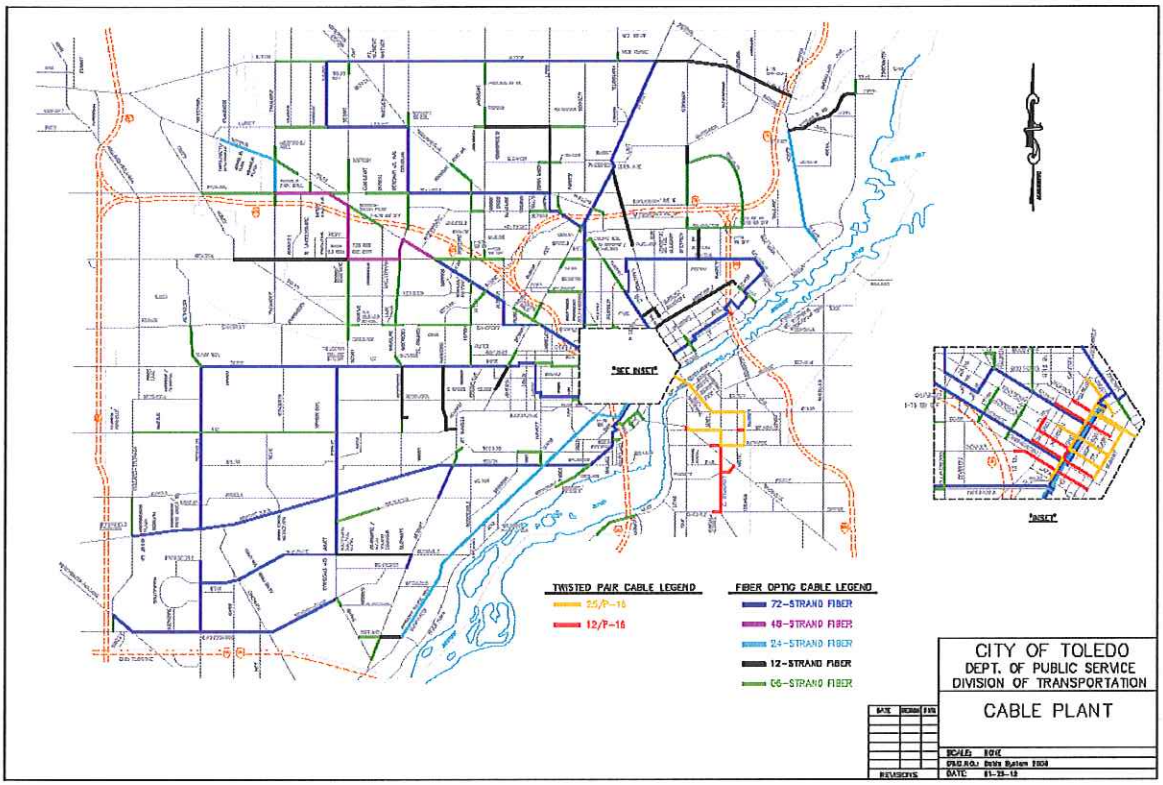
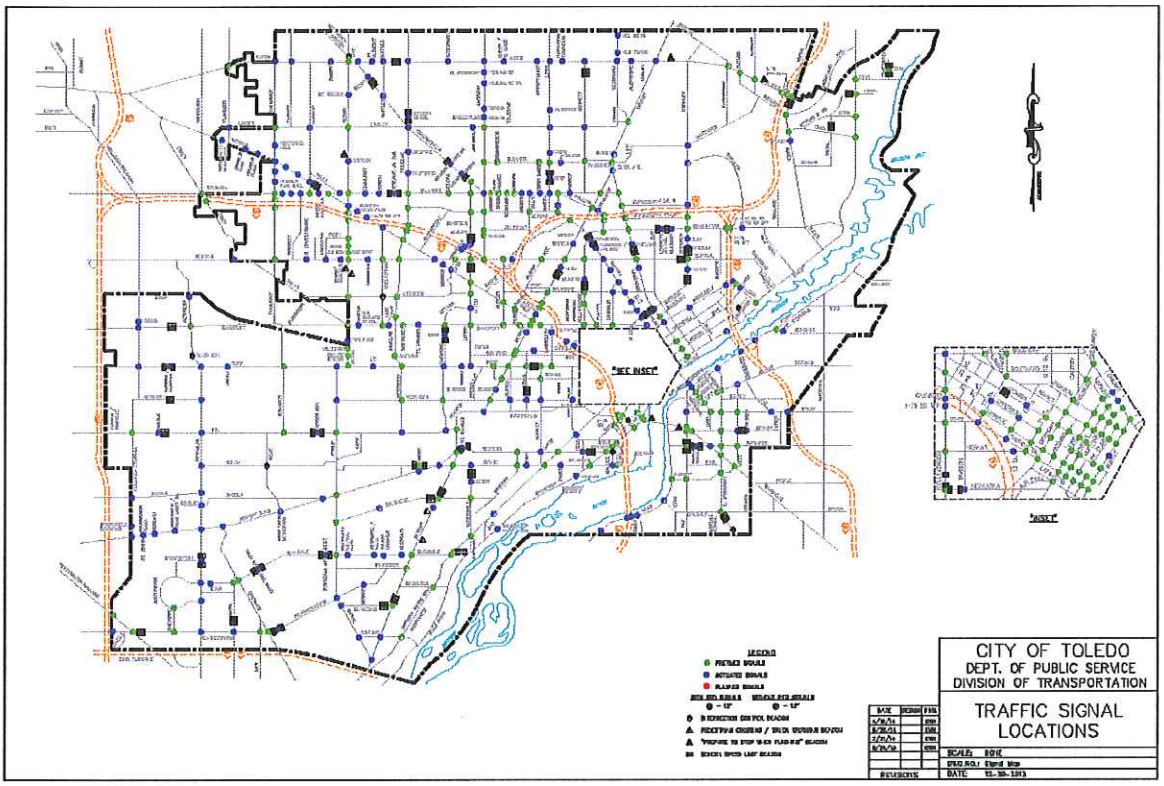
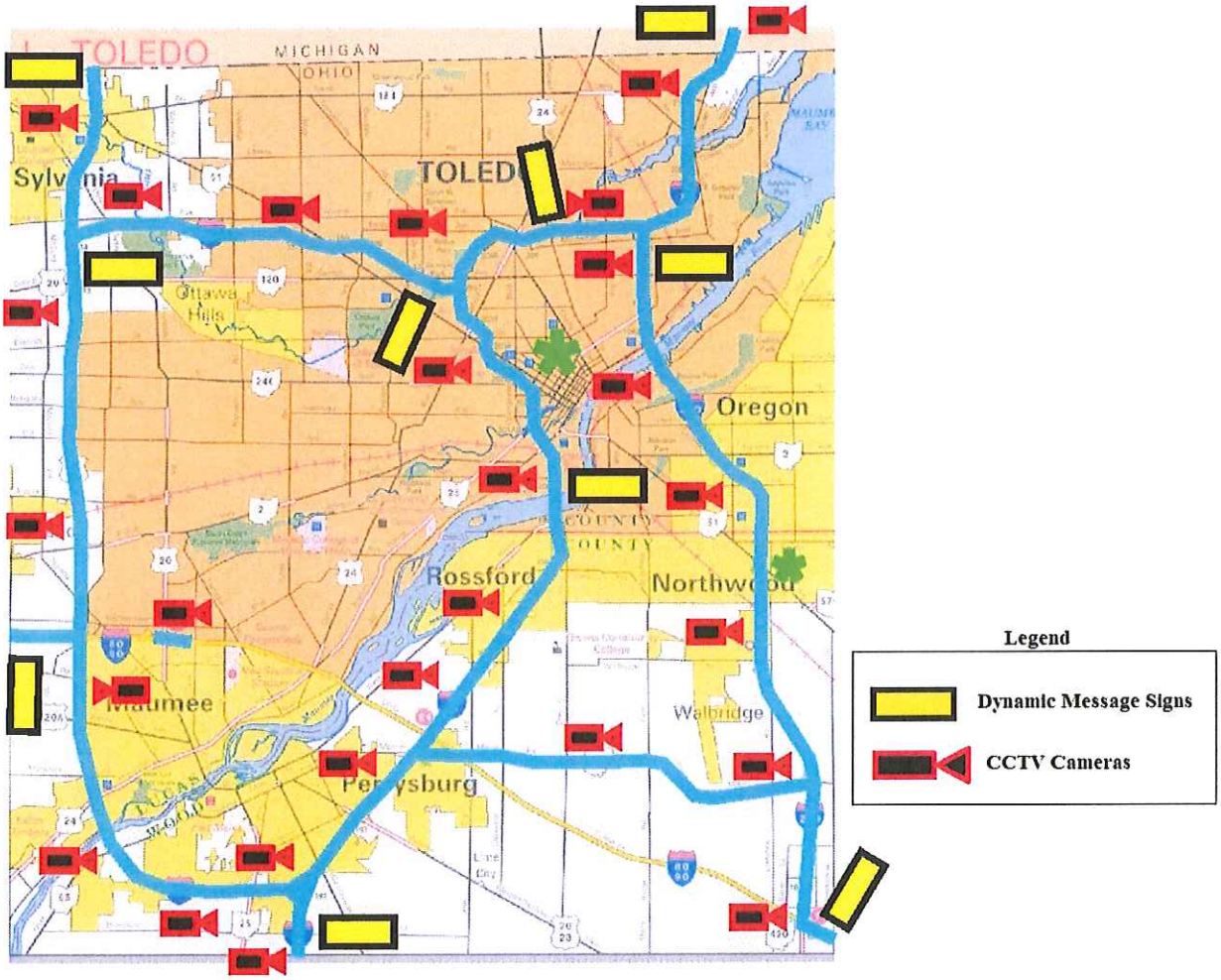


