University of Washington Subarea

Multimodal Integrated Corridor Mobility for All (MICMA)

VOLUME 1
TECHNICAL APPLICATION

Grant Application:

Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Initiative

NOFO 693JJ317NF0001

Submitted June 12, 2017

Ed Murray, Mayor

Scott Kubly, Seattle Department of Transportation (SDOT) Director

Seattle Department of Transportation

Project Name	Multimodal Integrated Corridor Mobility for All
Eligible Entity Applying to Receive Federal Funding	**City of Seattle Department of Transportation**
Total Project Cost (from all sources)	**$17,147,000**
ATCMTD Request	**$4,091,000**
Are matching funds restricted to a specific component? If so, which one?	Cash matches from SDOT and WSDOT are not restricted. Soft match from private sector partners are restricted to their specific components: • ***Siemens*** soft match is restricted to adaptive control software development and controller firmware development • ***Sensys*** soft match is restricted to GiveMeGreen bicycle X-to-I software and android app development • ***Verizon*** soft match is restricted to implementation of Mobility as a Service kiosks and Verizon wireless network improvements
State in which the project is located	Washington
Is the project currently programmed in the: • Transportation Improvement Program (TIP) • Statewide Transportation Improvement Program (STIP) • MPO Long Range Transportation Plan • State Long Range Transportation Plan	The SDOT funds are currently programed in SDOT's 3-year plan, and are local funds. WSDOT funds are part of the SR 520 project, and are programmed in the : • TIP: Puget Sound Regional Council 2017- 2020 TIP • STIP: WSDOT 2017-2020 STIP • MPO Long Range Plan: PSRC Transportation 2040 Long Range Plan • State Long Range Transportation Plan: Washington Transportation Plan 2035
Technologies Proposed to Be Deployed (briefly list)	• Traffic signal system upgrades, detection, communications network, CCTV and DMS • Passive pedestrian detection and pedestrian demand-based signal timing • Bicycle detection (V-to-I), traffic signal response, and mobile application • Green Wave for emergency vehicles • Integrated Corridor Management solutions for freeway incidents • Mobility- as-a-Service software and kiosks • Detection and analytics platform to enable adaptive traffic signal control

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2.Project Description

The following provides a description of the Multimodal Integrated Corridor Mobility for All (MICMA) project, proposed for deployment in the University of Washington (UW) subarea of Seattle.

2.1. INTRODUCTION

The MICMA project will create an urban arterial operations environment that is responsive to all modes, and all travelers, at all times.

The Challenge

The UW subarea is shown in *Figure 2 (page7)* and characterized by:

- *High pedestrian and cyclist volumes and higher than average crash occurence.*
- *Traffic and pedestrian surges due to university operations and events at the many venues at the UW, including the 72,500-person capacity Husky Stadium.*
- *Traffic disruptions due to moveable bridge operations, and incidents on freeways that bound the west and south of the subarea.*
- *Pedestrian surges at rail stations.*
- *The presence of major employment, education, and health centers, with disadvantaged and disabled persons needing access.*
- *Two emergency rooms (ER), and increasing emergency medical responder travel time*

The Texas Transportation Institute (TTI) ranks Seattle as having the 5th most expensive cost of congestion in the nation- estimated at almost $1500 per commuter, with TTI's Travel time index placing Seattle at the 3rd worst in the U.S.

Forbes ranked Seattle as #4 in its list of fastest growing cities. The UW subarea reflects this growth with increased traffic for all modes, increased risks and conflicts and increased congestion. An array of mode choices has been introduced in the UW subarea, but there remains a need to better integrate and manage them – and this issue is not unique to Seattle.

MICMA – The Solution

The MICMA project will leverage and enhance Intelligent Transportation System (ITS) and Mobility-as-a-Service (MaaS) platforms to create a multimodal operations environment that responds to all users. As shown in *Figure1*, MICMA provide systems that:

- *Allow traffic signals to respond, in real-time, to pedestrian volume demand.*
- *Allow traffic signals to respond, in real-time, to bicycle travelers.*
- *Improve emergency vehicle travel time to the two ERs in the subarea by implementing a Green Wave approach – setting signals to green downstream to clear traffic on the path to the ER.*
- *Integrate freeway data with arterial traffic signals to develop arterial timing plans that respond to freeway incidents, and integrating freeway and arterial travel time data to provide alternative route travel times to drivers.*
- *Provide Detection-as-a-Service approach to implementing detection that enables adaptive traffic signal control and arterial travel time calculation.*
- *Add real-time bicycle travel times to the MaaS platform to improve trip bundle choices.*
- *Enhance the MaaS platform to include barriers to disabled persons (stairs, steep grades, etc.) and wheelchair-accessible taxi service in the MaaS single point of payment and trip planning service, enhancing disabled person's mobility.*

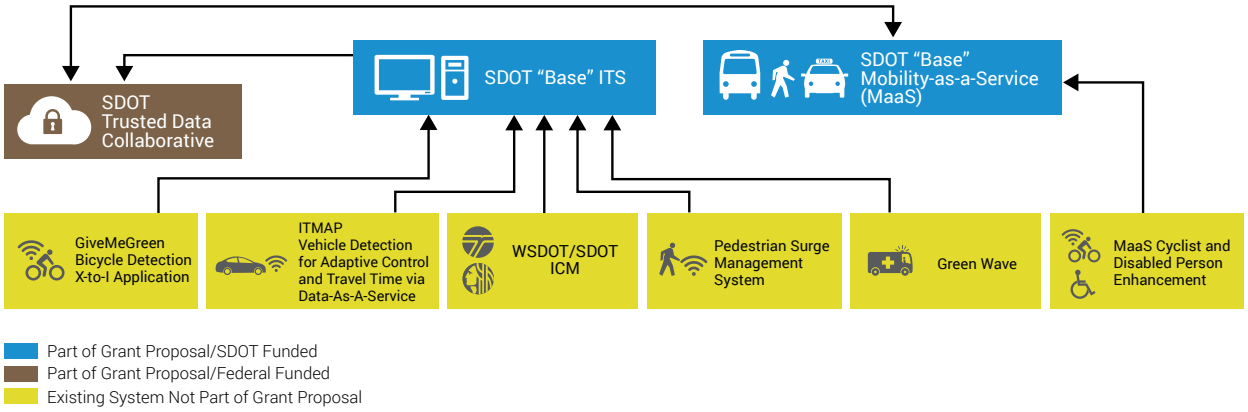

Figure 1: The MICMA Components

2.1.1 The MICMA Components

SDOT-Funded Base ITS. The Seattle Department of Transportation (SDOT) has programmed funds to install systems to address the major and unpredictable congestion in the University of Washington subarea. Core systems to be installed are:

- *Traffic signal system upgrades, including full detection and actuation for vehicles, bicycles (on designated bike corridors), and pedestrians at 25 intersections*
- *Upgraded traffic signal control at 8 intersections*
- *Transit Signal Priority (TSP) for queue jumps and early green operations (upgrade to existing systems)*
- *CCTV cameras for operation management and incident monitoring and detection*
- *Bridge opening detection*
- *Travel time detection*
- *DMS to post incident, event, and travel time messages*

This package of technologies is the basic set that SDOT implements across Seattle in locations with unpredictable congestion. Indeed, SDOT has been successfully implementing and operating all of these technologies for more than a decade. Adaptive signal control is the latest tool activated successfully by SDOT in February 2017.

SDOT-Funded MaaS. SDOT also has funds in place to develop requirements and implement (via a private vendor) a Mobility-as-a-Service (MaaS) mobile/personal computer application. The MaaS system leverages the already available Trusted Data Collaborative (TDC), which houses public and private sector data that will serve as the foundation of the MaaS services. The MaaS will integrate mobility options from different providers and provide a single point for multimodal trip planning and payment.

These two elements form the foundation of this grant proposal, and are fully funded using existing SDOT and partner funds. The TDC has already been implemented.

Why SDOT Is Seeking This Grant

The purpose of this grant application is to enhance the base set of technologies to provide innovative functions – indeed many "1st in the US" – needed in the UW subarea, across the City of Seattle, and across the US. These operations enhancements will enhance multimodal mobility and operations, including for underserved and disabled populations. Specifically, there are 6 proposed enhancements:

▶ Pedestrian Surge Management via demand-based detection and signal timing.

Install new passive pedestrian detection technology at locations where pedestrian surges occur – including at rail transit stations and near event venues. The technology proposed will not only detect pedestrians, but will count pedestrians. The traffic signal operations software will be modified to accept the pedestrian count input, and to allow for pedestrian crossing times to be adjusted to match the demand***. This project will provide for a first in the US – treating pedestrians as we do vehicles, in that the timing will respond to volume-based demand.***

U.S.DOT Focus Area: Multimodal ICM

Readiness: Detection technology is fully tested and highly reliable. New aspect is integration with traffic signal software/firmware.

Scalability/Portability: Fully scalable to unlimited number of intersections. Will be a portable "productized" technology upon completion.

Measures of Effectiveness:

- *Reduction in pedestrian/vehicle conflicts and crashes*
- *Cost:Benefit/ROI*
- *Impact on vehicle delay and travel time*

▶ GiveMeGreen bicycle detection and traffic signal communications and response.

