Performance Measurement Plan (PfMP)

for the Smart Columbus Demonstration Program

FINAL REPORT | June 2019
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Abstract

This Performance Measurement Plan describes the outcomes of Smart Columbus and how the objectives of each of 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. The responsibilities and types of interactions between the City of Columbus and an independent evaluator are also described.
## Table of Contents

Chapter 1. Introduction ........................................................................................................ 1
  1.1. Enabling Technologies .............................................................................................. 1
  1.2. Enhanced Human Services ....................................................................................... 2
  1.3. Emerging Technologies ............................................................................................ 2
  1.4. Outcomes .................................................................................................................... 2
  1.5. Purpose of Plan ......................................................................................................... 3
  1.6. Deployment Areas ..................................................................................................... 4
  1.7. Project Timeline ....................................................................................................... 7
  1.8. Methodology ............................................................................................................ 8
  1.9. Report Organization .................................................................................................. 9
    1.9.1. References ............................................................................................................. 10
  1.10. Relation to Other Documents .............................................................................. 10
    1.10.1. Project Systems Engineering Documentation ..................................................... 10
    1.10.2. Data Privacy Plan .................................................................................................. 11
    1.10.3. Data Management Plan ...................................................................................... 11
    1.10.4. Independent Evaluation Support Plan ............................................................... 11
    1.10.5. Safety Management Plan .................................................................................... 11

Chapter 2. Smart Columbus Outcomes .............................................................................. 13
  2.1. Introduction ............................................................................................................... 13
  2.2. Safety ........................................................................................................................ 14
  2.3. Mobility ..................................................................................................................... 15
  2.4. Opportunity ................................................................................................................. 15
  2.5. Environment ............................................................................................................... 15
  2.6. Agency Efficiency ..................................................................................................... 15
  2.7. Customer Satisfaction ............................................................................................... 16

Chapter 3. Confounding Factors ............................................................................................ 17
  3.1. Introduction ............................................................................................................... 17
  3.2. Definition of Confounding Factors .......................................................................... 17
  3.3. Study-Area-Specific Factor .................................................................................... 17
    3.3.1. Fuel Prices ............................................................................................................. 17
    3.3.2. Weather ............................................................................................................... 18
    3.3.3. Adjacent Projects ............................................................................................... 18
    3.3.4. Seasonal Traffic ................................................................................................. 18
    3.3.5. Traffic Incidents ................................................................................................. 19
<table>
<thead>
<tr>
<th>Chapter 4.</th>
<th>Experimental Strategies ........................................................................................................ 23</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1.</td>
<td>Introduction ......................................................................................................................... 23</td>
</tr>
<tr>
<td>4.2.</td>
<td>Design of Experiment ......................................................................................................... 23</td>
</tr>
<tr>
<td>4.2.1.</td>
<td>Randomized Experiments .................................................................................................... 24</td>
</tr>
<tr>
<td>4.2.2.</td>
<td>Quasi-Experimental Design .............................................................................................. 25</td>
</tr>
<tr>
<td>4.2.3.</td>
<td>Non-Experimental Design .................................................................................................. 25</td>
</tr>
<tr>
<td>4.3.</td>
<td>Sample Size Determination .............................................................................................. 27</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter 5.</th>
<th>Performance Measurement and Evaluation ............................................................................. 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.</td>
<td>Introduction ......................................................................................................................... 29</td>
</tr>
<tr>
<td>5.1.1.</td>
<td>Performance Measurement Background .............................................................................. 29</td>
</tr>
<tr>
<td>5.1.2.</td>
<td>Purpose of Performance Measurement ............................................................................... 29</td>
</tr>
<tr>
<td>5.2.</td>
<td>Performance Measurement and Evaluation Terminology .................................................... 29</td>
</tr>
<tr>
<td>5.2.1.</td>
<td>Introduction ......................................................................................................................... 30</td>
</tr>
<tr>
<td>5.2.2.</td>
<td>Logic Model ......................................................................................................................... 30</td>
</tr>
<tr>
<td>5.2.3.</td>
<td>Outcomes .............................................................................................................................. 30</td>
</tr>
<tr>
<td>5.2.4.</td>
<td>Project-Specific Confounding Factors ............................................................................... 32</td>
</tr>
<tr>
<td>5.2.5.</td>
<td>Project Costs ....................................................................................................................... 32</td>
</tr>
<tr>
<td>5.3.</td>
<td>Program-Level Performance Measures .............................................................................. 33</td>
</tr>
<tr>
<td>5.3.1.</td>
<td>Introduction ......................................................................................................................... 33</td>
</tr>
<tr>
<td>5.3.2.</td>
<td>Logic Model ......................................................................................................................... 34</td>
</tr>
<tr>
<td>5.3.3.</td>
<td>Outcome 0.1: Environment ................................................................................................. 35</td>
</tr>
<tr>
<td>5.3.4.</td>
<td>Outcome 0.2: Mobility ........................................................................................................ 38</td>
</tr>
<tr>
<td>5.3.5.</td>
<td>Outcome 0.3: Opportunity ................................................................................................. 41</td>
</tr>
<tr>
<td>5.4.</td>
<td>Project 1: The Smart Columbus Operating System ............................................................. 44</td>
</tr>
<tr>
<td>5.4.1.</td>
<td>Introduction ......................................................................................................................... 44</td>
</tr>
<tr>
<td>5.4.2.</td>
<td>Logic Model ......................................................................................................................... 45</td>
</tr>
<tr>
<td>5.4.3.</td>
<td>Outcome 1.1: Agency Efficiency ......................................................................................... 46</td>
</tr>
<tr>
<td>5.4.4.</td>
<td>Outcome 1.2: Customer Satisfaction ................................................................................. 57</td>
</tr>
<tr>
<td>5.4.5.</td>
<td>Project-Specific Confounding Factors ............................................................................... 61</td>
</tr>
<tr>
<td>5.4.6.</td>
<td>Project Cost ......................................................................................................................... 61</td>
</tr>
</tbody>
</table>
### 5.5. Project 2: Connected Vehicle Environment

- **5.5.1. Introduction** ......................................................... 62
- **5.5.2. Logic Model** .......................................................... 64
- **5.5.3. Outcome 2.1: Safety** .............................................. 65
- **5.5.4. Outcome 2.2: Mobility** ............................................ 74
- **5.5.5. Project Costs** .......................................................... 78

### 5.6. Project 3: Multimodal Trip Planning Application/Common Payment System

- **5.6.1. Introduction** ......................................................... 79
- **5.6.2. Logic Model** .......................................................... 80
- **5.6.3. Outcome 3.1: Mobility** ............................................ 81
- **5.6.4. Outcome 3.2: Opportunity** ...................................... 84
- **5.6.5. Outcome 3.3: Customer Satisfaction** .................... 86
- **5.6.6. Project-Specific Confounding Factors** .................. 89
- **5.6.7. Project Costs** .......................................................... 90

### 5.7. Project 4: Mobility Assistance for Persons with Cognitive Disabilities

- **5.7.1. Introduction** ......................................................... 91
- **5.7.2. Logic Model** .......................................................... 92
- **5.7.3. Outcome 4.1: Mobility** ............................................ 93
- **5.7.4. Outcome 4.2: Opportunity** ...................................... 96
- **5.7.5. Outcome 4.3: Agency Efficiency** ......................... 98
- **5.7.6. Project Specific Confounding Factors** ................. 100
- **5.7.7. Project Costs** .......................................................... 100

### 5.8. Project 5: Prenatal Trip Assistance

- **5.8.1. Introduction** ......................................................... 101
- **5.8.2. Logic Model** .......................................................... 102
- **5.8.3. Outcome 5.1: Mobility** ............................................ 103
- **5.8.4. Outcome 5.2: Opportunity** ...................................... 106
- **5.8.5. Outcome 5.3: Customer Satisfaction** .................... 107
- **5.8.6. Project Specific Confounding Factors** ................. 109
- **5.8.7. Project Costs** .......................................................... 109

### 5.9. Project 6: Smart Mobility Hubs

- **5.9.1. Introduction** ......................................................... 110
- **5.9.2. Logic Model** .......................................................... 111
- **5.9.3. Outcome 6.1: Mobility** ............................................ 112
- **5.9.4. Outcome 6.2: Customer Satisfaction** .................... 113
- **5.9.5. Project-Specific Confounding Factors** ................. 115
- **5.9.6. Project Costs** .......................................................... 116

### 5.10. Project 7: Event Parking Management

- **5.10.1. Introduction** ......................................................... 117
- **5.10.2. Logic Model** .......................................................... 118
- **5.10.3. Outcome 7.1: Customer Satisfaction** .................... 119
- **5.10.4. Project-Specific Confounding Factors** ................. 120
- **5.10.5. Project Costs** .......................................................... 122
5.11. Project 8: Connected Electric Autonomous Vehicles ............................................... 123
  5.11.1. Introduction ................................................................................................................... 123
  5.11.2. Logic Model .................................................................................................................. 124
  5.11.3. Outcome 8.1: Mobility ............................................................................................... 125
  5.11.4. Outcome 8.2: Opportunity .......................................................................................... 127
  5.11.5. Outcome 8.3: Customer Satisfaction .......................................................................... 129
  5.11.6. Project-Specific Confounding Factors ......................................................................... 132
  5.11.7. Project Costs ............................................................................................................... 132

5.12. Performance Targets .................................................................................................... 133

Chapter 6. Data Collection Plan .......................................................................................... 135
  6.1. Data Collection Timeframe ........................................................................................... 135
  6.2. Data Sources .................................................................................................................. 135
    6.2.1. Program-Level Measures ............................................................................................ 135
    6.2.2. Smart Columbus Operating System ........................................................................... 135
    6.2.3. Connected Vehicle Environment ................................................................................. 137
    6.2.4. Multimodal Trip Planning Application/Common Payment System ......................... 138
    6.2.5. Connected Electric Autonomous Vehicle .................................................................... 139
    6.2.6. Smart Mobility Hubs .................................................................................................. 140
    6.2.7. Mobility Assistance for People with Cognitive Disabilities ....................................... 141
    6.2.8. Prenatal Trip Assistance ............................................................................................. 142
    6.2.9. Event Parking Management ....................................................................................... 143
  6.3. Data Quality ................................................................................................................... 154
  6.4. Personally Identifiable Information ............................................................................... 156
  6.5. Data Security .................................................................................................................. 156
  6.6. Document Procedures for Data Archive ....................................................................... 157
  6.7. Data Management Plan ................................................................................................. 158

Chapter 7. Data-Sharing Framework ..................................................................................... 159

Chapter 8. Performance Rating ............................................................................................. 161

Chapter 9. Support for the Independent Evaluation Effort .................................................... 163

Chapter 10. Conclusions ........................................................................................................ 165

Appendix A. Acronyms and Definitions ................................................................................. 167

Appendix B. Performance Measures Matrix ........................................................................... 171

Appendix C. MAPCD Survey Questionnaire .......................................................................... 173

Appendix D. PTA Survey Questionnaire .................................................................................. 175
List of Tables

Table 1: Smart Columbus Projects’ Periods of Performance ............................................................. 7
Table 2: Smart Columbus Project Outcomes ..................................................................................... 16
Table 3: Sample Objective Table ...................................................................................................... 30
Table 4: Reduce Vehicle Emissions Objective 0.1.1 ......................................................................... 35
Table 5: Reduce Traffic Congestion Objective 0.2.1 ......................................................................... 38
Table 6: Improve Commuting Opportunities to Jobs and Services Objective 0.3.1 ......................... 41
Table 7: Operating System Agency Efficiency Objective 1.1.1 .......................................................... 46
Table 8: Operating System Agency Efficiency Objective 1.1.2 .......................................................... 49
Table 9: Operating System Agency Efficiency Objective 1.1.3 .......................................................... 52
Table 10: Operating System Agency Efficiency Objective 1.1.4 ......................................................... 54
Table 11: Operating System Customer Satisfaction Objective 1.2.1 .................................................... 57
Table 12: Operating System Customer Satisfaction Objective 1.2.2 ................................................. 59
Table 13: Quantities and Characteristics by Vehicle Type ................................................................. 62
Table 14: Connected Vehicle Environment Safety Objective 2.1.1 .................................................... 65
Table 15: Connected Vehicle Environment Safety Objective 2.1.2 .................................................... 69
Table 16: Connected Vehicle Environment Safety Objective 2.1.3 .................................................... 71
Table 17: Connected Vehicle Environment Mobility Objective 2.2.1 ................................................. 74
Table 18: Connected Vehicle Environment Mobility Objective 2.2.2 ................................................. 76
Table 19: Multimodal Trip Planning/Common Payment System Mobility Objective 3.1.1 ............... 81
Table 20: Multimodal Trip Planning/Common Payment System Opportunity Objective 3.2.1 ............ 84
Table 21: Multimodal Trip Planning/Common Payment System Customer Satisfaction Objective 3.3.1 86
Table 22: Mobility Assistance for Persons with Cognitive Disability Mobility Objective 4.1.1 ........ 93
Table 23: Mobility Assistance for Persons with Cognitive Disability Opportunity Objective 4.2.1 ... 96
Table 24: Mobility Assistance for Persons with Cognitive Disability Agency Efficiency Objective 4.3.1 98
Table 25: Prenatal Trip Assistance Mobility Objective 5.1.1 .............................................................. 103
Table 26: Prenatal Trip Assistance Opportunity Objective 5.2.1 ...................................................... 106
Table 27: Prenatal Trip Assistance Customer Satisfaction Objective 5.3.1 ......................................... 108
Table 28: Smart Mobility Hubs Mobility Objective 6.1.1 ................................................................. 112
Table 29: Smart Mobility Hubs Mobility Objective 6.2.1 ................................................................. 114
Table 30: Event Parking Management Customer Satisfaction Objective 7.2.1 ................................. 119
Table 31: Connected Electric Autonomous Vehicles Mobility Objective 8.1.1 ............................... 125
Table 32: Connected Electric Autonomous Vehicles Opportunity Objective 8.2.1 ......................... 127
Table 33: Connected Electric Autonomous Vehicles Customer Satisfaction Objective 8.4.1 ......... 129
Table 34: Project Data Used for Evaluation ..................................................................................... 144
Table 35: Project Survey Data ......................................................................................................... 147
Table 36: Third-Party (Nonproject) Data .......................................................................................... 151
Table 37: Confounding Factors Data ............................................................................................... 153
Table 38: Sample File Types .......................................................................................................... 157
Table 39: Acronym List .................................................................................................................. 167
<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Smart Columbus Projects</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Smart Columbus Vision, Mission, and Outcomes</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Smart Columbus Demonstration Site Map</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>Smart Columbus Project Timeline</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>Best Practices for Performance Measurement</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>USDOT’s 12 Vision Elements for Smart Cities</td>
<td>13</td>
</tr>
<tr>
<td>7</td>
<td>Design of Experiments – Classical Randomized</td>
<td>24</td>
</tr>
<tr>
<td>8</td>
<td>Design of Experiments – Classical Quasi-Experimental</td>
<td>25</td>
</tr>
<tr>
<td>9</td>
<td>Design of Experiments – Non-Experimental</td>
<td>26</td>
</tr>
<tr>
<td>10</td>
<td>Design of Experiments – Time-Series Design</td>
<td>26</td>
</tr>
<tr>
<td>11</td>
<td>Program-Level Logic Model</td>
<td>34</td>
</tr>
<tr>
<td>12</td>
<td>Operating System Performance Measurement Logic Model</td>
<td>45</td>
</tr>
<tr>
<td>13</td>
<td>Connected Vehicle Performance Measurement Logic Model</td>
<td>64</td>
</tr>
<tr>
<td>14</td>
<td>Fire Station and Police Precinct Locations</td>
<td>67</td>
</tr>
<tr>
<td>15</td>
<td>Multimodal Trip Planning Application/Common Payment System Performance Measurement Logic Model</td>
<td>80</td>
</tr>
<tr>
<td>16</td>
<td>Mobility Assistance for Persons with Cognitive Disability Performance Measurement Logic Model</td>
<td>92</td>
</tr>
<tr>
<td>17</td>
<td>Prenatal Trip Assistance Performance Measurement Logic Model</td>
<td>102</td>
</tr>
<tr>
<td>18</td>
<td>Smart Mobility Hubs Performance Measurement Logic Model</td>
<td>111</td>
</tr>
<tr>
<td>19</td>
<td>Event Parking Management Performance Measurement Logic Model</td>
<td>118</td>
</tr>
<tr>
<td>20</td>
<td>Connected Electric Autonomous Vehicles Performance Measurement Logic Model</td>
<td>124</td>
</tr>
<tr>
<td>21</td>
<td>Pre- and Post-Deployment Data Collection Timeframe</td>
<td>136</td>
</tr>
<tr>
<td>22</td>
<td>Connected Vehicle Environment Data Flow Diagram</td>
<td>137</td>
</tr>
<tr>
<td>23</td>
<td>MMTPA/CPS Data Flow Diagram</td>
<td>138</td>
</tr>
<tr>
<td>24</td>
<td>Connected Electric Autonomous Vehicle Context Diagram (Desired)</td>
<td>139</td>
</tr>
<tr>
<td>25</td>
<td>Smart Mobility Hubs Data Flow Diagram</td>
<td>140</td>
</tr>
<tr>
<td>26</td>
<td>Mobility Assistance for People with Cognitive Disabilities Data Flow Diagram</td>
<td>141</td>
</tr>
<tr>
<td>27</td>
<td>Prenatal Trip Assistance Data Flow Diagram</td>
<td>142</td>
</tr>
<tr>
<td>28</td>
<td>Event Parking Management Data Flow Diagram</td>
<td>143</td>
</tr>
<tr>
<td>29</td>
<td>Data Ingestion Workflow</td>
<td>155</td>
</tr>
</tbody>
</table>
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) to meet these challenges, while integrating data from various sectors and sources to simultaneously power these technologies while leveraging 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.

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, 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)/Common Payment System (CPS), Smart Mobility Hubs (SMH), Mobility Assistance for Persons with Cognitive Disability (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 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.
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. In addition, an independent evaluator (IE) who is funded and overseen by the USDOT under a separate contract will also conduct an evaluation. The City’s support to the USDOT IE team will be documented in a separate deliverable under Task E, the Independent Evaluation Support Plan.

Ultimately, this document serves to satisfy a mix of these three elements. Per the SCC Cooperative Agreement, the purpose of this PIMP 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 PIMP 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, 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/CPS**: The first release included both COTA and the Ohio State University (OSU) Campus Area Bus Service (CABS) as key providers. These service routes are called out on the map.
• **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 is not limited to PIECE program participants, and it is being 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**: The target ZIP codes are outlined to indicate the focused recruiting and participation for this application.

• **SMH**: The hub locations are noted.

• **EPM**: The downtown and Short North areas of Columbus are highlighted as the focus of this application will be on parking providers in these areas and visitors who will be traveling into and within these areas.

• **CEAV**: Both the Smart Circuit and Linden routes are called out with stops identified.
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.

![Smart Columbus Project Timeline](image)

**Figure 4: Smart Columbus Project Timeline**

*Source: City of Columbus*

All the Smart Columbus projects except CVE will have a one-year period of performance; however, MMTPA and CPS are expected to be evaluated together, so they will have the same end date for their period of performance. Unlike other projects, the Smart Columbus Operating System project follows an agile methodology; therefore, its components are developed and released at various stages in the timeline.

<table>
<thead>
<tr>
<th>Project</th>
<th>Implementation Date</th>
<th>Period of Performance End Date</th>
</tr>
</thead>
<tbody>
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</tr>
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<td>11/18/2020</td>
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<td>CPS</td>
<td>1/7/2020</td>
<td>1/6/2021</td>
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<tr>
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<tr>
<td>SMH</td>
<td>2/21/2020</td>
<td>2/20/2021</td>
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</table>
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 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, process, and archives data that will be 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 is beyond the scope of this performance measurement plan. It will be part of an independent evaluation.
• Step 10 presents evaluation results to stakeholders.

1.9. REPORT ORGANIZATION
The remainder of the report is organized into the following chapters:

• Chapter 2. Smart Columbus Outcomes: This chapter defines the six Smart Columbus outcomes and 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 that Chapter 3 identifies.

• 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 are discussed. 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 sharing 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. Support for the Independent Evaluation Effort: Another requirement of the SCC Cooperative Agreement is participation and cooperation with an independent evaluation of the demonstration. It will describe the interface between City of Columbus and its core agency partners with respect to the responsibility to participate in this independent evaluation effort. This chapter also discusses and differentiates the Smart Columbus performance measurement process from that of the USDOT’s independent evaluation of the demonstration.

Chapter 10. Conclusions: The last chapter provides the City’s conclusions regarding the performance measurement plans and activities.

1.9.1. References

It is envisioned that this plan will be revised to reflect the Smart Columbus Program as it is further developed, designed, and built. This chapter will serve as a catalog of reference material that has been utilized in planning the performance measurement of the demonstration.

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 relations. Most of these documents are available on the Smart Columbus website.¹

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 which will be used to support the collection of relevant data.
  - 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. These provide 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.

¹ [https://smart.columbus.gov/projects/](https://smart.columbus.gov/projects/)
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. Independent Evaluation Support Plan

The Independent Evaluation Support Plan (IESP) provides details regarding the City’s expected support to the independent evaluation effort funded by USDOT and executed by a team led by the Texas Transportation Institute. Presently, this plan has not yet been drafted but once complete, it will likely detail plans to provide frequently collected data and corresponding metadata, frequently monitored performance measures estimates and desired targets, availability of the site for additional field tests and experiments to supplement data not available through performance measurement, and contribution and collaboration on surveys and interviews conducted by the IEs. The IESP will complement the information in this PfMP and describe the City's support to additional efforts conducted by the IE. It is also intended to describe how the City will separate and differentiate between the datasets and performance information collected for purposes of performance measurement and independent evaluation. The PfMP and IESP complement one another to provide a complete assessment of the approach and information (both qualitative and quantitative) to assess the issues, benefits, performance, and lessons learned of the Smart Columbus demonstration from both the internal and independent perspectives.

### 1.10.5. Safety Management Plan

The safety management plan 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 safety management plan, so as not to introduce any additional risks or affect the mitigation strategy outlined in the safety management plan. The safety management plan has informed 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 Plan² and DOT Strategic Plan for FY 2018-2022.³

![Figure 6: USDOT’s 12 Vision Elements for Smart Cities](source: USDOT)

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The technology elements represent the highest priority. The three vision elements cover CVs, AVs, and the infrastructure they need to function effectively. This includes 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 data, analyzing it, and leveraging it 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. Additional information about the 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, to remain competitive, Columbus must plan for and implement ITS solutions that efficiently and effectively enable the flow of people and goods throughout the City. Solving urban challenges and creating a Smart City are integral elements of Columbus’ 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). 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.