Figure 2: Traffic Signal Locations – City of Toledo



This approach capitalizes on other traffic sensing investments already in place also. The Ohio Department of Transportation (ODOT) has already installed a Freeway Management System in our area consisting of freeway reference markers, Highway Advisory Radio (HAR) – AM 1630, automatic traffic recorders (ATR), road weather information system (RWIS) stations, 10 dynamic message signs, 66 CCTV and web cameras with full coverage of all area freeways, and 60 miles of speed detection with 20 vehicle flow detectors (see Figure 3). The Freeway Management System utilizes commercial internet networks to link these elements to a command center in Columbus Ohio that has management capabilities. An additional feed to this system can be directed to the downtown processing location. Much of the information from the freeway management system is displayed for the general public using ODOT's OHGO.com platform. But there is no link to arterial information to present true travel options to users of the area's transportation system.

Figure 3: ODOT's Freeway Monitoring System CCTV and Dynamic Message Sign Locations



1.3 Implementing Smart City Toledo

The mobility system will be developed and operated by the City of Toledo. The City is currently responsible for Signal control systems and will continue its responsibility for installation and maintenance of signal control systems in the City. Development and implementation of the ATCS elements will be accomplished by our technology partners, leaders in the field of signal control and ATCS with hundreds of corridors already implemented across the US. Integration, analysis and communication software and application development will also be completed by technology partners that are leaders in this area. Processing capability will be provided in a climate controlled secure area already established for this purpose in Government Center in downtown Toledo. Data feeds from the Freeway Management System will come from ODOT over commercial internet connections that serve Government Center. Information from the system will similarly be pushed through the cloud and a mobile transportation application and made available through internet and wireless networks to residents and commercial users throughout the City and region. This app will provide individuals with a single portal to make informed transportation decisions by prioritizing the time efficiency, cost and the carbon footprint of available modes of transportation

The system can be brought on-line in phases. The first phase would be development and small area testing of sensing capabilities at intersections and integration into traffic controllers. Various combinations of hardware configurations can be selected to proof connect and communication technology and results of coordination programs. Systems to receive inputs from transit tracking systems and provide information to transit scheduling software can be tested. Development of integration and route selection software can begin in this phase. Next, development of methodologies to combine signal sensing and freeway sensing into a holistic "picture" of highway system operations and data on speeds, congestion, etc. needs to be completed ("before condition"). Finally, all elements can be brought online and made operational. When fully operational an "after" condition can be measured and evaluated in a completely consistent fashion.