An android-based mobile application will be developed and provided to bicyclist in the area that will enable X-to-I and I-to-X "smart bicycle" functionality. This system will detect bicycles and place a call to the controller, with the controller enabled to provide a green extension to the cyclist, and communicating that the call was received back to the cyclist.

U.S.DOT Focus Area: Multimodal ICM, and Installation of Connected Vehicle Technologies at Intersections

Readiness: This project will develop software and functions for the mobile application, to be ready for market upon completion.

Scalability/Portability: Fully scalable to unlimited number of intersections. Will be a portable "productized" technology upon completion.

Measures of Effectiveness:

- *Traffic signal responsiveness (green extension) provision for bicycles.*
- *Impact on bicycle travel time.*
- *Impact on vehicle travel time and delay.*

▶ Green Wave.

This system will enable traffic signals to adjust, based on real-time congestion, to clear traffic in advance of approaching emergency vehicles. Existing Energency Vehicle Pre-Emption (EVPE) detection will be placed on freeways well in advance of the subarea, to provide time for the path to clear.

U.S.DOT Focus Area: Multimodal ICM

Readiness: Will use existing EVPE technology for detection. New aspect is applying Siemens CONCERT to develop rules for clearing traffic (providing green signal) in advance of the emergency vehicle.

Scalability/Portability: Fully scalable to unlimited number of intersections. Portable to any other traffic signal management/control software with like capabilities.

Measures of Effectiveness:

- *Reduction in emergency vehicle travel time to emergency room*
- *Impact on vehicle delay and travel time*.

▶ Integrated Corridor Management.

SR 520 and I-5 bound the south and west of the subarea. A suite of services is proposed to include freeway incident detection integrated with arterial traffic signal timing changes, and real-time travel time/alternative route calculation and provision to drivers.

U.S.DOT Focus Area: Multimodal ICM

Readiness: The needed systems are in place and ready to integrate incidents on freeways into traffic signal control. Alternative route travel time capabilities also exist. This work supports the integration of freeway and arterial information for the UW subarea, and assesses the effectiveness of such integration.

Scalability/Portability: Fully scalable to unlimited number of intersections. Portable to any other traffic signal management/control software with like capabilities.

Measures of Effectiveness:

- *Impact of alternative route and travel time messages on traffic patterns in the subarea*
- *Impact on vehicle delay and travel time, and total time the freeway and arterial network is congested due to the incident.*

▶ Adding Real-time Bicycle Travel Time and Disabled Persons Route Data to Mobility-as-a-Service (MaaS) Kiosks and PC and Mobile Applications.

SDOT is implementing MaaS under another program funding source. Under this grant proposal, the MaaS application will be enhanced in two ways. First, real-time bicycle travel times will be integrated so that bicycle travel time will be one of the considerations for users in selecting their trip bundle. Second, the application will be enhanced to add in wheelchair accessible taxi services and to integrate barriers to disabled persons, such as steep grades

and lack of pedestrian ramps, so they can better map their path or choose trip bundles that avoid these barriers. This grant proposal will also deploy MaaS kiosks at four high traffic locations in the UW subarea.

U.S.DOT Focus Area: Technologies to Support Connected Communities, and Unified Fare Collection and Payment System Across Transportation Modes and Jurisdictions

Readiness: The base Mobility-as-a-Service system is fully ready and available. The addition of bicycle travel time and wheelchair accessible taxi service and traveler barrier data to MaaS is new development proposed in this grant. The kiosks are an existing technology fully ready for deployment.

Scalability/Portability: Fully scalable and portable to any other location in the US.

Measures of Effectiveness:

- *Impact of travel time information on mode choices and trip bundles selected.*
- *Number of disabled individuals using the MAAS and their trip bundle choices.*

▶ ITMAP.

SDOT proposes to partner with Verizon to implement advanced traffic detection to support the adaptive traffic signal control operations and provision of key metrics, including travel time and origin-destination, via a Data-as-A-Service (DaaS) model called ITMAP. Under this approach, detection is installed, operated and maintained by the service provider (Verizon), with the data being streamed to the Verizon cloud, and provided to SDOT. A key value-added element of this service, called ITM, is a suite of data analytics tools, including Perdue analytics, that will support ongoing performance and operations monitoring of arterial operations. ***The analytics enabled by the ITMAP solution are in full alignment with FHWA's Everyday Counts Automated Traffic Signal Performance Measures (ATSPMs) – advancing the goals of that program.*** The suite of services will be enabled by Verizon's investment in the cellular data network in the UW Subarea – without which, this superior set of detection and analytics services could not be provided. SDOT is uniquely positioned to evaluate the ROI of this approach, as they have implemented the same technologies (Sensys detection and WiFi/Bluetooth sniffers) at other locations in the city, and are operating and maintaining them using SDOT resources.

U.S.DOT Focus Area: Multimodal ICM

Readiness: The suite of technologies is ready for deployment. The cellular data network will be upgraded via investment from Verizon to support data transmission.

Scalability/Portability: Fully scalable to unlimited number of intersections. Portable to any other traffic signal management/control software.

Measures of Effectiveness:

- *Uptime/reliability of data.*
- *ROI of Data-as-as Service versus agency-implemented detection and analytics model.*

2.2. THE CITY OF SEATTLE DEPARTMENT OF TRANSPORTATION (SDOT)

SDOT will act as the recipient of the federal award and be responsible for compliance with the regulatory and financial requirements associated with this project. SDOT has a long and proven track record of U.S. DOT grant management.

2.2.1 Project Partners

A consortium of partners including Washington State Department of Transportation (WSDOT), Sensys Networks, Verizon, Microsoft, Siemens, Southwest Research, and the University of Washington will deliver the project. A thoughtful program management structure with experienced and competent staff will enable the City to manage [redacted]

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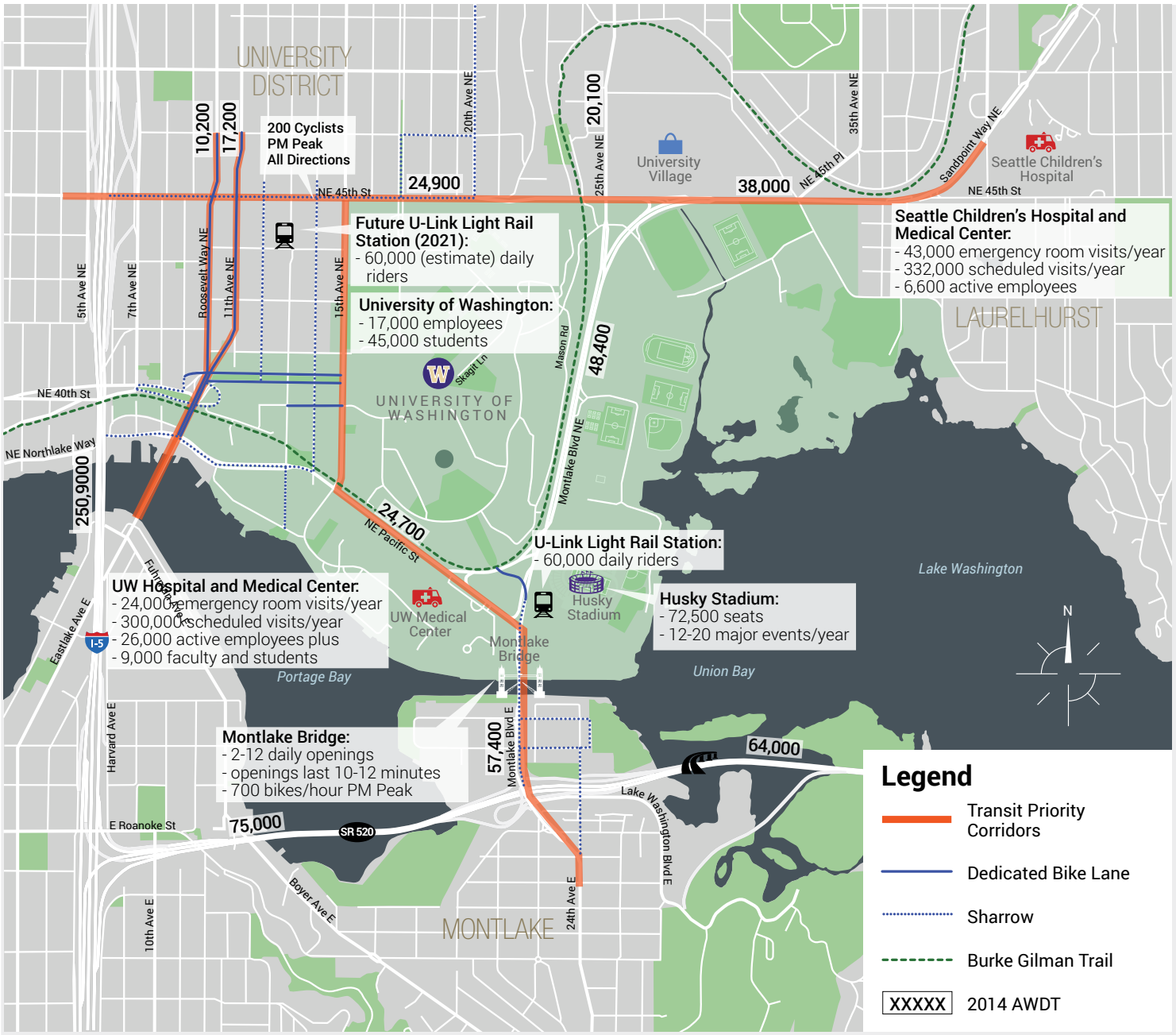