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4 Texas A&M Transportation Institute. Annual Urban Mobility Scorecard, 2015. [https://mobility.tamu.edu/ums/](https://mobility.tamu.edu/ums/)

5 [https://www.transportation.gov/sites/dot.gov/files/docs/USDOT-RD%26T-Strategic-Plan-Final-011117.pdf](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’ 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. Additionally, implementation of a common payment system will make the transportation network available to travelers that previously did not have a means to pay for these services due to payment restrictions. 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/CPS 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, while EPM may reduce parking congestion, all having 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 including 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 CPS or Smart Mobility Hubs (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

<table>
<thead>
<tr>
<th>SMART COLUMBUS PROJECTS</th>
<th>SMART COLUMBUS OUTCOMES</th>
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</thead>
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<tr>
<td></td>
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<td>1. The Smart Columbus Operating System</td>
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<td>2. Connected Vehicle Environment</td>
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<td>4. Mobility Assistance for Cognitive Disabilities</td>
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<td>5. Prenatal Trip Assistance</td>
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<td>6. Smart Mobility Hubs</td>
<td>P</td>
</tr>
<tr>
<td>7. Event Parking Management</td>
<td>S</td>
</tr>
</tbody>
</table>

P – Indicates project level outcome; S – indicates program-level outcome the above table reflects the most recent decisions by the project teams. The PMP will be reviewed, so that any changes to project outcomes presented in PfMP will be updated in the PMP.
Chapter 3. Confounding Factors

3.1. INTRODUCTION

This chapter identifies confounding factors that are likely to affect the performance measurement plan. Information about data collected, and sources is presented in detail in Chapter 6. Please note, throughout the PFMP when the term ‘evaluator’ is used, it is inclusive of Smart Columbus performance measurement staff and independent evaluation staff, as both will need to be aware of these factors.

3.2. DEFINITION OF CONFOUNDING FACTORS

Accuracy and effectiveness of performance measures depends 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 a priori (i.e., before demonstration implementation) be identified, recorded, and measured 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/CPS, 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.
Chapter 3. Confounding Factors

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 and provided for the IE’s use. 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/CPS, 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. That is, 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 though, 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 be accessible to evaluators.

3.3.3. Adjacent Projects

Construction projects will continue to occur throughout the City over the next three years. 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, or 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, which are derived from observations of seasonal variations from 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 when injuries and damages are minimal, fewer crashes are reported. 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, funding availability may determine the number of transit vehicles to be equipped with CV capabilities.

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 it 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 is at least one year long to ensure sufficient time for user error and to reduce the impact of this confounding factor.
Chapter 3. Confounding Factors

To address the need to learn to operate the technology, training and outreach will be provided inside applications, such as the MMTPA/CPS so that the user can access it when needed.

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 volumes 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 in which 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.

### 3.4. DEPLOYMENT-SPECIFIC FACTORS

Deployment-specific confounding factors include all those 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 safety management plan, 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 safety management plan 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 safety management plan, so as not to introduce any additional risks or affect the mitigation strategy outlined in the safety management plan. The safety management plan 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, both MMTPA/CPS and EPM will improve mobility during events near the event location. It is important not to count the improvements twice as part of both the MMTPA/CPS and EPM projects. In each project’s performance measurement plan, Smart Columbus and non-Smart Columbus projects that impact one another are identified.

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, book a trip at a Smart Mobility Hub, or access or pay for parking or a multimodal trip via the MMTPA/CPS, or, for application users, the EPM. 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.

3.4.4.2. 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 that represents 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.

3.4.4.3. PARTICIPANT ATTRITION

After they are enrolled, 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.
3.4.4.4. 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/CPS 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 the Chapter 5. As discussed in Chapter 3, the presence of confounding factors is 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.

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 control group, but assignment to the groups is non-random. Figure 8 shows this process.

![Design of Experiments – Classical Quasi-Experimental](https://www.k4health.org/toolkits/measuring-success/types-evaluation-designs)

In the pre-test/post-test 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 matching – 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.

In the post-test only with non-random assignment data are not collected before the treatment. Instead, data are collected only after the program has started up 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 and accounting for any relevant differences 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 treatment 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 treatment group, such as with a mass media campaign. **Figure 9** shows this process.

**Figure 9: Design of Experiments – Non-Experimental**

Source: https://www.k4health.org/toolkits/measuring-success/types-evaluation-designs

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 treatment 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.k4health.org/toolkits/measuring-success/types-evaluation-designs
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 treatment 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 ($\pi$) is inversely related to the probability of a type II error ($\beta$ 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 ($\alpha$) identifies the type-I error probability of rejecting the null when the null is true. Typical set up is $\alpha = 0.05$. 
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, key stakeholders (such as OSU, COTA, ODOT and Franklin County, among others) using 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. This evaluation is separate from the evaluation carried out by the IE.

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 chapter. 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 6 for each project. This chapter 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 finally the indicators to measure the performance.

5.2.3. **Outcomes**

This section identifies for each project the outcomes 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**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Provide useful data</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>The Operating System will provide useful data to public agencies and developers through an open data portal.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Ability to access and use the data</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Pre/Post Trend Analysis</td>
</tr>
<tr>
<td>Data Sources</td>
<td>Operating System</td>
</tr>
</tbody>
</table>
### Category | Description | Timeframe
--- | --- | ---
Baseline Timeframe | One year before implementation of the Operating System Data Platform 2.0 | 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. IEs will account for these confounding factors during evaluation.

5.2.5. Project Costs
This section provides the high-level project costs for each project. This PfMP does not include cost-benefit analyses; however, the City anticipates that an IE will evaluate the cost-benefit of each project and the Smart Columbus Program as a whole.
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 be performed to evaluate the program level impacts on the following measures.
### 5.3.2. Logic Model

**Figure 11** shows the identified Program-Level logic model.

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Objectives</th>
<th>Treatment</th>
<th>Hypothesis</th>
<th>Outcome Indicators</th>
</tr>
</thead>
</table>
| 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 to reduce vehicle related emissions. | • Total 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 | 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 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 FML 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>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Reduce vehicle emissions</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>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 vehicle-related emissions.</td>
</tr>
<tr>
<td>Indicator</td>
<td>• Total vehicle-related emissions</td>
</tr>
<tr>
<td></td>
<td>• Green House Gas (GHG) savings (light duty and heavy vehicles)</td>
</tr>
<tr>
<td></td>
<td>• Perceived reduction in idling time around parking facilities to find a parking spot</td>
</tr>
<tr>
<td></td>
<td>• Perceived reduction in distance traveled to find a parking spot</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Pre/Post Trend Analysis</td>
</tr>
<tr>
<td>Data Source</td>
<td>Operating System</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>Two years pre-deployment period</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>From the start of first portfolio project (April 29, 2019) until the end of period of performance of last portfolio project (March 31, 2021).</td>
</tr>
</tbody>
</table>

*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 cause by the Smart Columbus.

**MMTPA/CPS**

As more of the Columbus travelers start migrating from their personal vehicles to other modes based on use of the MMTPA/CPS 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. During the special event days, this reduction in emissions might be higher than during regular days.

5.3.3.1.2 Indicators

The objective will be measured using the following indicators:

- Total vehicle-related emissions
- 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/CPS project
- Estimated conversion rates from PMT to CO, NO$_2$, SO$_2$, and other PMs
- Reduced idle time for heavy vehicles equipped with RSU (CVE)
- Conversion rates from idle time savings to emission savings

The following data will be collected from user surveys:

- Percentage of travel through MMTPA/CPS 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/CPS 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 collected. An estimate of reduction in vehicle emissions due to migration of travelers from personal vehicles to alternative modes of travel offered by Smart Columbus will be calculated using EPA’s MOtor Vehicle
Emission Simulator (MOVES) model. Also, reduction in emissions due to reduction in CVE equipped heavy vehicles will be calculated.

Total emissions data in the Columbus region in the pre-deployment period will be compared with post-deployment through a trend analysis. The difference in emissions will be assessed along with the estimated reductions to capture the impact of Smart Columbus Program on reduction of vehicle-related emissions.

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 will be conducted every 3 months post-implementation of the projects, until the end of treatment timeframe. Surveys will be conducted by a third party and the results will be stored in the Operating System. All the data will be available for access from the Operating System. Refer to Chapter 6 for more information.

**BASELINE TIMEFRAME**

Two years pre-deployment period will be considered as 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:

**Total vehicle-related emissions:** A regional-level comparison of vehicle emissions pre- and post-deployment time periods of Smart Columbus projects will be made to assess the impact of the projects on reducing vehicle emissions. Motor Vehicle Emission Simulator (MOVES) model will be used by the evaluators to estimate the vehicle emissions. Annual growth rate will be considered when performing this assessment.

**GHG savings:**

- **From MMTPA/CPS:** Passenger Miles Traveled using the MMTPA/CPS 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 these projects as their travel modes, it is anticipated that a reduction in GHG emissions could be observed.

- **From CVE Freight Signal Prioritization:** Through freight signal prioritization, heavy-duty vehicles traveling through the signalized intersections will spend lesser time idling at the intersections and have a more continuous flow. This reduction in idling time might reduce the GHG emissions from the heavy-duty vehicles equipped with CV technology. The impact created by CVE project might not be significant because of the limited deployment fleet.

- **From EPM:** Perceived reduction in distance traveled around parking facilities to find a parking spot: As information about available parking spots become available to the travelers, they will travel lesser distances

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https://www.epa.gov/moves
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.

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 over 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.

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>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Reduce traffic congestion</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>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</td>
</tr>
</tbody>
</table>
| 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 Trend Analysis  
                      Pre/Post quasi-experimental design |
| Data Source       | Operating System; Customer Survey                                                                                                            |
| Baseline Timeframe | Two years pre-deployment period                                                                                                             |
| 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/CPS, 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/CPS
As travelers migrate from their personal vehicles to alternative travel options through MMTPA/CPS, 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, 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/CPS and CEAV projects
- AADT for road segments (pre- and post-deployment)
- Speed and travel time for XD level road segments (pre- and post-deployment)

The following data will be collected from user surveys:

- Percentage of travel through MMTPA/CPS 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/CPS 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/CPS project?
- What are your other modes of travel?
- How much time have you spent around parking facilities to find an unoccupied parking spot?
  - During regular days
  - During event days

5.3.4.1.3 Design of Experiments

BACKGROUND ON BASELINE CONDITIONS
For the baseline conditions, person miles travelled through the MMTPA/CPS 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 offered by Smart Columbus will be calculated. Traffic congestion data 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 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.

5.3.4.1.4 Data Collection Plan

DATA SOURCE

For this objective, the project usage data and survey data will be collected. Surveys will be conducted every three months post-implementation of the projects, until the end of treatment timeframe. Surveys will be conducted by a third party and the results will be stored in the Operating System. All the data will be available for access from the Operating System. Refer to Chapter 6 for more information.

BASELINE TIMEFRAME

Two years pre-deployment period will be considered as 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/CPS and CEAV projects, travelers will be able to migrate from their personal vehicles to multimodal travel options including usage of electric vehicles. 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 MMTPA/CPS and CEAV applications, 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 MMTPA/CPS and CEAV application.

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/CPS
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. 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 over
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.

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

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

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 the Smart Columbus.

**MMTPA/CPS**

MMTPA/CPS project enables the 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 thereby 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 Linden neighborhood. CEAVs would serve as a connecting mode between transit stations and pickup points of other modes located in the CEAV route.

### 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/CPS implementation
- Perceived ease of multimodal transfers pre- and post-SMH implementation
- Perceived ease of FMLM travel pre- and post-CEAV 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:

- How often do you use MMTPA/CPS?
- What is the ease of planning a multimodal trip to your job and service locations when compared to your previous/alternate trip planning options?
- How reliable is MMTPA/CPS project in the execution of scheduled trips?
- How easy is the FMLM travel through CEAVs when compared to your previous travel options?

### 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 on a quarterly basis 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 every three months post-implementation of the projects, until the end of treatment timeframe. Surveys will be conducted by a third party and the results will be stored in the Operating System. All the data will be available for access from the Operating System. Refer to Chapter 6 for more information.

BASELINE TIMEFRAME
Two years pre-deployment period will be considered as 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/CPS participants perception of access to trip planning options pre- and post-MMTPA/CPS 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 a coordinated travel between their origins and destinations.

*Perceived ease of multimodal transfers:* Through Smart Mobility Hubs, 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 Linden region will provide a reliable first mile and last mile transportation to residents in the nearby neighborhoods and travelers with their transfer and destination points in Linden region. Participants will be surveyed to capture their perception of reliable first mile and last mile transportation pre- and post-CEAV.

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 over 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.
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 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.

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Objectives</th>
<th>Treatment</th>
<th>Hypothesis</th>
<th>Outcome Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide useful data</td>
<td>The Operating System will provide useful data to public agencies, evaluators and developers through an open data portal</td>
<td></td>
<td>Ability to access and use the data</td>
<td></td>
</tr>
<tr>
<td>Provide improved data sharing method</td>
<td>The Operating System will enhance the ease of data sharing through the Open Data Portal</td>
<td></td>
<td>Usefulness of the accessed data for intended purpose</td>
<td></td>
</tr>
<tr>
<td>Provide easily discoverable data</td>
<td>The Operating System will provide users with data in an easily discoverable manner</td>
<td></td>
<td>Number of applications, reports, analytics and visualizations created using the Operating System data</td>
<td></td>
</tr>
<tr>
<td>Provide an easily accessible data exchange to providers and consumers of data</td>
<td>The Operating System will provide an easily accessible data exchange for all users of both internal and external applications.</td>
<td></td>
<td>Number of requests for datasets</td>
<td></td>
</tr>
<tr>
<td>Establish and enhance customer satisfaction with the Operating System</td>
<td>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</td>
<td></td>
<td>Customer Satisfaction ratings for:</td>
<td></td>
</tr>
<tr>
<td>Provide easily discoverable data</td>
<td>The Operating System will provide open data to the users in an easily discoverable fashion</td>
<td></td>
<td>- Quality, freshness and completeness of data</td>
<td></td>
</tr>
<tr>
<td>- Metadata quality</td>
<td></td>
<td></td>
<td>- Visualization tools/features</td>
<td></td>
</tr>
<tr>
<td>- Analytical tools/feature</td>
<td></td>
<td></td>
<td>- Method(s) of data extraction</td>
<td></td>
</tr>
<tr>
<td>- Method(s) of data ingestion</td>
<td></td>
<td></td>
<td>- Time spent on the Operating System</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Time spent on discovery of dataset(s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Ability to find the required/intended data</td>
<td></td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Provide useful data</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>The Operating System will provide useful data to public agencies, evaluators,</td>
</tr>
<tr>
<td></td>
<td>and developers through an open data portal.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Ability to access and use the data</td>
</tr>
<tr>
<td></td>
<td>Usefulness of the accessed data for intended purpose</td>
</tr>
<tr>
<td></td>
<td>Number of applications, reports, analytics, and visualizations created</td>
</tr>
<tr>
<td></td>
<td>using the Operating System data</td>
</tr>
<tr>
<td>Design of</td>
<td>Pre/Post Quasi Experimental Design</td>
</tr>
<tr>
<td>Experiment</td>
<td>Pre/Post Quasi Experimental Design</td>
</tr>
<tr>
<td></td>
<td>Post-only Trend Analysis</td>
</tr>
<tr>
<td>Data Source</td>
<td>Operating System</td>
</tr>
<tr>
<td>Baseline</td>
<td>One year before implementation of the Operating System Data Platform 2.0</td>
</tr>
<tr>
<td>Timeframe</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Treatment</td>
<td>From the implementation of the Operating System Data Platform 2.0 until the</td>
</tr>
<tr>
<td>Timeframe</td>
<td>period of implementation of last portfolio project (April 22, 2019, to March</td>
</tr>
<tr>
<td></td>
<td>31, 2021).</td>
</tr>
</tbody>
</table>

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, independent evaluators, 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 with the agency users. Following are some of the sample questions that will be used in the survey.

- How did you access the data for your intended purposes before implementation of the Operating System?
- What is your purpose for using data on the Operating System?
- Rate your ability to access and use the data for your intended purposes
- Did you develop any visualizations, analytics, reports, etc., using the data on the Operating System?

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. Agency employee survey conducted (post-implementation) by the Smart Columbus will focus on understanding the efficiency of previous data-sharing mechanisms. This will be used as a baseline to make 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 agency 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 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, independent evaluators)
- 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 on as a hardware or software developer independent of the city.

Information about the user groups will be collected through user surveys. Surveys are conducted every three months post-implementation of the Operating System Data Platform 2.0. The surveys will be conducted by a third party and the results will be stored in the Operating System.

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 every three months post-implementation 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 thereby increases their 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 thereby provides more opportunities for users.

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 over
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 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 an 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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>Provide improved data-sharing method</td>
</tr>
<tr>
<td><strong>Hypothesis</strong></td>
<td>The Operating System will enhance the ease of data-sharing method through the Open Data Portal</td>
</tr>
<tr>
<td><strong>Indicator</strong></td>
<td>Ease of data-sharing ability</td>
</tr>
<tr>
<td><strong>Design of Experiment</strong></td>
<td>Pre/Post Quasi Experimental Design</td>
</tr>
<tr>
<td><strong>Data Source</strong></td>
<td>Operating System</td>
</tr>
<tr>
<td><strong>Baseline Timeframe</strong></td>
<td>One year before implementation of the Operating System Data Platform 2.0</td>
</tr>
<tr>
<td><strong>Treatment Timeframe</strong></td>
<td>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).</td>
</tr>
</tbody>
</table>

*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 with the agency providers. Following are some of the sample questions that will be used in the survey.
• How was your data ingestion experience with the Operating System when compared to your previous data-sharing mechanisms?
• Is there a change in the number of data requests post-publishing on the Operating System?
• How long did it used to take to get access to data before implementation of the Operating System?

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 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 thereby 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 agency 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, independent evaluators)
Information about the user groups will be collected through user surveys. Surveys are conducted every three months post-implementation of the Operating System Data Platform 2.0. The survey results will be stored in the Operating System.

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 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 over four surveys (once every 3 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 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 in to 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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Provide easily discoverable data</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>The Operating System will provide users with data in an easily discoverable manner</td>
</tr>
<tr>
<td>Indicator</td>
<td>Ability to find data intended by the users</td>
</tr>
<tr>
<td>Data Source</td>
<td>Operating System</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>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).</td>
</tr>
</tbody>
</table>

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

Agency provider and user surveys will be conducted to capture the above data. Following are sample survey questions that will be asked during surveys:

- Is there a change in the number of data requests post-publishing on the Operating System? (agency provider)
- Were you able to find the data intended for your purpose? (agency user)

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 manually 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 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 thereby 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 users 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 have access to the latest data updates. Stakeholders that will store, retrieve, or otherwise use the Operating System include:

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

Information about the user groups will be collected through user surveys. Surveys are conducted every three months post-implementation of the Operating System Data Platform 2.0. The survey results will be stored in the Operating System.

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 every three months post-implementation 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 over 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>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>Provide an easily accessible data exchange to providers and consumers of data</td>
</tr>
<tr>
<td><strong>Hypothesis</strong></td>
<td>The Operating System will provide an easily accessible data-sharing method to enable data exchange for all users of both internal and external applications.</td>
</tr>
<tr>
<td><strong>Indicator</strong></td>
<td>Percentage of datasets accessible to applications (internal and external) in a usable format and method</td>
</tr>
<tr>
<td><strong>Design of Experiment</strong></td>
<td>Post-only trend analysis</td>
</tr>
<tr>
<td><strong>Data Source</strong></td>
<td>Operating System</td>
</tr>
<tr>
<td><strong>Baseline Timeframe</strong></td>
<td>Not Applicable</td>
</tr>
<tr>
<td><strong>Treatment Timeframe</strong></td>
<td>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).</td>
</tr>
</tbody>
</table>

_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): It is defined as the percentage of datasets accessible to internal and external applications.
- 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 with the agency providers and users. Following are some of the sample questions that will used in the survey.

- How did you access the data for your intended purposes before implementation of the Operating System?
- How was your data ingestion experience with the Operating System when compared to your previous data-sharing mechanisms?
- How was your data extraction experience with the Operating System when compared to your previous data-sharing mechanisms?

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.
Chapter 5. Performance Measurement and Evaluation

5.4.3.4.3 Data Collection Plan

DATA SOURCE

For this objective, the Operating System usage data and survey data will be collected. Surveys will be conducted every three months post-implementation of the Operating System Data Platform 2.0, until the end of treatment timeframe. All the data will be available for access from the Operating System. 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 to compare against.

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, 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 thereby increases 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 in the assessment of 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 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 over four surveys (once every three months). The survey data collected will be compared over the previous surveys to track the indicator for 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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>Establish and enhance customer satisfaction with the Operating System</td>
</tr>
<tr>
<td><strong>Hypothesis</strong></td>
<td>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</td>
</tr>
<tr>
<td><strong>Indicator</strong></td>
<td>Customer satisfaction ratings for:</td>
</tr>
<tr>
<td></td>
<td>• Quality, freshness, and completeness of data</td>
</tr>
<tr>
<td></td>
<td>• Metadata quality</td>
</tr>
<tr>
<td></td>
<td>• Visualization tools/features</td>
</tr>
<tr>
<td></td>
<td>• Analytical tools/features</td>
</tr>
<tr>
<td></td>
<td>• Method of ingesting data into the Operating System</td>
</tr>
<tr>
<td></td>
<td>• Method of extracting data from the Operating System</td>
</tr>
<tr>
<td><strong>Design of Experiment</strong></td>
<td>Post-only Trend Analysis</td>
</tr>
<tr>
<td><strong>Data Source</strong></td>
<td>Operating System</td>
</tr>
<tr>
<td><strong>Baseline Timeframe</strong></td>
<td>Not Applicable</td>
</tr>
<tr>
<td><strong>Treatment Timeframe</strong></td>
<td>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).</td>
</tr>
</tbody>
</table>

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

A user survey will be conducted to capture the above data. Following are some of the sample questions that will be used in the survey.

• On a scale of 1 to 5, rate the metadata quality for the data on the Operating System
• On a scale of 1 to 5, rate your satisfaction with the Operating System data extraction experience

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 make use of the Operating System, but it is capable, and should be utilized in a greater capacity. 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 every three months from the implementation 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
All the data will be available for access from the Operating System. 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 every three months post-implementation 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 to generate an accurate assessment of ground truth. We should note that the Smart Columbus could 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. 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 the user satisfaction with the functionality and usefulness of the tool.

