Performance Measurement Plan (PfMP)

for the Smart Columbus Demonstration Program

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Produced by City of Columbus

Notice

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Disclaimer

Acknowledgments

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Abstract

This Performance Measurement Plan describes the outcomes of Smart Columbus and how the objectives of each of the projects relate to them. The plan identifies and explains the methodology proposed to evaluate the indicators for each project, which will provide insight into the performance of a project in meeting the objectives. The plan also describes the data necessary to evaluate the objectives and the required reporting frequency and contents.

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Chapter 1. Introduction

The U.S. Department of Transportation (USDOT) pledged $40 million to Columbus, Ohio, as the winner of the Smart City Challenge (SCC). With this funding, Smart Columbus will demonstrate how advanced technologies can be integrated into other operational areas within the City, utilizing advancements in Intelligent Transportation System (ITS), Connected Vehicles (CV), Autonomous Vehicles (AV), and electric vehicles (EV) while integrating data from various sectors and sources to simultaneously power these technologies and leverage the new information they provide. Community and customer engagement will be present throughout the program, driving the requirements and outcomes for each project. This end-user engagement reinforces the idea that the residents of Columbus are ultimately the owner and co-creator of the Smart Columbus Program. Columbus intends to define what it means to be a "Smart City" and serve as a model for other cities wishing to fully integrate innovative technologies and community development that will be deployed in the Smart Columbus Program.

The Smart Columbus Program includes eight projects grouped into three overarching themes: Enabling Technologies, Enhanced Human Services (EHS), and Emerging Technologies. The program also includes the Smart Columbus Operating System (the Operating System), the integral backbone and heart of all current and future Smart City projects. **Figure 1** shows the Smart Columbus Program including each project.

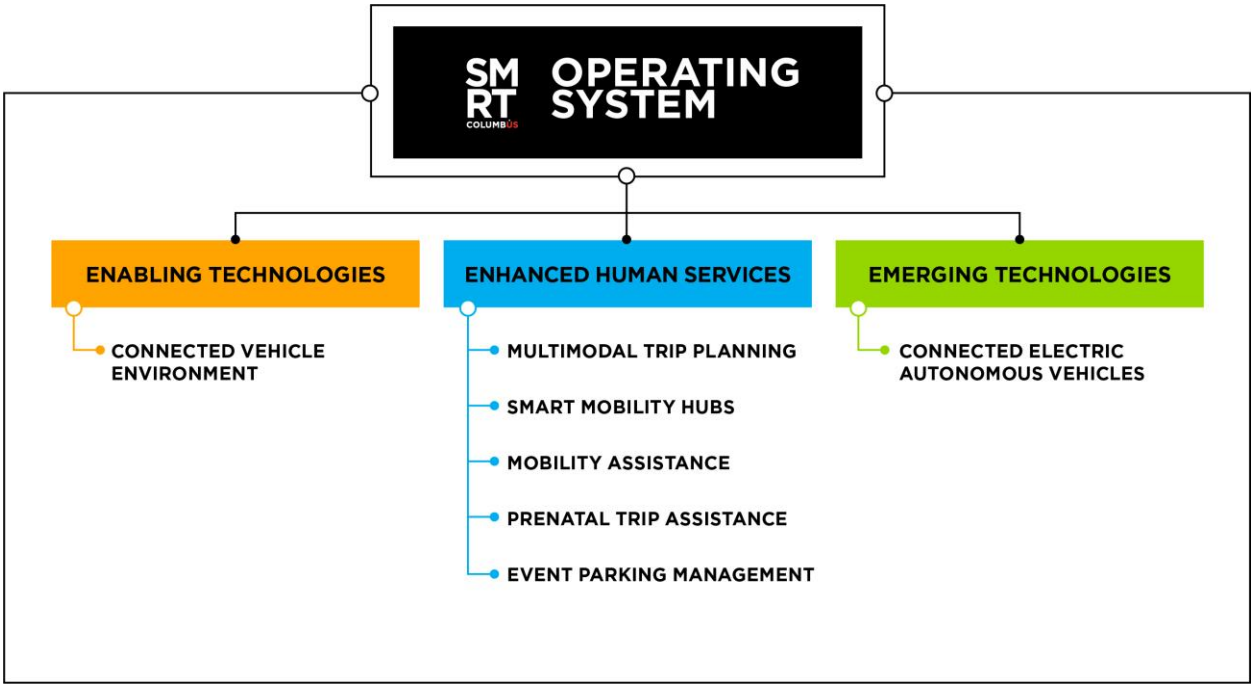

Figure 1: Smart Columbus Projects

Source: City of Columbus

1.1. ENABLING TECHNOLOGIES

These technologies leverage today's foundation in new and innovative ways to greatly enhance the safety and mobility of the transportation infrastructure. These advanced technologies empower deployments that

increase a city's capabilities because of rich data streams and infrastructure that are designed to handle on-demand responses. For example, the Connected Vehicle Environment (CVE) is an enabling technology that will improve safety, mobility, and the environment by leveraging cutting-edge technology to advance the sustainable movement of people and goods.

1.2. ENHANCED HUMAN SERVICES

EHS projects meet human needs with technology-based solutions that focus on preventing and remediating problems while maintaining a commitment to improving the overall quality of life for users. EHS projects create opportunities to improve access to jobs, healthcare, and events. The Smart Columbus Program includes the following EHS projects: Multimodal Trip Planning Application (MMTPA), Smart Mobility Hubs (SMH), Mobility Assistance for Persons with Cognitive Disabilities (MAPCD), Prenatal Trip Assistance (PTA), and Event Parking Management (EPM).

1.3. EMERGING TECHNOLOGIES

Emerging technologies are applications in development, or that will be developed during the next five to 10 years, that will substantially alter the business and social environment. By focusing on key emerging technologies, the City will be able to exhibit potential solutions to address and mitigate future transportation and data collection challenges. For example, the Connected Electric Autonomous Vehicle (CEAV) project is part of the emerging technologies theme.

1.4. OUTCOMES

The Smart Columbus Program will reorient Columbus to deliver more diversified and nimble transportation options by using data and a connected, complete network that supports healthy activity and a more attractive and sustainable urban form. **Chapter 2** describes in detail the outcomes associated with the projects, but **Figure 2** introduces them and how they are tied to the vision and outcomes for the Smart Columbus Demonstration Program.

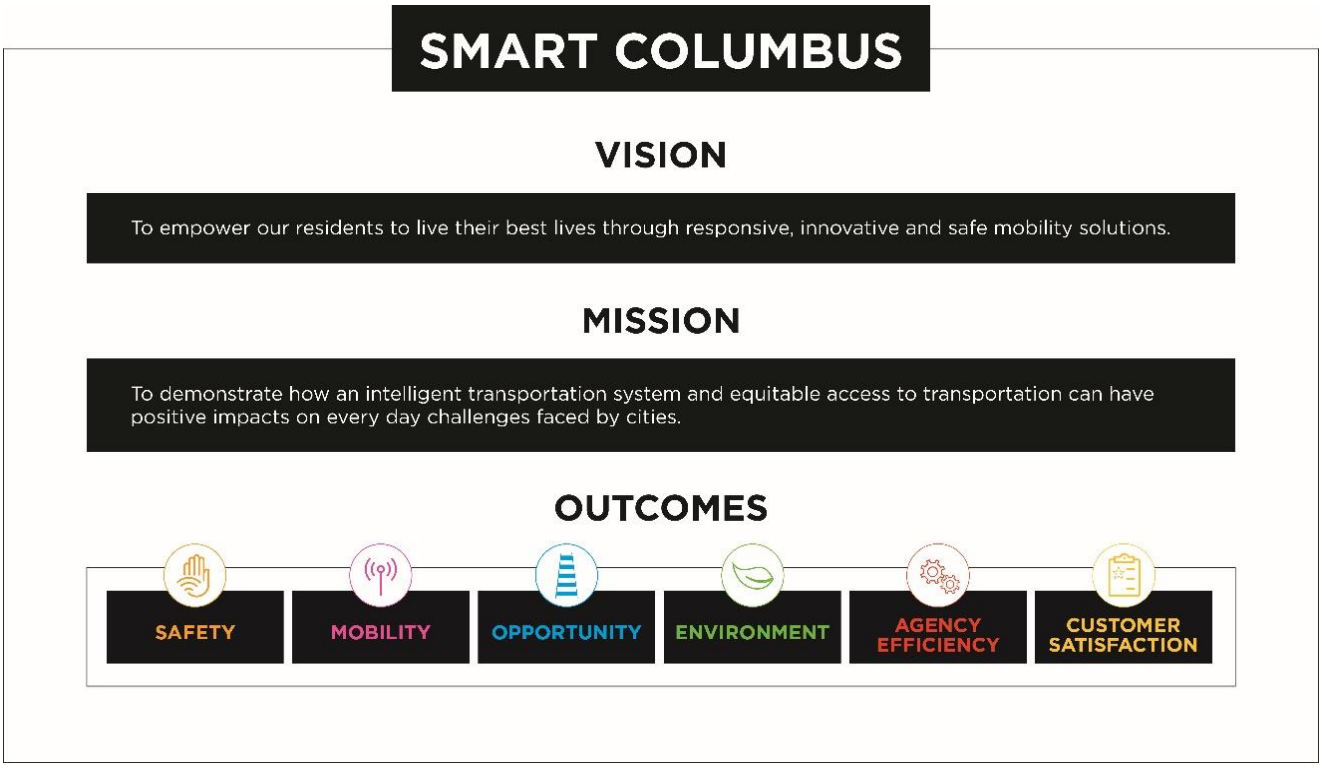

Figure 2: Smart Columbus Vision, Mission, and Outcomes

Source: City of Columbus

1.5. PURPOSE OF PLAN

A primary objective of the SCC is to demonstrate, quantify, and evaluate the impact of advanced technologies, strategies, and applications toward addressing the City's challenges. A set of rigorously defined performance measures can help understand the impact of integrated Smart City solutions on safety, mobility, opportunity, environment, agency efficiency, and customer satisfaction. The purpose of this Performance Measurement Plan (PfMP) is to identify each project's performance measures, as well as plans for collecting data and reporting on performance. The specific objectives of this plan are outlined below, and are presented within this document for each of the Smart Columbus projects:

- State hypothesis and assumptions about the project deployed.
- Identify evaluation indicators for the set outcomes and objectives.
- Develop an evaluation framework using logic models.
- Develop evaluation design including identification of confounding factors.
- Develop a data collection plan.
- Identify types of data to collect.
- Identify the methodology/source and timeframe to collect the data.
- Develop an impact evaluation plan.
- Identify data-sharing framework.
- Discuss performance reporting.

To provide additional clarity as to the purpose of this document it is important to understand the differences among performance measurement, performance monitoring, and performance evaluation:

- Performance measurement is the means of assessing the progress made towards achieving targeted outcomes. It answers the question, "Are the results improving, or not?"
- Performance monitoring tracks performance to assess if targets have been, or are likely to be, met. It enables system managers to take corrective and proactive actions to control and manage the system.
- Performance evaluation is the systematic and objective examination of measures and outcomes to understand the impacts of investments and policies on performance, thus improving current and future planning and investment decisions. It is typically conducted by an independent party who has no vested interest or stake in the project. The evaluation answers the question, "Did the treatment work, or not?" In the case of the SCC demonstration, the City of Columbus will conduct performance evaluation.
- Ultimately, this document serves to satisfy a mix of these three elements. Per the SCC Cooperative Agreement, the purpose of this PfMP is to identify and describe the performance measures for the various projects, describe the plans for collecting data in support of these measures, and ultimately report on performance. This PfMP discusses the following types of data and how they will be collected:
    - Pre-demonstration data that can be used as a performance baseline.
    - Continuous data during life of the demonstration to support performance monitoring and evaluation.
    - Cost data including unit costs and operations and maintenance costs.
    - Information on the timeframe that applications or other technology solutions are deployed during the demonstration period.

Within the context of the data collection for Smart Columbus, this plan describes how the City will release these performance measures as open data. Finally, from the perspective of performance evaluation, the plan contains proposed hypotheses for each project and how they will be evaluated in the context of the data being collected.

1.6. DEPLOYMENT AREAS

Smart Columbus will demonstrate effective implementation of a comprehensive portfolio of connected technologies that solve focused, relatable City issues and enhance mobility across the region. Like most mid-sized cities in the United States, the City of Columbus is divided into several neighborhoods, commercial districts, and other geographic zones that are connected by highways, transit, people, and culture. While some projects will be deployed within specific areas of the City, many projects will be deployed citywide and be designed in an integrated manner with the Operating System being the integral backbone and heart of all current and future Smart City projects.

Figure 3 provides an overview of the deployment area and captures the known elements of the following project deployments:

- **CVE:** The deployment corridors are highlighted, including Cleveland Avenue, High Street, Morse Road, and Alum Creek Drive. The intersections where freight signal priority will be deployed are highlighted to indicate the freight corridors. In addition, the existing bus rapid transit (BRT) corridors are indicated for reference. Last, the target ZIP codes from which private vehicles will be recruited (and where installation will be targeted) are highlighted in blue shading.
- **MMTPA:** The first release included both Central Ohio Transit Authority (COTA) and the Ohio State University (OSU) Campus Area Bus Service (CABS) as key providers. These service routes are called out on the map. MORPC's Gohio Commute platform, bike share, scooter share, and ride-hailing mobility providers have joined MMTPA in subsequent releases. These on-demand mobility services are not included in **Figure 3**.

- **MAPCD:** The OSU callout box indicates the project's background and focus around the OSU Prevocational Integrated Education and Campus Experience (PIECE) program, from which focus- and test-group participants were recruited to help refine the application's functionality. The development and refinement of the MAPCD application was conducted using routes centered on OSU's campus, with all but one route on campus. The application includes both COTA and CABS buses. The broad deployment of MAPCD was not limited to PIECE program participants, and it was conducted citywide in collaboration with OSU and ARC Industries, a community organization that helps adults with developmental disabilities find employment. The location of ARC Industries is not shown on the map, as it is an administrative office only—not one of the employment/job center origins or destinations for the project.
- **PTA:** PTA project recruiting included all of Franklin County. This area is delineated by a blue border on the map.
- **SMH:** The hub locations are noted.
- **EPM:** The downtown and Short North areas of Columbus are highlighted as the point of interest for this application, which will focus on parking providers in these areas and visitors who will be traveling into and within these areas.
- **CEAV:** Both the Smart Circuit and Linden LEAP routes are called out with stops identified. For the food pantry service of the Linden LEAP, the food distribution occurs at the northbound Rosewind Resident Council station.

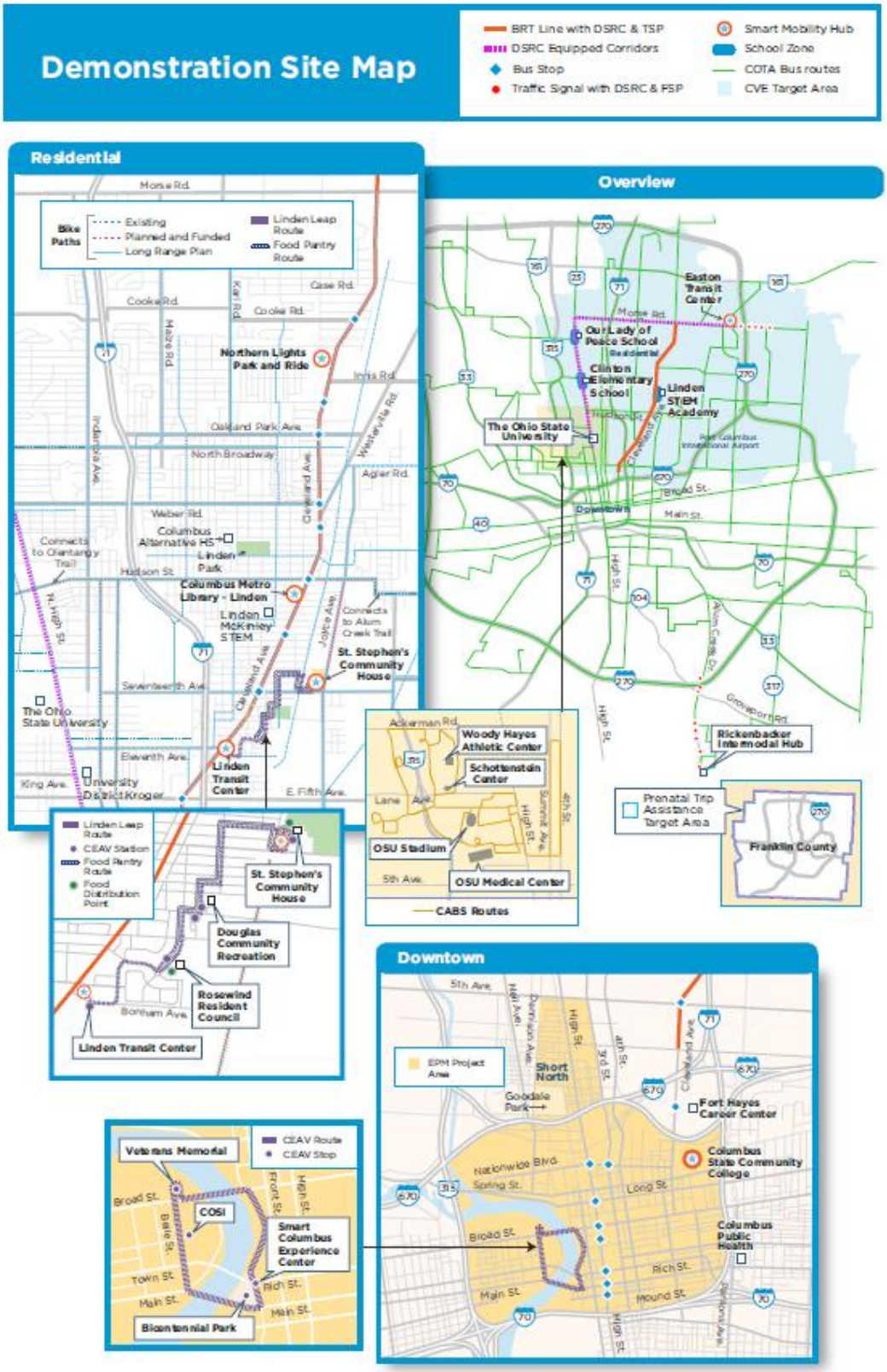

Figure 3: Smart Columbus Demonstration Site Map

Source: City of Columbus

1.7. PROJECT TIMELINE

Figure 4 presents the implementation timeline of Smart Columbus Portfolio projects. The dates represent the data where the functionality or project will be live.

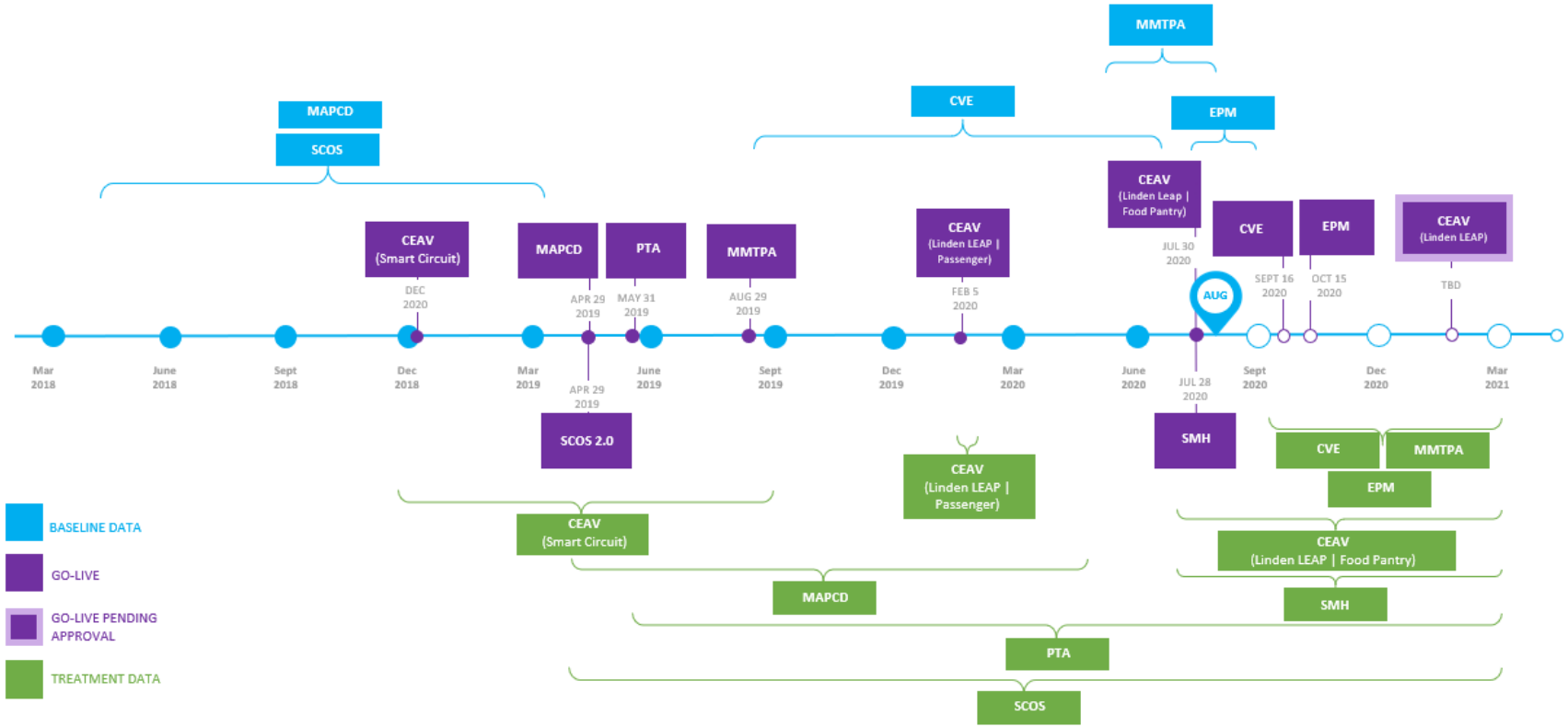

Figure 4. Smart Columbus Implementation Timeline

Source: City of Columbus

Originally, all Smart Columbus projects, except CVE, were planned to have a one-year period of performance. This update to the PfMP reflects the actual launch date for all projects and milestones launching after March 1, 2019. Due to project needs and COVID-19 impacts (to both the project(s) and the City of Columbus), several projects delayed their launch. Therefore the Project timeline reflects revised launch dates for all projects except the Operating System, MAPCD, and PTA, as shown in **Table 1**. The revised dates were selected to balance data collection and operational constraints with impacts and guidance related to COVID-19. If a project launch was delayed, the end date was similarly extended to allow for as much data collection as possible. Please note, the impact of COVID-19 on the Smart Columbus program will be discussed in more detail in **Chapter 3**.

Table 1: Smart Columbus Projects' Periods of Performance

	Original		Revised	
Project	**Launch Date**	**End Date**	**Launch Date**	**End Date**
Smart Columbus Operating System	4/22/2019	4/21/2020	(no change)	3/31/2021
MAPCD	4/29/2019	4/28/2020	(no change)	(no change)
PTA	5/31/2019	12/31/2020	(no change)	3/31/2021
MMTPA	8/29/2019	1/6/2021	(no change) Release 4: 10/1/20	3/31/2021 Release 4: 3/31/2021
CEAV	11/19/2019	11/18/2020	2/5/2020 Food Pantry Use Case: 7/28/20 Passenger Service: TBD	Alt. Use Case: TBD (dependent on if passenger service resumes) Passenger Service (if returns) 3/31/2021
EPM	3/26/2020	3/25/2021	10/15/2020	3/31/2021
SMH	2/21/2020	2/20/2021	7/28/2020	3/31/2021
CVE	7/7/2020	3/31/2021	(no change)	3/31/2021

Source: City of Columbus

1.8. METHODOLOGY

The Performance Measurement Plan for the Smart Columbus project is developed based on the USDOT recommended best practices for performance measurement, as shown in **Figure 5**.

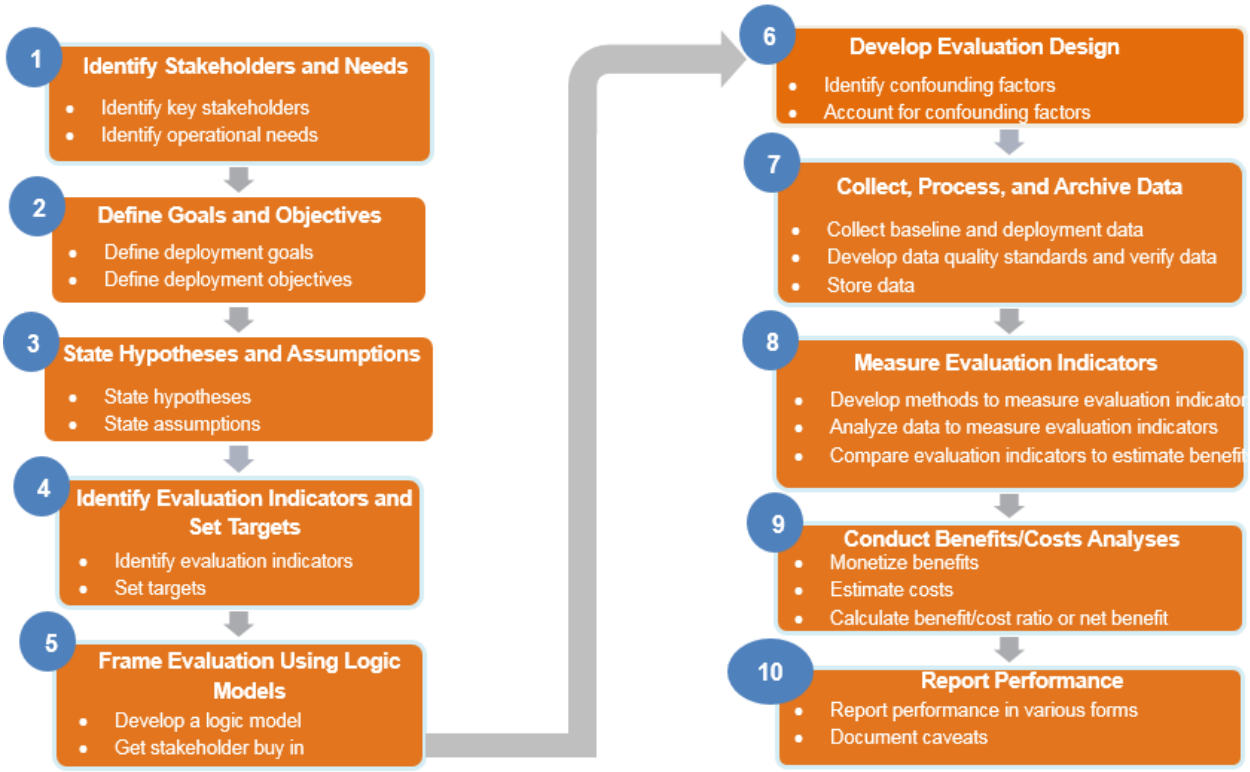

Figure 5: Best Practices for Performance Measurement

Source: Methodology to Evaluate the Benefits of Cooperative System Applications Report

A description of each of the steps is provided below:

- Step 1 identifies the stakeholders and operational needs for the project. The stakeholder and operational needs for the project are identified in the Concept of Operations (ConOps) of the individual projects and are not included in this plan.
- Step 2 defines the outcomes and objectives of the deployment.
- Step 3 states the hypotheses and assumptions about the application deployed.
- Step 4 identifies the right, appropriate, and consistent evaluation indicators to be used in assessing the objectives.
- Step 5 establishes the interdependencies and secures stakeholder buy-in.
- Step 6 develops evaluation design to account for confounding factors and isolate the impacts of the deployment.
- Step 7 collects, processes, and archives data used for measuring performance and assessing impacts of the deployment.
- Step 8 analyzes collected and verified data to calculate evaluation indicators using appropriate measurement methodologies.
- Step 9 conducts benefits-cost analyses to determine the cost-effectiveness of the deployment. Benefit-cost analyses are beyond the scope of this performance measurement plan.
- Step 10 presents evaluation results to stakeholders.

1.9. REPORT ORGANIZATION

The remainder of this report is organized into the following chapters:

- **Chapter 2. Smart Columbus Outcomes**: This chapter defines the six Smart Columbus outcomes and describes how they relate to individual projects, addressing Step 2 of the methodology.
- **Chapter 3. Confounding Factors**: Confounding factors are variables or influencers that, if left unaccounted for, may introduce bias or suggest correlation among variables where none exist. It is practical to seek and identify these factors before beginning the performance measurement process. This chapter provides the potential program-level confounding factors for the Smart Columbus projects, and discusses those factors that are identifiable and measurable beforehand (a priori). This chapter addresses Step 6 of the methodology.
- **Chapter 4. Experimental Strategies**: This chapter presents experimental strategies for the individual Smart Columbus projects, discussing typical application methods and modeling techniques to evaluate performance. It also describes how the projects will address the confounding factors identified in **Chapter 3**.
- **Chapter 5. Performance Measurement and Evaluation**: This chapter dives deeper into the City's approach to performance measurement for each project. Each project will include an introduction, a logic model with outcome and objectives, hypotheses and assumptions, performance indicators, design of experiment, data collection plan including data source, baseline timeframe, treatment timeframe, impact evaluation, project specific confounding factors, and project costs for each objective of the projects. This chapter also discusses the performance targets for the projects. This chapter addresses Steps 3, 4, 5, 7, and 8 of the methodology.
- **Chapter 6. Data Collection Plan**: The data collection plan identifies the data sources for each project's evaluation of the performance indicators and plan for managing data quality, personally identifying information, data security, data archival, and data management. This chapter does not supersede the Smart Columbus Program Data Management or Data Privacy Plans. Rather, it provides project-specific data information that supports performance measurement.
- **Chapter 7. Data-Sharing Framework**: This chapter provides a program-level summary for how the Smart Columbus Program will share data among the project teams and the Operating System. As with **Chapter 6**, it complements the Data Management and Data Privacy Plans—it does not supersede them.
- **Chapter 8. Performance Rating**: The SCC Cooperative Agreement requires the sharing of performance measurement results. This chapter discusses the way performance will be reported to USDOT and other stakeholders. This chapter addresses Step 10 of the methodology.
- **Chapter 9. Conclusions**: The last chapter provides the City's conclusions regarding the performance measurement plans and activities.

1.10. RELATION TO OTHER DOCUMENTS

The PfMP is related to several other program-level and project-level documents developed for the Smart Columbus Program. The following section identifies these related documents. Most of these documents are available on the Smart Columbus website.[1]

[1] https://smart.columbus.gov/projects/

1.10.1. Project Systems Engineering Documentation

Smart Columbus projects follow different Project Advancement Steps as defined in the Smart Columbus Systems Engineering Management Plan (SEMP). Depending on the project, they may be developed using the Vee Model or Agile methodology. The specific systems engineering deliverables that relate to the PfMP include:

- **Concept of Operations/Trade Study/Operational Concept:** These documents lay out the project description, outcomes, and objectives for all the projects. In addition, these documents contain user needs that were developed with key stakeholders, which included those with an interest in performance measurement. Performance measurement is a key consideration in the development of the ConOps content.
- **System Requirements/Agile Backlog:** The user needs related to performance measurement are carried forward by the system requirements. The best example of this may be the performance, data, interface, and policy/regulatory requirements, which capture and describe the specific data, frequency, and type of interface used to support the collection of relevant data.
- **Interface Control Document:** To a lesser extent, the Interface Control Document provides additional detail regarding the origin, destination, and data flows of each interface for the Vee Model projects and additional detail regarding the data that is collected in support of performance measurement (among other purposes).
- **System Design Document:** This document describes the specific elements of each project and trace back to system requirements, interfaces, and user needs (from the ConOps). It ensures that these elements have been accounted for in the design, including the execution of performance measurement.

Collectively, the PfMP uses the systems engineering documents as both the foundation for creating a performance measurement approach and then ensuring that it is executed in accordance with these documents.

1.10.2. Data Privacy Plan

The Smart Columbus Data Privacy Plan (DPP) provides an overarching framework for the ways in which Smart Columbus will protect the security of personal information that it collects and uses, and the privacy of the individuals to whom this information pertains. The data collection plan identified as part of this PfMP will ensure data privacy as documented in the DPP is maintained throughout the performance measurement process.

1.10.3. Data Management Plan

This Smart Columbus Data Management Plan (DMP) provides operational information for the use of data within the Smart Columbus Operating System platform to ensure optimal program functionality in addition to properly securing, backing up, maintaining, and sharing the data. The PfMP will ensure consistency with the DMP when developing the data collection plan and evaluation plan.

1.10.4. Human Use Approval Summary

The Human Use Approval Summary (HUAS) document describes the Smart Columbus institutional review board (IRB) process as it is applied at the program and project levels during both demonstration and performance measurement. Any methods and processes detailed in the PfMP that involve human subjects are described in the HUAS, including the method/process used, risks introduced to participants,

items/documents submitted for IRB review, and outcomes/clarifications provided by the IRB. It is important that the HUAS and PfMP are consistent in these items for program traceability.

1.10.5. Safety Management Plan

The Safety Management Plan (SMP) contains project-specific risks that pertain to the physical safety of the travelers interacting with the various project solutions. The methods and processes detailed in the PfMP need to be consistent with the safety operational concept in the SMP, so as not to introduce any additional risks or affect the mitigation strategy outlined in the SMP. The SMP has informed by and is considered as a source of confounding factors for this PfMP.

Chapter 2. Smart Columbus Outcomes

2.1. INTRODUCTION

A key aspect of measuring performance is identifying the central outcomes of the Smart Columbus demonstration program. This process began during application development and has continued as individual projects were developed further. During the application phase, the USDOT identified 12 elements to help set a vision for a Smart City demonstration. Applicants were encouraged to consider these 12 elements in developing ideas for their city's approach for a Smart City demonstration which addresses real-world issues and challenges citizens and cities are facing. These elements are shown in **Figure 6.** They build upon the USDOT's *Fiscal Year (FY) 2014-2018 Strategic Plan*[2] and *DOT Strategic Plan for FY 2018-2022.*[3]

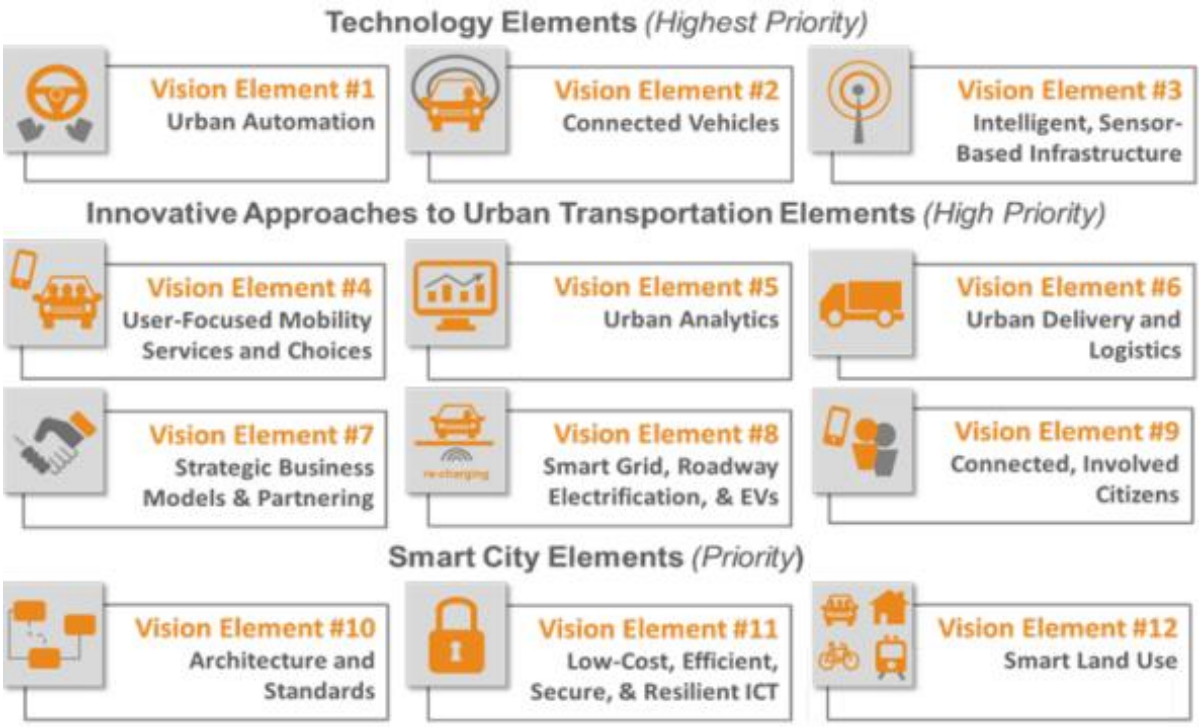

Figure 6: USDOT's 12 Vision Elements for Smart Cities

Source: USDOT

The technology elements represent the highest priority. These three vision elements cover CVs, AVs, and the infrastructure needed to function effectively. This includes vehicle-to-everything (V2X), which for the

[2] https://www.transportation.gov/sites/dot.gov/files/docs/2014-2018-strategic-plan_0.pdf

[3] https://www.transportation.gov/sites/dot.gov/files/docs/mission/administrations/office-policy/304866/dot-strategic-planfy2018-2022508.pdf

Smart Columbus program encompasses vehicle-to-vehicle (V2V) and vehicle to infrastructure (V2I) communications.

The next highest priorities are focused on increasing the efficiency of the transportation network through innovative approaches to urban transportation. By installing means of collecting, analyzing, and leveraging data through new applications and services, a Smart City accomplishes more with its infrastructure. Smart Cities are built through interactions with stakeholders, businesses, and citizens.

The remaining priorities include the development of standard architectures, which increases transferability to other urban areas. In addition, technology in communications and better land use improve the quality of life and further increase transportation efficiency.

Smart Columbus has established a vision, mission, and outcomes that reflect USDOT's 12 vision elements. These outcomes represent the potential impact of solutions developed to address challenges facing the City of Columbus, including traffic congestion, crashes, infant mortality, poverty, and unemployment. Continued studies verify these issues. For example, the annual Urban Mobility Report identifies issues for travelers and shippers in the Columbus area due to wasted fuel, lost productivity due to congestion delays, and increased stress for commuters.[4] Additional information about issues the Smart Columbus Program is addressing is on the Smart Columbus website, along with documentation such as the grant application and program management plan.

These challenges are common in urban areas, and they are challenges worth trying to solve. Columbus believes equitable access to transportation is an integral piece to solving these problems. Moreover, as the fastest growing city in the Midwest, Columbus must plan for and implement ITS solutions that efficiently and effectively enable the flow of people and goods throughout the City to remain competitive. Solving urban challenges and creating a Smart City are integral elements of Columbus's thriving future. Columbus plans to use transportation – powered by holistic solutions and integrated, open-source data – to give its residents opportunities to empower themselves. This could mean access to healthcare providers, jobs, school, job training, or other destinations. The City is shifting the transportation paradigm so that all residents can safely and efficiently traverse their neighborhoods in the manner they choose.

2.2. SAFETY

Smart Columbus aims to improve safety by reducing transportation-related fatalities and injuries. Promoting safety relates to safety issues affecting all modes and the development and deployment of countermeasures designed to address these issues (USDOT, 2016).[5] Applying emerging technologies presents Smart Columbus with the opportunity to improve the safety of the City's transportation network by reducing property-damage-only, injury and fatal crashes involving pedestrians, bicycles, and motor vehicles. To accomplish this, Smart Columbus will deploy and operate CV, including both vehicle and roadside, along multiple corridors in Columbus. Multiple vehicle types will be equipped including private/passenger, emergency, transit, and freight vehicles. Implementation of the CV project is anticipated to increase drivers' awareness of other vehicles in the corridors.

[4] *Texas A&M Transportation Institute. Annual Urban Mobility Scorecard, 2019.* https://mobility.tamu.edu/umr/

[5] https://www.transportation.gov/sites/dot.gov/files/docs/USDOT-RD%26T-Strategic-Plan-Final-011117.pdf

2.3. MOBILITY

Enhancing the mobility of Columbus's citizens within the context of Smart Columbus means providing new ways to connect to local destinations and transportation services. To improve mobility, the City considers demographic, economic, geographic, cultural, and technological trends affecting travel demand, personal and commercial mobility across all transportation modes, and the effects of those trends on quality of life and access to economic and educational opportunities. Enhancing mobility applies to all modes of transportation and will make these modes more accessible and useable to travelers by providing real-time traveler information and innovative technologies for mobility services. Smart Columbus will enhance the City's mobility by deploying projects that range from improving access to transportation services and multimodal trip planning to reducing roadway and parking congestion. For example, multimodal trip planning applications will allow users to compare and select multiple travel options and itineraries and provide a method to analyze user data to improve the application.

2.4. OPPORTUNITY

Providing opportunities for improved access to transportation options for Columbus' citizens is of vital importance to Smart Columbus. This outcome aims to increase access for underserved communities to a wide variety of services through transportation solutions focused on improved access to places of employment, education, healthcare, and other services, as well as increasing the use of the transportation network by bringing available services and users together. Opportunity is created with the implementation of transportation infrastructure in communities that connects people with jobs, housing, and an improved quality of life. Smart Columbus will create opportunity by addressing the barriers that travelers face with existing transportation systems. This includes facilitating multimodal trip planning that allows travelers to have a comprehensive view of transportation service options available to them, creating an application that helps people with cognitive disabilities achieve mobility independence, and streamlining access to non-emergency medical transportation for expectant women. For paratransit users, opportunity will be improved by providing measures to ease the transition from one transportation system to another. For users with a first-mile/last-mile (FMLM) obstacle, deploying CEAV can create more efficient access to transit and services.

2.5. ENVIRONMENT

Smart Columbus will reduce transportation's negative impacts on the environment through implementing advanced technologies and policies that support a more sustainable transportation system. For example, MMTPA will encourage many shared-use and transit-related projects that shift travelers away from single occupancy vehicles (SOVs). CVE Signal Priority (especially freight signal priority) will provide opportunity to reduce truck-related emissions and save fuel. Additionally, EPM may reduce parking congestion. Each of these technologies will yield positive environmental benefits.

2.6. AGENCY EFFICIENCY

Smart Columbus will improve the ability of government, transportation, and community agencies to provide services to citizens through advanced technologies. It will also enable easier access to real-time data, streamline internal processes to improve communications and information sharing, and make internal agency operations more efficient. Agency efficiency includes strategies to enhance agency coordination such as improved interagency sharing of information and resources to reduce operating costs and/or enhance productivity. For example, implementing the Operating System will provide a method to share data and improve efficiency within user agencies by supporting communications and facilitating the usage of data in agency programs more effectively and efficiently.

2.7. CUSTOMER SATISFACTION

Smart Columbus will only be successful if it provides services that are useful, easy to use, and embraced by the community. Smart Columbus will improve the user experience for citizens planning for, paying for, and using transportation services through the integrated exchange of data and use of advanced technologies to help travelers reach their destinations. By implementing advanced technologies, such as a MMTPA or SMH, the products or services supplied by the City will meet or surpass a traveler's expectation. Further, projects such as CEAV will increase the number of convenient, reliable FMLM trips that bridge transit gaps in the deployment area.

Chapter 5 discusses the objectives for each project. **Table 2** identifies the outcomes for the Smart Columbus Program and the projects contributing to these outcomes.

Table 2: Smart Columbus Project Outcomes

SMART COLUMBUS PROJECTS	SMART COLUMBUS OUTCOMES					
	Safety	Mobility	Opportunity	Environment	Agency Efficiency	Customer Satisfaction
1. The Smart Columbus Operating System					P	P
2. Connected Vehicle Environment	P	P, S		S		
3. Multimodal Trip Planning Application		P, S	P, S	S		P
4. Mobility Assistance for Cognitive Disabilities		P	P		P	P
5. Prenatal Trip Assistance		P	P			P
6. Smart Mobility Hubs		P	S			P
7. Event Parking Management		S		S		P
8. Connected Electric Autonomous Vehicles		P, S	P, S			P

P – Indicates project level outcome; S – indicates program-level outcome the above table reflects the most recent decisions by the project teams. The Performance Measurement Plan (PMP) will be reviewed, so that any changes to project outcomes presented in PfMP will be updated in the PMP.

Source: City of Columbus

Chapter 3. Confounding Factors

3.1. INTRODUCTION

This chapter identifies confounding factors that are likely to affect performance measurement activities. Information about data collected and sources is presented in detail in **Chapter 6**.

3.2. DEFINITION OF CONFOUNDING FACTORS

Accuracy and effectiveness of performance measures depend on identifying the presence of confounding factors and addressing their effects on the project. Confounding factors are any events that might arise during the project implementation, which can be associated with having an apparent effect on some dependent variables of interest. In an experiment, confounding factors that are not accounted for during design could either understate or overstate the relevance of treatment effects upon treated units. In extreme cases, confounding factors can lead to spurious relationships between explanatory and dependent variables, with the variables having no direct causal connection, while it may be wrongly inferred that they do.

Two types of confounding factors are likely to arise from the project implementation:

- Study-area specific factors (e.g., climate, special events)
- Deployment-specific factors (e.g., participant specific, technology-specific)

Factors that can be identified, recorded, and measured a priori (i.e., before demonstration implementation) are defined as observed factors. Factors that cannot be directly observed or measured are defined as unobserved factors. During performance measurement and statistical modeling, observed factors can be accounted for by their proper inclusion as explanatory variables and modeling method, while unobserved factors can be accounted for by utilizing appropriate statistical techniques to reduce omitted-variable bias.

3.3. STUDY-AREA-SPECIFIC FACTOR

When measuring performance by the selected indicators, the results will be viewed through a lens considering the environment not controlled by the experiment. This chapter discusses only general study-area-specific factors; **Chapter 5** discusses cases in which a specific confounding factor applies to an individual project.

3.3.1. Fuel Prices

The price of fuel impacts the miles driven in personal vehicles and mode choice. When fuel costs are high, travelers take fewer discretionary trips and are more likely to choose modes where they do not directly pay for fuel. Conversely, low fuel prices tend to encourage more miles driven in personal vehicles.

Projects that might be affected because of fuel price changes include MMTPA, SMH, EPM, and CEAV. Miles driven impacts many indicators that will be measured for performance, including crashes, emissions, congestion, and parking.

In addition, a fuel price change could drive a change in modal preference independent of Smart Columbus projects.

To account for these issues, trends in fuel prices will be assessed for the two years before and during deployment and two years post-deployment. Historic fuel prices by region and fuel type are available from the U.S. Energy Information Administration. This information will be used for the performance evaluation. Major increases or decreases in fuel price will be viewed alongside indicators that fuel price may impact.

3.3.2. Weather

Columbus has well-defined seasons, each presenting different challenges to mobility. For instance, snow and ice in the winter slows traffic, and the potholes created by the freeze-thaw cycle are present through much of the spring until temperatures rise high enough for maintenance to be effective.

For projects such as MMTPA, SMH, PTA, MAPCD, and CEAV, where participants would be using Smart Columbus resources for their travel needs, weather events might affect the on-time performance, safety, and mobility aspects of these solutions.

For the most part, considering seasonality is enough to address weather's impact on the results. Comparing data in one year to the same season in the next is generally valid unless one season was uncharacteristically intense.

On a daily or weekly scale, weather impacts may be more pronounced. Comparing the same week in two different years may not accurately represent the impact of a project if heavy rains fell one year and not in the next. Evaluators will consider the weather when assessing trends.

Historic weather data is available from the U.S. Department of Commerce's National Oceanic and Atmospheric Administration National Weather Service Forecast Office. Reports will be stored on the Operating System and will be accessible to evaluators.

3.3.3. Adjacent Projects

Construction projects will continue to occur throughout the City over the course of the program's development and demonstration. The scope will vary from basic pavement repair to new construction, with the scale of impact varying just as widely. Some projects may close and open roadways, change traffic patterns, and establish short and long-term work zones. Each of these situations would impact some indicators, such as crashes or transit route times.

To partially mitigate this, known projects have already been considered in choosing geographic deployment areas. However, needs for other road projects may arise after implementation. In these cases, evaluators must account for them through coordination with the other City projects, private projects, Ohio Department of Transportation (ODOT), Mid-Ohio Regional Planning Commission (MORPC), Franklin County Engineer Office, and surrounding cities. Evaluators will analyze indicators while considering the impact of nearby projects before and after implementation.

3.3.4. Seasonal Traffic

In addition to impacts from weather, the time of year also influences traffic due to seasonal demands. There are many seasonal variables that impact demand, such as the school year, holiday shopping near retailers, and sports seasons. Each has a unique impact and may occur at the same time as other influences. To account for this, traffic counts are adjusted using seasonal adjustment factors derived from observations of seasonal variations in previous years. In addition, traffic counts will be coordinated to the extent possible to be taken in similar situations to those with which they will be compared.

3.3.5. Traffic Incidents

Seasonal traffic factors typically cover the recurring traffic demands based on the historic observations. However, non-recurring traffic events, including crashes, dangerous slowdowns, stalled vehicles, etc., would affect the route planning, on-time performance, and safety aspects. Project evaluators will take non-recurring traffic incidents into consideration when evaluating unanticipated spike in the performance measures.

3.3.6. Underreporting of Crashes

Crash data is maintained by local police departments, the MORPC, and the Ohio Department of Public Safety. Each agency acquires data from the same source, law enforcement reports. Law enforcement officers record many aspects of the environment, vehicles, occupants, and resulting damages for crashes the officers are aware of. Most crashes are reported in cases of severe injuries and vehicular damage, but fewer crashes are reported when injuries and damages are minimal. Underreporting is encountered whenever crash data is used in analysis.

However, consistent crash reporting behavior pre- and post-deployment would not affect impact assessments. Any changes in reporting behavior between pre- and post-deployment periods will be taken into consideration when performing the measurement and evaluation. Where appropriate, other safety-related data, such as speeds, will be analyzed alongside crashes. Special events create traffic demands and sometimes restrictions that are far outside of normal operating conditions. Except for EPM, data from special events does not reflect the typical effectiveness of implemented technology, although they may test its ability to perform under the highest demands.

In many cases, the number, size, and timing of special events are consistent across multiple years. However, comparing data between a time with an event and time without one could misrepresent the impact of a project. Evaluators will consult a list of special events or closed roadways near deployment areas of before-after implementation. This list will be coordinated with the City of Columbus, Experience Columbus, and other parties that monitor special events.

3.3.7. Penetration Rate

Penetration refers to the portion of users that choose to, or are selected to, adopt the implemented project technology. In most cases, little change would occur at a low penetration percentage. However, for many reasons such as funding, time, compatibility, and user choice, it is often not possible to implement the treatment for all users at once.

Penetration may be limited based on users, location, or both. For instance, some CV applications will only be implemented in a limited geographic area and for some vehicles that travel in that area. Penetration will vary for each project over time and must be recorded. Data from roadside units (RSUs) will be used to measure penetration.

Penetration rate may also be a deployment confounding factor. For instance, the ability to recruit private vehicle owner participation in the CVE project may impact results.

3.3.8. User Understanding

When a new process or technology is implemented, many users will initially be unfamiliar with its operation. Over time, users will become more familiar with the technology—leading to more effective use. Therefore, an initial learning period is anticipated where improvements may be limited. A better depiction of the project's effectiveness will occur after the initial learning period. The demonstration period for the majority of projects was selected to ensure sufficient time for user error and to reduce the impact of this confounding

factor. The final length of demonstration was dependent on the launch date for each project. Many projects will be in deployment for less than one year, although at least six months of data was sought in most cases.

To address the need to learn to operate the technology, training and outreach will be provided in various ways. For complex systems such as CVE, training materials and videos will be provided to participants before equipment is installed in vehicles. For the projects providing publicly available services or applications such as MMTPA and SMH, training and guidance will be provided inside applications so that the user can access it when needed. For other apps such as MAPCD, in-depth training of participants and caregivers is provided to ensure understanding and comprehension of the systems' functionality prior to beginning demonstration.

Despite the training sessions and materials, time taken by users to understand and use the application depends on factors like application UI complexity, users' familiarity with similar applications, complexity of completing actions in the app, etc. For this reason, app user data during the first month of deployment will be carefully assessed by taking user understanding into consideration.

3.3.9. Signal Timing Updates

When traffic patterns change, or a signal network is coordinated, signal timing may be changed at one or more intersections. Changing signal times may have an impact on some indicators, especially traffic congestion near the signal. For projects that will be evaluated based on traffic counts or congestion, changes in the signal network may impact results.

To identify situations where this occurred, signal timings will be recorded whenever traffic counts are ordered at or near signalized intersections for Smart Columbus. For historic counts, the City will review its records maintained through the Columbus Traffic Signal System (CTSS) and post relevant signal timing data in the Operating System. Both sets of timing will be accessible to compare signal timings. In cases when the timing changed, evaluators will assess what impact the new timing would have had on traffic.

3.3.10. System Maintenance

To maintain optimal efficiency and functionality, systems sometimes must be taken fully or partially offline. During these maintenance periods, performance measures will be impacted. The extent will vary based on demand and type of maintenance and will be accounted for in this performance report. A list of downtime for maintenance will be planned and logged on the Operating System.

3.3.11. COVID-19

Perhaps the largest unobserved factor that has impacted the Smart Columbus program is the global COVID-19 pandemic occurring in 2020, which began as many of the projects were on the cusp of demonstration. In March 2020, the State of Ohio implemented a stay-at-home order, travel restrictions, and a state of emergency. While the stay-at-home order and travel restrictions were largely lifted at the end of May 2020, the State of Emergency remained in effect as of August 2020. As an immediate result, traveler behavior and needs, travel patterns, transit offerings, data collection, project timelines, and analysis approach were altered throughout the Central Ohio region. Traffic levels dropped by over 50% during the stay-at-home order. As these restrictions were lifted, these alterations persisted, even as the City, state, and region slowly re-opened.

Plans presented in this document are contingent on Columbus's plan to move forward with re-opening while accounting for the existing conditions, parameters, and guidelines put into place due to the potential future resurgence of the COVID-19 virus. As of the publication of this update (August 2020), much uncertainty remains, COVID-19 cases are again on the rise, and while restrictions have not yet gone into effect, school re-openings have been altered, COTA ridership remains significantly reduced, events cancelled, and social

distancing guidelines in place. Some businesses have opted to continue allowing employees to work from home even after the State's orders have been lifted, and many events have been cancelled, postponed, or will be held virtually—preventing travel behavior, transit demand and offerings, and parking needs from returning to pre-pandemic conditions. Additional details respective to the impact of the pandemic on each project's deployment are provided in the program- and project-level confounding factors sections in **Chapter 5**.

Regarding performance measurement activities, the program-level and project performance measurement logic models are designed to remain valid despite most disruptions and confounding factors. The nature and timing of the COVID-19 pandemic, however, necessitates some changes, primarily at the indicator and design of experiment level. For example, in many cases, shelter-in-place orders prior to project implementation distorts measurement baseline. In such cases, it is difficult to control for confounding factors, such as reduced traffic, due to COVID-19 responses. In such cases, rather than using a pre/post quasi experimental design, a difference-in-differences (DiD) model or other approach is proposed to better disentangle the effects of COVID-19. In the DiD model, propensity score matching (PSM) is used to match an adequate counterfactual control group with the treatment group, then controlling for confounding factors. Specific examples of alterations in experiment design include:

- The EPM project's planned deployment period was in 2020, so implementation will be entirely during the COVID-19 condition. As a result, most events have been or are likely to be cancelled, resulting in a shift away from event-centered analysis to routine visits to the study area.
- As the CEAV project requires a change of use case, more extensive changes to the logic model for that project were needed. Further details on project-specific confounding factors and COVID-19 impacts can be found throughout **Chapter 5** in the presentation of each project's approach.

One overarching area of change throughout many of the outcomes (whether program or project) are the timeframes for pre- and post- analysis. Many of the projects sought to directly impact travel patterns and behavior in the region and their launch and adoption are dependent on the traveling public utilizing them for both work and recreational trips. As such, the launch of projects that were especially dependent on travel patterns returning to pre-pandemic conditions were delayed and did not occur in late spring 2020 as planned. Specifically, MMTPA, EPM and SMH were all delayed to summer 2020 for this reason. The pandemic also created delays in resource availability, impacting vendors' ability to support development, integration, and testing activities due to staff layoffs and travel restrictions which prevented them from traveling to Columbus. These issues specifically affected the EPM and CVE projects.

Most dramatically, the pandemic impacted the overall architecture of the Common Payment System (CPS), resulting in a revision to the MMTPA project architecture. The financial implications on COTA, as a major stakeholder and future owner of the MMTPA/CPS application known as Pivot, were too great to continue this commitment. Likewise, other participating mobility providers were equally impacted by reductions in ridership (which lead to reductions in operating budgets, staff, etc.) constraining resources and impacting the ability to integrate into the system as originally designed. As of the publication of this update, MMTPA is recommending an alternate approach to connecting with mobility providers to enable multimodal trip booking and payment. The creation of a common, account-driven system is impossible to create and deliver in the current COVID-19 climate. The performance measures for MMTPA are likely intact, as they focused on the multimodal nature of trip planning and execution.

3.4. DEPLOYMENT-SPECIFIC FACTORS

Deployment-specific confounding factors include all factors or events that can be potentially triggered by the project implementations. These include instances as identified by the ConOps failure, degraded, and maintenance conditions and SMP, and induced errors by linking data across platforms. Other confounding factors are likely to be introduced by participant identification and selection, their personal use of installed vehicle equipment, and improper use of downloaded applications.

3.4.1. ConOps Non-Operational Conditions

ConOps' degraded and failure conditions, which are specific to each use case activation condition, are expected to arise when technologies, system, or devices are operational and in use during the activation phases, as described in the individual project ConOps.

3.4.2. ConOps Maintenance Conditions

During the project demonstrations, maintenance conditions are expected to arise, which will require temporarily "turning off" the systems during the time period where activation conditions will be present. Two types of maintenance situations are likely to occur: 1) Maintenance due to device failure (unexpected); and, 2) Planned system maintenance (expected). Unexpected maintenance conditions will require communication to the affected user(s) and prompt action to minimize the confounding effect. Scheduled maintenance will be conducted during expected normal conditions. When designing and planning maintenance capabilities, consideration for potential impacts to safety-related functionality will be included to eliminate or minimize potential safety risks.

3.4.3. Safety Management Plan

The SMP contains project-specific risks that pertain to the physical safety of the travelers interacting with the various project solutions. The methods and processes detailed in the PfMP need to be consistent with the safety operational concept in the SMP, so as not to introduce any additional risks or affect the mitigation strategy outlined in the SMP. The SMP has informed the development of, and is considered as a source of, confounding factors for this PfMP.

3.4.4. Measurement Errors Due to Concurrent Projects to Measure Performance

The concurrent use of different projects/technologies to measure the same performance indicator can lead to data integration issues and measurement error. In the case of Smart Columbus, this may include other Smart Columbus projects or external projects taking place in Columbus. These issues will be identified during the data recording and cleaning process before performance measurement. For example, it is possible that both MMTPA and SMH will improve mobility at and around SMH locations. It is important not to count the improvements twice as part of both the MMTPA and SMH projects. In **Chapter 5,** Smart Columbus and non-Smart Columbus projects that impact one another are identified as confounding factors.

3.4.4.1. DESIGN OF EXPERIMENT-INDUCED CONFOUNDING FACTORS

Participants in the Smart Columbus demonstration include those who may equip their personal vehicle with a CV onboard unit, ride a self-driving shuttle, plan a trip at a Smart Mobility Hub, access parking via EPM, or plan a multimodal trip via the MMTPA. Technology providers who enable these solutions are also participants.

Although the primary objective of the design of experiment is to minimize the presence and influence of confounding factors, the design of experiment approach, under case-specific constraints, is likely to introduce the following forms of errors:

- Participant self-selection
- Participant attrition
- Participant moral hazard

3.4.4.1.1 Participant Self-Selection

Participant recruitment identifies a treatment and control group following the suggested experimental design **Chapter 4** describes. The recruitment goal is to select a pool of participants in which treatment and control groups are randomly selected from a participant sample representing the users of a system.