Figure 2: The UW Subarea

A number of converging factors result in transportation system challenges in the subarea:

- *Pedestrian and cyclist volumes are very high, typical of university districts and urban centers throughout the country. Some 31,000 undergraduate and 14,000 graduate students are enrolled at the UW Seattle campus. Crash occurrence is among the highest in the City of Seattle, as shown on Figures 5 and 6.*
- *The UW is the site of many special events and conferences held year-round, including major sporting and other events held at Husky Stadium (capacity 72,500), at Hec Edmundson Pavilion (capacity 10,000), or on campus.*

- *The Sound Transit U-Link light rail station, opened in 2016, as well as regular UW operations and events, produce frequent pedestrian surges.*
- *Two major hospitals, each with ERs, are located in the subarea, and intense congestion adds delay to emergency medical responders.*
  - *The UW Medical Center ER provides specialized care in areas such as cardiology (Level I Cardiac Center), stroke (Level III Stroke Center), and high-risk pregnancy/neonatal (Level III neonatal intensive care) units.*
  - *Children's Seattle ER serves babies, children and teens with life-threatening medical needs with specialty pediatric emergency services.*
- *The only access to the UW subarea from the south (the connection to SR 520) features a moveable bridge, the Montlake Bridge, which regularly creates delays in the surface street network as the bridge opens 2 to 12 times daily to allow maritime traffic to pass.*

Bicycle Network. *Figure 2* also shows the bicycle network in the subarea, which includes dedicated bicycle lanes, sharrows, and the Burke-Gilman Trail, a separated bicycle/pedestrian shared use path.

Key Transit Features. In March 2016, Sound Transit opened the new University line of the Link light rail system, shown on *Figure 3*. The University line connects underserved and diverse populations from just south of SeaTac airport via Downtown Seattle to the UW subarea's employment, health, and education services. The ULink station is located adjacent to Husky Stadium, and is a major transportation anchor for the subarea. Ridership is at 60,000 per day.

Also shown on *Figure 2*, the road network serves conventional bus transit, and includes transit priority corridors, and two bus transit hubs managed by King County Metro - with one hub on NE Campus Parkway and on NE 45th Street.

Figure 3: Sound Transit Light Rail Connects Diverse Neighborhoods in the Region to the UW Subarea

2.4. ISSUES AND CHALLENGES TO BE ADDRESSED BY THE TECHNOLOGY

The overall challenge faced in the UW subarea is creating an arterial operations environment that is responsive to all modes, and all travelers. The following table presents the core issues and challenges to be directly addressed via this grant, that together will meet this challenge

Issue/Challenge	System Proposed
Pedestrian volumes surge due to normal university operations, events, and the new U-Link light rail station. Existing traffic signal timing is fixed for pedestrian crossings. Pedestrians commonly cross the intersection at the end of the pedestrian phase, seemingly feeling protected when there is a group of pedestrians doing the same. Ped crash occurrence is high in the subarea. SDOT's policy is to treat all modes in an equal manner to provide for true multimodal opportunity.	**Pedestrian Surge Management System**
Traffic signals provide timing in response to vehicle detection. Cyclists are not specifically detected, so the signal timing is not responsive to their travel. Cyclists are tempted to, and are often found to, enter the signal on yellow and even on red so they do not have to stop. This introduces additional crash risks. Cyclist crash occurrence is high in the subarea. SDOT's policy is to treat all modes in an equal manner to provide for true multimodal opportunity.	**GiveMeGreen Bicycle Detection System**
Congestion in the UW subarea is increasing, and medical response vehicle travel time to emergency rooms is increasing. The current EVPE approach (Fire Lane Green) at traffic signals does not improve travel times in congested periods, as downstream congestion is not cleared.	**Green Wave**
Incidents on I-5 and SR 520 – two freeways that bound the west and south end of the UW subarea – create congestion in the subarea. Arterial users do not know the source of the congestion, and do not have information on alternative route travel times. The added congestion can impede incident response. In addition, the traffic signals are not responsive to freeway incident-caused congestion, resulting in increased time to clear incident congestion from the arterial and freeway network.	**ICM with WSDOT**
Data providers for Mobility-As-A-Service applications do not provide real-time bicycle trip travel times, nor do the trip bundles provide options tailored to disabled individual's needs. The lack of complete information for bicyclists and disabled individuals does not align with SDOT policy to provide mobility options for all users on a level playing field.	**MaaS bicycle and disabled persons enhancements, with bike data from GiveMeGreen**
Traffic volumes are highly variable in the UW subarea, and conventional or even traffic responsive traffic signal timing cannot respond well to these demands. Even if detection is implemented to support adaptive control, core analytics including Perdue data analytics, are not available to enable detailed, comprehensive performance monitoring and improvement.	**ITMAP**

2.5. SYSTEMS AND SERVICES PROPOSED

MICMA provides a fully integrated suite of systems and services, as shown in *Figure 4*.

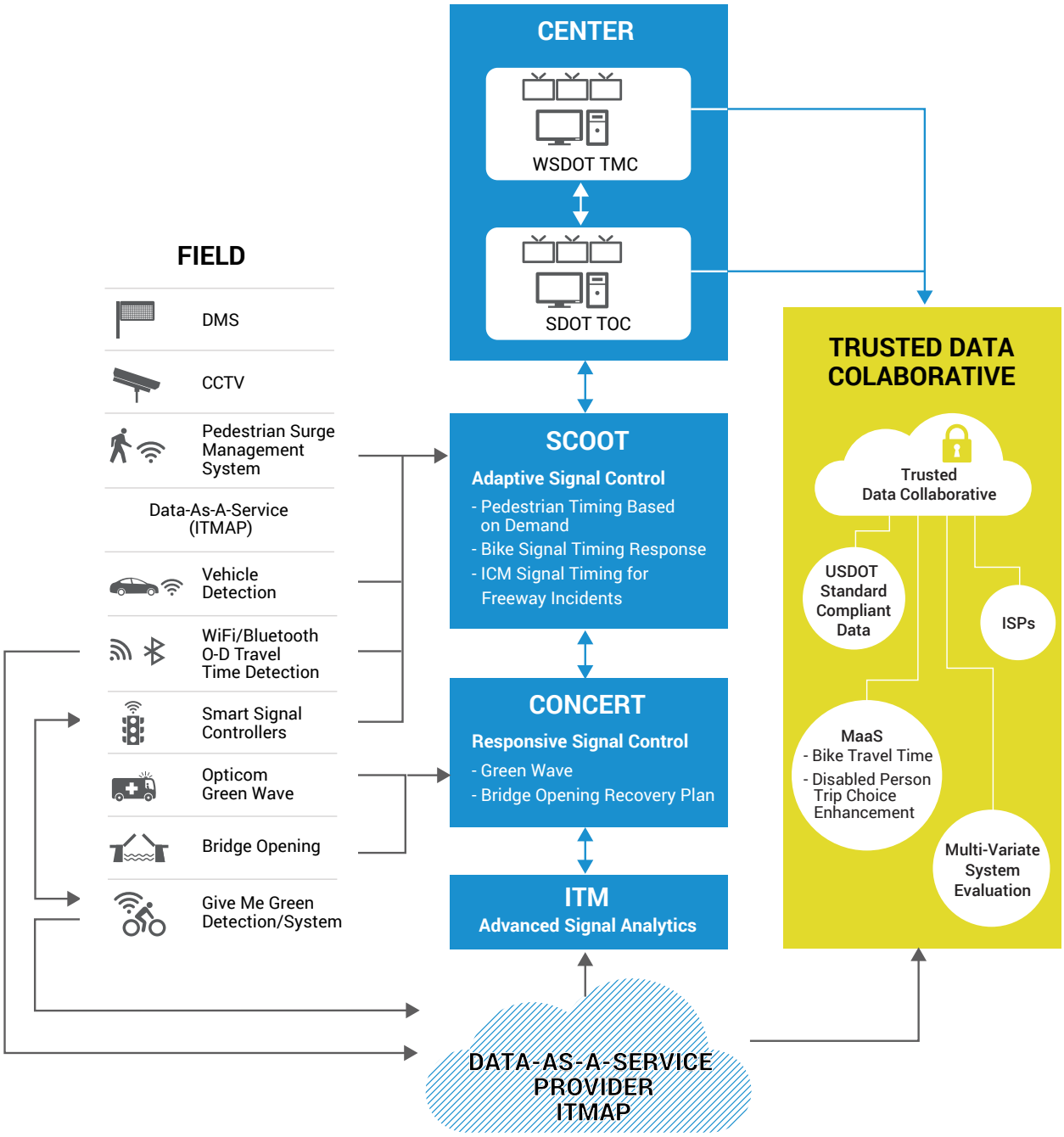


Figure 4: MICMA Integrated Systems

2.5.1 Pedestrian Surge Management System

System and Technologies – The pedestrian surge management system consist of two elements:

- *Pedestrian Count Detection. SDOT proposes to implement video image processing and cameras to provide pedestrian count detection at crossings and nearby approaches, at intersections serving the stadium and light rail station.*
- *Pedestrian Volume-Responsive Traffic Signal Control. SDOT (via Siemens) will modify traffic signal control software (in SCOOT), and traffic signal controller firmware (EPAC) to enable the signal to respond to actual pedestrian demand.*

Counting Pedestrians Using Proven Video Image Processing Technology.