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 Systems’ 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 every for three months, 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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Provide easily discoverable data</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>The Operating System will provide open data to the users in an easily</td>
</tr>
<tr>
<td></td>
<td>discoverable fashion.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Time spent on the Operating System</td>
</tr>
<tr>
<td></td>
<td>Time spent on discovery of dataset(s)</td>
</tr>
<tr>
<td></td>
<td>Ability to find the intended data</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Post-only trend analysis</td>
</tr>
<tr>
<td>Data Source</td>
<td>Operating System</td>
</tr>
</tbody>
</table>
### Chapter 5. Performance Measurement and Evaluation

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Timeframe</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>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).</td>
</tr>
</tbody>
</table>

*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

Operating System user surveys will be conducted to capture the above data. Following are sample survey questions that will be asked during surveys:

- Were you able to find the data intended for your purpose?

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 make use of the Operating System, but it is capable, and should be utilized in a greater capacity. 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 does 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**

All the data will be available for access from the Operating System. Refer to Chapter 6 for more information.
Chapter 5. Performance Measurement and Evaluation

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 every three months post-implementation 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 for searching datasets is an indicative 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 trend analysis monthly. 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 every three months 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 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 $11.6 million. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation and testing, and operations and maintenance. At the end of the demonstration, the project life cycle cost will be provided to the independent evaluator for cost benefits analysis.
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 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. All 86 intersections will be equipped with CV technology.

In conjunction with these intersections, 1,800 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

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Partner/Source</th>
<th>Quantity</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light-Duty Vehicle</td>
<td>Private Vehicle</td>
<td>1,019</td>
<td>All V2X safety apps, HMI, no data logging, integrator-led installation</td>
</tr>
<tr>
<td></td>
<td>Public Service City Fleet Vehicle</td>
<td>198</td>
<td>All V2X safety apps, HMI, no data logging, coordination of installation with City fleets</td>
</tr>
<tr>
<td></td>
<td>COTA Supervisor Vehicle</td>
<td>25</td>
<td>All V2X safety apps, HMI, no data logging, coordination with COTA maintenance</td>
</tr>
<tr>
<td>Emergency Vehicle</td>
<td>Public Safety Fire Truck/EMS</td>
<td>30</td>
<td>EVP only, minimal HMI (EVP granted), no data logging, integration with siren, coordination of installation with City fleet</td>
</tr>
<tr>
<td></td>
<td>Public Safety Police Cruiser</td>
<td>80</td>
<td>EVP only, minimal HMI (EVP granted), no data logging, integration with siren, coordination of installation with City fleet</td>
</tr>
<tr>
<td>Heavy-Duty Vehicle</td>
<td>Private Freight Vehicle</td>
<td>10</td>
<td>BSM and FSP only, no HMI, no data logging, coordination with fleet owner</td>
</tr>
<tr>
<td></td>
<td>County Engineer Heavy-Duty Vehicle</td>
<td>2</td>
<td>BSM only, no HMI, no data logging, coordination with fleet owner</td>
</tr>
<tr>
<td>Transit Vehicle</td>
<td>AV Shuttle (CEAV)</td>
<td>6</td>
<td>All V2X safety apps, no HMI, data logging and offloading, coordination with AV operator</td>
</tr>
<tr>
<td></td>
<td>COTA Transit Bus (fixed-route)</td>
<td>350</td>
<td>All V2X safety apps, TSP, no HMI, data logging and offloading, coordination with COTA maintenance</td>
</tr>
<tr>
<td></td>
<td>COTA Paratransit Bus</td>
<td>80</td>
<td>All V2X safety apps, no HMI, data logging and offloading, coordination with COTA maintenance</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>~1,800</td>
<td></td>
</tr>
</tbody>
</table>

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, possibly associated with a single application, or at best, a subset of the applications, will be necessary. 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 Concept of Operations for the Connected Vehicle Environment for the Smart Columbus Demonstration Program 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.
5.5.2. Logic Model

Figure 13 shows the logic model identified for this project.

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Objectives</th>
<th>Treatment</th>
<th>Hypothesis</th>
<th>Outcome Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase driver's awareness of speed limits in school zones</td>
<td>Reduce truck wait (delay) time at signalized intersections.</td>
<td>Emergency Vehicle Signal Preemption</td>
<td>Emergency Vehicle Preemption application will improve emergency response times by reducing delay at signalized intersections with DSRC.</td>
<td>• Emergency response time</td>
</tr>
<tr>
<td>Safety</td>
<td>Mobility</td>
<td>Red Light Violation Warning CVE application</td>
<td>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 CV corridor.</td>
<td>• Driver's awareness of traffic signal status</td>
</tr>
<tr>
<td>Demonstrate DSRC technology for TSP application</td>
<td></td>
<td>Reduced Speed School Zone CVE application</td>
<td>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.</td>
<td>• Driver's awareness of speed in school zones</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DSRC based TSP application will perform at the same level as Opticom based TSP application.</td>
<td>• Time of priority request</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Travel time through intersection</td>
</tr>
</tbody>
</table>

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 *Concept of Operations for the Connected Vehicle Environment for the Smart Columbus Demonstration Program* 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>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Reduce emergency response times in CVE corridor</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>The Emergency Vehicle Preemption application will improve emergency response times by reducing delay at signalized intersections with DSRC.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Emergency response times</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Pre/post Trend analysis</td>
</tr>
<tr>
<td>Data Source</td>
<td>Survey</td>
</tr>
<tr>
<td></td>
<td>City of Columbus Department of Public Safety EMS records</td>
</tr>
<tr>
<td></td>
<td>CVE Data via Operating System</td>
</tr>
</tbody>
</table>
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 every three months 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

The following are examples of questions that may be part of the survey:

- Has the emergency vehicle preemption application reduced the emergency response time within the CVE corridor?
- On an average, what is the approximate emergency response time within the CVE corridor?
- Do you perceive to be safer in the emergency vehicles with the emergency vehicle preemption?

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 emergency medical services (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 years’ 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 this analysis and 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 Emergency Vehicle Preemption equipment. Figure 14 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

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 as there is no pre-treatment data to consider.

5.5.3.1.4 Data Collection Plan

DATA SOURCE

Customer surveys will be conducted by a third party (who is yet to be determined) and the results will be made available for the City.

All the supplemental data will be available for access from the Operating System. Department of Public Safety will provide vehicle GPS records to the Operating System. The CVE will provide signal preempt data to the Operating System.

All the other data (traffic, weather, event, etc) 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 emergency vehicle response time will be collected for the nine-month period prior to deployment.

TREATMENT TIMEFRAME

Treatment data will be collected for nine months following the implementation of the CVE. Survey will be conducted once every three months.

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 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 over three surveys (once every three months). 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.
Survey regarding emergency vehicle response times for the nine (9) months prior to deployment will be compared with response times from nine (9) months following deployment 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 Concept of Operations for the Connected Vehicle Environment for the Smart Columbus Demonstration Program has additional detail on this application.

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Increase driver's awareness of signal status</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>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 corridor.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Driver's awareness of traffic signal status</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Pre/post Trend Analysis</td>
</tr>
<tr>
<td>Data Source</td>
<td>Survey</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>Three months following deployment before implementation</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>Six months post-implementation</td>
</tr>
</tbody>
</table>

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:

- Customer survey
- SPaT message content and time that would have been sent (before implementation)
- 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 every three months 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

The following are examples of questions that may be part of the survey:

- How would you rate your awareness of traffic signal status at the intersections?
- Do you have any red-light violation in the past 90 days?
- How frequently do you think were you on the dilemma zone?

How would you rate the red-light violation warning application?

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 three months following deployment (without activating the application) to allow for a small period to assess baseline conditions.

All the customers with the DSRC on their vehicles will be part of the treatment group. The control group doesn’t exist since all the vehicles equipped with DSRC will receive the warnings. During the pre-period, RSUs would not broadcast SPaT and 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 a third party (to be determined) and the results will be made available for the City.

BASELINE TIMEFRAME

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

TREATMENT TIMEFRAME

The project will be evaluated nine months following deployment of the CVE, with the final six 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 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 over three surveys (once every three months). 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 (which includes all pilot vehicles except COTA and truck platoon vehicles). 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 Concept of Operations for the Connected Vehicle Environment for the Smart Columbus Demonstration Program 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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Increase driver's awareness of speed limits in school zones</td>
</tr>
</tbody>
</table>
### Category | Description
--- | ---
**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

**Baseline Timeframe** | Three months following deployment before implementation

**Treatment Timeframe** | Six months post-implementation

*Source: City of Columbus*

#### 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:

- Customer survey
- 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 RSM activation

A customer survey will be conducted every three months 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

The following are examples of questions that may be part of the survey:

- How frequently do you cross school zones?
- How would you rate your awareness of speed in work zone?
- Have you reduced your excessive speed in school zones in the past 90 days?
- How would you rate the reduced speed school zone warning application?
5.5.3.3 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 three months following deployment (without activating the application) to allow for a small period to assess baseline conditions.

RECOMMENDED DESIGN OF EXPERIMENT

All the customers with the DSRC on their vehicles will be part of the treatment group. The control group doesn’t exist since all the vehicles equipped with DSRC will receive the warnings. During the pre-period, RSUs would not broadcast Roadside Safety Messages (RSM) that indicate the school zone speed and times when the school zone is active. During the post-period, RSUs would broadcast RSM, which would result in a warning issued to the driver should the vehicle’s trajectory place it at risk for excessive speeding in 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 a third party (to be determined) and the results will be made available for the City.

BASELINE TIMEFRAME

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

TREATMENT TIMEFRAME

The project will be evaluated nine months following deployment of the CVE, with the final six 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 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 over three surveys (once every three months). 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 to acquire priority status. The approaches enabled for priority is 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 *Concept of Operations for the Connected Vehicle Environment for the Smart Columbus Demonstration Program* provides additional detail on this application. TSP will be deployed at the following intersections:

- 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 Genesee 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 Elmore 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**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Demonstrate DSRC technology for TSP application</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>DSRC based TSP application will perform at the same level as Opticom-based TSP application.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Time of priority request</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Post-only quasi-experimental design</td>
</tr>
<tr>
<td>Data Source</td>
<td>COTA CAD/AVL data, Operating System</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>N/A</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>Nine (9) months post-implementation</td>
</tr>
</tbody>
</table>

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. The COTA will operate the two systems in parallel. Opticom-based system will request priority and DSRC based system will mimic the signal priority request.

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 Automated Vehicle Location (AVL) systems together are used to manage real-time operations in the control center and on the bus. All the 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 nine-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 doesn’t existing 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, thereby smoothing traffic flows for freight and reducing stop/start cycles, which reduces emissions. Trucks are given priority where feasible and only if there is no other overriding priority, for example an emergency vehicle.

Ten 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 (OH-317) at Port Road
• London Groveport Road at Alum Creek Drive
• Alum Creek Drive at Spiegel Drive
• Alum Creek Drive at Rohr Road
• Alum Creek Drive at Toy Road
• Alum Creek Drive at Amazon Drive
• Alum Creek Drive at Groveport Road
• 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 Concept of Operations for the Connected Vehicle Environment Project for the Smart Columbus Demonstration Program 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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Reduce truck wait (delay) time at signalized intersections</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>The freight signal priority will save travel time for trucks passing through equipped intersections by modifying signal timing.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Travel time through intersection</td>
</tr>
</tbody>
</table>
### 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 (via GPS geofences)
- Number of signal priority cycles granted

### 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 three months following deployment (without activating the application) to allow for a small period to assess baseline conditions.

**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 three 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 the data will be available for access from the Operating System.
BASELINE TIMEFRAME

For the first three 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 nine months following deployment of the CVE, with the final six 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 Costs

Approximate budget to design, build, and implement this project is $11 million. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation and testing, and operations and maintenance. At the end of the demonstration, the project life cycle cost will be provided to the IE for cost benefits analysis.
5.6. PROJECT 3: MULTIMODAL TRIP PLANNING APPLICATION/COMMON PAYMENT SYSTEM

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 and parking providers. Moreover, some Columbus residents are unbanked and therefore cannot access alternative modes of transportation including car- and bike-sharing systems. The Multimodal Trip Planning Application (MMTPA) and Common Payment System (CPS) 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 bike-share, transportation network companies (TNC) and car-share. Using the MMTPA/CPS, 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. Payment for transportation service providers and parking providers will be processed through the CPS. It is the City’s goal that this application 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/CPS 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 *Concept of Operations for the MMTPA/CPS for the Smart Columbus Demonstration Program* 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.
### 5.6.2. Logic Model

Figure 15 shows the logic model identified for MMTPA/CPS project.

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

**Figure 15: Multimodal Trip Planning Application/Common Payment System Performance Measurement Logic Model**

*Source: City of Columbus*
The MMTPA/CPS 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>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Provide a single point of access to multimodal trip planning information to plan, book, and pay for a multimodal trip.</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>The MMTPA/CPS will encourage travelers to take multimodal trips in central Ohio by providing a comprehensive multimodal planning/booking/payment tool.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Perceived improvement in access to multimodal trip planning and payment</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Pre/post quasi-experimental design</td>
</tr>
<tr>
<td>Data Source</td>
<td>Customer surveys</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>One-year prior to implementation</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>One-year post-implementation</td>
</tr>
</tbody>
</table>

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 and payment

The following data will be collected:

- Number of trips booked through MMTPA/CPS
- Number of trips paid through MMTPA/CPS
- Trip date and time
• Trip origin and destination
• Number of trips involving one or more mode shift
• Number of travelers using CPS to pay for transportation service options
• Customer survey

A survey will be conducted every six months through the application to evaluate the MMTPA/CPS’s impact on mobility from the customer’s point of view. The survey will be designed to seek rider-centric performance measures, such as:

• 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/CPS
• Preferred transportation services
• Most influential factors in choosing transportation services (cost, trip time, comfort, etc.)
• Additional transportation services that customers want to include in the MMTPA/CPS
• Most desired features
• Most valuable features offered
• Positive and negative experiences
• Suggestions for improvement

The following are examples of questions that may be part of the survey:

• Have you explored new modes of transportation after installing the MMTPA/CPS?
• Are there destinations that are too difficult to reach? If so, what type of destination (work, healthcare, etc.)?
• Do you think multimodal trip planning and payment have improved?
• Have you used the MMTPA/CPS for trip planning and payment for accessing jobs and services?
• How easy is MMTPA/CPS for trip planning and payment?

This feedback will include information that will help MMTPA/CPS 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/CPS 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

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

5.6.3.1.3 Data Collection Plan

DATA SOURCES

Customer surveys will be conducted by a third party (to be determined) and the results will be made available for the City and stored in the Operating System.

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 pre/post design of experiment, baseline data will be collected during the recruitment process for the one-year period prior to the implementation.

TREATMENT TIMEFRAME

Treatment data will be collected for one-year following the implementation of the MMTPA/CPS. Survey will be conducted once every six months.

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

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 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 over two surveys (once every six 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 project. Supplemental data may be collected and analyzed to support the conclusion.
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>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Facilitate access to jobs and services</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>MMTPA/CPS will provide better access to jobs and services by enabling travelers to use mobility services that were previously either unavailable to them or that they were unaware of.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Perceived ease of accessing jobs and services</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Pre/Post quasi-experimental design</td>
</tr>
<tr>
<td>Data Source</td>
<td>Customer Survey</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>One-year prior to implementation</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>One-year post-implementation</td>
</tr>
</tbody>
</table>

*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 CPS used
- Number of times MMTPA/CPS 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)
- Number of trips booked using CPS for payment
- Trips booked to and from job centers
- Perceived ease of accessing jobs and services
Chapter 5. Performance Measurement and Evaluation

Performance Measurement Plan (PfMP) – Final Report | Smart Columbus Program | 85

(*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.)

The perceived ease of accessing jobs and services will be gauged in the customer survey, which will ask customers about their experiences with MMTPA/CPS. The survey is described in earlier in Chapter 5.6.3.

The number of single and multimodal trips will be self-reported in the customer survey.

5.6.4.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

An existing system comparable to the MMTPA/CPS 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.

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

5.6.4.1.3 Data Collection Plan.

DATA SOURCES

Customer surveys will be conducted by a third party (to be determined) and the results will be made available for the City.

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 during the recruitment process for one-year period prior to the implementation.

TREATMENT TIMEFRAME

Treatment data will be collected for one-year following the implementation of the MMTPA/CPS. Survey will be conducted once every six months.

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

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 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 over two surveys (once every six 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 project. Supplemental data may be collected and analyzed to support the conclusion.

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>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Improve customer satisfaction</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>MMTPA/CPS will improve customer satisfaction by providing a comprehensive multimodal planning/booking/payment tool.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Customer satisfaction ratings</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Pre/Post Quasi Experimental Design</td>
</tr>
<tr>
<td>Data Sources</td>
<td>Customer Surveys</td>
</tr>
<tr>
<td>Mobility provider interviews</td>
<td></td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>One year prior to implementation</td>
</tr>
</tbody>
</table>

**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
• CPS application ratings
• Perceived ease of participating in a multimodal planning and payment solution

The following data will be collected:

• Customer survey
  o Perceived ease of participating in a multimodal planning and payment solution
• Mobility provider interviews
• MMTPA/CPS application ratings
• MMTPA/CPS application comments
• Application usage:
  o Trips explored
  o Trips booked
  o Funds deposited
    • Source
  o Profiles created
  o Frequency of booked trips
  o Retention - how long are they using the app

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

• Service providers where the CPS is the traveler’s preferred payment method
• Service providers where the CPS failed to work or exceeded expectations
• Service providers that travelers would like to see accept the CPS
• Travelers’ preferred method to add to CPS account balance
• Examples of opportunities opened by CPS (i.e. places that were previously difficult to reach, or ability to reach goods or services)
• Traveler’s access to other payment methods
• Positive and negative experiences
• Suggestions for improvement
• Other payment methods available to the traveler

The following are examples of questions that may be a part of the survey:

• What methods do you use to add to your CPS account balance?
• Is there a destination that was too hard to reach before you opened a CPS account? If so, what type of destination was it (work, healthcare, personal use, etc)?

The survey will also request feedback on the quality of users’ experiences. The survey (for MMTPA/CPS) is described in earlier in Chapter 5.6.3. If the MMTPA/CPS 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 obtained 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
- Number of users who have adopted/added CPS as a payment method
- Positive and negative experiences
- Suggestions for improvements

The following are examples of questions that may be part of the survey:

- Are there specific services or routes that are more popular with CPS users?
- Has CPS increased overall ridership? Have other payment methods declined?

Data from the Operating System, where the CPS 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/CPS 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**

Customer surveys will be administered to MMTPA/CPS users both during pre- and post-deployment of MMTPA/CPS. Since there will not be a treatment or control group and no random assignment of travelers to a particular group, a pre/post quasi-experimental design is recommended. For the mobility provider interviews and the MMTPA/CPS application ratings, the control group doesn't 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**

Customer Surveys and the mobility provider interviews will be conducted by a third party and the results will be made available for the City. App user surveys will be conducted on the MMTPA/CPS app.

MMTPA/CPS user ratings and comments will come from the MMTPA/CPS app and the MMTPA/CPS website.

All the other data related to MMTPA/CPS 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 during the recruitment process for one-year 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 for one-year following the implementation of the MMTPA/CPS. Survey/interviews will be conducted once every six months.
A one-year timeframe after implementation was chosen to provide travelers sufficient time to become informed, trained, and comfortable using technology.

5.6.5.2. IMPACT EVALUATION PLAN

The impact evaluation plan for the indicators is as follows:

- For the surveys and interviews, 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 over two surveys (once every six 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 project. Supplemental data may be collected and analyzed to support the conclusion.

- 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/CPS, as well as the applications functions and features; this evaluation will be ongoing throughout the deployment period. The application ratings and feedback in particular will be used to identify and prioritize enhancements to the MMTPA/CPS 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/CPS:

- **CPASS Program:** 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 will continue until December 31, 2020. 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/CPS and other mobility projects produce.

- **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/CPS 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/CPS to get to their destination. Evaluators will be assessing the impacts of these two projects on the usage trends.

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7 [https://www.cota.com/cpass/](https://www.cota.com/cpass/)
• **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.

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

### 5.6.7. Project Costs

Approximate budget to design, build, and implement this project is $2.5 million. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation and testing, and operations and maintenance. At the end of the demonstration, the project life cycle cost will be provided to the independent evaluator for cost benefits analysis.
Chapter 5. Performance Measurement and Evaluation

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 fixed-route bus service without assistance. The City’s goal is to develop and deploy a mobile application that would allow this population to independently 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 Smart Columbus Mobility Assistance for People with Cognitive Disabilities (MAPCD) Trade Study for the project area, outcomes and objectives and additional detail for this project.8

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

8https://smart.columbus.gov/uploadedFiles/Projects/Smart%20Columbus%20MAPCD%20Trade%20Study%202020180319.pdf
5.7.2. Logic Model

The following logic model is identified for this project.

![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**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>Improved access and use of COTA fixed route bus service for MAPCD participants</td>
</tr>
<tr>
<td><strong>Hypothesis</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Indicator</strong></td>
<td>Customer trips moved from paratransit to fixed route; Overall number of trips taken</td>
</tr>
<tr>
<td><strong>Design of Experiment</strong></td>
<td>Pre/Post Trend Analysis</td>
</tr>
<tr>
<td><strong>Data Source</strong></td>
<td>COTA, MAPCD Vendor, Operating System</td>
</tr>
<tr>
<td><strong>Baseline Timeframe</strong></td>
<td>One-year pre-implementation</td>
</tr>
<tr>
<td><strong>Treatment Timeframe</strong></td>
<td>One-year post-implementation</td>
</tr>
</tbody>
</table>

*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-routes 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 feeling of perceived independence and ease of use indicators might not typically be used as indicators for similar objectives, these are important indicators for indicating 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 their 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.

### 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, and 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 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 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 over 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 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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Improve independence of MAPCD participants by using fixed-route service</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>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.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Perceived independence</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Post-only Trend Analysis</td>
</tr>
<tr>
<td>Data Sources</td>
<td>MAPCD Participant and Caregiver Survey</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>One-year post-implementation</td>
</tr>
</tbody>
</table>

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:

- 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.
To record travelers’ and caregivers’ experience, the data will be collected through survey of both end user and caregiver. Refer to Appendix C for the list of draft survey questions for both MAPCD participants and caregivers.

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.

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 quarterly from the implementation of the project for one year.

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 once every three months.