When inviting participants to be involved in a project's demonstration, some individuals, due to socioeconomic, residential, and travel characteristics, will tend to self-select whether they will participate. Though the design of experiment approach will minimize the difference between treatment and control units, self-selection will still be an issue. Self-selection also depends on the adopted recruitment approach—for example, via phone, internet, mail, or shopping center booths.

3.4.4.1.2 Participant Attrition

After enrollment, some participants will likely exit the demonstration due to triggering events such as a change of job requiring a different commute pattern, vehicle replacement, lack of interest, or other factors. When measuring performance at the individual level, statistical methods such as those utilizing unbalanced panel data will be used to reduce the impacts of confounding factors.

3.4.4.1.3 Participant Moral Hazard

Other confounding factors are likely to arise due to participant moral hazard that might be induced by CV equipment or one of the smart applications such as MMTPA or EPM. Moral hazard is a situation in which an individual might undertake riskier behavior, knowing that they are protected against a risky situation. For example, car drivers may push the limits of their apps and take unnecessary risks.

Participant recruitment can reduce the impact of confounding factors due to moral hazard. Selected participants will be advised of the limits of the technology, and they must sign an informed-consent form that explains the limits of the technology and their personal liability in using an application in a manner not prescribed.

Chapter 4. Experimental Strategies

4.1. INTRODUCTION

This chapter details the proposed system deployment impact evaluation design to account and control for the confounding factors identified in **Chapter 3**. It discusses the general applicable methods and modeling techniques to evaluate performance. Specific experimental strategies for each of the projects are identified in **Chapter 5**. As discussed in **Chapter 3**, the presence of confounding factors are likely to pose a challenge in the assessment of the quantitative performance measures.

The Smart Columbus deployment provides a unique opportunity to implement an experimental design approach to optimize the level of control upon observed and unobserved confounding factors. An *experiment* is a test, or series of tests, in which ad hoc changes are made to the input variables of a process to purposefully observe and identify the reason for changes that may be observed in the output response. The event for which the City wants to estimate and quantify the causal effect is defined as the *treatment*. It follows that a treatment group is a group that receives the treatment or the intervention. In the Smart Columbus demonstration, the treatment or *intervention group* is the group that is exposed to the solution or application(s) being tested (note, this can be called the treatment, intervention, or exposed group). The *outcome* indicator indicates the variable(s) that is used to measure the effect of the treatment. In each demonstration project, the outcome indicator denotes the quantifiable performance measure(s).

A well-designed experiment is important because the results and conclusions drawn depend to a considerable extent on how the experiment is laid out and the data collected. A statistical design of experiments is a process of planning the experiment so that appropriate data can be analyzed by appropriately choosing statistical methods, resulting in valid and objective conclusions.

Furthermore, the demonstration will be implemented over time. This means that time will be an important variable used to distinguish group participation and to gauge the impact on performance measures. The passage of time, on the other hand, can introduce additional confounding factors, such as the presence of time-variant unobservable events that could mask the true performance of Smart Columbus projects.

4.2. DESIGN OF EXPERIMENT

Three following broad types of design of experiment exists:

1. Randomized experiments.
2. Quasi-experiments.
3. Non-experiments.

These address what would have happened in the absence of the Smart Columbus projects (the "counterfactual") in several ways. Addressing the counterfactual is a requirement for demonstrating the project(s) caused changes in outcomes or impacts.

4.2.1. Randomized Experiments

Randomized experiments are the most rigorous evaluation design. **Figure 7** shows this process.

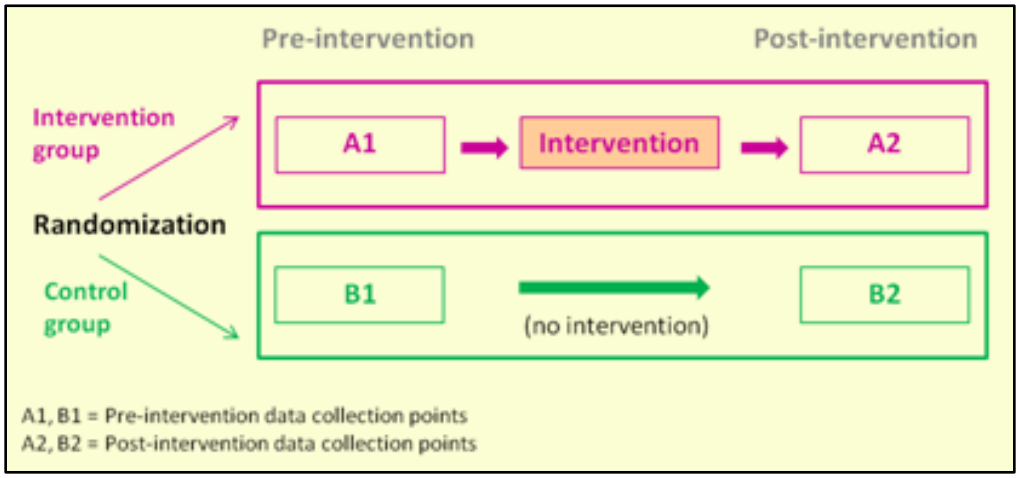

Figure 7: Design of Experiments – Classical Randomized

Source: https://www.healthpolicyproject.com/pubs/181_HSRPPTpresentationLaili.pdf

In the pre-test/post-test with random assignment to treatment or control groups, study subjects (or groups) are randomly assigned to a group that receives the treatment (treatment group) or a control group that does not receive the treatment (control or non-treatment group). Data for each group are collected before and after the treatment. At the end of the experiment, differences between the treatment and control groups can be attributed directly to the effect of the treatment if the sample is large enough. Notably, post-test only designs can also be used for design of experiment, if the groups are randomly assigned before the treatment began.

Randomization ensures that the treatment and control groups are equivalent with respect to all factors other than whether they received the treatment. In other words, the control group serves as the "counterfactual" of what would have happened in the absence of the project(s) – a key requirement in determining whether a project caused an outcome.

Randomized experiments often are not feasible in real-world scenarios due to the following reasons:

- Practical difficulties arise in randomly assigning subjects to the treatment and control groups, and it may be unethical to offer the treatment to one group but not to another group.
- Spillover effects can result in the control group being exposed to the treatment.
- High rates of dropouts in the treatment or control groups can bias the results.
- Randomized studies are often expensive to implement, which may limit the feasibility of this design for many projects.

4.2.2. Quasi-Experimental Design

When randomization of subjects or groups is neither practical nor feasible, a quasi-experimental design can approximate the randomized experiment. Quasi-experimental designs use a treatment and a control group, but assignment to the groups is non-random. **Figure 8** shows this process.

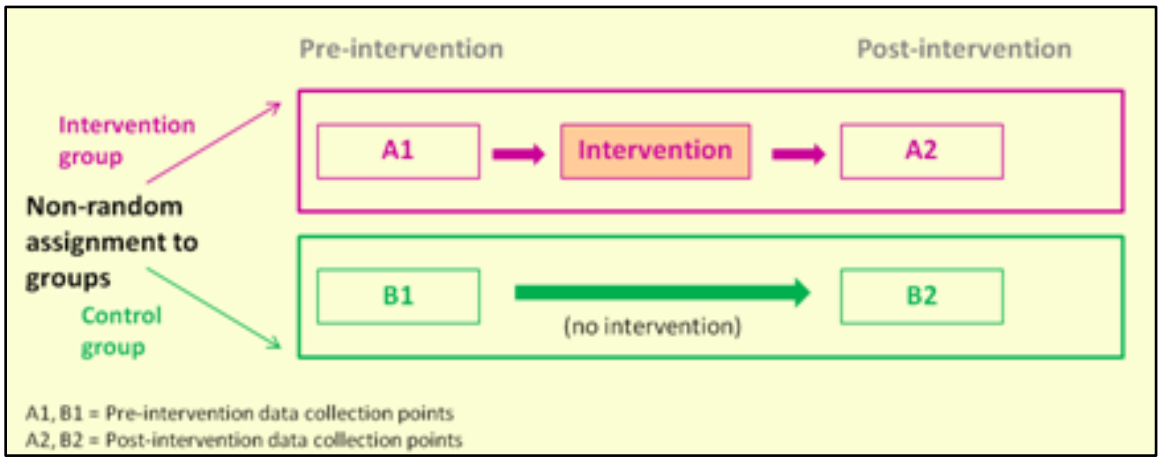

Figure 8: Design of Experiments – Classical Quasi-Experimental

Source: https://www.healthpolicyproject.com/pubs/181_HSRPPTpresentationLaili.pdf

4.2.2.1. PRE-TEST/POST-TEST MODEL

In the pre-test/post-test model with non-random assignment to treatment or control groups, as with randomized experiments, data are collected before and after the treatment. However, assigning subjects to the treatment and control groups is non-random. Thus, evaluators cannot assume equivalence between the two groups. Instead, they must assess the differences at baseline and account for any demographic or behavioral differences in the analysis.

Control groups in the quasi-experimental design can be identified through PSM – a process of identifying individuals that are like the participants in the treatment group on all relevant characteristics, such as age, sex, religion, and other factors associated with program exposure. A DiD or another case vs. control model can then be used to isolate effects of the treatment. A good example of when this technique should be applied is when system-wide confounding factors, such as the COVID-19 pandemic, make it difficult to isolate project-specific impacts. To address this issue, a DiD identification strategy with PSM can be used to match an adequate counterfactual control group with the treatment group. The DiD model compares differences in the average outcome for treatment group before and after the intervention with the differences in the controls over the same period. The resulting estimator is the direct impact of the intervention on the outcome.

4.2.2.2. POST-TEST ONLY MODEL

In the post-test only model with non-random assignment, data are not collected before the treatment. Instead, data are collected only after the program has started until a defined analysis timeframe among participants who had received the treatment and among non-participants, making for a weaker design. Matching participants and non-participants with similar characteristics (PSM) and accounting for any relevant differences (using DiD or another case vs. control model) are especially important in the post-test only design to isolate effects of the treatment.

4.2.3. Non-Experimental Design

The non-experimental design is a treatment group only and lacks a comparison/control group, making it the weakest study design. Without a control group, it is difficult for evaluators to determine what would have happened in the absence of the treatment. Evaluators choose to use non-experimental designs when there are resource constraints, when they are unable to form an appropriate treatment group, or when a project covers the entire population and thus there is no control group, such as with a mass media campaign. **Figure 9** shows this process.

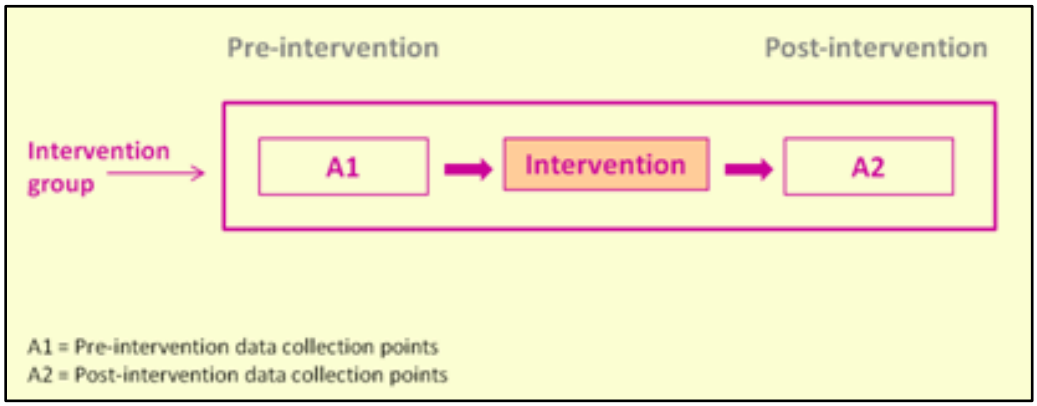

Figure 9: Design of Experiments – Non-Experimental

Source: https://www.healthpolicyproject.com/pubs/181_HSRPPTpresentationLaili.pdf

In non-experimental study designs, evaluators must have a clear conceptual understanding of how the treatment was intended to influence the outcomes. Thus, the program team needs to develop a robust framework during the program planning phase.

There are four commonly used types of non-experimental designs:

1. In pre-test/post-test designs, evaluators survey the treatment group before and after the treatment. While evaluators may observe changes in outcome indicators among the treatment participants, they cannot attribute all these changes to the treatment alone using this design because there is no control group. **Figure 9** shows this process.
2. Time-series (trend analysis) designs look for changes over time to determine trends. Evaluators observe the treatment group multiple times before and after the treatment and analyze trends before and after. **Figure 10** shows this process.
3. The longitudinal study is another type of time-series design. Evaluators take repeated measures of the same variables over short or extended periods of time.
4. A panel design is a special type of longitudinal design in which evaluators track a smaller group of people at multiple points in time and record their experiences in detail.

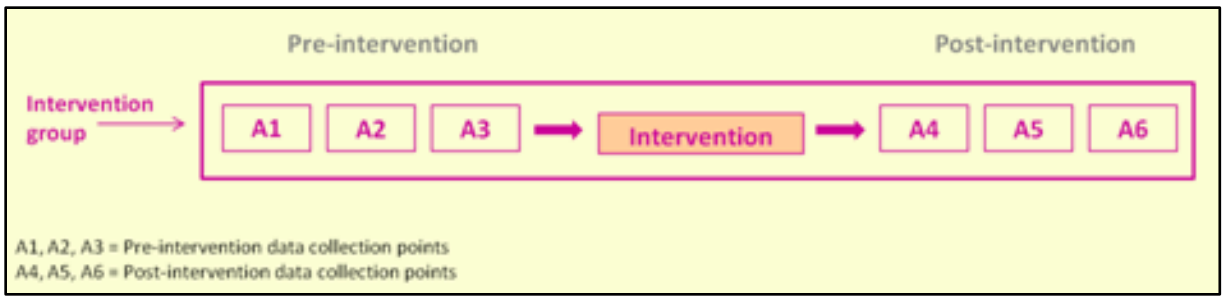

Figure 10: Design of Experiments – Time-Series Design

Source: https://www.healthpolicyproject.com/pubs/181_HSRPPTpresentationLaili.pdf

In a post-test only design, evaluators observe the treatment group at one point in time after the treatment, focusing particularly on comparing responses of subgroups based on such characteristics as age, sex, ethnicity, education, or level of exposure to the treatment. This is the weakest approach.

There are ways to strengthen the non-experimental design.

- Measure participants' level of exposure to the treatment. If people with greater exposure to the treatment showed greater change in the outcomes, it strengthens the argument that the treatment led to changes. However, because the non-experimental design lacks a control group, changes in outcomes could still be due to selection bias – that is, the changes could reflect differences in participants who were exposed to the treatment compared with people who were not exposed to the treatment.
- Collect data from the same participants over time using a panel or longitudinal design. These individuals serve as their own controls – characteristics of an individual observed earlier can be controlled for when analyzing changes in the outcomes.

4.3. SAMPLE SIZE DETERMINATION

Statistically meaningful difference and effect size represent the magnitude of an effect of interest, such as the performance metrics outlined in **Chapter 5**. Changes in the indicators between treated and control units represent the magnitude of the effect of interest to be detected by a test with a specified power.

A power and sample size (PSS) approach will be used to identify a minimum required sample size for those projects for which nonexperimental and quasi-experimental design approaches are considered. To identify the minimum required sample size, a PSS analysis will be conducted using the commercial statistical software package Stata (Stata PSS).

It is expected that minimum sample size requirements are a function of:

- Selected power of the test.
- Significance level.
- Expected difference in the effect size of each adopted performance measure between treatment and control units.

The power of the test is a measure of the probability of correctly rejecting the null hypothesis when the null hypothesis is false. Power (π) is inversely related to the probability of a type II error (β or fail to reject null when the null is false) and is computed as $\pi = 1 - \beta$. Typical values for power are 0.8 or 0.9, depending on the study objectives.

The significance level (α) identifies the type-I error probability of rejecting the null when the null is true. Typical set up is α =0.05.

Chapter 5. Performance Measurement and Evaluation

5.1. INTRODUCTION

5.1.1. Performance Measurement Background

Multiple performance measures have been identified for each Smart Columbus project and are discussed in this chapter. Each performance measure was established through collaboration between City of Columbus and key stakeholders (such as OSU, COTA, ODOT and Franklin County, among others) using the USDOT recommended process shown in **Figure 5**. The performance measures for Smart Columbus were designed to measure the impact of the projects on the Columbus region and provide a framework for the remaining tasks of data collection, evaluation, and reporting.

5.1.2. Purpose of Performance Measurement

Many technologies implemented in the Smart Columbus demonstration program are not yet widely used in transportation. As such, Smart Columbus serves as a model for other regions. By implementing technologies and measuring performance, Smart Columbus provides an understanding of the potential impacts each project may have in other jurisdictions.

Measuring the performance of the Smart Columbus projects is distinct from evaluating the functionality of the technology solutions themselves, which has already been accomplished through the systems engineering and development processes.

A logic model was used to guide the development of the performance measures and associated plan. The model connects baseline characteristics to the impacts caused by an activity.

5.2. PERFORMANCE MEASUREMENT AND EVALUATION TERMINOLOGY

Smart Columbus will measure performance for all eight projects using the performance measure structure described in this section. This chapter discusses the specific objectives, identified in the first row of each table within, that will be analyzed for each project and how the analysis will be implemented.

Each performance measure is broken down into several components. These components are defined below and discussed in **Chapter 5** for each project. **Chapter 5** defines the terminology used to describe performance measures in this PfMP.

5.2.1. Introduction

This section introduces the project and provides background information useful to its performance measure.

5.2.2. Logic Model

This section provides a diagrammatic logic model for a project's performance measurement, identifying the project outcomes and objectives, the treatment to achieve the project objectives, a hypothesis (and

assumptions) about how the objectives could be met through the treatment, and the indicators to measure the performance.

5.2.3. Outcomes

This section identifies the outcomes for each project that the performance measures will address, as **Chapter 2** discusses. These outcomes are broad statements about positive societal impacts, which tie the projects back to the original intent of the SCC. The Smart Columbus Program has the following central outcomes:

- Safety
- Mobility
- Opportunity
- Environment
- Agency Efficiency
- Customer Satisfaction

5.2.3.1. OBJECTIVES

This section discusses the objectives for each of the project outcomes. Each project has multiple objectives, each of which addresses one specific outcome. An objective is a statement about what specific, measurable impact the project is intended to have. **Table 3** is a sample objective table that summarizes the hypothesis, indicators, design of experiment, and data collection plan including data sources, baseline, and treatment timeframe for each of the objectives.

Table 3: Sample Objective Table

Category	Description		
Objective	Provide useful data		
Hypothesis	The Operating System will provide useful data to public agencies and developers through an Open Data Portal.		
Indicator	Ability to access and use the data	Usefulness of the accessed data for intended purpose	Number of applications, reports, analytics, and visualizations created using the Operating System data
Design of Experiment	Pre/Post Trend Analysis	Pre/Post Trend Analysis	Post-only Trend Analysis
Data Sources	Operating System; Surveys		
Baseline Timeframe	One year before implementation of the Operating System Data Platform 2.0 (April 22, 2018 to April 21, 2019)	Not Applicable	
Treatment Timeframe	From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021).		

Source: City of Columbus

5.2.3.1.1 Hypothesis

This section discusses the hypothesis associated with each objective. Each objective has a hypothesis that is a testable assertion about the way in which a project will impact an indicator. The projects have been designed such that each hypothesis anticipates a result that is an improvement from the baseline, and, therefore, a desired outcome for the project.

5.2.3.1.2 Indicators

This section discusses the indicators for each objective. Indicators are the measurements that will change over time. They will be assessed before, during, and after implementation as applicable to test the validity of the hypothesis. Multiple indicators may be applicable to each objective. Examples include:

- Customer satisfaction ratings
- Parking violations
- Mode shifts

Common indicator metrics are counts, percentages, rates, ratios, index, composite measures, and thresholds (presence, absence, predetermined level, or standard).

Factors to consider when selecting indicators are logic/link to framework, programmatic needs/information for decision-making, resources, external requirements (government, donor), data availability, standardized indicators, and alignment with national standards.

Common pitfalls in indicator selection are indicators not linked to program activities, poorly defined indicators, indicators that cannot realistically be collected, process indicators to measure outcomes and impacts, indicators that are insensitive to change, and too many indicators.

5.2.3.1.3 Design of Experiment

BACKGROUND CONDITIONS

This section provides background conditions as it relates to the experimental design.

RECOMMENDED DESIGN OF EXPERIMENT

This section provides a recommendation for the design of experiment for the indicators.

5.2.3.1.4 Data Collection Plan

This section provides a data collection plan for each indicator including the data source and the baseline and treatment timeframes specific to the indicators identified for each of the objectives.

DATA SOURCES

The data source is the source from which the indicator is gathered. Some data sources already exist and are composed of data collected to monitor performance of existing systems, such as COTA. Other data sources will be created specifically to address the data needs for Smart Columbus performance measurements, such as user or vendor surveys. A list of data sources and data collection methods is available in **Chapter 6**.

BASELINE TIMEFRAME

The baseline is the measurement of the indicator that occurs before project implementation. As such, this is the standard against which improvements will be measured. The baseline timeframe varies for each indicator but will occur before the implementation of the relevant project, but not necessarily before deployment. In that case, technology may be deployed to establish the baseline, but not activated.

TREATMENT TIMEFRAME

The treatment is implementation of a solution that impacts the indicator. In the context of Smart Columbus, the treatment is the implementation of a project and its applications. In most cases, the impact is best measured after some time has elapsed for users to become comfortable with the changes that have occurred, rather than directly following implementation. The treatment timeframe varies for each indicator but will occur after the implementation of the relevant project. The indicator will be measured at the treatment timeframe to evaluate the performance improvement.

5.2.3.1.5 Impact Evaluation Plan

This section discusses the procedures and methods for estimating each identified indicator. It details the empirical measurement of each performance measure and the methods to ascertain system improvements that can be attributed to each Smart Columbus project.

The performance measures will be analyzed by comparing the treatment to the baseline. However, an improvement against the baseline does not always mean that the project caused the change. Likewise, an apparent reduction in quality does not definitively mean that the project failed to improve the situation. Confounding factors represent the influence of variables outside of the control of the analysis. These factors may result from political, environmental, or economic variations that occur since implementation. Examples of confounding factors include weather conditions, special events, or fuel prices.

Because confounding factors that cannot be accounted for through experimental design cannot be controlled, they must be considered and discussed when reviewing the results. Confounding factors that can be accounted for through experimental design will be controlled and accounted for by including them as explanatory variables during the evaluation process. **Chapter 3** includes more information about confounding factors.

5.2.4. Project-Specific Confounding Factors

This section identifies project-specific confounding factors, if any, and the associated potential impact on project performance.

5.2.5. Project Costs

This section provides the high-level project costs for each project, although cost-benefit analysis is not included in program- and project-level performance measurement objectives.

5.3. PROGRAM-LEVEL PERFORMANCE MEASURES

5.3.1. Introduction

Emissions, congestion, and opportunity measures might be impacted by multiple Smart Columbus projects. The significance of impacts of the various portfolio projects depends upon the adoption, penetration, and deployment scale. For these reasons, a cumulative performance assessment will occur to evaluate the program-level impacts on the following measures.

5.3.2. Logic Model

Figure 11 shows the identified program-level logic model.

Outcomes	Objectives	Treatment	Hypothesis	Outcome Indicators
Environment	Reduce vehicle emissions	Implement all the Smart Columbus Projects	The Smart Columbus Program will implement multiple portfolio projects focused on shifting travelers from personal vehicles to shared-use and transit-related projects and reducing idling time to reduce vehicle-related emissions.	• Green House Gas (GHG) savings (light duty and heavy vehicles) • Perceived reduction in idling time around parking facilities to find a parking spot • Perceived reduction in distance traveled to find a parking spot
Mobility	Reduce traffic congestion		The Smart Columbus Program will implement multiple portfolio projects focused on shifting travelers from personal vehicles to shared-use and transit-related projects to reduce traffic congestion.	• Travel time and delay • Daily volumes • Perceived reduction in travel time to find a parking spot • Perceived overall congestion
Opportunity	Improve commuting opportunities to jobs and services		Through implementation of multiple portfolio projects, Smart Columbus Program will improve traveling opportunities for Columbus region residents to their jobs and services.	• Perceived ease of trip planning to jobs and services • Perceived ease of multimodal transfers • Perceived ease of FMLM travel

Figure 11: Program-Level Logic Model

Source: City of Columbus

Smart Columbus has identified the following three program-level outcomes:

1. Environment
2. Mobility
3. Opportunity

5.3.3. Outcome 0.1: Environment

Outcome 0.1 identified one objective: Reduce vehicle emissions.

5.3.3.1. OBJECTIVE 0.1.1: REDUCE VEHICLE EMISSIONS

Table 4 outlines the performance measurement methodology for this objective.

Table 4: Reduce Vehicle Emissions Objective 0.1.1

Category	Description	
Objective	Reduce vehicle emissions	
Hypothesis	The Smart Columbus Program will implement multiple portfolio projects focused on shifting travelers from personal vehicles to shared-use and transit-related projects and reducing idling time to reduce vehicle-related emissions.	
Indicator	• Green House Gas (GHG) savings (light duty and heavy vehicles)	• Perceived reduction in idling time around parking facilities to find a parking spot • Perceived reduction in distance traveled to find a parking spot
Design of Experiment	Pre/Post Trend Analysis	Pre/Post Quasi-Experimental Design
Data Source	Operating System	Customer Survey
Baseline Timeframe	Two years pre-deployment period (April 29, 2017 to April 28, 2019)	
Treatment Timeframe	From the start of first portfolio project (April 29, 2019) until the end of period of performance of last portfolio project (March 31, 2021)	

Source: City of Columbus

5.3.3.1.1 Contributing Factors

Below are the expectations of potential impacts created by the Smart Columbus projects in reduction of vehicle emissions. Since there are multiple projects affecting the emissions, it would be challenging to differentiate and attribute the impacts created by each project. Considering this, the evaluators will perform a program level assessment of changes in emissions caused by the Smart Columbus projects. Baseline data used for transportation-related consumption is provided by MORPC. The availability of this data typically lags one year behind collection.

MMTPA

As more Columbus travelers start migrating from their personal vehicles to other modes based on use of the MMTPA for their travel, a reduction in vehicle-related emissions might be observed.

CVE

Through freight signal prioritization, CVE project is focused on reducing the idling time of heavy-duty vehicles at signalized intersections. This reduction in idling time will reduce the vehicle emissions as the vehicles will have a continuous travel.

EPM

As parking-related information become available, travelers will have the ability to drive directly to an available parking spot instead of searching for unoccupied parking spots. This reduction in travel is expected to reduce the vehicle-related emissions.

5.3.3.1.2 Indicators

The objective will be measured using the following indicators:

- GHG savings (light duty and heavy vehicles).
- Perceived reduction in idling time around parking facilities to find a parking spot.
- Perceived reduction in distance traveled around parking facilities to find a parking spot.

The following data will be collected for measuring the objective:

- Person miles traveled (PMT) through MMTPA project.
- Estimated conversion rates from PMT to CO, NO_2, SO_2, and other PMs.
- Reduced idle time for heavy-duty vehicles (HDVs) equipped with On-board Units (OBUs) through the CVE project.
- Speed profiles of OBU-equipped HDVs (based on basic safety messages (BSMs)) to convert idle time savings to emission savings.

The following data will be collected from user surveys:

- Percentage of travel through MMTPA project.
- Alternative modes of travel.
- Change in travel mode pre- vs post-implementation of Smart Columbus projects.
- Distance traveled to find a parking spot pre- and post-EPM implementation.

Customer surveys will be conducted to capture the insights of project participants. Following are some of the sample questions that will be asked to the participants:

- What percentage of your total travel do you take through MMTPA project?
- What are your other modes of travel?
- How much time have you spent around parking facilities to find an unoccupied parking spot?

5.3.3.1.3 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

For the baseline conditions, regional vehicle emissions during the pre-deployment period will be collected for evaluation.

RECOMMENDED DESIGN OF EXPERIMENT

Vehicle emissions during the period of performance of Smart Columbus portfolio projects will be derived based on data obtained from projects. An estimate of reduction in vehicle emissions due to migration of travelers from personal vehicles to alternative modes of travel enabled by Smart Columbus will be

calculated using EPA's MOtor Vehicle Emission Simulator (MOVES) model.[6] Also, reduction in emissions due to reduction in CVE-equipped heavy vehicle idling at intersections will be calculated based on speed profile obtained from BSM.

A pre/post quasi-experimental design will be used for evaluating the survey data. Perceptions on change in travel behavior before and after the implementation of Smart Columbus projects will be evaluated to assess the impact of the projects.

5.3.3.1.4 Data Collection Plan

DATA SOURCE

For this objective, the project usage data and survey data will be collected. Surveys for the various projects will be conducted throughout the treatment timeframe. Depending on the outcome and project, surveys will be conducted by either OSU or a member of the project team, and the results will be stored in the Operating System. All aggregate survey results will be available for access from the Operating System at the end of the demonstration. Refer to **Chapter 6** for more information.

BASELINE TIMEFRAME

Two years pre-deployment will be considered as the baseline timeframe for this evaluation.

TREATMENT TIMEFRAME

The project will be evaluated from the implementation of the first portfolio project (April 29, 2019) until the period of performance of last portfolio project (March 31, 2021).

5.3.3.1.5 Impact Evaluation Plan

The impact evaluation plan for the indicators are as follows:

GHG savings:

From MMTPA: Passenger Miles Traveled (PMT) using the MMTPA along with the participant perception of their migration to these projects will be used for this assessment. Number of PMT migrated will be converted into GHG savings. As more people start using the solutions developed by the Smart Columbus projects to plan and/or change their travel modes or behavior, it is anticipated that a reduction in GHG emissions could be observed.

From CVE Freight Signal Prioritization: Through freight signal prioritization, HDVs traveling through the signalized intersections will spend less time idling at the intersections and have a more continuous flow. This reduction in idling time might reduce the GHG emissions from the HDVs equipped with CV technology.

From EPM: *Perceived reduction in time spent around parking facilities to find a parking spot:* As information about available parking spots become available to the travelers, they will travel lesser distances to find a parking spot. These reductions in travel distances would reduce emissions from vehicles. Travelers' perception of distance traveled finding a parking spot before and after EPM deployment will be an indicator of the project's ability to reduce the congestion around the parking facilities. The EPA's MOVES model will be used by the evaluators to estimate reduction in vehicle emissions based on idle time/user survey responses.

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and informational collection. For the quantitative questions, the value of measure will be collected. The

[6] https://www.epa.gov/moves

responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the deployment period (surveys will be post-deployment only). The survey data collected will be compared over the previous surveys to track the indicator for both the treatment and the control groups.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level and project level confounding factors, if any, it can be attributed to the program. Supplemental data may be collected and analyzed to support the conclusion.

5.3.4. Outcome 0.2: Mobility

5.3.4.1. OBJECTIVE 0.2.1: REDUCE TRAFFIC CONGESTION

Table 5 outlines the performance measurement methodology for this objective.

Table 5: Reduce Traffic Congestion Objective 0.2.1

Category	Description	
Objective	Reduce traffic congestion	
Hypothesis	The Smart Columbus Program will implement multiple portfolio projects focused on shifting travelers from personal vehicles to shared-use and transit-related projects to reduce traffic congestion	
Indicator	• Travel time and delay • Daily volumes	• Perceived reduction in travel time to find a parking spot • Perceived overall congestion
Design of Experiment	Pre/Post Quasi-Experimental Design	
Data Source	Operating System	Customer Surveys
Baseline Timeframe	Two years pre-deployment period (April 29, 2017 to April 28, 2019)	
Treatment Timeframe	From the start of first portfolio project (April 29, 2019) until the end of period of performance of last portfolio project (March 31, 2021)	

Source: City of Columbus

5.3.4.1.1 Contributing Factors

Similar to emissions, congestion is a performance measure that might be affected by multiple Smart Columbus projects including MMTPA, CVE, CEAV, SMH, and EPM. For this reason, it would be challenging to differentiate and attribute the impacts created by individual projects. A program-level evaluation would be performed by the evaluators for this objective.

MMTPA AND SMH

As travelers migrate from their personal vehicles to alternative travel options through MMTPA or SMH, a corridor-level reduction in congestion might be observed.

CEAV

As more travelers start using CEAVs as their reliable FMLM transportation option, a reduction in congestion might be observed in the routes where CEAV will be operating.

EPM

As the public are informed about the real-time parking availability and can reserve spots, travelers will have the ability to drive directly to the parking spaces instead of searching for unoccupied spaces. This reduction in searching for parking would reduce the congestion created around the parking facilities.

5.3.4.1.2 Indicators

The objective will be measured using the following indicators:

- Travel time and delay.
- Daily volumes.
- Perceived reduction in travel time to find a parking spot.
- Perceived overall congestion.

The following data will be collected for measuring the objective:

- Person miles traveled through MMTPA and CEAV projects.
- Annual Average Daily Traffic (AADT) for road segments (pre- and post-deployment).
- Speed and travel time for INRIX eXtreme Definition (XD) level road segments (pre- and post-deployment).

The following data will be collected from various project user surveys:

- Percentage of travel through MMTPA and CEAV projects.
- Alternative modes of travel.
- Change in travel mode pre- vs post-implementation of Smart Columbus projects.
- Time traveled to find a parking spot pre- and post-EPM implementation.
- Feeling of overall traffic congestion pre- and post-EPM/CEAV/MMTPA implementation.

Surveys will be conducted to capture the insights of project participants. See **Appendix C** for sample questions and further details.

5.3.4.1.3 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

For the baseline conditions, PMT through the MMTPA and CEAV projects and AADT volumes for road segments within the projects during the pre-deployment period will be collected for evaluation.

RECOMMENDED DESIGN OF EXPERIMENT

Traffic congestion during the period of performance of Smart Columbus portfolio projects will be collected. An estimate of reduction in traffic congestion due to migration of travelers from personal vehicles to alternative modes of travel enabled by Smart Columbus will be calculated. Traffic congestion data from the pre-deployment period will be compared with post-deployment. The difference in congestion will be assessed along with the estimated reductions to capture the impact of Smart Columbus Program on reduction of traffic congestion. Geographic boundaries of portfolio projects will be identified and specifically assessed for this evaluation.

A pre/post quasi-experimental design using DiD analysis with PSM will be used for evaluating the survey data. Perceptions of change in travel behavior due to the implementation of Smart Columbus projects will be evaluated to assess the impact of the projects.

5.3.4.1.4 Data Collection Plan

DATA SOURCE

For this objective, the project usage data and survey data will be collected. Surveys will be conducted throughout the projects' treatment timeframe. Depending on the project, surveys will be conducted by OSU or the project team, and the aggregate results will be stored in the Operating System. All data will be available for access from the Operating System at the end of the demonstration. Refer to **Chapter 6** for more information.

BASELINE TIMEFRAME

Two years pre-deployment (April 2017 to April 2019) will be considered as the baseline timeframe for this evaluation.

TREATMENT TIMEFRAME

The project will be evaluated from the implementation of the first portfolio project (April 29, 2019) until the period of performance of last portfolio project (March 31, 2021).

5.3.4.1.5 Impact Evaluation Plan

The impact evaluation plan for the indicators are as follows:

Travel time and delay: Through the MMTPA and CEAV projects, travelers will be able to migrate from their personal vehicles to multimodal travel options including usage of CEAV shuttles and non-single occupancy vehicle (SOV) modes of transportation. Also, with a comprehensive trip planning application, existing non-personal vehicle travelers will be encouraged to use the service more often. As more people start using the MMTPA application and CEAV service, there might be a reduction in travel times and increase in speeds of the vehicles in the transportation corridors at a regional level. Also, through EPM, travelers in search of parking spots would spend less time finding a spot, and thereby reduce the traffic congestion around the parking facilities.

Daily volumes: Similar to travel time and speed, a reduction in daily volumes might be observed as more people start using the MMTPA application and CEAV service.

Perceived reduction in travel time to find a parking spot: As information about available parking spots become available to the travelers, they will spend less time searching for a parking spot. Travelers' perception of time taken to travel before and after EPM deployment will be an indicator of the project's ability to reduce the congestion around the parking facilities.

Perceived overall congestion: As users change modes of transportation and more efficiently find parking, there will be less congestion through the project area. Travelers' perception of congestion before and after EPM deployment will be an indicator of the project's ability to reduce the congestion around the parking facilities. In addition, when users change their mode of transportation to transit service from SOVs, there will be a reduction in congestion. Travelers' perception of congestion before and after CEAV and MMTPA deployments will be an indicator of the project's ability to reduce the congestion through traveler mode shifts.

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and informational collection. For the quantitative questions, the value of measure will be collected. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the deployment period. The survey data collected will be compared over the previous surveys to track the indicator.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period. If the indicator shows an improvement trend after accounting for the program-level and project-level

confounding factors, if any, it can be attributed to the program. Supplemental data may be collected and analyzed to support the conclusion.

5.3.5. Outcome 0.3: Opportunity

5.3.5.1. OBJECTIVE 0.3.1: IMPROVE COMMUTING OPPORTUNITIES TO JOBS AND SERVICES

The table below outlines the performance measurement methodology for this objective.

Table 6: Improve Commuting Opportunities to Jobs and Services Objective 0.3.1

Category	Description
Objective	Improve commuting opportunities to jobs and services
Hypothesis	Through implementation of multiple portfolio projects, Smart Columbus Program will improve traveling opportunities for Columbus region residents to their jobs and services.
Indicator	• Perceived ease of trip planning to jobs and services • Perceived ease of multimodal transfers • Perceived ease of FMLM travel
Design of Experiment	Pre/Post Quasi-Experimental Design
Data Source	Operating System; Customer Survey
Baseline Timeframe	Two years pre-deployment period (April 29, 2017 to April 28, 2019)
Treatment Timeframe	From the start of first portfolio project (April 29, 2019) until the end of period of performance of last portfolio project (March 31, 2021)

Source: City of Columbus

5.3.5.1.1 Contributing Factors

Below are the expectations of potential impacts created by the Smart Columbus projects in enhancing the commuting opportunities to jobs and services. Since there are multiple projects affecting this measure, it would be challenging to differentiate and attribute the impacts created by each project. Considering this, the evaluators will perform a program-level assessment of changes in opportunities to jobs and services as a result of Smart Columbus.

MMTPA

The MMTPA project enables users to schedule a comprehensive and coordinated trip with mobility providers of multiple modes. This will expand the users' ability to travel to their points of interest with more ease and reliability when compared to their previous trip planning methods.

SMH

At Smart Mobility Hubs, travelers will have access to multiple mode choices at transfer points and will be presented with more opportunities to commute to their points of interest—including jobs and services locations.

CEAV

CEAVs provide reliable FMLM transportation option to travelers who reside nearby or travel through the Linden neighborhood. CEAVs would serve as a connecting mode between transit stations and pickup points of other modes located in the CEAV route. In addition, the food pantry use case, implemented after the COVID-19 pandemic, brings food pantry boxes to a secondary location from the main food pantry. Although not entirely bridging the FMLM gap, it is seeking to lessen the distanced traveled to access these types of services by bringing the resources to the community.

5.3.5.1.2 Indicators

The objective will be measured using the following indicators:

- Perceived ease of trip planning to jobs and services.
- Perceived ease of multimodal transfers.
- Perceived ease of FMLM travel.

The following data will be collected from user surveys:

- Perception of ease and reliability of trip planning to jobs and services pre- and post-MMTPA implementation.
- Perceived ease of multimodal transfers pre- and post-SMH implementation.
- Perceived ease of FMLM travel pre- and post-CEAV implementation.

Surveys will be conducted for the various projects to capture the insights of project participants. The timing of the survey depends on the project or program outcome it supports, but all surveys will contribute to evaluating these indicators. See **Appendix C** for sample questions and further details.

5.3.5.1.3 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

For the baseline conditions, regional surveys regarding opportunities to access jobs and services during the pre-deployment period will be collected for evaluation.

RECOMMENDED DESIGN OF EXPERIMENT

Participant surveys will be conducted throughout the deployment period for the various projects and responses will be evaluated. A pre/post quasi-experimental design will be used for evaluating the survey data. Perceptions on change in travel behavior due to the implementation of Smart Columbus projects will be evaluated to assess the impact of the projects.

5.3.5.1.4 Data Collection Plan

DATA SOURCE

For this objective, the project usage data and survey data will be collected. Surveys will be conducted throughout the demonstration of the projects, until the end of treatment timeframe. Surveys will be conducted by OSU, and the aggregate results will be stored in the Operating System. All the data will be available for access from the Operating System at the end of the demonstration. Refer to **Chapter 6** for more information.

BASELINE TIMEFRAME

Two years pre-deployment will be considered as the baseline timeframe for this evaluation.

TREATMENT TIMEFRAME

The project will be evaluated from the implementation of the first portfolio project (April 29, 2019) until the period of performance of last portfolio project (March 31, 2021).

5.3.5.1.5 Impact Evaluation Plan

The impact evaluation plan for the indicators are as follows:

Perceived ease of trip planning to jobs and services: MMTPA participants' perception of access to trip planning options pre- and post-MMTPA will be used to assess the impact of the project in enhancing the commuting opportunities to their jobs and services. As more multimodal providers partner with the project, travelers will have better opportunities to plan coordinated travel between their origins and destinations.

Perceived ease of multimodal transfers: Through SMH, travelers will have a reliable transfer point for mode shifts, as multiple mobility options will become available. Traveler perception will be captured to understand the access and reliability to multimodal travel options through hubs.

Perceived ease of FMLM travel: Implementation of CEAV in the Linden region will provide a reliable FMLM transportation to residents in the nearby neighborhoods and travelers with their transfer and destination points in the Linden region. Participants will be surveyed to capture their perception of reliable FMLM transportation pre- and post-CEAV. In addition, the CEAV food pantry use case brings food pantry boxes to a secondary location from the main food pantry. People picking up food pantry boxes at this secondary location will be surveyed (post-only) to capture their perception about CEAV technology and its utility in delivering goods and services to the community.

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and informational collection. For the quantitative questions, the value of measure will be collected. The average scale of the quality measure will be calculated for all the survey responders. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the deployment period. The survey data collected will be compared over the previous surveys to track the indicator for both the treatment and the control groups.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level and project level confounding factors, if any, it can be attributed to the program. Supplemental data may be collected and analyzed to support the conclusion.

5.4. PROJECT 1: THE SMART COLUMBUS OPERATING SYSTEM

5.4.1. Introduction

The Smart Columbus Operating System (Operating System) is envisioned as a web-based, dynamic, governed data delivery platform built on a federated architecture that is at the heart of the Smart Columbus system. It will ingest and disseminate data while providing access to data services from multiple sources and tenants, including the planned Smart Columbus technologies, traditional transportation data, and data from other community partners, such as food pantries and medical services. The Operating System will embody open-data, best-of-breed technologies including open-source and commercial off-the-shelf concepts that enable better decision-making and problem-solving for all users. It will support a replicable, extensible, sustainable data delivery platform. The Operating System will be the source for performance metrics for program monitoring and evaluation, serve the needs of public agencies, researchers, and entrepreneurs, and assist health and human services organizations and other agencies in providing more effective services to their clients. The Operating System will be scalable and demonstrate the potential for serving City and private sector needs well beyond the life of the demonstration period.

Additional details about this application can be found at www.smartcolumbusos.com.

The following sections identify the logic model, outcomes and objectives, hypotheses, indicators, data collection plan, and impact evaluation plan for this project.

5.4.2. Logic Model

Figure 12 shows the logic model identified for Operating System.

Outcomes	Objectives	Treatment	Hypothesis	Outcome Indicators
Agency Efficiency	Provide useful data	From Implementation of the Operating System until period of implementation of last portfolio project (CVE)	The Operating System will provide useful data to public agencies, evaluators, and developers through an Open Data Portal.	• Ability to access and use the data • Usefulness of the accessed data for intended purpose • Number of applications, reports, analytics and visualizations created using the Operating System data
	Provide improved data-sharing method		The Operating System will enhance the ease of data-sharing method through the Open Data Portal.	• Ease of data sharing ability • Number of requests for datasets • Amount of time to access the data • Number and frequency of data retrievals from the Operating System
	Provide easily discoverable data		The Operating System will provide users with data in an easily discoverable manner.	• Ability to find data intended by the users • Number of requests for datasets
	Provide an easily accessible data exchange to providers and consumers of data		The Operating System will provide an easily accessible data exchange for all users of both internal and external applications.	• Percentage of datasets accessible to applications (internal and external) in a usable format and method • Ability to access and use the data • Ability to ingest/harvest the data into the Operating System
Customer Satisfaction	Establish and enhance customer satisfaction with the Operating System		The Operating System will ensure the satisfaction of its customers (public agencies, evaluators, and developers) by providing and enhancing data, visualization, and analytical features through an Open Data Portal.	Customer Satisfaction ratings for: • Quality, freshness and completeness of data • Metadata quality • Visualization tools/features • Analytical tools/features • Method of ingesting data into the Operating System • Method of extracting data from the Operating System
	Provide easily discoverable data		The Operating System will provide open data to the users in an easily discoverable fashion	• Time spent on the Operating System • Time spent on discovery of dataset(s) • Ability to find the required/intended data

Figure 12: Operating System Performance Measurement Logic Model

Source: City of Columbus

The Operating System identified the following two outcomes:

1. Agency efficiency.
2. Customer satisfaction.

5.4.3. Outcome 1.1: Agency Efficiency

Outcome 1.1 identified the following four objectives:

1. Provide useful data.
2. Provide improved data-sharing method.
3. Provide easily discoverable data.
4. Provide an easily accessible data exchange to providers and consumers of data.

5.4.3.1. OBJECTIVE 1.1.1: PROVIDE USEFUL DATA

Table 7 outlines the performance measurement methodology for this objective.

Table 7: Operating System Agency Efficiency Objective 1.1.1

Category	Description		
Objective	Provide useful data		
Hypothesis	The Operating System will provide useful data to public agencies, evaluators, and developers through an Open Data Portal.		
Indicator	Ability to access and use the data	Usefulness of the accessed data for intended purpose	Number of applications, reports, analytics, and visualizations created using the Operating System data
Design of Experiment	Pre/Post Quasi Experimental Design	Pre/Post Quasi Experimental Design	Post-only Trend Analysis
Data Source	Operating System; Surveys		
Baseline Timeframe	One year before implementation of the Operating System Data Platform 2.0 (April 22, 2018 to April 21, 2019)		N/A
Treatment Timeframe	From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021)		

Source: City of Columbus

5.4.3.1.1 Indicators

The ideal indicator(s) for this project will be to measure the improvement in efficiency by using the data from the Operating System. A comprehensive survey will be conducted with the agency staff and other classifications of the Operating System users. A detailed list of survey topics is presented in **Chapter 6**.

The objective will be measured using the following indicators:

- Ability to access and use the data.
- Usefulness of the accessed data for intended purpose.
- Number of applications, reports, analytics, and visualizations created using the Operating System data.

The following data will be collected for evaluation:

- Ability to access and use the data pre-deployment of the Operating System.
- Ability to access and use the data post-deployment of the Operating System.
- Usefulness of the data accessed from the Operating System for the intended purpose.
- Number of applications created using the Operating System data.
- Number of reports created using the Operating System data.
- Number of visualizations created using the Operating System data.
- Number of analytics created using the Operating System data.

Surveys will be conducted to capture the insights of agency users. See **Appendix B** for sample questions and further details.

5.4.3.1.2 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

For the first two indicators, a baseline timeframe of one year will be used to compare against the previous data-sharing mechanisms with the Operating System. An agency employee survey conducted (post-implementation) by Smart Columbus will focus on understanding the efficiency of previous data-sharing mechanisms. This will be used as a baseline to make a comparison with the efficiency of the Operating System.

RECOMMENDED DESIGN OF EXPERIMENT

Project implementation timeline as presented in **Figure 4** will be taken into consideration while assessing the variations in data usage. In addition, ingestion of key datasets will also be documented to track the spikes in data usage. An agency employee survey will be conducted to capture information from the City staff and other agencies about the usefulness and efficiency of the Operating System. The survey responses captured will be used to compare the Operating System with the previous data-sharing mechanisms/methods. For the first two indicators, a pre/post quasi experimental design is recommended as a change in behavior before the after the implementation of the Operating System will be assessed. For the third indicator where information about *Number of applications, reports, analytics, and visualizations created using the Operating System data* is collected, there is no baseline condition and control group. So, a post-only trend analysis is recommended for this indicator. For restricted data, access is provided to designated users with a use case or project need. A similar survey method will be used to capture user feedback from these designated users of restricted data.

5.4.3.1.3 Data Collection Plan

DATA SOURCE

Planned sources of data to be stored in the Operating System are discussed in **Chapter 6**. The Operating System provides data to and stores data from either directly or as pass through for every other Smart Columbus project. In supporting these projects, the Operating System will improve the efficiency of providers and consumers of data. The Operating System offers agencies the ability to share data, communicate, and have access to the latest data updates. Stakeholders that will store, retrieve, or otherwise use the Operating System include:

- Researchers (academic, non-profit, USDOT)
- Regional partners
- Other public agencies
- In-house city developers
- Third-party application developers
- Public

In-house city developers are users that work on developing solutions for city needs. Third-party developers are users that work as a hardware or software developer independent of the city.

For this objective, the project usage data and survey data will be collected. Surveys will be conducted throughout the project's treatment timeframe. Surveys will be conducted by the project team and the aggregate results will be stored in the Operating System. All the data will be available for access from the Operating System at the end of the demonstration. Refer to **Chapter 6** for more information.

BASELINE TIMEFRAME

The Operating System minimal viable product launched in December 2017. The Operating System Data Platform 2.0 launched in April 2019. Therefore, the baseline timeframe will be the one-year period of Operating System operations that preceded the launch of Data Platform 2.0.

TREATMENT TIMEFRAME

The project will be evaluated from the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021). Surveys are conducted throughout the demonstration of the Operating System Data Platform 2.0.

5.4.3.1.4 Impact Evaluation Plan

Ability to access and use the data: As the Operating System users use the data in the Operating System for different purposes, using different tools, it is important to track the user's ability to access the data in a workable format and method. Ensuring proper data access will mitigate the formatting needs of the user and increases efficiency.

Usefulness of the accessed data for the intended purposes: Providing access to data that solves the intended purpose of the users plays a critical role in the success of the Operating System. This would encourage the agencies to share more useful data to the public and provides more opportunities for users.

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. For the quantitative questions, the value of measure will be collected. For the qualitative questions, the respondents will be asked to rate the qualitative measure in a scale of 1 to 5 (1 being the lowest and 5 being the highest) as part of the survey. The average scale of the quality measure will be calculated for all the survey responders. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the deployment period. The survey data collected will be compared over the previous surveys to track the indicator for both the treatment and the control groups.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program-level and project-level confounding factors, if any, it can be attributed to the program. Supplemental data may be collected and analyzed to support the conclusion.

Number of applications, reports, analytics, and visualizations created using the Operating System data: The number of products and artifacts created using data on the Operating System is indicative of usefulness and adaptability of the Operating System platform for different purposes. Number of applications, reports,

analytics, and visualizations created using the Operating System data will be collected and aggregated monthly and compared month over month to track number of applications, reports, analytics, and visualizations created. If the trend shows an increase in the applications, reports, analytic, and visualizations created, it can be attributed to this project. An increase in applications, reports, analytic, and visualizations is anticipated during the treatment timeframe.

5.4.3.2. OBJECTIVE 1.1.2: PROVIDE IMPROVED DATA-SHARING METHOD

Table 8: Operating System Agency Efficiency Objective 1.1.2

Category	Description			
Objective	Provide improved data-sharing method			
Hypothesis	The Operating System will enhance the ease of data-sharing method through the Open Data Portal			
Indicator	Ease of data-sharing ability	Number of requests for datasets	Amount of time to access the data	Number and frequency of data retrievals from the Operating System
Design of Experiment	Pre/Post Quasi Experimental Design	Pre/Post Trend Analysis	Pre/Post Quasi Experimental Design	Post-only Trend Analysis
Data Source	Operating System; Surveys			
Baseline Timeframe	One year before implementation of the Operating System Data Platform 2.0 (April 22, 2018 to April 21, 2019)			N/A
Treatment Timeframe	From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021).			

Source: City of Columbus

5.4.3.2.1 Indicators

The objective will be measured using the following indicators:

- Ease of data-sharing ability.
- Number of requests for datasets.
- Amount of time to access the data.
- Number and frequency of data retrievals from the Operating System.

The following data will be collected through system usage:

- Number of data retrievals from the Operating System.
- Frequency of data retrievals from the Operating System.

The following data will be collected through surveys:

- Ease of data-sharing ability before implementation of the Operating System.

- Ease of data-sharing ability after implementation of the Operating System.
- Number of requests received by the agency staff for datasets before publishing on the Operating System.
- Number of requests received by the agency staff for datasets after publishing on the Operating System.
- Amount of time taken to access the data before and after implementation of the Operating System.

Surveys will be conducted to capture the insights of agency users. See **Appendix** C for sample questions and further details.

5.4.3.2.2 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

Through an agency user survey, conditions of data requests and data-sharing abilities before implementation of the Operating System will be used as baseline conditions. During the baseline conditions, users across the Columbus region made requests for datasets with the agency providers through emails or phone calls. Agency providers shared their data through various data-sharing methods including emails, File Transfer Protocols, etc., which typically provides access only to the requested user. With the Operating System, agency providers have the ability to share the data as open data to all users and mitigate the duplication of data-sharing efforts.

RECOMMENDED DESIGN OF EXPERIMENT

An agency user survey will be conducted to capture information from the city staff and other agencies about the data-sharing ability of the Operating System and number of requests for data before and after publishing the data in the Operating System. In addition, data retrievals information will be captured through system usage data. The survey responses captured will be used to compare the Operating System with the previous data-sharing mechanisms/methods, specifically the ease of data sharing ability and the amount of time to access the data. These indicators will be analyzed using a pre/post quasi-experimental design since a change in behavior due to the implementation of the Operating System will be assessed. Post-only trend analysis is recommended for system usage data as there is no comparable pre-existing system.

5.4.3.2.3 Data Collection Plan

DATA SOURCE

The Operating System offers agencies the ability to share data, communicate, and have access to the latest data updates. Stakeholders that will store, retrieve, or otherwise use the Operating System include:

- Researchers (academic, non-profit, USDOT)
- Regional Partners
- Other public agencies
- In-house city developers
- Third-party application developers
- Public

For this objective, the project usage data and survey data will be collected. Surveys will be conducted throughout the project's treatment timeframe. Surveys will be conducted by project team, and the aggregate results will be stored in the Operating System. All data will be available for access from the Operating System at the end of the demonstration. Refer to **Chapter 6** for more information.

BASELINE TIMEFRAME

Since the Operating System is compared with pre-existing data-sharing mechanisms, a baseline timeframe of one year will be considered for this evaluation. For indicators using post-only trend analysis, no baseline will be considered.

TREATMENT TIMEFRAME

The project will be evaluated from the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021). Surveys are conducted every three months post-implementation of the Operating System Data Platform 2.0.

5.4.3.2.4 Impact Evaluation Plan

Ease of data-sharing ability: As the Operating System provides an easy/accessible/discoverable data-sharing platform, comparing the OS with the agencies' previous data-sharing methods/mechanisms will help understand the gaps in the data-sharing methods.

Number of requests for datasets: As more applications share data on the Operating System, agencies will be able to operate more efficiently by reducing data requests between themselves. Instead of emailing or asking for data, agency users will access the necessary data, providing the most recent information without the delays in response that occur today.

Amount of time taken to get access to data: As more agencies publish their data on the Operating System, it is expected that the users of the data will be able to get access to the data in a much less time-consuming manner, when compared to their previous data-sharing mechanisms.

For the surveys, the questions will be categorized as quantitative questions, qualitative questions, and information collection. For the quantitative questions, the value of measure will be collected. For the qualitative questions, the respondents will be asked to rate the qualitative measure in a scale of 1 to 5 (1 being the lowest and 5 being the highest) as part of the survey. The average scale of the quality measure will be calculated for all the survey responders. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the demonstration period. The survey data collected will be compared over the previous surveys to track the indicator for both the treatment and the control groups.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program-level and project-level confounding factors, if any, it can be attributed to the program. Supplemental data may be collected and analyzed to support the conclusion.

Number and frequency of data retrievals from the Operating System: In addition to the qualitative responses from the agency users, a quantitative measure of usage analytics of the Operating System data will help in validating the user responses. As more projects come online and applications tie into the Operating System, the number and frequency of retrievals may increase. Number and frequency of data retrievals will be collected and aggregated monthly, and compared month over month, to track number and frequency of occurrence. If the trend shows an increase in the number and frequency of data retrievals, it can be attributed to this project. An increase is anticipated during the treatment timeframe.

5.4.3.3. OBJECTIVE 1.1.3: PROVIDE EASILY DISCOVERABLE DATA

Table 9: Operating System Agency Efficiency Objective 1.1.3

Category	Description
Objective	Provide easily discoverable data

Category	Description	
Hypothesis	The Operating System will provide users with data in an easily discoverable manner	
Indicator	Ability to find data intended by the users	Number of requests for datasets
Design of Experiment	Post-only Trend Analysis	Pre/post Trend Analysis
Data Source	Operating System; Surveys	
Baseline Timeframe	N/A	One year before implementation of the Operating System Data Platform 2.0 (April 22, 2018 to April 21, 2019)
Treatment Timeframe	From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021)	

Source: City of Columbus

5.4.3.3.1 Indicators

The objective will be measured using the following indicators:

- Ability to find data intended by the users.
- Number of requests for datasets.

The following data will be collected through user surveys:

- Number of requests for datasets before publishing on the Operating System.
- Number of requests for datasets after publishing on the Operating System.
- Ability to find data intended by the users.

Surveys will be conducted to capture the insights of agency users. See **Appendix C** for sample questions and further details. In this context, discoverability is defined as the ability of the user to easily find the data they are looking for. Using appropriate metadata collected from the agencies will enhance the discovery of data. The data in the Operating System needs to be easily discoverable to citizens and agencies to promote use by those who benefit from it for work or personal use.

Through the Operating System, especially third-party applications, citizens and businesses will receive the information they need with a reduced burden to the City for record requests and manual sharing.

5.4.3.3.2 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

For the two indicators, conditions of data requests and data-sharing abilities before implementation of the Operating System will be used as baseline conditions. During the baseline conditions, users across the Columbus region make requests for datasets with the agency providers through emails or phone calls. Agency providers shared their data through various data-sharing methods including emails, File Transfer Protocols, etc., which typically provides access only to the requested user. With the Operating System, agency providers will have the ability to share the data as open data to all users and mitigate the duplication of data-sharing efforts.

RECOMMENDED DESIGN OF EXPERIMENT

An agency user survey will be conducted to capture information from the City staff and other agencies about the discoverability of the Operating System data and number of requests for data before and after publishing the data in the Operating System. A post-only trend analysis is recommended for *Ability to find data intended by the user's* indicator, as there is no control group and comparable pre-existing system. Pre/post trend analysis is recommended for *number of data requests* indicator.

5.4.3.3.3 Data Collection Plan

DATA SOURCE

The Operating System offers agencies the ability to share data, communicate, and access the latest data updates. Stakeholders that will store, retrieve, or otherwise use the Operating System include:

- Researchers (academic, non-profit, USDOT)
- Regional partners
- Other public agencies
- In-house city developers
- Third-party application developers
- Public

For this objective, the project usage data and survey data will be collected. Surveys will be conducted throughout the project's demonstration timeframe. Surveys will be conducted by project team and the aggregate results will be stored in the Operating System. All data will be available for access from the Operating System at the end of the demonstration. Refer to **Chapter 6** for more information.

