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DISCLAIMER
Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the Author(s) and do not necessarily reflect the view of the U.S. Department of Transportation.
ACKNOWLEDGMENTS

The Smart Columbus Program would like to thank the members of the many organizations who provided their time, resources, and support to the Smart Columbus Program.

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SMART COLUMBUS VISION
To empower our residents to live their best lives through responsive, innovative and safe mobility solutions.

SMART COLUMBUS MISSION
To demonstrate how an intelligent transportation system and equitable access to transportation can have positive impacts on every day challenges faced by cities.
THE SMART CITY CHALLENGE

The U.S. Department of Transportation’s (USDOT) Smart City Challenge (SCC) was created in 2015 to demonstrate and evaluate a holistic approach to using new technologies to improve surface transportation performance within a midsized city, and integrating this approach with other smart city domains such as public services, health, safety and energy.

Seventy-eight cities applied for the SCC funding, with seven cities selected as finalists. After a nine-month process, USDOT chose Columbus, Ohio, as the SCC winner in June 2016, with the Cooperative Agreement signed in August 2016.

In the application, the City of Columbus described managing aging infrastructure while striving to provide an improved quality of life for a growing population. Every family in every neighborhood should be able to share in the Columbus success story, but they do not. The City sought to create opportunities for economic development and job creation through the SCC, using transportation improvements to improve mobility and provide ladders of opportunity for residents to better access jobs, fresh food, services, education, health care and recreation. By implementing the Smart Columbus Program, the City began empowering residents to live their best lives through the application of responsive, innovative and safe emerging technologies.

A Springboard to Innovation

Along with the $40 million awarded via the USDOT Cooperative Agreement, the City also received a $10 million Paul G. Allen Family Foundation grant. With these efforts managed by the City, The Columbus Partnership also initiated the private-sector Acceleration Fund, which began with $90 million and has grown to over $700 million. These three efforts served collectively as a springboard to an innovation initiative within Columbus and the region. The Smart Columbus Program Management Office (PMO) led the USDOT and Paul G. Allen Family Foundation efforts, while The Columbus Partnership coordinated the Acceleration Fund.

The USDOT SCC project portfolio was part of a group of inspired and invigorated community initiatives that explored what’s next in urban mobility and technology.

EMPOWERING RESIDENTS TO LIVE THEIR BEST LIVES

Throughout his leadership at the City of Columbus, Mayor Andrew J. Ginther has said that “mobility is the great equalizer of the 21st century.” If the program outcomes and USDOT Smart City Vision Elements were the technical roadmap of what the City hoped to achieve, Mayor Ginther’s vision relates these outcomes and elements to the users: the residents of Columbus.

While connected, autonomous, shared and electric technologies are exciting technical advancements, many cities grapple with how to adopt them within legacy infrastructures. Mayor Ginther’s vision to harness these technologies to make the City more equitable and accessible made Columbus stand out in the SCC and the industry, and gave the Smart Columbus Program team its guiding principle. Because without access to modern, integrated transportation options, residents in central Ohio cannot live their best lives.

The City proposed a concentration of demonstrations in its Linden neighborhood because the future of Columbus – and cities like it nationwide – depends on vibrant, thriving neighborhoods. Opportunity neighborhoods such as Linden (lower income and underserved) exist throughout the United States and share many of the same challenges. By deploying smart technology solutions in Linden, the City sought to demonstrate how next-generation transportation technologies can address some of the damage from decades of redlining, disinvestment and isolation that interstate construction caused. The program collaborated directly with the people who reside in Columbus’ neighborhoods. Participation was key to success, and Linden residents were ready to work alongside City staff to show how mobility innovations can be deployed in an equitable way, so other neighborhoods across the United States that look like Linden could benefit in the future. Snapshots of resident impact are presented throughout this report to illustrate how these projects delivered on this proposal.
With the SCC now complete, and other efforts underway by the City, Central Ohio Transit Authority (COTA), DriveOhio, The Columbus Partnership, the Mid-Ohio Regional Planning Commission (MORPC), regional leaders continue to embrace new ideas and innovative solutions.