A one-year timeframe after implementation was chosen to provide travelers 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 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 over 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 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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Reduce COTA expenditures</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>The MAPCD application will reduce COTA operating expenses by moving passengers from paratransit service to fixed-route bus service.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Dollars saved in paratransit program</td>
</tr>
<tr>
<td>Design of experiment</td>
<td>Pre/post Trend Analysis</td>
</tr>
<tr>
<td>Data Sources</td>
<td>COTA</td>
</tr>
<tr>
<td></td>
<td>MAPCD Vendor</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>One year prior to implementation</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>One year after implementation</td>
</tr>
</tbody>
</table>

*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 who currently uses 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. Collecting this information will be part of the recruiting and training process.
• 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.

5.7.7. **Project Costs**

Approximate budget to design, build, and implement this project is $65,000. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation and testing, and operations and maintenance. At the end of the demonstration, the project life cycle cost will be provided to the independent evaluator for cost benefits analysis.
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 Concept of Operations for the Prenatal Trip Assistance for the Smart Columbus Demonstration Program 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.
5.8.2. Logic Model

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

![Logic Model Diagram]

**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>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>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.)</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>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.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Number of NEMT trips taken (by type, purpose)</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Post-only Randomized Experiment</td>
</tr>
<tr>
<td>Data Sources</td>
<td>• PTA vendor</td>
</tr>
<tr>
<td></td>
<td>• MCOs</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>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.</td>
</tr>
</tbody>
</table>

*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.

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.\(^9\)

Refer to the Concept of Operations for the pregnant woman selection and registration process for the PTA project.\(^10\) 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 D for a draft evaluation plan developed by OSU.

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\(^9\) For PTA study purposes, the treatment group is called the “exposed” group and the control group is called the “unexposed” group.

\(^{10}\) [https://smart.columbus.gov/uploadedFiles/Projects/SCC-B-ConOps_PTA_FINAL%202020180911.pdf](https://smart.columbus.gov/uploadedFiles/Projects/SCC-B-ConOps_PTA_FINAL%202020180911.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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Increase usage of NEMT benefits</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>Women in the intervention group will take more NEMT trips than women in the</td>
</tr>
<tr>
<td></td>
<td>“usual care” group.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Number of NEMT trips taken (by type and purpose)</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Post-only randomized experiment</td>
</tr>
</tbody>
</table>
| Data Sources      | • PTA vendor  
                   | • MCOs                                                                     |
| Baseline Timeframe| Not applicable                                                              |
| Treatment Timeframe| Throughout pregnancy to eight weeks after delivery. Note that passive followup |
|                   | 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.\textsuperscript{11}

Refer to the Concept of Operations for the pilot participant selection and registration process for the PTA project. 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.

\subsection*{5.8.4.1.3 Data Collection Plan}

\textbf{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.

\textbf{BASELINE TIMEFRAME}

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

\textbf{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.

\subsection*{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.

\section{5.8.5. Outcome 5.3: Customer Satisfaction}

\subsection*{5.8.5.1 OBJECTIVE 5.3.1: IMPROVE CUSTOMER SATISFACTION}

\textbf{Table 27} outlines the performance measurement methodology for this objective.

\textsuperscript{11} For PTA study purposes, the treatment group is called the "exposed" group and the control group is called the "unexposed group."
Table 27: Prenatal Trip Assistance Customer Satisfaction Objective 5.3.1

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

Source: City of Columbus

5.8.5.1.1 Indicators
The objective will be measured using the following indicator:

- Customer satisfaction rating

See Appendix D for the list of survey questions and data to be collected as part of the PTA user survey developed by OSU, who will also administer the survey.

5.8.5.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS
Pregnant women current uses 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. A post-only randomized experiment is recommended for these indicators.

Refer to the Concept of Operations for the pregnant woman selection and registration process for the PTA project.

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12 Please note: for PTA study purposes, the treatment group is called the “exposed” group and the control group is called the unexposed group.

13 https://smart.columbus.gov/uploadedFiles/Projects/SCC-B-ConOps_PTA_FINAL%202020180911.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 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 over 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 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.

5.8.7. Project Costs
Approximate budget to design, build, and implement this project is $1.2 million. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation and testing, and operations and maintenance. At the end of the demonstration, the project life cycle cost will be provided to the independent evaluator for cost benefits analysis.
5.9. PROJECT 6: SMART MOBILITY HUBS

5.9.1. Introduction

Enhanced mobility or multimodal transit features to alleviate FMLM challenges does not exist in the Linden area or along the Cleveland Avenue corridor. Columbus is working to make mobility a great equalizer in part 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 Concept of Operations for the SMH for the Smart Columbus Demonstration Program for the project area, outcomes and objectives and additional details about this project.

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

Figure 18 shows the logic model identified for the project.

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Objectives</th>
<th>Treatment</th>
<th>Hypothesis</th>
<th>Outcome Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility</td>
<td>Provide physical access to multimodal trip planning and payment options.</td>
<td>SMHs facilitate multimodal trips by allowing travelers to use kiosks and Wi-Fi to access the MMTPA/CPS application and by consolidating multiple modes of transportation at a single location.</td>
<td>• Number of trip planning requests/booking at SMH • Application usage (MMTPA/CPS: number of multimodal trips, number of multimodal trips planned at a kiosk).</td>
<td></td>
</tr>
<tr>
<td>Customer Satisfaction</td>
<td>Improve customer satisfaction</td>
<td>SMH facilities with easy and convenient access to enhanced trip planning, multi modal options, Wi-Fi access, and emergency call button will improve customer satisfaction.</td>
<td>Customer Satisfaction Rating • Ease of kiosks use • Usefulness • Accessibility • Feeling of perceived safety</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 18: Smart Mobility Hubs Performance Measurement Logic Model**

*Source: City of Columbus*
Chapter 5. Performance Measurement and Evaluation

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>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Provide physical access to multimodal trip-planning and payment options</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>SMHs facilitate multimodal trips by allowing travelers to use kiosks and Wi-Fi to access the MMTPA/CPS application and by consolidating multiple modes of transportation at a single location.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Number of trip planning requests/bookings at SMH</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Post-only Trend Analysis</td>
</tr>
<tr>
<td>Data Sources</td>
<td>MMTPA, CPS, Operating System, Interactive Kiosks – Central Management System (IK-CMS)</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>One-year post-implementation</td>
</tr>
</tbody>
</table>

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/CPS: 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 the data will be available for access from the Operating System. MMTPA and CPS applications will send the trip-planning and -booking 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 one-year following the implementation of the SMH.

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

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Improve customer satisfaction</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>SMH facilities with easy and convenient access to enhanced trip planning, multimodal options, Wi-Fi access, and emergency call button will improve customer satisfaction.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Customer satisfaction rating (ease of kiosk use, usefulness, accessibility, perceived feeling of safety)</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Post-only Trend Analysis</td>
</tr>
<tr>
<td>Data Sources</td>
<td>Customer Survey</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>One year after implementation</td>
</tr>
</tbody>
</table>

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\(^\text{14}\) of SMHs: The ease of reaching the user’s valued destination
- Feeling of perceived safety provided by various SMH components (call button and lighting)

The survey may include the following example questions:

- Do you find kiosks easy to use?
- Do you find the number of services provided by SMHs to be adequate?
- Do you find the number of modes of transportation provided by SMHs to be adequate?
- When using the SMHs, how easy do you find it to reach your final destination?
- How convenient is the SMH with multimodal options?
- How safe do you feel while at the SMHs?
- Does the emergency call button at the SMH increase your feeling of safety?
- Does the lighting of the SMH increase your feeling of safety?

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.

\(^\text{14}\) [https://www.fdot.gov/planning/fto/accessibility](https://www.fdot.gov/planning/fto/accessibility)
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.

5.9.4.1.3 Data Collection Plan

DATA SOURCES

Surveys will be conducted by a third party (to be determined), 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 one-year following the implementation of the SMH. Survey will be conducted once every three months.

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

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 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 over 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 project. Supplemental data may be collected and analyzed to support the conclusion.

5.9.5. Project-Specific Confounding Factors

Multimodal Trip Planning Application/Common Payment System: With the implementation of the MMTPA/CPS project, travelers may be more likely to use SMHs. It is anticipated that MMTPA/CPS 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 shares stops with two SMHs. It is anticipated that CEAV and SMH usage will be closely correlated and impact each other. Evaluators will assess the impacts of these two projects on application usage.
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 kiosks 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 their 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.

### 5.9.6. Project Costs

Approximate budget to design, build, and implement this project is $700,000. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation and testing, and operations and maintenance. At the end of the demonstration, the project life cycle cost will be provided to the independent evaluator for cost benefits analysis.
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 Concept of Operations for the Event Parking Management for the Smart Columbus Demonstration Program for project area, outcomes and objectives, and additional detail on this project.15

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

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

![Logic Model Diagram]

**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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Increase knowledge of available parking in the downtown area and Short North during events.</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>Users of EPM app will have increased knowledge of available parking in the downtown area and Short North during the events.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Knowledge of available parking</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Pre/post Quasi-Experimental design</td>
</tr>
<tr>
<td>Data Sources</td>
<td>Survey</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>One year prior to implementation</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>One-year post-implementation</td>
</tr>
</tbody>
</table>

Source: City of Columbus

5.10.3.1.1 Indicators

The following indicators will measure the objective:

- Knowledge of available parking

The above data will be collected through surveys. The questionnaire for the survey is currently being developed, and may include the following potential questions:

- How do you find available parking?
- Do you use any app for finding available parking? If so, which app do you use?
- Do you use the app to find parking during the events?
- Have you heard about the EPM app?
- Have you used the EPM app?
- How frequently do you use the EPM app to find available parking?
- Does the app help you in identifying the available parking?
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 all the 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. Customer surveys will be administered to both the treatment and control groups both during pre- and post-deployment of EPM. 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

Customer surveys will be conducted by a third party (to be determined) and the results will be made available for the City.

BASELINE TIMEFRAME

The baseline survey will be conducted one year before implementation of the EPM project.

TREATMENT TIMEFRAME

Treatment data will be collected for one-year following the implementation of the EPM. Survey will be conducted once every three months.

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

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 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 over two surveys (once every six 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 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/Common Payment System: The MMTPA/CPS project may be a confounding factor for the EPM project. 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, which could potentially make finding parking easier.

Special Events: The EPM project will encompass all parking facilities in the Downtown District and Short North. Usage of parking application will be tracked throughout the period of performance for impact assessment. However, an increase in parking demand is expected during the major events conducted in the Columbus region. To assess the performance of EPM in peak demand periods, the following events will be tracked:

- Arnold Sports Festival
- Red, White & Boom
- Komen Race for the Cure
- Columbus Marathon
- Columbus Community Fest (Comm Fest)
- Pelotonia
- Pride Parade
- Capital City Half Marathon
- Columbus Clippers and Express Live concert venue event conflict
- Gallery Hop
- 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: 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 Event Parking Management 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 on December 10, 2018. The goal of this program is to increase access for residents and resident guests around Nationwide Children's

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16 https://www.columbus.gov/publicservice/parking/Short-North-Special-Parking-Area/
17 https://www.columbus.gov/Templates/Detail.aspx?id=2147506111
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.

**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, build, and implement this project is $450,000. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation and testing, and operations and maintenance. At the end of the demonstration, the project life cycle cost will be provided to the independent evaluator for cost benefits analysis.
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; therefore, 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 option.
- Provide more access to jobs and services to residents from underserved communities.
- Improve the user experience.

Refer to Operational Concept for the CEAV project of the Smart Columbus Demonstration Program for project area, outcomes and objectives, and additional details for this project.

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

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

![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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Provide convenient, reliable FMLM transit option</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>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.</td>
</tr>
<tr>
<td>Indicators</td>
<td>CEAV passenger trips</td>
</tr>
<tr>
<td></td>
<td>• Walking distance</td>
</tr>
<tr>
<td></td>
<td>• Perceived convenience</td>
</tr>
<tr>
<td></td>
<td>• Perceived reliability</td>
</tr>
<tr>
<td></td>
<td>Perceived improvement in FMLM transit</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Post-only Trend Analysis</td>
</tr>
<tr>
<td>Data Sources</td>
<td>• CEAV Vendor</td>
</tr>
<tr>
<td></td>
<td>• Operating System</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>N/A</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>End of demonstration period</td>
</tr>
</tbody>
</table>

Source: City of Columbus

5.11.3.1. **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

The above data will be collected through surveys. Questionnaire for the survey is currently being developed. Potential list of sample survey questions includes:

• How far do you walk to reach your destination?
• Is the CEAV service reliable?
• Is the CEAV service convenient?
• Has the CEAV service improved your FMLM option?

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 doesn’t 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 survey developed and distributed by the City (or a third party) on board the vehicle.

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. Surveys will be conducted randomly from travelers on board the vehicle.

A one-year timeframe after implementation was chosen to align with the demonstration period for the project.

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 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 over 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 project. Supplemental data may be collected and analyzed to support the conclusion.

5.11.4. Outcome 8.2: Opportunity

Outcome 8.2 identified one objective: Provide more access to jobs and services to residents from underserved communities.

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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Provide more access to jobs and services to residents from underserved communities</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>Providing complementary service to COTA will increase access to jobs and services for underserved communities.</td>
</tr>
<tr>
<td>Indicator</td>
<td>COTA ridership at stations with CEAV</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Pre/post Trend Analysis</td>
</tr>
<tr>
<td>Data Sources</td>
<td>• COTA</td>
</tr>
<tr>
<td></td>
<td>• Operating System</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>One year prior to implementation</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>One year post-implementation</td>
</tr>
</tbody>
</table>

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.

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
• Customer surveys. Refer to Appendix E for a sample list of survey questions

5.11.4.1.2 Design of Experiment

BACKGROUND ON BASELINE CONDITIONS

Although an existing system comparable to the CEAV does not exist, COTA ridership at the CEAV stops (prior to the CEAV launch) and the adjacent stops north and south of them will be collected for the one-year period prior to deployment.

RECOMMENDED DESIGN OF EXPERIMENT

For the COTA ridership, the control group doesn’t exist. COTA ridership data will be collected for both pre- and post-deployment. Therefore, a pre/post trend analysis is recommended.

For increase in modal 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 doesn’t exist prior to the implementation, post-only analysis is recommended.

For increase in modal 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.

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.

BASELINE TIMEFRAME

Baseline data for COTA ridership will be obtained monthly for one year leading up to the project deployment. Ridership data at Linden TC and adjacent stops north and south of Linden TC will be used as the baseline.

Baseline data for increase in mode shift (post-only) will not be collected, however the post-deployment survey will inquire about travel behavior prior to deployment.

TREATMENT TIMEFRAME

The project will be evaluated for one-year following the implementation of the CEAV. Surveys will be conducted randomly from travelers on board the vehicle.
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 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 over 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 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

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Improve the user experience</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>CEAV will improve the user experience by reducing walking distance and providing on-time service.</td>
</tr>
<tr>
<td>Indicators</td>
<td>• CEAV on-time performance</td>
</tr>
<tr>
<td></td>
<td>• Walking distance</td>
</tr>
<tr>
<td></td>
<td>• Perceived convenience</td>
</tr>
<tr>
<td></td>
<td>• Perceived reliability</td>
</tr>
<tr>
<td>Design of Experiment</td>
<td>Post-only Trend Analysis</td>
</tr>
<tr>
<td></td>
<td>Pre/Post Trend Analysis</td>
</tr>
<tr>
<td>Data Sources</td>
<td>• CEAV vendor</td>
</tr>
<tr>
<td></td>
<td>• Operating System</td>
</tr>
<tr>
<td></td>
<td>Customer Survey</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>Baseline Timeframe</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Treatment Timeframe</td>
<td>One-year post-implementation</td>
</tr>
</tbody>
</table>

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 service. This information will be derived through user surveys and analysis of CEAV on-time performance. After service is established, a survey distributed on board 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

The user survey may include the following example questions:

- How often do you use the CEAV?
- Do you use the CEAV to reach another mode of transportation? If so, what kind?
- How reliable is the CEAV service?
- How convenient is the CEAV service?
- What is your walking distance in the CEAV deployment area?

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 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 doesn’t exist currently, a post-treatment non-experiment is recommended. Overall, a post-only trend analysis is recommended for measuring this indicator.

For the 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 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. Customer surveys will be conducted by the City 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 one-year following the implementation of the CEAV. Survey will be conducted once every three months.

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

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 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 over 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 project. Supplemental data may be collected and analyzed to support the conclusion.
5.11.6. Project-Specific Confounding Factors

**Multimodal Trip Planning Application and Common Payment System:** MMTPA/CPS and the CEAV will share location, which will impact CEAV ridership. Evaluators will assess the impact of this project on CEAV 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 usage.

5.11.7. Project Costs

Approximate budget to design, build, and implement this project is $3 million. Smart Columbus team is currently developing and tracking the entire project life cycle cost including planning, design, implementation and testing, and operations and maintenance. At the end of the demonstration, the project life cycle cost will be provided to the independent evaluator for cost benefits analysis.
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. Therefore, 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.

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 being available.

Smart Columbus will leverage existing data sources when available. A detailed description of methodology for fulfilling data needs is discussed below for 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.
Figure 21: Pre- and Post-Deployment Data Collection Timeframe

Source: City of Columbus
6.2.3. Connected Vehicle Environment

For the CVE project, all CV Onboard Units (OBUs) will broadcast Basic Safety Messages (BSM). When in the range of a Roadside Unit (RSU), these BSM messages will be received by the RSU and forwarded to the Operating System. Select vehicles will also transmit Signal Request Messages (SRM) to support preemption or priority requests, as applicable. When an RSU receives an SRM message, 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 Signal Phase and Timing (SPaT), MAP, and Radio Technical Commission for Maritime Services Position Correction Messages (RTCM) on a recurring basis. Further, the Signal Status Messages (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 RSM 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.

![Data Flow Diagram](image)

Figure 22: Connected Vehicle Environment Data Flow Diagram

*Source: City of Columbus*
6.2.4. **Multimodal Trip Planning Application/Common Payment System**

For the MMTPA/CPS project, which is shown in Figure 23, travelers will have the ability to plan and book trips through the MMTPA/CPS application. Once a trip is selected, CPS looks for sufficient funds in the traveler account and processes the payment. 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/CPS Data Flow Diagram

*Source: City of Columbus*

This data will be used to assess the impact of MMTPA/CPS application 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.

From the CPS application, the following data will be collected: number of executed transactions, payment method by mode/service provider, payment amount, number of trips booked using CPS for payment, and trips booked to and from job centers. Services data will be collected for evaluation purposes. Surveys of mobility providers will be focused on gaining insights on the perceived impact of CPS 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. Connected Electric Autonomous Vehicle

For the CEAV project (see Figure 24), 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. 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 24: 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.
6.2.6. Smart Mobility Hubs

For the SMH project (see Figure 25), travelers will have the option to plan and book the trips from the mobility hubs either through the kiosks or through the MMTPA/CPS application 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 buttons 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/CPS project and archived for evaluation. Customer surveys will be conducted to gain insights on convenience and safety of the service.

![Figure 25: Smart Mobility Hubs Data Flow Diagram](Source: City of Columbus)
6.2.7. **Mobility Assistance for People with Cognitive Disabilities**

For the MAPCD project (see Figure 26), 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 26: Mobility Assistance for People with Cognitive Disabilities Data Flow Diagram](source: City of Columbus)
6.2.8. Prenatal Trip Assistance

For the PTA project (see Figure 27), 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, The Ohio State University (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 27: Prenatal Trip Assistance Data Flow Diagram

Source: City of Columbus
6.2.9. Event Parking Management

For the EPM project (see Figure 28), 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. After a reservation is requested, the CPS will review the availability of sufficient funds in Traveler account and makes the reservation. In addition to Traveler account, EPM also provides other payment options. 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 28: Event Parking Management Data Flow Diagram

Source: City of Columbus
Table 34 shows all data sources relevant to performance measures and the projects to which they apply.

### Table 34: Project Data Used for Evaluation

<table>
<thead>
<tr>
<th>Project</th>
<th>Data Source</th>
<th>Data Collected</th>
</tr>
</thead>
</table>
| 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 RSM activation  
• Travel time through the intersection (via GPS geofences)  
• Number of priority requests granted/denied |
### Project Data Collection Plan

<table>
<thead>
<tr>
<th>Project</th>
<th>Data Source</th>
<th>Data Collected</th>
</tr>
</thead>
</table>
| 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  
- Funds deposited  
- 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 |
| CPS     | CPS (archived in the Operating System) | - Number of executed transactions  
- Payment method by mode/service provider  
- Payment amount  
- Number of trips booked using CPS for payment  
- Number of travelers using CPS to pay for transportation service options  
- 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-routes 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 prenatal traveler tracks the trips in real-time  
- Number of times a third-party accesses data from Operating System (refer to Operating System project for this indicator)  
- 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  
- Number of IK-based trip-booking completions  
- Wait time of passengers at SMH  
- Number of alternative modes of transportation at any time |
## Chapter 6. Data Collection Plan

<table>
<thead>
<tr>
<th>Project</th>
<th>Data Source</th>
<th>Data Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>- Number of trips beginning or shifting modes at Hubs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of IK and Wi-Fi-based trip-planning requests/booking (mobile device)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of additional modes/services at an SMH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of emergency button calls</td>
</tr>
<tr>
<td>EPM</td>
<td>EPM (archived in the Operating System)</td>
<td>- Number of EPM users using the application to find parking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of EPM users using the application to pay for parking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of EPM users using the application to find directions to parking facility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of EPM users using the parking facilities found and/or paid for using EPM Application</td>
</tr>
<tr>
<td>CEAV</td>
<td>CEAV (archived in the Operating System)</td>
<td>- Number of passengers traveled;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of CEAV miles traveled;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of CEAV trips;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Schedule time for CEAV at stops</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Actual arrival time of CEAV at stops</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of CEAV boards and alights at stops not shared by COTA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of CEAV boards and alights at stops shared by COTA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- COTA ridership at stops shared by CEAV</td>
</tr>
</tbody>
</table>

*Source: City of Columbus*
Table 35 presents the data collected from Smart Columbus surveys for performance evaluation.