SwRI has developed a highly accurate video-image processing pedestrian detection technology that can be used with a large range of high-definition cameras. Originally created to support autonomous vehicle operation to avoid pedestrian crashes, the technology will be adapted to provide pedestrian count information. Because the processing software includes the travel vector of the pedestrian, the count data can be created to count pedestrians bound for specific crossings.

Southwest Research Institute (SwRI) current object detection approach uses state-of-the-art deep learning algorithms employing neural network designs such as Convolutional Neural Networks (CNN), Resnet50, and Single Shot Detection. Key technology features include:

- *Intelligent Single Shot camera-based algorithms that accurately detect high-pose objects such as bicycles, people, and animals in cluttered environments*
- *>99.95% accuracy*
- *Detection, classification, and tracking algorithms use a custom convolutional neural network algorithm to increase performance in cluttered environments*
- *Semantic segmentation of desired object*
- *Detected objects include, but are not limited to, partially occluded bicycles, humans, vehicles, road signs, and work zone objects (cones, barrels, etc.)*

The technology will be tailored to be specific to pedestrian counting for traffic signal operations.

Outcome – Decrease pedestrian conflicts and crashes.

Data – The UW subarea sees some of the highest volumes of traffic related pedestrian injuries outside of downtown Seattle. In the last five years, the UW subarea saw seven pedestrian fatalities; in the last three years, the UW subarea saw 62 pedestrian collisions (see Figure 5). The Seattle Pedestrian Master Plan identifies many roadways in the UW subarea as being “high need”, due to their volume of crashes, speeds, and other criteria.

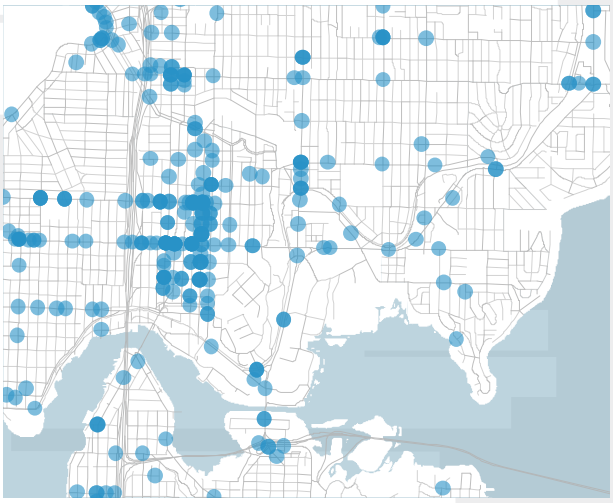


Figure 5: Pedestrian Crashes 2012-2016

2.5.2 GiveMeGreen Bicycle X-to-I and I-to-X Traffic Signal System

System and Technologies – Sensys Networks will provide a platform that sends infrastructure-based information to travelers and relevant traveler information to the infrastructure in unique and valuable ways. The solution leverages communications capabilities available with existing smartphones, and will be adapted by cyclists. The GiveMeGreen bicycle application will:

- *Provide secure two-way communications between the controller and smartphone*
- *Rely on low latency wireless communications that require no special hardware on the smartphone, only proprietary applications*
- *Include an edge gateway communications approach, with and associated X2I software application*
- *Provide precise location of a cyclist using both GPS and location-specific beacons*
- *Provide a smartphone application for cyclists developed by Sensys Networks to support placing a call to the traffic signal controller to request green extension. The application supports two-way communications, and the cyclist call will be confirmed*

SDOT proposes to procure this system as a complete service, with all hardware and software provided by the vendor, and including 5 years of ongoing maintenance service and system upgrades and enhancements. SDOT will support Sensys in marketing the product to the Seattle cycling community. The data will be further used to support MaaS enhancements.

Outcome – Reduce the number of cyclist stops, improving cyclist travel time and minimizing cyclist/vehicle conflicts.

Data – The UW Subarea sees some of the highest cyclist volumes in Seattle (with an associated higher crash occurrence rate) as shown on *Figure 6*.

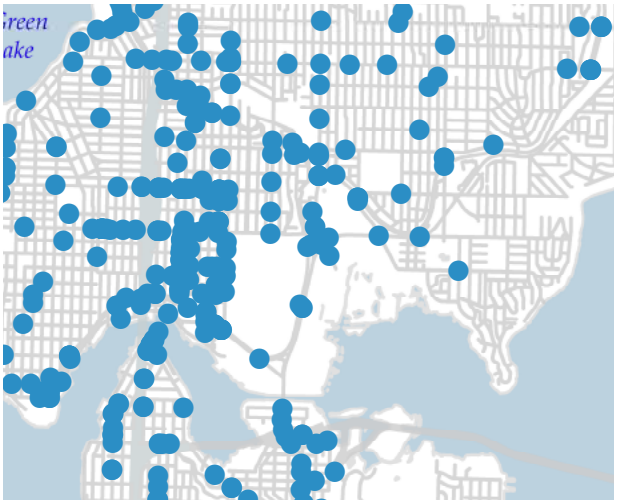


Figure 6: Bike Crashes 2012-2016

2.5.3 Green Wave Emergency Clearance System

System and Technologies – The Green Wave clearance system will develop an algorithm that will reside in SDOT's CONCERT responsive traffic signal system. The algorithm will assign green traffic signal display to sets of traffic signals, based on real-time congestion levels, to clear back-ups that impede emergency vehicle access to destinations. Opticom® EVPE detection installed well in advance of emergency room destinations, including at approaches to SR 520 off-ramps, will provide ample time for traffic to clear.

Outcome – Decrease medical emergency responder delays by providing a clear path for emergency vehicles to access hospitals. Congestion in the area creates delays beyond the capability of existing emergency vehicle preemption systems (EVPE) which clear one intersection at a time. Currently if traffic is grid-locked, no clearance is achieved. The Green Wave Emergency Clearance system overcomes existing challenges by clearing congestion well in advance of the emergency vehicle, with plans implemented based on measured real-time congestion.

Data – The Seattle Fire Department (SFD) provides a portion of the 6,000 ambulance trips in the area, with many of the most critical patient needs. SFD provided 592 patient transports to UW Hospital and 124 patient transports to Seattle Children's hospital in 2015. Peak hours for SFD emergency medical service trips tend to be in the late afternoon to early evening – periods of peak traffic congestion.

2.5.4 Integrated Corridor Management (ICM)

System and Technology – WSDOT and SDOT already have a data-sharing system in place. This work will integrate data from WSDOT's traffic sensors with the SDOT central traffic signal control system. The project will identify the freeway incident "triggers," and design signal timing plans for various incident scenarios. In addition, travel time algorithms that fuse WSDOT freeway and SDOT arterial data (including ITMAP data) will be developed to calculate travel times to key destinations. Alternative route travel times will be posted on arterial DMS and via the Traveler's website, plus via private-sector ISPs, and integrated with MaaS.

Outcome – Linking the State highway and the city aterial network using live streaming data will provide seamless optimized operation between the state highway and city arterial network. Providing users with alternate routes that will leverage both facilities, and better manage the congestion and/or incidents. With respect to freeway incident management, better managing the demand on arterials bound for freeways should improve overall incident-created congestion clearance times.

Data – Blocking Incidents on I-5 and SR 520 in the UW environs occur approximately 50 times per year. In addition, closures due to weather events on SR 520 occur as often as 5 days per year, and maintenance activity occurs with a similar frequency.

2.5.5 Mobility-as-a-Service Cyclist and Disabled Persons Enhancements

System and Technology – SDOT has funds to establish a Smart Mobility Initiative (SMI) that advances three core functions: trusted data sharing (via the SDOT Trusted Data Collaborative, or TDC), mobility innovation, and equity. One of the key elements, or products, of the SMI is the development of one or more private-sector provided Mobility- as-a-Service (MaaS) platforms. The MaaS platforms will provide integrated trip planning and mobility packages based on customer needs and real-time information. This type of platform and the mobility packages will allow people to pay for mobility options they use without the need to own a vehicle. SDOT's role is not to fund the platform, but rather to establish the operating parameters and performance metrics that governs a MaaS operator's access to mobility APIs within the TDC.