1.4 Summary

Toledo's Integrated Personal Mobility Management proposal is a practical demonstration of innovating urban transportation to achieve results for our residents NOW. It will primarily utilize proven sensor, control and communication technologies in a new and integrated way to optimize performance of existing arterial and freeway capacity and direct users to utilize available capacity that currently goes unused in slightly less direct routings or options to avoid lengthy and costly delays. Information disseminated to users will include modal options and freight information will be available to trucking and drayage companies. This system innovates by utilizing smart technologies to develop information to holistically manage the system and inform users how to most efficiently meet transportation needs.

2. Describe Population Characteristics and Alignment with USDOT Smart City Requirements

The City of Toledo's population and distribution aligns perfectly with USDOT's desired characteristics. The 2010 Census enumeration lists the population within the city limits as 287,208. The City's land area is 80.69 square miles so its population density is relatively dense at 3,559.3 persons per square mile (2010 Census). The City's population is 57% of the overall urbanized area population within its city limits. The city has 61.4% white population with minority populations of 27.2% black, 7.4% Hispanic or Latino, 3.9% two or more races, and 1.1% Asian and is fairly typical of many medium size American cities. Ohio and Toledo are many times utilized by market research and advertising firms as a representation in one compact area of a "typical" cross section of the American public and acceptance of innovation or new products is often tested here.

3. Describe Other City Characteristics

3.1 Existing Public Transportation System - Like most medium size cities in the US Toledo has a public transportation system with a heritage back to early 20th century traction companies radiating from the central business district/core area. The Toledo Area Regional Transit Authority (TARTA) serves the area with a fleet of 174 rubber tire buses serving 43 fixed routes. In addition TARTA provides paratransit services with 76 vehicles in the Toledo Area Regional Paratransit Service (TARPS) fleet to a growing number of disabled riders that cannot used the fixed route system. Daily TARTA ridership is estimated at 13,000 trips with 1,200 TARPS trips. TARTA has recently added a bus "tracking" system that provides real time information on the location of fixed route buses. This real time system information can be directed to the central communication center and added into the personal mobility system information that is provided to residents.

3.2 Environment Conducive to Demonstrating Proposed Strategies – As noted in the vision statement above the proposed system involves linking signal systems, sensors at arterial intersections and on the freeway, analyzing the operations data and the developing and disbursing travel information to the public. The City of Toledo maintains a committed engineering and field staff in its Transportation Division equipped to maintain traffic control and communication technology in the field and work with development staff in developing the signal system elements of the mobility system. Likewise, ODOT technology is also already deployed and supported by two field garages in the metropolitan area.

On the research side, the University of Toledo is a leading engineering school and home to the Intermodal Transportation Institute (ITI), a USDOT University Transportation Center (UTC). The

ITI provides leading researchers to address complex transportation issues and assist in documentation of the results of this demonstration project. The Goals and Objectives of UT-ITI are to:

- Create an internationally recognized center of excellence
- Advance technology and expertise in the many disciplines comprising transportation
- Educate a multi-disciplinary work force
- Attract students, faculty, and staff in undergraduate, graduate, and professional programs
- Enhance diversity in the various fields related to transportation

As relates to connecting citizens, the City of Toledo is already implementing new technology to engage citizens interactively in reporting issues and concerns related to infrastructure. City of Toledo has set up Engage Toledo - See-Click-Fix. This system allows users to report issues in the City, attach specific location and request services. Issues vary from potholes to overgrown grass to abandoned homes. Progress in responding to the concern can be followed by the user, all through their cell phone.

In addition to these elements the Toledo area presents an exceptional intermodal transportation "laboratory" opportunity to apply and demonstrate multimodal transportation strategies. In a medium sized city setting we have all elements of the US multimodal transportation system in place, yet at a scale that is not so complex as to defy having a real and tangible impact on the system. The interaction of various elements of the system is more readily apparent in this setting. Toledo is a crossroads of the Interstate Highway system with a major east-west toll road (I-80/90, the Ohio Turnpike) intersecting a major north south route essential to the manufacturing heartland of the country (I-75, "Auto Alley"). Toledo has a well developed arterial street system with, due to its history, a system of three street grids "colliding" with each other that presents typical grid operations and some challenging angled street systems also. TARTA is a typical transit agency utilizing buses and the street system to serve traditionally denser neighborhoods near the region's core but surrounded by less dense suburban areas. Development challenges typical of the overall US urban scene are present in Toledo with a suburban ring of less dense housing and retail, a declining core with a CBD that is seeing recent growth.

Toledo has an international seaport with both Great Lakes and ocean going vessels making calls. Both major rail companies east of the Mississippi River have extensive networks, yards and facilities in or near the City. Both have intermodal hubs in the area and many typical "last mile" issues are present. The research presence of the UTC presents a ready-made research partner.

3.3 Continuity of Committed Leadership and Capacity to Carry out Demonstration – Our community has a legacy of regional cooperative leadership working together to advance transportation improvements and strategies. TMACOG, our MPO, has taken a strong role in coordinating our leaders and this has resulted in construction of significant major transportation improvements over the past 20 years. Working together Toledo transportation leaders proposed, planned, partnered to obtain funding, developed the project and designed the then largest single project in ODOT history to address capacity and congestion issues in crossing the Maumee River (Veterans' Glass City Skyway). The construction of 22 miles of limited access "Fort to Port Highway" (US 24) in 2012 required a major cooperative effort to see it through from planning to construction. I-75 is being rebuilt through the region to address design deficiencies and bottlenecks that became apparent with time and use.

The University of Toledo ITI initiative began in the mid 1990s with public and private sector leaders working with the University of Toledo to develop a center focusing on transportation, logistics, and supply chain issues. From these cooperative efforts the Intermodal Transportation Institute was created in 2001 and began formal operation in 2002. The vision of the UT-ITI is to develop technology-enabled intermodal transportation systems and supply chains that promote economic development and quality of life.