Table 35: Project Survey Data

<table>
<thead>
<tr>
<th>Project</th>
<th>Data Source</th>
<th>Data Collected</th>
</tr>
</thead>
</table>
| CEAV    | User Surveys and interviews (archived in the Operating System) | **CEAV User 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 first/last mile transportation  
  - Perceived ease of first mile and last mile travel pre- and post-CEAV  
  - Overall customer satisfaction  
  - Mode of travel before and after CEAV deployment  
  - Approximate Walking distance  
  - Positive and negative experiences  
  - Suggestions for improvement |
| CVE     | User Surveys and interviews (archived in the Operating System) | **Emergency Responder Customer Survey**  
  - Emergency response times  
  - Perceived safety improvements  
  - **RLWV 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 |
### Chapter 6. Data Collection Plan

<table>
<thead>
<tr>
<th>Project</th>
<th>Data Source</th>
<th>Data Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMTPA/CPS</td>
<td>User Surveys and interviews (archived in the Operating System)</td>
<td><strong>MMTPA/CPS User Survey</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Changes in mode choice and fare payment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Changes in trip type (single mode vs. multimode)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Increase in ridership by mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Trip frequency and time by mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Examples of opportunities opened by the MMTPA/CPS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ease of accessing jobs and services pre- and post-deployment of MMTPA/CPS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ease of participating in a multimodal planning and payment solution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Preferred transportation services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Most influential factors in choosing transportation services (cost, trip time, comfort, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Percentage of travel through MMTPA/CPS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Alternative modes of travel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Additional transportation services that customers want to include in the MMTPA/CPS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Most desired features</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Most valuable features offered</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Positive and negative experiences</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Suggestions for improvement</td>
</tr>
<tr>
<td>Project</td>
<td>Data Source</td>
<td>Data Collected</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>----------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>CPS User Survey</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Service providers where the CPS is the traveler’s preferred payment method</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Service providers where the CPS failed to work or exceeded expectations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Service providers that travelers would like to see accept the CPS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Travelers’ preferred method to add to CPS account balance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Examples of opportunities opened by CPS (i.e. places that were previously difficult to reach, or ability to reach goods and services)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Traveler’s access to other payment methods</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Perceived ease of accessing jobs and services</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Positive and negative experiences</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Suggestions for improvement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Other payment methods available to the traveler</td>
</tr>
<tr>
<td></td>
<td>User Surveys and interviews (archived in the Operating System)</td>
<td><strong>CPS Mobility Provider Survey</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Change in ridership since implementation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Change in route or service popularity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of users who have adopted/added CPS as a payment method</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Positive and negative experiences</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Suggestions for improvement</td>
</tr>
<tr>
<td>MAPCD</td>
<td></td>
<td><strong>MAPCD Participant and Caregiver Surveys</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Feeling of safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Ease of use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Perceived independence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Help button usage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Trip selection – unique trips</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Past and current frequency using paratransit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Past and current frequency using fixed-route buses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Factors in mode choice decision</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Need for a caregiver on paratransit versus fixed route</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Examples of opportunities opened by this project (places that were previously difficult to reach)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Ease of use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Changes in travel behavior</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Positive and negative experiences</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Suggestions for improvement</td>
</tr>
<tr>
<td>Project</td>
<td>Data Source</td>
<td>Data Collected</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>----------------</td>
</tr>
</tbody>
</table>
| 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)  
- 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 |
<table>
<thead>
<tr>
<th>Project</th>
<th>Data Source</th>
<th>Data Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Columbus Operating System (SCOS)</td>
<td>User Surveys and interviews (archived in the Operating System)</td>
<td><strong>Data Provider Survey (Agency and Other Providers)</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ease of data-sharing ability before and after implementation of the Operating System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Number of requests for datasets pre- and post-publishing on the Operating System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ability to ingest/harvest the data into the Operating System vs. previous data-sharing mechanisms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Provider satisfaction with method(s) of data ingestion into the Operating System</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Agency User Survey and Public Survey</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ability to access and use the data pre- and post-Operating System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Usefulness of the accessed data for intended purpose</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Number of applications, reports, analytics and visualizations created using the Operating System data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Amount of time taken to get access to data before and after implementation of the Operating System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ability to find data required by the users</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Customer Satisfaction Ratings on</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Quality, freshness, and completeness of data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Metadata quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Visualization tools/features</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Analytical tools/features</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Method(s) of data extraction from the Operating System</td>
</tr>
</tbody>
</table>

*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 (Nonproject) Data

<table>
<thead>
<tr>
<th>Project</th>
<th>Data Source</th>
<th>KPI</th>
<th>Data Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVE</td>
<td>COTA CAD/AVL</td>
<td>On-time performance; Running time; Headway reliability</td>
<td>• Scheduled arrival times at bus stops</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Time of arrival at scheduled bus stops</td>
</tr>
<tr>
<td>City of Columbus</td>
<td>Department of Public Safety EMS records</td>
<td>Emergency Response Time</td>
<td>• Emergency response times for TSP-enabled EMS vehicles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Emergency response times for EMS vehicles</td>
</tr>
<tr>
<td>NTD</td>
<td></td>
<td></td>
<td>• Unlinked passenger trips</td>
</tr>
</tbody>
</table>
# Chapter 6. Data Collection Plan

<table>
<thead>
<tr>
<th>Project</th>
<th>Data Source</th>
<th>KPI</th>
<th>Data Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMTPA/CPS and CEAV</td>
<td>COTA</td>
<td>Customer trips moved from paratransit to fixed route</td>
<td>- Total boardings&lt;br&gt;- Passenger miles traveled</td>
</tr>
<tr>
<td>MMTPA/CPS</td>
<td>COTA</td>
<td>Percentage of new transportation service users</td>
<td>- Total number of transportation service users&lt;br&gt;- Number of new transportation service user's post-deployment of MMTPA</td>
</tr>
<tr>
<td>MMTPA/CPS</td>
<td>MORPC</td>
<td>Trips booked to and from Job Centers</td>
<td>- Locations of job centers and Services</td>
</tr>
<tr>
<td>MAPCD</td>
<td>COTA paratransit program records</td>
<td>Dollars saved in paratransit program</td>
<td>- Number of paratransit rides made by pilot participants the year before implementation&lt;br&gt;- Cost of paratransit program&lt;br&gt;- Cost of mobility assistance vendor to COTA per ride</td>
</tr>
<tr>
<td>PTA</td>
<td>The Ohio State University</td>
<td>Ratio of attended prenatal appointments</td>
<td>- Average number of appointments recommended for prenatal moms&lt;br&gt;- Average number of appointments attended by prenatal moms (in the study area)&lt;br&gt;- Anticipated number of prenatal moms who will live in the project area during this pilot demonstration program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gestation details</td>
<td>- Gestational age when woman learned she was pregnant&lt;br&gt;- Gestation week of first prenatal appointment&lt;br&gt;- Gestational age at delivery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of preterm births and infant mortality rate</td>
<td>- (number of preterm births, infant mortality)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of trips taken to different destinations (by type, purpose)</td>
<td>- Number of eligible prenatal moms&lt;br&gt;- Number of trips taken by type and purpose</td>
</tr>
<tr>
<td>Vital Statistics (CDC)</td>
<td>Infant Mortality Data</td>
<td></td>
<td>- Birth data&lt;br&gt;- Period linked birth - infant death data&lt;br&gt;- Birth cohort linked birth – infant death data&lt;br&gt;- Mortality multiple cause data&lt;br&gt;- Fetal death data</td>
</tr>
</tbody>
</table>

Source: City of Columbus
Table 37 presents the data collected as part of the confounding factors.

Table 37: Confounding Factors Data

<table>
<thead>
<tr>
<th>Confounding Factor</th>
<th>Data Source</th>
<th>Data Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Prices</td>
<td>U.S. Energy Information Administration</td>
<td>• Average weekly fuel prices for different grades of petrol/gasoline and diesel</td>
</tr>
<tr>
<td>Emissions</td>
<td>• MORPC</td>
<td>• GHG emissions and Ozone emissions using MOVES model</td>
</tr>
<tr>
<td></td>
<td>• Ohio Environmental Protection Agency</td>
<td>• Emissions conversion rates from PMT</td>
</tr>
<tr>
<td></td>
<td>• U.S. Environmental Protection Agency (EPA)</td>
<td>• Emissions conversion rates from idling time</td>
</tr>
<tr>
<td>Construction Activities</td>
<td>• Paving the Way</td>
<td>• Planned and historical construction activities</td>
</tr>
<tr>
<td></td>
<td>• City of Columbus</td>
<td>• Right-of-way permits occupancy and excavation</td>
</tr>
<tr>
<td></td>
<td>• ODOT</td>
<td></td>
</tr>
<tr>
<td>Weather</td>
<td>INRIX</td>
<td>• Historical weather events that affected lane closures</td>
</tr>
<tr>
<td></td>
<td>NOAA</td>
<td>• Historical weather data including (temperature, precipitation, etc.,)</td>
</tr>
<tr>
<td>Traffic Conditions</td>
<td>INRIX</td>
<td>• Speed and travel time data for XD-level segments</td>
</tr>
<tr>
<td>Traffic Incidents</td>
<td>INRIX</td>
<td>• Historical traffic incidents that resulted in lane closures</td>
</tr>
<tr>
<td>Change in Parking Fares</td>
<td>IPS Group</td>
<td>• Location based fare schedule of City-owned Metered Parking</td>
</tr>
<tr>
<td></td>
<td>Private parking garage vendors who participate in EPM project</td>
<td>• Updates in pricing policy</td>
</tr>
<tr>
<td>New Parking Facilities</td>
<td>Private parking garage vendors that participate in EPM project</td>
<td>• Newly established parking facilities</td>
</tr>
<tr>
<td>CPASS (Local Mobility</td>
<td>COTA</td>
<td>• Daily COTA ridership of CPASS riders</td>
</tr>
<tr>
<td>Program)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planned System Outages</td>
<td>All project vendors</td>
<td>• Time windows of system outages put into effect for maintenance and updates</td>
</tr>
<tr>
<td>Paul G. Allen Electrification Project</td>
<td>Smart Columbus/HNTB</td>
<td>• Percent GHG emission reductions from baseline year</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Total GHG reductions/savings from baseline year measured in MTCO2</td>
</tr>
</tbody>
</table>

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 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” (see Appendix D. National Institute of Standards and Technology Special Publication 800-122 Checklist Summary). 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.

 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

<table>
<thead>
<tr>
<th>Machine-Readable</th>
<th>Non-Machine-Readable</th>
</tr>
</thead>
<tbody>
<tr>
<td>JSON</td>
<td>PDF</td>
</tr>
<tr>
<td>XML</td>
<td>JPG</td>
</tr>
<tr>
<td>CSV</td>
<td>TIFF</td>
</tr>
<tr>
<td>RDF</td>
<td>MP4</td>
</tr>
<tr>
<td></td>
<td>WAV</td>
</tr>
</tbody>
</table>

*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.

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, 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
- 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 eventually 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 Personally Identifiable Information provides more information about policies regarding PII.

Public data that has been vetted through the Operating System project team and undergone 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 the project and evaluation data without PII will be routed to the USDOT’s ITS Public Data Hub. Similarly, any raw/PII containing data required for the evaluation will be routed to the Secure Data Commons (SDC) directly from the data source. The SDC offers capability to control access to the respective datasets. Designated USDOT representatives and IEs will be provided access to SDC datasets, as required for their evaluation of the Smart Columbus Program.

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 they subscribed to. 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.
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, the IE, and the USDOT will coordinate regularly. When there is a question regarding the status of a project, the USDOT may request an informal evaluation in which the City provides the most recent, relevant data and the IE describes the current state of operation. After an informal review or formal report, projects may be adjusted to improve performance. This includes modification, addition, or refinement of the implemented technology, and will be described in subsequent reports.

In addition to summarizing performance measurement results, the Smart Columbus team will also respond as required to the USDOT’s Survey on Deployment Tracking.¹⁹ 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.

¹⁹ http://www.itsdeployment.its.dot.gov/
Chapter 9. Support for the Independent Evaluation Effort

This PfMP was developed by the City of Columbus in coordination with the USDOT; however, a USDOT-selected IE will conduct an independent evaluation using data collected, curated, and provided by the City of Columbus through coordination with partner agencies. Having an IE evaluate the program adds confidence that bias has been minimized in the evaluation process.

The USDOT and IE will have access to the performance measurement data through the USDOT’s ITS Public Data Hub platform (if data is open data) and Secure Data Commons platform (if data contains PII). The Operating System team will coordinate with both the USDOT’s data platforms to setup the data harvesting pipeline. Any sensitive data containing PII will be directly harvested from the data source to the SDC platform. The City commits to cooperation and partnership with the IE, providing the data they need to complete their analysis if available. Fair and accurate performance measurement benefits all agencies involved as well as the public.

The City will also provide the IE access to field locations to inspect and review deployed technology and the facilities they serve.

Additional detail describing interactions and responsibilities with the IE will be included in the Independent Evaluation Support Plan that will be developed by the Smart Columbus team. This plan will be prepared based on the Evaluation Plan submitted by the IEs.
Chapter 10. 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 IE will carry out the analyses described herein considering the full context of Smart Columbus. Performance measurement will be further defined by the IE, which will carry out the evaluation. 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 39: Acronym List contains project-specific acronyms used throughout this document.

Table 39: Acronym List

<table>
<thead>
<tr>
<th>Abbreviation/Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AADT</td>
<td>Annual Average Daily Traffic</td>
</tr>
<tr>
<td>ADA</td>
<td>Americans with Disabilities Act</td>
</tr>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>ASP</td>
<td>Application Service Provider</td>
</tr>
<tr>
<td>AV</td>
<td>Autonomous Vehicle</td>
</tr>
<tr>
<td>AVL</td>
<td>Automatic Vehicle Location</td>
</tr>
<tr>
<td>BRT</td>
<td>Bus Rapid Transit</td>
</tr>
<tr>
<td>BSM</td>
<td>Basic Safety Message</td>
</tr>
<tr>
<td>CABS</td>
<td>Campus Area Bus System</td>
</tr>
<tr>
<td>CAD</td>
<td>Computer-aided Dispatch</td>
</tr>
<tr>
<td>CCTN</td>
<td>Columbus Connected Transportation Network</td>
</tr>
<tr>
<td>CEAV</td>
<td>Connected Electric Autonomous Vehicle</td>
</tr>
<tr>
<td>CMAX</td>
<td>Brand for COTA Cleveland Avenue Bus Rapid Transit</td>
</tr>
<tr>
<td>CMS</td>
<td>Collision Mitigation System</td>
</tr>
<tr>
<td>ConOps</td>
<td>Concept of Operations</td>
</tr>
<tr>
<td>CORS</td>
<td>Continuously Operating Reference Station</td>
</tr>
<tr>
<td>COTA</td>
<td>Central Ohio Transit Authority</td>
</tr>
<tr>
<td>C-Pass</td>
<td>COTA Pass</td>
</tr>
<tr>
<td>CPH</td>
<td>Columbus Public Health</td>
</tr>
<tr>
<td>CPS</td>
<td>Common Payment System</td>
</tr>
<tr>
<td>CSCC</td>
<td>Columbus State Community College</td>
</tr>
<tr>
<td>CTSS</td>
<td>Columbus Traffic Signal System</td>
</tr>
<tr>
<td>CV</td>
<td>Connected Vehicle</td>
</tr>
<tr>
<td>CVE</td>
<td>Connected Vehicle Environment</td>
</tr>
<tr>
<td>DMP</td>
<td>Data Management Plan</td>
</tr>
<tr>
<td>DPP</td>
<td>Data Privacy Plan</td>
</tr>
<tr>
<td>DSRC</td>
<td>Dedicated Short Range Communications</td>
</tr>
<tr>
<td>DVI</td>
<td>Driver-Vehicle Interface</td>
</tr>
<tr>
<td>Abbreviation/Acronym</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------</td>
</tr>
<tr>
<td>EHS</td>
<td>Enhanced Human Services</td>
</tr>
<tr>
<td>EMS</td>
<td>Emergency Medical Service</td>
</tr>
<tr>
<td>EPM</td>
<td>Event Parking Management</td>
</tr>
<tr>
<td>EV</td>
<td>Electric Vehicle</td>
</tr>
<tr>
<td>EVP</td>
<td>Emergency Vehicle Preemption</td>
</tr>
<tr>
<td>FHWA</td>
<td>Federal Highway Administration</td>
</tr>
<tr>
<td>FMLM</td>
<td>First Mile/Last Mile</td>
</tr>
<tr>
<td>FSP</td>
<td>Freight Signal Priority</td>
</tr>
<tr>
<td>GhG</td>
<td>Greenhouse Gas</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>HDV</td>
<td>Heavy-Duty Vehicle</td>
</tr>
<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
</tr>
<tr>
<td>IE</td>
<td>Independent Evaluator</td>
</tr>
<tr>
<td>IESP</td>
<td>Independent Evaluation Support Plan</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Provider</td>
</tr>
<tr>
<td>IRB</td>
<td>Institutional Review Board</td>
</tr>
<tr>
<td>ITS</td>
<td>Intelligent Transportation Systems</td>
</tr>
<tr>
<td>LED</td>
<td>Light-Emitting Diode</td>
</tr>
<tr>
<td>MAASTO</td>
<td>Mid America Association of State Transportation Officials</td>
</tr>
<tr>
<td>MAP</td>
<td>Intersection Geometry Message</td>
</tr>
<tr>
<td>MAPCD</td>
<td>Mobility Assistance for People with Cognitive Disabilities</td>
</tr>
<tr>
<td>MCO</td>
<td>Managed-Care Organization</td>
</tr>
<tr>
<td>MMITSS</td>
<td>Multimodal Intelligent Traffic Signal System</td>
</tr>
<tr>
<td>MMTPA</td>
<td>Multimodal Trip Planning Application</td>
</tr>
<tr>
<td>MORPC</td>
<td>Mid-Ohio Regional Planning Commission</td>
</tr>
<tr>
<td>MOVES</td>
<td>MOtor Vehicle Emission Simulator</td>
</tr>
<tr>
<td>NEMA</td>
<td>National Electrical Manufacturers Association</td>
</tr>
<tr>
<td>NEMT</td>
<td>Non-emergency Medical Transportation</td>
</tr>
<tr>
<td>NHTSA</td>
<td>National Highway Traffic Safety Administration</td>
</tr>
<tr>
<td>NIST</td>
<td>National Institute of Standards and Technology</td>
</tr>
<tr>
<td>NOC</td>
<td>Network Operations Center</td>
</tr>
<tr>
<td>NOFO</td>
<td>Notice of Funding Opportunity</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Operations and Maintenance</td>
</tr>
<tr>
<td>OBE</td>
<td>Onboard Equipment (many or all onboard devices)</td>
</tr>
<tr>
<td>Abbreviation/Acronym</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------</td>
</tr>
<tr>
<td>OBU</td>
<td>Onboard Unit (one onboard device)</td>
</tr>
<tr>
<td>ODM</td>
<td>Ohio Department of Medicaid</td>
</tr>
<tr>
<td>ODOT</td>
<td>Ohio Department of Transportation</td>
</tr>
<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
</tr>
<tr>
<td>OSADP</td>
<td>Open-Source Application Data Portal</td>
</tr>
<tr>
<td>OSU</td>
<td>Ohio State University</td>
</tr>
<tr>
<td>PDE</td>
<td>Pedestrian Detection Equipment</td>
</tr>
<tr>
<td>PEO</td>
<td>Parking Enforcement Officer</td>
</tr>
<tr>
<td>PfMP</td>
<td>Performance Measurement Plan</td>
</tr>
<tr>
<td>PIECE</td>
<td>Prevocational Integrated Education and Campus Experience</td>
</tr>
<tr>
<td>PII</td>
<td>Personally Identifiable Information</td>
</tr>
<tr>
<td>PMT</td>
<td>Personal Miles Traveled</td>
</tr>
<tr>
<td>PSCW</td>
<td>Pedestrian in Signalized Crosswalk Warning</td>
</tr>
<tr>
<td>PSS</td>
<td>Power and Sample Size</td>
</tr>
<tr>
<td>PTA</td>
<td>Prenatal Trip Assistance</td>
</tr>
<tr>
<td>RSE</td>
<td>Roadside Equipment (generic)</td>
</tr>
<tr>
<td>RDE</td>
<td>Research Data Exchange</td>
</tr>
<tr>
<td>RFID</td>
<td>Radio Frequency Identification</td>
</tr>
<tr>
<td>RFQ</td>
<td>Request for Quote</td>
</tr>
<tr>
<td>RLVW</td>
<td>Red Light Violation Warning</td>
</tr>
<tr>
<td>ROI</td>
<td>Return on Investment</td>
</tr>
<tr>
<td>RSSZ</td>
<td>Reduced Speed School Zone</td>
</tr>
<tr>
<td>RSU</td>
<td>Roadside Unit (DSRC)</td>
</tr>
<tr>
<td>RTCM</td>
<td>Radio Technical Commission for Maritime</td>
</tr>
<tr>
<td>SCC</td>
<td>Smart City Challenge</td>
</tr>
<tr>
<td>SEMP</td>
<td>Systems Engineering Management Plan</td>
</tr>
<tr>
<td>SFTP</td>
<td>Secure File Transfer Protocol</td>
</tr>
<tr>
<td>SMH</td>
<td>Smart Mobility Hub</td>
</tr>
<tr>
<td>SOV</td>
<td>Single Occupancy Vehicle</td>
</tr>
<tr>
<td>SPaT</td>
<td>Signal Phase and Timing</td>
</tr>
<tr>
<td>SPII</td>
<td>Sensitive Personally Identifiable Information</td>
</tr>
<tr>
<td>SSM</td>
<td>Signal Status Message</td>
</tr>
<tr>
<td>TNC</td>
<td>Transportation Network Company</td>
</tr>
<tr>
<td>TP</td>
<td>Truck Platooning</td>
</tr>
</tbody>
</table>
### Appendix A. Acronyms and Definitions

<table>
<thead>
<tr>
<th>Abbreviation/Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPI</td>
<td>Transit Pedestrian Indication</td>
</tr>
<tr>
<td>TSC</td>
<td>Traffic Signal Controller</td>
</tr>
<tr>
<td>TSP</td>
<td>Transit Signal Priority</td>
</tr>
<tr>
<td>UI</td>
<td>User Interface</td>
</tr>
<tr>
<td>USDOE</td>
<td>United States Department of Energy</td>
</tr>
<tr>
<td>USDOT</td>
<td>United States Department of Transportation</td>
</tr>
<tr>
<td>V2I</td>
<td>Vehicle-to-Infrastructure</td>
</tr>
<tr>
<td>V2V</td>
<td>Vehicle-to-Vehicle</td>
</tr>
</tbody>
</table>

*Source: City of Columbus*
Appendix B. Performance Measures Matrix
### Appendix B. Performance Measures Matrix