SDOT will establish the building blocks of the consumer model, including the following elements:

- *Secure connections and individual privacy*
- *Real-time trip planning with access to all transit, shared mobility, and parking APIs.* ***This grant will fund the addition of a real-time bicycle travel time API to the MaaS.***
- *Trip choice trade-offs/decision-making based on user profile values*
- *Integrated fare payment (likely a dual e-purse structure with Next Gen ORCA phased in) and mobility packages (e.g., monthly subscriptions and pay-as-you-go)*
- *Enhanced paratransit and Wheelchair Accessible Taxi booking and dispatch,* ***this grant will fund the Wheelchair Accessible Taxi booking API.***
- *The addition of barriers to disabled persons including grades, stairs, and lack of accessible ramps.* ***This grant will fund the development of this data set to be integrated with the MaaS API.***
- *Real-time routing and data flows between connected vehicles and infrastructure*

In, addition, as part of this grant proposal, Verizon will fund the implementation and maintenance of kiosks at four sites in the UW Subarea that will include the MaaS application. This will further provide access to the MaaS functions to those without computers or mobile devices.

Outcome - Studies have shown that integrated digital mobility platforms have the potential to increase the use of shared mobility assets (including transit), while reducing SOV trips, car ownership, and customer transportation costs. Additionally, the MaaS will increase access to employment, education, and health care for economically disadvantaged and disabled persons.

Data – The UW Subarea sees some of the highest cyclist volumes in Seattle. Cyclists frequently use transit and light rail to access the UW subarea. Metro Transit reports some 300,000 annual cyclists using transit.

This technology should help all people, but especially disadvantaged and disabled populations, in planning their trips and reaching their destination on time with fewer incidents and at a lower cost. Disabled persons mobility will be greatly improved, with the ability to create trip bundles targeted at accessible mobility solutions.

2.5.6 ITMAP

System and Technologies – This project will implement the ITMAP system, which includes a wireless magnetometer detection solution and WiFi/Bluetooth detection to enable traffic adaptive control (SCOOT) on key arterials (see *Figure 7*). The ITMAP DaaS will provide traffic signal and travel time data and an analytics platform. SDOT proposes to purchase this system in a Data-as-a-Service approach, which includes installation of all required hardware and software, the analytics platform and 5 years of maintenance and system upgrades.

The ITMAP analytics platform provides for detailed analysis and performance monitoring of signal operations including:

- *Optimized Signal Timing: The availability of historical 24x7 automatic turn movement counts enable signal timing optimization over multiple levels: (i) seasons (ii) days of the week (iii) Time-of-Day periods, and (iv) phase split-times. Hitherto, typically only phase split-times optimization was feasible due to the manual and limited duration of the turn movement count data.*
- *Intersection Performance Measures: The ITMAP analytics solution fuses detection data with traffic signal phase data to generate a wide variety of intersection performance and safety metrics: before/after comparison reports, Purdue Coordination Diagrams (PCDs), Volume/Capacity (V/C) ratios per phase, percentage arrivals on green, delays per approach, and red-light violation counts.*

Outcome - Improve real-time management of traffic volumes always, including in response to unpredictable congestion-causing events (game or concert at Husky stadium), incidents and/or construction. Adaptive traffic signal management will allow quick response and recovery from the Pedestrian Surge Management and Green Wave Emergency Clearance systems proposed, maximizing the overall benefits of those two functions. Plus, the ITMAP analytics tool provides reporting in compliance with the FHWA Every Day Counts Automated Traffic Signal Performance Measures (ATSPMs).

Data – Today's UW subarea traffic management system is coordinated for progression on a time-of-day basis. This is sub-optimal given the fluctuations in traffic demand due to events, bridge openings, emergency vehicle pre-emption and SR520 construction. The system often takes several cycles to recover from individual incidents. Implementation will also allow the project to create a baseline data. set and analytics for "Before" and "After" conditions analysis.

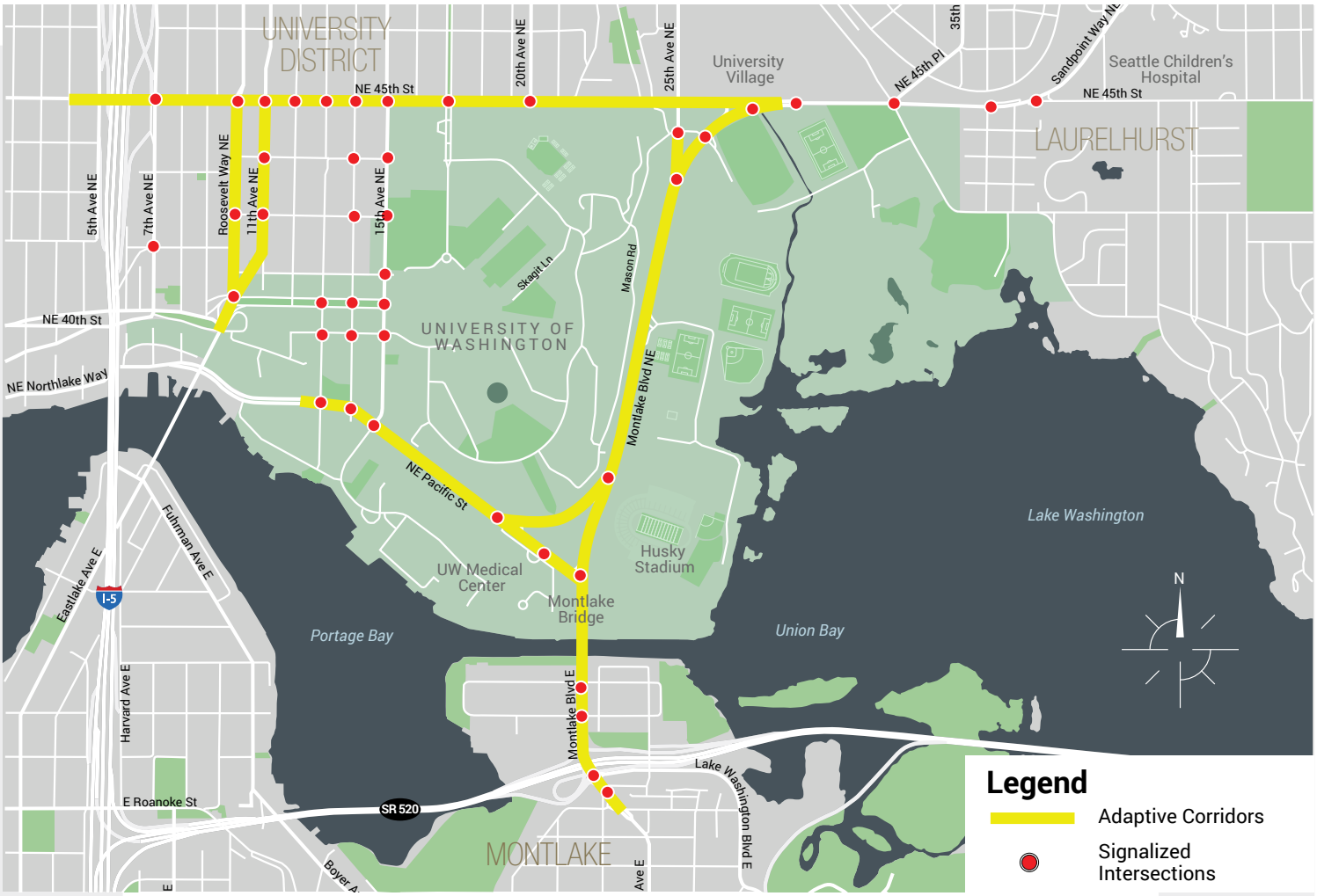


Figure 7: UW Subarea Corridor Traffic Signals

2.5.7 Data Architecture and Management

SDOT has implemented a Trusted Data Collaborative (TDC) that will support real-time advanced analytics and modeling, making the data enticing not just to private sector transportation providers, but to researchers and government agencies alike. The TDC provides a trusted environment for these public-private collaborations to take place, enabling connected, multi-modal, transportation applications to be built and delivered to the ecosystem without sacrificing security or testing personal privacy. The TDC enables the cross-functional sharing of data and assets between public and private entities without compromising security requirements at any level. This infrastructure is designed to manage highly classified secure data as well as publicly developed open data. Access to data is controlled by a series of gatekeepers that enforce policy on behalf of the data owner.

Ensuring Compliance with National ITS Data Standards and Framework
This project's data will be provided to the TDC. Some of the data sets generated by legacy systems comply with national ITS data standards, and some do not. All systems procured under this grant shall be required to comply with national ITS data standards. The TDC includes an environment where "use cases" can be defined and applied to the data. A use case will be developed to transform any ITS data that is not compliant with ITS data standards to compliant data. All data will be available to U.S. DOT, or any other eligible public or private entity.

2.6. DEPLOYMENT PLAN INCLUDING ONGOING OPERATIONS, MAINTENANCE, MONITORING AND IMPROVEMENTS

The deployment plan encompasses the following phases, and is designed as a step-wise approach. New functions will be added, step-by-step on top of existing functions as a risk management measure, and to support the project evaluation of the individual project elements. The project schedule in section 2.8 reflects this approach. Information on how the project components will be managed and delivered is shown in the table below.