BASELINE TIMEFRAME

For the post-only trend analysis, no baseline timeframe will be considered. For the pre-post analysis, the Operating System will be compared with pre-existing data-sharing mechanisms, a baseline timeframe of one year will be considered for this evaluation.

TREATMENT TIMEFRAME

The project will be evaluated from the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021). Surveys are conducted throughout the demonstration of the Operating System Data Platform 2.0.

5.4.3.3.4 Impact Evaluation Plan

Ability to find data required by the users: Once the agency data is ingested into the Operating System, it is important that the intended users of the data can find it. Metadata provided by the data provider will be used by the Operating System to enable the data discoverability feature. Surveys conducted with the agency users will be used to evaluate and enhance the data discovery feature.

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and informational collection. For the quantitative questions, the value of measure will be collected. For the qualitative questions, the respondents will be asked to rate the qualitative measure in a scale of 1 to 5 (1 being the lowest and 5 being the highest) as part of the survey. The average scale of the quality measure will be calculated for all the survey responders. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the year through four surveys (once every three months). The survey data collected will be compared over the previous surveys to track the indicator for both the treatment and the control groups.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level and project level confounding factors, if any, it can be attributed to the program. Supplemental data may be collected and analyzed to support the conclusion.

Number of requests for datasets: Lesser number of requests received by the agency data providers after being published on the Operating System is an indicative of users' ability to find, access, and use the intended data through the Operating System. A quantitative verification of this is done by observing dataset level usage analytics. Number of requests for datasets will be collected and aggregated on a monthly basis and compared month-over-month to track number of requests for datasets. If the trend shows an increase in the number of requests for datasets, it can be attributed to this project. An increase in requests for datasets is anticipated during the treatment timeframe.

5.4.3.4. OBJECTIVE 1.1.4: PROVIDE EASILY ACCESSIBLE DATA EXCHANGE

The table below outlines the performance measurement methodology for this objective.

Table 10: Operating System Agency Efficiency Objective 1.1.4

Category	Description		
Objective	Provide an easily accessible data exchange to providers and consumers of data		
Hypothesis	The Operating System will provide an easily accessible data-sharing method to enable data exchange for all users of both internal and external applications.		
Indicator	Percentage of datasets accessible to applications (internal and external) in a usable format and method	Ability to access and use the data	Ability to ingest/harvest the data into the Operating System
Design of Experiment	Post-only Trend Analysis	Pre/Post Quasi Experimental Design	Pre/Post Trend Analysis
Data Source	Operating System; Surveys		
Baseline Timeframe	N/A	One year before implementation of the Operating System Data Platform 2.0 (April 22, 2018 to April 21, 2019)	
Treatment Timeframe	From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021)		

Source: City of Columbus

5.4.3.4.1 Indicators

The objective will be measured using the following indicators:

- Percentage of datasets accessible to applications (internal and external).
- Ability to access and use the data.
- Ability to ingest/harvest the data into the Operating System.

In this context, accessibility is defined as making the data available in a workable format (for example, .csv, xml, etc.,) and method (direct download, API, etc.). A wide variety of applications accessing and storing data in the Operating System is a sign of good performance for the Operating System. The data in the Operating System needs to be accessible to citizens and agencies to promote use by those who benefit from it for work or personal use.

The following data will be collected through surveys:

- Percentage of datasets accessible to applications (internal and external) in a usable format and method.
- Ability to access and use the data pre- and post-Operating System.
- Ability to ingest/harvest the data into the Operating System when compared to previous data-sharing mechanisms.

Surveys will be conducted to capture the insights of agency users. See **Appendix C** for sample questions and further details.

Objective 1.1.1 contains indicators to assess the volume of use and number of users. Objective 1.1.2 focuses on the accessibility of data sets. The first indicator is the number of data sets, and to whom they are accessible. Some data sets will be useful and appropriate for the public, while others will contain information that is for agency use only. When assessing performance, evaluators will consider both types of data and assess if there is enough data to be useful to the public and agencies.

5.4.3.4.2 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

During the baseline conditions, the agency users shared the data through various mechanisms including emails, secure file transfer protocol (SFTPs), shared services, etc. Through the Operating System, agency users will have the ability to share a dataset with multiple users through a one-time ingestion process, which also gathers metadata information to provide more user context and data workability.

RECOMMENDED DESIGN OF EXPERIMENT

The indicators will be measured based on the system usage and surveys. A simple post-only trend analysis is recommended for system usage data. For the second indicator, a pre/post quasi experimental design is recommended as a change in behavior before and after the implementation of the Operating System will be assessed based on survey responses.

5.4.3.4.3 Data Collection Plan

DATA SOURCE

For this objective, the project usage data and survey data will be collected. Surveys will be conducted throughout the project's treatment timeframe. Surveys will be conducted by project team and the aggregate results will be stored in the Operating System. All the data will be available for access from the Operating System at the end of the demonstration. Refer to **Chapter 6** for more information.

BASELINE TIMEFRAME

For the two qualitative indicators, a one-year baseline timeframe is considered to compare the Operating System with the pre-existing data-sharing mechanisms. For the quantitative indicator, no baseline timeframe is considered as there is not an equivalent system for comparison.

TREATMENT TIMEFRAME

The project will be evaluated from the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021). Surveys are conducted every three months post-implementation of the Operating System Data Platform 2.0.

5.4.3.4.4 Impact Evaluation Plan

The impact evaluation plan for the indicators are as follows:

Percentage of datasets accessible to applications (internal and external) in a usable format and method: Datasets accessible to applications for both internal and external agencies will be observed. Percentage of internal datasets accessible will be calculated as the ratio of datasets accessible to internal agencies over the total of datasets accessible to both internal and external agencies. Percentage of external datasets accessible will be calculated as the ratio of datasets accessible to external agencies over the total of datasets accessible to both internal and external agencies. Some data sets will be useful and appropriate for the public and other agencies (external), while others will contain information that is for the City's use only (internal). When assessing performance, evaluators will consider both types of data and assess the usability of data to the internal and external agencies.

Ability to access and use the data: As the Operating System users use the data in the Operating System for different purposes, utilizing different tools, it is important to track the users' ability to access the data in a workable format and method. Ensuring proper data access will mitigate the formatting needs of the user and increase their efficiency.

Ability to ingest/harvest the data into the Operating System vs. previous data-sharing mechanisms: Comparing the agency data providers' ability to ingest data into the Operating System and their other data-sharing mechanisms will help assess the efficiency of the data-sharing mechanism/method provided by the Operating System.

For the surveys, the questions will be categorized as quantitative questions, qualitative questions, and information collection. The responses to the informational questions will be collected and stored for future use, if necessary. The survey data collected will be compared over the previous surveys to track the indicator before and after implementation of the Operating System.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the users. If the indicator shows an improvement trend after accounting for the program level and project level confounding factors, if any, it can be attributed to the program. Supplemental data may be collected and analyzed to support the conclusion.

5.4.4. Outcome 1.2: Customer Satisfaction

Two objectives are identified for this outcome.

5.4.4.1. OBJECTIVE 1.2.1: ESTABLISH AND ENHANCE CUSTOMER SATISFACTION WITH THE OPERATING SYSTEM PLATFORM

The table below outlines the performance measurement methodology for this objective.

Table 11: Operating System Customer Satisfaction Objective 1.2.1

Category	Description
Objective	Establish and enhance customer satisfaction with the Operating System
Hypothesis	The Operating System will ensure the satisfaction of its customers (public agencies, evaluators, and developers) by providing and enhancing data, visualization, and analytical features through an Open Data Portal

Category	Description
Indicator	Customer satisfaction ratings for: • Quality, freshness, and completeness of data • Metadata quality • Visualization tools/features • Analytical tools/features • Method of ingesting data into the Operating System • Method of extracting data from the Operating System
Design of Experiment	Post-only Trend Analysis
Data Source	Operating System; Surveys
Baseline Timeframe	N/A
Treatment Timeframe	From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021)

Source: City of Columbus

5.4.4.1.1 Indicators

The following indicators will be used for evaluation:

- Quality, freshness, and completeness of data.
- Metadata quality.
- Visualization tools/features.
- Analytical tools/features.
- Method of ingesting data into the Operating System.
- Method of extracting data from the Operating System.

The following data will be collected:

- Customer satisfaction ratings on
  - Quality, freshness, and completeness of data available through the Operating System.
  - Metadata quality for the data available on the Operating System.
  - Visualization tools/features available on the Operating System.
  - Analytical tools/features available on the Operating System.
  - Method(s) of data extraction from the Operating System.
    - Performance of streaming feature.
    - Performance of throughput.
  - Method(s) of data ingestion into the Operating System.
    - Performance of streaming feature.
    - Performance of throughput.

Surveys will be conducted to capture the insights of OS users. See **Appendix C** for sample questions and further details**.** In the context of the Operating System, customer satisfaction refers to satisfactory experiences on the part of the Operating System users. Smart Columbus will develop several applications that use the Operating System. Data, visualizations, and analytics useful to many user types will be present, and, by making it easily accessible to them, the Operating System will be a success.

5.4.4.1.2 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

For all the indicators, there is no existing equivalent of the Operating System to compare progress.

RECOMMENDED DESIGN OF EXPERIMENT

The indicators will be measured using surveys conducted throughout the demonstration of the Operating System until the period of implementation of the final portfolio project. Since the objective is to establish and enhance the customer satisfaction with the Operating System, there is no baseline system data to perform a pre/post evaluation. Also, there is no control group to perform a quasi-experimental design. Therefore, a post-only trend analysis is recommended for this evaluation.

5.4.4.1.3 Data Collection Plan

DATA SOURCE

For this objective, the project usage data and survey data will be collected. Surveys will be conducted throughout the project's treatment timeframe. Surveys will be conducted by project team, and the aggregate results will be stored in the Operating System. All data will be available for access from the Operating System at the end of the demonstration. Refer to **Chapter 6** for more information.

BASELINE TIMEFRAME

Since, a post-only design of experiment is recommended, a baseline timeframe is not applicable for the indicators of this objective.

TREATMENT TIMEFRAME

The project will be evaluated from the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021). Surveys are conducted throughout the demonstration of the Operating System Data Platform 2.0.

5.4.4.1.4 Impact Evaluation Plan

Quality, freshness, and completeness of data: Providing quality, complete, and fresh data would help the end users generate an accurate assessment of ground truth. It should be noted that Smart Columbus can only control the quality of data generated from the Smart Columbus Portfolio projects. For all other data sources, data quality is the responsibility of the data providers.

Metadata quality: Metadata plays a critical role in discovering, understanding, using, and relating data. The Operating System follows Project Open Data Metadata Schema version 1.1[7]. The evaluation will assess the usefulness and quality of the metadata to the end users in the discovery and application of datasets for different purposes.

Visualization tools/features: Providing end users with access to visualization tools will expand the scope of data understanding and usage. As the tools like Jupyter Notebook and others are made available to users, the Operating System team will conduct quarterly surveys to capture user satisfaction with the functionality and usefulness of the tool.

[7] https://resources.data.gov/resources/dcat-us/

Analytical tools/features: As the analytical tools become available to the users through the Operating System platform, the users will be able to perform simple to complex analytics based on their needs. User satisfaction with the analytics tools will be captured through customer surveys.

Method of ingesting data into the Operating System: User satisfaction with the Operating System's ability to ingest the data into the data platform, either through PULL (where the Operating System will pull the data from the source API) or PUSH (where the source will push the data into the API provided by the Operating System) model, will be used for assessing the performance of Operating System.

Method of extracting data from the Operating System: Making the datasets on the Operating System available to users in workable formats, methods with adequate throughput speed is critical in establishing and expanding the usage of the Operating System. This indicator will assess the customers' satisfaction with the available methods of data extraction. Currently available methods include API and direct download.

All the indicators will be evaluated to assess the satisfaction of customers with the Operating System features. Enhancements to the Operating System features will be performed based on the customer feedback. Since the survey is conducted throughout the demonstration, a trend analysis of customer satisfaction will depict the efficiency of each feature and the enhancements performed. Enhancements to the Operating System features will be performed based on the user feedback. Feature evaluation and enhancement will be an iterative process until the end of the treatment timeframe.

5.4.4.2. OBJECTIVE 1.2.2: PROVIDE EASILY DISCOVERABLE DATA

The table below outlines the performance measurement methodology for this objective.

Table 12: Operating System Customer Satisfaction Objective 1.2.2

Category	Description	
Objective	Provide easily discoverable data	
Hypothesis	The Operating System will provide open data to the users in an easily discoverable fashion.	
Indicator	Time spent on the Operating System Time spent on discovery of dataset(s)	Ability to find the intended data
Design of Experiment	Post-only Trend Analysis	
Data Source	Operating System; Surveys	
Baseline Timeframe	N/A	
Treatment Timeframe	From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021).	

Source: City of Columbus

5.4.4.2.1 Indicators

The objective will be measured using the following indicators:

- Time spent on the Operating System: It indicates the total number of minutes spent on the Operating System every time the users log on.
- Time spent on discovery of dataset(s): It indicates the total number of minutes spent on discovery of dataset(s) every time the users log on.
- Ability to find the intended data.

The following data will be collected through system data:

- Time spent on the Operating System (based on user IP address).
- Time spent for data discovery (based on user IP address).

The following data will be collected through surveys:

- User's ability to find the required/intended data.

Surveys will be conducted to capture the insights of Operating System users. See **Appendix C** for sample questions and further details. In the context of the Operating System, customer satisfaction refers to satisfactory experiences on the part of the Operating System users. Smart Columbus will develop several applications that use the Operating System. Data useful to many user types will be present, and by making it easily accessible to them, the Operating System will be a success.

5.4.4.2.2 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

For all the indicators, there is no existing equivalent of the Operating System to compare progress.

RECOMMENDED DESIGN OF EXPERIMENT

The indicators will be measured based on the system usage and post-implementation surveys. A simple post-only trend analysis is recommended for system usage data. In addition, since a comparable system and control group do not exist, post-only trend analysis is also recommended for the 'ability to find the intended data' indicator.

5.4.4.2.3 Data Collection Plan

DATA SOURCE

For this objective, the project usage data and survey data will be collected. Surveys will be conducted throughout the project's treatment timeframe. Surveys will be conducted by the project team and the aggregate results will be stored in the Operating System. All the data will be available for access from the Operating System at the end of the demonstration. Refer to **Chapter 6** for more information.

BASELINE TIMEFRAME

Since a post-only design of experiment is recommended, a baseline timeframe is not applicable for the indicators of this objective.

TREATMENT TIMEFRAME

The project will be evaluated from the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021). Surveys are conducted throughout the demonstration of the Operating System Data Platform 2.0.

5.4.4.2.4 Impact Evaluation Plan

Time spent on the Operating System and Discovery of Data: These two indicators will help in the assessment of user behavior while using the Operating System. Increase in amount of time spent on the Operating System and decrease in the amount of time spent searching for datasets are indicators that users are spending more time with the data portal and less time for searching the data.

Ability to find intended data: Users' feedback on their ability to find their intended data on the Operating System is a critical factor that defines the success of data discovery features provided. Feedback is collected every three months, as well as when new discovery features become available.

The first two indicators will be compared using a monthly trend analysis. Timeline points will be identified when new user discovery features are made available to capture the impacts of those features. Customer surveys will be conducted over the demonstration period and feedback will be used to assess the efficiency of each user discovery feature. Enhancements to the discovery features will be performed based on the user feedback. Feature evaluation and enhancement will be an iterative process until the end of the treatment timeframe.

5.4.5. Project-Specific Confounding Factors

The following confounding factor might affect the usage of Operating System:

- **Changes to Operating System features:** Any feature changes in the Operating System during the treatment timeframe may impact the usage of Operating System. Evaluators will assess the impacts of any changes to the application during the evaluation.

5.4.6. Project Cost

Approximate budget to design, build, and implement the project is $14.3 million, inclusive of vendor and other direct costs (ODC). Smart Columbus PMO and PM/SE labor costs are tracked separately and not included in this project-specific amount. Smart Columbus team is currently developing and tracking the entire project life cycle cost—including planning, design, implementation, testing, operations, and maintenance.

5.5. PROJECT 2: CONNECTED VEHICLE ENVIRONMENT

5.5.1. Introduction

The anticipated outcomes of the CVE project are to enhance safety, environment, and mobility throughout the City's transportation system utilizing CV technologies (specifically dedicated short range communication, DSRC) and applications with an emphasis on congested and high crash intersections and corridors. The environmental outcome will be assessed for the Smart Columbus Program as a whole, with the CVE project being a contributor. The safety and mobility outcomes will be assessed specifically for CVE. Safety applications are intended to be installed on multiple vehicle types including transit buses, first responder vehicles, City and partner fleet vehicles, and private vehicles.

Columbus has identified several corridors and intersections that have high crash numbers related to vehicles, bicyclists, and pedestrians. In addition, these same corridors have congestion levels that result in poor mobility conditions for emergency vehicles, freight, and transit buses. The four (4) CVE corridors were selected based on regional crash data, enhanced transit services, recent infrastructure investments, and relationship to other projects. Further, 17 of the 86 intersections along these corridors are in the top 100 regional high-crash intersections[8]. All 86 intersections will be equipped with CV technology.

In conjunction with these intersections, up to 1,200 vehicles, spanning multiple vehicle types, are targeted for CV technology. The vehicles will have different configurations of CV applications installed, depending on the vehicle type and use. **Table 13** shows the breakdown of vehicle types and quantities.

Table 13: Quantities and Characteristics by Vehicle Type

Vehicle Type	Partner/Source	Quantity	Characteristics
Light-Duty Vehicle	Private Vehicle	350-500	All V2X safety apps, human machine interface (HMI), no data logging, integrator-led installation
	Public Service City Fleet Vehicle	198	All V2X safety apps, HMI, no data logging, coordination of installation with City fleets
	COTA Supervisor Vehicle	25	All V2X safety apps, HMI, no data logging, coordination with COTA maintenance
Emergency Vehicle	Public Safety Fire Truck/EMS	30	Emergency vehicle preemption (EVP) only, minimal HMI (EVP granted), no data logging, integration with siren, coordination of installation with City fleet
	Public Safety Police Cruiser	80	EVP only, minimal HMI (EVP granted), no data logging, integration with siren, coordination of installation with City fleet
Heavy-Duty Vehicle	Private Freight Vehicle	14	BSM and freight signal priority (FSP) only, no HMI, no data logging, coordination with fleet owner
	County Engineer Heavy-Duty Vehicle	2	BSM only, no HMI, no data logging, coordination with fleet owner
Transit Vehicle	COTA Transit Bus (fixed-route)	315	All V2X safety apps, transit signal priority (TSP), no HMI, data logging and offloading, coordination with COTA maintenance
	COTA Paratransit Bus	80	All V2X safety apps, no HMI, data logging and offloading, coordination with COTA maintenance

[8] *MORPC TOP 100 REGIONAL HIGH-CRASH INTERSECTIONS (2014 TO 2016).*

Vehicle Type	Partner/Source	Quantity	Characteristics
Total		**~1,100-1,200**	

Source: City of Columbus

As noted, not all vehicles will implement all applications. The exact count of vehicles implementing each application will be detailed for each performance measure.

Unlike other projects within the Smart Columbus portfolio, the CVE consists of multiple applications fulfilling multiple, and sometimes varying, objectives. As a result, multiple, distinct performance measures are necessary for each application or subset of applications. The following objectives are identified for the CVE project:

- Reduce emergency response times.
- Improve motorist's adherence to red lights.
- Improve adherence to speed limits in school zones.
- Improve reliability of transit vehicle schedule adherence.
- Reduce truck wait (delay) time at signalized intersection.

To meet these objectives, three V2I applications will be deployed that will have associated performance measures. These applications are:

- Red-Light Violation Warning
- Reduce Speed School Warning
- Traffic Signal Priority/Preemption (includes transit signal priority, emergency vehicle preempt, and freight signal priority)

Two additional V2I applications, Vehicle Data for Traffic Operations and Transit Vehicle Intersection Event Recording are focused on capturing data from the CVE, but specific use of this data has not yet been identified and, as such, no performance measures will be captured. Additional performance measures for these applications may be developed to assess the impact of this data on users. The City will determine if these are needed, and, if so, they will be added to a later revision of this document.

The CVE also intends to deploy five (5) V2V applications focused on safety. However, as most equipped vehicles will not have any data logging features, no performance measures have been developed for these applications.

Refer to the *Connected Vehicle Environment Concept of Operations for the Smart Columbus Demonstration Program*[9] for project area, outcomes and objectives, and additional detail on this project.

The following sections identify logic model, outcomes and objectives, hypotheses, indicators, data collection plan, and impact evaluation plan for each of the two project outcomes.

[9] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Connected%20Vehicle%20Environment%20Concept%20of%20Operations.pdf

5.5.2. Logic Model

Figure 13 shows the logic model identified for this project.

Outcomes	Objectives	Treatment	Hypothesis	Outcome Indicators
Safety	Reduce emergency response times in CVE corridor	Emergency Vehicle Signal Preemption	The Emergency Vehicle Preemption application will improve emergency response times by reducing delay at signalized intersections with DSRC.	• Emergency response time
Safety	Increase driver's awareness of signal status	Red Light Violation Warning CVE application	The Red-Light Violation Warning application will increase the driver's awareness of traffic signal status by providing drivers with warnings of impending signal violation at every signalized intersection in the CVE corridors.	• Driver's awareness of traffic signal status
Safety	Increase driver's awareness of speed limits in school zones	Reduced Speed School Zone CVE application	The Reduced Speed School Zone application will increase driver's awareness of speed in school zones by providing drivers with warnings to reduce speed due to the proximity of school zones.	• Driver's awareness of speed in school zones
Mobility	Demonstrate DSRC technology for TSP application	Transit Signal Priority	DSRC based TSP application will perform at the same level as Opticom*-based TSP application.	• Time of priority request
Mobility	Reduce truck wait (delay) time at signalized intersections	Heavy Duty Signal Priority	The FSP will save travel time for trucks passing through equipped intersections by modifying signal timing.	• Travel time through intersection

**Opticom is a traffic control system that provides signal priority.*

Figure 13: Connected Vehicle Performance Measurement Logic Model

Source: City of Columbus

(Note: Environmental Outcome is measured at program level.)

The CVE project identified the following two outcomes:

1. Safety
2. Mobility

Note that the environmental outcome is measured at the program-level with CVE being one of the contributing projects.

5.5.3. Outcome 2.1: Safety

Outcome 2.1 identified the following three objectives:

1. Reduce emergency response times in CVE corridor.
2. Increase drivers' awareness of signal status.
3. Increase drivers' awareness of speed limits in school zones.

5.5.3.1. EMERGENCY VEHICLE PREEMPTION

5.5.3.1.1 Objective 2.1.1: Reduce Emergency Response Times

The Emergency Vehicle Preemption (EVP) application provides improved mobility for emergency response vehicles. Preemption can operate in collaboration with or independently of surrounding intersections. Also, vehicles approaching from either approach communicate with roadside equipment at intersections to acquire preemption status, though the application can be configured to limit which approaches can receive priority/preemption based on traffic management policy. Clearing queues and holding conflicting phases can facilitate emergency vehicle movement. In addition, transitioning back to normal traffic signal operations after providing preemption is an important consideration. The *Connected Vehicle Environment Concept of Operations for the Smart Columbus Demonstration Program*[10] provides additional detail on this application. Presently, all intersections within the CVE will be EVP capable, however only emergency vehicles that frequent the Cleveland Ave./Morse Rd./High St. corridors intersections are presently planned to be equipped with EVP.

Table 14 outlines how the impact of implementing the EVP application on safety will be measured.

Table 14: Connected Vehicle Environment Safety Objective 2.1.1

Category	Description
Objective	Reduce emergency response times in CVE corridor
Hypothesis	The Emergency Vehicle Preemption application will improve emergency response times by reducing delay at signalized intersections with DSRC.
Indicator	Emergency response times
Design of Experiment	Pre/post Trend Analysis

[10] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Connected%20Vehicle%20Environment%20Concept%20of%20Operations.pdf

Category	Description
Data Source	Survey City of Columbus Department of Public Safety emergency medical services (EMS) records CVE Data via Operating System
Baseline Timeframe	Nine months prior to implementation (Fall 2019 to Summer 2020)
Treatment Timeframe	Seven months post-implementation (Fall 2020 to Spring 2021)

Source: City of Columbus

5.5.3.1.2 Indicators

The objective will be measured using the following indicators:

- Emergency response times.

The following data will be collected:

- Emergency response times for EVP-enabled EMS vehicles.
- Number of preemption requests granted/denied.

A customer survey will be conducted twice among the stakeholders to evaluate the impact on safety. The survey will be designed to seek performance measures, such as:

- Emergency response times.
- Perceived safety improvements.

Surveys will be conducted to capture the insights of project participants. See **Appendix C** for sample questions and further details. The mobility outcome related to EVP is driven by the City's desire to minimize injury, death, and property destruction due to fire, natural disaster, and other emergencies while providing timely and effective EMS. EMS includes those in the Engine Company, Rescue Company, Medic Company, and Ladder Company. Emergency response vehicles also include those operated by the Division of Police. The calculation of emergency response time will be primarily based on the input of fire and police personnel. For fire, these staff define response time as the entire time, from dispatch time to on-scene time. For police, the origin of the response for police vehicles are random since they are patrolling. The Columbus Police Department will provide one year's worth of priority-one calls, which will then be matched with PubServ GPS records to determine if baseline response times can be calculated. This document will be updated once this analysis is complete to describe whether response times can be measured on the CVE corridors.

The exact number and composition of Department of Public Safety vehicles that will be equipped with EVP technologies as part of the Columbus Smart City initiative have not been determined, but it is estimated that approximately 110 vehicles will be equipped. This includes both police and fire vehicles. Fire comprises 30 of those vehicles.

With regards to geographic coverage, only vehicles that typically operate within the CVE deployment area will be equipped with the EVP equipment. **Figure 14.** Fire Station and Police Precinct Locations illustrates the geographic location of the stations and their proximity to the CV-equipped corridor. It is planned that the vehicles operating out of the following stations will be equipped with the EVP applications, including:

- Station 7 - Buckeye Fire Station located at 1425 Indianola Avenue
- Station 13 - Olde North Columbus Fire Station located at 309 Arcadia Avenue
- Station 16 – Mock Orchard Fire Station located at 1130 E. Weber Road
- Station 18 - Herbert F. Turner South Linden Fire Station located at 1630 Cleveland Avenue

- Station 19 - Lieutenant Jerry Kuhn Northmoor Engine House located at 3601 N. High Street
- Station 24 - Northland Area Fire Station located 1585 Morse Road

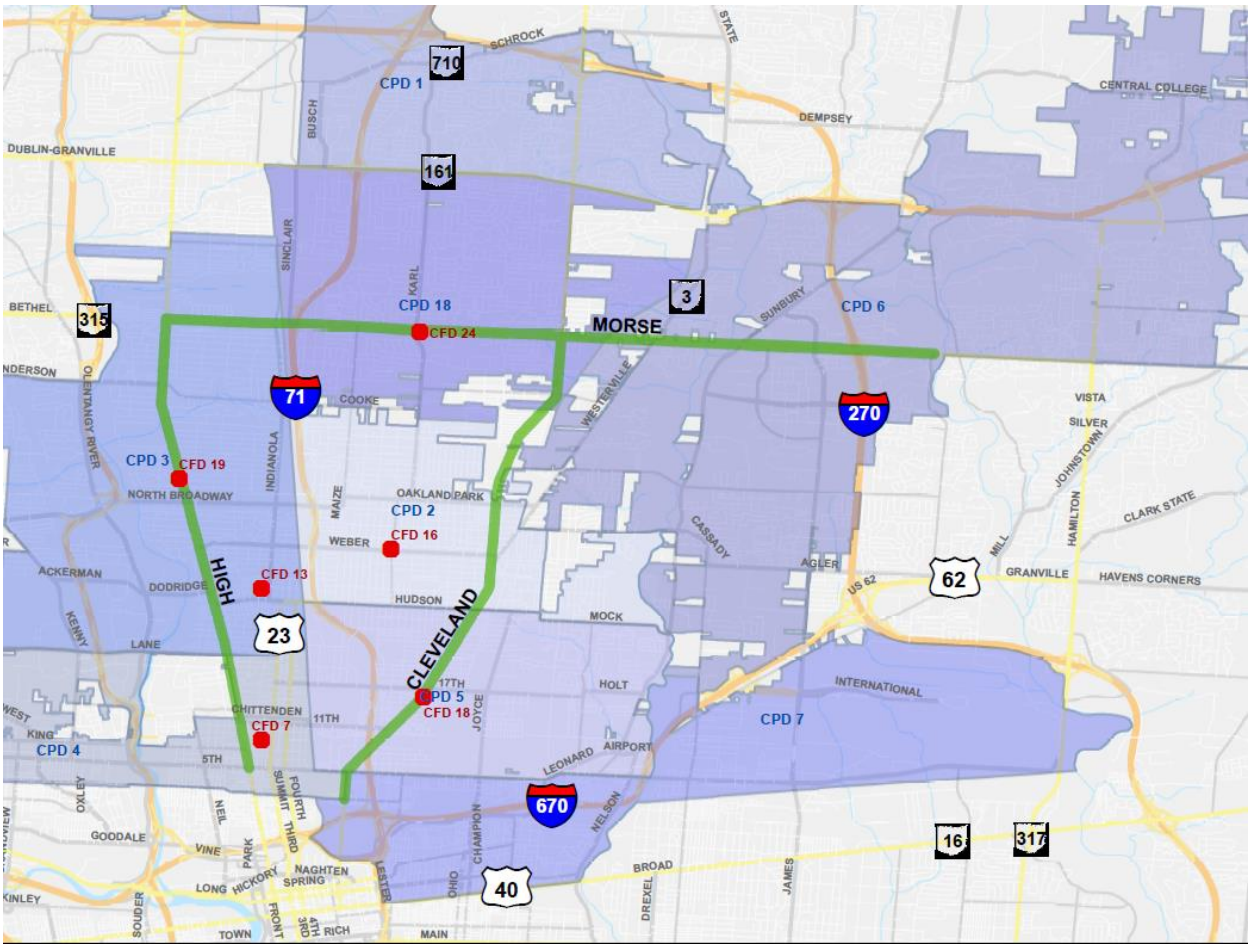

Figure 14. Fire Station and Police Precinct Locations

Source: City of Columbus

5.5.3.1.3 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

By City Council Resolution, the Division of Fire must maintain an overall maximum response time of eight minutes or less in at least 80 percent of Fire and EMS incident responses. To measure this outcome, the City tracks response times using data derived from their computer-aided dispatch (CAD) system. The same data will serve as the baseline for this analysis.

RECOMMENDED DESIGN OF EXPERIMENT

Currently, emergency response data exists for emergency vehicles (prior to implementation). This data is captured for every run that is made. Since all the emergency vehicles will be able to get preemption, there will be no control vehicles. Since there are no control vehicles and the data exist prior to EVP implementation, a pre/post trend analysis is recommended to evaluate the response time of emergency vehicles operated by the City of Columbus Department of Public Safety.

For the supplemental data, the ability for CV technology will be supported by analyzing the number of runs which traversed CV-equipped intersections, the number of preempt requests received by the infrastructure, and the number of requests granted. The number of requests made by the vehicle must be inferred from analyzing GPS data and assuming the request would be made based on proximity to the intersection, as no other conditions are being required for this application. The analysis will be performed using post-only analysis since there is no pre-treatment data to consider.

5.5.3.1.4 Data Collection Plan

DATA SOURCE

For this objective, the project usage data and survey data will be collected. Surveys will be conducted throughout the project's treatment timeframe. Surveys will be conducted by the project team, and the aggregate results will be stored in the Operating System. All the data will be available for access from the Operating System at the end of the demonstration. Refer to **Chapter 6** for more information.

BASELINE TIMEFRAME

Baseline data for emergency vehicle response time will be collected for the nine-month period prior to deployment.

TREATMENT TIMEFRAME

Treatment data will be collected for demonstration period following the implementation of the CVE. Surveys will be conducted during this time.

5.5.3.1.5 Impact Evaluation Plan

The impact evaluation plan for the indicator is as follows:

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. For the quantitative questions, the value of measure will be collected. For the qualitative questions, the respondents will be asked to rate the qualitative measure in a scale of 1 to 5 (1 being the lowest and 5 being the highest) as part of the survey. The average scale of the quality measure will be calculated for all the survey responders. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the deployment period. The survey data collected will be compared over the previous surveys to track the indicator for the treatment group.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level confounding factors, if any, it can be attributed to the project.

Surveys regarding emergency vehicle response times for the nine (9) months prior to deployment will be compared with response times from the demonstration deployment period to determine the impact of the EVP application. Emergency response times will be collected based on the type of emergency responder. For fire responders, response time will be collected from dispatch time to time on-scene. Police response time is still being evaluated, as origins with police vehicles are random while they are patrolling. It is anticipated that response time may only be collected for the portion within the CV corridor to reduce confounding factors outside the project area.

For the supplemental data, CV performance will be determined by comparing the number of expected preempt requests, based on GPS probe-data for the vehicles, and comparing to requested received by the roadside. Number of requests granted/denied will also be determined. If sufficient dataset is available, analysis will be stratified based on the number of preemption requests requested/granted.

5.5.3.2. RED-LIGHT VIOLATION WARNING

5.5.3.2.1 Objective 2.1.2 – Increase driver's awareness of signal status

The Red-Light Violation Warning (RLVW) application enables a CV approaching a signalized intersection to receive information about the signal timing and geometry of the intersection. The application in the vehicle uses its speed and acceleration profile (along with the signal timing and geometry information) to determine if it appears likely that the vehicle will enter the intersection in violation of a traffic signal. If the violation seems likely to occur, a warning is provided to the vehicle operator. This application addresses crashes between multiple vehicles at intersections and is planned to be deployed on all vehicles with an HMI (which includes all pilot vehicles except COTA vehicles). The *Connected Vehicle Environment Concept of Operations for the Smart Columbus Demonstration Program*[11] has additional detail on this application.

Table 15 outlines how the impact of implementing the project on safety will be measured.

Table 15: Connected Vehicle Environment Safety Objective 2.1.2

Category	Description
Objective	**Increase driver's awareness of signal status**
Hypothesis	The Red-Light Violation Warning application will increase the driver's awareness of traffic signal status by providing drivers with warnings of impending signal violation at every signalized intersection in the CVE corridors.
Indicator	Driver's awareness of traffic signal status
Design of Experiment	Pre/Post Trend Analysis
Data Source	Survey; CVE data via operating system
Baseline Timeframe	Two months following deployment before implementation (Fall 2020)
Treatment Timeframe	Five months post-implementation (Winter 2020 to Spring 2021)

Source: City of Columbus

5.5.3.2.2 Indicators

The objective will be measured using the following indicators:

- Driver's awareness of traffic signal status.

The following data will be collected for analysis:

- Customer survey.

The following data will be collected as a backup and not directly used for analysis:

- Signal Phase and Timing (SPaT) message content and time that would have been sent (before implementation).

[11] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Connected%20Vehicle%20Environment%20Concept%20of%20Operations.pdf

- SPaT message content and time (after implementation).
- BSM message containing vehicle trajectory information. No other vehicle data will be collected.
- Frequency of CV passing RSU.
- Period of SPaT activation.

The safety outcome of implementing RLVW relates to increasing the driver's awareness of traffic signal status.

A customer survey will be conducted twice among the participants to evaluate the impact on safety from the customer's point of view. The survey will be designed to seek performance measures, such as:

- Driver awareness of traffic signal status.
- Change in driver behavior.

Surveys will be conducted to capture the insights of project participants. See **Appendix C** for sample questions and further details.

5.5.3.2.3 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

The process of evaluating the effectiveness of the RLVW is limited. However, baseline data will be collected for two months following deployment (without activating the application) to allow for a small period to assess baseline conditions.

All customers with the DSRC on their vehicles will be part of the treatment group. The control group does not exist, since all vehicles equipped with DSRC will receive the warnings. During the pre-period, RSUs would not broadcast SPaT and Intersection Geometry Message (MAP) messages that are used by the vehicle to determine if running a red light is imminent. During the post period, RSUs would broadcast SPaT and MAP messages, which would result in a warning issued to the driver should the vehicle's trajectory place it at risk for running a red light. Surveys will be conducted for both pre- and post-periods. A pre/post trend analysis is recommended for this application.

5.5.3.2.4 Data Collection Plan

DATA SOURCE

Customer surveys will be conducted by the project team and the results will be made available for the City. In addition to survey data used for analysis, SPaT, BSM message, and RSU data will be collected as backup and is not needed for direct measurement of the indicator.

BASELINE TIMEFRAME

Baseline data for customer surveys will be conducted for two months post-deployment but prior to implementation (the period between installation and device activation).

TREATMENT TIMEFRAME

The project will be evaluated seven months following deployment of the CVE, with the final five months implementing the post treatment by enabling RSU broadcasts.

5.5.3.2.5 Impact Evaluation Plan

The impact evaluation plan for the indicator is as follows:

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. For the quantitative questions, the value of measure will be collected. For the qualitative questions, the respondents will be asked to rate the qualitative measure in a scale of 1 to 5 (1 being the lowest and 5 being the highest) as part of the survey. The average scale of the quality measure will be calculated for all the survey responders. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the two surveys through the demonstration period. The survey data collected will be compared over the previous surveys to track the indicator for the treatment group.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level confounding factors, if any, it can be attributed to the project. Supplemental BSM data may be collected and analyzed to support the conclusion.

5.5.3.3. REDUCED SPEED SCHOOL ZONE APPLICATION

5.5.3.3.1 Objective 2.1.3 – Increase driver's awareness of speed limits in school zones

The Reduced Speed School Zone Application (RSSZ) provides CVs with information on a school zone's posted speed limit. RSSZ is planned to be deployed on all vehicles with an HMI. The RSSZ application inside the CV uses the speed limit to determine whether to provide an alert or warning to the vehicle operator. The application will provide an alert to vehicle operators exceeding this limit. The *Connected Vehicle Environment Concept of Operations for the Smart Columbus Demonstration Program*[12] provides additional detail on this application.

Table 16 outlines how the impact of implementing the project on safety will be measured.

Table 16: Connected Vehicle Environment Safety Objective 2.1.3

Category	Description
Objective	Increase driver's awareness of speed limits in school zones
Hypothesis	The Reduced Speed School Zone application will increase driver's awareness of speed in school zones by providing drivers with warnings to reduce speed due to the proximity of school zones.
Indicator	Driver's awareness of speed in school zones
Design of Experiment	Pre/Post Trend Analysis
Data Source	Survey; CVE data via operating system
Baseline Timeframe	Two months following deployment before implementation (Fall 2020)
Treatment Timeframe	Five months post-implementation (Winter 2020 to Spring 2021)

Source: City of Columbus

[12] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Connected%20Vehicle%20Environment%20Concept%20of%20Operations.pdf

5.5.3.3.2 Indicators

The objective will be measured using the following indicators:

- Driver's awareness of speed in school zones.

The following data will be collected for analysis:

- Customer survey.

The following data will be collected as a backup and not directly used for analysis:

- CV speeds in school zone before implementation.
- CV speeds in school zone after implementation.
- Frequency of CV passing RSU.
- BSM message containing vehicle trajectory information. No other vehicle data will be collected.
- Period of Traveler Information Message (TIM) activation.

A customer survey will be conducted two times among the participants to evaluate the impact on safety from the customer's point of view. The survey will be designed to seek performance measures, such as:

- Driver awareness of speed in school zones.
- Change in driver behavior.

Surveys will be conducted to capture the insights of project participants. See **Appendix C** for sample questions and further details.

5.5.3.3.3 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

The process of evaluating the effectiveness of the RSSZ is limited. However, baseline data will be collected for one to two months following deployment (without activating the application) to allow for a small period to assess baseline conditions. As of this document update, at least one school zone will be active during the deployment period.

RECOMMENDED DESIGN OF EXPERIMENT

All customers with the DSRC on their vehicles (except those noted in Section 5.5.3.3.1) will be part of the treatment group. The control group does not exist since all vehicles equipped with DSRC will receive the warnings. During the pre-period, RSUs would not broadcast TIM that indicate the school zone speed and times when the school zone is active. During the post-period, RSUs would broadcast TIM, which would result in a warning issued to the driver should the vehicle's trajectory place it at risk for excessive speeding in a school zone. Surveys will be conducted for both pre- and post-periods. A pre/post trend analysis is recommended for this application.

5.5.3.3.4 Data Collection Plan

DATA SOURCE

Customer surveys will be conducted by the project team, and the results will be made available for the City. In addition to survey data used for analysis, BSM and TIM data will be collected as backup and is not needed for direct measurement of the indicator.

BASELINE TIMEFRAME

Baseline data for customer survey will be conducted for two months post-deployment but prior to implementation.

TREATMENT TIMEFRAME

The project will be evaluated seven months following deployment of the CVE, with the final five months implementing the post treatment by enabling RSU broadcasts.

5.5.3.3.5 Impact Evaluation Plan

The impact evaluation plan for the indicator is as follows:

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. For the quantitative questions, the value of measure will be collected. For the qualitative questions, the respondents will be asked to rate the qualitative measure in a scale of 1 to 5 (1 being the lowest and 5 being the highest) as part of the survey. The average scale of the quality measure will be calculated for all the survey responders. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked by two surveys through the demonstration period. The survey data collected will be compared over the previous surveys to track the indicator for the treatment group.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level confounding factors, if any, it can be attributed to the project. Supplemental BSM data may be collected and analyzed to support the conclusion.

5.5.4. Outcome 2.2: Mobility

Outcome 2.2 identified the following two objectives:

1. Demonstrate DSRC Technology for Transit Signal Priority.
2. Reduce truck wait (delay) time at signalized intersections.

5.5.4.1. TRANSIT SIGNAL PRIORITY

5.5.4.1.1 Objective 2.2.1: Demonstrate DSRC Technology for Transit Signal Priority

The Transit Signal Priority (TSP) application provides improved mobility for the 15 Bus Rapid Transit (BRT) vehicles that will be enabled with TSP. Presently, these are the only vehicles which will feature TSP. TSP is able to operate in collaboration with or independently of surrounding intersections. CV-equipped vehicles approaching on the mainline communicate with roadside equipment at intersections which are TSP-enabled, operating in parallel with the existing Opticom system—allowing priority requests to be made by the Transit Vehicle OBU without affecting signal operations. The approaches enabled for priority are based on traffic management policy. TSP is generally considered a lower level of priority compared to the needs of emergency vehicle operators. TSP is characterized by providing either an early green or an extended green for a specified phase. The *Connected Vehicle Environment Concept of Operations for the Smart Columbus Demonstration Program*[13] provides additional detail on this application. TSP will be deployed at the following intersections:

[13] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Connected%20Vehicle%20Environment%20Concept%20of%20Operations.pdf

- Cleveland Avenue and Second Avenue
- Cleveland Avenue and Fifth Avenue
- Cleveland Avenue and 11th Avenue
- Cleveland Avenue and Windsor Avenue
- Cleveland Avenue and 17th Avenue
- Cleveland Avenue and 20th Avenue
- Cleveland Avenue and 24th Avenue
- Cleveland Avenue and Duxberry Avenue
- Cleveland Avenue and Hudson Street
- Cleveland Avenue and Myrtle Avenue
- Cleveland Avenue and Genessee Avenue
- Cleveland Avenue and Westerville Road
- Cleveland Avenue and Weber Road
- Cleveland Avenue and Oakland Park Avenue
- Cleveland Avenue and Huy Road
- Cleveland Avenue and Innis Road
- Cleveland Avenue and Elmore Avenue
- Cleveland Avenue and Cooke Road
- Cleveland Avenue and Ferris Road
- Cleveland Avenue and Plaza Entrance

Table 17 outlines how the impact of implementing the project on mobility will be measured.

Table 17: Connected Vehicle Environment Mobility Objective 2.2.1

Category	Description
Objective	Demonstrate DSRC technology for TSP application
Hypothesis	DSRC based TSP application will perform at the same level as Opticom-based TSP application.
Indicator	Time of priority request
Design of Experiment	Post-only Quasi-Experimental Design
Data Source	COTA CAD/automatic vehicle location (AVL) data; Operating System
Baseline Timeframe	N/A
Treatment Timeframe	Five months post-implementation (Winter 2020 to Spring 2021)

Source: City of Columbus

5.5.4.1.2 Indicators

The objective will be measured using the following indicators:

- Time of priority request.

The following data will be collected:

- Time of signal priority request by Opticom.
- Time of signal priority request by DSRC.

5.5.4.1.3 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

Upon the completion of the CV infrastructure deployment, the DSRC for TSP will also be installed and available for use on the BRT fleet of 15 vehicles along with the Opticom technology. COTA will operate the two systems in parallel. CV-equipped vehicles approaching on the mainline communicate with roadside equipment at intersections which are TSP-enabled, operating in parallel with the Opticom system and allowing priority requests to be made by the Transit Vehicle OBU without affecting signal operations.

RECOMMENDED DESIGN OF EXPERIMENT

DSRC based TSP will be part of the treatment group and Opticom-based TSP will be part of the control group. Since both the technologies will be on all the 15 vehicles, a random assignment is not applicable. Also, since the technologies will be compared only post-deployment, a post-only quasi-experiment is recommended.

5.5.4.1.4 Data Collection Plan

DATA SOURCE

Data will be available from both systems for the duration of the operational period, allowing for the evaluation of system performance. CAD and AVL systems together are used to manage real-time operations in the control center and on the bus. All data will be available for access from the Operating System. The CVE will provide signal priority data to the Operating System.

BASELINE TIMEFRAME

For the post-only quasi design of experiment, baseline data will not be collected.

TREATMENT TIMEFRAME

Treatment data will be collected for six-months following the implementation of the CVE.

5.5.4.1.5 Impact Evaluation Plan

The impact evaluation plan for the indicator is as follows:

The time of signal priority request at each of the intersection on each of the BRT runs will be collected as applicable from the CAD/AVL system for Opticom based TSP. Similarly, time of signal priority request at each of the intersection with RSUs on each of the BRT runs will be collected as applicable. The time of signal priority requests between the DSRC based TSP and Opticom-based TSP will be compared for the collected data to determine any statistical differences. It is anticipated that statistical difference does not exist between the time of signal requests between the two technologies.

5.5.4.2. FREIGHT SIGNAL PRIORITY

5.5.4.2.1 Reduce truck wait (delay) time at signalized intersections Objective 2.2.2

FSP technology uses V2I wireless communications to make the traffic signal system aware of trucks approaching properly equipped intersections. The system can then adjust signal phase timing as needed to assign priority to freight trucks, smoothing traffic flows for freight and reducing stop/start cycles and reducing emissions. Trucks are given priority where feasible and only if there is no other overriding priority, like an emergency vehicle.

Fourteen trucks are planned to be equipped with CV equipment to enabled FSP. Further, equipped trucks will broadcast BSM.

FSP-enabled intersections will exist at the following locations:

- London Groveport Road at Alum Creek Drive
- Alum Creek Drive at Spiegel Drive
- Alum Creek Drive at Rohr Road
- Alum Creek Drive at Global Court
- Alum Creek Drive at Toy Road
- Alum Creek Drive at Groveport Road

- I-270 East bound off ramp at Alum Creek Drive I-270 access road at Morse Road
- Morse Road at Appian Way
- Morse Road at Stygler Road

The above locations are owned by ODOT, City of Columbus, Franklin County, and the Village of Obetz. The information is subject to change based on finalization of the partner agreement. The *Connected Vehicle Environment Concept of Operations for the Smart Columbus Demonstration Program*[14] has additional detail on this application.

Table 18 outlines how the impact of implementing the project on mobility will be measured.

Table 18: Connected Vehicle Environment Mobility Objective 2.2.2

Category	Description
Objective	Reduce truck wait (delay) time at signalized intersections
Hypothesis	The FSP will save travel time for trucks passing through equipped intersections by modifying signal timing.
Indicator	Travel time through intersection
Design of Experiment	Pre/post Trend Analysis
Data Source	CVE data via Operating System
Baseline Timeframe	Two months following deployment before implementation (Fall 2020)
Treatment Timeframe	Five months post-implementation (Winter 2020 to Spring 2021)

Source: City of Columbus

5.5.4.2.2 Indicators

The objective will be measured using the following indicators:

- Travel time through intersection.

The following data will be collected:

- Travel time through the intersection (based on BSM data).
- Number of signal priority cycles granted (based on Signal Request Messages (SRM)/Signal Status Message (SSM) data).

5.5.4.2.3 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS

An existing system comparable to the FSP does not currently exist. However, baseline data will be collected for one month following deployment (without activating the application) to allow for a small period to assess baseline conditions.

[14] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Connected%20Vehicle%20Environment%20Concept%20of%20Operations.pdf

RECOMMENDED DESIGN OF EXPERIMENT

The systems evaluation approach will use the data collected to compare the travel time of trucks passing through intersections pre- and post-deployment of FSP. To assess baseline conditions, the equipment will be installed, but not activated at first. For two months, the equipment will collect data listed above. Then FSP will be activated and the same metrics will continue to be recorded for pre/post trend analysis. A Global Positioning System (GPS) geofence will facilitate the measurement of truck times through the corridor. An analysis of the number of signal priority cycles and a comparison of truck travel time (pre and post) will be used to determine a percent improvement in travel time. Since the number of instrumented vehicles will be minimal (only 10), any results comparing with any control group will be insignificant. Hence a pre/post trend analysis is recommended.

5.5.4.2.4 Data Collection Plan

DATA SOURCE

Data will be available from the CVE for the duration of the installation period, both before and after the activation of the application, allowing for the evaluation of system performance. A Global Positioning System (GPS) geofence will facilitate the measurement of truck times through the corridor. All data will be available for access from the Operating System.

BASELINE TIMEFRAME

For the first two months after deployment, CVE will capture all data produced by both vehicles traversing CV-equipped intersections as well as all data produced by infrastructure with intent to broadcast via the RSU. However, FSP will not be granted.

TREATMENT TIMEFRAME

The project will be evaluated seven months following deployment of the CVE, with the final five months implementing the treatment by enabling FSP.

5.5.4.2.5 Impact Evaluation Plan

The impact evaluation plan for the indicators are as follows:

Travel time through intersection: An analysis of the number of signal priority cycles and a comparison of truck travel time (pre and post) will be used to determine a percent improvement in travel time through intersection. Reduction in travel time through intersection is anticipated as the result of this project.

5.5.5. Project-Specific Confounding Factors

The following confounding factor might affect usage of the CVE:

- **COVID-19 Pandemic:** In March 2020, the State of Ohio implemented a stay-at-home order, travel restrictions and a state of emergency. While the stay-at-home order and travel restrictions were largely lifted at the end of May 2020, the State of Emergency remained in effect as of August 2020. Other potential restrictions or orders may be issued during the deployment period. The Columbus school district will move to online learning for the fall 2020 to spring 2021 session, however the parochial school is still planning in-person learning as of August 2020. Overall, traveler behavior and needs, travel patterns, traffic patterns, and school zone speed limit implementation have been or may be altered. Due to COVID-19, the deployment period was shortened due to delays in receiving the necessary equipment and travel restrictions which delayed system testing. As such, the private participant recruiting, and installations were similarly delayed. To account for reduced time for recruiting, the target number of private vehicles was reduced. Combined, these factors may impact analysis and findings by reducing the amount of data collected overall.

5.5.6. Project Costs

Approximate budget to design, build, and implement the project is $11 million, inclusive of vendor and ODC. Smart Columbus PMO and project management (PM)/systems engineering (SE) labor costs are tracked separately and not included in this project-specific amount. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation, testing, operations, and maintenance.

5.6. PROJECT 3: MULTIMODAL TRIP PLANNING APPLICATION

5.6.1. Introduction

Columbus residents and visitors do not have access to a system that allows for the seamless planning of or paying for a trip involving multiple transportation service providers. The Multimodal Trip Planning Application (MMTPA) – known as the application called Pivot - will make multimodal options easily accessible to all by providing a robust set of transit and alternative transportation options including routes, schedules, and dispatching possibilities. The application will allow travelers to request and view multiple trip itineraries and make reservations for shared-use transportation options such as public transit, bike-share, ride-hailing, and scooters. Using the MMTPA, users will be able to compare travel options across modes, plan and pay for their travel based upon current traffic conditions and availability of services. It is the City's goal that Pivot will allow residents to access the transportation systems more easily in Columbus today and in the future, so they can maximize services to live their best lives. This project is anticipated to provide an innovative solution to improve mobility and access to opportunity. The City of Columbus identified the following objectives to evaluate the measurable impact the MMTPA project is intended to have:

- Mobility – provide a single point of access to multimodal trip planning information to plan, book, and pay for a multimodal trip.
- Opportunity – facilitate access to jobs and services.
- Customer satisfaction – improve customer satisfaction.

Refer to the *Multi-Modal Trip Planning System Concept of Operations for the Smart Columbus Demonstration Program*[15] for project area, outcomes and objectives, and additional detail on this project.[16]

The following sections identify logic model, outcomes and objectives, hypotheses, indicators, data collection plan, and impact evaluation plan for this project.

[15] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Multi-Modal%20Trip%20Planning%20System%20Concept%20of%20Operations.pdf

[16] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Multi-Modal%20Trip%20Planning%20System%20Concept%20of%20Operations.pdf

5.6.2. Logic Model

Figure 15 shows the logic model identified for MMTPA project.

MULTIMODAL TRIP PLANNING APP

Outcomes	Objectives	Treatment	Hypothesis	Outcome Indicators
Mobility	Provide a single point of access to multimodal trip planning information to plan and book a multimodal trip	Implement MMTPA	The MMTPA will encourage travelers to take multimodal trips in central Ohio by providing a comprehensive multimodal planning/booking tool.	• Perceived improvement in access to multimodal trip planning
Opportunity	Facilitate access to jobs and services		The MMTPA will provide better access to jobs and services by enabling travelers to use mobility services that were previously either unavailable to them or of which they were unaware.	• Perceived ease of accessing jobs and services
Customer Satisfaction	Improve customer satisfaction		The MMTPA will improve customer satisfaction by providing a comprehensive multimodal planning/booking tool.	• Customer satisfaction ratings • MMTPA/CPS application ratings • Perceived ease of participating in a multimodal planning solution

Figure 15: Multimodal Trip Planning Application Performance Measurement Logic Model

Source: City of Columbus

The MMTPA project identified the following three outcomes:

1. Mobility
2. Opportunity
3. Customer satisfaction

5.6.3. Outcome 3.1: Mobility

Outcome 3.1 identified one objective: Provide a single point of access to multimodal trip planning information to plan, book, and pay for a multimodal trip.

5.6.3.1. OBJECTIVE 3.1.1: PROVIDE A SINGLE POINT OF ACCESS

Table 19 outlines the performance measurement methodology for this objective.

Table 19: Multimodal Trip Planning Mobility Objective 3.1.1

Category	Description
Objective	Provide a single point of access to multimodal trip planning information to plan and book a multimodal trip
Hypothesis	The MMTPA will encourage travelers to take multimodal trips in central Ohio by providing a comprehensive multimodal planning/booking tool.
Indicator	Perceived improvement in access to multimodal trip planning.
Design of Experiment	Pre/Post Quasi-Experimental Design
Data Source	Customer Surveys
Baseline Timeframe	Summer 2020
Treatment Timeframe	Fall 2020 to Spring 2021 (six months)

Source: City of Columbus

5.6.3.1.1 Indicators

The objective will be measured using the following indicator:

- Perceived improvement in access to multimodal trip planning.

The following data will be collected for analysis:

- Customer surveys (OSU survey and Pivot in-app survey).

The following data will be collected as a backup and not directly used for analysis:

- Number of trips booked through MMTPA.
- Trip date and time.
- Trip origin and destination.
- Number of trips involving one or more mode shift.

Surveys will be conducted to capture the insights of project participants. See **Appendix B** for sample questions and further details. This feedback will include information that will help MMTPA opportunity evaluations in **Chapter 5.6.4. Outcome 3.2: Opportunity** and **Chapter 5.6.5. Outcome 3.3: Customer Satisfaction**

5.6.3.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

An existing system comparable to the MMTPA does not exist to compare progress. However, survey questions (used both in the beta tester recruiting process and post-deployment) will inquire about pre-deployment travel behavior and tools that were used. This survey information will be used to assess baseline conditions.

RECOMMENDED DESIGN OF EXPERIMENT

Customer surveys will be administered to MMTPA user's post-deployment of MMTPA. Since there will not be a treatment or control group and no random assignment of travelers to a group, a pre/post quasi-experimental design is recommended.

5.6.3.1.3 Data Collection Plan

DATA SOURCES

For this objective, the project usage data and survey data will be collected. Surveys will be conducted throughout the project's deployment timeframe. Surveys will be conducted by OSU, while in-app surveys will be collected by the project team. For both efforts, aggregate results will be stored in the Operating System. All data will be available for access from the Operating System at the end of the demonstration. Refer to **Chapter 6** for more information.

BASELINE TIMEFRAME

For pre/post design of experiment, baseline data will be collected throughout the recruitment process during summer 2020 prior to the implementation.

TREATMENT TIMEFRAME

Treatment data will be collected until spring 2021 following the implementation of the MMTPA. Surveys will be conducted twice during the six-month demonstration period.

A six-month timeframe after implementation was chosen to provide travelers sufficient time to become informed, trained, and comfortable using technology while considering operational constraints.

5.6.3.1.4 Impact Evaluation Plan

The impact evaluation plan for the indicator is as follows:

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. For the quantitative questions, the value of measure will be collected. For the qualitative questions, the respondents will be asked to rate the qualitative measure in a scale developed as part of the survey. The average scale of the quality measure will be calculated for all the survey responders. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the deployment period, in two survey 'waves', wave 1 in summer 2020 and wave 2 in spring 2021.

Changes will be interpreted considering confounding factors such as COVID-19, which the OSU survey will inquire directly about. However, the specific effects of Pivot or any factor cannot be definitively identified.

5.6.4. Outcome 3.2: Opportunity

Outcome 3.2 identified one objective: Facilitate access to jobs and services.

5.6.4.1. OBJECTIVE 3.2.1: FACILITATE ACCESS TO JOBS AND SERVICES

Table 20 outlines the performance measurement methodology for this objective.

Table 20: Multimodal Trip Planning Opportunity Objective 3.2.1

Category	Description
Objective	Facilitate access to jobs and services
Hypothesis	The MMTPA will provide better access to jobs and services by enabling travelers to use mobility services that were previously either unavailable to them or of which they were unaware.
Indicator	Perceived ease of accessing jobs and services
Design of Experiment	Quasi-Experimental Design
Data Source	Resident Surveys
Baseline Timeframe	Summer 2020
Treatment Timeframe	Fall 2020 to Spring 2021 (six months)

Source: City of Columbus

5.6.4.1.1 Indicators

The objective will be measured using the following indicator:

- Perceived ease of accessing jobs and services.

The following data will be collected:

- Number of times MMTPA used.
- Percentage of travelers having tried new transportation mode to access jobs and services.
- Percentage of new transportation service users.
- Number of trips (single and multimode).
- Trips booked to and from job centers*.
- Perceived ease of accessing jobs and services.

*(*Job centers are defined as areas that have a dense number of points of interest. See Chapter 6 for the data sources that contain the job center locations.)*

Surveys will be conducted by OSU to capture the insights of Columbus residents who may or may not use MMTPA, while in-app surveys will be conducted by the project team to gauge overall satisfaction with the app. See **Appendix C** for sample questions and further details.

5.6.4.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

An existing system comparable to the MMTPA does not exist to compare progress. However, survey questions (used both in the recruiting process and post-deployment) will inquire about pre-deployment travel behavior and tools that were used. This survey information will be used to assess baseline conditions.

RECOMMENDED DESIGN OF EXPERIMENT.

OSU will conduct traditional surveys of Columbus residents who may or may not use MMTPA, while the MMTPA project team will collect in-app surveys from users. A quasi-experimental study design using a DiD model with propensity scoring will be used.