<table>
<thead>
<tr>
<th>Objective</th>
<th>Methodology</th>
<th>Hypothesis</th>
<th>Indicator</th>
<th>Data Source</th>
<th>Baseline</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce vehicle emissions</td>
<td>Pre/post trend analysis; Pre/post quasi experimental design</td>
<td>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 vehicle related emissions.</td>
<td>Total 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</td>
<td>Operating System</td>
<td>Two years pre-implementation</td>
<td>From the start of first portfolio project (4/29/2019) until the end of period of performance of last portfolio project (3/31/2021)</td>
</tr>
<tr>
<td>Reduce traffic congestion</td>
<td>Pre/post trend analysis; Pre/post quasi experimental design</td>
<td>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.</td>
<td>Travel time and delay; Daily volumes; Perceived reduction in travel time to find a parking spot; Perceived overall congestion</td>
<td>Operating System</td>
<td>Two years pre-implementation</td>
<td>From the start of first portfolio project (4/29/2019) until the end of period of performance of last portfolio project (3/31/2021)</td>
</tr>
<tr>
<td>Improve commuting opportunities to jobs and services</td>
<td>Pre/Post quasi experimental design</td>
<td>Through implementation of multiple portfolio projects, Smart Columbus Program will improve traveling opportunities for Columbus region residents to their jobs and services.</td>
<td>Perceived ease of trip planning to jobs and services; Perceived ease of multimodal transfers; Perceived ease of FMLM travel</td>
<td>Operating System</td>
<td>Two years pre-implementation</td>
<td>From the start of first portfolio project (4/29/2019) until the end of period of performance of last portfolio project (3/31/2021)</td>
</tr>
<tr>
<td>Provide useful data</td>
<td>Pre/post quasi experimental design; Post-only trend analysis</td>
<td>The Operating System will provide useful data to public agencies, evaluators, and developers through an open data portal.</td>
<td>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</td>
<td>Operating System</td>
<td>Two years before implementation of the Operating System Data Platform 2.0; N/A</td>
<td>From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (04/22/19 – 03/31/21)</td>
</tr>
<tr>
<td>Provide improved data sharing method</td>
<td>Pre/post quasi experimental design; Pre/post quasi experimental design; Post-only trend analysis</td>
<td>The Operating System will enhance the ease of data sharing through the Open Data Portal</td>
<td>Ease of data sharing ability; Number of requests for datasets; Amount of time taken to get access to data; Number and frequency of data retrievals from the Operating System</td>
<td>Operating System</td>
<td>Two years before implementation of the Operating System Data Platform 2.0; N/A</td>
<td>From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (04/22/19 – 03/31/21)</td>
</tr>
<tr>
<td>Provide easily discoverable data</td>
<td>Post-only trend analysis; Pre/post trend analysis</td>
<td>The Operating System will provide users with data in an easily discoverable manner</td>
<td>Ability to find data intended by the users; Number of requests for datasets</td>
<td>Operating System</td>
<td>Two years before implementation of the Operating System Data Platform 2.0; N/A</td>
<td>From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (04/22/19 – 03/31/21)</td>
</tr>
<tr>
<td>Provide an easily accessible data exchange to providers and consumers of data.</td>
<td>Post-only trend analysis; Pre/post trend analysis</td>
<td>The Operating System will provide an easily accessible data exchange for all users of both internal and external applications.</td>
<td>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</td>
<td>Operating System</td>
<td>Two years before implementation of the Operating System Data Platform 2.0; N/A</td>
<td>From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (04/22/19 – 03/31/21)</td>
</tr>
<tr>
<td>Provide easily discoverable data</td>
<td>Post-only trend analysis; Pre/post quasi experimental design; Pre/post trend analysis</td>
<td>The Operating System will provide open data to the users in an easily discoverable fashion.</td>
<td>Time spent on the Operating System; Time spent on discovery of dataset(s); Ability to find the required/intended data</td>
<td>Operating System</td>
<td>N/A</td>
<td>From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (04/22/19 – 03/31/21)</td>
</tr>
</tbody>
</table>
### Appendix B. Performance Measures Matrix

<table>
<thead>
<tr>
<th>Objective</th>
<th>Methodology</th>
<th>Hypothesis</th>
<th>Indicator</th>
<th>Data Source</th>
<th>Baseline</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Establish and enhance the customer satisfaction with the Operating System</strong></td>
<td>Post-only trend analysis</td>
<td>The Operating System will ensure the satisfaction of its customers (public, agency staff and developers) by providing and enhancing data, visualization, and analytical features through an open data portal.</td>
<td>Customer satisfaction ratings for: - Quality, freshness and completeness of data; - Metadata quality; - Visualization tools/features; - Analytical tools/features; - Method(s) of data ingestion; - Method(s) of data extraction.</td>
<td>Operating System</td>
<td>Post-only Non-Experimental Design</td>
<td>From the implementation of the Operating System Data Platform 2.0 until the period of implementation of last portfolio project (04/22/19 – 03/31/21)</td>
</tr>
<tr>
<td><strong>Reduce emergency response times in CVE corridor</strong></td>
<td>Pre/post trend analysis;</td>
<td>The Emergency Vehicle Preemption application will improve emergency response times by reducing delay at signalized intersections with DSRC.</td>
<td>Emergency response times</td>
<td>City of Columbus Department of Public Safety EMS records; CVE Data via Operating System</td>
<td>Nine month period starting one year prior to implementation</td>
<td>Nine months post-implementation</td>
</tr>
<tr>
<td><strong>Increase driver's awareness of signal status</strong></td>
<td>Pre/post trend analysis</td>
<td>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 CV corridor.</td>
<td>Driver's awareness of traffic signal status</td>
<td>Operating System; Comparison of vehicle situation data received at RSU to traffic signal phase and timing data</td>
<td>0-3 months after deployment</td>
<td>Six months post implementation. With timeframe starting 3 months after deployment</td>
</tr>
<tr>
<td><strong>Increase driver's awareness of speed limits in school zones</strong></td>
<td>Pre/post trend analysis</td>
<td>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.</td>
<td>Driver's awareness of speed in school zones</td>
<td>Operating System; Comparison of vehicle situation data received at RSU to school zone active indications</td>
<td>0-3 months after deployment</td>
<td>Nine months post implementation. With timeframe is 3-9 months after deployment</td>
</tr>
<tr>
<td><strong>Demonstrate DSRC technology for TSP application</strong></td>
<td>Post-only quasi experimental design</td>
<td>DSRC based TSP application will perform at the same level as Opticom based TSP application.</td>
<td>Time of priority request</td>
<td>COTA CAD/AVL data</td>
<td>One year prior to implementation</td>
<td>Nine (9) months post-implementation (Collected and checked monthly)</td>
</tr>
<tr>
<td><strong>Reduce truck wait (delay) time at signalized intersections</strong></td>
<td>Pre/post trend analysis</td>
<td>The Freight Signal Priority will save travel time for trucks passing through equipped intersections by modifying signal timing.</td>
<td>Travel time through intersection</td>
<td>Operating System</td>
<td>Six months following deployment before implementation</td>
<td>Nine months post-implementation</td>
</tr>
<tr>
<td><strong>Provide a single point of access to multimodal trip planning information to plan, book, and pay for a multimodal trip</strong></td>
<td>Pre/post quasi experimental design</td>
<td>The MMTPA will encourage travelers to take multimodal trips in central Ohio by providing a comprehensive multimodal planning/booking/payment tool.</td>
<td>Perceived improvement in access to multimodal trip planning and payment</td>
<td>Customer surveys</td>
<td>During recruiting process</td>
<td>One-year post-implementation</td>
</tr>
<tr>
<td><strong>Facilitate access to jobs and services</strong></td>
<td>Pre/post quasi experimental design</td>
<td>MMTPA/CPS will provide better access to jobs and services by enabling travelers to use mobility services that were previously either unavailable to them or that they were unaware of.</td>
<td>Perceived ease of accessing jobs and services</td>
<td>Customer surveys</td>
<td>During recruiting process</td>
<td>One-year post-implementation</td>
</tr>
<tr>
<td><strong>Improve customer satisfaction</strong></td>
<td>Pre/post quasi experimental design; Post-only trend analysis;</td>
<td>MMTPA/CPS will improve customer satisfaction by providing a comprehensive multimodal planning/booking/payment tool.</td>
<td>Customer satisfaction ratings; MMTPA/CPS application ratings; Perceived ease of participating in a multimodal planning and payment solution</td>
<td>Customer Surveys; Mobility provider interviews; MMTPA/CPS; Customer Surveys</td>
<td>During recruiting process; N/A</td>
<td>One-year post-implementation</td>
</tr>
<tr>
<td>Objective</td>
<td>Methodology</td>
<td>Hypothesis</td>
<td>Indicator</td>
<td>Data Source</td>
<td>Baseline</td>
<td>Treatment</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
<td>------------</td>
<td>-----------</td>
<td>-------------</td>
<td>----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Improved access and use of COTA fixed route bus service for MAPCD participants</td>
<td>Pre/post trend analysis; Post-only trend analysis; Post-only trend analysis</td>
<td>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.</td>
<td>Customer trips moved from paratransit to fixed route; Overall number of trips taken; Perceived independence; Ease of Use</td>
<td>COTA; MAPCD Vendor; Operating System; MAPCD User and Caregiver Survey (every 3 months)</td>
<td>One-year prior to implementation; During recruiting process</td>
<td>One-year post-implementation</td>
</tr>
<tr>
<td>Improve independence of MAPCD participants by using fixed route service</td>
<td>Post-only trend analysis; Post-only trend analysis</td>
<td>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.</td>
<td>Perceived independence; MAPCD Participant and Caregiver experience</td>
<td>COTA; MAPCD Vendor; Operating System; MAPCD User and Caregiver Survey (every 3 months)</td>
<td>During selection process</td>
<td>One year post-implementation</td>
</tr>
<tr>
<td>Reduce COTA expenditures</td>
<td>Pre/post trend analysis</td>
<td>The MAPCD application will reduce COTA operating expenses by moving passengers from paratransit service to fixed route bus service.</td>
<td>Dollars saved in paratransit program</td>
<td>COTA; MAPCD Vendor</td>
<td>One-year prior to implementation</td>
<td>One year post-implementation</td>
</tr>
<tr>
<td>Examine pregnant women’s improved access to NEMT trip in those assigned to PTA project compared to those assigned to usual transportation services.</td>
<td>Post-only randomized experiment</td>
<td>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 pre-term delivery.</td>
<td>Number of NEMT trips taken (by type, purpose); Ratio of attended prenatal appointments to recommended (Kotelchuck Index)</td>
<td>ODH birth records; Survey data; PTA Vendor; MCOs</td>
<td>During selection process</td>
<td>Throughout pregnancy to 8 weeks after delivery</td>
</tr>
<tr>
<td>Increase usage of the NEMT benefits</td>
<td>Post-only randomized experiment</td>
<td>Women in the intervention group will take more NEMT trips than women in the “usual care” group.</td>
<td>Number of NEMT trips taken (by type and purpose)</td>
<td>PTA Vendor; MCOs</td>
<td>During selection process</td>
<td>Throughout pregnancy to 8 weeks after delivery</td>
</tr>
<tr>
<td>Improve customer satisfaction</td>
<td>Post-only randomized experiment</td>
<td>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.</td>
<td>Customer satisfaction rating</td>
<td>Surveys</td>
<td>During selection process</td>
<td>Throughout pregnancy to 8 weeks after delivery</td>
</tr>
<tr>
<td>Provide physical access to multimodal trip planning and payment options.</td>
<td>Post-only trend analysis; Post-only trend analysis</td>
<td>SMHs facilitate multimodal trips by allowing travelers to use kiosks and Wi-Fi to access the MMTPA/CPS application and by consolidating multiple modes of transportation at a single location.</td>
<td>Number of trip planning requests /bookings at SMH; Application usage (MMTPA/CPS: number of multimodal trips, number of multimodal trips planned at a kiosk)</td>
<td>MMTPA; CPS; Operating System; W-KCMS</td>
<td>N/A</td>
<td>One-year post-implementation</td>
</tr>
<tr>
<td>Improve customer satisfaction</td>
<td>Post-only trend analysis</td>
<td>SMH facilities with easy and convenient access to enhanced trip planning, multimodal options, Wi-Fi-access, and emergency call button will improve customer satisfaction.</td>
<td>Customer satisfaction rating; Ease of kiosk Usefulness Accessibility Feeling of perceived safety</td>
<td>Customer survey</td>
<td>N/A</td>
<td>One-year post-implementation</td>
</tr>
<tr>
<td>Increase knowledge of available parking in the downtown area and Short North during events.</td>
<td>Pre/post quasi experimental design</td>
<td>Users of EPM app will have increased knowledge of available parking in the downtown area and Short North during events.</td>
<td>Knowledge of available parking</td>
<td>Survey</td>
<td>One-year prior to implementation</td>
<td>One-year post-implementation</td>
</tr>
<tr>
<td>Provide convenient, reliable FMLM transit option</td>
<td>Pre/post trend analysis; Pre/post trend analysis; Pre/post quasi experimental design</td>
<td>CEAV will increase the number of convenient, reliable first mile/last mile trips in the deployment area by providing an autonomous shuttle service, which will reduce walking distances to destinations.</td>
<td>CEAV passenger trips; Walking distance; Perceived convenience; Perceived reliability; Perceived improvement in FMLM transit</td>
<td>CEAV Vendor; Operating System; Customer Survey</td>
<td>N/A</td>
<td>One-year pre-implementation</td>
</tr>
</tbody>
</table>
## Appendix B. Performance Measures Matrix

<table>
<thead>
<tr>
<th>Objective</th>
<th>Methodology</th>
<th>Hypothesis</th>
<th>Indicator</th>
<th>Data Source</th>
<th>Baseline</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEAV</td>
<td>Pre/post trend analysis; Post only trend analysis; Pre/post quasi experimental design</td>
<td>Providing complementary service to COTA will increase access to jobs and services for underserved communities.</td>
<td>COTA ridership at stations with CEAV; increment in mode shift</td>
<td>COTA; Operating System; Customer Survey</td>
<td>One-year prior to implementation</td>
<td>End of demonstration period</td>
</tr>
<tr>
<td></td>
<td>CEAV will improve the user experience by reducing walking distance and providing on-time service.</td>
<td>CEAV on-time performance; Walking distance; Perceived convenience; Perceived reliability</td>
<td>CEAV Vendor; Operating System; Survey</td>
<td>N/A; One-year pre-implementation</td>
<td>End of demonstration period</td>
<td></td>
</tr>
</tbody>
</table>

CEAV

Pre/post trend analysis; Post only trend analysis; Pre/post quasi experimental design

Providing complementary service to COTA will increase access to jobs and services for underserved communities.

COTA ridership at stations with CEAV; increment in mode shift

COTA; Operating System; Customer Survey

One-year prior to implementation

End of demonstration period

Pre/post trend analysis; Post only trend analysis; Pre/post quasi experimental design

Providing complementary service to COTA will increase access to jobs and services for underserved communities.

COTA ridership at stations with CEAV; increment in mode shift

COTA; Operating System; Customer Survey

One-year prior to implementation

End of demonstration period

Pre/post trend analysis; Post only trend analysis; Pre/post quasi experimental design

Providing complementary service to COTA will increase access to jobs and services for underserved communities.

COTA ridership at stations with CEAV; increment in mode shift

COTA; Operating System; Customer Survey

One-year prior to implementation

End of demonstration period

Pre/post trend analysis; Post only trend analysis; Pre/post quasi experimental design

Providing complementary service to COTA will increase access to jobs and services for underserved communities.

COTA ridership at stations with CEAV; increment in mode shift

COTA; Operating System; Customer Survey

One-year prior to implementation

End of demonstration period
Appendix C. MAPCD Survey Questionnaire

C.1 MAPCD FOCUS GROUP QUESTIONNAIRE

C.2 MAPCD TASK ANALYSIS ASSESSMENT
Appendix C1: MAPCD 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?

TRANSITION:
- 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?
Appendix C2: Task Analysis Assessment of WayFinder App

<table>
<thead>
<tr>
<th>Name of Participant:</th>
<th>Name of Researcher:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of Route:</td>
<td>Name of Community Specialist:</td>
</tr>
<tr>
<td>Route Taken (circle all that apply):</td>
<td>Walking</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>While using the WayFinder app, what was the challenge level of:</th>
<th>Indirect Verbal Guidance</th>
<th>Gestural Cues</th>
<th>Direct Verbal Assistance</th>
<th>Physical Assistance</th>
<th>Do for Participant</th>
<th>Total Number of Cues</th>
<th>Level of Independ.</th>
<th>Additional Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressing the power button</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unlocking the screen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locating the App</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening the App</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selecting the correct route</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening the correct route</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tapping “Start” button</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressing the “Ok” button at correct time</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tapping the screen to repeat instructions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assistance with</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Scoring Key

**Cueing Definitions:** **provide two of each cue before moving to the next level; always restart cues back at Level 1 when moving onto the next task**

**Level 1: Indirect Verbal Guidance**: cues that do not tell the participant exactly what to do but hint that they are missing a step ex: “Are you forgetting something?”

**Level 2: Gestural Cues**: using gestures without any verbal prompts to assist in step ex: pointing

**Level 3: Direct Verbal Assistance**: one simple command telling them what to do

**Level 4: Physical Assistance**: hand over hand assistance but participant is still involved

**Level 5: Do for Participant**: participant not involved in completing step

**Level of Independence:**

- **Independent/Modified Independent**: 0 cues
- **Minimal Assistance**: 1-2 cues
- **Moderate Assistance**: 3-4 cues
- **Maximum Assistance**: 4-5 cues
- **Dependent**: 6 or more cues required

---

Appendix D. PTA Survey Questionnaire

D.1 PTA SCREENING QUESTIONNAIRE
D.2 PTA BASELINE QUESTIONNAIRE
D.3 PTA FINAL QUESTIONNAIRE
D.4 PTA FOLLOW UP QUESTIONNAIRE
D.5 PTA RANDOMIZED TRIAL PROTOCOL
Rides4Baby Screening Questionnaire

We will need to ask you a few questions to determine if you are eligible to participate in the Rides4Baby study.

1. Are you currently pregnant?
   0  No
   1  Yes

   98  Don’t know
   99  Refused

2. How many weeks pregnant are you?
   __________ weeks  [Skip to question 4]

   98  Don’t know  [Continue]
   99  Refused  [Continue]

3. 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.

   _____/_____/_____

   98  Don’t know
   99  Refused

4. Do you currently have health insurance?
   0  No  [Skip to question 6]
   1  Yes  [Continue]

   98  Don’t know  [Skip to question 6]
   99  Refused  [Skip to question 6]
5. What kind of insurance do you currently have? [Read responses.]

<table>
<thead>
<tr>
<th></th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CareSource</td>
</tr>
<tr>
<td>2</td>
<td>Molina</td>
</tr>
<tr>
<td>3</td>
<td>Buckeye Community Health</td>
</tr>
<tr>
<td>4</td>
<td>United Healthcare</td>
</tr>
<tr>
<td>5</td>
<td>Paramount Advantage</td>
</tr>
<tr>
<td>6</td>
<td>Ohio Medicaid (fee for service plan)</td>
</tr>
<tr>
<td>7</td>
<td>Private health insurance</td>
</tr>
<tr>
<td>8</td>
<td>Other health insurance (Specify: _______________________________ )</td>
</tr>
<tr>
<td>98</td>
<td>Don’t know</td>
</tr>
<tr>
<td>99</td>
<td>Refused</td>
</tr>
</tbody>
</table>

6. Do you need help with transportation to the doctor or other healthcare provider?

<table>
<thead>
<tr>
<th></th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>98</td>
<td>Don’t know</td>
</tr>
<tr>
<td>99</td>
<td>Refused</td>
</tr>
</tbody>
</table>

7. Do you have any mobility challenges? For instance, are you in a wheelchair or do you have difficulty getting in or out of a car by yourself?

<table>
<thead>
<tr>
<th></th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>Yes, in a wheelchair</td>
</tr>
<tr>
<td>2</td>
<td>Yes, other mobility impairment</td>
</tr>
<tr>
<td>98</td>
<td>Don’t know</td>
</tr>
<tr>
<td>99</td>
<td>Refused</td>
</tr>
</tbody>
</table>

8. Do you plan to move out of Franklin County before you deliver your baby?

<table>
<thead>
<tr>
<th></th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>98</td>
<td>Don’t know</td>
</tr>
<tr>
<td>99</td>
<td>Refused</td>
</tr>
</tbody>
</table>
9. In what zip code do you currently live?

_________ Write in zip code

[Auto-code zip code.]

1 43203, 43205 (Near East)
2 43204 (Hilltop)
3 43206, 43207 (South)
4 43211 (Linden)
5 43219, 43224, 43229 (North)
6 43222, 43223 (Franklinton)
8 43227, 43232 (Southeast)
9 Other zip code

98 Don’t know
99 Refused

10. How old are you?

_____ years

98 Don’t know
99 Refused

11. What is your race? Please tell me all that apply. [Read responses.]

1 White
2 Black
3 Asian
4 Native Hawaiian or other Pacific Islander
5 Native American or Alaskan Native
6 Other (specify: ______________________)

98 Don’t know
99 Refused

12. Are you Hispanic or Latina?

0 No
1 Yes

98 Don’t know
99 Refused
13. Can you read and understand English?

0   No
1   Yes

98  Don’t know
99  Refused

14. [Interviewer Assessment.]

Did the potential participant have difficulty communicating in English?

0   No
1   Yes

[Eligibility will be automatically assessed by the system.]

[If NOT eligible.] Thank you for taking the time to answer my questions. Unfortunately, you are not eligible to participate in this project.

[If eligible, continue.]

16. Congratulations! You’re eligible to participate in Rides4Baby! Are you interested in enrolling in the project?

0   No   [Continue]
1   Yes  [Skip to question 18]

17. No problem. Would you please tell me why you aren’t interested in participating?

1   No time
2   Just not interested
3   Other (specify: ________________)

98  Don’t know
99  Refused

Thank you for your time and interest in the program.
Okay, great! To continue with the enrollment process, I will need some additional information.

What is your current legal name?

First: ____________________________

Middle: ____________________________ □ Does not have a middle name

Last: ____________________________

Do you have a nickname that you’d like us to use?

0 No
1 Yes (Specify: ____________________)

The next step in the enrollment process is for one of our team members to come and meet with you to complete a brief interview. Is that okay with you?

0 No [Continue]
1 Yes [Skip to question 22]

Would you please tell me why you aren’t interested in meeting with one of our team members?

1 No time
2 Don’t meet people that I don’t know
3 No childcare
4 No transportation
5 Other (Specify: ____________________)

Thank you for your time and interest in the program.

[Use calendar to schedule appointment for interview.]

Interview location:

1 Main Library (96 S. Grant Avenue)
2 Martin Luther King Branch (1467 E. Long Street)
3 Franklinton Branch (1061 W. Town Street)
4 Hilltop Branch (511 S. Hague Street)
5 Linden Branch (2223 Cleveland Avenue)
6 Karl Road Branch (5590 Karl Road)
7 Northside Branch (1423 N. High Street)
23. What day and time would work best for you?