Project Element	Management Approach	Delivery Approach
Base ITS	Design conducted via existing consultant contract agreements	• SDOT Crews will install communications and ITS technologies that do not require "heavy" construction. • A single PS&E contract will be competitively advertised and issued for DMS's and foundations, and any required ADA ramp construction.
Base MaaS	Requirements for MaaS to be developed by SDOT staff with consultant support.	MaaS to be delivered by private contractor or contractors via procurement.
Pedestrian Surge Management System	SDOT will lead the development of system requirements, in coordination with SwRI and Siemens	Contracts with SwRI and Siemens will be executed. Field installation of pedestrian detection cameras will be by SDOT Crews.
GiveMeGreen	SDOT will lead the development of system requirements, in coordination with Sensys Networks and Siemens	A contract covering equipment installation and 5 years of ongoing maintenance and system upgrades will be entered into with Sensys Networks
Green Wave	PS&E will be managed by SDOT via existing consulting contract agreements. Work will be submitted for approval to WSDOT.	Construction will be via the same private contractor contract issued for Base ITS.
MaaS Enhancements	SDOT MaaS staff will lead the development of system requirements	MaaS enhancements to be delivered by same private contractor or contractors selected under Base MaaS. Verizon will deploy kiosks with the MaaS application at 4 locations in the subarea.
ITMAP	SDOT staff will design detection locations needed, for provision to Verizon to install as part of ITMAP	A contract for Data-as-a-Service, including detection and equipment installation and delivery of the analytics platform, and 5 years of ongoing maintenance and system upgrades will be entered into with Verizon.

2.6.1 Ongoing Operations, Maintenance, Monitoring and Improvements

The City of Seattle's commitment to arterial operations is reflected in SDOT's history of ongoing budget support for ITS initiatives and staffing. SDOT has programmed ongoing operations and maintenance in their budgets to ensure the systems installed in this project provide lasting value.

- *SDOT has programmed over $18.9 million annually for ITS maintenance in 2017 and 2018. The budget planning requests for future out years include annual escalation through 2023.*
- *SDOT has funded the current ITS TOD staff positions through 2018, and the budget plan includes escalation and planning for additional positions through 2023.*
- *SDOT has currently programmed $169,000 in 2018 for ongoing operations and maintenance of the MaaS, with ongoing operations and maintenance budget requests, including annual escalation, included in the capital budget request through 2023.*
- *The GiveMeGreen and ITMAP DaaS systems provide for full maintenance for a 5-year period.*
- *Kiosks will be maintained by Verizon (included in their soft match).*

2.7. CHALLENGES

SDOT does not anticipate any significant regulatory, legislative, or institutional challenges will arise to impede this project. In our review of potential challenges, the following were identified, and a mitigation approach developed:

- *Placement of kiosks in City-owned public right-of-way may conflict with City of Seattle advertising prohibitions. Kiosks will be located on properties owned by other entities.*
- *SDOT has reviewed all relevant public privacy concerns with respect to data sharing, and the systems proposed all comply with current law and City policy.*

SDOT has long-standing partnerships with many of the entities included in this grant proposal, and does not anticipate any institutional issues. Our partners have provided letters of commitment or support (attached to this proposal). Our history with our partners includes:

- *SDOT and WSDOT already partner for data sharing and are currently working on a regional incident management improvement initiative to better integrate freeway and arterial operations during incidents.*
- *SDOT has worked with Sensys Networks for ten years, having been one of the initial deployment sites.*
- *SDOT has worked with Siemens ITS for 15 years and has existing contracts and relationships with Siemens ITS. The history includes software development/modification experience, such as proposed on this project. Siemens has identified Seattle as a "Center of Excellence" in their corporate planning, and is committed to SDOT's success.*
- *SDOT has been working successfully with Microsoft on other data initiatives in the past, and most recently on the Trusted Data Platform.*
- *SDOT and the UW have a long-standing relationship, with SDOT supporting UW initiatives by providing data and other resources.*

New partners to SDOT in this work are Verizon and SwRI. Both entities are familiar with working in the public space, and understand the unique relationship such a partnership requires. All partner relationships will be bound by contract agreements.

2.8. SYSTEM PERFORMANCE IMPROVEMENTS

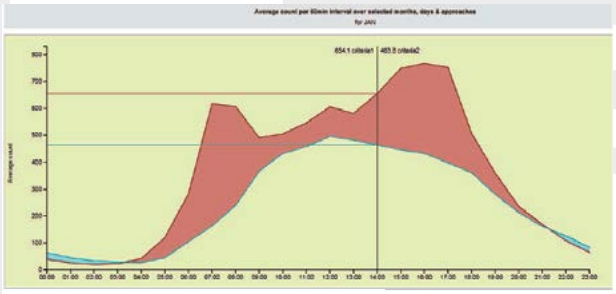
The system performance measures for the UW subarea relate to the interconnected challenges being addressed by the project. SDOT will enhance their data set using detection installed as part of this grant. Analysis will be conducted using data from continuous measuring collected by traffic and WiFi/Bluetooth sensors connected in real time to the SDOT TOC, and sent to the TDC where the data can be extracted, or used with other data for analysis. Systems performance improvements will be measured using both before and after and, when appropriate, multivariate analysis for:

- *How well the project improves travel for all modes. Quantifiable measures due to the project include overall sub-area and street-specific:*
  - *Reductions in vehicle and bicycle travel time by time-of-day – using TDC data*
  - *Vehicle delay reduction by time-of-day – using TDC data and ITMAP*
  - *Reduction in vehicle and bicycle stops - using TDC data and ITMAP*
  - *Vehicle travel time reliability - using TDC data and ITMAP*
  - *Transit travel time – using transit AVL/CAD data*
  - *Reduction in pedestrian crashes – based on police crash reports input to the TDC*
  - *Reduction in bicycle crashes – based on police crash reports input to the TDC*
  - *Reduction in medical emergency responder travel time to emergency rooms – based on SFD AVL/CAD data*
  - *All of the above during major events*
  - *All of the above during freeway incidents, plus time to clear incident-related congestion*
- *How the MaaS improves access for all to transportation services, with a specific focus on users who are cyclists, and the disabled.*
  - *Impact of travel time for bicycles information on trip bundles selected*
  - *Number of disabled persons using MaaS, and their trip choices selected*
  - *Overall user satisfaction and perceived value of these services*

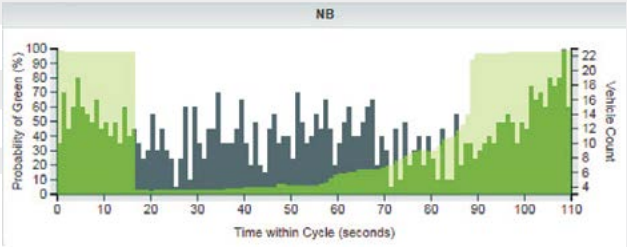
Enhanced Analysis Capabilities Due to Richer, Accurate Data. SDOT is ready and eager to support the project evaluation. The project will implement systems to provide real-time data gathering (vehicle detection, pedestrian detection, bicycle detection, vehicle travel time detection), and an analytics platform via the ITMAP DaaS. In addition, SDOT's TDC houses a broad range of data from SDOT, WSDOT, and other sources that will be useful in understanding the project effects, including a "big picture" view of the overall impacts to the UW Subarea and freeways.

This project, via the TDC, will allow for multivariate analysis, resulting in the ability to attribute changes to specific actions or projects.

Using the TDC and ITMAP analytics platform resources, this project will be able to provide an unmatched level of project evaluation and ongoing performance monitoring. The system will enable use of multivariate analysis for aspects such as pedestrian and cyclist crashes that incorporates geometric, land use, time of day, traffic volume, and a wide variety of other data to move beyond simple trend analysis to understand the conditions which cause these crashes.



PERFORMANCE COMPARISON REPORTS:
Allow measurement of before/after benefits of signal retiming



PURDUE COORDINATION DIAGRAMS (PCD):
In addition to percenral arrival on green and waiting time by approach, PCDs provide a graphical vie o signal coordination

The ITMAP Analytics Platform Enables the Type of Analysis Needed for the MICMA Evaluation as Well as Ongoing Performance Monitoring and Improvements

Figure 8: ITMAP Offers Unparalleled Analytics to Support Ongoing and Project Performance Analysis

2.9. BENEFIT PROJECTIONS

The project summary included proposed measures of effectiveness for the project elements. The following provides those measures, and the estimated benefits, when such estimate is available. It is noted that modeling has not been completed to estimate benefits, and any estimates are based on comparison to other locations and sketch-level planning.