Another example of strong committed local leadership in transportation is the Toledo Region Transportation Legislative Agenda. Since 2001, the Toledo Region Transportation Legislative Agenda has been a way to communicate with lawmakers at all levels in one consistent voice. The purpose of the agenda is to promote policies that are consistent with the locally identified needs of the Toledo region, especially as presented in the region's Long Range Transportation Plan. It deals with all the modes we use for moving people and goods including air, rail, and marine transport, highways, streets, and bridges, public transportation, and bike and pedestrian travel.

The agenda is produced and endorsed by a group of 17 stakeholder organizations called the Toledo Region Transportation Coalition. These are highly engaged members with a deep understanding of the connection between transportation and regional economic advancement. They share their perspectives and priorities on a continuous basis and every two years they combine efforts to produce a document for legislators. The consensus view that is reflected in the agenda enables all these different coalition members to speak with a unified voice for the resources and policies that will enable our region to grow. Coalition members are:

- City of Bowling Green
- City of Toledo
- Lucas County Economic Development Corporation (LCEDC)

- Lucas County Engineer
- Northwest Ohio Mayors & Managers Association (NOMMA)
- Northwest Ohio Regional Economic Development Association (NORED)
- Ohio Contractors Association-Northwest Ohio Chapter (OCA)
- Regional Growth Partnership (RGP)
- Toledo Advocacy Group of Northwest Ohio (TAGNO)
- Toledo Area Regional Transit Authority (TARTA)
- Toledo-Lucas County Port Authority (TLCPA)
- Toledo Metropolitan Area Council of Governments (TMACOG)
- Toledo Regional Chamber of Commerce
- Toledo Trucking Association (TTA)
- Intermodal Transportation Institute and University Transportation Center of the University of Toledo
- Wood County Economic Development Corporation (WCEDC)
- Wood County Engineer

3.4 Commitment to Integrating with the Sharing Economy – As the demographics of the City's urban core shift towards a younger age group, the sharing economy is becoming increasingly important, both as an economic driver for this group, and as a preferred means of transportation for this region of the City. Currently, the Toledo area has ride services such as UBER and non emergency medical transport through Need a Ride. These services are available throughout the region. The University of Toledo has an on-going Bike Share Program, "Rocket Wheels." UT students use their college identification cards to use bikes throughout the campus area and return them to one of three "corral" locations located through the campus area. As a part of the City's vision, we plan to integrate and consolidate all available shared transportation options into a mobile transportation application. This app will provide individuals with a single portal to make informed transit decisions by prioritizing (1) the time efficiency, (2) the cost, and (3) the carbon footprint of available modes of transportation

3.5 Commitment to Open Accessible Data Usable by the Public – One of the most tangible elements of the commitment of the Toledo area's leadership to open accessible data is a new venture just launched by the Jack Ford Urban Affairs Center at the University of Toledo called BizView. BizView is an online data and consulting resource developed by the center. Developed in cooperation with local partners BizView provides a cloud-hosted resource that allows all user to access, inspect, depict and retrieve economic and statistical data specific to the Toledo area and surrounding communities. Small and large businesses, developers, agencies and other community stakeholders find BizView invaluable for economic planning and development, academic and applied research, policy development, forecasting and a host of

other applications. In addition to a highly user friendly resource users can call for professional expertise and support from center staff.

Resources to fuel entrepreneurship and innovation also include a privately led development group, the Regional Growth Partnership. RGP provides data and information on development initiatives and assists business start ups. Their affiliated Rocket Ventures, LLC provides investment funding and no cost business assistance services to northwest Ohio companies with innovative technologies and novel business concepts. Since 2007 Rocket Ventures has assisted client companies in achieving over $300 million in sales revenue, investments and other income.

4. Site Map

See next full page.

5. Describe alignment of Smart City Toledo with 12 USDOT Vision elements

5.1 Vision Element #1 – Urban Automation – The integrated mobility system utilizes direct input from traffic sensors to develop real time signal timing to optimize traffic control. This automates a cumbersome lengthy process of obtaining traffic data and developing traditional time of day traffic signal timing plans for corridors or individual intersections. Automating this process allows for real time changes in traffic control with significant impact on the efficiency and safety of the system. Additionally, direct notification of system conditions to users eliminates current reliance on human generated incident reports or user calls to radio/television stations or other information outlets and dissemination via broadcast media. These reports are often incomplete, do not provide alternate routing and do not include real time updates (". . . not sure if that's cleared up yet so better avoid the area . . . " on the local traffic update report).

5.2 Vision Element #2 – Connected Vehicles – As vehicle connectivity reaches broad adoption and more deeply integrated capabilities develop over the next decade, a key element will be a vehicle's ability to communicate with elements of the transportation infrastructure, in addition to nearby vehicles. This V2I communication capability will allow the City to explore: (1) new models for traffic management and vehicle prioritization; (2) new economic models to both reduce Vehicle Miles Travelled (VMT) and raise revenue to offset system investments through perhaps tolling (a city "street use fee") or congestion charges in the urban core; and (3) new public safety applications by leveraging License Plate Recognition (LPR) in child abduction and other law enforcement scenarios. This will all be enabled through implementation of an ATCS now that is integrated with other systems across the City – enabling the foundation of a true smart city transportation platform