Date: _____/_____/_____
Time: ________ AM/PM

[If potential participant suggests date more than 10 days out, let her know that we must schedule the interview within the next 10 days.]

24. What would be the best number to call if we need to talk to you before our meeting?

Phone number: _____ - _____ - ________

25. Can we text you at the number as well?

0 No
1 Yes

Great! I look forward to seeing you on (date). Please bring your Medicaid card with you.

If you have any questions, please call us back. My name is [INSERT FIRST NAME] and I can be reached at 614-293-R4BB.
Rides4Baby Baseline Questionnaire

The purpose of this interview is to help us learn more about you as you begin the Rides4Baby study. The information that you give us will not be shared with anyone else. 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

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?

<table>
<thead>
<tr>
<th>Condition</th>
<th>Ever diagnosed?</th>
<th>Currently being treated?</th>
</tr>
</thead>
<tbody>
<tr>
<td>High blood pressure</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Asthma</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Thyroid disease</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Heart disease</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Kidney disease</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Hepatitis B</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Hepatitis C</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>HIV/AIDS</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Depression</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Anxiety</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Bipolar disorder</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Post-traumatic stress disorder</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Borderline personality disorder</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Other mental health disorder</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Developmental disability</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Lupus</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Seizure disorder | Yes | Yes  
Sickle cell disease | Yes | Yes  
Sickle cell trait | Yes | Yes  
Cancer; what kind(s)? | Yes | Yes  

3. How tall are you without shoes?  
   ________ feet _________ inches  

4. How much did you weigh just before you became pregnant?  
   __________________ pounds  

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  

6. Are you blind, or do you have serious difficulty seeing, even when wearing glasses?  
   0  No  
   1  Yes  

7. Because of a physical, mental, or emotional condition, do you have serious difficulty concentrating, remembering, or making decisions?  
   0  No  
   1  Yes  

8. Do you have serious difficulty walking or climbing stairs?  
   0  No  
   1  Yes  

9. Do you have difficulty dressing or bathing?  
   0  No  
   1  Yes
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

**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

[If 11="1" then skip to question 16.]

12. How many live births have you had?

______________ live births

13. In what year did you have your first live birth?

______________ (enter 4-digit year, like 2013)

14. How many of your babies were born preterm (before 37 weeks of gestation)? The average pregnancy lasts 40 weeks.

______________ preterm births

15. Were you prescribed progesterone, either shots or vaginal inserts, during a previous pregnancy?

0  No  
1  Yes  
8  Don’t know
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

17. What is your due date?

   _____/ _____/ _____ (enter as MMDDYYY)

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)

19. How many weeks pregnant were you when you found out for sure that you were pregnant?

   _____ weeks (enter a number 4-42)

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: ____________________________)

21. Is the father of your baby currently involved in your life?

   0  No
   1  Yes
The next few questions will as about your substance use.

22. Have you smoked at least 100 cigarettes in your entire life?
   0 No [Skip to question 24]
   1 Yes [Continue]

23. 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

24. 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 26]
   1 Yes [Continue]

25. 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

26. 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

27. 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
28. 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

MORE ABOUT YOU

This last set of questions will ask about your lifestyle and living situation.

29. 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.

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

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

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

*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.

<table>
<thead>
<tr>
<th>Situations</th>
<th>Almost Everyday</th>
<th>At least once a week</th>
<th>A few times a month</th>
<th>A few times a year</th>
<th>Less than once a year</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>You are treated with less courtesy than other people are.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>You receive poorer service that other people at restaurants or stores.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>People act as if they think you are not smart.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>People act as if they are afraid of you.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>You are threatened or harassed.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

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.]

<table>
<thead>
<tr>
<th>Modes of Transportation</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>My own car</td>
<td>Yes</td>
</tr>
<tr>
<td>Ride from family member</td>
<td>Yes</td>
</tr>
<tr>
<td>Ride from friend</td>
<td>Yes</td>
</tr>
<tr>
<td>Ride from husband, partner, father of baby</td>
<td>Yes</td>
</tr>
<tr>
<td>COTA bus</td>
<td>Yes</td>
</tr>
<tr>
<td>Ride share (like Lyft, Uber) for which I paid</td>
<td>Yes</td>
</tr>
<tr>
<td>Taxi (for which I paid)</td>
<td>Yes</td>
</tr>
<tr>
<td>Non-emergency medical transportation (ride paid for by CareSource or Molina)</td>
<td>Yes</td>
</tr>
<tr>
<td>Rode a bike</td>
<td>Yes</td>
</tr>
<tr>
<td>Walked</td>
<td>Yes</td>
</tr>
<tr>
<td>Any other type? Specify: _____________________________________________</td>
<td>Yes</td>
</tr>
</tbody>
</table>

[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
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 family member
3. Ride from friend
4. Ride from husband, partner, father of baby
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: ________________)

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.

<table>
<thead>
<tr>
<th>Place</th>
<th>Difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctor’s office</td>
<td>Yes</td>
</tr>
<tr>
<td>Pharmacy or drugstore</td>
<td>Yes</td>
</tr>
<tr>
<td>Grocery store or food bank</td>
<td>Yes</td>
</tr>
<tr>
<td>Women Infants and Children (WIC) Clinic</td>
<td>Yes</td>
</tr>
<tr>
<td>Job training center</td>
<td>Yes</td>
</tr>
<tr>
<td>Work</td>
<td>Yes</td>
</tr>
<tr>
<td>School</td>
<td>Yes</td>
</tr>
<tr>
<td>Childcare provider/child(ren)’s school</td>
<td>Yes</td>
</tr>
<tr>
<td>Friend’s house</td>
<td>Yes</td>
</tr>
<tr>
<td>Family’s house</td>
<td>Yes</td>
</tr>
<tr>
<td>Any other place? Please specify: __________</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Device</th>
<th>Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landline phone</td>
<td>Yes</td>
</tr>
<tr>
<td>Smartphone</td>
<td>Yes</td>
</tr>
<tr>
<td>Flip phone or other type of cell phone</td>
<td>Yes</td>
</tr>
<tr>
<td>Laptop or desktop computer</td>
<td>Yes</td>
</tr>
<tr>
<td>Tablet (like an iPad)</td>
<td>Yes</td>
</tr>
</tbody>
</table>

[If smartphone or cell phone, continue; otherwise, skip to question 43.]
39. 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

40. Do you usually run out of phone minutes before the end of the month?
   0. No
   1. Yes

41. 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.

42. 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.

43. 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 45.]

44. 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

45. 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. Widowed
46. 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

47. Do you have a job(s) either full or part-time?

0  No  [Skip to question 49.]
1  Yes  [Continue]

48. 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

49. What is your typical monthly household income? Do not include food stamps. [Code “0” if participant has no income.]

$__________

50. Including yourself, how many people are in your household?

_________ person/people

51. How many children under the age of 18 are in your household?

_________ child(ren)

52. In what country were you born?

Name of country: ______________________________________________________________________
It is very important that we be able to reach while you are participating in the study. In the next few questions, we'll collect your contact information.

53. What is your current address?

    Street address:_____________________________________________________________

    City:_________________________ State:____________________ Zip code:________

54. Do you receive mail at this address?

    0  No  [Continue]
    1  Yes  [Skip to question 56.]

55. What is the address at which you receive mail?

    Street address:_____________________________________________________________

    City:_________________________ State:____________________ Zip code:________

56. Now I’d like to record your telephone numbers.

    Home:_________________________  □  Does not have a home phone

    Cell:_________________________  □  Does not have a home phone

    Other:_________________________  □  Does not have an additional phone

57. What is the best number to reach you?

    1  Home
    2  Cell
    3  Other

58. What is your email address?

    ___________________________@____________________

    □  Do not have an email address.
59. 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:__________________________________________

    Relationship to participant:____________________________________________________

    E-mail: ___________________________@_________________

2) Name:_______________________________________________

    Phone:__________________________________________

    Relationship to participant:____________________________________________________

    E-mail: ___________________________@_________________

Thank you for taking the time to complete this interview. Welcome to Rides4Baby!
Rides4Baby Final Questionnaire

Thank you for working with us on the Rides4Baby Study. We appreciate your time and feedback. 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 getting your prenatal care during your pregnancy? [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  Other place, specify:_______________________________________________________
   9  Did not get prenatal care

2. 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.]

<table>
<thead>
<tr>
<th>Service</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>WIC (Women, infants, and children)</td>
<td></td>
</tr>
<tr>
<td>Job and family services (like job training programs)</td>
<td></td>
</tr>
<tr>
<td>Non-emergency medical transportation (like rides to the doctor)</td>
<td></td>
</tr>
<tr>
<td>Food bank or food pantry</td>
<td></td>
</tr>
<tr>
<td>Food stamps</td>
<td></td>
</tr>
<tr>
<td>Homeless shelter</td>
<td></td>
</tr>
<tr>
<td>Moms2B</td>
<td></td>
</tr>
<tr>
<td>Centering pregnancy</td>
<td></td>
</tr>
<tr>
<td>Home visiting program</td>
<td></td>
</tr>
<tr>
<td>Other, specify</td>
<td></td>
</tr>
</tbody>
</table>
3. Now I’m going to read you a list of services that you might have received from your Medicaid managed care organization. As I read the list, please tell me if you have received any of these services? [Read responses.]

<table>
<thead>
<tr>
<th>Service</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informational mailings or packets</td>
<td></td>
</tr>
<tr>
<td>Informational texts or emails</td>
<td></td>
</tr>
<tr>
<td>In-person educational sessions</td>
<td></td>
</tr>
<tr>
<td>Incentive program to encourage me to attend my appointments</td>
<td></td>
</tr>
<tr>
<td>Ask a nurse line</td>
<td></td>
</tr>
<tr>
<td>Case management</td>
<td></td>
</tr>
<tr>
<td>Anything else? Specify:______________________</td>
<td></td>
</tr>
</tbody>
</table>

**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.]

<table>
<thead>
<tr>
<th>Condition</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>High blood pressure</td>
<td></td>
</tr>
<tr>
<td>Gestational diabetes</td>
<td></td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td></td>
</tr>
<tr>
<td>Sexually transmitted infection</td>
<td></td>
</tr>
<tr>
<td>Pre-eclampsia</td>
<td></td>
</tr>
<tr>
<td>Preterm labor</td>
<td></td>
</tr>
<tr>
<td>Short cervix</td>
<td></td>
</tr>
<tr>
<td>Baby has a birth defect</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td></td>
</tr>
<tr>
<td>Any other conditions? Specify:________________</td>
<td></td>
</tr>
</tbody>
</table>

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

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

*Adapted from the Subjective Health Complaints Inventory
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: _____)

8. What was the outcome of your pregnancy? Was it... [read responses].

1  Live birth   [continue]
2  Stillbirth   [skip to question 10]
3  Miscarriage  [skip to question 10]
4  Abortion     [skip to question 10]
5  Tubal or ectopic pregnancy  [skip to question 10]
6  Molar pregnancy [skip to question 10]

9. What was the date of birth?

_____ / _____ / _____ (enter as MMDDYYYY)  [skip to question 11]

10. What was the date the pregnancy ended?

_____ / _____ / _____ (enter as MMDDYYYY)

[skip to question 12]

11. Now I'm going to ask you a few questions about your baby or babies.

<table>
<thead>
<tr>
<th></th>
<th>How much did the baby weigh?</th>
<th>Was it a boy or a girl?</th>
<th>What was they baby's full legal name?</th>
<th>Was the baby admitted to the neonatal intensive care unit?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baby A</td>
<td>_____ lbs _____ oz</td>
<td>1 Boy</td>
<td>First name: __________</td>
<td>0  No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Girl</td>
<td>Middle name: _______________</td>
<td>1  Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 Unknown</td>
<td>Last name: _______________</td>
<td></td>
</tr>
<tr>
<td>Baby B</td>
<td>_____ lbs _____ oz</td>
<td>1 Boy</td>
<td>First name: __________</td>
<td>0  No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Girl</td>
<td>Middle name: _______________</td>
<td>1  Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 Unknown</td>
<td>Last name: _______________</td>
<td></td>
</tr>
<tr>
<td>Baby C</td>
<td>_____ lbs _____ oz</td>
<td>1 Boy</td>
<td>First name: __________</td>
<td>0  No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 Girl</td>
<td>Middle name: _______________</td>
<td>1  Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 Unknown</td>
<td>Last name: _______________</td>
<td></td>
</tr>
</tbody>
</table>
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]

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 Other reason? Specify: ___________________________________________________

14. Since your pregnancy ended, have you had a postpartum checkup for yourself? A postpartum checkup is the regular checkup a woman has about 4-6 weeks after the end of pregnancy.

0 No [Continue]
1 Yes [Skip to question 16]

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: ___________________________________________________

16. Are you or your partner currently using any kind of birth control?

0 No [Skip to question 18]
1 Yes [Continue]
17. 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.]

<table>
<thead>
<tr>
<th>Method</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tubes tied or blocked (female sterilization or Essure)</td>
<td>Yes</td>
</tr>
<tr>
<td>Vasectomy (male sterilization)</td>
<td>Yes</td>
</tr>
<tr>
<td>Birth control pill</td>
<td>Yes</td>
</tr>
<tr>
<td>Condoms</td>
<td>Yes</td>
</tr>
<tr>
<td>Shots or injections (Depo-Provera)</td>
<td>Yes</td>
</tr>
<tr>
<td>Contraceptive patch (OrthoEvra) or vaginal ring (NuvaRing)</td>
<td>Yes</td>
</tr>
<tr>
<td>IUD (Mirena, ParaGard, Liletta, Skyla)</td>
<td>Yes</td>
</tr>
<tr>
<td>Contraceptive implant in the arm (Nexplanon, Implanon)</td>
<td>Yes</td>
</tr>
<tr>
<td>Natural family planning (including the rhythm method)</td>
<td>Yes</td>
</tr>
<tr>
<td>Withdrawal (pulling out)</td>
<td>Yes</td>
</tr>
<tr>
<td>Not having sex (abstinence)</td>
<td>Yes</td>
</tr>
<tr>
<td>Anything else? Specify:</td>
<td>Yes</td>
</tr>
</tbody>
</table>

18. 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.]

<table>
<thead>
<tr>
<th>Mode</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>My own car</td>
<td>Yes</td>
</tr>
<tr>
<td>Ride from family member</td>
<td>Yes</td>
</tr>
<tr>
<td>Ride from friend</td>
<td>Yes</td>
</tr>
<tr>
<td>Ride from husband, partner, father of baby</td>
<td>Yes</td>
</tr>
<tr>
<td>COTA bus</td>
<td>Yes</td>
</tr>
<tr>
<td>Ride share (like Lyft, Uber) for which I paid</td>
<td>Yes</td>
</tr>
<tr>
<td>Taxi (for which I paid)</td>
<td>Yes</td>
</tr>
<tr>
<td>Non-emergency medical transportation (ride paid for by CareSource or Molina)</td>
<td>Yes</td>
</tr>
<tr>
<td>Rode a bike</td>
<td>Yes</td>
</tr>
<tr>
<td>Walked</td>
<td>Yes</td>
</tr>
<tr>
<td>Any other type? Specify:</td>
<td>Yes</td>
</tr>
</tbody>
</table>

19. 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 21]
20. 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.]

<table>
<thead>
<tr>
<th>Reason</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>I had a car.</td>
<td>Yes</td>
</tr>
<tr>
<td>I was able to get a ride from a friend.</td>
<td>Yes</td>
</tr>
<tr>
<td>I was able to get a ride from a family member.</td>
<td>Yes</td>
</tr>
<tr>
<td>I rode the bus.</td>
<td>Yes</td>
</tr>
<tr>
<td>I walked.</td>
<td>Yes</td>
</tr>
<tr>
<td>I rode a bike.</td>
<td>Yes</td>
</tr>
<tr>
<td>It takes too long.</td>
<td>Yes</td>
</tr>
<tr>
<td>I tried, but the ride never came or I missed my ride.</td>
<td>Yes</td>
</tr>
<tr>
<td>I could not contact the transportation services to set up a ride.</td>
<td>Yes</td>
</tr>
<tr>
<td>I tried but was not able to schedule a ride.</td>
<td>Yes</td>
</tr>
<tr>
<td>The last time I used it, it was a bad experience.</td>
<td>Yes</td>
</tr>
<tr>
<td>It was too difficult to set up a ride.</td>
<td>Yes</td>
</tr>
<tr>
<td>I didn’t have enough minutes available to call and schedule a ride.</td>
<td>Yes</td>
</tr>
<tr>
<td>Other reason? Specify: ____</td>
<td>Yes</td>
</tr>
</tbody>
</table>

[Skip to end of questionnaire.]

21. 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.

<table>
<thead>
<tr>
<th>Service</th>
<th>Very Satisfied</th>
<th>Somewhat satisfied</th>
<th>Neither satisfied or dissatisfied</th>
<th>Somewhat dissatisfied</th>
<th>Very dissatisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Ease of scheduling a ride</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Call center hold times</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Courtesy of call center staff</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Promptness of the driver(s)</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Courtesy of the driver(s)</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Wait time for a ride</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Safety of the ride</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Availability of car seats</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

22. Since you started the study, what did you like most about the Rides 4Baby transportation services that you received?
23. Since you started the study, what did you **like least** about the Rides 4Baby transportation services that you received?

_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

QUESTIONS FOR WOMEN IN THE INTERVENTION GROUP

24. Did you use the Rides4Baby mobile application to schedule a ride?

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No</td>
<td></td>
<td>[Skip to question 27.]</td>
</tr>
<tr>
<td>1</td>
<td>Yes</td>
<td></td>
<td>[Continue]</td>
</tr>
</tbody>
</table>

25. Now I’d like to ask you a few questions 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.

<table>
<thead>
<tr>
<th>Item</th>
<th>Very Satisfied</th>
<th>Somewhat satisfied</th>
<th>Neither satisfied or dissatisfied</th>
<th>Somewhat dissatisfied</th>
<th>Very dissatisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>The mobile application and text service overall</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>The mobile application overall</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Compatibility of the app with your phone</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>How easy was it to learn to use the app</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>How easy it was to use</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Layout of the app</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Ability to navigate the app</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Ability of the app to help you schedule a ride</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Ability to track the location of driver</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Ability to provide feedback on the ride</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Use of text service to schedule a ride</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

26. Would you recommend the Rides4Baby mobile application to other pregnant women?

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Definitely</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Probably not</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Maybe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Probably not</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Definitely not</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Don’t know</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[Skip to question 28.]
27. 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.]

<table>
<thead>
<tr>
<th>Reason</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>I didn’t have a phone.</td>
<td></td>
</tr>
<tr>
<td>Couldn’t download the mobile application.</td>
<td></td>
</tr>
<tr>
<td>Mobile application didn’t work.</td>
<td></td>
</tr>
<tr>
<td>Didn’t understand the mobile application.</td>
<td></td>
</tr>
<tr>
<td>Couldn’t access the internet.</td>
<td></td>
</tr>
<tr>
<td>Prefer to talk to someone</td>
<td></td>
</tr>
<tr>
<td>Other reasons? Specify:</td>
<td></td>
</tr>
</tbody>
</table>

28. 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 30; otherwise, continue.]

29. Do you think that being able to take Rides4Baby transportation to the grocery store or foodbank had a positive impact on your health?

0  No
1  Yes

30. 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.]

31. Do you think that being able to take Rides4Baby transportation to the pharmacy had a positive impact on your health?

0  No
1  Yes

Thank you for participating in the Rides4Baby study!
Hi there! It’s the Rides4Baby team checking in.

1. How many times did you use Rides4Baby transportation services this 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 this 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 this 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 this month?

   ______ times

Thank you for your responses!
RIDES4BABY: A RANDOMIZED TRIAL EXAMINING THE EFFICACY OF EXPANDED “SMART” TRANSPORTATION TO IMPROVE CUSTOMER SATISFACTION AND PREGNANCY OUTCOMES AMONG HIGH-RISK WOMEN PROTOCOL

Background
Franklin County, Ohio, home of the state’s capital of Columbus, has one of the highest rates of infant mortality in the U.S. at 8.2 per 1,000 live births. Further, there is a pronounced racial disparity in infant mortality in the county with non-Hispanic black infants nearly three times more likely to die than non-Hispanic white infants (14.8 vs 4.9 per 1,000, 2017). In response to this public health crisis, in 2014, the City of Columbus and Franklin County convened an infant mortality task force that developed recommendations and formed CelebrateOne, a dedicated office in the City of Columbus, to carry out the community’s plan.

In analyzing patterns of infant deaths in the county, CelebrateOne found that the majority of deaths were occurring in eight “hot spots” throughout the community (Figure 1), hereafter referred to as target areas, with all of the hot spots being impoverished neighborhoods. More than half of infant deaths were related to prematurity, with birth defects, and sleep-related deaths being the other most frequently identified causes.

Figure 1. Infant mortality hot spots, Franklin County, Ohio, 2018

Receipt of early and adequate prenatal care is essential for preventing the two main causes of infant mortality, preterm birth (<37 weeks of gestation), and congenital anomalies. Safe and reliable transportation to prenatal care appointments remains a constant challenge for women living in poverty in our community. Bus passes are often outside women’s budget and the bus stops are not always conveniently located to women’s home and/or prenatal care providers. Most women living in poverty in Greater Columbus have their medical care paid for by a Medicaid Managed Care Plan (MCO). While these plans do provide transportation to and from medical appointments during pregnancy and during the 8-week postpartum period, services may present challenges and as such, some women elect to pursue other transportation options. Further, while all MCOs serving the local community provide non-emergency medical transportation (NEMT) in some form, many do not cover other important health-related trips like trips to the pharmacy, food bank, or grocery store.

There have been many advances in “smart” applications in transportation over the past 10 years. However, despite the fact that the vast majority of impoverished women have a mobile phone, with many having a smartphone (albeit with limited data plans), the transportation providers (predominantly taxis) currently used by the MCOs are low tech with no mobile alerts or two-way communication with the woman. The purpose of the proposed study is to examine the efficacy of providing expanded and “smart” transportation services to increase communications, reliability, and customer satisfaction and reduce adverse pregnancy outcomes among women whose children are at high risk of infant mortality. “Smart” transportation services include:

- Access to on-demand transportation;
- Knowledge of real-time driver location and arrival time;
- Enhanced capabilities for patients to schedule pregnancy-related trips (call center, web portal, and mobile application); and
- Increased communications between NEMT mobility provider, patient, and healthcare providers.
The primary aim of this randomized controlled trial is:
1) To examine women’s satisfaction with transportation services in those assigned to expanded “smart” transportation compared to those assigned to usual transportation services

The secondary aims are:
1) To examine adequacy of prenatal care as measured by the Kotelchuck Index between groups
2) To examine rates of preterm delivery (<37 weeks) between groups
3) To describe & examine rates of infant mortality between groups

Study Design
We will examine the efficacy of providing expanded and “smart” transportation services to increase customer satisfaction and reduce adverse pregnancy outcomes among women whose children are at high-risk of infant mortality using a randomized controlled trial design. The study will be called Rides4Baby, as the investigators have found that having a strong study identity (i.e., catchy title/logo) increases participant retention. Eligible women will be randomly assigned to one of two groups:
1) Usual transportation services from their MCO.
2) Expanded “smart” transportation services, as previously defined. Trips include standard trips provided by MCOs to pregnant or postpartum members, with the addition of freestanding pharmacy trips, and trips to the food bank/grocery store.