Community leaders have rallied around Columbus’ emergence as a smart city. Policymakers are inspired to generate further change, advance new collaborative initiatives, and support transformative efforts like LinkUS, which was in development before Smart Columbus. Throughout the regional mobility ecosystem, the spirit of collaboration that fueled the innovation behind Smart Columbus continues. Some projects built upon the infrastructure assets and knowledge the SCC projects created; other partnerships created new programs, introduced new solutions, and promoted adoption of new mobility technologies. This summary concludes with a glimpse at these exciting activities.

Demonstrating Success
Program successes include Ohio’s first autonomous vehicle (AV) deployment on public streets, a multimodal transportation planning app that has been downloaded over 1,000 times, improvements to a parking management app that has been downloaded over 30,000 times, and an operating system that is built largely on open-source software, and it is easy and cost-effective for other cities to implement.

The City’s experience also resulted in a collection of technical information and lessons learned for other regions interested in implementing smart cities projects. Importantly, five of the eight Smart Columbus Program projects are continuing after the SCC funding ends, proving both the value of these projects to residents and their efficiencies for local government.

Later sections summarize the impacts related to USDOT’s Smart City Vision, the City’s performance measurement outcomes, and the City-specific impacts to residents and the local economy.

PROGRAM OVERVIEW
The City’s SCC application outlined 15 projects grouped according to district (downtown, residential, commercial and logistics) and by theme (Enabling Technologies, Enhanced Human Services and Emerging Technologies).

While the original framework was envisioned as a cohesive program, it did not define connections and coordination points during the projects’ development and design. As the first year concluded, the Smart Columbus PMO worked to streamline the original portfolio and bring more clarity to the program and schedule.

After reevaluating the 15 proposed projects in the context of USDOT’s expected outcomes, the City’s original goals, and end-user and stakeholder feedback gathered throughout the program’s first year, the PMO removed some projects, consolidated others, and added one. The reduced portfolio preserved the program’s focus on Columbus’ communities, keeping in place the three overarching themes developed since the SCC award.

Of the nine projects that remained after the first year, one – Truck Platooning – was removed in 2019 because the systems engineering process identified user needs that existing technology could not meet, and the project partner could not support a 12-month demonstration. In 2020, the Common Payment System was removed from the Multimodal Trip Planning Application project. The COVID-19 pandemic exacerbated this project’s existing challenges, which included the inability to finalize participation and terms-of-ownership agreements between mobility providers and COTA.

The Final Portfolio
Figure 2 presents the final portfolio of eight projects: Seven that fall under the three original themes, and the Smart Columbus Operating System project, which acts as the point of integration and collects, manages and produces the data needed to operate all current and future smart city projects.

The Smart Columbus Program demonstrated the following eight projects:
1. Smart Columbus Operating System
2. Connected Vehicle Environment
3. Multimodal Trip Planning Application
4. Mobility Assistance for People with Cognitive Disabilities
5. Prenatal Trip Assistance
6. Smart Mobility Hubs
7. Event Parking Management
8. Connected Electric Autonomous Vehicles

OVERALL PROGRAM THEMES

<table>
<thead>
<tr>
<th>ENABLING TECHNOLOGIES</th>
<th>ENHANCED HUMAN SERVICES</th>
<th>EMERGING TECHNOLOGIES</th>
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<tr>
<td>leverage today’s technology in new and innovative ways to greatly enhance the safety and mobility of transportation infrastructure.</td>
<td>meet human needs through the application of technology that focuses on prevention as well as remediation of problems to improve the overall quality of life of users of the technology-based solutions.</td>
<td>represent technologies that are in development or will be developed over the next five to 10 years that will substantially alter the business and social environment.</td>
</tr>
</tbody>
</table>
FIGURE 1: SMART COLUMBUS PROJECTS

SMART COLUMBUS OPERATING SYSTEM

The SCOS is a platform designed for big data, analytics and complex data exchange. It collects, manages and produces over 2,000 datasets, including data from each of the Smart Columbus projects listed below, and it provides multiuser access to aggregate, fuse and consume data.