5.6.4.1.3 Data Collection Plan.

DATA SOURCES

Online resident surveys will be conducted by OSU and in-app surveys will be conducted by the City (MMTPA project team). OSU's results will be made available for the City and focus on access to jobs. In-app surveys will be the primary source for information regarding access to services.

All the other data related to this objective will be available through the Operating System. Refer to **Chapter 6** for additional information on specific data sources for each data.

BASELINE TIMEFRAME

For the pre/post design of experiment, baseline data will be collected throughout the recruitment process during the summer 2020 period prior to the implementation.

TREATMENT TIMEFRAME

Treatment data will be collected in fall 2020 through spring 2021 for six months following the implementation of the MMTPA. Surveys will be conducted in two waves.

A six-month timeframe after implementation was chosen to align with the MMTPA deployment timeframe while still providing travelers sufficient time to become informed, trained, and comfortable using technology while considering operational constraints.

5.6.4.1.4 Impact Evaluation Plan

The impact evaluation plan for the indicator is as follows:

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. For the quantitative questions, the value of measure will be developed to analyze results. The average scale of the quality measure will be calculated for all the survey responders. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the deployment period, via two surveys, wave 1 and wave 2.

Changes will be interpreted in light of confounding factors such as COVID-19, which the OSU survey will inquire directly about. However, the specific effects of Pivot or any factor cannot be definitively identified.

5.6.5. Outcome 3.3: Customer Satisfaction

Outcome 3.3 identified one objective: Improve customer satisfaction.

5.6.5.1. OBJECTIVE 3.3.1: IMPROVE CUSTOMER SATISFACTION

Table 21 outlines the performance measurement methodology for this objective.

Table 21: Multimodal Trip Planning Customer Satisfaction Objective 3.3.1

Category	Description		
Objective	Improve customer satisfaction		
Hypothesis	The MMTPA will improve customer satisfaction by providing a comprehensive multimodal planning and booking tool.		
Indicator	Customer satisfaction ratings	MMTPA application ratings	Perceived ease of participating in a multimodal planning solution
Design of Experiment	Quasi-Experimental Design	Post-only Trend Analysis	Quasi-Experimental Design
Data Sources	Resident Surveys Mobility Provider Interviews	MMTPA Application Analytics	Customer (In-App) Surveys
Baseline Timeframe	Summer 2020	N/A	Summer 2020
Treatment Timeframe	Fall 2020 to Spring 2021 (six months)		

Source: City of Columbus

5.6.5.1.1 Indicators

The objective will be measured using the following indicators:

- Customer satisfaction ratings.
- MMTPA application ratings.
- Perceived ease of participating in a multimodal planning solution.

The following data will be collected:

- Resident survey (OSU's online survey).
  - Perceived ease of participating in a multimodal planning solution.
- Mobility provider interviews (by City).
- MMTPA application ratings (Project team's in-app survey).
- MMTPA application comments (Project team's in-app survey).
- Application usage:
  - Trips explored
  - Trips booked
  - Profiles created
  - Frequency of booked trips
  - Retention - how long are they using the app

The customer survey will be delivered through MMTPA, and will request feedback on the MMTPA, including:

- Examples of opportunities opened by MMTPA (i.e. places that were previously difficult to reach, or ability to reach goods or services).
- Positive and negative experiences.
- Suggestions for improvement.
- Payment methods available to the traveler.

The in-app customer survey will also request feedback on the quality of users' experiences. The survey (for MMTPA) is described in earlier in **Chapter 5.6.3**. If the MMTPA is easy to use and does not lead to issues or delays, users will be more likely to continue or expand their usage.

Mobility provider interviews will be conducted by the City to assess how the mobility providers feel as a customer to the system. Feedback solicited will include:

- Change in ridership since implementation.
- Change in route or service popularity.
- Positive and negative experiences.
- Suggestions for improvements.

Resident surveys performed by OSU will be conducted to capture the insights of all travelers, who may or may not use MMTPA. See **Appendix C** for sample questions and further details. Data from the Operating System, where the MMTPA trip data will be housed, will also be used for assessment to provide context to the survey results.

5.6.5.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

An existing system comparable to the MMTPA does not exist to compare progress. However, survey questions (used both in the recruiting process and post-deployment) will inquire about pre-deployment travel behavior and tools that were used. This survey information will be used to assess baseline conditions.

RECOMMENDED DESIGN OF EXPERIMENT

Resident surveys performed by OSU will be administered during pre- and post-deployment of MMTPA. A quasi-experimental study design using a DiD model with propensity scoring will be used to analyze results. For the mobility provider interviews, in-app surveys and the MMTPA application analytics and ratings, the control group does not exist. Also, feedback will be provided only post-implementation. Therefore, a post-only trend analysis is recommended.

5.6.5.1.3 Data Collection Plan

DATA SOURCES

Online resident surveys will be conducted by OSU and in-app surveys and mobility provider interviews will be conducted by the City and MMTPA project team. The results will be made available for the City. App user surveys will be conducted on the MMTPA app. MMTPA user ratings and comments will come from the MMTPA app.

All the other data related to MMTPA will be available through the Operating System. Refer to **Chapter 6** for additional information on specific data sources for each data.

BASELINE TIMEFRAME

For the pre/post design of experiment, baseline data will be collected throughout the recruitment process in the summer 2020 period prior to the implementation.

For the post only design of experiment, baseline data will not be collected.

TREATMENT TIMEFRAME

Treatment data will be collected throughout the deployment period, from fall 2020 through spring 2021. Survey/interviews will be conducted twice during this period, in two waves: wave 1 in fall 2020 and wave 2 in spring 2021.

A six-month timeframe after implementation was chosen to align with the project's development schedule and to provide travelers sufficient time to become informed, trained, and comfortable using technology while considering operational constraints

5.6.5.2. IMPACT EVALUATION PLAN

The impact evaluation plan for the indicators is as follows:

For the surveys and interview, the questions will be categorized as quantitative questions, qualitative questions, and informational collection. For the quantitative questions, the value of measure will be determined and applied. This scale and the average scale of the quality measure will be calculated for all the survey responders. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the year over the deployment period.

Changes will be interpreted considering confounding factors such as COVID-19, which the OSU survey will inquire directly about. However, the specific effects of Pivot or any factor cannot be definitively identified.

For the application ratings, the ratings will be collected throughout the demonstration period. These ratings will be evaluated to assess the satisfaction of customers with the trips planned, booked or paid for through MMTPA, as well as the applications functions and features; this evaluation will be ongoing throughout the deployment period. The application ratings, and feedback, will be used to identify and prioritize enhancements to the MMTPA features. This will be an iterative process until the end of the treatment timeframe.

5.6.6. Project-Specific Confounding Factors

The following confounding factors might affect the usage of MMTPA:

- **CPASS Program:**[17] Mid-Ohio Regional Planning Commission (MORPC) and COTA launched a mobility project on June 1, 2018, through which eligible downtown employees can get unlimited COTA bus access at no cost. This program is planned to continue until December 31, 2020 but is subject to potential extension. This program is expected to increase the ridership of COTA by a significant margin. Similarly, at the end of the program, there might a considerable drop in the transit ridership. The evaluators will consider the ridership counts of CPASS subscribers to account for any changes in the ridership and to differentiate between the changes in ridership MMTPA and other mobility projects produce.

[17] https://www.cota.com/cpass/

- **SMH and CEAV:** With the implementation of SMHs, especially those located close to residential neighborhoods, nearby residents and travelers who have FMLM transportation offered by CEAV program would be encouraged to adopt to MMTPA for their travel. Evaluators will be assessing the impacts of these two projects on ridership trends, specifically at the locations where SMHs and CEAV are present.
- **EPM:** Patrons who use EPM application may find a convenient parking spot away from the destination and may use MMTPA to get to their destination. Evaluators will be assessing the impacts of these two projects on the usage trends.
- **Changes in Mobility Providers:** Any changes in the mobility provider (addition or removal) during the treatment timeframe may impact the traveler planning and payment decisions. Evaluators will be assessing the impacts of the changes in mobility providers during the evaluation.
- **Changes in COTA Services:** Any changes in COTA's services during the treatment timeframe may impact the traveler planning and payment decision. Evaluators will assess the impacts of any changes in COTA's services during the evaluation. This factor is directly linked to the COVID-19 pandemic, since, as a result of this pandemic, COTA stopped collecting fares. In addition, as the pandemic continued, COTA's commitment to the MMTPA project changed, with COTA unable to support the project as future owner due to the financial impacts on their organization as a result of fare collection and ridership reduction.
- **Changes to MMTPA Application Features:** Any feature changes in MMTPA application during the treatment timeframe may impact the usage of MMTPA. Evaluators will assess the impacts of any changes to the application during the evaluation.
- **COVID-19 Pandemic:** In March 2020, the State of Ohio implemented a stay-at-home order, travel restrictions and a state of emergency. While the stay-at-home order and travel restrictions were largely lifted at the end of May 2020, the State of Emergency remained in effect as of August 2020. As a result, traveler behavior and needs, travel patterns, transit offerings have been altered, potentially impacting analysis and findings. As COTA's service changed as result of the pandemic (eliminating fare collection and having to drop out as future owner), the City ultimately decided to alter the payment portion of the project, eliminating the creation of a common account/payment system and instead deep linking with mobility providers to enable trip booking and payment. Deep linking directs the user to the mobility provider's mobile application to complete the payment transaction.

5.6.7. Project Costs

Approximate budget to design, build, and implement the project is $1.2 million, inclusive of vendor costs. Smart Columbus PMO and PM/SE labor costs are tracked separately and not included in this project-specific amount. The Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation, testing, operations, and maintenance.

5.7. PROJECT 4: MOBILITY ASSISTANCE FOR PERSONS WITH COGNITIVE DISABILITIES

5.7.1. Introduction

Mobility assistance is needed to provide more independence to residents with cognitive disabilities. Persons with cognitive disabilities who wish to independently use public transit services in Columbus must either qualify for special paratransit services in accordance with federal law or they must be sufficiently independent such that they are able to safely use the fixed-route bus service without assistance. The City's goal is to procure and deploy a mobile application that would allow this population to traverse the city via COTA's fixed-route bus system either independently or with the help of a caregiver. The application will include step-by-step visual and audio instructions designed to be sufficiently intuitive such that older adults and groups with cognitive disabilities, including the visually impaired, can travel independently.

This project provides an opportunity for users to empower themselves and gain mobility independence without having to rely on more expensive paratransit services for travel. The City of Columbus identified the following objectives to evaluate the measurable impact. The mobility assistance project is intended to:

- Improve access and use of COTA fixed-route bus service for MAPCD participants.
- Improve independence of travelers with cognitive disabilities by using fixed-route bus service.
- Reduce COTA expenditures.

Refer to the *Mobility Assistance for People with Cognitive Disabilities (MAPCD) Trade Study for the Smart Columbus Demonstration Program* for the project area, outcomes and objectives and additional detail for this project.[18]

The following sections identify logic model, outcomes and objectives, hypotheses, indicators, data collection plan, and impact evaluation plan for this project.

[18] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Mobility%20Assistance%20for%20People%20with%20Cognitive%20Disabilities%20Trade%20Study.pdf

5.7.2. Logic Model

The following logic model is identified for this project.

Outcomes	Objectives	Treatment	Hypothesis	Outcome Indicators
Mobility	Improved access and use of COTA fixed route bus service for MAPCD participants	Implement MAPCD Project	The MAPCD application will allow MAPCD participants who use paratransit service or don't feel confident to use fixed-route bus service by providing navigation directions to, during, and from trips involving use of fixed-route bus service.	• Customer trips moved from paratransit to fixed route • Overall numbers of trips taken • Perceived independence • Ease of use
Opportunity	Improve independence of MAPCD participants by using fixed-route service		The MAPCD application will allow MAPCD participants to use fixed-route service to feel a greater sense of independence by providing navigation directions to, during, and from trips involving use of fixed-route bus service.	• Perceived independence • MAPCD Participant and Caregiver experience
Agency Efficiency	Reduce COTA expenditures		The MAPCD application will reduce COTA operating expenses by moving passengers from paratransit service to fixed-route bus service.	• Dollars saved in paratransit program

Figure 16: Mobility Assistance for Persons with Cognitive Disability Performance Measurement Logic Model

Source: City of Columbus

The MAPCD project identified the following three outcomes:

1. Mobility
2. Opportunity
3. Agency efficiency

5.7.3. Outcome 4.1: Mobility

Outcome 4.1 identified one objective: Improve access and use of COTA fixed-route bus service for MAPCD Participants.

5.7.3.1. OBJECTIVE 4.1.1: IMPROVE ACCESS AND USE OF COTA FIXED-ROUTE BUS SERVICE FOR MOBILITY ASSISTANCE FOR PERSONS WITH COGNITIVE DISABILITY PARTICIPANTS

Table 22 outlines the performance measurement methodology for this objective.

Table 22: Mobility Assistance for Persons with Cognitive Disability Mobility Objective 4.1.1

Category	Description		
Objective	Improved access and use of COTA fixed route bus service for MAPCD participants		
Hypothesis	The MAPCD application will allow MAPCD participants who use paratransit service or don't feel confident to use fixed-route bus service by providing navigation directions to, during, and from trips involving use of fixed-route bus service.		
Indicator	Customer trips moved from paratransit to fixed route; Overall number of trips taken	Perceived independence	Ease of use
Design of Experiment	Pre/Post Trend Analysis	Post-only Trend Analysis	Post-only Trend Analysis
Data Source	COTA, MAPCD Vendor, Operating System	MAPCD Participant and Caregiver Survey	MAPCD Participant and Caregiver Survey
Baseline Timeframe	One-year pre-implementation (April 29, 2018 to April 28, 2019)	N/A	N/A
Treatment Timeframe	One-year post-implementation (April 29, 2019 to April 28, 2020)		

Source: City of Columbus

5.7.3.1.1 Indicators

The objective will be measured using the following indicators:

- Customer trips moved from paratransit to fixed route; Overall numbers of trips taken.
- Perceived independence.

- Ease of use.

The following data will be collected:

- Number of paratransit rides.
- Number of COTA ridership on fixed-route by demonstration participants using MAPCD vendor.
- Trip selection (route, date/time).
- On trip performance (on/off route, mode, stuck).
- Help button usage.
- Perceived independence.
- Ease of use.
- Physical layer (Global Positioning System (GPS) accuracy, battery charge, cellular network coverage).

Customer trips moved from paratransit to fixed route will be measured two ways. Some participants are currently COTA paratransit users and have a pass. The pass activity can be monitored for the ride type. Alternatively, for users without a pass or aren't currently a COTA paratransit user, the activity can be monitored through customer surveys.

Although the feeling of perceived independence and ease of use indicators might not typically be used as indicators for similar objectives, these are important indicators to show that the app is positively affecting riders with cognitive disabilities. Due to the nature of certain cognitive disabilities, something as simple as perceived independence could greatly impact the rider's quality of life. Specifically, self-confidence in the ability to not get lost is a safety issue because negative experiences on board the COTA buses could result in the rider accidently hurting themselves or others. Therefore, by improving their feeling of independence, users with cognitive disabilities could have improved mobility using MAPCD.

Surveys will be conducted to capture the insights of project participants. See **Appendix C** for sample questions and further details.

5.7.3.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

Several people with cognitive disabilities primarily use COTA's mainstream (paratransit) service for mobility in the City. COTA tracks the number of people who use the paratransit service and the cost of the paratransit service. It is anticipated that many of these people who currently use the paratransit service will be encouraged to use the fixed-route service.

RECOMMENDED DESIGN OF EXPERIMENT

The indicators for customer trips moved from paratransit to fixed route will be assessed via pre-post trend analysis for those travelers who used COTA paratransit prior to the demonstration.

For the other indicators, MAPCD participants and/or their caregiver will be part of the treatment group. Since the registration is voluntary and there is no control group, only a non-experimental design is possible, which will assess participant travel experience after system implementation. Therefore, a post-only trend analysis is recommended for the other indicators.

5.7.3.1.3 Data Collection Plan

DATA SOURCES

The following data sources are identified for the data to be collected:

- COTA, OSU, and other agencies will recruit participants with cognitive disabilities who use paratransit services for both pre- and post-implementation.
- COTA will provide COTA and paratransit ridership data.

The MAPCD vendor will provide the following information directly to the Operating System for post-implementation only:

- Trip selection (route data/time); On trip performance; Help button usage; Physical layer.
- Perceived independence and ease of use will be collected through survey for both pre- and post-implementation. Survey will be conducted quarterly for the one-year timeframe post-implementation. A draft list of survey questions is identified in the **Appendix C**.
- All the other data related to this objective will be available through the Operating System. Refer to Data Collection Plan **Chapter 6** for additional information on specific data sources for each data.

BASELINE TIMEFRAME

For post-only trend analysis, a baseline timeframe is not applicable for the indicators of this objective. For pre-post trend analysis, COTA paratransit ridership will be collected and reviewed.

TREATMENT TIMEFRAME

The project will be evaluated one year following the implementation of the MAPCD project. A one-year timeframe after implementation was chosen to provide travelers sufficient time to become informed, trained, and comfortable using technology.

5.7.3.1.4 Impact Evaluation Plan

The impact evaluation plan for the indicators are as follows:

For the customer trips moved from paratransit to fixed route and overall numbers of trips taken, the data will be collected and aggregated monthly and compared month-over-month to track the trend. If the trend shows an increase in the indicator, it can be attributed to this objective. The MAPCD participant's COTA fixed-route service use is anticipated to increase with a corresponding decrease in paratransit services.

For the survey (perceived independence and ease of use), the questions will be categorized as quantitative questions, qualitative questions, and information collection. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked during the deployment period. The survey data collected will be compared over the previous surveys to track the indicator for both the treatment and the control groups.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level and project level confounding factors, if any, it can be attributed to the project. Supplemental data may be collected and analyzed to support the conclusion.

5.7.4. Outcome 4.2: Opportunity

Outcome 4.2 identified one objective: Improved independence.

5.7.4.1. OBJECTIVE 4.2.1: IMPROVED INDEPENDENCE

Table 23 outlines the performance measurement methodology for this objective.

Table 23: Mobility Assistance for Persons with Cognitive Disability Opportunity Objective 4.2.1

Category	Description	
Objective	Improve independence of MAPCD participants by using fixed-route service	
Hypothesis	The MAPCD application will allow MAPCD participants to use fixed-route service to feel a greater sense of independence by providing navigation directions to, during, and from trips involving use of fixed-route bus service.	
Indicator	Perceived independence	MAPCD Participant and Caregiver experience
Design of Experiment	Post-only Trend Analysis	Post-only Trend Analysis
Data Sources	MAPCD Participant and Caregiver Survey	MAPCD Participant and Caregiver Survey
Baseline Timeframe	N/A	N/A
Treatment Timeframe	One-year post-implementation (April 29, 2019 to April 28, 2020)	

Source: City of Columbus

5.7.4.1.1 Indicators

The following indicators will measure the objective:

- Perceived independence.
- MAPCD participant and caregiver experience.

The following data will be collected via survey:

- Perceived independence.
- MAPCD participant and caregiver experience.

Qualitative data about travelers' experience on the trips will paint the picture of how mobility assistance supports travelers' independence. Frequent use of the mobility assistance application will show that the technology is beneficial, but only if trips are completed successfully.

The caregiver survey aims to fill in gaps where the traveler is unable to respond. The survey will be administered quarterly after adequate time to assess changes in travel behavior and experiences using the application. Surveys will be provided directly to the MAPCD participants and caregivers through email or mail. See **Appendix B** for sample questions and further details.

5.7.4.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

Several people with cognitive disabilities use paratransit service as their primary mode of transportation. It is anticipated that many of these people who currently uses the paratransit service will be encouraged to use the fixed-route service.

RECOMMENDED DESIGN OF EXPERIMENT

For the survey, since the perceived independence and participant and caregiver survey are only applicable for MAPCD participants post-implementation, a post-only trend analysis is recommended.

5.7.4.1.3 Data Collection Plan

DATA SOURCES

The following source is identified for the data to be collected:

- Perceived independence and MAPCD participant and caregiver experiences will be collected through surveys post-implementation only. Surveys will be conducted throughout the deployment period and at the conclusion of the deployment.

BASELINE TIMEFRAME

Because a post-only design of experiment is recommended, a baseline timeframe is not applicable for the indicators of this objective.

TREATMENT TIMEFRAME

Treatment data will be collected for one-year following the implementation of the MAPCD. Survey will be conducted throughout the deployment period and at the conclusion of the deployment.

A one-year timeframe after implementation was chosen to provide travelers and caregivers sufficient time to become informed, trained, and comfortable using technology.

5.7.4.1.4 Impact Evaluation Plan

The impact evaluation plan for the indicators are as follows:

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the deployment period. The survey data collected will be compared over the previous surveys to track the indicator for the treatment group.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level and project level confounding factors, if any, it can be attributed to the project. Supplemental data may be collected and analyzed to support the conclusion.

5.7.5. Outcome 4.3: Agency Efficiency

Outcome 4.3 identified one objective: Reduce COTA expenditures.

5.7.5.1. OBJECTIVE 4.3.1: REDUCE COTA EXPENDITURES

Table 24 outlines the performance measurement methodology for this objective.

Table 24: Mobility Assistance for Persons with Cognitive Disability Agency Efficiency Objective 4.3.1

Category	Description
Objective	Reduce COTA expenditures
Hypothesis	The MAPCD application will reduce COTA operating expenses by moving passengers from paratransit service to fixed-route bus service.
Indicator	Dollars saved in paratransit program
Design of experiment	Pre/post Trend Analysis
Data Sources	COTA MAPCD Vendor
Baseline Timeframe	One-year pre-implementation (April 29, 2018 to April 28, 2019)
Treatment Timeframe	One-year post-implementation (April 29, 2019 to April 28, 2020)

Source: City of Columbus

5.7.5.1.1 Indicators

The objective will be measured using the following indicator:

- Dollars saved in paratransit program.

The following data will be collected:

- Paratransit cost.
- Number of paratransit rides made by pilot participants the year before implementation.
- Cost of MAPCD vendor to COTA per ride.
- Number of rides through MAPCD vendor.

The MAPCD will allow COTA to cost-effectively provide better service to former paratransit users. COTA will provide their operating expenses and the number of paratransit users, as well as the number of qualifying paratransit users that are now using fixed-route service.

5.7.5.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

Several people with cognitive disabilities use paratransit service as their primary mode of transportation. It is anticipated that many of these people currently using the paratransit service will be encouraged to use the fixed-route service.

RECOMMENDED DESIGN OF EXPERIMENT

MAPCD participants will be part of the treatment group. Because the registration is voluntary, and there is no control group, only a nonexperimental design is possible. Also, COTA paratransit trip and cost information will be collected both before and after the implementation. A pre-/post-implementation trend analysis is recommended for this project.

5.7.5.1.3 Data Collection Plan

DATA SOURCES

The following sources are identified for the data to be collected:

- COTA will provide number and cost of paratransit rides for MAPCD participants for both pre- and post-implementation.
- MAPCD vendor will provide number of trips assisted by MAPCD vendor for post-implementation.

All the data related to this objective will be available through the Operating System. Refer to Chapter 6 for additional information on specific data sources for each data

BASELINE TIMEFRAME

Baseline data for number and cost of paratransit trips for registered MAPCD participants will be collected during the one-year period prior to deployment.

TREATMENT TIMEFRAME

Treatment data will be collected for one-year following the implementation of the MAPCD.

A one-year timeframe after implementation was chosen to provide travelers sufficient time to become informed, trained, and comfortable using technology.

5.7.5.1.4 Impact Evaluation Plan

The following assessments will comprise the impact evaluation plan for the indicator:

The total cost per registered MAPCD participant for pre- and post-implementation will be calculated and aggregated monthly and compared month-over-month to track the trend. If the trend shows an increase in the indicator, it can be attributed to this objective. The total cost is calculated as the total number of trips multiplied by the per cost trip.

5.7.6. Project Specific Confounding Factors

The following confounding factors might affect the usage of MAPCD:

- **Changes to MAPCD Application Features:** Any feature changes in MAPCD application during the treatment timeframe may impact the usage of MAPCD. Evaluators will assess the impacts of any changes to the application during the evaluation.
- **COVID-19 Pandemic:** In March 2020, the State of Ohio implemented a stay-at-home order, travel restrictions and a state of emergency. While the stay-at-home order and travel restrictions were largely lifted at the end of May 2020, the State of Emergency remained in effect as of August 2020. As a result, traveler behavior and needs, travel patterns, transit offerings have been altered, potentially impacting analysis and findings. The MAPCD project was nearly complete as the state issued its orders. Therefore, the date of these orders can be used to flag potential changes in indicators during the final two months of the deployment.

5.7.7. Project Costs

Approximate budget to design, build, and implement the project is $333,000, inclusive of vendor and ODC. Smart Columbus PMO and PM/SE labor costs are tracked separately and not included in this project-specific amount. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation, testing, operations, and maintenance.

5.8. PROJECT 5: PRENATAL TRIP ASSISTANCE

5.8.1. Introduction

The Smart Columbus PTA project will focus on one of the factors that can impact preterm birth: transportation. The PTA project will enhance mobility and increase opportunity, efficiency and customer satisfaction for prenatal travelers who use Non-Emergency Medical Transportation (NEMT) provided through Medicaid benefits. PTA will provide sources of high-quality data for the Ohio Department of Medicaid (ODM), managed-care organizations (MCOs), and others involved in tracking the prenatal care of Columbus Medicaid recipients.

Many NEMT services exist, but the lack of patient-centered technology and service has created gaps for certain prenatal travelers. The PTA project would provide the following improvements to fill these gaps for prenatal travelers:

- Reliable transportation to and from medical appointments.
- Access to on-demand transportation.
- Knowledge of real-time driver location and arrival time.
- Enhanced capabilities for patients to schedule NEMT trips.
- Increased communications between NEMT mobility provider, patient, and doctor.

The City of Columbus identified the following objectives to evaluate the measurable impact that the PTA project is intended to provide:

- Examine pregnant women's improved access to NEMT trip in those assigned to PTA project compared to those assigned to usual transportation services.
- Increase usage of the NEMT benefits.
- Improve customer satisfaction.

Refer to the *Prenatal Trip Assistance Concept of Operations for the Smart Columbus Demonstration Program*[19] for project area, outcomes and objectives, and additional detail on this project.

The following sections identify logic model, outcomes and objectives, hypotheses, indicators, data collection plan, and impact evaluation plan for this project.

[19] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Prenatal%20Trip%20Assistance%20Concept%20of%20Operations.pdf

5.8.2. Logic Model

Figure 17 shows the logic model identified for the PTA project.

Outcomes	Objectives	Treatment	Hypothesis	Outcome Indicators
Mobility	Examine pregnant women's improved access to NEMT trip in those assigned to PTA project compared to those assigned to usual transportation services. (Key secondary outcomes include prenatal visit adherence and the rate of preterm delivery in each group.)	Implementation of PTA System	Women in the intervention group (assigned to PTA project) will be more likely to be satisfied with the transportation services than women in the "usual care" group, and they will also have increased prenatal trip adherence and a lower rate of preterm delivery.	• Number of NEMT trips taken (by type, purpose)* • Adequacy of prenatal care Kotelchuck Index
Opportunity	Increase usage of NEMT benefits		Women in the intervention group will take more NEMT trips than women in the "usual care" group.	• Number of trips taken (by type, purpose)*
Customer Satisfaction	Improve customer satisfaction		The PTA will increase customer satisfaction by providing an on-demand mobile and web-based application to schedule NEMT services, as well as on-demand transportation services.	• Customer satisfaction rating

** Collected by type (web, phone, call center) & purpose (medical appts, pharmacy, food bank, grocery store, pregnancy support program, hospital)*

Figure 17: Prenatal Trip Assistance Performance Measurement Logic Model

Source: City of Columbus

The PTA project identified the following three outcomes:

1. Mobility
2. Opportunity
3. Customer satisfaction

5.8.3. Outcome 5.1: Mobility

Outcome 5.1 identified the following three outcomes:

1. Mobility
2. Opportunity
3. Agency efficiency

5.8.3.1. OBJECTIVE 5.1.1: EXAMINE PREGNANT WOMEN'S IMPROVED ACCESS TO NEMT TRIP

Table 25 outlines the performance measurement methodology for this objective.

Table 25: Prenatal Trip Assistance Mobility Objective 5.1.1

Category	Description	
Objective	Examine pregnant women's improved access to NEMT trip in those assigned to PTA project compared to those assigned to usual transportation services. (Key secondary outcomes include prenatal visit adherence and the rate of preterm delivery in each group.)	
Hypothesis	Women in the intervention group (assigned to PTA project) will be more likely to be satisfied with the transportation services than women in the "usual care" group, and they will also have increased prenatal trip adherence and a lower rate of preterm delivery.	
Indicator	Number of NEMT trips taken (by type, purpose)	Adequacy of prenatal care Kotelchuck Index
Design of Experiment	Post-only Randomized Experiment	Post-only Randomized Experiment
Data Sources	• PTA Vendor • MCOs	• ODH (Birth record) • Customer Survey
Baseline Timeframe	N/A	
Treatment Timeframe	Throughout pregnancy to eight weeks after delivery. Note that passive follow up of infant mortality will continue through one year after birth although treatment timeframe will have concluded.	

Source: City of Columbus

5.8.3.1.1 Indicators

The following indicators will measure the objective:

- Number of NEMT trips taken by type and purpose: It includes the number of trips taken by provider type and by various purpose including medical appointments, pharmacy, food bank, grocery store, pregnancy support program, and hospital.
- Adequacy of prenatal care Kotelchuck Index: It is calculated as the total number of prenatal appointments attended over the total number of appointments expected.

The following data will be collected:

- Number of NEMT trips taken (by type and purpose).
- Gestational age when woman learned she was pregnant.
- Gestation week of first prenatal appointment.
- Number of prenatal appointments attended.
- Gestational age at delivery.
- Satisfaction with transportation.

In addition to the above data, preterm births (as a contributor to infant mortality) will be an additional indicator of the impact of transportation. Preterm birth, any birth before 37 weeks gestation, will be measured from the birth record. While the rate of infant mortality is high in Columbus, this outcome is still quite rare. The City does not expect to have enough statistical power to detect differences in infant mortality given the modest size of this pilot. However, OSU will be tracking infant mortality to evaluate the work in the context of the community's ongoing infant mortality efforts.

Surveys will be conducted to capture the insights of project participants. See **Appendix C** for sample questions and further details.

5.8.3.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

Medical benefits for NEMT trips currently exist for eligible prenatal travelers through Medicaid MCO programs. The following data for baseline conditions will be collected from 2017 vital statistics data:

- Birth data.
- Period linked birth – infant death data.
- Birth cohort linked birth – infant death data.
- Mortality multiple cause data.
- Fetal death data.

The following data for baseline conditions will be collected from vital records in the targeted ZIP codes:

- Average number of appointments recommended for pregnant women.
- Average number of appointments attended by pregnant women.

RECOMMENDED DESIGN OF EXPERIMENT

The intervention group includes the pregnant women who are registered for the PTA pilot project and are randomly assigned to receive NEMT services through the PTA vendor. The "usual care" group includes the

pregnant women who are registered for the PTA pilot project but will continue to receive their MCO benefits from the MCO's transportation broker.[20]

Refer to the *Prenatal Trip Assistance Concept of Operations for the Smart Columbus Demonstration Program* for the pregnant woman selection and registration process for the PTA project.[21] Because the selection is randomized, a post-only randomized experiment is the best-case scenario for these indicators. Given the numerous initiatives in Franklin County aimed at reducing poor birth outcomes, a post-only randomized experiment is a preferred design to one of repeated cross-sections.

5.8.3.1.3 Data Collection Plan

DATA SOURCES

The total number of NEMT trips (by type and purpose) of both treatment and control pregnant women within the project area during the demonstration period will be obtained from the PTA Vendor and stored in the Operating System.

Additional data will be collected from the MCOs to identify the number of required prenatal appointments, the number of attended prenatal appointments, and gestational age at delivery. In addition, a survey will be conducted with all the prenatal pilot (both the control and treatment groups) participants to identify the number of appointments made by type and purpose.

BASELINE TIMEFRAME

Because a post-only randomized trial is recommended, a baseline timeframe is not applicable for the indicators of this objective.

TREATMENT TIMEFRAME

The treatment exposure will initiate at the time of randomization through eight weeks postpartum. Passive follow up of infant mortality will continue through one year after birth.

5.8.3.1.4 Impact Evaluation Plan

The following assessments will comprise the impact evaluation plan for the indicators:

Number of trips taken (by type and purpose): The increase in total number of NEMT trips taken by prenatal pilot participants in the treatment group during the pilot period will be compared to the number of trips taken by those in the control group to determine the effectiveness of the PTA system. It is expected that the treatment group will take more NEMT trips using the PTA system. The PTA project is expected to increase the number of NEMT trips and attended appointments for the treatment group.

The Kotelchuck Index (ratio of attended prenatal appointments to the recommended number): See **Appendix J** for a draft evaluation plan developed by OSU.

[20] *For PTA study purposes, the treatment group is called the "exposed" group and the control group is called the "unexposed" group.*

[21] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Prenatal%20Trip%20Assistance%20Concept%20of%20Operations.pdf

5.8.4. Outcome 5.2: Opportunity

Outcome 5.2 identified one objective: Increase use of NEMT benefits.

5.8.4.1. OBJECTIVE 5.2.1: INCREASE USAGE OF NEMT BENEFITS

Table 26 outlines the performance measurement methodology for this objective.

Table 26: Prenatal Trip Assistance Opportunity Objective 5.2.1

Category	Description
Objective	Increase usage of NEMT benefits
Hypothesis	Women in the intervention group will take more NEMT trips than women in the "usual care" group.
Indicator	Number of NEMT trips taken (by type and purpose)
Design of Experiment	Post-only Randomized Experiment
Data Sources	• PTA Vendor • MCOs
Baseline Timeframe	N/A
Treatment Timeframe	Throughout pregnancy to eight weeks after delivery. Note that passive follow up of infant mortality will continue through one year after birth although treatment timeframe will have concluded.

Source: City of Columbus

5.8.4.1.1 Indicators

The following indicator will measure the objective:

- Number of trips taken to different destinations (by type, purpose) during the pilot period.

The following data will be collected:

- Number of trips taken (by type and purpose) during the pilot period.

5.8.4.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

Medical benefits for NEMT trips currently exist for eligible prenatal travelers through the Medicaid MCO programs.

RECOMMENDED DESIGN OF EXPERIMENT

The intervention group includes the pregnant women who are registered for the PTA pilot project and will receive NEMT services through the PTA vendor and the "usual care" group includes the pregnant women

who are registered for the PTA pilot project who will continue to receive their MCO benefits from the MCO's transportation broker.[22]

Refer to the *Prenatal Trip Assistance Concept of Operations for the Smart Columbus Demonstration Program* for the pilot participant selection and registration process for the PTA project.[23] The comparison in the number of NEMT trips between enhanced NEMT transportation and usual NEMT transportation will be compared between these randomized treatment groups. An individual will be eligible to participate only once during the pilot project. Therefore, a post-only randomized experiment is recommended for this indicator.

5.8.4.1.3 Data Collection Plan

DATA SOURCES

The total number of NEMT trips (by type and purpose) of both the treatment (exposed) and control (unexposed) groups during the pilot period will be obtained from the PTA vendor and MCOs and stored in the Operating System.

In addition, a survey will be conducted with all pilot participants (both the control and treatment groups) to identify the number of appointments made by type and purpose.

BASELINE TIMEFRAME

Because a post-only randomized trial is recommended, a baseline timeframe is not applicable for the indicators of this objective.

TREATMENT TIMEFRAME

The treatment exposure will initiate at the time of randomization through eight weeks postpartum. Passive follow up of infant mortality will continue through one year after birth.

5.8.4.1.4 Impact Evaluation Plan

The impact evaluation plan for the indicators are as follows:

Number of trips taken (by type and purpose): The total number of NEMT trips (by type and purpose) taken by treatment pilot participants during the pilot period will be compared to the number of NEMT trips taken by the control group to determine the effectiveness of the PTA system. It is expected that the treatment group will take more NEMT trips using the PTA system.

5.8.5. Outcome 5.3: Customer Satisfaction

5.8.5.1. OBJECTIVE 5.3.1: IMPROVE CUSTOMER SATISFACTION

Table 27 outlines the performance measurement methodology for this objective.

[22] *For PTA study purposes, the treatment group is called the "exposed" group and the control group is called the "unexposed group."*

[23] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Prenatal%20Trip%20Assistance%20Concept%20of%20Operations.pdf

Table 27: Prenatal Trip Assistance Customer Satisfaction Objective 5.3.1

Category	Description
Objective	Improve customer satisfaction
Hypothesis	The PTA will increase customer satisfaction by providing an on-demand mobile and web-based application to schedule NEMT services, as well as on-demand transportation services.
Indicator	Customer satisfaction rating
Design of Experiment	Post-only Randomized Experiment
Data Sources	Customer Surveys
Baseline Timeframe	Not applicable
Treatment Timeframe	Throughout pregnancy to eight weeks after delivery. Note that passive follow up of infant mortality will continue through one year after birth although treatment timeframe will have concluded.

Source: City of Columbus

5.8.5.1.1 Indicators

The objective will be measured using the following indicator:

- Customer satisfaction rating.

Surveys will be conducted to capture the insights of project participants. See **Appendix C** for sample questions and further details.

5.8.5.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

Pregnant women current use existing system to access NEMT trips.

RECOMMENDED DESIGN OF EXPERIMENT

The intervention group includes the pregnant women who are registered for the PTA pilot project and are randomly assigned to receive NEMT services through the PTA vendor. The "usual care" group includes the pregnant women who are registered for the PTA pilot project but will continue to receive their MCO benefits from the MCO's transportation broker.[24] A post-only randomized experiment is recommended for these indicators.

Refer to the *Prenatal Trip Assistance Concept of Operations for the Smart Columbus Demonstration Program* for the pregnant woman selection and registration process for the PTA project.[25]

[24] *Please note: for PTA study purposes, the treatment group is called the "exposed" group and the control group is called the unexposed group.*

[25] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Prenatal%20Trip%20Assistance%20Concept%20of%20Operations.pdf

5.8.5.1.3 Data Collection Plan

DATA SOURCES

Participants enrolled and randomized to the PTA project will complete a baseline and follow-up survey designed and implemented by OSU, a key partner on the project. The aggregated results will be made available for the City.

BASELINE TIMEFRAME

Because a post-only randomized trial is recommended, a baseline timeframe is not applicable for the indicators of this objective.

TREATMENT TIMEFRAME

The treatment exposure will initiate at the time of randomization through eight weeks postpartum. Passive follow up of infant mortality will continue through one year after birth.

5.8.5.1.4 Impact Evaluation Plan

The impact evaluation plan for the indicator is as follows:

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. For the quantitative questions, the value of measure will be collected. For the qualitative questions, the respondents will be asked to rate the qualitative measure in a scale of 1 to 5 (1 being the lowest and 5 being the highest) as part of the survey. The average scale of the quality measure will be calculated for all the survey responders. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the deployment period. The survey data collected will be compared over the previous surveys to track the indicator for both the treatment and the control groups.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level and project level confounding factors, if any, it can be attributed to the project. Supplemental data may be collected and analyzed to support the conclusion.

5.8.6. Project Specific Confounding Factors

The following confounding factors might affect the usage of PTA:

- **Changes to PTA Application Features:** Any feature changes in PTA application during the treatment timeframe may impact the usage of PTA. Evaluators will assess the impacts of any changes to the application during the evaluation.
- **COVID-19 Pandemic:** In March 2020, the State of Ohio implemented a stay-at-home order, travel restrictions and a state of emergency. While the stay-at-home order and travel restrictions were largely lifted at the end of May 2020, the State of Emergency remained in effect as of August 2020. As a result, traveler behavior and needs, travel patterns, transit offerings have been altered, potentially impacting analysis and findings. For the PTA project specifically, there were only minor changes needed to the research protocol to indicate updated safety procedures for NEMT providers and the recruitment process. The OSU IRB required all participant recruitment to occur remotely due to COVID-19. The number of participants had been set prior to the restrictions and was completed in June 2020. However, the date of the orders will be flagged when analyzing project-related data post-deployment.

5.8.7. Project Costs

Approximate budget to design, develop, and implement the project is $1.4 million, inclusive of vendor and ODC. Smart Columbus PMO and PM/SE labor costs are tracked separately and not included in this project-specific amount. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation, testing, operations, and maintenance.

5.9. PROJECT 6: SMART MOBILITY HUBS

5.9.1. Introduction

Enhanced mobility or multimodal transit features to alleviate FMLM challenges do not exist in the Linden area or along the Cleveland Avenue corridor. Columbus is working to make mobility a great equalizer by embracing multimodal transportation and making it as accessible and easy to use as possible. Our vision is to transform various locations, including some COTA bus stops along the BRT line (called CMAX) and transit centers, and community facilities such as a public library and community center, into SMH. At these locations, someone getting on or off the bus or accessing other community services can easily access information about transportation options or the next leg of their trip. Public Wi-Fi will be a key enabler for the SMH and its points of connection (Wi-Fi is also present in COTA's stations, CMAX, and buses). The City plans to outfit the SMH with interactive kiosks (IKs) to assist in travel planning and expanded transportation options via other modes such as bike- and car-sharing. The SMH will be linked with COTA systems to provide transit information with real-time arrival and departure times to the passengers waiting at the SMH.

This project provides an opportunity for residents and visitors to access multiple modes of travel to solve FMLM challenges. The City of Columbus identified the following objectives to evaluate the measurable impact the SMH project:

- Provide physical access to multimodal trip planning and payment options.
- Improve customer satisfaction of SMH users.

Refer to the *Smart Mobility Hubs Concept of Operations for the Smart Columbus Demonstration Program* for the project area, outcomes and objectives and additional details about this project.[26]

The following sections identify the logic model, outcomes and objectives, hypotheses, indicators, data collection plan, and impact evaluation plan for this project:

[26] https://d2rfd3nxvhnf29.cloudfront.net/2020-03/SCC-B-SMH-ConOps-Update-Final-20191224.pdf

5.9.2. Logic Model

Figure 18 shows the logic model identified for the project.

Outcomes	Objectives	Treatment	Hypothesis	Outcome Indicators
Mobility	Provide physical access to multimodal trip-planning and payment options	Implement SMHs with amenities including: • bike racks • bike and scooter share • car share • ride hail pick-up/drop-off • public transit • parking area • park and ride lots • kiosks • Wi-Fi • emergency call button	SMHs facilitate multimodal trips by allowing travelers to use kiosks and Wi-Fi to access the MMTPA and by consolidating multiple modes of transportation at a single location.	• Number of trip planning requests/bookings at SMH • Application usage (MMTPA: number of multimodal trips, number of multimodal trips planned at a kiosk).
Customer Satisfaction	Improve customer satisfaction		SMH facilities with easy and convenient access to enhanced trip planning, multimodal options, Wi-Fi access, and emergency call button will improve customer satisfaction.	Customer Satisfaction Rating: • Ease of kiosks use • Usefulness • Accessibility • Feeling of perceived safety

Figure 18: Smart Mobility Hubs Performance Measurement Logic Model

Source: City of Columbus

The SMH project identified the following two outcomes:

1. Mobility
2. Customer satisfaction

5.9.3. Outcome 6.1: Mobility

Outcome 6.1 identified one objective: Improve physical access to multimodal trip-planning and payment options.

5.9.3.1. OBJECTIVE 6.1.1: PROVIDE PHYSICAL ACCESS TO MULTIMODAL TRIP PLANNING AND PAYMENT OPTIONS

Table 28 outlines the performance measurement methodology for this objective.

Table 28: Smart Mobility Hubs Mobility Objective 6.1.1

Category	Description	
Objective	Provide physical access to multimodal trip-planning and payment options	
Hypothesis	SMHs facilitate multimodal trips by allowing travelers to use kiosks and Wi-Fi to access the MMTPA and by consolidating multiple modes of transportation at a single location.	
Indicator	Number of trip planning requests/bookings at SMH	Application usage (MMTPA: number of multimodal trips, number of multimodal trips planned at a kiosk)
Design of Experiment	Post-only Trend Analysis	Post-only Trend Analysis
Data Sources	MMTPA, Operating System, Interactive Kiosks – Central Management System (IK-CMS)	MMTPA, Operating System, IK-CMS
Baseline Timeframe	N/A	
Treatment Timeframe	Summer 2020 to Spring 2021	

Source: City of Columbus

5.9.3.1.1 Indicators

The following indicators will measure the objective:

- Number of trip-planning requests/booking at SMHs.
- Application use (MMTPA: numbers of multimodal trips and multimodal trips planned at a kiosk).

The following data will be collected for the indicator:

- Number of trip-planning requests using kiosks.
- Number of trip-booking completed using kiosks.

5.9.3.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

An existing system comparable to the SMH does not exist to compare progress.

RECOMMENDED DESIGN OF EXPERIMENT

As the indicators will be measured based on the system usage (which will exist only after implementation of the system), a simple trend analysis is recommended. Because a comparable system does not exist, post-treatment only non-experiment is recommended. Overall, a post-only trend analysis is recommended for measuring all the indicators for this objective.

5.9.3.1.3 Data Collection Plan

DATA SOURCES

All data will be available for access from the Operating System. MMTPA will send the trip-planning data to the Operating System. The IK vendor will provide app usage data from the IK-CMS.

BASELINE TIMEFRAME

For the post-only design of experiment, baseline data will not be collected.

TREATMENT TIMEFRAME

Treatment data will be collected for approximately nine months (summer 2020 to spring 2021) following the implementation of the SMH.

A nine-month timeframe after implementation was chosen to align with the project deployment timeframe and to allow travelers to become aware and informed about the SMH while considering operational constraints.

5.9.3.1.4 Impact Evaluation Plan

The following actions will comprise the impact evaluation plan for the indicators:

For the number of trip planning requests/bookings at SMH and application usage, the data will be collected and aggregated monthly and compared month-over-month to track the trend. If the trend shows an increase in the indicator, it can be attributed to this objective.

5.9.4. Outcome 6.2: Customer Satisfaction

Outcome 6.2 identified one objective: Improve customer satisfaction.

5.9.4.1. OBJECTIVE 6.2.1: IMPROVE CUSTOMER SATISFACTION

Table 29 outlines the performance measurement methodology for this objective.

Table 29: Smart Mobility Hubs Mobility Objective 6.2.1

Category	Description
Objective	Improve customer satisfaction

Category	Description
Hypothesis	SMH facilities with easy and convenient access to enhanced trip planning, multimodal options, Wi-Fi access, and emergency call button will improve customer satisfaction.
Indicator	Customer satisfaction rating: Ease of kiosk use Usefulness Accessibility Perceived feeling of safety
Design of Experiment	Post-only Trend Analysis
Data Sources	Customer Survey
Baseline Timeframe	N/A
Treatment Timeframe	Summer 2020 to Spring 2021

Source: City of Columbus

5.9.4.1.1 Indicators

The objective will be measured using the following indicator:

- Customer satisfaction rating.

To record SMH users' experiences, the following data will be collected through survey:

- Ease of IK use.
- Usefulness of SMHs (number of services and modes of transportation).
- Accessibility[27] of SMHs: The ease of reaching the user's valued destination.
- Feeling of perceived safety provided by various SMH components (emergency call button and lighting).

Surveys will be conducted to capture the insights of project participants. See **Appendix CAppendix B** for sample questions and further details.

5.9.4.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

An existing system comparable to the SMH does not exist to compare progress.

RECOMMENDED DESIGN OF EXPERIMENT

As the indicators will be measured based on the system usage (which will exist only after implementation of the system), a simple trend analysis is recommended. Because a comparable system does not exist, a post-only trend analysis is recommended. However, surveys will be administered throughout the demonstration period, allowing for an assessment of improvement from the launch to the end of the demonstration period.

[27] https://www.fdot.gov/planning/fto/accessibility

5.9.4.1.3 Data Collection Plan

DATA SOURCES

Surveys will be conducted by OSU, and the results will be made available to the City.

BASELINE TIMEFRAME

For the post-only design of experiment, baseline data will not be collected.

TREATMENT TIMEFRAME

Treatment data will be collected for approximately nine months following the implementation of the SMH. Surveys will be conducted throughout the deployment timeline.

A nine-month timeframe after implementation was chosen to align with the project development timeline and to allow travelers to become aware and informed about the SMH while considering operational constraints.

5.9.4.1.4 Impact Evaluation Plan

The impact evaluation plan for the indicators are as follows:

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. For the quantitative questions, the value of measure will be collected. For the qualitative questions, the respondents will be asked to rate the qualitative measure in a scale of 1 to 5 (1 being the lowest and 5 being the highest) as part of the survey. The average scale of the quality measure will be calculated for all the survey responders. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the deployment period. The survey data collected will be compared over the previous surveys to track the indicator for both the treatment and the control groups.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level and project level confounding factors, if any, it can be attributed to the project. Supplemental data may be collected and analyzed to support the conclusion.

5.9.5. Project-Specific Confounding Factors

The following confounding factors might affect the usage of SMH:

- **Multimodal Trip Planning Application:** With the implementation of the MMTPA project, travelers may be more likely to use SMHs. It is anticipated that MMTPA and SMH usage will be closely correlated and impact each other. Evaluators will assess the impacts of these two projects on application usage.
- **Connected Electric Autonomous Vehicles:** The CEAV project (passenger service) shares stops with two SMHs. It is anticipated that CEAV and SMH usage will be closely correlated and impact each other while passenger service is in operation. Evaluators will assess the impacts of SMH usage should CEAV passenger service resume during the SMH deployment period.
- **Changes to SMH Application Features:** Any feature changes in SMH application during the treatment timeframe may impact the usage of SMH. Evaluators will assess the impacts of any changes to the application during the evaluation.
- **Experience Columbus and Short North Alliance Interactive Kiosk Deployments:** Experience Columbus, through a contract with Orange Barrel Media/IKE Smart City (IKE Smart City), began a project which will deploy 61 interactive kiosks and 29 static pillars around the downtown Columbus area. The deployment area for the Experience Columbus interactive kiosks is focused on high tourist attraction areas and does not include the SMH deployment sites. The project began in 2018

and will incrementally deploy the kiosks, which offer a wide variety of applications related to public service and safety, navigation, community services, and opportunity. Experience Columbus is phasing out its deployment and has a goal to complete deployment by 2021. The Short North Alliance, a non-profit serving business and property owners, also has a contract with IKE Smart City to deploy seven interactive kiosks in the Short North District. The Short North Alliance and Experience Columbus are working together to coordinate messaging to provide seamless interaction for the user. These initiatives may impact travel patterns and traveler behavior and familiarity and comfort level using kiosks for trip planning. Evaluators will assess the impacts of these two projects on SMH usage.

- **COVID-19 Pandemic:** In March 2020, the State of Ohio implemented a stay-at-home order, travel restrictions and a state of emergency. While the stay-at-home order and travel restrictions were largely lifted at the end of May 2020, the State of Emergency remained in effect as of August 2020. As a result, traveler behavior and needs, willingness or ability to interact with kiosk touch screens, travel patterns, transit offerings have been altered, potentially impacting analysis and findings. The timing of these orders impacted the target launch date for SMH, which was originally in April 2020. The launch took place on July 28, 2020. The main impact of the pandemic is on the amount of data that can be collected for the SMH deployment, as well as the survey methodology that will be used by OSU. Given that the SMH launched during the pandemic, it is expected that other quantitative indicators related to kiosk usage will be less than what was originally planned.

5.9.6. Project Costs

Approximate budget to design, build, and implement the project is $292,000, inclusive of vendor and ODC. Smart Columbus PMO and PM/SE labor costs are tracked separately and not included in this project-specific amount. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation, testing, operations, and maintenance.

5.10. PROJECT 7: EVENT PARKING MANAGEMENT

5.10.1. Introduction

The City of Columbus lacks an integrated system for residents and visitors to view available parking spaces easily and efficiently at parking garages, surface lots, and parking meters – especially during large events. Non-direct routing of travelers causes congestion and inefficiency in the transportation network. The City's goal is to integrate parking information from multiple parking facilities into a single availability and reservation services solution. This will allow travelers to plan, search, and reserve parking near their destination. More direct routing of travelers during large events is expected to reduce congestion during those times.

The City of Columbus identified the following objectives to measure the impact EPM is expected to provide:

- Reduce parking-related congestion.
- Reduce vehicle emissions.
- Increase knowledge of available parking in the downtown area and Short North during events.

Congestion and vehicle emissions reductions will be measured at the program level. Refer to the *Event Parking Management Concept of Operations for the Smart Columbus Demonstration Program* for project area, outcomes and objectives, and additional detail on this project.[28]

The following sections identify logic model, outcomes and objectives, hypotheses, indicators, data collection plan, and impact evaluation plan for this project.

[28] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Event%20Parking%20Management%20Concept%20of%20Operations.pdf

5.10.2. Logic Model

Figure 19 shows the logic model identified for the EPM project.

Outcomes	Objectives	Treatment	Hypothesis	Outcome Indicators
Customer Satisfaction	Improved perception of available parking in the downtown area and Short North.	Implement EPM System	Users of EPM app will have improved perception of available parking in the downtown area and Short North.	• Perception of available parking

Figure 19: Event Parking Management Performance Measurement Logic Model

Source: City of Columbus

The EPM project identified one outcome: Customer satisfaction.

5.10.3. Outcome 7.1: Customer Satisfaction

Outcome 7.1 identified one objective: Increase knowledge of available parking in the downtown area and Short North during events.

5.10.3.1. OBJECTIVE 7.2.1: INCREASE KNOWLEDGE OF AVAILABLE PARKING IN THE DOWNTOWN AREA AND SHORT NORTH DURING EVENTS

Table 30 outlines the performance measurement methodology for this objective.

Table 30: Event Parking Management Customer Satisfaction Objective 7.2.1

Category	Description
Objective	Improved perception of available parking in the downtown area and Short North.
Hypothesis	Users of EPM app will have improved perception of available parking in the downtown area and Short North.
Indicator	Perception of available parking
Design of Experiment	Pre/Post Quasi-Experimental Design
Data Sources	Surveys: resident and in-app
Baseline Timeframe	August 2020 (one month)
Treatment Timeframe	Fall 2020 to Spring 2021 (six months)

Source: City of Columbus

5.10.3.1.1 Indicators

The following indicators will measure the objective:

- Perception of available parking.

The following data will be collected through surveys:

- Mode of travel preference.
- Level of concern with current parking situation.
- Perception of availability.
- Likelihood to use app for future trips (in-app only).

Surveys will be conducted to capture the insights of project participants. See **Appendix C** for sample questions and further details.

5.10.3.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

Multiple parking solutions exist in the market. However, a comparable comprehensive system that consolidates information from all parking facilities does not exist.

RECOMMENDED DESIGN OF EXPERIMENT

EPM users will be part of the treatment group, and the non-users will be part of the control group. Resident surveys will be administered to both the treatment and control groups both during pre- and post-deployment of EPM whereas in-app surveys will be administered to the treatment group only. Since use of the EPM application is voluntary and users cannot be assigned randomly, only a quasi-experimental design is possible. Therefore, a pre/post quasi-experimental design is recommended.

5.10.3.1.3 Data Collection Plan

DATA SOURCES

Resident surveys will be conducted by the City and EPM project team, and the results will be made available for the City. In addition, in-app surveys will be conducted by the City and EPM project teams.

BASELINE TIMEFRAME

The baseline resident survey will be conducted in the month before implementation of the EPM project.

TREATMENT TIMEFRAME

Treatment data will be collected following the implementation of the EPM. Both resident and in-app surveys will be conducted throughout the demonstration period.

The survey timeframe was chosen to align with the EPM development schedule, while still providing travelers sufficient time to become informed and comfortable using technology. This timeframe also accounts for operational constraints and confounding factors.

5.10.3.1.4 Impact Evaluation Plan

The impact evaluation plan for the indicator is as follows:

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the demonstration period. The survey data collected will be compared over the previous surveys to track the indicator for both the treatment and the control groups.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level and project level confounding factors, if any, it can be attributed to the project. Supplemental data may be collected and analyzed to support the conclusion.

5.10.4. Project-Specific Confounding Factors

The following sections detail the confounding factors that will impact the EPM project.

- **Multimodal Trip Planning Application:** The MMTPA project may be a confounding factor for the EPM project. The need for finding available parking in the downtown area could be potentially influenced by the fact that users now have a convenient mobility method after users park their vehicles. Users may be willing to park farther from their final destination or shift modes for their travel, which could potentially make finding parking easier.

- **COVID-19 Pandemic:** In March 2020, the State of Ohio implemented a stay-at-home order, travel restrictions and a state of emergency. While the stay-at-home order and travel restrictions were largely lifted at the end of May 2020, the State of Emergency remained in effect as of August 2020. As a result, traveler behavior and parking demand has been significantly impacted. Although some businesses will have reopened prior to the start of the EPM project's treatment timeframe, many employers have implemented remote work policies and many events have been cancelled or postponed. The general public may also be reluctant to frequent establishments in the Downtown District and Short North due to fears of the spread of COVID-19. In such cases, potentially decreased demand for parking may make finding parking easier. Because of the rise in COVID-19 cases in the state, the governor has issued additional restraints which deter travel.
- **Public Protests:** Ongoing protests in the Downtown District and Short North since May 28, 2020 has impacted travel and parking behavior in the area and caused temporary closure of parking meters in the area. This may reduce data availability, especially for on-street parking. The timing of these protests is noted so that it can be flagged in the timescale of the analysis.
- **Special Events:** The EPM project will encompass all parking facilities in the Downtown District and Short North. Use of parking application will be tracked throughout the period of performance for impact assessment. Due to the COVID-19 pandemic explained above, many events have been or are likely to be canceled or held virtually during the deployment period. If events are held during the deployment period, an increase in parking demand is expected.

  Due to the large percentage of events that have been (or may still be) cancelled, the alternative analysis for parking data and surveys may have to change focus to recurring downtown and short north parking demand as opposed to event-driven demand.
- **Changes in Parking Fares:** Like fuel prices, any significant changes in parking prices would affect the vehicle owners in using/not using their vehicles to travel. A significant hike in prices would influence travelers to pursue alternate options. Similarly, significant drop in parking prices would encourage the drivers to drive their points of interest and thereby increase parking demand. In addition to changes in parking prices for garages and off-street parking facilities, on-street parking meters with dynamic pricing policy will also be observed for any significant changes.
- **Newly Built Parking Facilities:** Any new parking facilities that are constructed and made available during the post-deployment period might encourage the vehicle owners to drive to their destinations nearby the new facilities. In this case, an increased usage of application might be observed. Evaluators will assess newly established parking facilities for performance measurement.
- **Short North Parking Project**[29]: The City of Columbus Parking Services Department has initiated a streetscaping project on January 22, 2019 and would last beyond the Smart Columbus Projects' periods of performance. This project would enable residents and businesses in Short North region to register and use parking permits for their parking needs. The first phase of his project will be available for Short North residents throughout the period of performance of EPM project. The evaluators will assess the impact of this project on the parking demand trends.
- **Children's Hospital Parking Project:** The City of Columbus launched the Children's Hospital (CH) Parking Project[30] on December 10, 2018. The goal of this program is to increase access for residents and resident guests around Nationwide Children's Hospital. Residents nearby CH will be able to register for parking permits. The evaluators will assess the impact of this project on the parking demand trends.

[29] https://www.columbus.gov/publicservice/parking/Short-North-Special-Parking-Area/

[30] https://www.columbus.gov/Templates/Detail.aspx?id=2147506111

- **Changes to EPM Application Features:** Any feature changes in EPM application during the treatment timeframe may impact the usage of EPM. Evaluators will assess the impacts of any changes to the application during the evaluation.

5.10.5. Project Costs

Approximate budget to design, develop, and implement the project is $450,000, inclusive of vendor and ODC. Smart Columbus PMO and PM/SE labor costs are tracked separately and not included in this project-specific amount. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation, testing, operations, and maintenance.