2.9.1 Estimated Benefits:

"Base" SDOT ITS Elements

- *Reduced vehicle delay - estimated at 20%*[1]
- *Reduced travel time - estimated at 25%*[1]
- *Maintain transit travel time – no change to transit travel time*[2]
- *Improved travel time reliability – no estimate available*
- *Reduced vehicle emissions - estimated at 4%*[3]
- *Reduced fuel consumption – estimated at 6%*[3]

Pedestrian Demand-Based Detection and Signal Timing

- *At locations where the system is installed:*
- *Reduction in pedestrian/vehicle conflicts – estimated at 5% during peak periods*[4]
- *Reduction in pedestrian/vehicle crashes – no estimate available*
- *Increase in vehicle delay – no estimate available*
- *Increase in travel time – no estimate available*

GiveMeGreen

- *Traffic signal provision of green extension – estimated at 100% when within timing parameters*
- *Reduction in bicycle stops – no estimate available*

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[1] *Based on combination of SDOT measurements of benefit in the Mercer Corridor, and Siemens reporting of average benefits from all SCOOT installations*

[2] *Based on SDOT-measured experience in the Mercer Corridor*

[3] *Based on Siemens reporting of average benefits from all SCOOT locations*

[4] *Based on estimated number of extended pedestrian phases to be provided*

- *Reduction in bicycle travel time – estimated at 5%*[5]
- *Increase in vehicle delay – estimated at 0%*[6]
- *Increase in vehicle travel time – estimated at 0%*[6]

Green Wave

- *Reduction in medical emergency responder travel time to ER – estimated at 30 seconds (average)*[7]
- *Increase in vehicle delay – no estimate available*
- *Increase in vehicle travel time – no estimate available*

ICM

- *Vehicle delay reduction – no estimate available*
- *Vehicle travel time reduction – no estimate available*
- *Reduction in total time freeway and arterial network is congested due to incident – estimated at 10%*[8]

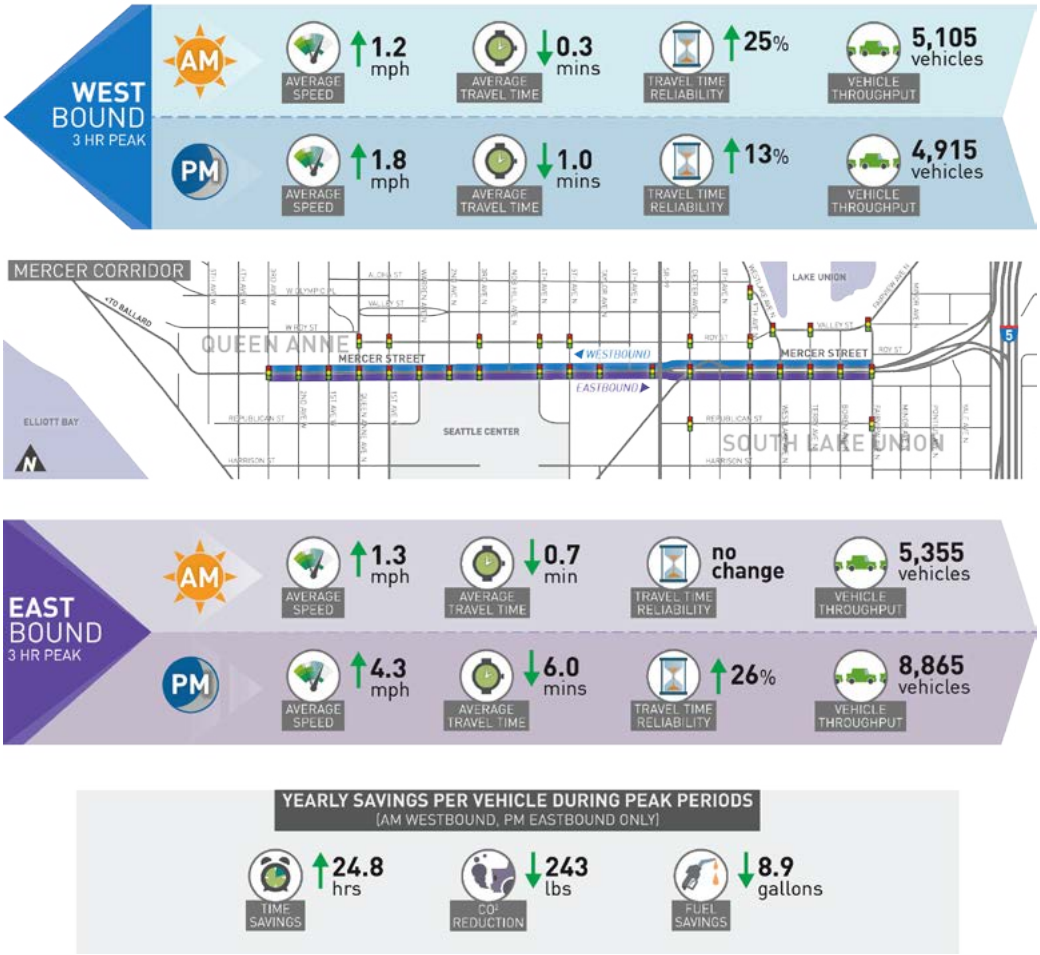

Figure 9: Adaptive Control Improvements in the Mercer Corridor

[5] *Based on reducing travel delay by one 90 second signal cycle on key corridors*

[6] *Based on performance of SCOOT, added green extensions for bicycles should not affect overall vehicle delay or travel time*

[7] *Based on congested versus uncongested travel time for emergency responders to UW ER*

[8] *Based on estimate of available capacity on alternative routes*

2.9.2 Commitment to Project Evaluation and Ongoing Performance Monitoring

SDOT is a data-driven organization, and is already applying evaluation/performance monitoring to manage and continuously improve traffic incident management, traffic signal operations and maintenance, and other core functions of the TOD. For example, the infographic in *Figure 9* is produced weekly for the Mercer corridor project.

SDOT understands that FHWA will provide an independent evaluator to perform the project evaluation. To ensure there are sufficient resources to support the FHWA evaluator, SDOT will additionally contract with the University of Washington (UW) TRAC. Their role will be to support this evaluator by ensuring they are provided with the data sets required, to coordinate any needed focus groups, or any other local support needed to complete the evaluation. The UW TRAC staff are skilled in extracting data from the TDC, and will develop the required use cases to extract accurate and appropriate data sets from the TCS to support the evaluator's data needs and to create automated tools (via the TDC) to provide ongoing performance monitoring aligned with FHWA guidelines.

2.10. VISION, GOALS AND OBJECTIVES

SDOT is invested in deploying leading-edge ITS systems and services because they produce results. SDOT's 2010 ITS Strategic Plan establishes the vision for ITS in Seattle.

The SDOT ITS Vision is…

To support development of a sustainable transportation system, and to contribute to the City's economic vitality by implementing, operations and maintaining the most appropriate technology to meet multimodal transportation safety and mobility needs. Implementing this vison will result in protection of traffic safety, reduced environmental impacts of transportation, improved multimodal mobility and enhanced efficiencies of the transportation network.

Since the 2010 adoption of this vision, SDOT has adopted a nearly $40 million ITS work program, and invested more than $20 million in high-priority ITS projects that optimize the city's very constrained road capacity. Part of that investment has been in the deployment and maintenance of core systems that will support the expansion of services across the City including:

- *SCOOT traffic adaptive control*
- *CONCERT central traffic responsive control*
- *Upgrading the ITS communications network to a layer 3 topology support added systems and improve resiliency*
- *Travelers ATIS web site and mobile applications*
- *Trusted Data Collaborative*
- *Upgrading the SDOT Transportation Operation Center and increasing staffing, coverage, and functions*

The MICMA goals and objectives flow from the ITS Vision and are:

Goals	Objectives
Improve access to jobs, health care, and education to all travelers.	• Provide access to mobility choice information that improves accessibility for all users including cyclists and disabled persons.
Treat all modes equally while reducing delay to each.	• Increase travel time reliability. • Maximize throughput. • Provide traffic signal timing based on demand of vehicles, transit, bicycles and pedestrians. • Manage queues. • Changing objectives under various circumstances. • Reduce emergency medical vehicle travel time to ERs. • Reduce emissions from vehicles.
Reduce crash risks for all modes.	• Time traffic signals for pedestrian demand at high pedestrian volume locations, and respond to cyclists at traffic signals.

2.11. PARTNERING PLAN

SDOT has a history of establishing and maintaining true partnerships with public and private sector entities. For SDOT, the meaning of "true" partnerships is that each partner receives benefits. In this proposal, SDOT's partners' goals align with SDOT's, with each deriving benefits

Partner	Systems/Services Provided	Partner Funding Contribution	Benefit to Partner	Benefit to SDOT
SWRI	Pedestrian count video image processing technology for Pedestrian Surge Management System.	No funds are being sought for prior development. (Not included in grant request)	Funding to create pedestrian count function, opportunity to productize the technology.	Confidence in deploying a highly accurate pedestrian identification technology, previously developed and tested, to support pedestrian surge management.
Verizon	ITMAP	$3,500,000 (soft match)	Enables deployment of ITMAP system, proposed to be funded via this grant. Verizon-branded kiosks are deployed with MaaS application.	Allows provision of ITMAP and its enhanced detection, data gathering, and data analytics capabilities, enabling adaptive signal control and ongoing performance monitoring. Kiosks provide access to MaaS for those without tablets or cell phones.

continued pg.23

Sensys Networks	GiveMeGreen bicycle app	$370,000 (soft match) for software development and hardware/system installation plus 5 years ongoing maintenance and support.	Provides a real-world deployment to further test and refine the product.	Cyclist flow is improved, with signals responsive to approaching bikes.
Siemens ITS	Green Wave and Pedestrian Surge Management System	$120,000 (soft match) for controller firmware and central control software development	Provides a real-world deployment to further test and refine the product.	Reduce delays for medical emergency response to emergency rooms and provide pedestrian surge management.
WSDOT	Funds are tied to SR 520 reconstruction mitigation, and support upgrades to ATIS and traffic signal control.	$3,500,000 (hard match)	Improved multimodal operations. Minimize disruption due to construction.	Improved multimodal operations. Minimize disruption due to construction.