Integrated Mobility System Strategy

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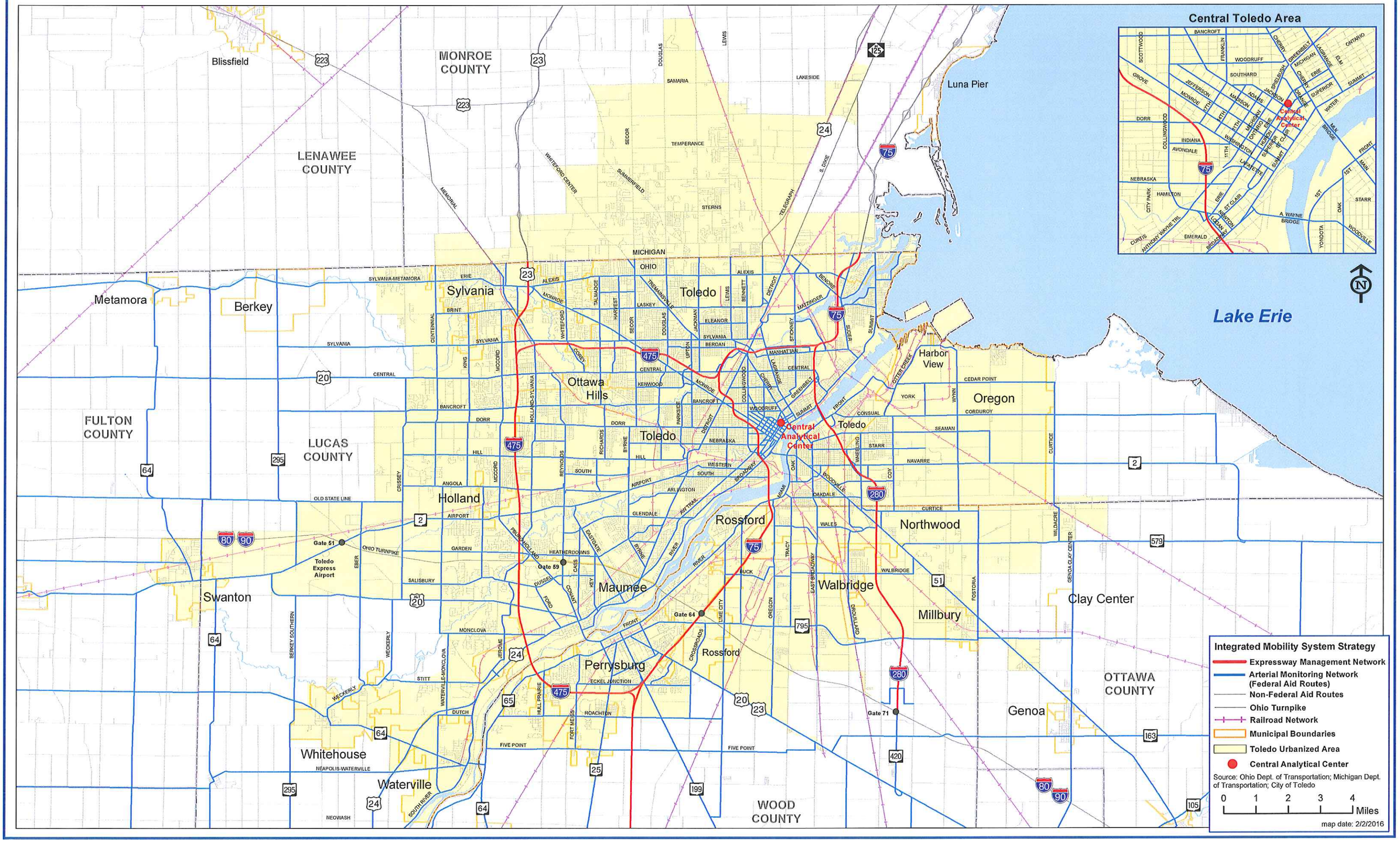

5.3 Vision Element #3 – Intelligent, Sensor Based Infrastructure – The integrated mobility system is primarily a demonstration of utilizing arterial and freeway sensor based systems connected in an new holistic and innovative way to signal control systems, analytical systems to provide real time information on mobility choices and communications technologies to get this information directly to the user. What has been missing in previous applications of intelligent sensor based systems in the holistic approach to provide feedback to control systems and users to improve the overall efficiency of the urban transportation system. The integrated mobility system provides that capability.

5.4 Vision Element #4 – User-Focused Mobility Services and Choices – As noted above developing and utilizing technology to provide real time mobility information and choices to system users is an essential element of the integrated mobility system proposed in Toledo.

Working with technology software partners, data available from infrastructure sensors and service providers will be gathered and integrated to present a holistic status of the system and available services. This date will then be analyzed, translated into real time mobility information on time and cost, and then presented to users in an easily accessible and easy to use format. This should provide real choice to users based on real time information and with real tangible and specific information on how to access and use various modes in an efficient manner to satisfy transportation needs.

5.5 Vision Element #5 – Urban Analytics – The integrated mobility system will provide solid information on system utilization and performance as a by –product of its day to day operation. The data utilized by the system can be stored and provide a first true time based data set on overall operation of the system. Performance data can be utilized to analyze delay, real world detour routing by system users, information on requested origin destination pairs requested by system users and many useful indicators of demand, capacity and performance of the urban transportation system.

5.6 Vision Element #6 – Urban Delivery and Logistics – The freight delivery component of the system would utilize data on real time performance of the system and combine it with delivery capacity and scheduling requirements to improve overall performance of delivery and logistics to major transportation hubs. Existing technologies have been developed for individual freight hubs but never integrated into a system that links real time performance of the overall system with individual hub needs. Delays on the highway system can factor into demanded delivery windows at major freight hubs to provide direction to trucking and drayage companies.

5.7 Vision Element #7 – Strategic Business Models and Partnering – Already in developing just this vision narrative, industry leaders in ATCS have established contacts and are partnering with industry leaders in systems integration and software development to explore the concept and to support the integration of ATCS with overall sensor based systems to provide real time information about urban mobility. Deployment of this system will cement this business model, demonstrate its capabilities and efficacy, and provide a template for how to do this across the nation.

5.8 Vision Element #8 – Smart Grid, Roadway Electrification and EVs – The integrated systems approach does not address this vision element directly.

5.9 Vision Element #9 – Connected Involved citizens – The Integrated system proposed places real time accurate data on system operations into the hands of every citizen. Combined with analytics made possible by data collected for operation of the system every citizen has information on delays in the system, information on modal options and how to use them and their direct costs, and direct information on non-recurring events and their impact on the system.