5.11. PROJECT 8: CONNECTED ELECTRIC AUTONOMOUS VEHICLES

5.11.1. Introduction

The use of connected and autonomous shuttles has been widely proposed as a solution to the FMLM problem. This project will address, investigate, and develop solutions to the social and technical challenges associated with the use of connected and autonomous electric vehicle technology for safer and more efficient access to jobs in a Smart City. Social challenges include determining how to gradually introduce and expand such a solution for best results, how to develop and improve user acceptance and user benefits, how to integrate with the rest of the transportation network for improving mobility, and how to increase the user perception of safety and reliability.

This project will focus on the following technical challenges:

- Determining penetration rates for improved mobility.
- Mixed traffic interactions in an urban environment.
- Autonomous shuttle right-of-way challenges at intersections.
- All-weather operation of autonomous shuttles.
- Latency and high network traffic problems in connectivity through V2X to other road users, infrastructure, and the data management hub.
- Handling uncertainty due to unpredictable operation of non-autonomous vehicles, other road users, and environmental conditions.

Although the above technical challenges will be addressed, the most important technical hurdle blocking the deployment of connected and autonomous shuttles in a Smart City to enhance mobility is that no certification, testing, and rating system for safe pre-deployment evaluation methods for these shuttles exists—forcing City officials and shuttle developers to rely on public road testing for the determination and solution of technical challenges like the ones above. This project will introduce and develop holistic modeling and simulation tools that will enable a priori determination and solution of connected and autonomous mobility technical challenges—including the actual route and other vehicles and mobility improvements. This will be followed by proof-of-concept work and pilot deployments to demonstrate that connected and autonomous mobility can be used to improve the FMLM access to jobs in a Smart City.

The CEAV project will be conducted with partners from ODOT, OSU, and The Columbus Partnership, and the City will coordinate with COTA to plan, implement, and evaluate the deployment of AVs in the City. Working with these partners allows for the generation of various use cases, which will result in the deploy CEAVs in various settings.

This project provides an opportunity for residents and visitors to access cutting-edge mobility technologies to solve FMLM challenges. The City of Columbus is in the process of finalizing specific objectives to be evaluated in terms of measuring the impact of the CEAV project; however, the project identified the following preliminary objectives:

- Provide convenient, reliable FMLM transit.
- Provide more access to jobs and services to residents from underserved communities.
- Improve the user experience.
- Provide improved FMLM access to food.

Refer to *Connected Electric Autonomous Vehicle Operational Concept for the Smart Columbus Demonstration Program* for project area, outcomes and objectives, and additional details for this project.[31] In addition, refer to Appendix on the Operational Concept for the alternate use case of the FMLM food pantry for the details for that use case.[32]

The following sections identify the project's logic model, outcomes and objectives, hypotheses, indicators, data collection plan, and impact evaluation plan.

[31] https://d3hzplpmmz6qe4.cloudfront.net/2019-07/Smart%20Columbus%20Connected%20Electric%20Autonomous%20Vehicle%20Operational%20Concent.pdf

[32] https://d2rfd3nxvhnf29.cloudfront.net/2020-08/SCC-B-CEAV-OpCon-APPENDIX_A-clean.pdf

5.11.2. Logic Model

Figure 20 shows the identified logic model for the CEAV project.

Outcomes	Objectives	Treatment	Hypothesis	Outcome Indicators
Mobility	Provide convenient, reliable FMLM transit option	Implement CEAV	CEAV will increase the number of convenient, reliable FMLM trips in the deployment area by providing an autonomous shuttle service, which will reduce walking distances to destinations.	• CEAV passenger trips • Walking distance • Perceived convenience • Perceived reliability • Perceived improvement in FMLM transit
Opportunity	Provide more access to jobs and services to residents from underserved communities		Providing complementary service to COTA will increase access to jobs and services for underserved communities. Bridging the FMLM gap for food access will increase food distribution.	• COTA ridership at stations with CEAV • Increase in mode shift • Number of food assistance packages transported
Customer Satisfaction	Improve the user experience		CEAV will improve the user experience by reducing walking distance and providing on-time service.	• CEAV on-time performance • Walking distance • Perceived convenience • Perceived reliability

Figure 20: Connected Electric Autonomous Vehicles Performance Measurement Logic Model

Source: City of Columbus

The CEAV project identified the following three outcomes:

1. Mobility
2. Opportunity
3. Customer satisfaction

5.11.3. Outcome 8.1: Mobility

Outcome 8.1 identified one objective: Provide convenient, reliable FMLM transportation.

5.11.3.1. OBJECTIVE 8.1.1: PROVIDE CONVENIENT, RELIABLE FMLM TRANSIT OPTION

Table 31 outlines the performance measurement methodology for this objective.

Table 31: Connected Electric Autonomous Vehicles Mobility Objective 8.1.1

Category	Description		
Objective	Provide convenient, reliable FMLM transit option		
Hypothesis	CEAV will increase the number of convenient, reliable FMLM trips in the deployment area by providing an autonomous shuttle service, which will reduce walking distances to destinations.		
Indicators	CEAV passenger trips	• Walking distance • Perceived convenience • Perceived reliability	Perceived improvement in FMLM transit
Design of Experiment	Post-only Trend Analysis	Pre/post Trend Analysis	
Data Sources	• CEAV Vendor • Operating System	Customer Survey	Customer Survey
Baseline Timeframe	N/A	One year prior to implementation	
Treatment Timeframe	Smart Circuit: 12/2018 to 09/2019 Linden LEAP: 2/5/2020-2/20/2020 (or through 3/31/2021 if passenger service resumes)		

Source: City of Columbus

5.11.3.1.1 Indicators

The following indicators will measure the objective:

- CEAV passenger trips.
- Walking distance.
- Perceived convenience.
- Perceived (travel time) reliability.
- Perceived improvement in FMLM transit.

The following data will be collected:

- CEAV boardings.
- Customer Surveys.
- Surveys will be conducted to capture the insights of project participants. See **Appendix C** for sample questions and further details.

5.11.3.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

An existing system comparable to the CEAV does not exist to compare progress on the number of trips. For the other indicators, surveys will ask travelers about their pre-deployment travel options.

RECOMMENDED DESIGN OF EXPERIMENT

For the CEAV passenger trips, this indicator will be measured based on the system usage. Since this data will only exist following the implementation of the system, a simple trend analysis is recommended. In addition, since a comparable system does not exist, post-only trend analysis is recommended for this indicator.

Customer surveys will be administered during the deployment of CEAV; however, the survey questions will inquire about pre-deployment travel behavior. Therefore, a pre/post trend analysis is recommended.

5.11.3.1.3 Data Collection Plan

DATA SOURCES

CEAV passenger trip data will be available for access from the Operating System provided by the CEAV vendor.

A customer survey will be developed by OSU and distributed to residents by the City/CEAV Project Team on board the vehicle and at CEAV stop locations.

BASELINE TIMEFRAME

An existing system comparable to the CEAV does not exist to compare progress, however the survey questions will inquire about pre-deployment travel behavior.

TREATMENT TIMEFRAME

The project will be evaluated for one-year following the implementation of the CEAV, depending on whether passenger service is operational. Surveys will be conducted randomly from travelers on board the vehicle and residents in and around the stop locations.

Data and surveys will be collected while the CEAV is actively engaged in passenger service. Any service suspension would halt operational and survey data collection. Data collection will continue as service does, through the end of the demonstration period.

5.11.3.1.4 Impact Evaluation Plan

The impact evaluation plan for the indicators is as follows:

For the CEAV passenger trips indicator, CEAV data will be collected and aggregated monthly and compared month-over-month to track the CEAV passenger trips trend. If the trend shows an increase in CEAV passenger trips, it can be attributed to this objective.

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. The responses to the informational questions will be collected and stored for future

use, if necessary. The survey information will be tracked over the deployment period. The survey data collected will be compared over the previous surveys to track the indicator for both the treatment and the control groups.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level and project level confounding factors, if any, it can be attributed to the project. Supplemental data may be collected and analyzed to support the conclusion.

5.11.4. Outcome 8.2: Opportunity

Outcome 8.2 identified two objectives: provide more access to jobs and services to residents from underserved communities and help bridge the FMLM gap in food access.

5.11.4.1. OBJECTIVE 8.2.1: PROVIDE MORE ACCESS

Table 32 outlines the performance measurement methodology for this objective.

Table 32: Connected Electric Autonomous Vehicles Opportunity Objective 8.2.1

Category	Description		
Objective	Provide more access to jobs and services to residents from underserved communities		
Hypothesis	Providing complementary service to COTA will increase access to jobs and services for underserved communities. Bridging the FMLM gap for food access will increase food distribution.		
Indicator	COTA ridership at stations with CEAV	Increase in mode shift	Number of food pantry packages distributed
Design of Experiment	Post-only Trend Analysis		
Data Sources	• COTA • Operating System	• COTA • Operating System • Resident Survey	• St. Stephen's Food and Nutrition Center • EasyMile
Baseline Timeframe	N/A		
Treatment Timeframe	Smart Circuit: 12/2018 to 09/2019 Linden LEAP: 2/5/2020-2/20/2020 (or through 3/31/2021 if passenger service resumes)		Food Pantry: July 30, 2020 (end date TBD)

Source: City of Columbus

5.11.4.1.1 Indicators

The following indicators will measure the objective:

- COTA ridership at stations with CEAV: Includes the number of passengers riding the COTA at stations where the CEAV stops.
- Increase in mode shift: Includes the number of passengers transferring between COTA and CEAV, and vice-versa, at combined stops.

- Number of food pantry packages distributed: Includes the number of individual boxes transported from St. Stephen's Community House to the Rosewind Community Center.

The following data will be collected:

- Number of COTA boardings and alightings at stops shared by CEAV.
- Number of CEAV boardings and alightings at stops not shared by COTA.
- Number of CEAV boardings and alightings at stops shared by COTA.
- Number of food pantry packages transported from St. Stephen's Community House to Rosewind Community Center and packages distributed to patrons.
- Trend in number of food pantry packages distributed by St. Stephen's Community House and in Franklin County

Surveys will be conducted to capture the insights of project participants. See **Appendix C** for sample questions and further details.

5.11.4.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

Since an existing system comparable to the CEAV does not exist, baseline data will not be collected for this project.

RECOMMENDED DESIGN OF EXPERIMENT

COTA ridership data will be collected from COTA stops served by CEAV and those that are not for an analysis of differences. Therefore, a post-only trend analysis is recommended.

For increase in mode shift (CEAV/COTA boardings), as the indicator will be measured based on the CEAV usage (which will exist only following the implementation of the system), a simple trend analysis is recommended. In addition, since a comparable system does not exist prior to the implementation, post-only analysis is recommended.

For increase in mode shift (survey), customer surveys will be administered during the deployment of CEAV, however the survey questions will inquire about pre-deployment travel behavior. Therefore, a pre/post quasi experimental design is recommended.

For number of food pantry packages transported, as the number of packages transported and distributed will be measured based on St. Stephen's Food and Nutrition Center data (which will exist only following the implementation of the system), a simple trend analysis is recommended. The project team will also review trends in the number of food assistance packages distributed by St. Stephen's Community House and in Franklin County to contextualize project impact. In addition, since a comparable system does not exist prior to the implementation, post-only analysis is recommended.

5.11.4.1.3 Data Collection Plan

DATA SOURCES

Number of boards and alights at stops shared by CEAV will be provided by COTA to the Operating System and number of CEAV boards and alights at stops both shared and not shared by COTA will be available in the Operating System provided by the CEAV vendor. In addition, surveys will be distributed to CEAV riders throughout the deployment period. The number of food pantry packages transported and distributed will be provided by EasyMile and the number of packages distributed at the physical food pantry will be provided by St. Stephen's Food and Nutrition Center.

BASELINE TIMEFRAME

Baseline data for COTA ridership, increase in mode shift, and number of food assistance packages transported (post-only) will not be collected. However the post-deployment survey will inquire about travel behavior prior to deployment.

TREATMENT TIMEFRAME

Smart Circuit passenger service implementation was from December 2018 to September 2019. Linden LEAP passenger service began February 5, 2020 but was suspended due to an incident with passenger injury. Potential resumption of passenger service, including timeline, has yet to be determined. Although safety mitigations approved by the National Highway Traffic Safety Administration (NHTSA) were installed in June 2020, the social distancing guidelines resulting from the COVID-19 pandemic prevent the shuttle from receiving approval to resume passenger service. Alternatively, the food assistance package delivery use case began operation in July 2020, but end of implementation period is yet to be determined and will be based on whether or not passenger service is resumed.

Surveys were conducted randomly from travelers on the Smart Circuit and initial Linden LEAP deployments. Due to COVID-19, alternative survey implementation is under consideration for food delivery and future passenger service (if resumed) since social distancing may make in-person survey distribution difficult.

5.11.4.1.4 Impact Evaluation Plan

The impact evaluation plan for the indicator is as follows:

COTA ridership data at CEAV stops will be collected and aggregated monthly and compared month-over-month to track the increase in ridership at all the combined COTA/CEAV stops. If the trend shows an increase in COTA boards and alights at the CEAV stops, it can be attributed to this objective. An increase in COTA ridership (especially at the CEAV stops) is anticipated during the treatment timeframe.

Number of CEAV boards and alights at COTA stops will be collected and aggregated monthly and compared month-over-month to track the increase in ridership at all the combined COTA stops. If the trend shows an increase in CEAV board and alights, it can be attributed to this objective. An increase in the number of CEAV ridership (especially at the COTA stops) is anticipated during the treatment timeframe.

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the deployment period. The survey data collected will be compared over the previous surveys to track the indicator for both the treatment and the control groups.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level and project level confounding factors, if any, it can be attributed to the project. Supplemental data may be collected and analyzed to support the conclusion.

5.11.5. Outcome 8.3: Customer Satisfaction

Outcome 8.3 identified one objective: Improve the user experience.

5.11.5.1. OBJECTIVE 8.3.1: IMPROVE THE USER EXPERIENCE

Table 33 outlines the performance measurement methodology for this objective.

Table 33: Connected Electric Autonomous Vehicles Customer Satisfaction Objective 8.4.1

Category	Description	
Objective	Improve the user experience	
Hypothesis	CEAV will improve the user experience by reducing walking distance and providing on-time service.	
Indicators	• CEAV on-time performance	• Walking distance • Perceived convenience • Perceived reliability
Design of Experiment	Post-only Trend Analysis	Pre/Post Trend Analysis
Data Sources	• CEAV vendor • Operating System	• Resident Survey
Baseline Timeframe	N/A	
Treatment Timeframe	Smart Circuit: 12/2018 to 09/2019 Linden LEAP: 2/5/2020-2/20/2020 (or through 3/31/2021 if passenger service resumes)	

Source: City of Columbus

5.11.5.1.1 Indicators

The following indicators will measure the objective:

- CEAV on-time performance.
- Walking distance.
- Perceived convenience.
- Perceived reliability.

The following data will be collected:

- Schedule time for CEAV at stops.
- Actual arrival time of CEAV at stops.
- Customer survey.

The customer satisfaction outcome of implementing the CEAVs relates to ensuring ridership satisfaction with the new passenger service. This information will be derived through user surveys and analysis of CEAV on-time performance. During deployment, a survey distributed to residents who may ride the shuttle or frequent the shuttle stop locations will collect the following information:

- Mode of travel before and after CEAV deployment.
- Expectations for the service and perception of reliability and convenience.
- Origin and destination.
- Mode of FMLM transportation.
- Frequency of transit use.
- Walking distance.
- Positive and negative experiences.
- Suggestions for improvement.

Surveys will be conducted to capture the insights of project participants. See **Appendix C** for sample questions and further details. CEAV on-time performance data will also be collected to help determine rider satisfaction.

5.11.5.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

An existing system comparable to the CEAV does not exist to compare progress, however for the customer satisfaction surveys, travelers will be asked about their travel behavior before CEAV.

RECOMMENDED DESIGN OF EXPERIMENT

For CEAV on-time performance, since the indicator will be measured based on the CEAV usage (which will exist only following the implementation of the system), a simple trend analysis is recommended. In addition, since a comparable system does not exist currently, a post-treatment non-experiment is recommended. Overall, a post-only trend analysis is recommended for measuring this indicator.

For the survey, resident surveys will be administered during the deployment of CEAV, however the survey questions will inquire about pre-deployment travel behavior. Therefore, a pre/post trend analysis is recommended.

5.11.5.1.3 Data Collection Plan

DATA SOURCES

Scheduled and on-time arrival of CEAV will be provided by the CEAV vendor to the Operating System. Resident surveys will be conducted by OSU as part of the project and used for analysis.

BASELINE TIMEFRAME

For the post-only design of experiment (CEAV on-time performance), baseline data will not be collected. For the pre-post trend analysis (customer satisfaction), the post-deployment survey will inquire about travel behavior prior to deployment.

TREATMENT TIMEFRAME

Treatment data will be collected for during the implementation period, but specific duration is dependent on whether or not passenger service is resumed. Duration and survey frequency will be updated as that information becomes available.

The timeframe after implementation is dependent on the CEAV resuming passenger service.

5.11.5.1.4 Impact Evaluation Plan

The impact evaluation plan for the indicators is as follows:

For the CEAV on-time performance, the difference in the scheduled and actual arrival time will be collected and aggregated monthly and compared month-over-month to track the CEAV on-time performance. If the actual travel time is as close as possible to the scheduled arrival time (if the difference is zero), it can be attributed to customer satisfaction.

For the survey, the questions will be categorized as quantitative questions, qualitative questions, and information collection. The responses to the informational questions will be collected and stored for future use, if necessary. The survey information will be tracked over the deployment period. The survey data collected will be compared over the previous surveys to track the indicator for both the treatment and the control groups.

Both the quantitative and qualitative measures are expected to improve during the post-implementation period for the treatment group. If the indicator shows an improvement trend for the treatment group after accounting for the program level and project level confounding factors, if any, it can be attributed to the project. Supplemental data may be collected and analyzed to support the conclusion.

5.11.6. Project-Specific Confounding Factors

The following confounding factors might affect the usage of the CEAV:

- **Multimodal Trip Planning Application:** MMTPA and the CEAV will share location, which will impact CEAV ridership. Evaluators will assess the impact of this project on CEAV passenger usage.
- **Smart Mobility Hub:** CEAV will share two stops with the SMH. It is anticipated that CEAV and SMH usage will be closely correlated and impact each other. Evaluators will assess the impact of this project on CEAV passenger usage.
- **Reliability**: The shuttles have limited capacity to carry food assistance boxes could cause delays if additional round trips are needed to keep up with demand.
- **COVID-19 Pandemic:** In March 2020, the State of Ohio implemented a stay-at-home order, travel restrictions and a state of emergency. While the stay-at-home order and travel restrictions were largely lifted at the end of May 2020, the State of Emergency remained in effect as of August 2020. As a result, traveler behavior and needs, willingness and ability to ride in the CEAV, travel patterns, transit offerings have been altered, potentially impacting analysis and findings. The CEAV project has been greatly disrupted by the social distancing guidelines that are required due to the pandemic. It has prevented the CEAV from resuming passenger service. The project team has implemented and will evaluate an alternative use case, but the customer/rider centric indicators are at risk if the CEAV is not able to resume passenger service before the end of the grant. In such case, Mobility Objective 8.1.1 will not be measured.
- **CEAV Operations:** If the CEAV is involved in an incident or requires maintenance, passenger or food pantry delivery would pause while it is investigated. Since service would be interrupted, these types of activities would be logged so that they can be referenced during data and survey analysis.

5.11.7. Project Costs

Approximate budget to design, build, and implement the project (both Smart Circuit and Linden Leap) is $1.6 million, inclusive of vendor and ODC. Smart Columbus PMO and PM/SE labor costs are tracked separately and not included in this project-specific amount. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation, testing, operations, and maintenance.

5.12. PERFORMANCE TARGETS

Smart Columbus demonstration projects are without precedent. Therefore, setting performance targets is challenging. For example, the degree of improvement due to mobility apps deployment will depend on the efficiency conditions of the current or baseline traffic network conditions. For users, traffic signal preemption may see improvements in trip time as high as 15 percent more than signalized network users, although some efficiency loss on side streets may occur.

Signal system improvements of 10 percent will be considered quite effective in carefully managed traffic signal systems. The study will assess the current baseline and determine the project improvements. Generic mobility improvements of about 10 percent will be considered acceptable. This stage does not definitively prescribe precise outcomes, but improvements are expected.

It is unlikely that safety will be directly measurable from the small number of incidents that will occur within the study limits. The relatively small samples of reported incidents and confounding factors, such as weather, comprise a challenge to obtaining statistically significant safety performance measures. For this type of experimental setting, such targets might not be achieved or meaningful.

Chapter 6. Data Collection Plan

This chapter provides an overview of the data that must be collected to effectively analyze Smart Columbus project performance according to the approach **Chapter 5** outlines. Identifying the data sources at this stage will allow recording of data needed to analyze performance. Initial steps to ensure the quality of data will be identified, as well as establishing a preliminary process to remove Personally Identifiable Information (PII). Finally, the process for storing and collecting data will be described.

6.1. DATA COLLECTION TIMEFRAME

Figure 21 shows the pre- and post-deployment data collection timeframe for all Smart Columbus projects.

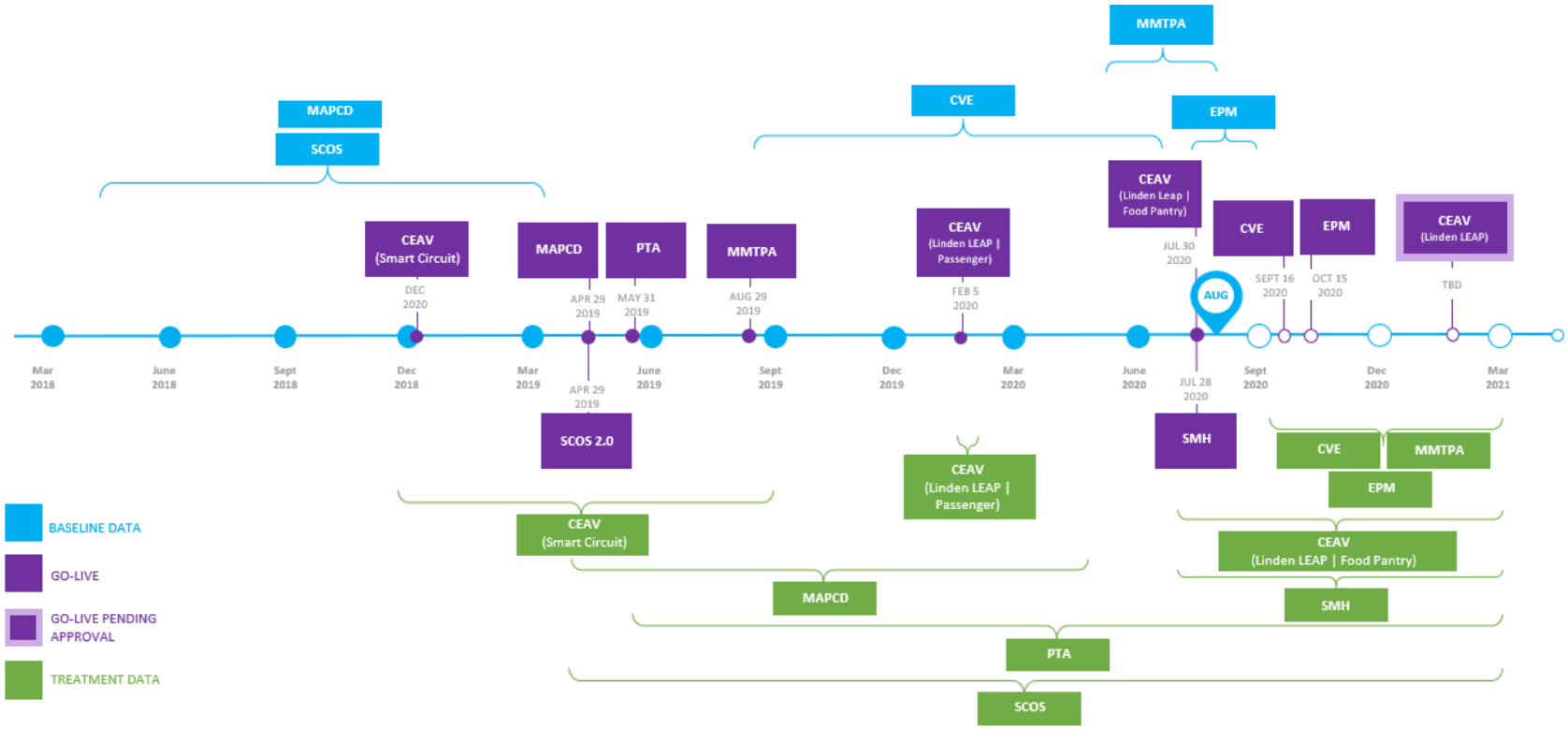

Figure 21: Pre- and Post-Deployment Data Collection Timeframe

Source: City of Columbus

6.2. DATA SOURCES

The performance measurement process will use information derived from many data sources. This chapter will focus on acquiring and maintaining data that will be used for evaluation of performance measures, although other data is available. Data will be passed through or stored in the Operating System and made available through APIs with the option to download datasets.

Smart Columbus will leverage existing data sources when available. A detailed description of methodology for fulfilling data needs is discussed below for the eight Smart Columbus Projects.

6.2.1. Program-Level Measures

For program level measures, vehicle related GHG emissions information before and after implementation of various Smart Columbus projects will be collected from the United States Environmental Protection Agency and MORPC. For the traffic congestion measure, traffic characteristics data (volume, speed and travel time) will be collected from INRIX and MORPC. Passenger miles traveled from the MMTPA project and travel time saved through freight signal priority on CVE project will also be collected. User surveys will be conducted to capture perceptions on change in travel time, migration of mode choice, change in available opportunities to jobs and services, etc.

6.2.2. Smart Columbus Operating System

For the Operating System project, an analytics dashboard will be setup to track the user analytics including usage and time spent, discoverability of the data. Also, datasets available in workable formats and methods will be continuously tracked. In addition to quantitative data, surveys will be conducted with data providers and users. User categories will be captured in the surveys to differentiate between different user groups including agency users, researchers, developers, etc. These survey results will be made available to evaluators for performance evaluation. These surveys focus on capturing the impact of Operating System when compared to previous data-sharing methods and efficiency of the Operating System in meeting the user needs.

6.2.3. Connected Vehicle Environment

For the CVE project, all CV OBUs will broadcast BSM. When in the range of a RSU, these BSM messages will be received by the RSU and forwarded to the Operating System. Select vehicles will also transmit SRM to support preempt or priority requests, as applicable. When an RSU receives an SRM messages, roadside processing will act upon this message and place the necessary call to the traffic signal controller to make the request.

All RSUs will broadcast SPaT, MAP, and Radio Technical Commission for Maritime Services Position Correction Messages (RTCM) on a recurring basis. Further, the SSM may also be requested by an OBU. Both the SPaT and SSM messages are sourced by data from the traffic signal controller. MAP and RTCM are generated by roadside processing using data input from outside source, including the CV Traffic Management Center, and Ohio Department of Transportation's Continuously Operating Reference Station (CORS). Roadside Safety Messages used to support the Reduced Speed School Zone application will also be broadcast from select RSUs located adjacent to the school zones. All BSM, SPaT, MAP, SRM, SSM, RTCM and TIM messages produced or captured by the RSU will also be forwarded to the Operating System. These messages will be archived in the Operating System and used for performance measurement evaluation, among other purposes. Data from other sources including EMS emergency response times and transit on-time performance will be collected from respective sources and made available for evaluation. In addition to field data, surveys will be conducted to capture driver perception about the effectiveness of the CVE.

Figure 22 presents the data flow between different subsystems in the CVE project.

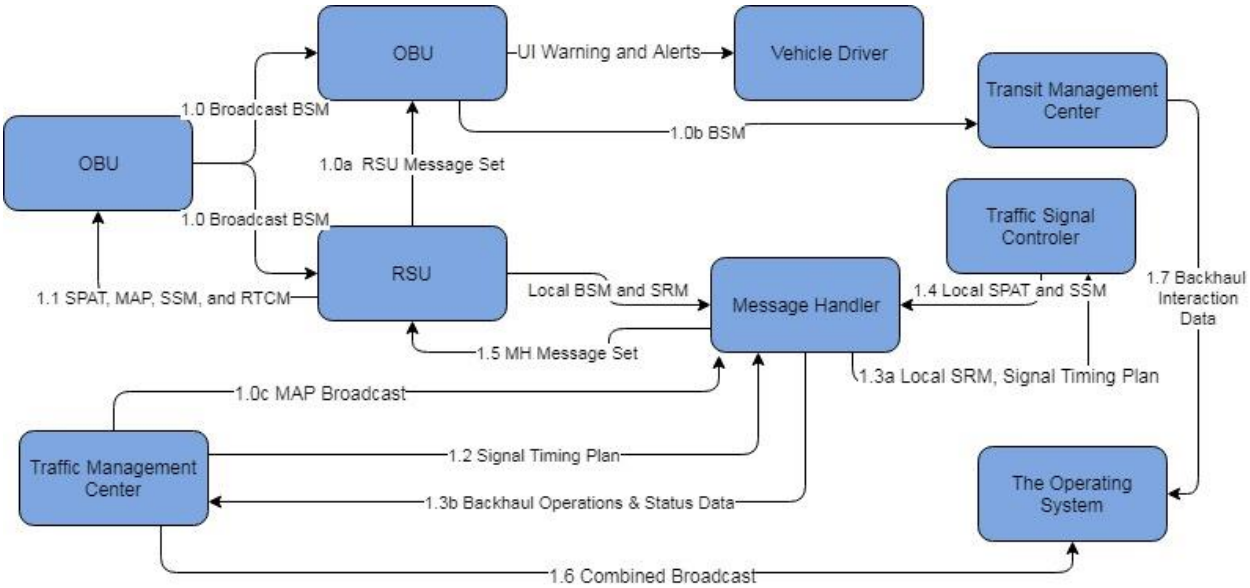

Figure 22: Connected Vehicle Environment Data Flow Diagram

Source: City of Columbus

6.2.4. Multimodal Trip Planning Application

For the MMTPA project, which is shown in **Figure 23**, travelers will have the ability to plan and book trips through the MMTPA. Upon payment completion, trip information is communicated with mobility providers. All the user details and executed trip details will be logged by the MMTPA provider. After redaction of PII, executed trip details will be transmitted to the Operating System. This data includes number of trips booked, trips per mobility provider, trip length, duration, wait time, mode choice, cost of trip, obfuscated/aggregated start and end points, and trip start and end times. In addition, trip data will be collected from the participating mobility providers during the pre- and post- deployment periods.

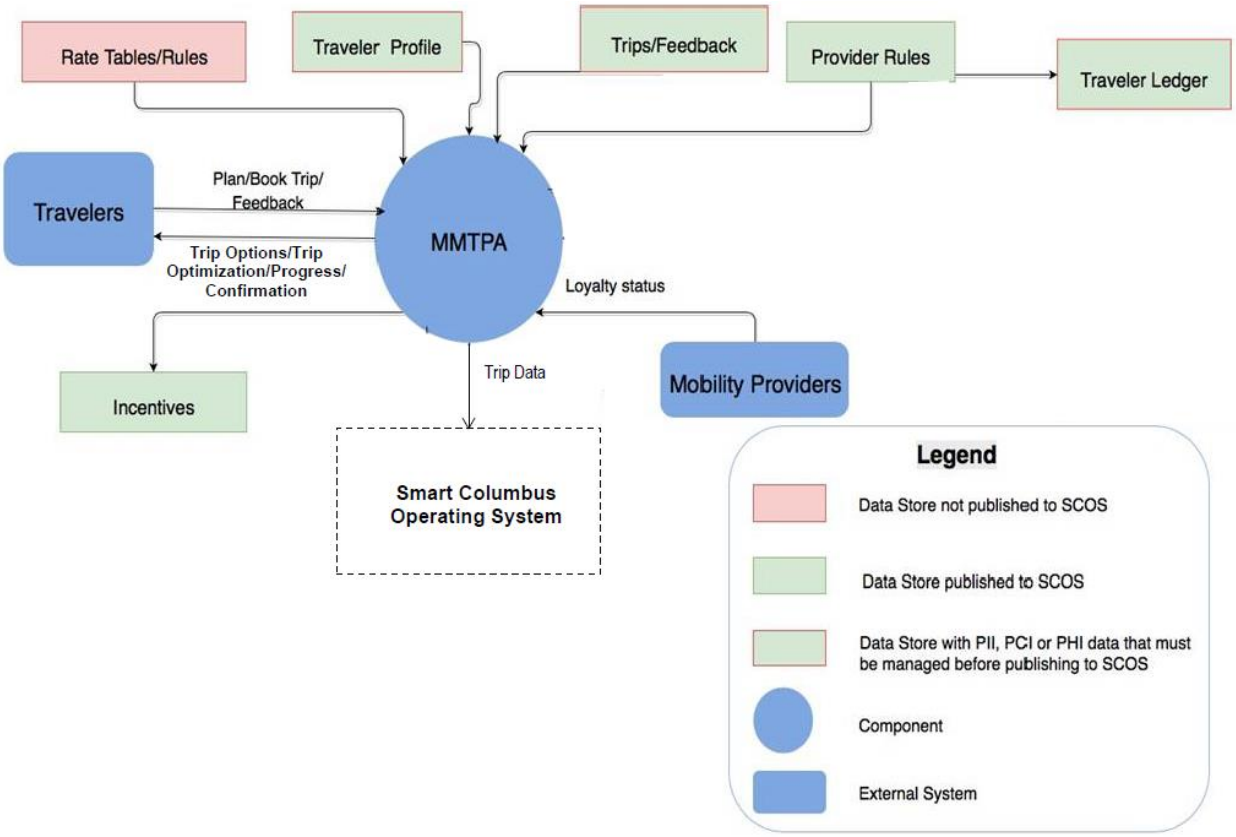

Figure 23: MMTPA Data Flow Diagram

Source: City of Columbus

This data will be used to assess the impact of MMTPA on the change in ridership for mobility providers. Also, customer and mobility provider surveys will be conducted to capture insights on perceived changes in improved access, mode choices, trip type, ease-of-use, and convenience of the application. Resulting data will be used for evaluation.

Surveys of mobility providers will be focused on gaining insights on the perceived impact of MMTPA implementation on the ridership changes, efficiency in comparison to other payment methods and additional feedback. Customer surveys will capture insights on perceived ease of accessing jobs and services, ease of use, and convenience.

6.2.5. Mobility Assistance for People with Cognitive Disabilities

For the MAPCD project (see **Figure 24**), participants will have the options to specify travel preferences including accessibility requirements, route choices, pickup and destination time, etc. Executed trip data will be collected from the project and archived after PII redaction. In addition, paratransit ridership data on both paratransit and fixed routes will be collected from COTA and archived for evaluation. Customer surveys are conducted to capture insights on caregiver experience, perceived independence, ease of use, and safety of the executed trips.

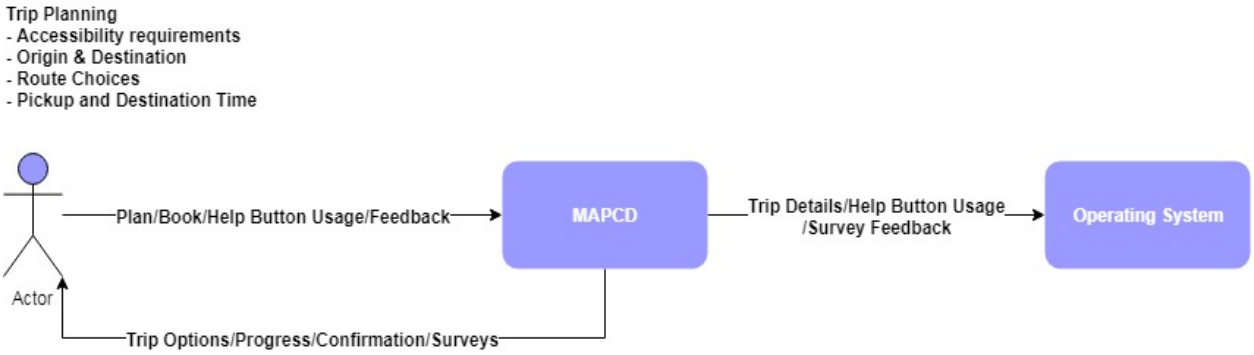

Figure 24: Mobility Assistance for People with Cognitive Disabilities Data Flow Diagram

Source: City of Columbus

6.2.6. Prenatal Trip Assistance

For the PTA project (see **Figure 25**), demonstration participants will have the ability to reserve on-demand transportation services for their prenatal and postnatal appointments, pharmacy visits, food banks, and other services. Trip data, including trips status (scheduled, unscheduled, canceled, missed), will be collected from the project. In addition, customer surveys will be conducted to capture insights on time spend on trip planning and execution, wait times, reliability, safety, friendliness of staff, and ride satisfaction. Also, OSU will compare the number of recommended versus attended appointments. Data containing PII that is required for the evaluation will be directly transmitted from the data source (PTA system and MCOs) to the OSU. The Operating System team will work in conjunction with OSU to ensure that the connection is made with the required data sources. As needed, the Operating System team will record transactional information void of any personal data used to validate the usage of the system.

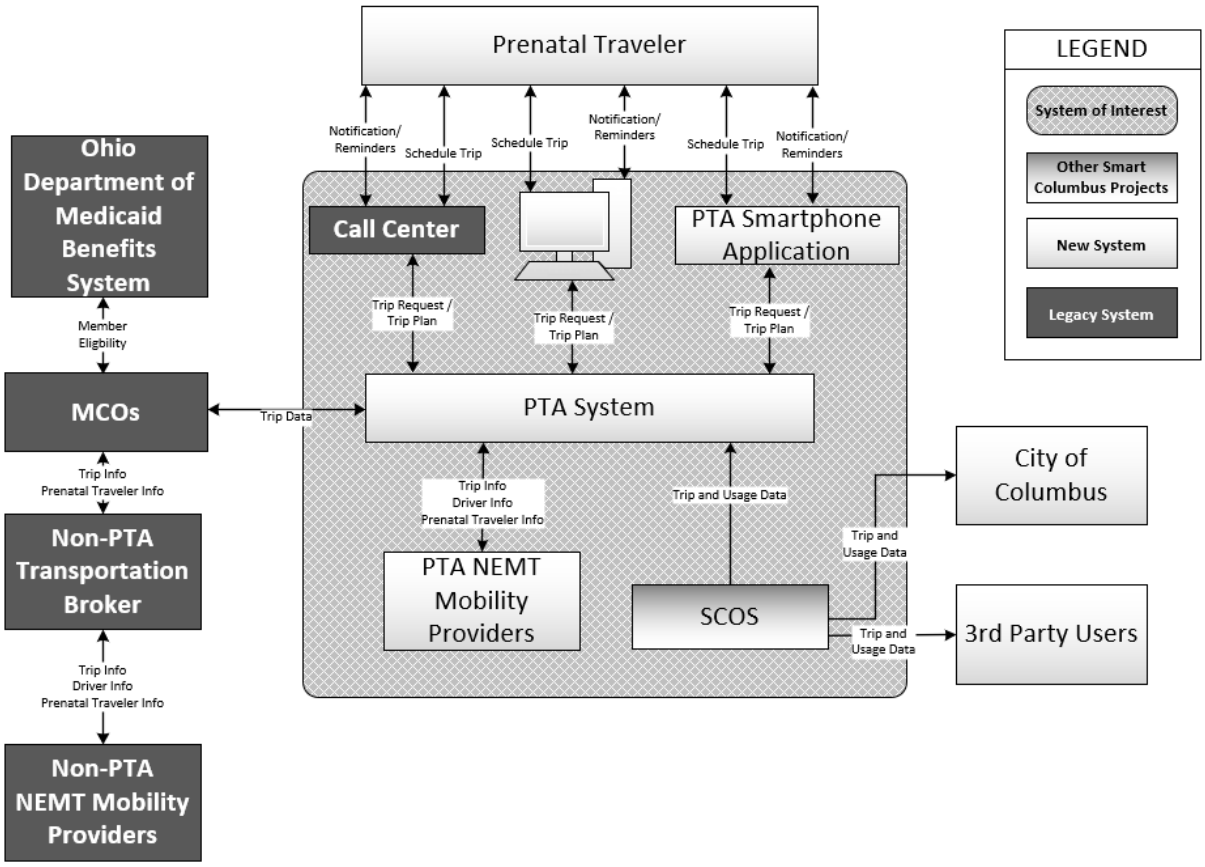

Figure 25: Prenatal Trip Assistance Data Flow Diagram

Source: City of Columbus

6.2.7. Smart Mobility Hubs

For the SMH project (see **Figure 26**), travelers will have the option to plan and book the trips from the mobility hubs either through the kiosks or through the MMTPA using the free Wi-Fi service at the hub. Travelers will be provided with emergency buttons at all SMH locations in case of emergency or help needed. Kiosk or personal device-based trip planning and booking data, additional modes/services available at SMH and emergency call button data will be collected by the Operating System and made available for evaluation. Average wait times, duration connected to the internet, and availability of alternative transportation modes data will be collected from the MMTPA project and archived for evaluation. Customer surveys will be conducted to gain insights on convenience and safety of the service.

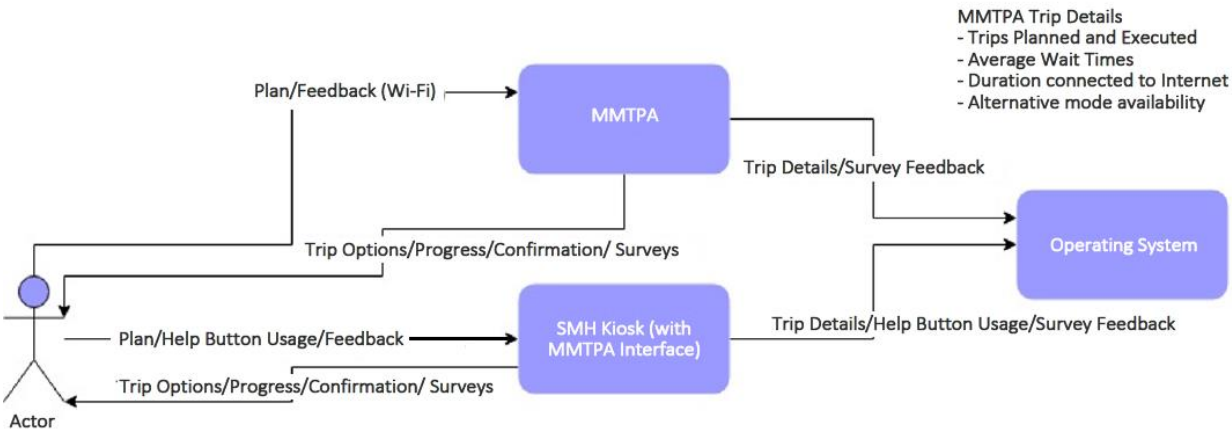

Figure 26: Smart Mobility Hubs Data Flow Diagram

Source: City of Columbus

6.2.8. Event Parking Management

For the EPM project (see **Figure 27**), the application will provide travelers with the ability to search, identify, and reserve available parking spots. Travelers will submit their preferences including location of interest, date and time, number of spots, duration of parking, and type of facility (garage, lot, meter, etc.). The EPM application will return all the available parking spots to the traveler and gives the option to reserve available ones. The EPM application will log all the parking search requests, reservations, cancelations, and utilization status (reservation used vs. not used). Customer surveys will be conducted to gain insights on idling time for parking spot search, ease and accuracy of finding parking, convenience, awareness, and frequency of usage. All the data will be transmitted from the application to the Operating System after PII redaction. This data will be archived and made available for evaluation purposes.

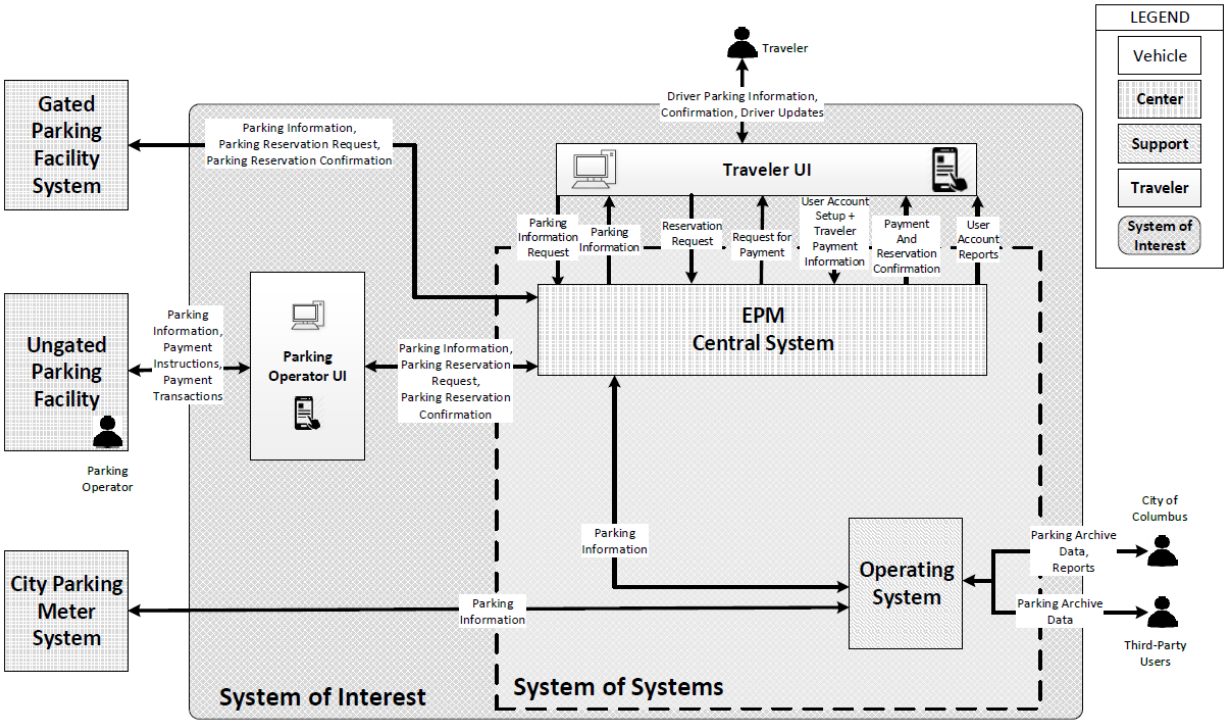

Figure 27: Event Parking Management Data Flow Diagram

Source: City of Columbus

6.2.9. Connected Electric Autonomous Vehicle

For the CEAV project Smart Circuit and Linden LEAP deployments (see **Figure 28**), the following data will be collected: number of travelers boarding and alighting at each stop, vehicle miles traveled, number of trips, and travel routes data will be collected by the mobility service provider. For the Food Pantry deployment, the number of boxes transported will be collected manually instead of traveler boardings and alightings and all other data collected will remain the same. This data is transmitted to the Operating System, where it will be archived and made available for evaluation. Other non-project data includes ridership data from COTA, including ridership data at the stops where both CEAV and COTA service is available. In addition, traveler surveys will be conducted to capture insights including frequency of usage, walking distance, service reliability, other modes of travel, etc.

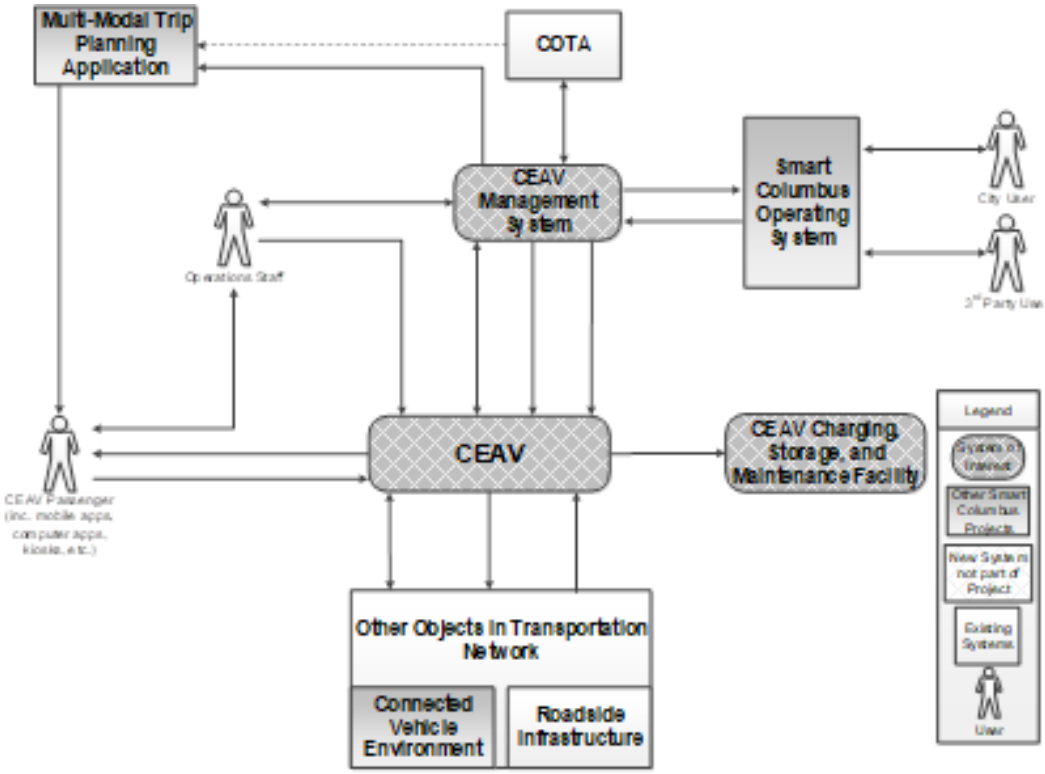

Figure 28: Connected Electric Autonomous Vehicle Context Diagram (Desired)

Source: City of Columbus

Note: *The data fields this diagram presents are desired and they might be subject to change.*

Table 34 shows all data sources relevant to performance measures and the projects to which they apply.

Table 34: Project Data Used for Evaluation

Project	Data Source	Data Collected
Operating System	Operating System	• Number of applications created using the Operating System data • Number of reports created using the Operating System data • Number of visualizations created using the Operating System data • Number of analytics created using the Operating System data
		• Number and frequency of data retrievals from the Operating System (Analytics tracking) • Number of requests received by the agency staff for datasets before publishing on the Operating System • Number of requests received by the agency staff for datasets after publishing on the Operating System
		• Number of requests for datasets before publishing on the Operating System • Number of requests for datasets after publishing on the Operating System
		• Percentage of datasets accessible to applications (internal and external)
		• Time spent on the Operating System (based on user IP address) • Time spent for data discovery (based on user IP address)
CVE	CVE (archived in the Operating System)	• SPaT message content and time that would have been sent (before implementation) • SPaT message content and time (after implementation) • Rate of deceleration • BSM message containing vehicle trajectory information. No other vehicle data will be collected. • Frequency of CV passing RSU • Period of SPaT activation
		• Number of preemption requests granted/denied
		• CV speeds in school zone before implementation • CV speeds in school zone after implementation • Frequency of CV passing RSU • BSM message containing vehicle trajectory information (no other vehicle data will be collected) • Period of TIM activation
		• Travel time through the intersection (via GPS geofences) • Number of priority requests granted/denied

Project	Data Source	Data Collected
MMTPA	MMTPA (archived in the Operating System)	• Number of trips explored through MMTPA • Number of trips booked through MMTPA
		• Trip date and time
		• Trip origin and destination • Trip distance
		• Source • Profiles created • Frequency of booked trips • Retention – how long are they using the app
		• Number of trips involving one or more mode shift
		• Number of trips booked for each mobility provider
		• MMTPA ratings • MMTPA comments
		• Trips booked to and from job centers and services
MAPCD	MAPCD (archived in the Operating System)	• Number of paratransit rides
		• Number of COTA ridership on fixed-route by demonstration participants using Mobility Assistance application vendor
		• Trip selection (route, date/time) • On trip performance (on/off route, mode, stuck) • Help button usage
PTA	PTA (archived in the Operating System) NEMT Providers	• Number of times PTA system is accessed (by type)
		• Number of scheduled, rescheduled, canceled, missed trips • Type and purpose of trips • Trip distance
SMH	SMH (archived in the Operating System)	• Number of IK-based trip-planning requests
		• Wait time of passengers at SMH
		• Number of alternative modes of transportation at any time
		• Number of trips beginning or shifting modes at Hubs
		• Number of Wi-Fi-based trip-planning requests/booking (mobile device)
		• Number of additional modes/services at an SMH
		• Number of emergency button calls
EPM	EPM (archived in the Operating System)	• Number of EPM users using the application to find parking
		• Number of EPM users using the application to pay for parking

Project	Data Source	Data Collected
		• Number of EPM users using the application to find directions to parking facility • Number of EPM users using the parking facilities found and/or paid for using EPM Application
CEAV	CEAV (archived in the Operating System)	• Number of passengers traveled;
		• Number of CEAV miles traveled;
		• Number of CEAV trips;
		• Schedule time for CEAV at stops • Actual arrival time of CEAV at stops
		• Number of CEAV boards and alights at stops not shared by COTA
		• Number of CEAV boards and alights at stops shared by COTA.
		• COTA ridership at stops shared by CEAV
		• The number of food pantry boxes transported in the shuttle and the number of boxes distributed to patrons on a daily basis.

Source: City of Columbus

Table 35 presents the data collected from Smart Columbus surveys for performance evaluation.

Table 35: Project Survey Data

Project	Data Source	Data Collected
CEAV	User Surveys and interviews (archived in the Operating System)	***CEAV Passenger Survey*** • Mode of travel before and after CEAV deployment • Number of destinations visited while at CEAV deployment area • Number of times vehicle is moved after arriving at CEAV deployment area • Number of times CEAV used once arriving at CEAV deployment area • Frequency of CEAV use • Percentage of travel through CEAV • Expectation for the service • Perceived travel time reliability • Perception of convenience • Mode of FMLM transportation • Perceived ease of FMLM travel pre- and post-CEAV • Overall customer satisfaction • Mode of travel before and after CEAV deployment • Approximate Walking distance • Positive and negative experiences

Project	Data Source	Data Collected
		• Suggestions for improvement ***CEAV Food Pantry User Survey*** • Date of food pickup at Rosewind • Type of transportation used for food pick-up at Rosewind • Distance traveled to Rosewind • Time traveled to Rosewind • Time of walking as part of trip to Rosewind • Length of wait for food pantry box at Rosewind • Satisfaction of food pantry boxes at Rosewind • Visitation to St. Stephen's food pantry • Date of St. Stephen's food visit • Type of transportation used for food pick-up at St. Stephen's • Distance traveled to St. Stephen's • Time traveled to St. Stephen's • Time of walking as part of trip to St. Stephen's • Length of wait for food pantry box at St. Stephen's • Satisfaction of food pantry boxes at St. Stephen's • Transportation options used weekly • Mode used most • Transportation options available • Locations of food access • Most used location for food access • Amount of food that household has access to • Amount of food and available money to get more • Food received was enough to meet needs • Frequency of balanced meals provided • Frequency of skipping meals due to money • Number of times accessing a food pantry • When learning of Linden LEAP • How interacting with Linden LEAP • When first interacted with Linden LEAP • Level of trust in technology • How the vehicle should operate in a neighborhood • Benefits to Linden • How the shuttle fits in the neighborhood • Personal situation changes due to pandemic • Food situation changes due to pandemic
CVE	User Surveys and interviews (archived in the Operating System)	***Emergency Responder Customer Survey*** • Emergency response times • Perceived safety improvements • RLVW

Project	Data Source	Data Collected
		• customer survey • Driver awareness of traffic signal status • Change in driver behavior ***RSSZ Customer Survey*** • Driver awareness of speed in school zones • Change in driver behavior ***TSP Customer Survey*** • Perceived reliability of the signal prioritization feature • On-time performance of the transit service
MMTPA	User Surveys (archived in the Operating System)	***MMTPA User Survey*** • Changes in mode choice and fare payment • Changes in trip type (single mode vs. multimode) • Increase in ridership by mode • Trip frequency and time by mode • Examples of opportunities opened by the MMTPA • Ease of accessing jobs and services pre- and post-deployment of MMTPA • Ease of participating in a multimodal planning and payment solution • Preferred transportation services • Most influential factors in choosing transportation services (cost, trip time, comfort, etc.) • Percentage of travel through MMTPA • Alternative modes of travel • Additional transportation services that customers want to include in the MMTPA • Perceived ease of accessing jobs and services • Most desired features • Most valuable features offered • Positive and negative experiences • Suggestions for improvement ***Mobility Provider Survey*** • Change in ridership since implementation • Change in route or service popularity • Positive and negative experiences • Suggestions for improvement
MAPCD	User Surveys and interviews (archived in the Operating System)	***MAPCD Participant and Caregiver Surveys*** • Feeling of safety • Ease of use • Perceived independence • Help button usage • Trip selection – unique trips • Past and current frequency using paratransit

Project	Data Source	Data Collected
		• Past and current frequency using fixed-route buses • Factors in mode choice decision • Need for a caregiver on paratransit versus fixed route • Examples of opportunities opened by this project (places that were previously difficult to reach) • Ease of use • Changes in travel behavior • Positive and negative experiences • Suggestions for improvement
SMH	User Surveys and interviews (archived in the Operating System)	***SMH User Survey*** • Ease of kiosk use • Trip time • Accessibility of SMHs • Convenience of SMHs • Usefulness of SMH • Average wait time at SMH • Feeling of perceived safety provided by various SMH components (call button and lighting) • Perceived ease of multimodal transfers pre- and post-SMH
		SMH Mobility Provider Interviews • Perceived usefulness of SMH
PTA	User Surveys and interviews (archived in the Operating System)	***PTA User Survey*** • Ease of PTA system use • Convenience of PTA system • Usefulness of PTA system • Accessibility of PTA system • Reliability of PTA system • On-time performance • Satisfaction with transportation • Number of trips taken to different destinations (by type, purpose) • Number of times that the participant has used another form of transportation to visit a doctor or healthcare provider • Perceived ease of trip planning to prenatal visits pre- and post-PTA
EPM	User Surveys and interviews (archived in the Operating System)	***EPM User Survey*** • Awareness and frequency of use of the app • Knowledge of available parking • Time spent around parking facilities in finding a parking spot pre- and post-EPM • Distance traveled to find a parking spot pre- and post-EPM • Ease and accuracy of finding parking (garages, lots, meters, loading zones)

Project	Data Source	Data Collected
		• Convenience (one-stop shop – search, reserve, pay, confirm, drive (directions) and use) • Perceived change in time traveled around parking facilities to find a parking spot pre- and post-EPM
Operating System	User Surveys and interviews (archived in the Operating System)	***Data Provider Survey (Agency and Other Providers)*** • Ease of data-sharing ability before and after implementation of the Operating System • Number of requests for datasets pre- and post-publishing on the Operating System • Ability to ingest/harvest the data into the Operating System vs. previous data-sharing mechanisms • Provider satisfaction with method(s) of data ingestion into the Operating System ***Agency User Survey and Public Survey*** • Ability to access and use the data pre- and post-Operating System • Usefulness of the accessed data for intended purpose • Number of applications, reports, analytics and visualizations created using the Operating System data • Amount of time taken to get access to data before and after implementation of the Operating System • Ability to find data required by the users • Customer Satisfaction Ratings on • Quality, freshness, and completeness of data • Metadata quality • Visualization tools/features • Analytical tools/features • Method(s) of data extraction from the Operating System

Source: City of Columbus

Table 36 presents the data collected for performance evaluation from third-party sources including the City of Columbus, COTA, National Transit Database (NTD) and Columbus Public Health (CPH).