Contractual arrangements will be made with our partners detailing each party's commitments and responsibilities. Letters of commitment are provided as an attachment to this grant proposal. With WSDOT, no additional agreement is needed, as agreements are already in place in alignment with each agency's goals, and their commitment is assured.

2.12. LEVERAGING OTHER SYSTEMS

This project will leverage and optimize many existing technology investments including:

- *SDOT has deployed ITS infrastructure across the City, with some ITS already in place in the UW subarea. The prior investment in the UW subarea includes existing traffic detection, CCTV cameras, DMS, traffic signal infrastructure, and communications infrastructure and is estimated at $10 million. This project will optimize this existing investment through system and communications upgrades.*
- *$1.75 million investment in advanced, central traffic signal control platforms – SCOOT for adaptive control and CONCERT for responsive control. SDOT has also invested in TACTICS (central traffic signal control software) and associated upgrades for 15 years.*
- *$4.22 million investment in establishing the Trusted Data Collaborative. All data gathered in the UW subarea will be placed within the TDC environment which include data gathered from systems across Seattle.*
- *$1.5 million invested in the Travelers ATIS web site and mobile app. These systems will be enhanced with the data gathered in the UW subarea, increasing geographic coverage and accuracy.*
- *WSDOT brings their highly sophisticated advanced freeway traffic management software and systems. This project will leverage their existing travel time algorithms and data systems.*

It is SDOT's plan to expand the systems and services in this proposal city-wide.

2.13. SCHEDULE

The project technology deployments are anticipated to be complete within 2 1/2 years of NTP. Evaluation will require additional time to ensure a full set of data is provided, for a total of 3 years. In developing the schedule, care was taken to minimize overlap in the technology deployment phases. It was designed so that no more than 2 items will be in final (field) testing at the same time. This was done to ensure that each element can be evaluated separately, to minimize conflicts among technologies, and to allow for a more graceful roll out of the new technologies.

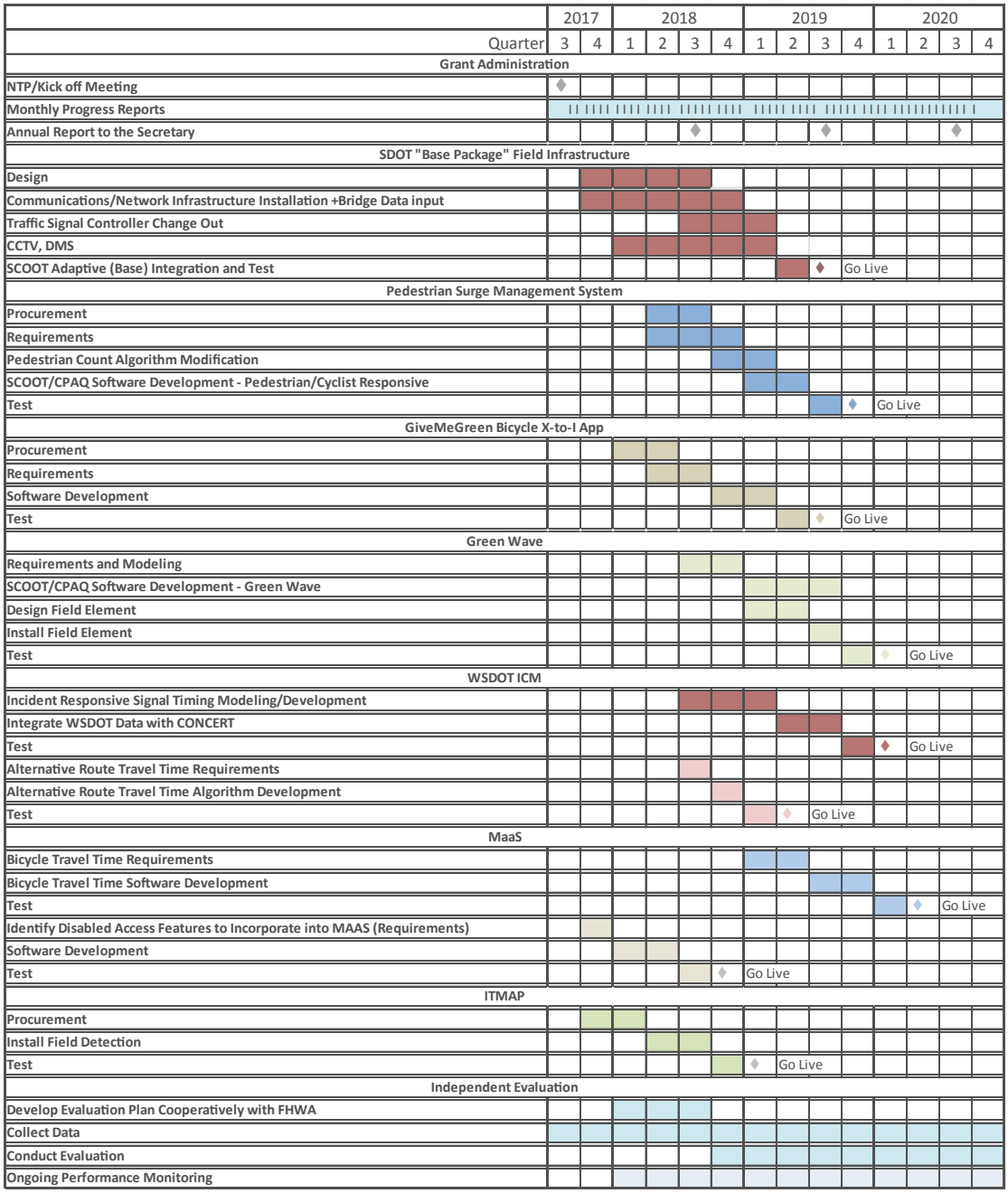

Figure 10: Proposed Schedule

2.14. CONNECTING TO U.S.DOT ITS INITIATIVES

SDOT is committed to support the U.S.DOT in advancing ITS initiatives. The following table connects this grant proposal with the Program Categories identified in the JPO's ITS 2015-2019 Strategic Plan:

U.S. DOT Program Area	How This Project Supports the Program Area
Connected Vehicles	GiveMeGreen (funded by Sensys Networks) can inform the program in the area of "other CV technologies and communications media", and the interaction of these media with traffic signal control.
Emerging Capabilities	With three different innovations proposed in this project, an understanding of the path to market of the products can help inform U.S.DOT's Emerging Capabilities Program Area.
Enterprise Data	SDOT is already implementing a data and analytical environment designed to store data from any public or private sector source in a secure environment. This Trusted Data Collaborative (TDC) will be where all data from this project will reside, with this data being the source of project evaluation and ongoing performance monitoring. SDOT and its partner, Microsoft, can support any assessment of this solution deemed valuable to U.S.DOT.
Interoperability	SDOT will implement a "use case" for all data within the TDC that ensures that appropriate ITS data standards are applied, or transforms the data to comply. This will allow for the data to be accessible to any other user.
Accelerating Deployment	This project will accelerate deployment of new products and services in the operations arena. The project can help U.S.DOT assess the impact of the program on product development, launch, and subsequent product phases.

The project evaluation can be designed to gather findings important to advancing the U.S.DOT's ITS Program Areas

3.Staffing

SDOT brings its top ITS staff to this project, each with significant and extensive depth of knowledge, skills and abilities to ensure success. Additionally, SDOT has supplemented their staff through on-call services contracts (already in place) to support ITS design, systems engineering and program management.

The SDOT Traffic Operations Division contains 123 staff. The Transportation Operations Center and ITS Program (27 staff), and the Signal Design and Field Operations (55 staff) groups reside within the TOD, and are leading this project. Key to this project are the following numbers of staff resources within these two groups:

12 – Traffic data specialists
3 – ITS engineers
9 – Traffic signal timing/arterial operations engineers
6 – Traffic signal/ITS design engineers
30 – ITS/Signal electricians and electronics staff
4 – IT/Network engineers

[redacted]

[redacted]

Figure 12: Project Organization and Key Staff

[redacted] staff, the project partners and consultants are shown. It is noted that the University of Washington will be brought on to support data management and evaluation. They are involved with and understand the Trusted Data Collaborative, and will support SDOT and FHWA in managing the data needed for the evaluation in that environment. They will also be able to provide a third-party independent viewpoint in the evaluation phase.

[redacted]

3.2. POINT OF CONTACT

The point of contact for this proposal is **Adiam Emery**.

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700 Fifth Avenue, Suite 3800
Seattle, WA 98124-4996

RESUMES

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