ENABLING TECHNOLOGIES

CONNECTED VEHICLE ENVIRONMENT

CVE deployed connected vehicle (CV) technology at 85 intersections and in over 1,000 vehicles across four City corridors. The CV devices enable vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, supporting safety and mobility apps that alert drivers, coordinate signal priority and preemption for emergency vehicles, and capture data for the City and COTA.

EMERGING TECHNOLOGIES

CONNECTED ELECTRIC AUTONOMOUS VEHICLES

CEAV deployed automated shuttles that operated in mixed traffic, interacting with other vehicles, bicyclists and pedestrians. CEAV conducted two demonstrations: one in Downtown Columbus and one in the Linden community.

ENHANCED HUMAN SERVICES

MULTIMODAL TRIP PLANNING APPLICATION

MMTPA created a website and smartphone app called Pivot, which allows travelers to request and view multiple-trip itineraries and reserve transportation options such as ride-hailing services and bike- and scooter-sharing.

MOBILITY ASSISTANCE FOR PEOPLE WITH COGNITIVE DISABILITIES

MAPCD demonstrated an innovative smartphone app – WayFinder by AbleLink – for older adults and people with cognitive disabilities to facilitate independent travel via the fixed-route bus system. The app features highly accurate, turn-by-turn navigation that is sufficiently intuitive for users who have cognitive disabilities.

PRENATAL TRIP ASSISTANCE

PTA created a call center, smartphone app and website called Rides4Baby for use by pregnant individuals to schedule flexible, reliable, two-way transportation to medical-related services. The project delivered non-emergency medical transportation (NEMT) through Medicaid Managed Care Organizations.

SMART MOBILITY HUBS

The SMH project gives physical space to transportation resources and comprehensive trip-planning tools at six locations, mostly adjacent to existing transit facilities. The hubs consolidate travel information for services such as ride-hailing and bike- and car-sharing, and an interactive kiosk and public Wi-Fi allow travelers to view real-time travel information and book multimodal trips via the Pivot app (see MMTPA above).

EVENT PARKING MANAGEMENT

EPM expanded the City’s ParkColumbus app features and created a website to integrate parking information from City meters and multiple parking facilities into a single availability search and reservation service for use in advance or on the go. The app identifies current, projected on-street parking availability near users’ target destinations using predictive analytics, and by routing travelers more directly, the solution is expected to reduce congestion during large events.

EVENT PARKING MANAGEMENT

PARKCOLUMBUS APP

FIVE OF THESE EIGHT PROJECTS WILL CONTINUE after the Smart City Challenge funding ends, proving the value of these projects to residents and their efficiencies for local government.

★ = CONTINUING PROJECT
**Intended Outcomes for Measuring Performance**

The Smart Columbus Program identified outcomes, or broad statements about positive societal impacts, which connect the eight projects to the SCC’s original intent (see Figure 2 on Page 6).

The following six intended outcomes, which represent the many potential indicators that make a city a greater place to live, work or visit, were at the forefront of the development and demonstration of the projects.

1. **SAFETY**
   Three Safety objectives related to increasing drivers’ awareness of signals and other vehicles in the corridors were evaluated for the CVE project.

2. **MOBILITY**
   Eight Mobility objectives were evaluated at the program level and for the CVE, MMTPA, SMH, MAPCD, PTA and CEAV projects. The Mobility objectives focused on how enhancing mobility applies to all transportation modes, and how making these modes more accessible and usable with real-time traveler information and innovative technologies impacts individual mobility.

3. **OPPORTUNITY**
   Five Opportunity objectives were evaluated at the program level and for the MMTPA, MAPCD, PTA, CEAV projects.

   Opportunity objectives focused on improving access to transportation options for Columbus residents, including those in underserved communities, by connecting them to employment, education, health care and other services while increasing transportation network use by bringing together available services and users.

4. **ENVIRONMENT**
   One Environment objective was evaluated at the program level, with the CVE, MMTPA and EPM projects contributing (and assessed as a group).