Table 36: Third-Party (Non-project) Data

Project	Data Source	KPI	Data Collected
CVE	COTA CAD/AVL	On-time performance; Running time; Headway reliability	• Scheduled arrival times at bus stops
			• Time of arrival at scheduled bus stops
	City of Columbus Department of Public Safety EMS records	Emergency Response Time	• Emergency response times for TSP-enabled EMS vehicles
			• Emergency response times for EMS vehicles
MMTPA	NTD		• Unlinked passenger trips

Project	Data Source	KPI	Data Collected
		Customer trips moved from paratransit to fixed route	• Total boardings
			• Passenger miles traveled
MMTPA	COTA	Percentage of new transportation service users	• Total number of transportation service users • Number of new transportation service user's post-deployment of MMTPA
MMTPA	MORPC	Trips booked to and from Job Centers	• Locations of job centers and Services
MAPCD	COTA paratransit program records	Dollars saved in paratransit program	• Number of paratransit rides made by pilot participants the year before implementation
			• Cost of paratransit program
			• Cost of mobility assistance vendor to COTA per ride
PTA	OSU	Ratio of attended prenatal appointments	• Average number of appointments recommended for prenatal moms • Average number of appointments attended by prenatal moms (in the study area) • Anticipated number of prenatal moms who will live in the project area during this pilot demonstration program
		Gestation details	• Gestational age when woman learned she was pregnant • Gestation week of first prenatal appointment • Gestational age at delivery
		Number of preterm births and infant mortality rate	• Number of preterm births, infant mortality
		Number of trips taken to different destinations (by type, purpose)	• Number of eligible prenatal moms • Number of trips taken by type and purpose
	Vital Statistics (CDC)	Infant Mortality Data	• Birth data • Period linked birth - infant death data • Birth cohort linked birth – infant death data • Mortality multiple cause data • Fetal death data

Source: City of Columbus

Table 37 presents the data collected as part of the confounding factors.

Table 37: Confounding Factors Data

Confounding Factor	Data Source	Data Collected
Fuel Prices	U.S. Energy Information Administration	• Average weekly fuel prices for different grades of petrol/gasoline and diesel
Emissions	• MORPC • Ohio Environmental Protection Agency • U.S. Environmental Protection Agency (EPA)	• GHG emissions and Ozone emissions using MOVES model • Emissions conversion rates from PMT • Emissions conversion rates from idling time
Construction Activities	• Paving the Way • City of Columbus • ODOT	• Planned and historical construction activities • Right-of-way permits occupancy and excavation
Weather	INRIX	• Historical weather events that affected lane closures
	NOAA	• Historical weather data including (temperature, precipitation, etc.,)
Traffic Conditions	INRIX	• Speed and travel time data for XD-level segments
Traffic Incidents	INRIX	• Historical traffic incidents that resulted in lane closures
Change in Parking Fares	IPS Group	• Location based fare schedule of *City-owned Metered Parking*
	Private parking garage vendors who participate in EPM project	• Updates in pricing policy
New Parking Facilities	Private parking garage vendors that participate in EPM project	• Newly established parking facilities
CPASS (Local Mobility Program)	COTA	• Daily COTA ridership of CPASS riders
Planned System Outages	All project vendors	• Time windows of system outages put into effect for maintenance and updates
Paul G. Allen Electrification Project	Smart Columbus/HNTB	• Percent GHG emission reductions from baseline year • Total GHG reductions/savings from baseline year measured in MTCO2
COVID-19 pandemic	Traffic impacts: OS (from 3rd party data); Transit: COTA; On-street parking: City (via OS); State of OH and City of Columbus for SAH and social distancing	• Traffic impacts • Transit ridership impacts • On-street parking impacts • Dates/Length of stay-at-home orders • Social distancing requirements

Confounding Factor	Data Source	Data Collected
Public Protests	Department of Public Service Division of Parking Services	• Parking meter closures

Source: City of Columbus

Evaluators will request and curate data maintained by other agencies. In many cases, Smart Columbus will encourage agencies, such as COTA and MORPC to maintain their datasets on the Operating System, sharing the relevant and appropriate portions.

6.3. DATA QUALITY

The Operating System is focused on providing high-quality datasets to meet the following objectives:

- Minimize the data cleaning efforts by the end users.
- Provide 'Ready-To-Use' datasets for the evaluators.
- Make the datasets on the Operating System as fusion-friendly as possible with datasets from other sources.

To ensure this, a formal data curation process is used. During this process, the data curator works with the source entity to provide as much information as possible with the dataset so that it has value to users. A complete overview of Data Ingestion Workflow process followed by the Operating System is depicted in **Figure 29**. Whether collected by the Smart Columbus project or provided by a partner agency, every data set will undergo an assessment by the City in the "Feed Intake Process" to ensure quality, completeness, and accuracy.

In the "Curate Feed" process, the criteria for data quality assessment will be established based on the information provided by the Data Steward of the providing agency. Information collected includes update frequency, expected outages, method of collection, spatial and temporal boundaries, treatment/redaction strategy applied (if data contains PII), etc.

Measures to ensure the quality of data include:

- Conducting spot checks against original materials.
- Performing checks for completeness to determine all expected records are present.
- Performing checks for validness to determine all records are present in the specified field format/data type.
- Performing checks for standardization to determine consistency of all records present in each field.
- Performing checks to identify misfielded values.
- Establishing processes and technologies to ensuring the conformance of data values to business requirements and acceptance criteria.

The established criteria will be used to perform quality and completeness checks for all the datasets during "Schedule Feed" process. Validation Rules and Standardization Policies will be applied to perform the checks. If the data feed did not pass the checks, apparent errors will be flagged and returned to the data provider for clarification. The returned data set will receive the same data quality analysis. In cases where the Smart Columbus team combines data sets, the combined data set will be reviewed according to the same data quality procedures. Additionally, datasets will be re-evaluated for quality and value on a regular basis. Detail description on data quality practices to be enacted can be found in the Smart Columbus Data Management Plan.

As needed for the individual projects, selected datasets will undergo a data transformation process to meet the evaluator needs.

Figure 29: Data Ingestion Workflow

Source: City of Columbus

6.4. PERSONALLY IDENTIFIABLE INFORMATION

The privacy of workers and citizens is an important consideration while collecting and using data. While many data sets are impersonal, such as anonymous surveys, other data will be tied to individuals and contain sensitive information. During the data curation process of a dataset, there is a heavy focus on privacy and confidentiality—if a dataset contains PII or Sensitive Personally Identifiable Information (SPII), an evaluation will be performed to determine if the sensitive data is necessary.

If the sensitive data is not necessary, the data provider will be asked to remove the data before transferring it to the Operating System. If the data steward cannot remove the sensitive data, it will be anonymized, redacted, or removed during the ingestion process based on the technical controls defined in the *Smart Columbus Data Privacy Plan*[33] so that it will contain no confidential data. If performing this process renders the data unusable for research purposes, then the dataset will be made private or will not be ingested into the system. If ingested as personal data, it will be masked during the data ingestion process. If data must be masked, procedures defined in the *Smart Columbus Data Privacy Plan* will be utilized. Datasets that are anonymized will contain metadata indicating that they have been anonymized. Any sensitive data (without masking) deemed necessary for evaluation purposes will be directly transmitted from the source systems to the evaluators' systems.

Periodically throughout the program and part of the peer review processes for updates, changes to the system will be reviewed to ensure that no SPII/PII data is stored in databases, logs, files, or anywhere that it should not be stored.

6.5. DATA SECURITY

Data security is fundamental to public confidence in the Smart Columbus project demonstrations and the overall success of the program's objectives. While no information system can guarantee that a breach will never happen, the Smart Columbus team views data security as a foundational principle, and it is dedicated to ensuring that all Smart Columbus data including PII and SPII will be stored only on IT infrastructure that employs security controls commensurate with the risk to the individual that would result from unauthorized access, disclosure of use of the information.

Information Security is based on maintaining the "CIA Triad": confidentiality, integrity, and availability of information. The Smart Columbus approach to system threat assessment, analysis of application flows, and device classifications is based on the process defined by the Federal Information Processing Standards (FIPS) Publications 199 and 200.

The development and application of security controls and standards for Smart Columbus demonstration data are based on the recommendations of *National Institute of Standards and Technology (NIST) 800-122 "Guide to Protecting the Confidentiality of PII"* and *NIST 800-53 "Security and Privacy Controls for Federal Information Systems and Organizations"*[34]. The following security controls will apply to all PII and SPII collected, stored, and used in Smart Columbus demonstration information systems:

Consistent with the Cooperative Agreement, Smart Columbus will meet the following minimum-security baselines for demonstration PII as required by USDOT:

- Protect all PII, electronic and hardcopy, in its custody from unauthorized disclosure, modification, or destruction so that the confidentiality, integrity, and availability of the information are preserved.
- Store PII only on IT infrastructure employing security controls commensurate with the risk to the individual that would result from unauthorized access, disclosure, or use of the information.

[33] https://d2rfd3nxvhnf29.cloudfront.net/2019-09/SCC-D-Data%20Privacy%20Plan-FINAL-20190906%5B1%5D.pdf

[34] https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-122.pdf

- Encrypt all PII in transit or at rest.
- Encrypt all PII transmitted or downloaded to mobile computers/devices.
- Ensure that all individuals having access to PII have received training in the policies.

The following Security Controls are discussed in detail in the *Smart Columbus Data Privacy Plan*:

- Anonymity.
- Encryption.
- Access Control – Cabinet locks, etc.
- Access Control – Remote Electronic Access to Devices and System.
- Authorization – Identification-Based.
- Authorization – Role-Based.
- Penetration Testing.

6.6. DOCUMENT PROCEDURES FOR DATA ARCHIVE

This section describes the long-term storage and handling of the data sets and related documentation, and naming conventions of the data sets and data files.

Every data intake request will be followed up by collecting all the data and metadata information from the providing data source. All the Operating System datasets will comply with Open Data Metadata Schema v.1.1. This schema is a standard defined and used by the U.S. Government and is extensible to include other necessary fields. The Operating System complies with all Project Open Data requirements for its catalog and datasets. The Operating System platform extends the metadata to include other common metadata fields that are populated when the dataset is first scheduled for ingestion.

When metadata is changed through the application program interface (API) or through a web browser by a user, an audit log of that action is recorded and stored in the dataset's activity stream for others to see. This enables users to view a history of the dataset metadata.

The Operating System platform will only use platform-independent and nonproprietary formats to focus on machine-readability of the data. To accomplish this, it will be encouraged that any data source that is in a format that is not machine-readable attempt to be converted to a different format during the data ingestion design process. A sample, non-comprehensive, list of machine readable and non-machine-readable formats is provided in **Table 38**.

Table 38: Sample File Types

Machine-Readable	Non-Machine-Readable
JSON	PDF
XML	JPG
CSV	TIFF
Shape	MP4
GeoJSON	WAV

Source: City of Columbus

Once metadata is completely identified and submitted through the "Data Provider Submission Form," which is part of DMP, data from both the Smart Columbus projects and other partnering agencies will be ingested

into the Operating System after being redacted from PII. All the data will be stored in the Operating System data lake, which is a storage repository that holds a massive amount of raw data in a secure way and makes it available to all the other supported operations in the system.

The Operating System follows the following data hierarchy structure for ingesting/archiving data:

- Data Category/Organization: A logical collection or grouping of data sets which were obtained under the same contract or agreement. (It is anticipated that the data from a given prototype, demonstration, or project will make up one data category/organization on the Operating System).
- Dataset: Contains a certain type of data, such as highway detector data, traffic signal timing data, or weather data. Each type of file in a data set contains the same contents, in the same format with the only difference among these files being the time and the location at which the data elements were collected. There are two data set types: archived and real-time.
- Data File: An archived collection of data that can be comma separated values (CSV), text, binary, or other file types, which might be zipped/compressed depending on the size of the original file.

During the data ingestion process, a data retention policy/criterion will be established for each dataset to ensure moving of infrequently accessed data to other, less expensive storage, or to make a recommendation to purge it in accordance to Ohio Public Records law requirements if data will no longer be valid or needed for evaluation/program needs. A detailed description of data retention policy is provided in the *Smart Columbus' Data Privacy Plan*.[35]

Once ingested, datasets are available for access through an API and a CSV downloadable file. For private datasets, authenticated access will be provided for the designated users.

6.7. DATA MANAGEMENT PLAN

Many partner agencies have agreed to contribute data for performance evaluation, as well as using the Operating System as the nucleus for their data. When a data need is identified, the project team will actively seek an efficient means of collection or coordination with another agency.

The Performance Measurement Plan identifies many elements that will serve as baseline data. In some cases, these baselines must be collected before deployment. Post-treatment data will be collected in the same way as the baseline or using new deployed technology. In either case, evaluators will ensure that the formats are compatible and comparable. Data will be requested, presented, and stored in common file formats. If acquired data is not in such a format, it will be converted so that the common format is available for use by the providing agency.

Data collection and management procedures and policies are detailed in the *Smart Columbus Data Management Plan*[36], which describes:

- How data will be collected, managed, integrated, archived, and disseminated.
- The City's plans for managing their data as a strategic asset and making open data available to the public.
- How and where the data will be shared, subject to applicable privacy, security, and other safeguards.
- How the City will make that data available in a secure environment for the use of qualified researchers to enable performance measurement and support independent evaluation.
- The City's plans for data management and auditing controls.

[35] https://d2rfd3nxvhnf29.cloudfront.net/2019-09/SCC-D-Data%20Privacy%20Plan-FINAL-20190906%5B1%5D.pdf

[36] https://d2rfd3nxvhnf29.cloudfront.net/2020-08/SCC-E-DataManagementPlan-Update-v1_0.pdf

- Existing and future data standards.
- Terms of existing and future data-sharing agreements.
- Re-use, redistribution and derivative product policies.
- Archiving and preservation plans.

Chapter 7. Data-Sharing Framework

The objective of the data-sharing framework is to facilitate the sharing of the data generated in the Smart Columbus projects so that they can be used for further research into Smart Cities applications and deployments.

While this document identifies a list of data to be shared, collected, and analyzed, it does not represent the end of coordination between agencies and the City of Columbus. Coordination will continue as projects are further refined and implemented. Should one party realize that another has data that would facilitate their progress or ability to evaluate performance, the data owner will provide that data if possible and practical. In general, the data owner will provide data in a format consistent with its intended use.

Smart Columbus data security and participant PII are under the oversight of an Institutional Review Board (IRB). IRB approval or exemption will be determined within each of the constituent projects of the Smart Columbus demonstration. Documents for submission to the IRB will be developed for each project, with oversight by an IRB compliance consultant, and will include the research protocol documents, participant recruitment plans, informed-consent documents, training plans and materials, and ongoing amendments as needed.

Upon IRB approval, PII related fields will be identified and redacted from the source data as a part of the data cleaning and transformation process. In other words, if a user or agency does not need the portion of data that contains PII, it will be removed before sharing. In cases where data containing PII is deemed necessary for the evaluation purposes of the project, the data will be directly transmitted from the source system to the evaluator system. This is to minimize the amount of unnecessary spreading of PII, even among partner agencies. **Section 6.4** provides more information about policies regarding PII.

Public data that has been vetted through the Operating System project team and underwent the data curation, design, and ingestion processes will be shared publicly and available to all users. Once data is identified that needs access control and authorization mechanisms, the appropriate controls will be put into place – specifically for when other Smart Columbus Programs are ready to begin sharing data through the Operating System. The Operating System has a concept of private datasets with built in authentication which can be used. To access private datasets, authentication and authorization will be required for the user interface and the API.

All project and evaluation data without PII will be routed to the USDOT's ITS Public Data Hub. The public will be able to access only the datasets that are designed for public consumption – that is, free from PII and useful to the public. Project participants will have access to their PII data through the applications to which they are subscribed. The public will have the option to access the data through an API, as well as download the data in a CSV format.

Throughout the data collection and analysis process, updated and new information will become available. This added information will be shared so that evaluators and users are able to make use of the latest information. Previous datasets will be archived and available as well. Update frequency will vary based on the data type. For example, survey responses will be posted after surveys have been formatted and transcribed if necessary. Crash data will be added when it becomes available, which may be months after the crashes described in the dataset. Project and third-party datasets that will be available in USDOT's ITS Public Data Hub are shown in Tables 39 and 40 below.

Table 39. Project dataset availability in USDOT's ITS Public Data Hub

Project	Data Source	Data	Link	Description	Key Performance Indicators	Research Value	Data Collection Start Date	Data Collection End Date	Expected Complete Data Availability Date
MAPCD	SCOS	Number of Trips Taken	https://discovery.smartcolumbusos.com/?q=cota%20unlinked&page=1&facets%5Borganization%5D%5B%5D=Central%20Ohio%20Transit%20Authority	Trips taken using COTA fixed route service	• Customer trips moved from paratransit to fixed route • Overall number of trips taken	Analyze the usage trends of Cognitively Disabled Participants and conduct a comparative analysis against project objectives. Other prospective deployments sites could learn about the impact of the pilot deployment and plan their projects accordingly.	4/29/2019	4/28/2020	Available
		Trip Data	https://discovery.smartcolumbusos.com/dataset/able-link/mapcd_trip_data	Trip metrics provided from the application: Route, date/time, trip performance, help button usage, GPS accuracy, battery usage.			4/29/2019	4/28/2020	Available
PTA	SCOS	NEMT trips taken in the intervention group	Available at the end of the project	This dataset presents information about the prenatal trips including obfuscated origins, destinations, trip status (scheduled, completed, rescheduled, canceled, etc.,), trip purpose and distance.	• Number of NEMT trips taken (by type, purpose) • Adequacy of prenatal care Kotelchuck Index	Analyze the usage trends of Prenatal Moms and conduct a comparative analysis against project objectives. Other prospective deployments sites could learn about the impact of the pilot deployment in helping expectant moms to adhere to prenatal visit schedules and plan their projects accordingly.	5/31/2019	3/30/2021	5/31/2021
		NEMT trips taken in the "usual care" transportation group	Available at the end of the project	This dataset presents information about the prenatal trips including obfuscated origins, destinations, trip status (scheduled, completed, rescheduled, canceled, etc.,), trip purpose and distance.	• Number of NEMT trips taken (by type, purpose) • Adequacy of prenatal care Kotelchuck Index		5/31/2019	3/30/2021	5/31/2021
MMTPA (Pivot)	SCOS	Multimodal Trip Data	https://discovery.smartcolumbusos.com/dataset/pivot/mmtpa	This dataset presents information about the trips taken using the Pivot Application. The trip information is aggregated using SharedStreets. This method aggregates information based on time of day or geographic areas. Trip information is aggregated and anonymized to street segments and bins so that origin, destination, and mobility provider are obfuscated. Data includes: Number of trips booked (single and multimode), trips booked to and from job centers, and number of times MMTPA used.	• Perceived improvement in access to multimodal trip planning	The major research value of this project data is to understand the user adaptiveness of multi-modal travel planning. It also helps in the predictive models that predict the migration of travelers from a SOV to multi-occupancy modes. Also, this data provides insights on changes in ridership for all participating mobility providers pre- and post-MMTPA so that the prospective deployment mobility providers can use for their infrastructure planning to accommodate additional trips.	8/29/2019	3/30/2021	5/31/2021

Project	Data Source	Data	Link	Description	Key Performance Indicators	Research Value	Data Collection Start Date	Data Collection End Date	Expected Complete Data Availability Date
CVE	SCOS	DSRC Messages communicated between RSU and OBU including BSM, Map, SPaT, SSM, TIM, and SRM	Link will be provided after project goes-live *(project team to work with USDOT to determine what portion can be real-time/streaming)*	Contents of BSM, SRM, SSM, SPaT, TIM, and Map messages communicated between Connected vehicles and infrastructure to enable various use cases demonstrated by the project. The number of alerts, requests/responses will be derived by the performance measurement team using this data.	• Emergency response times • Driver's awareness of traffic signal status • Driver's awareness of speed in school zones • Time of priority request • Travel time through intersection	As the auto manufacturers are moving towards connected vehicle communications (V2X), the raw and de-identified data would be very insightful in understanding the latency, accuracy, usefulness and adaptability of CV environment at varying levels of penetration. Since, this is one of the very few deployments across the US that deployed in an uncontrolled environment, this data could be valuable to compare against the traffic behavior and crash studies and there by access the mobility and safety impacts of the technology.	7/7/2020	3/31/2021	4/7/2021
		Transit Vehicle Interaction Event Recording (TVIER)	Post-deployment	Sanitized logs of transit vehicle interactions with other equipped vehicles in the corridor. The TVIER application will collect the event data, which will be offloaded regularly at COTA facilities. COTA will provide sanitized records of these events to the OS for lessons learned and final reporting purposes.			7/7/2020	3/31/2021	4/7/2021
SMH	SCOS	Pivot trips planned using SMHs	Link will be posted once the project goes-live	This dataset presents information about the pivot trips planned at SMH kiosks or Wi-Fi connections.	• Number of trip planning requests at SMH • Application usage (MMTPA: number of multimodal trips, number of multimodal trips planned at a kiosk)	A majority of this data helps in understanding the impact of deploying hubs on mode transfers and enabling micro-transit usage for first and last mile connections.	8/1/2020	3/31/2021	5/31/2020
CEAV	SCOS	Boardings and Alightings (Easy Mile states - Linden Deployment Dataset)	https://discovery.smartcolumbusos.com/dataset/easymile/linden_states	This dataset presents information about the number of passengers onboarding and alighting at each CEAV stop.	• CEAV passenger trips • Walking distance • Perceived convenience • Perceived reliability • Perceived improvement in FMLM transit • COTA ridership at stations with CEAV • Increase in mode shift	The CEAV usage data provides insights for assessing the impact of CEAV in serving as the FMLM option and improving modal ridership and shift. Prospective deployment sites could tailor their implementation based on the analysis findings.	2/5/2020	2/4/2021	2/11/2021
		Actual Arrival Times (Easy Mile states - Linden Deployment Dataset)	https://discovery.smartcolumbusos.com/dataset/easymile/linden_states	This dataset presents information about the actual arrival times of all CEAV shuttles at CEAV stops.			2/5/2020	2/4/2021	2/11/2021
		CEAV Ramp Deployment Status	https://discovery.smartcolumbusos.com/dataset/easymile/linden_states	This dataset presents information about the Ramp deployment status of CEAV shuttles deployed in Linden region.			2/5/2020	2/4/2021	2/11/2021
		CEAV Mileage	https://discovery.smartcolumbusos.com/dataset/easymile/linden_states	The dataset presents information about the miles traveled by the CEAV shuttle deployed in Linden region.			2/5/2020	2/4/2021	2/11/2021
		CEAV Trip Duration	https://discovery.smartcolumbusos.com/dataset/easymile/linden_states	This dataset presents information about the time taken by the CEAV shuttles to travel along their designated routes in the Linden region.			2/5/2020	2/4/2021	2/11/2021

Project	Data Source	Data	Link	Description	Key Performance Indicators	Research Value	Data Collection Start Date	Data Collection End Date	Expected Complete Data Availability Date
		CEAV Speeds	https://discovery.smartcolumbusos.com/dataset/easymile/linden_states	This dataset presents information about the speeds of the CEAV shuttles deployed in the Linden Region.			2/5/2020	2/4/2021	2/11/2021
		CEAV Battery Status	https://discovery.smartcolumbusos.com/dataset/easymile/linden_states	This dataset presents information about the battery status of the CEAV shuttles deployed in the Linden Region.			2/5/2020	2/4/2021	2/11/2021
		CEAV disengagements	https://discovery.smartcolumbusos.com/dataset/easymile/linden_states	This dataset presents information about the disengagements and reasons for the CEAV shuttles.			2/5/2020	2/4/2021	2/11/2021
		CEAV mode status	https://discovery.smartcolumbusos.com/dataset/easymile/linden_states	This dataset presents information about the drive mode (manual vs auto) of the CEAV shuttles.			2/5/2020	2/4/2021	2/11/2021
		CEAV Scheduled Arrival and Departure Times	https://discovery.smartcolumbusos.com/dataset/easymile/linden_lines	This dataset presents information about the scheduled arrival and departure times of the CEAV shuttles at their designated stops in the linden region.			2/5/2020	2/4/2021	2/11/2021
		CEAV Food Pantry Packages Transported	Link will be provided once available	This dataset presents information about the number of boxes transported by the CEAV shuttles from St. Stephen's Community House to Rosewind Community Center and distributed to patrons.			7/30/2020	TBD	TBD
EPM	SCOS	Parking Transactions	Link will be provided after project goes-live	This dataset presents information about the parking transactions made by using the EPM application. Transaction details include parking zone, timestamps of entry and exit, parking duration, location, etc.,	• Knowledge of available parking	This data provides insights into parking usage trends. When combined with traffic characteristics data, insights could be drawn into the reduction of idling time searching for parking. This metric is especially helpful during event days where travelers spend a lot of time searching for available parking spots. A comparison of usage against the project objectives will give the prospective vendors an idea of the impact created by the application, its pros and cons.	8/182020	3/31/2021	5/1/2021

Source: City of Columbus

Table 40. Third-party dataset availability in USDOT's ITS Public Data Hub

Project	Data Source	Data	Link	Description	Data Collection Start Date	Data Collection End Date	Expected Complete Data Availability Date
MAPCD	SCOS	Paratransit Rides Data	Available at the end of the project	Trip details for paratransit rides including obfuscated origin, destination, start and end timestamps, trip length, trip purpose, etc.,	4/29/2019	4/28/2020	6/30/2020
		On-time performance of Paratransit Rides	Available at the end of the project	Scheduled vs actual arrival times of the MAPCD trips	4/29/2019	4/28/2020	5/30/2020
		COTA Ridership on Fixed Routes	Pre-deployment - https://discovery.smartcolumbusos.com/?q=cota%20unlinked&page=1 https://discovery.smartcolumbusos.com/?q=cota%20unlinked&page=2	COTA Ridership information including number of boardings and alightings at each of the COTA bus stops.	4/29/2018	4/28/2029	Available
			Post-deployment - Available at the end of the project		4/29/2019	4/28/2020	7/30/2020
		COTA ADA Client Ridership	Pre-deployment - Available at the end of the project	COTA ADA Client ridership data refers to the paratransit rides taken using COTA Paratransit service. Obfuscated client IDs will be used to understand travel patterns of different users before and after deployment.	4/29/2018	4/28/2020	Available
			Post-deployment - Available at the end of the project		4/29/2019	4/28/2020	7/30/2020
CVE		COTA On-Time Performance	Available at the end of the project	This dataset presents information about the scheduled vs actual arrival times of COTA buses at their designated stops.	6/7/2019	3/31/2021	4/7/2021
		Emergency Response Times - City of Columbus	Available at the end of the project	This dataset presents emergency response time of fire and EMS service vehicles pre- and post- deployment of CVE Signal Prioritization feature.	6/7/2019	3/31/2021	4/7/2021
CEAV	SCOS	Number of COTA boardings and alightings at stops shared by CEAV	Available at the end of the project	COTA ridership data will be collected for both pre- and post-deployment.	2/5/2020	2/4/2021	2/11/2021
		Emergency Response Times - City of Columbus	Available at the end of the project	This dataset presents emergency response time of fire and EMS service vehicles pre- and post- deployment of CVE Signal Prioritization feature.	6/7/2019	3/31/2021	4/7/2021

Source: City of Columbus

Chapter 8. Performance Rating

Final Performance Measurement information will be developed to summarize the impact of each project and the progress made on each objective at the end of the program. This information will be part of the Final Smart Columbus Demonstration Report.

This will include the progress towards each objective as identified in this plan including:

- Description of the objective.
- Tables.
- Exhibits.
- Data that has been collected and analyzed.
- Assessment of progress towards objective.
- Influence of confounding factors.
- Recommendations for improvement, if needed.
- Anticipated status of objective at next report.

This report will be developed with the intent to share publicly (upon approval from USDOT) and made available on the Smart Columbus website. In addition to formal reviews, the City of Columbus and the USDOT will coordinate regularly.

In addition to summarizing performance measurement results, the Smart Columbus team will also respond as required to the USDOT's Survey on Deployment Tracking.[37] This is the USDOT's national project which has conducted surveys regularly since 1997 and assists USDOT in measuring the deployment of ITS technology nationally. The Smart Columbus team will also respond to any other USDOT survey instruments related to ITS or other deployment tracking.

[37] http://www.itsdeployment.its.dot.gov/

Chapter 9. Conclusions

The Smart Columbus Demonstration Program performance measurement process is the key means of measuring the success in achieving the six outcomes of the program:

1. Safety
2. Mobility
3. Opportunity
4. Environment
5. Agency Efficiency
6. Customer Satisfaction

This PfMP describes the context for each of the Smart Columbus projects, their objectives, and the measures by which performance will be evaluated. Each project is anticipated to benefit the Columbus region by enhancing the attributes expressed through one or more outcomes. There are 31 objectives that vary widely in scope across the projects, but all aim to enhance safety and mobility throughout the City of Columbus while improving the quality of life for residents and visitors alike. Smart Columbus will serve as a model to other regions that implement similar technologies. The performance measures were selected to determine the areas where Smart Columbus makes the intended progress towards the expected outcomes.

Please note that the project outcome for each project presented in this document reflects the most recent decisions by the project teams. PMP will be reviewed so that changes to project outcomes in the PfMP will be updated in the PMP.

Further, this document focuses on performance measurement, the associated data requirements, and the anticipated results. Smart Columbus is described through many other Concepts of Operations, Trade Studies, Product Visions, reports, and plans. The evaluations themselves will be contained in future documents, that summarize and describe the system before, during, and after project implementation, built on the foundation set in this plan.

Appendix A. Acronyms and Definitions

Table 41 contains project-specific acronyms used throughout this document.

Table 41: Acronym List

Abbreviation/Acronym	Definition
AADT	Annual Average Daily Traffic
ADA	Americans with Disabilities Act
API	Application Programming Interface
ASP	Application Service Provider
AV	Autonomous Vehicle
AVL	Automatic Vehicle Location
BRT	Bus Rapid Transit
BSM	Basic Safety Message
CABS	Campus Area Bus System
CAD	Computer-aided Dispatch
CCTN	Columbus Connected Transportation Network
CEAV	Connected Electric Autonomous Vehicle
CMAX	Brand for COTA Cleveland Avenue Bus Rapid Transit
CMS	Collision Mitigation System
ConOps	Concept of Operations
CORS	Continuously Operating Reference Station
COTA	Central Ohio Transit Authority
C-Pass	COTA Pass
CPH	Columbus Public Health
CPS	Common Payment System
CSCC	Columbus State Community College
CTSS	Columbus Traffic Signal System
CV	Connected Vehicle
CVE	Connected Vehicle Environment
DiD	Difference-in-differences (analysis method)
DMP	Data Management Plan
DPP	Data Privacy Plan
DSRC	Dedicated Short Range Communications

Abbreviation/Acronym	Definition
DVI	Driver-Vehicle Interface
EHS	Enhanced Human Services
EMS	Emergency Medical Service
EPM	Event Parking Management
EV	Electric Vehicle
EVP	Emergency Vehicle Preemption
FHWA	Federal Highway Administration
FMLM	First Mile/Last Mile
FSP	Freight Signal Priority
GHG	Greenhouse Gas
GPS	Global Positioning System
HDV	Heavy-Duty Vehicle
HMI	Human Machine Interface
HUAS	Human Use Approval Summary
IP	Internet Provider
IRB	Institutional Review Board
ITS	Intelligent Transportation Systems
LED	Light-Emitting Diode
MAASTO	Mid America Association of State Transportation Officials
MAP	Intersection Geometry Message
MAPCD	Mobility Assistance for People with Cognitive Disabilities
MCO	Managed-Care Organization
MMITSS	Multimodal Intelligent Traffic Signal System
MMTPA	Multimodal Trip Planning Application
MORPC	Mid-Ohio Regional Planning Commission
MOVES	MOtor Vehicle Emission Simulator
NEMA	National Electrical Manufacturers Association
NEMT	Non-emergency Medical Transportation
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute of Standards and Technology
NOC	Network Operations Center
NOFO	Notice of Funding Opportunity
O&M	Operations and Maintenance
OBE	Onboard Equipment (many or all onboard devices)

Abbreviation/Acronym	Definition
ODC	Other Direct Costs
OBU	Onboard Unit (one onboard device)
ODM	Ohio Department of Medicaid
ODOT	Ohio Department of Transportation
OEM	Original Equipment Manufacturer
OSADP	Open-Source Application Data Portal
OSU	Ohio State University
PDE	Pedestrian Detection Equipment
PEO	Parking Enforcement Officer
PfMP	Performance Measurement Plan
PIECE	Prevocational Integrated Education and Campus Experience
PII	Personally Identifiable Information
PM	Project Management
PMP	Project Management Plan
PMT	Personal Miles Traveled
PSCW	Pedestrian in Signalized Crosswalk Warning
PSM	Propensity score matching
PSS	Power and Sample Size
PTA	Prenatal Trip Assistance
RSE	Roadside Equipment (generic)
RDE	Research Data Exchange
RFID	Radio Frequency Identification
RFQ	Request for Quote
RLVW	Red Light Violation Warning
ROI	Return on Investment
RSSZ	Reduced Speed School Zone
RSU	Roadside Unit (DSRC)
RTCM	Radio Technical Commission for Maritime
SCC	Smart City Challenge
SEMP	Systems Engineering Management Plan
SFTP	Secure File Transfer Protocol
SMH	Smart Mobility Hub
SMP	Safety Management Plan
SOV	Single Occupancy Vehicle

Abbreviation/Acronym	Definition
SPaT	Signal Phase and Timing
SE	Systems Engineering
SPII	Sensitive Personally Identifiable Information
SSM	Signal Status Message
TIM	Traveler Information Message
TNC	Transportation Network Company
TPI	Transit Pedestrian Indication
TSC	Traffic Signal Controller
TSP	Transit Signal Priority
UI	User Interface
USDOE	United States Department of Energy
USDOT	United States Department of Transportation
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
XD	INRIX eXtreme Definition roads

Source: City of Columbus

Appendix B. Performance Measures Matrix

Appendix B summarizes objectives, hypotheses, indicators, design of experiment, data sources and baseline and treatment timeframes for all program- and project-level outcomes.

	Outcome	Objective	Hypothesis	Indicator	Design of Experiment	Data Source	Baseline	Treatment
Program Level	Environment	Reduce vehicle emissions	The Smart Columbus Program will implement multiple portfolio projects focused on shifting travelers from personal vehicles to shared-use and transit-related projects and reducing idling time to reduce vehicle-related emissions.	Green House Gas (GHG) savings (light duty and heavy vehicles)	Pre/Post Trend Analysis	Operating System	Two years pre-deployment period (April 29, 2017 to April 28, 2019)	From the start of first portfolio project (April 29, 2019) until the end of period of performance of last portfolio project (March 31, 2021)
				Perceived reduction in idling time around parking facilities to find a parking spot	Pre/Post Quasi-Experimental Design	Customer Surveys		
				Perceived reduction in distance traveled to find a parking spot	Pre/Post Quasi-Experimental Design			
	Mobility	Reduce traffic congestion	The Smart Columbus Program will implement multiple portfolio projects focused on shifting travelers from personal vehicles to shared-use and transit-related projects to reduce traffic congestion.	Travel time and delay	Pre/Post Quasi-Experimental Design	Operating System		
				Daily volumes				
				Perceived reduction in travel time to find a parking spot		Customer Surveys		
				Perceived overall congestion				
	Opportunity	Improve commuting opportunities to jobs and services	Through implementation of multiple portfolio projects, Smart Columbus Program will improve traveling opportunities for Columbus region residents to their jobs and services.	Perceived ease of trip planning to jobs and services	Pre/Post Quasi-Experimental Design	Operating System; Customer Survey		
				Perceived ease of multimodal transfers				

	Outcome	Objective	Hypothesis	Indicator	Design of Experiment	Data Source	Baseline	Treatment
				Perceived ease of FMLM travel				
Operating System	Agency Efficiency	Provide useful data	The Operating System will provide useful data to public agencies, evaluators, and developers through an Open Data Portal.	Ability to access and use the data	Pre/Post Quasi Experimental Design	Operating System; Surveys	One year before implementation of the Operating System Data Platform 2.0 (April 22, 2018 to April 21, 2019)	From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (April 22, 2019 to March 31, 2021)
				Usefulness of the accessed data for intended purpose				
				Number of applications, reports, analytics, and visualizations created using the Operating System data	Post-only Trend Analysis		N/A	
		Provide improved data-sharing method	The Operating System will enhance the ease of data-sharing method through the Open Data Portal.	Ease of data-sharing ability	Pre/Post Quasi Experimental Design	Operating System; Surveys	One year before implementation of the Operating System Data Platform 2.0 (April 22, 2018 to April 21, 2019)	
				Number of requests for datasets	Pre/Post Trend Analysis			
				Amount of time to access the data	Pre/Post Quasi Experimental Design			
				Number and frequency of data retrievals from the Operating System	Post-only Trend Analysis		N/A	
				Ability to find data intended by the users	Post-only Trend Analysis	Operating System; Surveys	N/A	

	Outcome	Objective	Hypothesis	Indicator	Design of Experiment	Data Source	Baseline	Treatment
		Provide easily discoverable data	The Operating System will provide users with data in an easily discoverable manner.	Number of requests for datasets	Pre/post Trend Analysis		One year before implementation of the Operating System Data Platform 2.0 (April 22, 2018 to April 21, 2019)	
		Provide an easily accessible data exchange to providers and consumers of data	The Operating System will provide an easily accessible data exchange for all users of both internal and external applications.	Percentage of datasets accessible to applications (internal and external) in a usable format and method	Post-only Trend Analysis	Operating System; Surveys	N/A	
				Ability to access and use the data	Pre/Post Quasi Experimental Design		One year before implementation of the Operating System Data Platform 2.0 (April 22, 2018 to April 21, 2019)	
				Ability to ingest/harvest the data into the Operating System	Pre/Post Trend Analysis			
	Customer Satisfaction	Establish and enhance customer satisfaction with the Operating System	The Operating System will ensure the satisfaction of its customers (public agencies, evaluators, and developers) by providing and enhancing data, visualization, and analytical features through an Open Data Portal.	Customer satisfaction ratings for:	Post-only Trend Analysis	Operating System; Surveys	N/A	From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project
				Quality, freshness, and completeness of data				
				Metadata quality				
				Visualization tools/features				
				Analytical tools/features				
				Method of ingesting data into the Operating System				

	Outcome	Objective	Hypothesis	Indicator	Design of Experiment	Data Source	Baseline	Treatment
				Method of extracting data from the Operating System				(April 22, 2019 to March 31, 2021)
		Provide easily discoverable data	The Operating System will provide open data to the users in an easily discoverable fashion.	Time spent on the Operating System				
				Time spent on discovery of dataset(s)				
				Ability to find the intended data				
CVE	Safety	Reduce emergency response times in CVE corridor	The Emergency Vehicle Preemption application will improve emergency response times by reducing delay at signalized intersections with DSRC.	Emergency response times	Pre/post Trend Analysis	Survey City of Columbus Department of Public Safety emergency medical services (EMS) records CVE Data via Operating System	Nine months prior to implementation (Fall 2019 to Summer 2020)	Seven months post-implementation (Fall 2020 to Spring 2021)
	Safety	Increase driver's awareness of signal status	The Red-Light Violation Warning application will increase the driver's awareness of traffic signal status by providing drivers with warnings of impending signal violation at every signalized intersection in the CVE corridors.	Driver's awareness of traffic signal status	Pre/Post Trend Analysis	Survey; CVE data via operating system	Two months following deployment before implementation (Fall 2020)	Five months post-implementation (Winter 2020 to Spring 2021)
	Safety	Increase driver's awareness of speed limits in school zones	The Reduced Speed School Zone application will increase driver's awareness of speed in school zones by providing drivers with warnings to reduce speed due to the proximity of school zones.	Driver's awareness of speed in school zones				

	Outcome	Objective	Hypothesis	Indicator	Design of Experiment	Data Source	Baseline	Treatment
	Mobility	Demonstrate DSRC technology for TSP application	DSRC based TSP application will perform at the same level as Opticom-based TSP application.	Time of priority request	Post-only Quasi-Experimental Design	COTA CAD/AVL data; Operating System	N/A	
	Mobility	Reduce truck wait (delay) time at signalized intersections	The FSP will save travel time for trucks passing through equipped intersections by modifying signal timing.	Travel time through intersection	Pre/post Trend Analysis	CVE data via Operating System	Two months following deployment before implementation (Fall 2020)	
MMTPA	Mobility	Provide a single point of access to multimodal trip planning information to plan and book a multimodal trip	The MMTPA will encourage travelers to take multimodal trips in central Ohio by providing a comprehensive multimodal planning/booking tool.	Perceived improvement in access to multimodal trip planning	Pre/Post Quasi-Experimental Design	Customer Surveys	Summer 2020	Fall 2020 to Spring 2021 (six months)
	Opportunity	Facilitate access to jobs and services	The MMTPA will provide better access to jobs and services by enabling travelers to use mobility services that were previously either unavailable to them or of which they were unaware.	Perceived ease of accessing jobs and services	Quasi-Experimental Design	Resident Surveys	Summer 2020	Fall 2020 to Spring 2021 (six months)
	Customer Satisfaction	Improve customer satisfaction	The MMTPA will improve customer satisfaction by providing a comprehensive multimodal planning/booking tool.	Customer satisfaction ratings	Quasi-Experimental Design	Resident Surveys Mobility Provider Interviews	Summer 2020	Fall 2020 to Spring 2021 (six months)
				MMTPA application ratings	Post-only Trend Analysis	MMTPA Application Analytics	N/A	

	Outcome	Objective	Hypothesis	Indicator	Design of Experiment	Data Source	Baseline	Treatment
				Perceived ease of participating in a multimodal planning solution	Quasi-Experimental Design	Customer (In-App) Surveys	Summer 2020	
MAPCD	Mobility	Improved access and use of COTA fixed route bus service for MAPCD participants	The MAPCD application will allow MAPCD participants who use paratransit service or don't feel confident to use fixed-route bus service by providing navigation directions to, during, and from trips involving use of fixed-route bus service.	Customer trips moved from paratransit to fixed route	Pre/Post Trend Analysis	COTA, MAPCD Vendor, Operating System	One-year pre-implementation (April 29, 2018 to April 28, 2019)	One-year post-implementation (April 29, 2019 to April 28, 2020)
				Overall number of trips taken		MAPCD Participant and Caregiver Survey		
				Perceived independence;	Post-only Trend Analysis		N/A	
				Ease of Use				
	Opportunity	Improve independence of MAPCD participants by using fixed-route service	The MAPCD application will allow MAPCD participants to use fixed-route service to feel a greater sense of independence by providing navigation directions to, during, and from trips involving use of fixed-route bus service.	Perceived independence	Post-only Trend Analysis	MAPCD Participant and Caregiver Survey		
				MAPCD Participant and Caregiver experience				
	Agency Efficiency	Reduce COTA expenditures	The MAPCD application will reduce COTA operating expenses by moving passengers from paratransit service to fixed-route bus service.	Dollars saved in paratransit program	Pre/post Trend Analysis	COTA MAPCD Vendor	One-year pre-implementation (April 29, 2018 to April 28, 2019)	
PTA	Mobility	Examine pregnant	Women in the intervention group (assigned to PTA project) will be	Number of NEMT trips taken (by type, purpose)		PTA Vendor MCOs	N/A	Throughout pregnancy to

	Outcome	Objective	Hypothesis	Indicator	Design of Experiment	Data Source	Baseline	Treatment
		women's improved access to NEMT trip in those assigned to PTA project compared to those assigned to usual transportation services. (Key secondary outcomes include prenatal visit adherence and the rate of preterm delivery in each group.)	more likely to be satisfied with the transportation services than women in the "usual care" group, and they will also have increased prenatal trip adherence and a lower rate of preterm delivery.	Adequacy of prenatal care Kotelchuck Index	Post-only Randomized Experiment	ODH (Birth record) Customer Survey		eight weeks after delivery. Note that passive follow up of infant mortality will continue through one year after birth although treatment timeframe will have concluded.
	Opportunity	Increase usage of NEMT benefits	Women in the intervention group will take more NEMT trips than women in the "usual care" group.	Number of NEMT trips taken (by type and purpose)		PTA Vendor MCOs		
	Customer Satisfaction	Improve customer satisfaction	The PTA will increase customer satisfaction by providing an on-demand mobile and web-based application to schedule NEMT services, as well as on-demand transportation services.	Customer satisfaction rating		Customer Surveys		
SMH	Mobility	Provide physical	SMHs facilitate multimodal trips by allowing travelers to use kiosks and	Number of trip planning requests/bookings at SMH	Post-only Trend Analysis		N/A	Summer 2020 to Spring 2021

	Outcome	Objective	Hypothesis	Indicator	Design of Experiment	Data Source	Baseline	Treatment
		access to multimodal trip-planning and payment options	Wi-Fi to access the MMTPA and by consolidating multiple modes of transportation at a single location.	Application usage (MMTPA: number of multimodal trips, number of multimodal trips planned at a kiosk)		MMTPA, Operating System, IK-CMS		
	Customer Satisfaction	Improve customer satisfaction	SMH facilities with easy and convenient access to enhanced trip planning, multimodal options, Wi-Fi access, and emergency call button will improve customer satisfaction.	Customer satisfaction rating:	Post-only Trend Analysis	Customer Survey		
				Ease of Kiosk use				
				Usefulness				
				Accessibility				
				Perceived feeling of safety				
EPM	Customer Satisfaction	Improved perception of available parking in the downtown area and Short North.	Users of EPM app will have improved perception of available parking in the downtown area and Short North.	Perception of available parking	Pre/Post Quasi-Experimental Design	Surveys: resident and in-app	August 2020 (one month)	Fall 2020 to Spring 2021 (six months)
CEAV	Mobility	Provide convenient, reliable FMLM transit option	CEAV will increase the number of convenient, reliable FMLM trips in the deployment area by providing an autonomous shuttle service, which will reduce walking distances to destinations.	CEAV passenger trips	Post-only Trend Analysis	CEAV Vendor Operating System	N/A	Smart Circuit: 12/2018 to 09/2019 Linden LEAP: 2/5/2020-2/20/2020 (or through 3/31/2021 if passenger service resumes)
				Walking distance	Pre/post Trend Analysis	Customer Survey	One year prior to implementation	
				Perceived convenience				
				Perceived reliability				
				Perceived improvement in FMLM transit				

	Outcome	Objective	Hypothesis	Indicator	Design of Experiment	Data Source	Baseline	Treatment
	Opportunity	Provide more access to jobs and services to residents from underserved communities	Providing complementary service to COTA will increase access to jobs and services for underserved communities.	COTA ridership at stations with CEAV	Post-only Trend Analysis	COTA Operating System	N/A	
				Increase in mode shift		COTA Operating System Resident Survey		
				Number of food pantry packages distributed		St. Stephen's Food and Nutrition Center EasyMile		Food Pantry: July 30, 2020 (end date TBD)
	Customer Satisfaction	Improve the user experience	CEAV will improve the user experience by reducing walking distance and providing on-time service.	CEAV on-time performance		CEAV Vendor	N/A	Smart Circuit: 12/2018 to 09/2019 Linden LEAP: 2/5/2020-2/20/2020 (or through 3/31/2021 if passenger service resumes)
				Walking distance		Operating System		
				Perceived convenience		Survey		
				Perceived reliability				

Source: City of Columbus

Appendix C. Survey Inventory

Appendix C provides an inventory of program- and project-level surveys and question topics.

Section	Project	Survey	Lead	Outcome	Question Topics
5.4	Program	User	HNTB	Environment	• Percentage of travel through MMTPA project • Alternative modes of travel • Change in travel mode pre- vs post-implementation of Smart Columbus projects • Distance traveled to find a parking spot pre- and post-EPM implementation
5.4	Program	Community	OSU	Opportunity Mobility	• MOBILITY: • Percentage of travel through MMTPA and CEAV projects • Alternative modes of travel • Change in travel mode pre- vs post-implementation of Smart Columbus projects • Time traveled to find a parking spot pre- and post-EPM implementation • Feeling of overall traffic congestion pre- and post-EPM/CEAV/MMTPA implementation • OPPORTUNITY: • Travel purpose (work, school, health, leisure, shopping trips) • Mode use frequency (personal vehicle, borrowed vehicle, bus, taxi, bicycle, etc.) • Walkability • Parking and congestion • trip planning and multimodal trips • Payment ease/difficulty • Travel Satisfaction • Resident plans for reducing travel • Perceptions of risk relating to COVID-19 and various travel model
5.4	Program	COVID-19 Impact Survey	OSU	Opportunity Mobility	• Resident plans for reducing travel • Perceptions of risk relating to COVID-19 and various travel model

Section	Project	Survey	Lead	Outcome	Question Topics
5.5	OS	User	OS Project Team (Accenture)	Customer Satisfaction	• User satisfaction
5.6	CVE	Private LDV-HUD-SV	City	Mobility	• Vehicle use frequency and distance • Level of concern regarding roadway safety on the Connected Corridor • Satisfaction with driving and CV technology experiences • Perception of safety, distraction, driver attentiveness, etc.
5.6	CVE	Fleet HDV-HUD-SV	City	Mobility	• Vehicle use frequency and distance • Ability to drive through intersections in a timely manner • Perception of CV technology (Ex. all trucks should have CV technology installed to get extended green, all intersections should have CV technology installed, etc.) • Concerns regarding CV technology (privacy, reliability, distraction, vehicle hacking, etc.)
5.6	CVE	Emergency – EMG-HUD-SV	City	Safety	• Vehicle use frequency and distance • Ability to drive through intersections in a timely manner during an emergency response • Perception of response time and safety
5.7	MMTPA	Resident	OSU	Mobility	• Current travel behavior (frequency, distance, time, mode(s), etc.) • Frequency, purpose of and issues with intermediate stop(s) during commute • Satisfaction level with commute • Interest in/openness to shared transportation if (or after) COVID-19 is no longer a threat • Frequency, purpose of and issues with intermediate stop(s) during commute • Post-MMTPA implementation improvements (travel time, access to destinations, fewer stops, lower cost, etc.) • OSU employees: campus parking and bus pass use and cost
5.7	MMTPA	App Experience	City	Customer Satisfaction	• Most desired features • Most valuable features offered • Positive and negative experiences • Suggestions for improvement

Section	Project	Survey	Lead	Outcome	Question Topics
5.8	MAPCD	Participant Survey	OSU	Mobility Opportunity	• Ability to see and helpfulness of pictures • Helpfulness of on-screen and audio instructions • Comfort level with using app • Perceived safety while using app • Satisfaction with and helpfulness of training (safety, COTA, Smartphone and Wayfinding)
5.8	MAPCD	Participant (focus group)	OSU	Mobility Opportunity	• Perceived safety • Challenges in learning the app • Most and least helpful features • Perception of quizzes (helpful or scary) • Likelihood to use COTA with/without this app • Comfort using app without anyone else with them • Comfort using public transportation
5.8	MAPCD	Participant check-in	OSU	Mobility Opportunity	• Number of times per week the participant leaves the house • Destination when using Wayfinder app • Wayfinder app frequency of use
5.8	MAPCD	Caregiver (focus group)	OSU	Mobility Opportunity	• Perception of training (setup and presentation, completeness, time required, etc.) • Training's impact on participants' ability to use the app more independently • App's and training's impact on participants' independence in the community • Which population(s) could benefit from this app the most
5.9	PTA	Participant: Traveler satisfaction	OSU	Mobility Opportunity Customer Satisfaction	• Satisfaction with ride (scale of 1 to 5)
5.9	PTA	Participant: Driver satisfaction	OSU	Customer Satisfaction	• Satisfaction with ride (scale of 1 to 5)

Section	Project	Survey	Lead	Outcome	Question Topics
5.9	PTA	Participant: Baseline	OSU	Mobility Opportunity Customer Satisfaction	• General health history • Reproductive health history • Current pregnancy • Lifestyle • Transportation modes used • Satisfaction with NEMT received since learning of pregnancy • Demographics
5.9	PTA	Participant: Follow-up	OSU	Mobility Opportunity Customer Satisfaction	• R4B transportation use frequency and satisfaction • Safety perception during R4GB rides in last month • Frequency of use of other forms of transportation to get to doctor or healthcare in last month
5.9	PTA	Participant: Final	OSU	Mobility Opportunity Customer Satisfaction	• Location of majority of prenatal care • Services received during pregnancy (IC, Job and family services, NEMT, food bank or food pantry, food stamps, homeless shelter, Moms2B, Centering pregnancy, Home visit program, other) • Services received from Medicaid MCO during pregnancy (informational mailings or packets, information texts or emails, in-person educational sessions, incentive program to encourage you to attend your appointments, ask a nurse line, case management, other) • Modes of transportation used • Reasons for not using R4B transportation services • Satisfaction with services (Ex. overall, ease of scheduling a ride, call center hold times, courtesy of call center staff, etc.)
5.10	SMH	Resident	OSU	Mobility Customer Satisfaction	• Under development
5.10	SMH	Mobility Provider	City	Mobility Customer Satisfaction	• To be determined (may be in conjunction with MMTPA mobility provider interviews)
5.11	EPM	Resident	Project Team	Customer Satisfaction	• Frequency of visit to project area (downtown Columbus and the Short North Arts District)

Section	Project	Survey	Lead	Outcome	Question Topics
5.11	EPM	User (in-app)	Project Team	Customer Satisfaction	• Awareness of how to locate a parking place in the project area • Awareness of how to locate a parking space for special accommodations (Ex. EV or handicap access) in the project area • Awareness of how to locate a parking place in the project area compared to same time one year earlier

Source: City of Columbus

Appendix D. Glossary

Table 42: Glossary contains project-specific terms used throughout this document.

Table 42: Glossary

Term	Definition
App	A software application.
Travelers (end users)	Travelers are end users who utilize the features of SMHs to begin, pass through, or complete their trips.
Commercial Off-the-Shelf System (COTS)	Software or hardware product that are ready-made and available for sale to the public.
Data Management System (DMS)	A secure, Software as a Service (SaaS) web-based app that allows management of an entire parking meter network.
Data Privacy	The reasonable expectation that data of a sensitive nature will be kept confidential, sanitized and/or encrypted, and respectfully and responsibly maintained by all users, managers, and collectors of the data.
Data Retention	The continued storage of data for compliance or business reasons.
Data Security	The tools, policies, practices, and procedures used to protect data from being accessed, manipulated or destroyed, or being leveraged by those with a malicious intent or without authorization, as well as the corrective actions taken when data breaches are suspected or have been identified.
Dependency	When one project, agency, or entity requires data or functionality provided by another project, agency or entity to meet its objectives.
Dockless	A station-free concept developed for bicycles that allows riders to end their rides and park the bikes anywhere. This mechanism offers affordable transit, attempts to solve FMLM issues, services areas without transit, and offers to cities ridership data.
Enabling Technologies	An innovation that alone or paired with an existing solution produces a better end user solution at a rapid rate.
Experience Columbus	An organization whose mission is to market and promote Columbus services, attractions, and facilities to visitors, meeting planners, convention delegates and residents.
Failure Operations	When a complete failure of the intersection occurs, primarily due to loss of power or other malfunctions.
Interactive Voice Response (IVR)	IVR technology allows a computer to interact with humans. Through voice prompts, a user tactilely enters tones using number keys on a keypad. In telecommunications, IVR allows users to interact with a company's host system via a telephone keypad, after which users can inquire about services through the IVR dialogue.
Multimodal Transportation	Travel done via more than one mode of transportation.
Normal Operations	When a signalized intersection is cycling through its preplanned phases correctly, servicing all approaches including pedestrian phases.

Term	Definition
Open Data	Information that is freely available for anyone to use and republish as they wish.
Open-Source Concepts	The notion of open collaboration and voluntary contribution for software development by writing and exchanging programming code.
Parking Facility	Land or a structure used for light-duty vehicle parking.
Procurement	The act of obtaining or acquiring goods, services or works, from a competitive bidding process.
Real-Time Data	Information that is delivered immediately after collection.
Requirement Number	An integer incrementing by one, indicating the number of requirements established.
"v" Static Character	Static letter "v" represents the requirement version.
Version Number	An integer incrementing by one, indicating the number of revisions made to the requirement.
System Analytics or Data Analytics	The analysis of data, procedures or business practices to locate information which can be used to create more efficient solutions.
Software as a Service (SaaS)	An extension of the Application Service Provider (ASP) centralized computing model, the SaaS delivery model hosts and provides web-based interface access to a software app over a network. The service is managed centrally, in large data centers, most often in a cloud-computing environment.
Third Party	Organizations not affiliated with the Smart Columbus Program.
Transportation Network Companies (TNCs)	Private businesses, nonprofits and quasi-governmental agencies that offer one or more types of transportation for use in exchange for payment.

Source: City of Columbus

Appendix E. Program-Level Surveys

E.1 OSU MOBILITY AND OPPORTUNITY OUTCOMES SURVEY – WAVE 1 (MAIL-IN)

E.2 OSU MOBILITY AND OPPORTUNITY OUTCOMES SURVEY – WAVE 2 (MAIL-IN)

Resident Travel in Columbus

A study conducted by The Ohio State University
for the City of Columbus

Please return your completed questionnaire in the enclosed envelope.
The envelope is self-addressed and no postage is required.
Your help on this study is greatly appreciated!

THE OHIO STATE UNIVERSITY

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The Environmental and Social Sustainability Lab
School of Environment & Natural Resources
210 Kottman Hall | 2021 Coffey Road | Columbus, Ohio 43210

A. Your weekly travel

1. Consider your travel on an average week. Think about how you travel for all purposes: work, school, health, leisure, and shopping trips. How often do you use the following modes of transportation?

	Never	One trip a week	2-3 trips a week	4-6 trips a week	Daily trips
My (or my household's) motor vehicle	☐	☐	☐	☐	☐
Borrow (or carpool with) a motor vehicle from another household	☐	☐	☐	☐	☐
Motorcycle	☐	☐	☐	☐	☐
Bus (e.g., COTA)	☐	☐	☐	☐	☐
Taxi	☐	☐	☐	☐	☐
Uber/Lyft	☐	☐	☐	☐	☐
Carshare (e.g., Zipcar)	☐	☐	☐	☐	☐
My bicycle	☐	☐	☐	☐	☐
My electric bicycle	☐	☐	☐	☐	☐
Bicycle share (e.g., CoGo)	☐	☐	☐	☐	☐
My scooter	☐	☐	☐	☐	☐
My electric scooter (standing)	☐	☐	☐	☐	☐
Scooter share (e.g., Lime, Bird)	☐	☐	☐	☐	☐
Walking	☐	☐	☐	☐	☐

2. What modes of transportation would you ideally want to use more of? Select all that apply

- ☐ My (or my household's) motor vehicle
- ☐ Borrow (or carpool with) a motor vehicle from another household
- ☐ Motorcycle
- ☐ Bus (e.g., COTA)
- ☐ Taxi
- ☐ Uber/Lyft
- ☐ Carshare (e.g., Zipcar)
- ☐ Bicycle
- ☐ Electric bicycle
- ☐ Bicycle share (e.g., CoGo)
- ☐ Scooter
- ☐ Electric scooter (standing)
- ☐ Scooter share (e.g., Lime, Bird)
- ☐ Walking
- ☐ None

B. Your vehicle

1. Think about the most recent automobile you acquired. When did you get this vehicle?

- ☐ In the past year
- ☐ 1-3 years ago
- ☐ 4-6 years ago
- ☐ 7-9 years ago
- ☐ 10+ years ago
- ☐ My household does not have an automobile

2. Thinking of the vehicle in the previous question, what is its fuel type?

☐ Gasoline ☐ Diesel ☐ Electric ☐ Hybrid ☐ Other: _____ ☐ Not applicable

3. Think about your next vehicle purchase or lease. How likely are you to purchase or lease an all-electric vehicle (EV)?

By EV, we are referring to vehicles powered by plugging into a specialized outlet and using electricity to charge a battery pack, with no gasoline engine. A Nissan Leaf is an example of an EV. EV does not refer to hybrid electric vehicles. A Toyota Prius is an example of a hybrid.