5.10 Vision Element #10 – Architecture and Standards – Much of the development effort required for this proposal will center on developing communication protocols and connections between existing management technologies (ATCS and Freeway) and information development and communication/dissemination systems to users. This will require an overall system architecture that will have to be consistent with the area's ITS systems architecture developed by TMACOG. Utilizing existing systems but developing the architecture of communication from sensors to the analytical center and from the center to methods of dissemination of information will be a primary task.

5.11 Vision Element #11 – Low Cost, Efficient, Secure and Resilient ICT – Although a smart city system is in reality a "system of systems," the key to creating value is to approach ICT from a shared systems perspective to ensure that the system is optimized, resilient, and secure. The City's vision in implementing this common system platform involves a three step approach, based on best practices across IT, government, and construction industries:

1. Connect your assets, secure and deliver the data;
    - Connecting new and legacy assets over a single shared-use hybrid network,
    - Cyber and physical security is an issue TODAY,
2. Interpret, analyze, and share a common dataset;
    - Enterprise Service Bus (ESB) layer that can integrate data across legacy, current, and future systems,

- Select an analytics platform to enable easy information sharing and analysis across departments,

3. Present, collaborate, and converse with flexible applications;
   - Smart city system integration is a cross department initiative that requires a broad technology expertise,
   - Deploy a mobile platform to create a two-way conversation with the public and city employees.

5.12 Vision Element #12 – Smart Land Use – The mobility system affects this element only indirectly in that real information on mobility allows system performance to be part of location decisions for residents.

6. Identify Key Technical, Policy and Institutional Risks and Plans for Mitigating Those Risks – Technical risks include: problems with installation/compatibility of existing sensor and control technology with those necessary for the ATCS function; integration/analysis of sensor data to identify crash or other non-recurring events; integration of sensor data with route assignment systems; integration/geo-coding of requests for travel information. The City of Toledo intends to work with respected industry leaders in the field of ATCS design, routing and operations software, and a renowned software integration engineering firm. Installation work can be performed with contract staff and if need be initial contract schedules and replacement functions can be modified as needed to complete the timely installation of the system.

Policy and institutional risks include addressing different jurisdictional responsibility for signals and controls; allowing cross jurisdiction signal control; liability for operation of the signal systems. The Toledo area has some limited experimented with corridor coordination of signal control but this work will need to be upgraded to allow full automation. If these barriers prove insurmountable the approach can be focused in on just the portion of the system under the direct control of the City of Toledo. While not providing full coverage the coverage of this system would address a large coverage of overall daily travel of the region.

7. Outline Team Partners, Key Stakeholders and Governance

Overall project management: City of Toledo – The City of Toledo has two Divisions focused on major transportation system improvements and traffic engineering and signal systems. Engineering Services Division would be tasked with overall project management/coordination and procurement and contracting of services with outside technology and research partners for the demonstration project. If selected a separate project manager assigned exclusively to this project will be hired. The Transportation Division would oversee signal and control technologies including installation of the signal technology and sensor communication and the

ATCS. A signal engineer will be assigned specifically to this project and working with our ATCS technology development partner to implement the system. In both Divisions other staff capabilities can be utilized and brought to bear on the project as needed.

Research/Documentation Partner: The University of Toledo (UT) – The UT Intermodal Transportation Institute (ITI) is a University Transportation Center (UTC) funded through the USDOT. The ITI is housed in the College of Engineering and utilizes all the resources of the university to apply technical expertise to transportation challenges. Advanced researchers in civil, electrical and computer engineering, as well as geospatial systems, business and communications technologies are available to team with the City of Toledo through the UT ITI structure. ITI at UT will be an essential partner in developing the mobility system.

Freeway Management System and Suburban Signalization Partner: Ohio Department of Transportation – ODOT has made significant investments in the Freeway Management System in the Toledo area and is responsible for traffic signal control at many intersections along several corridors in suburban areas surrounding the City of Toledo. They have signal and control expertise and experience both in District 2 offices in Bowling Green, Ohio and in Central Office in Columbus, Ohio. ODOT is another essential partner in developing the system.

Transit Services Partner: Toledo Area Regional Transit Authority (TARTA) serves the City of Toledo and much of the urbanized area with fixed route and on-demand paratransit public transit service. TARTA has implemented bus tracker and other mobile apps to improve services to transit riders in the area and information on routes and travel time will be essential elements of the mobility system. See their attached letter of support.

Suburban Signal Systems Partners: Cities of Maumee, Northwood, Oregon, Perrysburg, and Sylvania are responsible for signal systems on arterial and collector routes. The Lucas County and Wood County Engineers' offices are responsible for non-state route arterials in unincorporated areas surrounding Toledo and suburban Cities. Partnering to incorporate these systems will strengthen the effectiveness and expand the coverage of the mobility system.

Technology Development Partners: The following Technology firms have expressed their interest in and support of the Toledo mobility system proposal and would be partners to address technology challenges. These firms would be under contract with the City of Toledo:

System Integration/Programming/ATCS Technology: Leidos, Inc. / Rhythm Engineering – Leidos is a leading technology developer and provider with a proven record of innovation in national security, health and engineering. Their scientists and engineering professionals have developed

software and hardware solutions related to power grid and smart grid distribution systems, systems integration, communications network design, audio video and visualization technologies, physical and cyber security systems and many others. They have partnered with an industry leader in adaptive traffic control system technology, Rhythm Engineering, in support of developing the integrated mobility system proposed for Toledo. Rhythm developed the In|Sync ATCS currently deployed on over 350 corridors in more than 140 cities in 31 states across the U.S. See their attached letters of support.

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ATCS Technology/Simulation: Trafficware, Inc. – Trafficware is an industry leader in transportation simulation software and traffic control systems. The SynchroGreen adaptive traffic control system was designed by Trafficware. They have a proven track record in development of the Synchro intersection modeling system to analyze real time intersection performance. See their attached letter of support.