   The Environment objective focused on reducing transportation’s negative impacts on the environment by implementing advanced technologies and policies that support a more sustainable transportation system.

5. **AGENCY EFFICIENCY**
   Five Agency Efficiency objectives were originally applied to the SCOS and MAPCD projects; however, the MAPCD objectives were not evaluated due to a change in participant recruiting.

   The Agency Efficiency objectives focused on improving agencies’ ability to provide services to residents through advanced technologies that enabled easier access to real-time data, streamlined internal processes, and improved information-sharing.

6. **CUSTOMER SATISFACTION**
   Seven Customer Satisfaction objectives were evaluated for the SCOS, MMTPA, SMH, PTA, EPM, and CEAV projects.

   The Customer Satisfaction objectives focused on providing services embraced by the community and improving the user experience of transportation and community services through integrated data exchange and advanced technologies.

**DEPLOYMENT AREAS**

Like most midsized U.S. cities, Columbus is divided into several neighborhoods, commercial districts, and other geographic zones connected by highways, transit, people and culture. While the Smart Columbus Program deployed some projects within specific areas, many projects were deployed citywide. Figure 3 shows the following geographic areas of the projects:

- **CVE**: The deployment corridors were Cleveland Avenue, High Street, Morse Road and Alum Creek Drive.
- **MMTPA and MAPCD**: As one of the key mobility providers, the map highlights COTA’s service area.
- **PTA**: Franklin County was the recruiting area for the project, which focused on Linden and other zip codes with high rates of poor birth outcomes.
- **SMH**: Most hub locations are along COTA’s CMAX Cleveland Avenue bus rapid transit route; one is in Easton.
- **EPM**: The map highlights Downtown and the Short North Arts District because the ParkColumbus app uses parking providers in these areas, and focuses on travel to and around them.
- **CEAV**: The map shows both the Smart Circuit and Linden LEAP routes and stations, and the passenger and food pantry routes for the Linden service.

**MANAGEMENT AND DELIVERY**

Delivery of the SCC demonstrations relied on several program management pillars. The City used the structure outlined by USDOT in the Cooperative Agreement to deliver the program, while managing the systems engineering tasks at the individual project level.

Program-level items were program management (including budget); performance measurement; data management and privacy; safety management and assurance (including the Institutional Review Board); communications and outreach; and reporting. Overall, this structure provided consistent guidance to the project teams, and a more cohesive and integrated program portfolio while satisfying all Cooperative Agreement requirements and deliverables.

This summary highlights the final budget, a timeline of the program’s major milestones, lessons learned, challenges and how the deployment approach sought to mitigate them.
FIGURE 2: SMART COLUMBUS PROJECTS DEPLOYMENT AREAS
### FIGURE 3: SMART COLUMBUS PROGRAM AND OUTCOMES

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<tr>
<th>OUTCOMES</th>
<th>SMART COLUMBUS PROGRAM</th>
<th>SMART COLUMBUS OPERATING SYSTEM</th>
<th>CONNECTED VEHICLE ENVIRONMENT</th>
<th>MULTIMODAL TRIP PLANNING APPLICATION</th>
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<td>SAFETY</td>
<td>3 Objectives</td>
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<td>Emergency response times</td>
<td>Single point of access to plan and book trip</td>
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<td>5 Objectives</td>
<td>Evaluated: 4 Projects</td>
<td>Reduced traffic congestion</td>
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<td>ENVIROMENT</td>
<td>1 Objectives</td>
<td>Evaluated: Program, CVE, MMPTA, EPM</td>
<td>Reduced vehicle emissions</td>
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<td>AGENCY EFFICIENCY</td>
<td>5 Objectives</td>
<td>Evaluated: 2 Projects</td>
<td>Usefulness of data</td>
<td>Satisfaction with transportation options, travel time, distance, flexibility and comfort</td>
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<td>CUSTOMER SATISFACTION</td>
<td>7 Objectives</td>
<td>Evaluated: 6 Projects</td>
<td>Improved data-sharing ability</td>
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#### Key:
- ![Successful](image)
- ![Part-Successful](image)
- ![Inconclusive](image)
## SMART COLUMBUS PROGRAM SUMMARY