☐	☐	☐	☐	☐	☐	☐
Extremely unlikely	Moderately unlikely	Slightly unlikely	Neither likely nor unlikely	Slightly likely	Moderately likely	Extremely likely

C. Your most recent travel

1. Think about <u>the last time you traveled somewhere from your home</u> (e.g., traveling to work, school, a health-related appointment, a leisure activity, or shopping). This trip could have been today, yesterday, or even a week ago. What was the purpose of your trip?

- ☐ Work
- ☐ Education
- ☐ Medical (e.g. doctor appointment, pharmacy, therapy)
- ☐ Leisure and Recreation (e.g., social event, restaurant, gym)
- ☐ Grocery Shopping or Food Pantry
- ☐ Retail Shopping
- ☐ Other: _____

2. Help us locate <u>where you were traveling from</u>. Please either provide the address (Example: 275 W Woodruff Ave) OR a close-by landmark (Example: Kroger at Chambers Rd) OR two streets that intersect close to this place (Example: Street 1: West 5th Ave Street 2: McKinley Ave).

You do not need to provide all three. At the very least, please provide the ZIP code.

Address _____

Close-by landmark _____

Road intersection: street 1 _____

Road intersection: street 2 _____

3. Help us locate <u>where you were traveling to</u>. Again, please either provide the address OR a close-by landmark OR two streets that intersect close to this place.

You do not need to provide all three. At the very least, please provide the ZIP code.

Address _____

Close-by landmark _____

Road intersection: street 1 _____

Road intersection: street 2 _____

4. When did you start your trip?

☐ Before 7am ☐ Between 9am and 4pm ☐ After 6pm

☐ Between 7am and 9am ☐ Between 4pm and 6pm

5. When did you arrive at your destination?

☐ Before 7am ☐ Between 9am and 4pm ☐ After 6pm

☐ Between 7am and 9am ☐ Between 4pm and 6pm

6. On what day of the week was this trip?

☐ Sunday ☐ Monday ☐ Tuesday ☐ Wednesday ☐ Thursday ☐ Friday ☐ Saturday

7. Were you traveling with small children (i.e., under the age of 5)? ☐ Yes ☐ No

8. What was the weather like on the day of your travel? Select all that apply

☐ Rainy ☐ Windy ☐ Sunny ☐ Cloudy ☐ Cold ☐ Pleasant ☐ Hot ☐ Dry ☐ Humid

9. How far did you travel?

☐ Less than 0.5 mile ☐ 1-2 miles ☐ 6-10 miles ☐ 21-30 miles ☐ Over 40 miles
☐ 0.5-1 mile ☐ 3-5miles ☐ 11-20 miles ☐ 31-40 miles

10. How long did it take you to get to your destination?

☐ 5 minutes or less ☐ 11-15 min ☐ 21-30 min ☐ 41-50 min ☐ Over 60 min
☐ 6-10 min ☐ 16-20 min ☐ 31-40 min ☐ 51-60 min

11. What mode of transportation did you use to get to your destination?

Mark your primary mode of transportation (i.e., the transportation mode you used for the longest distance) in the "primary" column. If you used more than one transportation mode, please also select your secondary mode of transportation (i.e., the transportation mode you used for the second to longest distance) in the "secondary" column.

	Primary: Used for the longest distance (select one)	Secondary: Used for the second to longest distance (select one)
My (or my household's) motor vehicle	☐	☐
Borrow (or carpool with) a motor vehicle from another household	☐	☐
Motorcycle	☐	☐
Bus (e.g., COTA)	☐	☐
Taxi	☐	☐
Uber/Lyft	☐	☐
Carshare (e.g., Zipcar)	☐	☐
My bicycle	☐	☐
My electric bicycle	☐	☐
Bicycle share (e.g., CoGo)	☐	☐
My scooter	☐	☐
My electric scooter (standing)	☐	☐
Scooter share (e.g., Lime, Bird)	☐	☐
Walking	☐	☐

12. How often do you make this trip?

☐	☐	☐	☐	☐
Almost never	Rarely	Sometimes	Often	Very often

13. People vary in the amount of attention they pay to these kinds of surveys. Some take them seriously and read each question, whereas others go very quickly and might not read the questions fully. If you have read this question carefully, please select the "Support" option below.

☐	☐	☐	☐	☐
Strongly support	Support	Neither	Oppose	Strongly oppose

14. Think about the <u>primary mode of transportation you used in your last trip</u> (your response to question B12). How would you describe your experience while completing this trip?

Choose the circle between the adjectives which best represents your attitude toward your trip. Marking a circle closer to the left side (1 and 2) indicates a strong agreement with the word on the left. Marking a circle closer to the right side (5 and 6) indicates a strong agreement with the word on the right.

	1	2	3	4	5	6	
Very stressed	☐	☐	☐	☐	☐	☐	Very relaxed
Very bored	☐	☐	☐	☐	☐	☐	Very enthusiastic
Worked very poorly	☐	☐	☐	☐	☐	☐	Worked very well
Very tired	☐	☐	☐	☐	☐	☐	Very alert
Held low standard	☐	☐	☐	☐	☐	☐	Held high standard
Very worried	☐	☐	☐	☐	☐	☐	Very calm
Very hurried	☐	☐	☐	☐	☐	☐	Very confident
Worst imaginable	☐	☐	☐	☐	☐	☐	Best imaginable
Very fed-up	☐	☐	☐	☐	☐	☐	Very engaged
Wasted time	☐	☐	☐	☐	☐	☐	Time well-spent
Very unsafe	☐	☐	☐	☐	☐	☐	Very safe

15. Think about the <u>primary mode of transportation you used in your last trip</u> and answer the question below. ***During this trip I felt:***	Strongly disagree	Somewhat Disagree	Neutral	Somewhat agree	Strongly agree
That my choices were based on my true interests and values	☐	☐	☐	☐	☐
Free to do things my own way	☐	☐	☐	☐	☐
That my choices expressed my "true self"	☐	☐	☐	☐	☐
That I was successfully completing difficult tasks	☐	☐	☐	☐	☐
That I was taking on and mastering a challenge	☐	☐	☐	☐	☐
Very capable in what I did	☐	☐	☐	☐	☐
A sense of contact with people	☐	☐	☐	☐	☐
Close and connected with other people	☐	☐	☐	☐	☐
A sense of intimacy with people around me	☐	☐	☐	☐	☐

D. YOUR WELL-BEING AND IDENTITY

1. Please indicate your agreement with the statements below:	Strongly disagree	Somewhat Disagree	Neutral	Somewhat agree	Strongly agree
The conditions of my life are excellent	☐	☐	☐	☐	☐
In most ways my life is close to my ideal	☐	☐	☐	☐	☐
I am satisfied with my life	☐	☐	☐	☐	☐
So far I have gotten the important things I want in life	☐	☐	☐	☐	☐
If I could live life over, I would change almost nothing	☐	☐	☐	☐	☐

2. Please indicate your agreement with the following statements:	Strongly disagree	Somewhat Disagree	Neutral	Somewhat agree	Strongly agree
I see myself as pro-environmental	☐	☐	☐	☐	☐
I am pleased to be pro-environmental	☐	☐	☐	☐	☐
I feel strong ties with pro-environmental people	☐	☐	☐	☐	☐
I identify with pro-environmental people	☐	☐	☐	☐	☐
Please mark this row with the answer Somewhat agree	☐	☐	☐	☐	☐

E. Walking in Columbus

1. In your experience, how walkable are the following areas:

a. Your primary residence	b. Your primary workplace	c. Where you most often go out for fun
☐ Not at all walkable	☐ Not at all walkable	☐ Not at all walkable
☐ Slightly walkable	☐ Slightly walkable	☐ Slightly walkable
☐ Moderately walkable	☐ Moderately walkable	☐ Moderately walkable
☐ Very walkable	☐ Very walkable	☐ Very walkable
☐ Extremely walkable	☐ Extremely walkable	☐ Extremely walkable
☐ Unable to answer	☐ Unable to answer	☐ Unable to answer

2. Would your friends/family who live in Columbus prefer to walk more than they currently do?

☐	☐	☐	☐	☐
Strongly disagree	Somewhat disagree	Neutral/Unsure	Somewhat agree	Strongly agree

F. Parking in Columbus

1. How long do you normally spend looking for a parking spot around the following areas:

a. Your primary residence	b. Your primary workplace	c. Where you most often go out for fun
☐ Under 1 min	☐ Under 1 min	☐ Under 1 min
☐ 1-5 min	☐ 1-5 min	☐ 1-5 min
☐ 6-10 min	☐ 6-10 min	☐ 6-10 min
☐ 11-15 min	☐ 11-15 min	☐ 11-15 min
☐ 16-20 min	☐ 16-20 min	☐ 16-20 min
☐ Over 20 min	☐ Over 20 min	☐ Over 20 min
☐ Not applicable	☐ Not applicable	☐ Not applicable

2. In your experience, are Columbus roads congested? (i.e., slow traffic, traffic jams)

☐	☐	☐	☐	☐
Not at all congested	Slightly congested	Moderately congested	Very congested	Extremely congested

F. Planning your trip

1. Think about your daily experience of getting around in Columbus. When planning a trip in Columbus you may be deciding how to get from where you are to your destination, figuring out how long it will take you to travel there, understanding when and how you will return, etc.

a. Planning my trip is	b. Transferring from one mode of transport to another (e.g., from bus to scooter) is:	c. Finding travel solutions for the first and last segment of my trip (e.g., to and from the bus) is:
☐ Extremely easy	☐ Extremely easy	☐ Extremely easy
☐ Somewhat easy	☐ Somewhat easy	☐ Somewhat easy
☐ Neither easy nor difficult	☐ Neither easy nor difficult	☐ Neither easy nor difficult
☐ Somewhat difficult	☐ Somewhat difficult	☐ Somewhat difficult
☐ Extremely difficult	☐ Extremely difficult	☐ Extremely difficult
☐ I don't usually do this	☐ I don't usually do this	☐ I don't usually do this

2. Considering trips around Columbus that require you to use multiple travel modes (e.g., bus, scooter), do you have access to a service (e.g., mobile phone app, website) or other means that enables you to <u>pay for</u> the entire trip at once (i.e., not every time you switch transit modes)?

☐	☐	☐	☐
Not at all	A small extent	A moderate extent	A large extent

3. Considering trips around Columbus that require you to use multiple travel modes (e.g., bus, scooter), do you have access to a service (e.g., mobile phone app, website) or other means that enables you to <u>plan</u> your entire trip at once?

☐	☐	☐
No	Yes	Not sure

4. Considering the services or other means you use to <u>plan</u> trips spanning multiple travel modes, how easy or difficult is it to plan travel?

☐	☐	☐	☐	☐	☐
Extremely easy	Somewhat easy	Neither easy nor difficult	Somewhat difficult	Extremely difficult	I don't usually do this

5. Considering the services or other means you use to pay for trips spanning multiple travel modes, how easy or difficult is it to pay for travel?

☐	☐	☐	☐	☐	☐
Extremely easy	Somewhat easy	Neither easy nor difficult	Somewhat difficult	Extremely difficult	I don't usually do this

G. Travel satisfaction

1. In general, how easy or difficult is it for you to get from your residence in Columbus to the following?	Extremely difficult	Somewhat difficult	Neutral	Somewhat easy	Extremely easy	Not applicable
Your primary workplace	☐	☐	☐	☐	☐	☐
Schools	☐	☐	☐	☐	☐	☐
Supermarket or grocery store	☐	☐	☐	☐	☐	☐
Healthcare services	☐	☐	☐	☐	☐	☐
Financial services (e.g., bank)	☐	☐	☐	☐	☐	☐
Utility providers (e.g., internet, telephone, water)	☐	☐	☐	☐	☐	☐
Other professional or technical services (e.g., legal help, auto care)	☐	☐	☐	☐	☐	☐
Park or other outdoor green space	☐	☐	☐	☐	☐	☐
Entertainment / recreational activities	☐	☐	☐	☐	☐	☐

2. Overall, how satisfied are you with your transportation options to access your basic household needs?	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied	Not applicable
Travel Time (includes waiting)	☐	☐	☐	☐	☐	☐
Travel Distance	☐	☐	☐	☐	☐	☐
Travel Cost (e.g., fare, gas)	☐	☐	☐	☐	☐	☐
Reliability	☐	☐	☐	☐	☐	☐
Simplicity	☐	☐	☐	☐	☐	☐
Flexibility	☐	☐	☐	☐	☐	☐
Comfort	☐	☐	☐	☐	☐	☐
Safety	☐	☐	☐	☐	☐	☐

H. Smart Columbus

1. Have you heard of the Smart Columbus program?

☐ Yes ☐ No → please skip to the next page

2. What do you know about the Smart Columbus program?

_____

_____

_____

_____

3. How likely is it that the Smart Columbus program will impact your daily life?

☐	☐	☐	☐	☐	☐
Extremely unlikely	Somewhat unlikely	Neither likely nor unlikely	Somewhat likely	Extremely likely	I am not sure

4. If the Smart Columbus program would impact your daily life, what impact would you expect it to have?

☐	☐	☐	☐	☐	☐
Extremely negative	Somewhat negative	Neither positive nor negative	Somewhat positive	Extremely positive	I am not sure

The following demographic information will be used to help make general conclusions about the residents of Columbus. Your responses will remain completely confidential.

I. Demographic Information

1. What is your year of birth?

_____

2. What is your current gender identity? Select all that apply

☐ Man
☐ Woman
☐ Trans Man
☐ Trans Woman
☐ Agender
☐ Genderqueer or Gender fluid
☐ Preferred identity: _____
☐ Prefer not to say

3. Which transportation resources are available to you as part of your weekly routine? Select all that apply

- ☐ I own a personal vehicle
- ☐ Someone else in my household supports me with their personal vehicle
- ☐ Someone outside my household supports me with their personal vehicle
- ☐ I have a current driver's license
- ☐ I have my own bicycle
- ☐ I have a mobile device that contains transportation service apps
- ☐ I have a credit card
- ☐ I have a bus pass provided by my employer
- ☐ Other: _____

4. If your household does not own a four-wheeled motor vehicle, why is that? Select all that apply

- ☐ No interest/need
- ☐ No driver's license
- ☐ Financial concerns
- ☐ Environmental concerns
- ☐ Prefer using alternative transportation modes (e.g., bicycle)
- ☐ Physical, mental, or emotional condition
- ☐ Other: _____
- ☐ Prefer not to say

5. What is the highest level of school you have completed or the highest degree you have received?

- ☐ Less than high school degree
- ☐ High school graduate (high school diploma or equivalent including GED)
- ☐ Some college but no degree
- ☐ Associate degree in college (2-year)
- ☐ Bachelor's degree in college (4-year)
- ☐ Master's degree
- ☐ Doctoral degree
- ☐ Professional degree (JD, MD)
- ☐ Prefer not to say

6. Choose one or more races that you consider yourself to be:

- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Pacific Islander
- ☐ Other: _____
- ☐ Prefer not to say

7. Are you Spanish, Hispanic, or Latino or none of these?

- ☐ Yes
- ☐ None of these
- ☐ Prefer not to say

8. What is your marital status?

- ☐ Now married
- ☐ Widowed
- ☐ Divorced
- ☐ Separated
- ☐ Never married
- ☐ Prefer not to say

9. How many children under the age of 18 live in your household?

_____

10. If there are children living in your household, what is the age of the youngest child?

- ☐ Under 2 years old
- ☐ Between 2 and 6 years
- ☐ Between 7 and 12 years
- ☐ Older than 12 years old

11. What is your zip code?

_____

12. For how many years have you been living in your current residence?

- ☐ 1 year or less
- ☐ 2 years
- ☐ 3 years
- ☐ 4 years
- ☐ 5 years
- ☐ 6 years
- ☐ 7 years
- ☐ 8 or more years

13. If you moved within the last 8 years, what was the zip code of your most recent residence, before your current residence? _____

14. Which statement best describes your current employment status?

- ☐ Working (paid employee)
- ☐ Working (self-employed)
- ☐ Not working (temporary layoff from a job)
- ☐ Not working (looking for work)
- ☐ Not working (retired)
- ☐ Not working (disabled)
- ☐ Not working (Other): _____
- ☐ Prefer not to say

15. When it comes to politics, how do you usually think of yourself?

☐	☐	☐	☐	☐	☐	☐
Extremely liberal	Liberal	Slightly liberal	Moderate, middle of the road	Slightly conservative	Conservative	Extremely conservative

- ☐ Don't know or haven't thought about it
- ☐ Prefer not to say

16. Please indicate the answer that includes your entire household income in 2018 before taxes:

- ☐ Less than $15,000
- ☐ $15,000 to $29,999
- ☐ $30,000 to $44,999
- ☐ $45,000 to $59,999
- ☐ $60,000 to $74,999
- ☐ $75,000 to $89,999
- ☐ $90,000 to $104,999
- ☐ $105,000 to $119,999
- ☐ $120,000 to $134,999
- ☐ $135,000 to $149,999
- ☐ $150,000 or more
- ☐ Prefer not to say

17. Because of a physical, mental, or emotional condition, do you have serious difficulty with any of the following? Select all that apply

- ☐ Hearing
- ☐ Seeing (even when wearing glasses)
- ☐ Concentrating, remembering, or making decisions
- ☐ Doing errands alone (e.g., visiting a doctor's office or shopping)
- ☐ Walking or climbing stairs
- ☐ Dressing or bathing
- ☐ None of the above
- ☐ Prefer not to say

Please make any additional comments in the space provided:

_____

_____

_____

_____

Thank you for taking the time to complete this survey!

We invite you to provide more detailed information about your travel choices in an online survey. By entering the below URL address into your web browser, you can access the additional online survey. This separate online survey will also provide a $5 prize as a sign of our thanks.

[insert URL code for travel diary]

Resident Travel in Columbus

A study conducted by The Ohio State University
for the City of Columbus

Please return your completed questionnaire in the enclosed envelope.
The envelope is self-addressed and no postage is required.
Your help on this study is greatly appreciated!

THE OHIO STATE UNIVERSITY

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The Environmental and Social Sustainability Lab
School of Environment & Natural Resources
210 Kottman Hall | 2021 Coffey Road | Columbus, Ohio 43210

A. Your weekly travel

1. Consider your travel on an average week. Think about how you travel for all purposes: work, school, health, leisure, and shopping trips. How often do you use the following modes of transportation?

	Never	One trip a week	2-3 trips a week	4-6 trips a week	Daily trips
My (or my household's) motor vehicle	☐	☐	☐	☐	☐
Borrow (or carpool with) a motor vehicle from another household	☐	☐	☐	☐	☐
Motorcycle	☐	☐	☐	☐	☐
Bus (e.g., COTA)	☐	☐	☐	☐	☐
Taxi	☐	☐	☐	☐	☐
Uber/Lyft	☐	☐	☐	☐	☐
Carshare (e.g., Zipcar)	☐	☐	☐	☐	☐
My bicycle	☐	☐	☐	☐	☐
My electric bicycle	☐	☐	☐	☐	☐
Bicycle share (e.g., CoGo)	☐	☐	☐	☐	☐
My scooter	☐	☐	☐	☐	☐
My electric scooter (standing)	☐	☐	☐	☐	☐
Scooter share (e.g., Lime, Bird)	☐	☐	☐	☐	☐
Walking	☐	☐	☐	☐	☐

2. What modes of transportation would you ideally want to use more of? Select all that apply

- ☐ My (or my household's) motor vehicle
- ☐ Borrow (or carpool with) a motor vehicle from another household
- ☐ Motorcycle
- ☐ Bus (e.g., COTA)
- ☐ Taxi
- ☐ Uber/Lyft
- ☐ Carshare (e.g., Zipcar)
- ☐ Bicycle
- ☐ Electric bicycle
- ☐ Bicycle share (e.g., CoGo)
- ☐ Scooter
- ☐ Electric scooter (standing)
- ☐ Scooter share (e.g., Lime, Bird)
- ☐ Walking
- ☐ None

B. Your vehicle

1. Think about the most recent automobile you acquired. When did you get this vehicle?

- ☐ In the past year
- ☐ 1-3 years ago
- ☐ 4-6 years ago
- ☐ 7-9 years ago
- ☐ 10+ years ago
- ☐ My household does not have an automobile

2. Thinking of the vehicle in the previous question, what is its fuel type?

☐ Gasoline ☐ Diesel ☐ Electric ☐ Hybrid ☐ Other: _____ ☐ Not applicable

3. Think about your next vehicle purchase or lease. How likely are you to purchase or lease an all-electric vehicle (EV)?

By EV, we are referring to vehicles powered by plugging into a specialized outlet and using electricity to charge a battery pack, with no gasoline engine. A Nissan Leaf is an example of an EV. EV does not refer to hybrid electric vehicles. A Toyota Prius is an example of a hybrid.

☐	☐	☐	☐	☐	☐	☐
Extremely unlikely	Moderately unlikely	Slightly unlikely	Neither likely nor unlikely	Slightly likely	Moderately likely	Extremely likely

C. Your most recent travel

1. Think about <u>the last time you traveled somewhere from your home</u> (e.g., traveling to work, school, a health-related appointment, a leisure activity, or shopping). This trip could have been today, yesterday, or even a week ago. What was the purpose of your trip?

- ☐ Work
- ☐ Education
- ☐ Medical (e.g. doctor appointment, pharmacy, therapy)
- ☐ Leisure and Recreation (e.g., social event, restaurant, gym)
- ☐ Grocery Shopping or Food Pantry
- ☐ Retail Shopping
- ☐ Other: _____

2. Help us locate <u>where you were traveling from</u>. Please either provide the address (Example: 275 W Woodruff Ave) OR a close-by landmark (Example: Kroger at Chambers Rd) OR two streets that intersect close to this place (Example: Street 1: West 5th Ave Street 2: McKinley Ave).

You do not need to provide all three. At the very least, please provide the ZIP code.

Address _____

Close-by landmark _____

Road intersection: street 1 _____

Road intersection: street 2 _____

3. Help us locate <u>where you were traveling to</u>. Again, please either provide the address OR a close-by landmark OR two streets that intersect close to this place.

You do not need to provide all three. At the very least, please provide the ZIP code.

Address _____

Close-by landmark _____

Road intersection: street 1 _____

Road intersection: street 2 _____

4. When did you start your trip?

☐ Before 7am ☐ Between 9am and 4pm ☐ After 6pm

☐ Between 7am and 9am ☐ Between 4pm and 6pm

5. When did you arrive at your destination?

☐ Before 7am ☐ Between 9am and 4pm ☐ After 6pm

☐ Between 7am and 9am ☐ Between 4pm and 6pm

6. On what day of the week was this trip?

☐ Sunday ☐ Monday ☐ Tuesday ☐ Wednesday ☐ Thursday ☐ Friday ☐ Saturday

7. Were you traveling with small children (i.e., under the age of 5)? ☐ Yes ☐ No

8. What was the weather like on the day of your travel? Select all that apply

☐ Rainy ☐ Windy ☐ Sunny ☐ Cloudy ☐ Cold ☐ Pleasant ☐ Hot ☐ Dry ☐ Humid

9. How far did you travel?

☐ Less than 0.5 mile ☐ 1-2 miles ☐ 6-10 miles ☐ 21-30 miles ☐ Over 40 miles
☐ 0.5-1 mile ☐ 3-5miles ☐ 11-20 miles ☐ 31-40 miles

10. How long did it take you to get to your destination?

☐ 5 minutes or less ☐ 11-15 min ☐ 21-30 min ☐ 41-50 min ☐ Over 60 min
☐ 6-10 min ☐ 16-20 min ☐ 31-40 min ☐ 51-60 min

11. What mode of transportation did you use to get to your destination?

Mark your primary mode of transportation (i.e., the transportation mode you used for the longest distance) in the "primary" column. If you used more than one transportation mode, please also select your secondary mode of transportation (i.e., the transportation mode you used for the second to longest distance) in the "secondary" column.

	Primary: Used for the longest distance (select one)	Secondary: Used for the second to longest distance (select one)
My (or my household's) motor vehicle	☐	☐
Borrow (or carpool with) a motor vehicle from another household	☐	☐
Motorcycle	☐	☐
Bus (e.g., COTA)	☐	☐
Taxi	☐	☐
Uber/Lyft	☐	☐
Carshare (e.g., Zipcar)	☐	☐
My bicycle	☐	☐
My electric bicycle	☐	☐
Bicycle share (e.g., CoGo)	☐	☐
My scooter	☐	☐
My electric scooter (standing)	☐	☐
Scooter share (e.g., Lime, Bird)	☐	☐
Walking	☐	☐

12. How often do you make this trip?

☐	☐	☐	☐	☐
Almost never	Rarely	Sometimes	Often	Very often

13. People vary in the amount of attention they pay to these kinds of surveys. Some take them seriously and read each question, whereas others go very quickly and might not read the questions fully. If you have read this question carefully, please select the "Support" option below.

☐	☐	☐	☐	☐
Strongly support	Support	Neither	Oppose	Strongly oppose

14. Think about the <u>primary mode of transportation you used in your last trip</u> (your response to question B12). How would you describe your experience while completing this trip?

Choose the circle between the adjectives which best represents your attitude toward your trip. Marking a circle closer to the left side (1 and 2) indicates a strong agreement with the word on the left. Marking a circle closer to the right side (5 and 6) indicates a strong agreement with the word on the right.

	1	2	3	4	5	6	
Very stressed	☐	☐	☐	☐	☐	☐	Very relaxed
Very bored	☐	☐	☐	☐	☐	☐	Very enthusiastic
Worked very poorly	☐	☐	☐	☐	☐	☐	Worked very well
Very tired	☐	☐	☐	☐	☐	☐	Very alert
Held low standard	☐	☐	☐	☐	☐	☐	Held high standard
Very worried	☐	☐	☐	☐	☐	☐	Very calm
Very hurried	☐	☐	☐	☐	☐	☐	Very confident
Worst imaginable	☐	☐	☐	☐	☐	☐	Best imaginable
Very fed-up	☐	☐	☐	☐	☐	☐	Very engaged
Wasted time	☐	☐	☐	☐	☐	☐	Time well-spent
Very unsafe	☐	☐	☐	☐	☐	☐	Very safe

15. Think about the <u>primary mode of transportation you used in your last trip</u> and answer the question below. ***During this trip I felt:***	Strongly disagree	Somewhat Disagree	Neutral	Somewhat agree	Strongly agree
That my choices were based on my true interests and values	☐	☐	☐	☐	☐
Free to do things my own way	☐	☐	☐	☐	☐
That my choices expressed my "true self"	☐	☐	☐	☐	☐
That I was successfully completing difficult tasks	☐	☐	☐	☐	☐
That I was taking on and mastering a challenge	☐	☐	☐	☐	☐
Very capable in what I did	☐	☐	☐	☐	☐
A sense of contact with people	☐	☐	☐	☐	☐
Close and connected with other people	☐	☐	☐	☐	☐
A sense of intimacy with people around me	☐	☐	☐	☐	☐

D. YOUR WELL-BEING AND IDENTITY

1. Please indicate your agreement with the statements below:	Strongly disagree	Somewhat Disagree	Neutral	Somewhat agree	Strongly agree
The conditions of my life are excellent	☐	☐	☐	☐	☐
In most ways my life is close to my ideal	☐	☐	☐	☐	☐
I am satisfied with my life	☐	☐	☐	☐	☐
So far I have gotten the important things I want in life	☐	☐	☐	☐	☐
If I could live life over, I would change almost nothing	☐	☐	☐	☐	☐

2. Please indicate your agreement with the following statements:	Strongly disagree	Somewhat Disagree	Neutral	Somewhat agree	Strongly agree
I see myself as pro-environmental	☐	☐	☐	☐	☐
I am pleased to be pro-environmental	☐	☐	☐	☐	☐
I feel strong ties with pro-environmental people	☐	☐	☐	☐	☐
I identify with pro-environmental people	☐	☐	☐	☐	☐
Please mark this row with the answer Somewhat agree	☐	☐	☐	☐	☐

E. Walking in Columbus

1. In your experience, how walkable are the following areas:

a. Your primary residence	b. Your primary workplace	c. Where you most often go out for fun
☐ Not at all walkable	☐ Not at all walkable	☐ Not at all walkable
☐ Slightly walkable	☐ Slightly walkable	☐ Slightly walkable
☐ Moderately walkable	☐ Moderately walkable	☐ Moderately walkable
☐ Very walkable	☐ Very walkable	☐ Very walkable
☐ Extremely walkable	☐ Extremely walkable	☐ Extremely walkable
☐ Unable to answer	☐ Unable to answer	☐ Unable to answer

2. Would your friends/family who live in Columbus prefer to walk more than they currently do?

☐	☐	☐	☐	☐
Strongly disagree	Somewhat disagree	Neutral/Unsure	Somewhat agree	Strongly agree

F. Parking in Columbus

1. How long do you normally spend looking for a parking spot around the following areas:

a. Your primary residence	b. Your primary workplace	c. Where you most often go out for fun
☐ Under 1 min	☐ Under 1 min	☐ Under 1 min
☐ 1-5 min	☐ 1-5 min	☐ 1-5 min
☐ 6-10 min	☐ 6-10 min	☐ 6-10 min
☐ 11-15 min	☐ 11-15 min	☐ 11-15 min
☐ 16-20 min	☐ 16-20 min	☐ 16-20 min
☐ Over 20 min	☐ Over 20 min	☐ Over 20 min
☐ Not applicable	☐ Not applicable	☐ Not applicable

2. In your experience, are Columbus roads congested? (i.e., slow traffic, traffic jams)

☐	☐	☐	☐	☐
Not at all congested	Slightly congested	Moderately congested	Very congested	Extremely congested

F. Planning your trip

1. Think about your daily experience of getting around in Columbus. When planning a trip in Columbus you may be deciding how to get from where you are to your destination, figuring out how long it will take you to travel there, understanding when and how you will return, etc.

a. Planning my trip is	b. Transferring from one mode of transport to another (e.g., from bus to scooter) is:	c. Finding travel solutions for the first and last segment of my trip (e.g., to and from the bus) is:
☐ Extremely easy	☐ Extremely easy	☐ Extremely easy
☐ Somewhat easy	☐ Somewhat easy	☐ Somewhat easy
☐ Neither easy nor difficult	☐ Neither easy nor difficult	☐ Neither easy nor difficult
☐ Somewhat difficult	☐ Somewhat difficult	☐ Somewhat difficult
☐ Extremely difficult	☐ Extremely difficult	☐ Extremely difficult
☐ I don't usually do this	☐ I don't usually do this	☐ I don't usually do this

2. Considering trips around Columbus that require you to use multiple travel modes (e.g., bus, scooter), do you have access to a service (e.g., mobile phone app, website) or other means that enables you to <u>pay for</u> the entire trip at once (i.e., not every time you switch transit modes)?

☐	☐	☐	☐
Not at all	A small extent	A moderate extent	A large extent

3. Considering trips around Columbus that require you to use multiple travel modes (e.g., bus, scooter), do you have access to a service (e.g., mobile phone app, website) or other means that enables you to <u>plan</u> your entire trip at once?

☐	☐	☐
No	Yes	Not sure

4. Considering the services or other means you use to <u>plan</u> trips spanning multiple travel modes, how easy or difficult is it to plan travel?

☐	☐	☐	☐	☐	☐
Extremely easy	Somewhat easy	Neither easy nor difficult	Somewhat difficult	Extremely difficult	I don't usually do this

5. Considering the services or other means you use to pay for trips spanning multiple travel modes, how easy or difficult is it to pay for travel?

☐	☐	☐	☐	☐	☐
Extremely easy	Somewhat easy	Neither easy nor difficult	Somewhat difficult	Extremely difficult	I don't usually do this

G. Travel satisfaction

1. In general, how easy or difficult is it for you to get from your residence in Columbus to the following?	Extremely difficult	Somewhat difficult	Neutral	Somewhat easy	Extremely easy	Not applicable
Your primary workplace	☐	☐	☐	☐	☐	☐
Schools	☐	☐	☐	☐	☐	☐
Supermarket or grocery store	☐	☐	☐	☐	☐	☐
Healthcare services	☐	☐	☐	☐	☐	☐
Financial services (e.g., bank)	☐	☐	☐	☐	☐	☐
Utility providers (e.g., internet, telephone, water)	☐	☐	☐	☐	☐	☐
Other professional or technical services (e.g., legal help, auto care)	☐	☐	☐	☐	☐	☐
Park or other outdoor green space	☐	☐	☐	☐	☐	☐
Entertainment / recreational activities	☐	☐	☐	☐	☐	☐

2. Overall, how satisfied are you with your transportation options to access your basic household needs?	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied	Not applicable
Travel Time (includes waiting)	☐	☐	☐	☐	☐	☐
Travel Distance	☐	☐	☐	☐	☐	☐
Travel Cost (e.g., fare, gas)	☐	☐	☐	☐	☐	☐
Reliability	☐	☐	☐	☐	☐	☐
Simplicity	☐	☐	☐	☐	☐	☐
Flexibility	☐	☐	☐	☐	☐	☐
Comfort	☐	☐	☐	☐	☐	☐
Safety	☐	☐	☐	☐	☐	☐

H. Smart Columbus

1. Have you heard of the Smart Columbus program?

☐ Yes ☐ No → please skip to the next page

2. What do you know about the Smart Columbus program?

_____

_____

_____

3. Has the Smart Columbus program impacted your daily life?

☐	☐	☐	☐	☐	☐
Not at all	Slightly	Moderately	Considerably	Extremely	I am not sure

4. What impact did the Smart Columbus program have on your daily life?

☐	☐	☐	☐	☐	☐
Extremely negative	Somewhat negative	Neither positive nor negative	Somewhat positive	Extremely positive	I am not sure

5. What was your experience of the following Smart Columbus projects, if any?	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied	Not applicable
Smart Mobility Hubs	☐	☐	☐	☐	☐	☐
Smart Columbus Experience Center	☐	☐	☐	☐	☐	☐
Multi-Modal Trip Planning Application & Common Payment System (Pivot)	☐	☐	☐	☐	☐	☐
Self-Driving Shuttles	☐	☐	☐	☐	☐	☐
Event Parking Management	☐	☐	☐	☐	☐	☐
Smart Columbus Ride and Drive Roadshow	☐	☐	☐	☐	☐	☐
Prenatal trip assistance	☐	☐	☐	☐	☐	☐
Mobility assistance for cognitive disabilities	☐	☐	☐	☐	☐	☐

The following demographic information will be used to help make general conclusions about the residents of Columbus. Your responses will remain completely confidential.

I. Demographic Information

1. What is your year of birth?

_____

2. What is your current gender identity? Select all that apply

- ☐ Man
- ☐ Woman
- ☐ Trans Man
- ☐ Trans Woman
- ☐ Agender
- ☐ Genderqueer or Gender fluid
- ☐ Preferred identity: _____
- ☐ Prefer not to say

3. Which transportation resources are available to you as part of your weekly routine? Select all that apply

- ☐ I own a personal vehicle
- ☐ Someone else in my household supports me with their personal vehicle
- ☐ Someone outside my household supports me with their personal vehicle
- ☐ I have a current driver's license
- ☐ I have my own bicycle
- ☐ I have a mobile device that contains transportation service apps
- ☐ I have a credit card
- ☐ I have a bus pass provided by my employer
- ☐ Other: _____

4. If your household does not own a four-wheeled motor vehicle, why is that? Select all that apply

- ☐ No interest/need
- ☐ No driver's license
- ☐ Financial concerns
- ☐ Environmental concerns
- ☐ Prefer using alternative transportation modes (e.g., bicycle)
- ☐ Physical, mental, or emotional condition
- ☐ Other: _____
- ☐ Prefer not to say

5. What is the highest level of school you have completed or the highest degree you have received?

- ☐ Less than high school degree
- ☐ High school graduate (high school diploma or equivalent including GED)
- ☐ Some college but no degree
- ☐ Associate degree in college (2-year)
- ☐ Bachelor's degree in college (4-year)
- ☐ Master's degree
- ☐ Doctoral degree
- ☐ Professional degree (JD, MD)
- ☐ Prefer not to say

6. Choose one or more races that you consider yourself to be:

- ☐ White
- ☐ Black or African American
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Native Hawaiian or Pacific Islander
- ☐ Other: _____
- ☐ Prefer not to say

7. Are you Spanish, Hispanic, or Latino or none of these?

☐ Yes ☐ None of these ☐ Prefer not to say

8. What is your marital status?

- ☐ Now married
- ☐ Widowed
- ☐ Divorced
- ☐ Separated
- ☐ Never married
- ☐ Prefer not to say

9. How many children under the age of 18 live in your household?

_____

10. If there are children living in your household, what is the age of the youngest child?

- ☐ Under 2 years old
- ☐ Between 2 and 6 years
- ☐ Between 7 and 12 years
- ☐ Older than 12 years old

11. What is your zip code?

_____

12. For how many years have you been living in your current residence?

- ☐ 1 year or less
- ☐ 2 years
- ☐ 3 years
- ☐ 4 years
- ☐ 5 years
- ☐ 6 years
- ☐ 7 years
- ☐ 8 or more years

13. If you moved within the last 8 years, what was the zip code of your most recent residence, before your current residence? _____

14. Which statement best describes your current employment status?

- ☐ Working (paid employee)
- ☐ Working (self-employed)
- ☐ Not working (temporary layoff from a job)
- ☐ Not working (looking for work)
- ☐ Not working (retired)
- ☐ Not working (disabled)
- ☐ Not working (Other): _____
- ☐ Prefer not to say

15. When it comes to politics, how do you usually think of yourself?

☐	☐	☐	☐	☐	☐	☐
Extremely liberal	Liberal	Slightly liberal	Moderate, middle of the road	Slightly conservative	Conservative	Extremely conservative

☐ Don't know or haven't thought about it ☐ Prefer not to say

16. Please indicate the answer that includes your entire household income in 2018 before taxes:

☐ Less than $15,000
☐ $15,000 to $29,999
☐ $30,000 to $44,999
☐ $45,000 to $59,999
☐ $60,000 to $74,999
☐ $75,000 to $89,999
☐ $90,000 to $104,999
☐ $105,000 to $119,999
☐ $120,000 to $134,999
☐ $135,000 to $149,999
☐ $150,000 or more
☐ Prefer not to say

17. Because of a physical, mental, or emotional condition, do you have serious difficulty with any of the following? Select all that apply

☐ Hearing
☐ Seeing (even when wearing glasses)
☐ Concentrating, remembering, or making decisions
☐ Doing errands alone (e.g., visiting a doctor's office or shopping)
☐ Walking or climbing stairs
☐ Dressing or bathing
☐ None of the above
☐ Prefer not to say

Please make any additional comments in the space provided:

_____

_____

_____

_____

Thank you for taking the time to complete this survey!

We invite you to provide more detailed information about your travel choices in an online survey. By entering the below URL address into your web browser, you can access the additional online survey. This separate online survey will also provide a $5 prize as a sign of our thanks.

[insert URL code for travel diary]

Appendix F. Operating System Surveys

F.1 CONSUMER SURVEY

F.2 AGENCY SURVEY

Define your role at work?

Academia

Entrepreneur

Government/ Agency Employee

Non-profit

Corporate employee

Other (explain)

~~**Which datasets did you access? (Remove questions)**~~

In the past 12 months, how often have you visited the OS?

10+ visits

8-10 visits

5-7 visits

1-4 visits

What is your focus for working with the Smart Columbus Operating System data

Research

App development

Visualization

Analytics

Reports

Other (explain)

How are you accessing and using the data? (Select all applicable options)

Download

Run API Queries

Run Data Analytics

Run Applications using Data

Develop Reports

Other (explain)

Compared to data sharing mechanisms (email, ftp, etc) you've used in the past, rate the ease of finding data in the operating system

Compared to data sharing mechanisms (email, ftp, etc) you've used in the past, rate your ability to query and download the data through the operating system

Rate your ability to use the data with the related information (metadata, data dictionary) from the operating system

Rate your ability to use the data for your intended purpose(s)

Survey ratings are collected on a scale of 1 to 5 stars
★ *- Very Poor*
★★ *- Poor*
★★★ *- Fair*
★★★★ *- Good*
★★★★★ *- Very Good*

PfMP Agency Survey

Visit the Smart Columbus Operating System at www.smartcolumbusos.com

The operating system is the nexus, where our city becomes "smart."
- EXPLORE open data about our smart city
- SHARE data to inspire mobility insights and innovation
- LEARN about the technology that is transporting Columbus to the future
- VISUALIZE data to tackle open challenges

The operating system is still under development. Once you have visited the site, please return to this survey to provide feedback to our team.

* Required

1. Define your role at work * *Mark only one oval.*

- Data Analyst
- Manager/Deputy Manager
- Director
- Other: _____

2. Which organization do you represent? *

_____

3. Did you notice a change in number of requests for datasets before and after publishing on the Operating System? * *Mark only one oval.*

- Number of requests decreased
- Number of requests remained the same

4. How user friendly would you rate the OS? *Mark only one oval.*

	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

5. Is there a change in wait time to get access to data before and after publishing data on the Operating System from a 3rd party vendor? * *Mark only one oval.*

- ◯ Yes. The wait times reduced post-publishing on the Operating System.
- ◯ No. There was no notable change in wait times.
- ◯ Wait times increased after publishing on the Operating System.

6. What is your purpose for using data on the Operating System? (Select all that apply) *
Check all that apply.

- ☐ Developing visualizations
- ☐ Generating reports
- ☐ Performing analysis
- ☐ Information tracking

Other: ☐ _____

7. Have you identified a new purpose for the OS that was not a part of your original intent?

_____

_____

_____

_____

_____

8. If you developed any visualizations, analytics, reports, etc. using data on the Operating System, did the Operating System allow you to: * *Mark only one oval.*

- More efficiently produce work/deliverable
- No change in efficiency to produce work/deliverable
- Less efficiently produce work/deliverable

9. How did you access the data for your intended purposes before implementation of the Operating System? * *Mark only one oval.*

- Via email
- Posting on a server
- Made internal database requests
- Other: _____

10. What impact has the Operating System had on your ability to access and share data? *

Mark only one oval.

- OS has improved data sharing efficiency
- OS has not changed data sharing efficiency
- OS has reduced data sharing efficiency

11. Rate your data ingestion experience with your data-sharing mechanisms before implementation of the Operating System * *Mark only one oval.*

	1	2	3	4	5	
Low						High

12. Rate your data ingestion experience with the Operating System * *Mark only one oval.*

	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

13. How do you see the OS meeting your data sharing needs in the future? *Mark only one oval.*

- ◯ The OS will become your primary data sharing mechanism
- ◯ The OS will be used in conjunction with another data sharing method(s)
- ◯ A previous data sharing method will be the preferred method

14. If you decide to continue the use of a previous data sharing method, why?

15. Based on your experience with the Operating System, how likely are you to recommend the Operating System platform to other agencies? * *Mark only one oval.*

	1	2	3	4	5	
Very unlikely	◯	◯	◯	◯	◯	Very likely

16. Can you identify other agencies that would benefit from the OS? *Mark only one oval.*

- Yes
- No

17. Who would you recommend to benefit from the OS?

18. What additional features would you like to see on the Operating System in the future? Why? *

19. How helpful is it to use the Operating System platform for inter-agency data transfers? *

Mark only one oval.

	1	2	3	4	5	
Not helpful	◯	◯	◯	◯	◯	Very helpful

Appendix G. CVE Surveys

G.1 UNDER DEVELOPMENT

Appendix H. MMTPA Surveys

H.1 UNDER DEVELOPMENT/IRB REVIEW

Appendix I. MAPCD Survey Questionnaire

I.1 MAPCD FOCUS GROUP QUESTIONNAIRE

I.2 MAPCD USER SATISFACTION SURVEY

I.3 MAPCD CHECK-IN SURVEY

K. Focus Group Questions

Focus Group Questions: Participants

GENERAL:

- Tell us your ID number and your favorite thing about your experience with this study.

TRANSITION:

- Have you ever used a smartphone prior to this study?
- Have you ever used a COTA fixed route before this study?
- How do you typically get around the community or get to new places?
- Do you live alone?
- Do you make your own meals, transport yourself, go into the community or work on your own?

KEY QUESTIONS:

- Did you feel safe while using the app?
- What was the most challenging part of learning the app?
- Which training did you find most helpful?
- Which training was the least helpful?
- Was it easy to learn the information through this style?
- Were the quizzes helpful or scary?
- Was 1-2 times a week enough time to learn this information?

FINAL QUESTION:

- What is your final opinion of the app?
- What is your overall opinion of the trainings?
- Would you be more likely to use COTA with this app? (instead of COTA mainstream services)
- Would you feel comfortable using the app without anyone else with you?
- Did you feel more connected with the community through this study?
- Do you feel more comfortable using public transportation?
- Would anyone be interested in participating in this study again in the future?

Focus Group Questions: Community Specialists

GENERAL:

- Tell us your ID number and your place of employment
- How long have you been working with this population?
- How long have been taking individuals out on community outings?

TRANISTION:

- What were some of your observations throughout this study?
- Did you find the training helpful for the individual?
- Did you find splitting up the individuals into different levels to be helpful for the individuals learning and carryover?

KEY QUESTIONS:

- Was there any information that you felt was missing from the trainings?
- What did you think about the set up and presentation of the training information?
- What did you think about the length and time commitment of the training?
- Do you think the training increased their ability to use the app more independently?
- Do you think the app and trainings allowed the participants to be more independent in the community?
- Did you notice any positive or negative changes in the participants?

FINAL QUESTIONS:

- What population do you think this app would be most beneficial and useful for?
- Is there anything you would like to add to the training program?

Satisfaction Survey: Using the App

Satisfaction with App Features	Happy	Moderately Happy	Unhappy	Additional Comments
Could you see the pictures okay?				
Were the pictures helpful?				
Were the words on the screen helpful?				
Were the directions you heard helpful?				
Would you feel comfortable using this on your own?				
What would make you feel safer while using this app?				

What did you like about the app?

What did you not like about the app or thought was missing?

Satisfaction Survey: Safety Training

How much did you like:	Happy	Moderately Happy	Unhappy	Additional Comments
Did you like what was talked about?				
Did you find it helpful?				
Do you think this will help you when you're traveling in the community?				
What did you think of the tests at the end?				
Were they helpful?				
Did you like how the information was shown to you?				

What did you like about the training?

What did you not like about the training or would like to see more of?

Satisfaction Survey: COTA Training

How much did you like:	Happy	Moderately Happy	Unhappy	Additional Comments
Did you like what was talked about?				
Did you find it helpful?				
Do you think this will help you when you're traveling in the community?				
What did you think of the tests at the end?				
Were they helpful?				
Did you like how the information was shown to you?				

What did you like about the training?

What did you not like about the training or would like to see more of?

Satisfaction Survey: Smartphone Training

How much did you like:	Happy	Moderately Happy	Unhappy	Additional Comments
Did you like what was talked about?				
Did you find it helpful?				
Do you think this will help you when you're traveling in the community?				
What did you think of the tests at the end?				
Were they helpful?				
Did you like how the information was shown to you?				

What did you like about the training?

What did you not like about the training or would like to see more of?

Satisfaction Survey: WayFinder Training

How much did you like:	Happy	Moderately Happy	Unhappy	Additional Comments
Did you like what was talked about?				
Did you find it helpful?				
Do you think this will help you when you're traveling in the community?				
What did you think of the tests at the end?				
Were they helpful?				
Did you like how the information was shown to you?				

What did you like about the training?

What did you not like about the training or would like to see more of?

Check-in Survey

The survey will be administered via secure online survey (RedCap or equivalent), phone or paper depending on the participants preference.

How many times per week do you leave your house?

- 0-1 ☐
- 2-3 ☐
- 4-6 ☐
- 7 or more ☐

Where do you go when you use the Wayfinder app?

- Work/volunteering ☐
- School ☐
- Visiting friends or family ☐
- Recreation or organized activities ☐
- Shopping/errands ☐
- Medical appointments ☐

How many times per week do you use WayFinder?

- 0-1 ☐
- 2-3 ☐
- 4-6 ☐
- 7 or more ☐

Where did you go using the app?

- Work/volunteering ☐
- School ☐
- Visiting friends or family ☐
- Recreation or organized activities ☐
- Shopping/errands ☐
- Medical appointments ☐

Appendix J. PTA Survey Questionnaire

J.1 PTA BASELINE QUESTIONNAIRE

J.2 PTA FINAL QUESTIONNAIRE

J.3 PTA FOLLOW UP QUESTIONNAIRE

J.4 PTA KAIZEN SATISFACTION SURVEY

Study ID Number:_____

Rides4Baby Baseline Questionnaire

The purpose of this interview is to help us learn more about you as you begin the Rides4Baby study. When the results of the study are reported, answers from all women in the study will be combined, and your answers will not be linked to your name.

GENERAL HEALTH HISTORY

The first few questions that I will ask you are about your health status.

1. In general, would you say your health is [read responses]:

   1 Excellent
   2 Very good
   3 Good
   4 Fair
   5 Poor

   98 Don't know
   99 Refused

2. I am going to read a list of common medical conditions. As I read each of the conditions, please let me know whether or not a health care provider has diagnosed you with that condition.

   [Read if individual endorses a condition.]

   Are you being treated for that condition now?

	Ever diagnosed?		**Currently being treated?**	
High blood pressure	Yes	No	Yes	No
Asthma	Yes	No	Yes	No
Diabetes	Yes	No	Yes	No
Thyroid disease	Yes	No	Yes	No
Heart disease	Yes	No	Yes	No
Kidney disease	Yes	No	Yes	No
Hepatitis B	Yes	No	Yes	No
Hepatitis C	Yes	No	Yes	No
Depression	Yes	No	Yes	No
Anxiety	Yes	No	Yes	No
Bipolar disorder	Yes	No	Yes	No
Post-traumatic stress disorder	Yes	No	Yes	No
Borderline personality disorder	Yes	No	Yes	No
Other mental health disorder	Yes	No	Yes	No
Developmental disability	Yes	No	Yes	No
Rheumatoid arthritis	Yes		Yes	

Lupus	Yes	No	Yes	No
Seizure disorder	Yes	No	Yes	No
Sickle cell disease	Yes	No	Yes	No
Sickle cell trait	Yes	No	Yes	No
Cancer; what kind(s)? _____	Yes	No	Yes	No

3. How tall are you without shoes?

   _____ feet _____ inches

   98 Don't know
   99 Refused

4. How much did you weigh just before you became pregnant?

   _____ pounds

   98 Don't know
   99 Refused

The next few questions address some challenges that you might or might not face.

5. Are you deaf, or do you have serious difficult hearing?

   0 No
   1 Yes

   98 Don't know
   99 Refused

6. Are you blind, or do you have serious difficulty seeing, even when wearing glasses?

   0 No
   1 Yes

   98 Don't know
   99 Refused

7. Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?

   0 No
   1 Yes

   98 Don't know
   99 Refused

8. Do you have serious difficulty walking or climbing stairs?

   0 No
   1 Yes

   98 Don't know
   99 Refused

9. Do you have difficulty dressing or bathing?

   0 No
   1 Yes

   98 Don't know
   99 Refused

10. Because of a physical, mental, or emotional condition, do you have difficulty doing errands alone such as visiting a doctor's office or shopping?

    0 No
    1 Yes

    98 Don't know
    99 Refused

YOUR REPRODUCTIVE HISTORY

The next few questions relate to your pregnancy history.

11. Including this pregnancy, how many times have you been pregnant? Please include any miscarriages, abortions, still births, and live births.

_____ times

98 Don't know
99 Refused

[If 11="1" then skip to question 16.]

12. How many live births have you had?

_____ live births

98 Don't know
99 Refused

13. In what year did you have your first live birth?

_____ (enter 4-digit year, like 2013)

98 Don't know
99 Refused

14. How many of your babies were born preterm (before 37 weeks of gestation)? The average pregnancy lasts 40 weeks.

_____ preterm births

98 Don't know
99 Refused

15. Were you prescribed progesterone, either shots or vaginal inserts, during a previous pregnancy?

0 No
1 Yes

98 Don't know
99 Refused

YOUR CURRENT PREGNANCY

The next few questions that I will ask relate to your current pregnancy.

16. Thinking back to just before you got pregnant with this baby, how did you feel about becoming pregnant? [Read responses.]

    1 I wanted to be pregnant later
    2 I wanted to be pregnant sooner
    3 I wanted to be pregnant then
    4 I didn't want to be pregnant then or at any time in the future
    5 I wasn't sure what I wanted

    98 Don't know
    99 Refused

17. What is your due date?

    _____/ _____/ _____ (enter as MMDDYYY)

    98 Don't know
    99 Refused

18. What was the date of the first day of your last menstrual period? That is, the first day of the last time that you were bleeding enough to need a tampon or pad.

    _____/ _____/ _____ (enter as MMDDYYY)

    98 Don't know
    99 Refused

19. How many weeks pregnant were you when you found out <u>for sure</u> that you were pregnant?

    _____ weeks (enter a number 4-42)

    98 Don't know
    99 Refused

20. How did you find out that you were pregnant? [Read responses.]

    1 Home pregnancy test
    2 Pregnancy test taken at a doctor's office or clinic
    3 Other (Specify: _____)

    98 Don't know
    99 Refused

YOUR LIFESTYLE

The next few questions will ask about your substance use.

21. Have you smoked at least 100 cigarettes in your entire life?

0 No [Skip to question 23]
1 Yes [Continue]

98 Don't know
99 Refused

22. In the three months before you learned that you were pregnant, did you smoke cigarettes every day, some days, or not at all?

1 Every day
2 Some days
3 Not at all

98 Don't know
99 Refused

23. Have you ever used an e-cigarette or other electronic vaping product, even just one time, in your entire life?

0 No [Skip to question 25]
1 Yes [Continue]

98 Don't know
99 Refused

24. In the three months before you learned that you were pregnant, did you use an e-cigarette or other electronic vaping product every day, some days, or not at all?

1 Every day
2 Some days
3 Not at all

98 Don't know
99 Refused

25. In the three months before you learned that you were pregnant, did you use marijuana or cannabis every day, some days, or not at all?

1 Every day
2 Some days
3 Not at all

98 Don't know
99 Refused

26. In the three months before you learned that you were pregnant, did you use heroine every day, some days, or not at all?

1 Every day
2 Some days
3 Not at all

98 Don't know
99 Refused

27. In the three months before you learned that you were pregnant, did you use a prescription opioid medication, whether it was prescribed for you or you obtained it from another source, every day, some days, or not at all?

1 Every day
2 Some days
3 Not at all

98 Don't know
99 Refused

MORE ABOUT YOU

This last set of questions will ask about your lifestyle and living situation.

28. Which of the following best describes your current housing situation? [Read responses.]

1 My housing is stable.
2 My housing is unstable.
3 I am homeless.

98 Don't know
99 Refused

29. Is the father of your baby currently involved in your life?

0 No
1 Yes

98 Don't know
99 Refused

30. How satisfied are you with the social support that you get from family and friends? Are you…[read responses]:

1 Very satisfied
2 Somewhat satisfied
3 Neither satisfied or dissatisfied
4 Somewhat dissatisfied
5 Very dissatisfied

98 Don't know
99 Refused

31. Over the last month, how much have you been bothered by anxiety? [Read responses.]

1 Not at all
2 A little
3 Some
4 A lot

98 Don't know
99 Refused

32. Over the last month, how much have you been bothered by depression or sadness? [Read responses.]

1 Not at all
2 A little
3 Some
4 A lot

98 Don't know
99 Refused

*Adapted from the Subjective Health Complaints Inventory

33. I'm going to read you a list of situations. As I read each one, please tell me how often you have experienced that situation, if at all, in your day to day life. Specifically, please tell me if you have experienced the situation: almost every day, at least once a week, a few times a month, a few times a year, less than once a year, or never.

	Almost Everyday	At least once a week	A few times a month	A few times a year	Less than once a year	Never
You are treated with less courtesy than other people are.	5	4	3	2	1	0
You receive poorer service than other people at restaurants or stores.	5	4	3	2	1	0
People act as if they think you are not smart.	5	4	3	2	1	0
People act as if they are afraid of you.	5	4	3	2	1	0
You are threatened or harassed.	5	4	3	2	1	0

34. Now I'm going to read you a list of modes of transportation. As I read the list, please tell me which modes of transportation you have used in the last 3 months? [Read responses.]

Your own car	Yes	No
Ride from husband, partner, father of the baby	Yes	No
Ride from another family member (not the father of the baby)	Yes	No
Ride from friend	Yes	No
COTA bus	Yes	No
Ride share (like Lyft, Uber) for which you paid	Yes	No
Taxi (for which you paid)	Yes	No
Non-emergency medical transportation (ride paid for by CareSource or Molina)	Yes	No
Rode a bike	Yes	No
Walked	Yes	No
Any other type? Specify:_____	Yes	No

98 Don't know
99 Refused

[If "Yes" to NEMT, then continue; otherwise, skip to question 36.]

35. Overall, how satisfied have you been with the non-emergency medical transportation services that you have received since you learned that you were pregnant? Were you... [read responses].

1 Very satisfied
2 Somewhat satisfied
3 Neither satisfied or dissatisfied
4 Somewhat dissatisfied
5 Very dissatisfied

98 Don't know
99 Refused

36. In the last 3 months, which of the following has been your main form of transportation? [Read responses.]

1 My own car
2 Ride from husband, partner, father of baby
3 Ride from another family member (not the father of the baby)
4 Ride from a friend
5 COTA bus
6 Ride share service (like Lyft, Uber) for which I paid
7 Taxi (for which I paid)
8 Non-emergency medical transportation (ride paid by someone else)
9 Rode a bike
10 Walked
11 Other (Specify:_____)

98 Don't know
99 Refused

37. I am going to read you a list of places. As I read the list, please tell me if you have had difficulty with transportation to that place in the last 3 months. If you don't go to that place, please tell me not applicable.

Doctor's office	Yes	No	N/A
Pharmacy or drugstore	Yes	No	N/A
Grocery store or food bank	Yes	No	N/A
Women Infants and Children (WIC) Clinic	Yes	No	N/A
Job training center	Yes	No	N/A
Work	Yes	No	N/A
School	Yes	No	N/A
Childcare provider/child(ren)'s school	Yes	No	N/A
Friend's house	Yes	No	N/A
Family's house	Yes	No	N/A
Any other place? Please specify:_____	Yes	No	N/A

38. Now I'm going to read you a list of devices. As I read the list, please tell me which of the devices you own or have had regular access to in the last 3 months.

Landline phone	Yes	No
Smartphone	Yes	No
Flip phone or other type of cell phone	Yes	No
Laptop or desktop computer	Yes	No
Tablet (like an iPad)	Yes	No

[If smart phone=No, skip to question 40.]

39. What type of smart phone do you have?

1 iPhone
2 Android
3 Something else (specify: _____)

97 Don't have a smart phone
98 Don't know
99 Refused

40. Which of the following best describes the number of cell phone minutes you have each month? [Read responses.]

1 It varies. I pay as I go.
2 Less than 500 minutes
3 501 to 750 minutes
4 More than 750 minutes
5 Unlimited minutes

97 Don't have a phone [Skip to question 43]
98 Don't know
99 Refused

41. Do you usually run out of phone minutes before the end of the month?

0 No
1 Yes

98 Don't know
99 Refused

42. Which of the following best describes your texting plan on your cell phone? [Read responses.]

1 I cannot text on my phone.
2 I can text, but the number of texts per month is limited.
3 I have unlimited texting ability.

98 Don't know
99 Refused

43. Which of the following best describes your data plan on your cell phone? [Read responses.]

1 I do not have a data plan.
2 I have a data plan but I'm limited in the amount of data that I use each month.
3 I have an unlimited data plan.

98 Don't know
99 Refused

44. Which of the following best describes your internet access? [Read responses.]

1 I always have internet access [Continue]
2 I sometimes have internet access [Continue]
3 I never have internet access [Skip to question 46.]

98 Don't know
99 Refused

45. How do you usually access the internet? [Read responses.]

1 Wi-Fi at home
2 Wi-Fi at work
3 Public Wi-Fi (like at the library or other public place)
4 Cellular access on my phone

98 Don't know
99 Refused

My last few questions relate to demographic information.