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Mobile Application Developer: Civic Resource Group - Civic Resource Group (CRG) is one of the world's leading technology providers of Mobile/Data/Cloud products for governments and the broad public sector around the globe. CRGI delivers highly secure digital solutions that touch every facet of citizens' lives. By leveraging the award-winning and first-of-a-kind CivicConnect ™ Mobile/Data/Cloud platform, and deep domain expertise, CRGI has delivered impactful, engaging and

cutting-edge solutions that facilitate openness, transparency, safety and efficient service delivery for governments at all levels, public sector agencies and constituents. See their attached letter of support.

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Key Stakeholders – In addition to team partners key stakeholders include:

MPO: Toledo Metropolitan Area Council of Governments (TMACOG) – TMACOG has developed and maintains the ITS System Architecture for our region and will be a key stakeholder related to implementation and evaluation of the mobility system. See their attached letter of support.

8. Describe Existing Transportation Infrastructure and System Features

8.1 Arterial & Collector (fed. aid) Lane/Center Line Miles - 1,838 / 655 - urbanized area (Ohio);
Arterial & Collector (fed. aid) Lane/Center Line Miles - 914 / 268 - City of Toledo.

8.2 Freeway & Expressway Lane/Center Line Miles - 383 / 81 - urbanized area (Ohio);
Freeway & Expressway Lane/Center Line Miles - 111 / 20 – City of Toledo.

8.3 Transit Services: Toledo Area Regional Transit Authority – 174 buses; 43 fixed routes, 13,000 daily trips.
Toledo Area Regional Paratransit Service – 76 buses; call a ride for disabled users; 1,200 daily trips.
Perrysburg Transit, Call a Ride (24 hour in advance) – 3 vans; ride service within the City of Perrysburg.

8.4 Shared Use Mobility Services: Active UBER system; UT Bike Share Program.

8.5 Information and Communication Technology (ICT) – full wireless coverage of region by all major wireless communication providers; fiber optic signal control network with nearly full coverage of all City signals (see Section 1.1 for description).

8.6 Intelligent Transportation Systems (ITS) – Freeway Management System with full speed sensor coverage, weather system, CCTV coverage and dynamic message signs (see Section 1.1 for more detailed description).

8.7. Smart Grid Infrastructure – Public charging stations downtown on St Clair Street.

9. Define the Data Your City Currently Collects, Describe How Data Will Be Integrated, Existing Policies, Partnership Agreements for Data Sharing – The City of Toledo currently collects traffic operations data for streets and intersections within its jurisdiction. This includes daily and turn counts, level of service information for intersections and signal timing plans. Traffic signal sensors and actuation are available at many locations in the city and this data is utilized at the intersection level but is not available for use for other purposes.

TMACOG maintains regional data systems available to the City to monitor system performance of all arterials and freeways as this is an important component of comprehensive transportation planning. This includes maintaining a regional traffic count database system available on line (http://tmacog-all.ms2soft.com/tcds/tsearch.asp?loc=Tmacog-all&mod=), a transportation safety (high accident) database and multi-year analyses on line, congestion management process and report with data on congestion locations and operation as well as information on physical condition of bridges and pavements.

ODOT maintains a full inventory of streets and roadways and maintains similar information as TMACOG available on line through a very user friendly connection, the Transportation Information Mapping System (TIMS portal - https://www.dot.state.oh.us/Divisions/Planning/TechServ/Pages/tims.aspx). In addition ODOT has direct links to all signals within its jurisdiction, links to freeway management surveillance and sensing systems and weather systems. The Ohio Department of Public Safety maintains a statewide safety reporting system with accident reports and crash data available for all streets and roadways in Ohio.

Some of the data sources above are publicly available and will be useful to the project team to assist in design of the mobility system elements. However, traffic signal and traffic sensor based data is now routinely only communicated within each jurisdiction's traffic control system and there is concern that sharing this data may somehow affect operation or affect maintenance of signals or liability for malfunction. The revolutionary element of data use in this mobility system is the holistic vision of bringing these disparate data and sensing systems together to optimize control and provide real time travel information to system users. In effect

all signalized intersection sensors, the freeway management system sensors, the bus tracking capabilities and other elements are linked together and become real time data input on speeds, delays and operation of the overall system

One element of system development to be demonstrated with this project is overcoming these institutional "silos" and bringing data and control of signal systems together for a comprehensive picture of system operations and for system optimization. We do not envision operation of this system to modify any of the jurisdictions' responsibility or liability for signals and controllers but to allow sharing of information and control protocols for optimization and real time operations data. Our technology partners will have to develop the communications hardware and software to allow different controller technologies to "talk with each other" and work together. Fail safe mechanisms are to be part of system development that at any time any jurisdiction could "uncouple" from the system and control their own traffic control at their option should an unanticipated problem develop. Partnership agreements will also need to be forged to address this concern.

Data from all sources will be collected through existing telecommunication channels (much like ODOT's Freeway Management System provides information from our area to the control center in Columbus). The data will be brought together and "assembled" at Government Center in downtown Toledo. Information will be analyzed using software systems developed for ATCS and signal adjustments communicated to intersection controllers. Information will also be distributed and subsequently analyzed by other analytical and decision algorithms integrated into the system to provide real time information on operations. This operations information will be communicated to general system users directly if a non-recurring event of a significant nature occurs. This information will also be input into and affect determination and description of travel options for users. When users query the system for information and seek recommendations on travel mode and routing for their particular trip the response will be informed by this real time operations information.

Partnership agreements will include terms and conditions that dictate communications protocols and architecture and protect access to sensitive elements of the traffic control system. Appropriate firewalls and protections will be incorporated into the systems to limit exposure to intrusion from hackers or other general access. The entire central processing system will be maintained as part of the commitment of the City of Toledo to maintain its signal system.

Most all operations data envisioned for evaluation of performance of the system are public information sources and there should be no restriction on use.

10. Existing Standards, Architectures and Certification Processes for ITS – TMACOG developed and maintains the existing ITS Architecture for the region. Our technology partners will use this architecture and provide feedback as appropriate on desired modifications or updates.