Population
We will enroll and randomize 500 eligible pregnant women beginning in mid-May 2019.

<table>
<thead>
<tr>
<th>Eligibility criteria</th>
<th>Final screening criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pregnant &amp; &lt;32 weeks of gestation</td>
<td>No plans to move out of Franklin County prior to delivery</td>
</tr>
<tr>
<td>At least 18 years old</td>
<td>Able to read, understand, and communicate in English</td>
</tr>
<tr>
<td>Enrolled in CareSource or Molina</td>
<td>Woman has not been previously enrolled in Rides4Baby</td>
</tr>
<tr>
<td>Residence in CelebrateOne zip code (43211, 43203, 43205, 43206, 43207, 43204, 43222, 43223, 43224, 43229, 43219, 43227, 43232)</td>
<td>Race/ethnicity stratum is not full</td>
</tr>
<tr>
<td>Ambulatory</td>
<td>Willing to meet staff to be interviewed</td>
</tr>
<tr>
<td>English speaking</td>
<td></td>
</tr>
</tbody>
</table>

* Assessed by StepOne
** Prescreening criteria confirmed by OSU along with final screening criteria

Recruitment
Potentially eligible women will be identified via referrals from StepOne, a hotline of the city’s office of infant mortality reduction initiatives, CelebrateOne, that pregnant women are encouraged to call if they need assistance being connected with prenatal care or other supportive services. During the course of its normal business, StepOne collects demographic information from women to assess their eligibility for various services. If during that routine screening process a woman meets the prescreening eligibility criteria for the Rides4Baby program outlined in Table 1, StepOne staff will tell her that she might be eligible for a new transportation project. If the woman is interested in learning more, StepOne staff will ask permission to pass the woman’s contact information on to Rides4Baby staff at The Ohio State University (OSU) who will contact the woman, explain the study, and if the woman is interested, will complete the screening process. In an effort to increase the number of women who call StepOne during the study period, the two Medicaid MCOs participating in the project (i.e.,

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CareSource and Molina) will send postcards to women of reproductive aged residing the in target areas in Columbus. The postcard will encourage these women to call StepOne to see if they are eligible for the transportation project.

<table>
<thead>
<tr>
<th>Race/ethnicity of mother</th>
<th>% of target area births</th>
<th>Enrollment target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Hispanic black</td>
<td>54%</td>
<td>270</td>
</tr>
<tr>
<td>Non-Hispanic white</td>
<td>32%</td>
<td>160</td>
</tr>
<tr>
<td>Other race/ethnicity</td>
<td>14%</td>
<td>70</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>500</td>
</tr>
</tbody>
</table>

Table 2. Enrollment strata

To ensure that the study sample is representative of women at highest risk of infant mortality, enrollment efforts will be stratified by race/ethnicity as shown in Table 2. Once the recruitment target in a given stratum is reached, enrollment of women in that stratum will cease. If enrollment appears to lag behind for a given group, efforts will be made to increase outreach efforts in that group.

The Rides4Baby study will be headquartered at the OSU College of Medicine under the direction of Dr. Courtney Lynch and Dr. Erinn Hade. Study staff will be centrally located and will be responsible for recruitment and enrollment, data collection, data management, and data analysis. The Rides4Baby office and study hotline will be staffed Monday through Friday from 9:00am to 5:00pm. The hotline will be equipped with voicemail so that women can leave a message outside normal business hours. Calls will be returned on the next business day.

Informed Consent and Enrollment

Rides4Baby staff will schedule an in-person baseline interview with women who screen eligible and are interested in participating. Interviews will be scheduled within 10 days of screening. Rides4Baby staff will confirm the interview date and time 24 hours in advance of the appointment to remind women to attend. If a woman does not wish to meet in person to conduct the interview, she will be considered ineligible for participation.

Before proceeding with enrollment, Rides4baby staff will review the informed consent document with the potential participant and give her the opportunity to ask questions. Once the woman has had all of her questions addressed, she will be asked to sign the informed consent document. Women will be asked to sign the informed consent document in REDCap and then will be provided with a hard copy for her records.

Intervention

Women assigned to the usual care group will receive the usual transportation services from their MCO. Women randomly assigned to the intervention group will be advised to contact Kaizen Health, the study transportation broker, rather than their MCO should they require transportation services. MCO transportation call centers will have a list of women enrolled in the study and if contacted by a member assigned to the intervention group will advise her to contact Kaizen Health for help with transportation.

Women randomized to the intervention group will be able to contact the transportation broker via telephone, web portal, or the broker’s mobile application. In addition to the current trips provided by their MCO, women assigned to the intervention group will be provided with extra trips to the pharmacy and grocery store or food bank. Women randomized to the usual care group will only be able to arrange a trip by calling their MCO’s transportation call center.

For women in the intervention group, when arranging a ride, participants will enter the pickup and destination addressed into the web portal or mobile application. They can also provide this information via telephone if they wish to use the call center. Destination addresses will be checked against a database of approved locations that has been curated by the study team. Transportation services will only be provided within Franklin and contiguous counties (e.g., Delaware, Fairfield, Licking, Pickaway, Franklin and contiguous counties (e.g., Delaware, Fairfield, Licking, Pickaway, etc.).

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Madison, and Union counties). When using the web portal or mobile map, if a participant selects an ineligible address, she will receive an error message that directs her to call the transportation broker for more assistance.

Each day, during the study recruitment period, Rides4Baby staff will transmit an updated notice of enrollment and randomization to the participating MCO via secure FTP. Each MCO will receive information for only the women in its plan.

After verifying all eligibility criteria (see Table 1), women will be randomized immediately after the baseline interview. All women assigned to the intervention group will be informed that they are eligible to receive trips to the grocery store or food bank as well as freestanding trips to the pharmacy. The participant will receive her first gift card at the end of the interview.

**Study Outcomes**

The primary outcome for the proposed trial will be overall satisfaction with transportation services as assessed by the final study questionnaire (i.e., two months after delivery or miscarriage). The satisfaction questions on the final questionnaire have been adapted from a previously published transportation satisfaction survey (Bellamy, 2003). Responses for each domain and for the overall assessment of satisfaction will include: Very satisfied (5), somewhat satisfied (4), neither satisfied nor dissatisfied (3), somewhat dissatisfied (2), and very dissatisfied (1). Individuals who indicate that they are either somewhat satisfied or very satisfied with their transportation services overall will be considered to be satisfied in the analysis.

The secondary outcomes will be assessed using Ohio vital records data. Adequacy of prenatal care will be assessed with the Kotelchuck Index using the gestational age at entry into prenatal care, the number of prenatal care visits, and the gestational age at which the child delivered (Kotelchuck, 1994). Preterm birth will be defined as any birth occurring before 37 weeks gestation. Infant mortality will be defined as death of a live born infant within the first year of life as measured using the linked live birth and death records. Exploratory outcomes will include: early or extreme preterm birth (before 32 or 28 weeks), low birthweight (<2500 grams), number of trips taken, cancelled, missed, and on time.

**Data Collection**

The Rides4Baby baseline interview will be conducted as soon as the informed consent document is signed. The baseline questionnaire will query women about: gravidity, parity, number of prior preterm births (<37 weeks), due date, educational attainment, self-rating of overall health, chronic medical conditions (e.g., hypertension, diabetes, sickle cell), access to a car, satisfaction with prior use of MCO transportation services, smoking status, marijuana use and opioid use, age, race/ethnicity, country of birth of mother, monthly household income, household size, address, best telephone number, type of mobile phone (TracFone® versus smart phone), and the names and telephone numbers of individuals we can contact if we lose touch with the participant.

Every 30 days following enrollment, women will be texted several questions to assess use of and satisfaction with transportation services. These questions will include: (1) “How many times did you use Rides4baby transportation this month?”, (2) “On a scale of 1-5, how satisfied were you with that transportation this month?”, (3) “During any of your Rides4baby rides this month, did you feel unsafe?”, and (4) “How many times did you use another form of transportation to get to the doctor or healthcare provider this month?”. Women who have taken no Rides4Baby trips in the last month will be texted only the first and last questions.

Women will be asked to notify Rides4Baby staff when they deliver or have a miscarriage. For women who notify us immediately of their delivery, Rides4Baby staff will offer to meet them in the hospital to bring them a gift (described below under Remuneration). If, for whatever reason, Rides4Baby staff are unable to get to women who deliver before they are discharged from the hospital, Rides4Baby staff will

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provide women with their delivery gifts when they meet them for their interview at 8 weeks postpartum. For women who miscarry, Rides4Baby staff will provide them with all of their remaining remuneration when they meet them for an interview at 8 weeks after miscarriage. Self-reported data collection will cease at two months postpartum or if ten attempts to contact the participant (at varying days/times) fail.

Trip data will be collected by Kaizen Health (the study transportation broker) as well as both Medicaid MCOs. Data to be collected include: the participant ID, number of trips taken, dates of trips, trip timeliness information, and compliance data (whether or not the trip occurred, was cancelled, or was rescheduled). These data will be incorporated into the study database for analysis.

Following delivery, the study team will obtain pregnancy outcome data from the Ohio Department of Health. Specifically, we will obtain the index vital records (i.e., birth, fetal death, and infant death certificates) for each participant to verify pregnancy outcomes. Women will be linked to their index vital records via a probabilistic matching procedure based on mother’s name, mother’s date of birth, address, and child’s date of birth or the miscarriage date. All record links will be reviewed by the study statistical team for accuracy.

**Participant Remuneration**

To encourage active participation in Rides4Baby, participants will receive monetary and non-cash incentives. Women will be given a $20 Kroger gift card for enrolling and completing the baseline questionnaire. Every trimester of active participation thereafter, women will receive an additional $10 Kroger gift card. Women will receive a $20 Kroger gift card for letting us know by phone or text that they delivered or experienced a pregnancy loss. Participants will receive $30 Kroger gift card for completing the final study questionnaire two months after delivery or miscarriage. Participant remuneration will vary from $20 (if lost to follow-up right after enrollment) to $100 for those enrolling in the first trimester, delivering at term, and completing postpartum data collection. The main non-cash incentive that women will receive will be a large package of diapers after delivery. Women will also receive some small personal items such as a body lotion.

**Human Subjects Considerations**

Investigators will seek approval for human subjects research from both the Ohio State University and the Ohio Department of Health. While this study is the evaluation of a public program, which is exempt from institutional review board approval (IRB) under category 5, the study team intends to publish the study findings both as a report and as peer-reviewed publication(s) in medical or public health journals. The investigators will also pursue obtaining a National Institutes of Health Certificate of Confidentiality for the project, which if granted will protect women against the unauthorized disclosure of their study data, even under court order. Any adverse events associated with study participation will be reported to the IRBs as required.

**Data Management**

Study data will be collected and managed in a REDCap database, which will be located behind the firewall at the OSU Wexner Medical Center. REDCap permits distributed data entry, allowing study staff to enter data concurrently from a variety of research sites. All questionnaire data will be entered directly into REDCap by study staff. Transportation data will be provided by the study transportation broker and the MCOs and incorporated into the study database. Once vital record data are linked to each participant, those data will be imported into the REDCap database as well. Text messages will be facilitated by the security compliant mobile application Twilio, which will collect text message responses directly to our study database.
Sample Size Considerations

There were over 20,000 transportation grievances (not limited to perinatal transportation) filed with the Ohio Department of Medicaid last year. Therefore, dissatisfaction with currently available transportation services is high. Assuming a baseline satisfaction rate with current NEMT (somewhat satisfied or very satisfied) transportation services of 30-50%, with 500 women randomized (250 in each intervention arm), we expect to have 90% power to detect a 15% point increase in satisfaction in the Rides4Baby intervention group (e.g., 30% versus 45%), assuming a two-sided type one error rate of 5% (Table 3). A 15% increase in satisfaction will be a substantial, yet reasonable target for this pilot intervention. Power estimates assume approximately 15% non-differential attrition in study participant contact during the course of follow-up (assumes approximately 426 participants will have satisfaction outcomes available). While we will look at the all secondary outcomes, we will likely be underpowered to detect differences, particularly in infant mortality given rarity of the outcome and the modest sample size.

<table>
<thead>
<tr>
<th>Expected proportion satisfied in usual transportation group</th>
<th>Expected proportion satisfied with enhanced technology group</th>
<th>Power*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.30</td>
<td>0.45</td>
<td>90%</td>
</tr>
<tr>
<td>0.40</td>
<td>0.55</td>
<td>88%</td>
</tr>
<tr>
<td>0.50</td>
<td>0.65</td>
<td>88%</td>
</tr>
</tbody>
</table>

*Assumes 426 participants will have satisfaction data available, a 5% two-sided type I error for a difference in proportions with un-pooled standard error.

Analytic Plan

Randomization

As described under Informed Consent and Enrollment, following completion of the baseline questionnaire and verification of eligibility criteria, women will be randomly assigned to the usual transportation group or the intervention group, in a 1:1 ratio. The permuted block randomization allocation scheme will be stratified by race/ethnicity of mother and MCO provider and implemented via the randomization module in the study’s REDCap database. The randomization scheme will be created by the study statisticians and will not be shared with other study investigators. All study staff involved in collection of study outcomes will not have access to participant randomization allocation until after the study completes follow up activities.

Statistical Approach

Demographic and baseline characteristics of all participants will be summarized and presented overall and by assigned treatment group. A key advantage of a well conducted randomized trial (RCT) study design is the expectation that measured or unmeasured participant characteristics are balanced by treatment assignment group. Any chance imbalance in measured characteristics known to be related to primary or secondary outcomes will be considered as adjustment variables in outcomes analyses. As discussed above, randomization will be stratified by race/ethnicity and MCO to ensure balance by these important factors.

Analysis of our primary outcome, the proportion of women satisfied (i.e., overall satisfaction responses of somewhat satisfied or very satisfied) with their Rides4Baby transportation, will be compared between the randomized groups for all those randomized, regardless of treatment adherence or dose of intervention received (i.e., intent to treat analysis, (ITT)). The proportion of those satisfied will
be estimated by assigned treatment group and compared for superiority (higher proportion of satisfaction) of the enhanced technology group over the usual transportation scheduling, adjusted for stratification factors used at the time of randomization. The adjusted treatment difference will be estimated and compared through the marginal effects obtained through logistic regression models. The estimated risk difference will be estimated from the adjusted predicted probabilities via marginal standardization, accounting stratification factors (Muller, 2014). Subsequent analysis of this primary outcome will consider adjustment for any chance imbalances of prognostic factors observed between groups through similar regression models. Finally, we will investigate the effect of treatment received per-protocol, rather than as assigned. These analyses will employ inverse probability of treatment weighting (IPTW) to control participant pre-treatment characteristics.

For analysis of secondary outcomes, we will use the same approaches as those used for primary outcome. First, the association between treatment arms secondary outcomes will be examined as randomized and as treatment was received. Subsequent analyses of these secondary outcomes will consider adjustment for any chance imbalances of prognostic factors observed between groups. Heterogeneity of treatment effects will be explored where possible. Factors of interest to be explored include: age group, education (some college vs. less), and race (black vs. other races). We will evaluate these factors as potential effect modifiers by including each in a model to include the main treatment effect, the main factor effect, and the interaction term for the treatment by factor (VanderWeele, 2009). Treatment effects will be estimated for each level of factor and compared across these groups. Identification of effect modification will be made through tests of interaction in these models, which control the family-wise error rate of each of these 6 comparisons at the 2% level (translating to a maximum family-wise error rate of 12%).

Data on participant characteristics, particularly those necessary to characterize participants who may not complete the study and characteristics known to be related to study outcomes, will be collected in a standardized fashion both at enrollment and throughout the follow-up period. Exploration into the patterns of missing data will be investigated and methods for missing data imputation will be considered for adjustment in sensitivity analyses. These sensitivity analyses will include multiple imputation to replace missing outcome data, subgroup analyses as detailed above, and ITT versus per-protocol treatment (PPT) effect. PPT will utilize inverse probability weighting by the inverse odds.

**Data and Safety Monitoring Plan**

The principal investigators will hold weekly team meetings at which they will discuss recruitment and follow-up progress. Study staff will notify the principal investigators of any suspected adverse event within 8 hours of occurrence and any event deemed reportable will be reported to the MCOs and the IRBs within 24 hours.

Data collection will be monitored by the study data manager weekly and missing data and error reports generated to reconcile potentially inaccurate or incomplete data. In addition, a Data Safety and Monitoring Committee (DSMC) will be formed prior to study initiation and will meet every 6 months throughout the study period via teleconference. The DSMC will review recruitment and safety data provided by the primary study statisticians and other study staff involved in data management and analysis (overall and by treatment group). Throughout the trial, the proportion satisfied (very satisfied or somewhat satisfied) and the rate of preterm birth will be monitored for safety. These rates will be regularly reported to the DSMC for consideration. The overall proportion satisfied in the enhanced technology intervention group is expected to be no lower than 30%. Further, if the proportion of preterm birth exceeds 15% in either group, close investigation will be undertaken by the statistical analysis team and the DSMC to determine if the trial should be stopped for safety reasons.
Study Team

The study/evaluation team will be led by Drs. Courtney Lynch and Erinn Hade. Courtney Lynch is a reproductive epidemiologist in the Department of Obstetrics and Gynecology at the Ohio State University College of Medicine with extensive experience enrolling and following women through pregnancy and beyond. Erinn Hade, PhD is a faculty biostatistician in the Department of Biomedical Informatics and Program leader for Population Studies in the Center for Biostatistics, at the Ohio State University College of Medicine. She possesses extensive experience in maternal and child health research and the design and analysis of intervention studies. The database developer and manager for the project will be Heather Lansky in the OSU Department of Biomedical Informatics. Lead data analyst on the project with notable experience in the probabilistic matching of vital records data will be Kenneth Jackson, MS from the Center for Biostatistics, Department of Biomedical Informatics. Sara Conroy, a PhD student in Epidemiology, will serve as graduate research assistant and subsequently post-doctoral fellow with the project. Three research assistants will support data collection and participant follow-up.
**Timeline**

The study/evaluation timeline is presented in Figure 2.

**Figure 2. Rides4Baby study timeline**

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<td>Prepare study questionnaires</td>
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<td>Obtain human subjects approvals</td>
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<td>Develop study data collection systems</td>
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<td>Match and merge Medicaid data</td>
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<td>Prepare reports and manuscript(s)</td>
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</table>
References


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.
### Appendix F. Glossary

Table 40: Glossary contains project-specific terms used throughout this document.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>App</td>
<td>A software application.</td>
</tr>
<tr>
<td>Travelers (end users)</td>
<td>Travelers are end users who utilize the features of SMHs to begin, pass through, or complete their trips.</td>
</tr>
<tr>
<td>Commercial Off-the-Shelf System (COTS)</td>
<td>Software or hardware product that are ready-made and available for sale to the public.</td>
</tr>
<tr>
<td>Data Management System (DMS)</td>
<td>A secure, Software as a Service (SaaS) web-based app that allows management of an entire parking meter network.</td>
</tr>
<tr>
<td>Data Privacy</td>
<td>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.</td>
</tr>
<tr>
<td>Data Retention</td>
<td>The continued storage of data for compliance or business reasons.</td>
</tr>
<tr>
<td>Data Security</td>
<td>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.</td>
</tr>
<tr>
<td>Dependency</td>
<td>When one project, agency, or entity requires data or functionality provided by another project, agency or entity to meet its objectives.</td>
</tr>
<tr>
<td>Dockless</td>
<td>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.</td>
</tr>
<tr>
<td>Enabling Technologies</td>
<td>An innovation that alone or paired with an existing solution produces a better end user solution at a rapid rate.</td>
</tr>
<tr>
<td>Experience Columbus</td>
<td>An organization whose mission is to market and promote Columbus services, attractions, and facilities to visitors, meeting planners, convention delegates and residents.</td>
</tr>
<tr>
<td>Failure Operations</td>
<td>When a complete failure of the intersection occurs, primarily due to loss of power or other malfunctions.</td>
</tr>
<tr>
<td>Interactive Voice Response (IVR)</td>
<td>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.</td>
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<tr>
<td>Multimodal Transportation</td>
<td>Travel done via more than one mode of transportation.</td>
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</table>
### Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Normal Operations</td>
<td>When a signalized intersection is cycling through its preplanned phases correctly, servicing all approaches including pedestrian phases.</td>
</tr>
<tr>
<td>Open Data</td>
<td>Information that is freely available for anyone to use and republish as they wish.</td>
</tr>
<tr>
<td>Open-Source Concepts</td>
<td>The notion of open collaboration and voluntary contribution for software development by writing and exchanging programming code.</td>
</tr>
<tr>
<td>Parking Facility</td>
<td>Land or a structure used for light-duty vehicle parking.</td>
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<tr>
<td>Procurement</td>
<td>The act of obtaining or acquiring goods, services or works, from a competitive bidding process.</td>
</tr>
<tr>
<td>Real-Time Data</td>
<td>Information that is delivered immediately after collection.</td>
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<tr>
<td>Requirement Number</td>
<td>An integer incrementing by one, indicating the number of requirements established.</td>
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<tr>
<td>“v” Static Character</td>
<td>Static letter “v” represents the requirement version.</td>
</tr>
<tr>
<td>Version Number</td>
<td>An integer incrementing by one, indicating the number of revisions made to the requirement.</td>
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<tr>
<td>System Analytics or Data</td>
<td>The analysis of data, procedures or business practices to locate information which can be used to create more efficient solutions.</td>
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<tr>
<td>Analytics</td>
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<tr>
<td>Software as a Service (SaaS)</td>
<td>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.</td>
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<tr>
<td>Third Party</td>
<td>Organizations not affiliated with the Smart Columbus Program.</td>
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<tr>
<td>Transportation Network</td>
<td>Private businesses, nonprofits and quasi-governmental agencies that offer one or more types of transportation for use in exchange for payment.</td>
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<tr>
<td>Companies (TNCs)</td>
<td></td>
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*Source: City of Columbus*