46. Which of the following best describes your current marital status? [Read responses.]

1 Married
2 Living as married (cohabitating)
3 Never married
4 Separated or divorced
5 Widowed6

98 Don't know
99 Refused

47. What is the highest education level you have completed? [Read responses.]

0 No formal school
1 Grade school (1-8 years of school)
2 Some high school
3 High school graduate or GED
4 Some college
5 College graduate
6 Graduate or professional school

98 Don't know
99 Refused

48. Do you have a job(s) either full or part-time?

0 No [Skip to question 50.]
1 Yes [Continue]

98 Don't know
99 Refused

49. About, how many hours per week do you usually work at your job(s) combined? [Code participant response.]

1 <10 hours
2 10-19 hours
3 20-40 hours
4 41-59 hours
5 60+ hours

98 Don't know
99 Refused

50. What is your typical monthly household income? Do not include food stamps. [Code "0" if participant has no income.]

$_____

98 Don't know
99 Refused

51. Including yourself, how many people are in your household?

_____ person/people

98 Don't know
99 Refused

52. How many children under the age of 18 are in your household?

_____ child(ren)

98 Don't know
99 Refused

53. In what country were you born?

Name of country: _____

98 Don't know
99 Refused

It is very important that we can reach while you are participating in this project. In the next few questions, we'll collect your contact information.

54. What is your current address?

Street address:_____

City: _____ State:_____ Zip code: _____

55. Do you receive mail at this address?

0 No [Continue]
1 Yes [Skip to question 57.]

56. What is the address at which you receive mail?

Street address:_____

City: _____ State:_____ Zip code: _____

57. Which of the following phone numbers do you have?

Home:_____ ☐ Does not have a home phone

Cell :_____ ☐ Does not have a cell phone

Additional/Other:_____ ☐ Does not have an additional phone

58. What is the best number to reach you?

1 Home
2 Cell
3 Other

59. Do you have an email address?

0 No [Skip to question 61.]
1 Yes [Continue.]

60. What is your email address?

_____@_____

61. We'd like to get the name and contact information for two people who could help us to contact you if we are unable to reach you. We will only contact these individuals if we are unable to reach you.

1) Name:_____

Phone:_____

E-mail: _____@_____

Relationship to participant:_____

2) Name:_____

Phone:_____

E-mail: _____@_____

Relationship to participant:_____

Thank you for taking the time to complete this interview. Now I need to take a moment to confirm some information before we can continue.

62. Date interview completed:

_____/_____/_____

63. Interviewer notes:

_____
_____
_____
_____

Study ID Number:_____

Rides4Baby Final Questionnaire

Thank you for working with us on the Rides4Baby project. We appreciate your time and feedback. For this final interview, I am going to ask you some questions about your pregnancy and travel experiences.

USE OF HEALTHCARE AND OTHER SERVICES DURING PREGNANCY

The first few questions relate to your use of healthcare services.

1. Where did you get the majority of your prenatal care during your pregnancy? [If participant needs prompting, read responses.]

   1 Ohio State University
   2 Primary One
   3 Heart of Ohio Family Health Centers
   4 Lower Lights Christian Healthcare Center
   5 Riverside OBGYN Community Care
   6 Noor Community Clinic
   7 Southeast Healthcare Services
   8 Midwife at home
   8 Did not get prenatal care
   10 Other place, specify:_____

   98 Don't know
   99 Refused

2. Now, I am going to read a list of services that you might have received during your pregnancy. As I read the list, tell me if you used that service during this pregnancy. [Read responses.]

WIC (Women, infants, and children)	Yes	No
Job and family services (like job training programs)	Yes	No
Non-emergency medical transportation (like rides to the doctor)	Yes	No
Food bank or food pantry	Yes	No
Food stamps	Yes	No
Homeless shelter	Yes	No
Moms2B	Yes	No
Centering pregnancy	Yes	No
Home visiting program	Yes	No
Other, specify	Yes	No

3. Next I'm going to read you a list of services that you might have received from your Medicaid managed care organization during your pregnancy. As I read the list, please tell me if you have received any of these services? [Read responses.]

Informational mailings or packets	Yes	No
Informational texts or emails	Yes	No
In-person educational sessions	Yes	No
Incentive program to encourage you to attend your appointments	Yes	No
Ask a nurse line	Yes	No
Case management	Yes	No
Anything else? Specify:_____	Yes	No

YOUR PREGNANCY AND YOUR BABY (BABIES)

The next few questions relate to your pregnancy and reproductive health.

4. I am going to read you a list of medical conditions. As I read the list, please tell me if you experienced any of these conditions in your most recent pregnancy. [Read responses.]

High blood pressure	Yes	No
Gestational diabetes	Yes	No
Urinary tract infection	Yes	No
Sexually transmitted infection	Yes	No
Pre-eclampsia	Yes	No
Preterm labor	Yes	No
Short cervix	Yes	No
Baby has a birth defect	Yes	No
Depression	Yes	No
Any other conditions? Specify:	Yes	No

5. Over the last month, how much have you been bothered by anxiety? [Read responses.]

1 Not at all
2 A little
3 Some
4 A lot

98 Don't know
99 Refused

6. Over the last month, how much have you been bothered by depression or sadness? [Read responses.]

1 Not at all
2 A little
3 Some
4 A lot

98 Don't know
99 Refused

*Adapted from the Subjective Health Complaints Inventory

Now I'm going to ask you a few questions about your baby or babies.

7. Were you pregnant with one baby or was it twins or triplets?

0 No
1 Yes, twins
2 Yes, triplets
3 Yes, more babies (specify number: _____)

98 Don't know
99 Refused

8. What was the outcome of your pregnancy? Was it… [read responses].

1 A live birth [continue]
2 A stillbirth [skip to question 10]
3 A miscarriage [skip to question 10]
4 An abortion [skip to question 10]
5 A tubal or ectopic pregnancy [skip to question 10]
6 A molar pregnancy [skip to question 10]

98 Don't know
99 Refused

9. What was the date of birth?

_____/ _____/ _____ (enter as MMDDYYY) [skip to question 11]

98 Don't know
99 Refused

10. What was the date the pregnancy ended? [skip to intro before question 12]

_____/ _____/ _____ (enter as MMDDYYY)

98 Don't know
99 Refused

11.

	How much did the baby weigh?	Was it a boy or a girl?	What was they baby's full legal name?	Was the baby admitted to the neonatal intensive care unit?
Baby A	____lbs ____ oz	1 Boy 2 Girl 3 Unknown	First name: _____ Middle name: _____ Last name: _____	0 No 1 Yes
Baby B	____lbs ____ oz	1 Boy 2 Girl 3 Unknown	First name: _____ Middle name: _____ Last name: _____	0 No 1 Yes
Baby C	____lbs ____ oz	1 Boy 2 Girl 3 Unknown	First name: _____ Middle name: _____ Last name: _____	0 No 1 Yes

Next I am going to ask you about things that might have happened since you left the hospital after delivery.

[If live birth, continue. If not, skip to question 14.]

12. Since you left the hospital, has/have your baby/babies gone to the doctor for a well-baby checkup?

0 No [Continue]
1 Yes [Skip to question 14]

98 Don't know
99 Refused

13. Which of the following reasons describe why your baby/babies has/have not yet been to the doctor for a checkup? [read responses.]

1	Baby/babies doesn't/don't have a doctor
2	Didn't think that baby/babies needed it
3	Too busy
4	Couldn't get the time off work/school
5	Couldn't get there
6	Didn't know where to go
7	Couldn't afford it
8	Baby is still in the hospital
9	Other reason? Specify: _____
98	Don't know
99	Refused

14. Since your pregnancy ended, have you had a postpartum checkup for yourself? A postpartum checkup is the regular checkup a woman should have about 4-6 weeks after the end of pregnancy.

0	No	[Continue]
1	Yes	[Skip to question 16]
98	Don't know	
99	Refused	

15. Which of the following reason describe why you have not yet been to the doctor for a postpartum checkup? [read responses.]

1	Don't have a doctor or midwife
2	Didn't think that I needed it
3	Too busy
4	Couldn't get the time off work/school
5	Couldn't get there
6	Didn't know where to go
7	Couldn't afford it
8	Other reason? Specify: _____
98	Don't know
99	Refused

16. In which **one** position do you **most often** lay your baby down to sleep?

1 On his or her side
2 On his or her back
3 On his or her stomach

98 Don't know
99 Refused

17. In the past two weeks, how often has your new baby slept alone in his or her own crib or bed?

5 Always
4 Often
3 Sometimes
2 Rarely
1 Never

98 Don't know
99 Refused

18. I am going to read you a list of advice that a doctor, nurse, or other health care worker might have given you about your baby's/babies' sleep environment. For each item, tell me "no" if they did not give you that advice or "yes" if they did.

Place my baby on his or her back to sleep	Yes	No
Place my baby to sleep in a crib, bassinet, or pack and play	Yes	No
Place my baby's crib or bed in my room	Yes	No
What things should and should not go in bed with my baby	Yes	No

19. Are you currently sexually active?

0 No
1 Yes

98 Don't know
99 Refused

20. I am going to read you a list of birth control methods. As I read the list, please tell me if you or your partner are currently using that form of birth control. [Read responses.]

Tubes tied or blocked (female sterilization or Essure)	Yes	No
Vasectomy (male sterilization)	Yes	No
Birth control pill	Yes	No
Condoms	Yes	No
Shots or injections (Depo-Provera)	Yes	No
Contraceptive patch (OrthoEvra) or vaginal ring (NuvaRing)	Yes	No
IUD (Mirena, ParaGard, Liletta, Skyla)	Yes	No
Contraceptive implant in the arm (Nexplanon, Implanon)	Yes	No
Natural family planning (including the rhythm method)	Yes	No
Withdrawal (pulling out)	Yes	No
Not having sex (abstinence)	Yes	No
Anything else? Specify: _____	Yes	No

YOUR USE OF TRANSPORTATION

21. Now I'm going to read you a list of modes of transportation. As I read the list, please tell me which modes of transportation you have used since you learned you were pregnant. [Read responses.]

My own car	Yes	No
Ride from husband, partner, father of baby	Yes	No
Ride from another family member (not the father of the baby)	Yes	No
Ride from a friend	Yes	No
COTA bus	Yes	No
Ride share (like Lyft, Uber) for which you paid	Yes	No
Taxi (for which you paid)	Yes	No
Non-emergency medical transportation (ride paid for by CareSource or Molina)	Yes	No
Rode a bike	Yes	No
Walked	Yes	No
Any other type? Specify:_____	Yes	No

22. Since you started the study, how many times have you used Rides4Baby transportation services to get to the doctor or healthcare provider?

_____ times [If 0, continue; otherwise, skip to question 24]

98 Don't know
99 Refused

23. I am going to read a list of possible reasons why you didn't use Rides4Baby transportation services. As I read the list, please tell me all that apply. [Read responses.]

I had a car.	Yes	No
I was able to get a ride from a friend.	Yes	No
I was able to get a ride from a family member.	Yes	No
I rode the bus.	Yes	No
I walked.	Yes	No
I rode a bike.	Yes	No
It takes too long.	Yes	No
I tried, but the ride never came or I missed my ride.	Yes	No
I could not contact the transportation services to set up a ride.	Yes	No
I tried but was not able to schedule a ride.	Yes	No
The last time I used it, it was a bad experience.	Yes	No
It was too difficult to set up a ride.	Yes	No
I didn't have enough minutes available to call and schedule a ride.	Yes	No
Other reason? Specify:_____	Yes	No

24. We are very interested in your satisfaction with various aspects of Rides4Baby transportation services. I am going to read you a list of items. As I read each item, please tell me how satisfied you were with that item. Specifically, please tell me if you were very satisfied, somewhat satisfied, neither satisfied or dissatisfied, somewhat dissatisfied, or very dissatisfied.

	Very Satisfied	Somewhat satisfied	Neither satisfied or dissatisfied	Somewhat dissatisfied	Very dissatisfied	Not applicable
Transportation services overall	5	4	3	2	1	0
Ease of scheduling a ride	5	4	3	2	1	0
Call center hold times	5	4	3	2	1	0
Courtesy of call center staff	5	4	3	2	1	0
Promptness of the driver(s)	5	4	3	2	1	0
Courtesy of the driver(s)	5	4	3	2	1	0
Wait time for a ride	5	4	3	2	1	0
Safety of the ride	5	4	3	2	1	0
Availability of car seats	5	4	3	2	1	0

25. Since you started the study, what did you **like most** about the Rides 4Baby transportation services that you received?

_____
_____
_____

97 Didn't use any Rides4Baby services
98 Don't know
99 Refused

26. Since you started the study, what did you **like least** about the Rides 4Baby transportation services that you received?

_____
_____
_____

97 Didn't use any Rides4Baby services
98 Don't know
99 Refused

QUESTIONS FOR WOMEN IN THE INTERVENTION GROUP

Now I'd like to ask you a few questions with various aspects of Rides4Baby transportation services.

27. Did you use the Rides4Baby mobile application to schedule a ride?

0 No [Skip to question 30.]
1 Yes [Continue]

98 Don't know
99 Refused

28. I am going to read you a list of items. As I read each item, please tell me how satisfied you were with that item. Specifically, please tell me if you were very satisfied, somewhat satisfied, neither satisfied or dissatisfied, somewhat dissatisfied, or very dissatisfied.

	Very Satisfied	Somewhat satisfied	Neither satisfied or dissatisfied	Somewhat dissatisfied	Very dissatisfied
The mobile application and text service overall	5	4	3	2	1
The mobile application overall	5	4	3	2	1
Compatibility of the app with your phone	5	4	3	2	1
Ease of learning to use the app	5	4	3	2	1
East of using the app	5	4	3	2	1
Layout of the app	5	4	3	2	1
East of navigating the app	5	4	3	2	1
Using the app to schedule a ride	5	4	3	2	1
Using the app to track the location of the driver	5	4	3	2	1
Ability to provide feedback on the ride	5	4	3	2	1
Use of text service to schedule a ride	5	4	3	2	1

29. Would you recommend the Rides4Baby mobile application to other pregnant women?

5 Definitely
4 Probably
3 Maybe
2 Probably not
1 Definitely not

98 Don't know
99 Refused

[Skip to question 31.]

30. I am going to read a list of possible reasons why you didn't use Rides4Baby mobile application. As I read the list, please tell me all that apply. [Read responses.]

I didn't have a phone.	Yes	No
Couldn't download the mobile application.	Yes	No
Mobile application didn't work.	Yes	No
Didn't understand the mobile application.	Yes	No
Couldn't access the internet.	Yes	No
Prefer to talk to someone	Yes	No
Other reasons? Specify:_____	Yes	No

31. How many times during the study did you use Rides4Baby transportation services to go to the grocery store or a foodbank?

_____ times [If 0 skip to question 33; otherwise, continue.]

98 Don't know
99 Refused

32. What kind of impact do you think using Rides4Baby transportation to get to the grocery store or food bank has had on your health? Has it had… [Read responses.]

1 A positive impact
2 Neither a positive nor a negative impact
3 A negative impact

98 Don't know
99 Refused

33. How many times during the study did you use Rides4Baby transportation services to go to the pharmacy?

_____ times [If 0 skip to end of questionnaire; otherwise, continue.]

98 Don't know
99 Refused

34. What kind of impact do you think using Rides4Baby transportation to get to the pharmacy has had on your health? Has it had… [Read responses.]

1 A positive impact
2 Neither a positive nor a negative impact
3 A negative impact

98 Don't know
99 Refused

Thank you for participating in the Rides4Baby study!

35. Date interview completed:

_____/_____/_____

36. Interviewer notes:

_____
_____
_____
_____

Study ID Number:_____

Rides4Baby Follow-Up Questionnaire

[Link sent monthly via text message.]

Hi there! It's the Rides4Baby team checking in.

1. How many times did you use Rides4Baby transportation services in the last month?

   _____ times [If 0 then skip to question 4; otherwise, continue.]

2. On a scale of 1 to 5, how satisfied were you overall with that transportation in the last month?

   5 Very satisfied
   4 Somewhat satisfied
   3 Neither satisfied or dissatisfied
   2 Somewhat dissatisfied
   1 Very dissatisfied

3. During any of your Rides4Baby rides in the last month, did you ever feel unsafe?

   0 No
   1 Yes

   [If participant says yes, Rides4Baby staff will call to collect more information about the incident. Managed Care Organizations and/or the IRB will be notified, as needed.]

4. How many times did you use another form of transportation to get to the doctor or other healthcare provider in the last month?

   _____ times

   Thank you for your responses!

   [Make all responses required.]

Kaizen Satisfaction Surveys

Texted to rider after the ride:

On a scale of 1 to 5, how satisfied were you with your ride?

5	Very satisfied
4	Somewhat satisfied
3	Neither satisfied or dissatisfied
2	Somewhat dissatisfied
1	Very dissatisfied

Texted to the driver after the ride:

On a scale of 1 (lowest) to 5 (highest), please rate [RIDER NAME].

Appendix K. SMH Surveys

K.1 SMH RESIDENT SURVEY [UNDER DEVELOPMENT]

K.2 SMH MOBILITY PROVIDER INTERVIEWS [UNDER DEVELOPMENT]

Appendix L. EPM Survey

L.1 EPM USER SURVEY

Appendix M. CEAV Survey Questionnaire

M.1 CEAV SMART CIRCUIT SURVEY

M.2 CEAV LINDEN LEAP SURVEY

M.3 CEAV FOOD PANTRY SURVEY

Smart Circuit Survey Questions

Landing page note: You must be 18 or over to complete this survey.

Questions

Respondent Information

1. What is your zip code?
    a.
2. Please identify your gender
    a. Male
    b. Female
    c. Other
    d. Prefer Not to Answer
3. What year were you born?
    a.
4. How did you hear about the shuttle?
    a. Social Media
    b. News
    c. Friend
    d. Newsletter
    e. Other describe
5. Did you bring young children (less than 12) aboard the shuttle?
    a. Yes
    b. No
    c. Prefer not to answer
6. Where did you get on the shuttle?
    a. COSI
    b. National Veterans Memorial & Museum
    c. Smart Columbus
    d. Bicentennial Park
7. Where did you get off the shuttle?
    a. COSI
    b. National Veterans Memorial & Museum
    c. Smart Columbus
    d. Bicentennial Park
8. How frequently do you use public transit (e.g. COTA)?
    a. Not at all
    b. A few trips per year
    c. 1-3 trips per month
    d. 1-4 trips per week
    e. 5-9 trips per week
    f. 10-14 trips per week
9. What is your primary mode of transportation?

    a. Car
    b. Transit (bus, train, etc.)
    c. Bicycle
    d. Walk
    e. Carpool
    f. Other describe
10. Which of the following have you used in the past year as an alternative to driving a personal vehicle (check all that apply??
    a. Car sharing (Zipcar, Car2Go, etc.)
    b. Ridesharing (Uber, Lyft, etc.)
    c. Carpool/Vanpool
    d. Bicycle
    e. Manual bicycle share
    f. Electric bicycle share
    g. Public bus
    h. Subway or train
    i. Other
    j. None of the above

AV Impressions

11. Have you ever ridden in a self-driving vehicle prior to this trip?
    a. Yes
    b. No
    c. Not sure
12. What was your trust level in self-driving technology prior to this trip?
    a. 1 – None
    b. 2 – Some
    c. 3 – Moderate
    d. 4 – High
13. How has your trust level with self-driving technology changed following your ride?
    a. Less trusting
    b. Remained unchanged
    c. More trusting
14. Were you more or less comfortable with an operator on-board that could intervene if a situation arises?
    a. More comfortable
    b. Neutral
    c. Less comfortable
15. Did you notice the operator take control of the vehicle?
    a. Yes
    b. No
    c. Don't know
16. How likely are you to recommend this self-driving shuttle to others?
    a. 1 – Not at all likely
    b. 2

c. 3
d. 4
e. 5
f. 6
g. 7
h. 8
i. 9
j. 10 – Extremely likely

17. What is the most important reason for your score?
18. How might we improve your experience?
    a.

Linden Shuttle Survey Questions

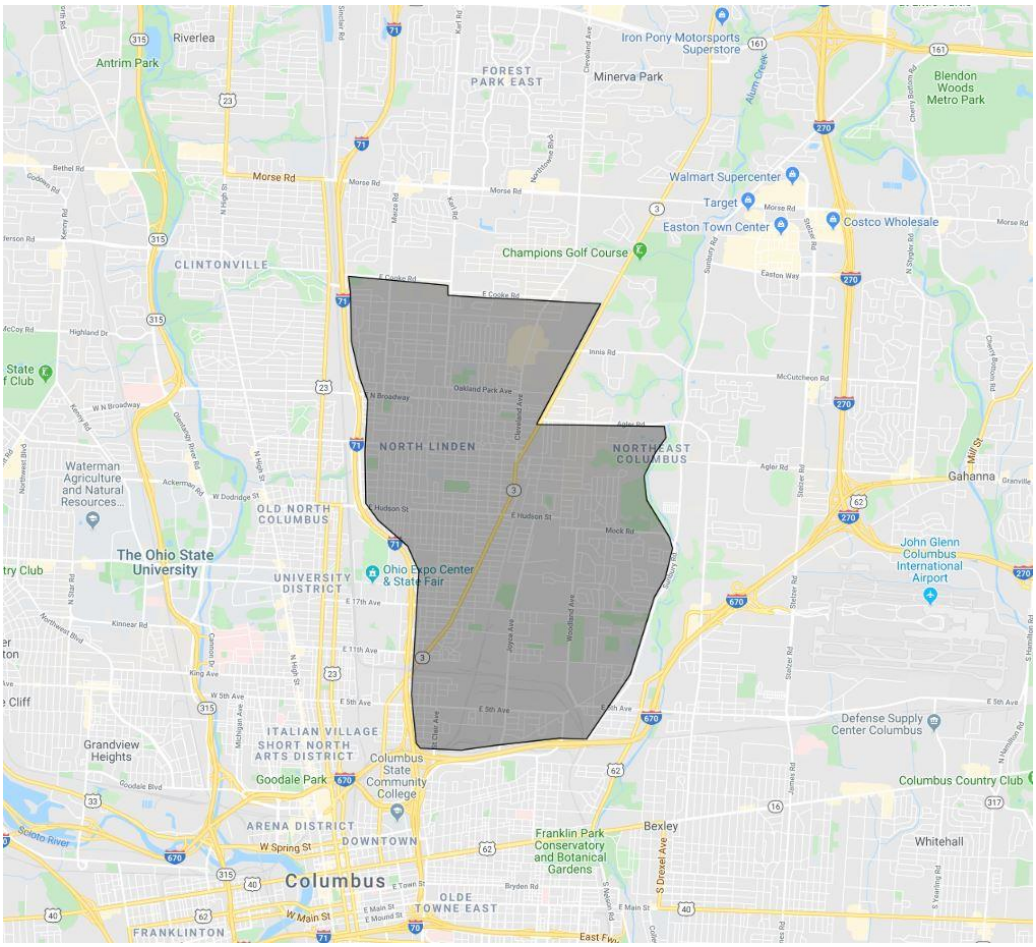
Landing page note: You must be 18 or over to complete this survey.

Questions

Respondent Information (demographics)

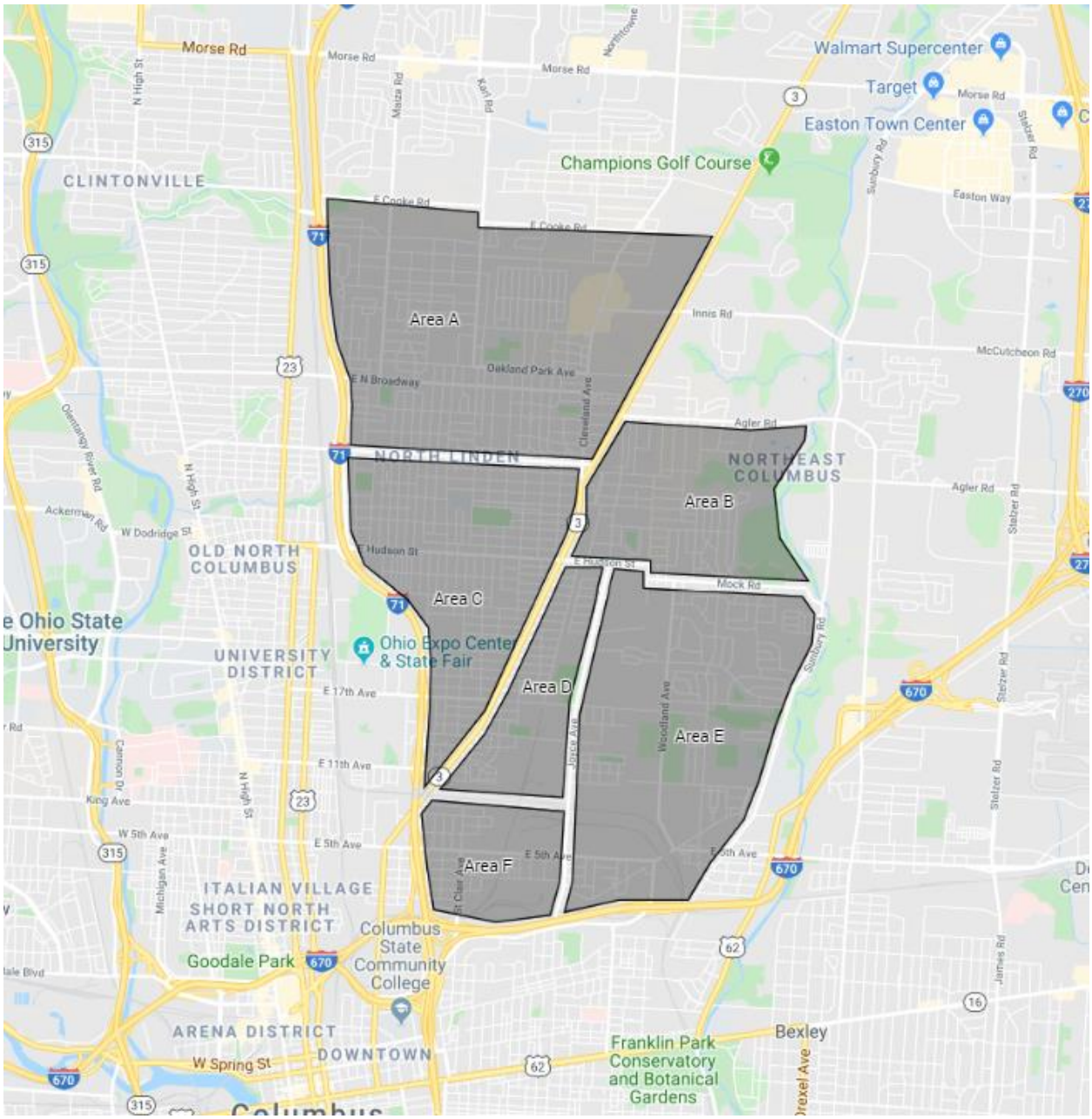
1. Is your primary residence within the area shaded in the map?
    a. Yes
    b. No, I live in a different part of the Columbus region.
    c. No, I live in a different part of Ohio.
    d. No, I live outside of Ohio.
    e. Prefer not to answer

IMAGE FOR QUESTION 1:



2. (Logic: Show option “a” with map image if respondent records “a. YES” for Question 1. Ask for zip code if they respond with “b, c, or d” for Question 1. Letter below corresponds with letter selected in Question 1. Skip if “e.” is answered.):
    a. Select the area you live: [Map shown of Linden neighborhood with options Area A, Area B, Area C, Area D, E, F]
    b. What is the zip code for your primary residence? [Enter number]
    c. What is the zip code for your primary residence? [Enter number]
    d. What is the zip code for your primary residence? [Enter number]

IMAGE FOR QUESTION 2:



3. What is your gender identity?
    a. Male
    b. Female
    c. Other
    d. Prefer not to answer
4. What is your age?
    a. 18-24
    b. 25-34
    c. 35-44
    d. 45-54
    e. 55-64
    f. 65+
    g. Prefer not to answer
5. How would you describe your race/ethnicity? (check all that apply):
    a. Black or African American
    b. White
    c. Asian
    d. American Indian or Alaska Native
    e. Native Hawaiian or Pacific Islander
    f. Hispanic, Spanish, or Latino
    g. Biracial
    h. Prefer not to answer
6. What was your household income in the year 2018 (before taxes)?
    a. Less than $15,000
    b. $15,000 to $29,999
    c. $30,000 to $44,999
    d. $45,000 to $59,999
    e. $60,000 to $74,999
    f. $75,000 to $89,999
    g. $90,000 to $99,999
    h. $100,000 or more
    i. Prefer not to answer
7. What is your highest level of education that you have completed?
    a. Less than high school degree
    b. High school diploma or GED
    c. Some college but no degree
    d. Associate degree in college (2-year)
    e. Bachelor's degree in college (4-year)
    f. Master's degree
    g. Doctoral degree
    h. Professional degree (JD, MD)

    i. Prefer not to answer
8. What answer best describes your employment status?
    a. Working less than 32 hours per week
    b. Working 32 or more hours per week
    c. Not working (looking for work)
    d. Not working (not looking for work)
    e. Prefer not to answer

Respondent Information (general travel behavior)

9. On average, how frequently do you use public transit (e.g. COTA)?
    a. Not at all
    b. A few trips per year
    c. 1-3 trips per month
    d. 1-4 trips per week
    e. 5-9 trips per week
    f. 10+ trips per week
10. What mode of transportation do you rely on the most to complete your typical weekly routine? Select the best response.
    a. Personal Vehicle
    b. Public transit (eg. COTA, Campus Area Bus Service, CEAV shuttle)
    c. Personal Bicycle
    d. Bicycle share
    e. Walk
    f. Carpool/Vanpool (Share, EmpowerBus, MORPC)
    g. Ride-hailing service (Taxi, Lyft, etc.)
    h. Other [describe]
11. Which transportation resources are available to you as part of your weekly routine? (select all that apply)
    a. I own a personal vehicle.
    b. Someone else in my household supports me with their personal vehicle.
    c. Someone outside my household supports me with their personal vehicle.
    d. I have a current driver's license.
    e. I have my own bicycle.
    f. I have a mobile device that contains transportation service apps.
    g. I have a credit card.
    h. I have a bus pass provided by my employer or am a C-Pass user.
    i. None of the above.
12. Which of the following transportation options have you used in the past year in Columbus? (check all that apply)
    a. Personal/ household vehicle
    b. Personal/ household bicycle
    c. Carpool/ vanpool (Share, EmpowerBus, MORPC)
    d. Car-sharing service (eg. Zipcar)
    e. Ride-hailing service (eg. Taxi, Lyft)
    f. Bike-sharing service (eg. COGO, Lime)

g. Scooter-sharing service (eg. Lime, Bird)
h. Public bus (eg. COTA)
i. None of the above

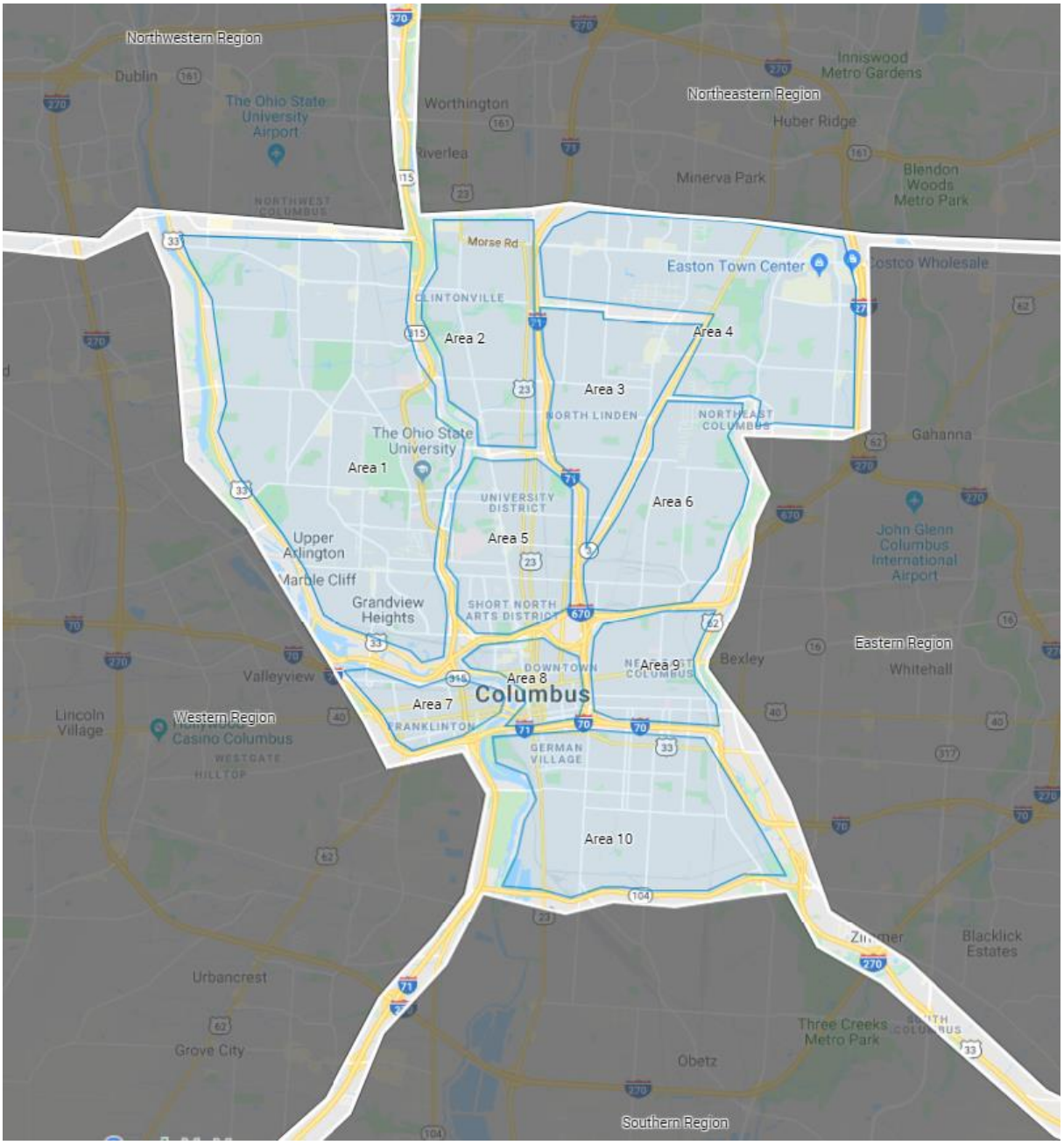
Current trip details

For the questions in this section, please consider your most recent trip on the Linden LEAP.

13. Were you on your way to or from one of the following activities? Select the activity that best describes the purpose of your current trip:
    a. Work Commute
    b. Education
    c. Medical (eg. Doctor appointment, pharmacy, therapy)
    d. Leisure or Recreation (eg. Event, restaurant, gym, park)
    e. Grocery Shopping or Food Pantry
    f. Retail Shopping
    g. Technical, professional, or social services (eg. Legal help)
    h. Personal or family matters
    i. Other: [enter response]
14. How often do you make this trip to complete that activity?
    a. Very often
    b. Often
    c. Sometimes
    d. Rarely
    e. Almost never
15. In miles, what is the approximate total distance of that trip? (door to door)
    a. Less than 0.5 miles
    b. 0.5 – 1 mile
    c. 1-2 miles
    d. 3-5 miles
    e. 6-10 miles
    f. 11-20 miles
    g. Over 20 miles
16. In minutes, what is the approximate total travel time of that trip? (door to door)
    a. 5 minutes or less
    b. 6-10 minutes
    c. 11-15 minutes
    d. 16-20 minutes
    e. 21-30 minutes
    f. 31-40 minutes
    g. 41-50 minutes
    h. 51-60 minutes
    i. Over 60 minutes

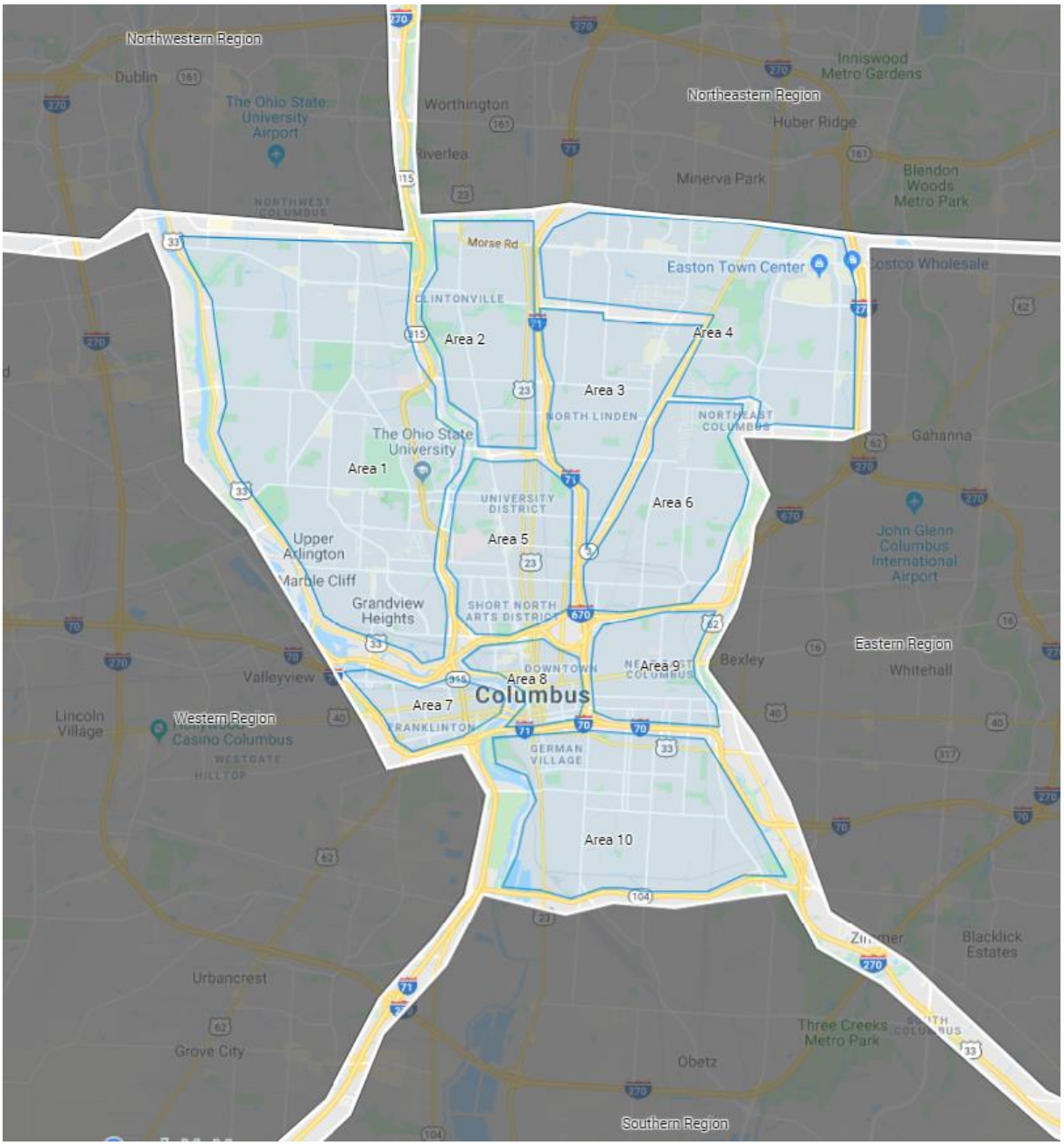
17. Please select the area on the map that best represents where you **began** your trip.
    a. Area 1 (eg. Upper Arlington, Grandview)
    b. Area 2 (eg. Clintonville)
    c. Area 3 (eg. North Linden)
    d. Area 4 (eg. Easton)
    e. Area 5 (eg. OSU, Weinland Park)
    f. Area 6 (eg. South Linden, Milo)
    g. Area 7 (eg. Franklinton)
    h. Area 8 (eg. Downtown)
    i. Area 9 (eg. King-Lincoln, Old Towne East)
    j. Area 10 (eg. German Village, Merion Village)
    k. Eastern region. (eg. Bexley, Gahanna)
    l. Northeastern region. (eg. Polaris, Westerville)
    m. Northwestern region. (eg, Dublin)
    n. Western region. (eg. Hilliard, Grove City)
    o. Southern region. (eg. Rickenbacker)
    p. Not available

IMAGE FOR QUESTION 17:



18. Please select the area on the map that best represents where you **ended** your trip.
    a. Area 1 (eg. Upper Arlington, Grandview)
    b. Area 2 (eg. Clintonville)
    c. Area 3 (eg. North Linden)
    d. Area 4 (eg. Easton)
    e. Area 5 (eg. OSU, Weinland Park)
    f. Area 6 (eg. South Linden, Milo)
    g. Area 7 (eg. Franklinton)
    h. Area 8 (eg. Downtown)
    i. Area 9 (eg. King-Lincoln, Old Towne East)
    j. Area 10 (eg. German Village, Merion Village)
    k. Eastern region. (eg. Bexley, Gahanna)
    l. Northeastern region. (eg. Polaris, Westerville)
    m. Northwestern region. (eg, Dublin)
    n. Western region. (eg. Hilliard, Grove City)
    o. Southern region. (eg. Rickenbacker)
    p. Not available

IMAGE FOR QUESTION 18:



19. Where did you **get on** the shuttle for this trip?
    a. Linden Transit Center
    b. Rosewind
    c. Douglas Community Recreation Center
    d. St. Stephens Community House
20. Where did you **get off** the shuttle for this trip?
    a. Linden Transit Center
    b. Rosewind
    c. Douglas Community Recreation Center
    d. St. Stephens Community House
21. How long did you wait to catch the shuttle?
    a. less than 5 minutes
    b. between 5 and 10 minutes
    c. between 10 and 15 minutes
    d. between 15 and 20 minutes
    e. more than 20 minutes
22. Did you bring any children (3-12 years old) aboard the shuttle?
    a. Yes
    b. No
    c. Prefer not to answer
23. Did you bring any infants or toddlers (less than 3 years old) aboard the shuttle?
    a. Yes
    b. No
    c. Prefer not to answer

Mobility Outcomes

(Logic based on Question 1. Only shown if option 'a' or 'b' is selected)

24. Do you rely on a COTA bus line to complete your most recent trip (door to door)? Choose all that apply.
    a. No, I did not rely on a COTA bus to complete this trip.
    b. Yes, I relied on Line 8 to complete my trip.
    c. Yes, I relied on Line 6 to complete my trip.
    d. Yes, I relied on CMAX to complete my trip.
    e. Yes, I relied on another COTA line to complete my trip.
25. In order to complete your most recent trip (door to door), how many total miles will you walk? Choose the best answer.
    a. Walking is not a significant part of my trip.
    b. Less than 0.25 mile (<5 minutes)
    c. 0.25- 0.5 mile (<10 minutes)
    d. 0.5 – 1 mile
    e. 1-2 miles

    f. 2-3 miles
    g. 3-5 miles
    h. Over 5 miles
26. If you did not have access to the shuttle to complete your current trip, how many miles would you need to walk? Choose the best answer.
    a. Less than 0.25 mile (<5 minutes)
    b. 0.25- 0.5 mile (<10 minutes)
    c. 0.5 – 1 mile
    d. 1-2 miles
    e. 2-3 miles
    f. 3-5 miles
    g. Over 5 miles
    h. If I did not have access to the shuttle, I would not complete this trip.
    i. If I did not have access to the shuttle, walking would not be a significant part of my trip.
27. In addition to the shuttle, which of the following did you use to complete your trip?
    a. Car sharing (Zipcar, etc.)
    b. Ride-hailing (Taxi, Lyft, etc.)
    c. Carpool/Vanpool
    d. Personal Bicycle
    e. Bike share
    f. Bicycle share
    g. Scooter
    h. Public bus
    i. Walk
    j. Other [describe]
    k. None of the above
28. What impact has the shuttle had on your ability to transfer from one mode of transport to another?
    a. Much easier
    b. Somewhat easier
    c. Neither easier nor harder
    d. Somewhat harder
    e. Much harder
    f. I don't usually transfer between modes

Opportunity Outcomes

(Logic based on Question 1. Only shown if option 'a' or 'b' is selected)

29. In general, has the shuttle improved your ability to travel from your primary residence to access any of the following activities? (Select all that apply)
    a. Work Commute
    b. Education
    c. Medical (eg. Doctor appointment, pharmacy, therapy)
    d. Leisure or Recreation (eg. Event, restaurant, gym, park)
    e. Grocery Shopping or Food Pantry

f. Retail Shopping
g. Technical, professional, or social services (eg. Legal help)
h. Personal or family matters
i. Other: [enter response]

Customer Satisfaction Outcomes

For the questions in this section, please consider your most recent trip on the Linden LEAP.

30. Have you ever ridden in a self-driving vehicle prior to this trip?
    a. Yes, many times
    b. Yes, a few times
    c. Yes, once
    d. No
    e. I am not sure
31. (Logic based on Question 30. If answering 'a', 'b', or 'c') Was your previous self-driving experience on the Linden LEAP route?
    a. Yes
    b. No
32. What was your trust level in self-driving technology prior to this trip?
    a. Very trusting
    b. Somewhat trusting
    c. Neither trusting or distrusting
    d. Somewhat distrusting
    e. Very distrusting
33. How has your trust level with self-driving technology changed following your ride?
    a. Much more trusting
    b. Somewhat more trusting
    c. Neither more or less trusting
    d. Somewhat less trusting
    e. Much less trusting
34. How does the on-board human operator affect your comfort level during this trip?
    a. Much more comfortable
    b. Somewhat more comfortable
    c. Neither more or less comfortable
    d. Somewhat less comfortable
    e. Much less comfortable
35. How likely are you to recommend this self-driving shuttle to others?
    a. 1 – Not at all likely
    b. 2
    c. 3
    d. 4
    e. 5
    f. 6
    g. 7
    h. 8

i. 9
j. 10 – Extremely likely

Survey completed. Thank you for your time and effort! If you'd like to enter into a monthly raffle for one of XXX $25 gift cards, please click the link below and enter your information.

Note: You need to pick the gift card up in person in the Columbus area.

THE OHIO STATE UNIVERSITY

Welcome

Thank you for your interest in our survey!

You are being asked to participate in a survey about your experience with Linden LEAP. **Linden LEAP is the self-driving shuttle that distributes food from the Mid Ohio Food Collective to the Linden Community via the Rosewind pick-up location.** The purpose of this survey is to understand the convenience and impact of the Linden LEAP food delivery service. Please consider the following information carefully. If you decide to participate, you will be asked to indicate your willingness by stating “I agree to participate” at the end of this statement.

This survey should take approximately **20 minutes to complete** and you may skip any questions that you do not wish to answer. You may end the survey at any time with no penalty to you. Participation is voluntary. You must be 18 or older to complete this survey. For participating in the survey you will receive a **$20 Veggie Van voucher** that can be redeemed at the Rosewind Estates location. By law, payments to subjects are considered taxable income. There will be no other direct benefits from participating in the research. If you decide not to participate, there will be no penalty or loss of benefits to which you are otherwise entitled. You can, of course, decline to answer any question and/or stop participating at any time, without any penalty or loss of benefits to which you are otherwise entitled.

No one will see your responses except for the OSU researchers analyzing this data. This study has been determined Exempt from IRB Review. We will work to

ensure that no one sees your survey responses without approval. But, because we are using the Internet, there is a chance that someone could access your online responses without permission. In some cases, this information could be used to identify you. Your de-identified information will not be used or shared with other researchers.

For questions, concerns, or complaints about the study, or if you feel you have been harmed as a result of study participation, you may contact Jason Reece at The Ohio State University. Email: reece.35@osu.edu; phone: (614) 292-7412.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact the Office of Responsible Research Practices at 1-800-678-6251.

- ○ Yes, I agree to participate
- ○ No, I do not agree to participate

Rosewind Mobile Pantry Trip

Recall your **most recent trip** to pick up a food pantry box from the Linden LEAP shuttle at the Rosewind pick-up location. Please answer the following questions regarding your most recent trip.

This is an image of the Linden LEAP shuttle.

Using the calendar below, please select the date when you picked up your food pantry box from the Linden LEAP shuttle at the Rosewind location. If you do not know the date, please leave the response blank.

Enter a date:

← August 2020 →

Su	Mo	Tu	We	Th	Fr	Sa
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

← August 2020 →

Su	Mo	Tu	We	Th	Fr	Sa
30	31	1	2	3	4	5

What type of transportation did you use to travel to the Rosewind pick-up location? Please select all that apply.

- [ ] I walked
- [ ] I drove my personal vehicle
- [ ] A friend/family member gave me a ride in their personal vehicle
- [ ] I rode my own bicycle
- [ ] I used the bus (eg. COTA)
- [ ] I used bike share (eg. COGO)
- [ ] I used a ride-hailing service (eg. Taxi, Lyft)
- [ ] Other

In miles, how far did you travel to the Rosewind pick-up location? Please record one-way travel distance (not round trip).

In minutes, how long did it take you to travel to the Rosewind pick-up location? Please record one-way travel time (not round trip).

If walking was part of your trip, how long (in minutes) you did you walk? Please record one-way travel time (not round trip).

From the time you arrived at the Rosewind pick-up location, how long (in minutes) did you wait to receive your food pantry items?

How many times have you picked up a food pantry box at the Rosewind pick-up location?

How satisfied are you with the Rosewind pick-up location for food pantry boxes?

	Extremely satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Extremely dissatisfied
Overall convenience	○	○	○	○	○
Schedule flexibility	○	○	○	○	○
Respectful staff	○	○	○	○	○
Pandemic safety	○	○	○	○	○
Security	○	○	○	○	○
Food quality	○	○	○	○	○
Food quantity	○	○	○	○	○

Since March 2020, have you visited the food pantry at the St Stephen's Community House?

- ○ Yes
- ○ No
- ○ I'm not sure

St Stephen's Pantry Trip

Recall your **most recent trip** to the food pantry at the St Stephen's Community House. Please answer the following questions regarding one of those trips.

Using the calendar below, please select the date when you picked up your food pantry box at the St Stephen's location. If you do not know the date, please leave the response blank.

Enter a date:

←	August 2020					→
Su	Mo	Tu	We	Th	Fr	Sa
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	1	2	3	4	5

What type of transportation did you use to travel to the food pantry at the St Stephen’s Community House? Please select all that apply.

- [ ] I walked
- [ ] I drove my personal vehicle
- [ ] A friend/family member gave me a ride in their personal vehicle
- [ ] I rode my own bicycle
- [ ] I used the bus (eg. COTA)
- [ ] I used bike share (eg. COGO)
- [ ] I used a ride-hailing service (eg. Taxi, Lyft)
- [ ] Other

In miles, how far did you travel to the food pantry at the St Stephen's Community House? Please record one-way travel distance (not round trip).

In minutes, how long did it take you to travel to the food pantry at the St Stephen's Community House? Please record one-way travel time (not round trip).

If walking was part of your trip, how long (in minutes) you did you walk? Please record one-way travel time (not round trip).

From the time you arrived at St Stephen's, how long (in minutes) did you wait to receive your food pantry items?

How satisfied are you with the St. Stephen's pick-up location for food pantry boxes?

	Extremely satisfied	Somewhat satisfied	Neither satisfied nor dissatisfied	Somewhat dissatisfied	Extremely dissatisfied
Overall convenience	○	○	○	○	○
Schedule flexibility	○	○	○	○	○
Respectful staff	○	○	○	○	○
Pandemic safety	○	○	○	○	○
Security	○	○	○	○	○
Food quality	○	○	○	○	○
Food quantity	○	○	○	○	○

Transport Resources

Please answer the following questions to help us understand your transportation resources since March 2020.

Since March 2020, which of the following transportation options have been important for your weekly routine? Select all that apply.

- ☐ Personal/ household vehicle
- ☐ Personal/ household bicycle
- ☐ Getting a ride from friends/ family
- ☐ Public bus (eg. COTA, Campus Area Bus Service)
- ☐ Walk
- ☐ Ride-hailing service (eg. Taxi, Lyft)
- ☐ Bike-sharing service (eg. COGO, Lime)
- ☐ Scooter-sharing service (eg. Lime, Bird)

- [ ] Carpool/vanpool service (eg. Gohio Commute, Share, MORPC)
- [ ] Car-sharing service (eg. Zipcar)

Since March 2020, what mode of transportation have you **relied on the most to get food**? Choose the best answer.

Which transportation resources are **currently** available to you? Select all that apply.

- [ ] I own a personal vehicle.
- [ ] Someone else in my household supports me with their personal vehicle.
- [ ] Someone outside my household supports me with their personal vehicle.
- [ ] I have a current driver's license (that allows me to rent or share vehicles).
- [ ] I have my own bicycle.
- [ ] I have a mobile device (eg. cell phone) that contains one or more transportation service apps (eg. Uber).
- [ ] I have a credit card or debit card (to digitally pay for transportation services).
- [ ] I have a bus pass provided by my employer (eg. C-Pass users).
- [ ] None of the above.

Food Resources

Please answer the following questions to help us understand your food resources since March 2020.

Since March 2020, where do you typically get your food? Select all that apply.

- [ ] Supermarkets (eg. Walmart, Giant, Kroger, Aldi) Giant Eagle

- [ ] Dollar store (eg. Dollar General, Family Dollar)
- [ ] Food pantry
- [ ] Small grocery stores
- [ ] Mobile grocer (eg. Veggie Van)
- [ ] Farmers market
- [ ] Warehouse club store (eg. Sam's Club, Costco)
- [ ] Drug store (eg. CVS, Walgreens)
- [ ] Convenience Store (eg. UDF, gas station)
- [ ] Health food Store / Co-op
- [ ] Gardens

Since March 2020, where do you get **most** of your food? Choose the best answer.

Since March 2020, which of these statements best describes the food eaten in your household?

- ○ Enough of the kinds of food (I/we) want to eat
- ○ Enough, but not always the kinds of food (I/we) want
- ○ Sometimes not enough to eat
- ○ Often not enough to eat

Since March 2020, how often was the following statement true for your household?

"I worried whether my food would run out before I got money to buy more."

- ○ Never

- Sometimes
- Often

Since March 2020, how often was the following statement true for your household?

"The food that (I/we) bought just didn't last, and (I/we) didn't have money to get more."

- Never
- Sometimes
- Often

Since March 2020, how often was the following statement true for your household?

"(I/we) couldn't afford to eat balanced meals."

- Never
- Sometimes
- Often

Since March 2020, how often was the following statement true for your household?

"(I/we) cut the size of meals or skipped meals because there wasn't enough money for food."

- Never
- Sometimes

- ○ Often

Since March 2020, how often have you accessed food that was distributed by a food pantry? Choose the best answer.

- ○ This is my first time
- ○ Occasionally
- ○ Monthly
- ○ Weekly

Perceptions - CEAV Technology

Please answer the following questions to help us understand your views of the Linden LEAP shuttle and self-driving vehicles.

When did you **first** learn about the Linden LEAP shuttle? Choose the best answer.

- ○ Within the last few weeks
- ○ 1 - 3 months ago
- ○ 3 - 6 months ago
- ○ 6 - 12 months ago
- ○ More than a year ago

How have you interacted with the Linden LEAP shuttle? Select all that apply.

- ☐ I saw the shuttle at the Rosewind pick-up location.
- ☐ I asked a staff member or operator about the shuttle.
- ☐ I witnessed the shuttle driving on the street.
- ☐ I made physical contact with the shuttle.

- [ ] I boarded the shuttle while it was parked.
- [ ] I rode on the shuttle as a passenger.

When did you **first** interact with the Linden LEAP shuttle? Choose the best answer.

- ○ Within the last few weeks
- ○ 1 - 3 months ago
- ○ 3 - 6 months ago
- ○ 6 - 12 months ago
- ○ More than a year ago

After interacting with the Linden LEAP shuttle, how has your level of trust in self-driving technology changed?

- ○ Much more trusting
- ○ More trusting
- ○ No change
- ○ Less trusting
- ○ Much less trusting
- ○ I did not have a meaningful interaction with the shuttle.

How do you think a self-driving vehicle should operate on neighborhood streets? Choose the option that best represents your views.

- ○ Operate like any other vehicle. (any street, any lane)
- ○ Operate like any other vehicle, but only on specific streets. (some streets, any lane)
- ○ Operate in a dedicated self-driving lane. (any street, separate lane)
- ○ Operate in a dedicated self-driving lane, but only on specific streets. (some streets, separate lane)

- ○ Operate on a completely separate infrastructure system. (similar to a railway or subway)
- ○ Operation is prohibited everywhere. (no operation at all)
- ○ No opinion.

How much do you agree or disagree with the following statements about the Linden LEAP self-driving shuttle?

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I think it enhances the character of the Linden neighborhood.	○	○	○	○	○
I think it is a source of pride for Linden residents.	○	○	○	○	○
I think it is unnecessary for the Linden community.	○	○	○	○	○
I think it provides an essential service for Linden residents.	○	○	○	○	○
I think it reduces the stigma around food assistance in Linden.	○	○	○	○	○

How much do you agree or disagree with the following statements about the Linden LEAP self-driving shuttle?

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
I think it is a danger to children in Linden.	○	○	○	○	○
I think it is a traffic hazard in Linden.	○	○	○	○	○
I think it is safe for the Linden community.	○	○	○	○	○
I think it should always have an on-board operator.	○	○	○	○	○
I think it should carry passengers.	○	○	○	○	○

Perceptions - Pandemic Circumstances

Please answer the following questions to help us understand how your life circumstances have changed since the pandemic. Consider the time prior to the pandemic (between March 2019 and March 2020) and the time after the pandemic started (between March 2020 and today).

How would you describe changes to...

	Much better	Somewhat better	About the same	Somewhat worse	Much worse
your employment status?	○	○	○	○	○
your income?	○	○	○	○	○
your household's overall financial situation?	○	○	○	○	○

How would you describe changes to your ability to access...

	Much better	Somewhat better	About the same	Somewhat worse	Much worse
enough food for your household?	○	○	○	○	○
healthy food for your household?	○	○	○	○	○
culturally preferred food for your household?	○	○	○	○	○

Respondent Demographics

Please answer the following questions to help us understand your social and economic station.

How would you describe your gender?

How would you describe yourself? Select all that apply.

- ☐ Black or African American
- ☐ White or Caucasian
- ☐ Asian or Asian American
- ☐ American Indian or Alaska Native
- ☐ Native Hawaiian or Pacific Islander
- ☐ Hispanic or Latino
- ☐ Biracial or Multiracial
- ☐ _____ Other

What is your age?

How many children, **under age 12**, are in your household?

How many children, **age 12-17**, are in your household?

How many other adults, **age 18-65**, are in your household?
Do not include yourself.

How many other adults, **over age 65**, are in your household?
Do not include yourself.

What was your household income in the year 2019 (before taxes)?

What answer best describes your current employment status?

- Working less than 32 hours per week
- Working 32 or more hours per week

- ○ Not working (looking for work)
- ○ Not working (not looking for work)

What is the highest level of education that you have completed?

What is the zip code for your primary residential address?

How long have you lived at your primary residential address?

Please answer the following questions to create an anonymous response code. (example: AC4)

First letter of your first name
("A" for Andrea)

First letter of your street address
("C" for Cleveland Ave)

Last digit of your birthdate
("4" for the 4th, 14th, or 24th of the month)

Incentives Data

As a thank you for your time, we would you like to provide you with $20 in "Veggie Van" vouchers. The Veggie Van is a mobile grocery service provided by Local Matters. The vouchers can be redeemed for fresh produce and groceries

at the Rosewind Estates "Veggie Van" location on Wednesdays 3:00pm-6:00pm .

Would you like to provide your contact information to receive the voucher? If you select "Yes", you will be redirected to another page to provide your contact information. Your contact information will be stored separately from your survey responses.

- ○ Yes, I would like to receive the voucher.
- ○ No, I do not want to receive the voucher.

SMART COLUMBUS

THE CITY OF COLUMBUS
ANDREW J. GINTHER, MAYOR