11. Measureable Goals and Objectives - This system will operate within the purview of the existing national and regional transportation planning process. TMACOG's 2045 Regional Transportation Plan highlighted that these planning processes:

> . . . had previously defined seven goals for the transportation system: 1. Safety – Achieve a significant reduction in traffic fatalities and serious injuries on all public roads; 2. Infrastructure Condition – Maintain the highway infrastructure asset system in a state of good repair; 3. Congestion Reduction – Achieve a significant reduction in congestion on the National Highway System; 4. System Reliability – Improve efficiency of the transportation system; 5. Freight Movement and Economic Vitality – Improve the National Freight Network, strengthen the ability of rural communities to access national and international trade markets, and support regional economic development; 6. Environmental Sustainability – Enhance the performance of the transportation system while protecting and enhancing the natural environment; and, 7. Reduce Project Delivery Delays – Reduce project costs, promote jobs and the economy, and accelerate project completion through eliminating delays in the project development and delivery process."

We propose these as goals for our demonstration. Implementation of this system directly affects operation of the city's and the region's transportation system to assist in achieving all of these goals directly with the exception of #7. As relates to Goal 1, the Mobility System will "smooth out" and improve traffic flow and also reduce congestion, especially related to non-recurring events. Research shows that congestion, especially at unexpected locations, is directly related to traffic crashes. Traffic signals and frequent stops from poorly timed signal configurations leads to driver frustration and signal violations. These conditions cause accidents. By smoothing the flow of traffic with continuously updated traffic progression for all arterial streets these crashes should be reduced.

Upgrading signal control will improve the condition of this vital transportation infrastructure element in our region thus helping to reach Goal 2. Traffic optimization along arterial streets will address the leading cause of congestion in medium sized cities such as Toledo as was discussed above (Goal 3). Advanced signal control and real time communication with users will greatly improve system reliability and approach Goal 4 from an innovative and fresh perspective – provision of information on roughly equivalent options to fulfill the needs of users

of the system. Reliability is negatively affected by not having critical information on system performance early in the trip making process (as you leave your home or starting location). By filling this gap the system delivers a new kind of reliability – satisfying travel need with several options based on real time information.

Freight movement occurs primarily on the highway system. The mobility system improves highway operation and provides additional real time information to trucking and draying firms – the availability of docking space and unloading windows at major facilities. This strengthens the freight system and provides real time reliability for delivering of goods (Goal 5). For Goal 6 the mobility system will greatly reduce one of the largest contributors of green house gases from the transportation system – wasted fuel consumption idling at signals unnecessarily due to fixed time of day signal timing plans only revised very infrequently.

Using this general framework we would propose the following specific measures: 1. Reduce overall number of crashes on the system; 2. Reduce the extent of congestion (travel delay) from accidents and other non-recurring events; 3. Reduce the duration of congestion (travel delay) in our area; 4. Reduce the number of stops along major arterial corridors in the region before and after system implementation; 5. Reduce overall travel time on the system (arterial and freeway) for select travel pairs before and after system implementation; 6. Complete installation of traffic detection at all signalized intersections; 7. Number of system users requesting travel information on a typical weekday; 8. Number of freight facilities utilizing the freight delivery element of the system; and, 9. Estimated reduction in greenhouse gases (model based) after implementation of the system.

12. Evidence of Capacity to Take On a Project of This Magnitude – the Toledo region has a strong transportation project management capability as demonstrated by many successful major projects completed over the past few years. The Veteran's Glass City Skyway was, at the time of its completion, the largest single transportation project completed in Ohio. Major reconstruction of the Interstate System in the area is ongoing. Various projects including innovative multimodal improvements to the Port of Toledo were accomplished under the federal stimulus program – TIGER including major updates of freight handling capabilities at The General Cargo Terminal and Ironville Terminal.

The City of Toledo is a certified local public agency (LPA) for delivery of projects within the City. To maintain this ODOT and FHWA designation the city maintains an engineering staff familiar with federal regulations and development requirements. Innovative gateway and corridor projects (with installation of multiple roundabout intersections) have been accomplished in the past several years. The UT ITI maintains its status as a University Transportation Center (UTC)

managing multiple research programs under USDOT auspices and regulations. A strong partnership of research expertise, project development and management experience have resulted in delivery of major transportation improvements in this region and point to our capacity to take on a major project such as the mobility system.
In addition the City plans to engage the assistance of an experienced System Engineering & Integration (SE&I) firm that specializes in smart city and transportation projects. By definition smart city initiatives span across multiple stakeholders and across a multitude of systems that are in place today. A system level approach is required to understand and anticipate the connectivity, interoperability, and security opportunities and challenges inherent in a smart city project.

Our supporting partner Leidos Engineering is a trusted and future-focused solutions provider that specializes in technology intensive infrastructure programs for all levels of government. Leidos has been a thought leader in the smart city planning and SE&I space. Together we have a comprehensive program approach that maximizes the value to all stakeholders with risk and cost optimization components. This approach was presented as a part of Smart City Week where the White House funding for this Challenge was originally announced.

13. Describe Opportunities to Leverage Federal Resources – The City of Toledo's existing signal system provides a large portion of the costs necessary to demonstrate this innovative concept through the mobility system and represents a huge in kind contribution to the project. Even if system requirements require replacement of a substantial portion of controllers and control technology the City has provided and remains committed to providing the very costly and necessary physical infrastructure for the signal systems envisioned. Poles, masts, heads, and most control boxes will utilize existing infrastructure and all be provided by the City of Toledo. Most all of the fiber optic network required for the system is already in place and will provided by the City of Toledo. A control area will be provided by the City of Toledo.

Likewise the Freeway Management System and arterial signal systems have already been installed by ODOT. Likewise the ODOT commitment to this system means that this critical portion of the system will be provided into the future. Speed sensors, CCTV cameras, and other elements of the freeway system will be available for the system.

There may be other opportunities to leverage federal resources in working with vendors of systems anxious to be part of the USDOT Smart City Challenge, also. The example of Mobileye's commitment to partner with the transit provider in the selected smart city is illustrative. Other opportunity to demonstrate systems more directly related to the Integrated Personal Mobility System proposed in Toledo may surface as the proposal develops.