### OUTCOMES

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<td>CVE, MMPTA, EPM</td>
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<td>PRENATAL TRIP ASSISTANCE</td>
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<tr>
<td>EVENT PARKING MANAGEMENT</td>
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- Physical access to multimodal trip planning and payment options
- Use of nonemergency medical transportation
- Participant independence through use of fixed-route bus service
- Improve last-mile goods mobility in Linden neighborhood
- Access to services for underserved communities
- Central Ohio Transit Authority expenditures
- Satisfaction with user experience and convenience
- Perception of available parking in downtown area and Short North Arts District
Budget Summary
During the course of the program, the budget was revised multiple times as changes were made to the individual projects, including those that were removed such as Truck Platooning and Common Payment System.

What was initially scoped to cost approximately $59 million concluded at an approximate cost of $55 million. This cost was divided between the federal award of almost $40 million and the following four cost-share partners, who collectively provided over $15 million:

- City of Columbus
- Franklin County, Ohio
- Ohio Department of Transportation
- The Ohio State University (OSU)

Costs of the eight individual Smart Columbus projects represented nearly $37 million dollars of the total program budget, as of March 2021 (see Figure 4). Unspent funds were allocated during the final two months of the program (April and May 2021). The City of Columbus will return the remaining balance to the program sponsor.

The Value of Partnerships
Not included in the Figure 3 charts is the value of the support that 13 key leveraged partners gave to the Smart Columbus Program.

These partners provided about $37.5 million in support of the demonstration, as specified in the USDOT Cooperative Agreement.

Contributions ranged from key concept contributions like Sidewalk Labs’ PTA user needs research, to foundational structural support for the SCOS from Amazon Web Services (AWS) for hosting and Battelle for data curation, to essential roles in developing and assessing the overall program and individual project findings.

The program deferred to DriveOhio’s expertise with interoperability, security, location accuracy, and AV permitting and registration.

The Mid-Ohio Regional Planning Commission (MORPC) provided invaluable data and guidance for development of the SCOS. Post-Smart Columbus, the commission is committed to sending data to the SCOS as it looks to undertake data regionalization efforts.

OSU was the Principal Investigator for the MAPCD and PTA projects and had a vital role in measuring the performances of the overall program, most of the projects, and the safety management process.

The City partnered with COTA to develop requirements and procedures for several projects including MMTPA and MAPCD. Having access to COTA’s experience and insights was critical to the program’s success.
**Timeline and Milestones**

*Figure 5 on Page 10 captures highlights of the Smart Columbus Program.*

**YEAR 1**

The first year of the program was spent developing a comprehensive approach for program management and systems engineering, anchored by a structured stakeholder engagement process. Highlights from the first year included work associated with establishing communications, beginning the systems engineering process, and defining the integrated data exchange, later known as the SCOS.

The demonstration also encountered several challenges its first year, which encouraged further changes and adaptations, helping the City identify where to chart a better path forward. Intra-program communications – among and between the projects and the SCOS at its core – were front and center as a lesson learned for continued enhancement.

**YEAR 2**

As a result of these challenges, during the second year, the team finalized the program management structure and the portfolio of projects. Key milestones in these first two years were the consolidation and reorganization of the portfolio (September 2017), the launch of the data environment that would become the SCOS (December 2017), and the opening of the Smart Columbus Experience Center (June 2018), which gave the Smart Columbus Program a headquarters co-located with partners, as well as an additional platform for community engagement.

**YEAR 3**

The third year focused on procurement and launching three projects, including the first CEAV project (Smart Circuit) on the Scioto Mile in December 2018. Recruiting for the MAPCD project began in February 2019. Recruiting for the PTA project began in June 2019.

**YEAR 4**

The fourth year focused on launching all remaining projects, while navigating the complexities and challenges of deploying mobility solutions in the COVID-19 pandemic environment.

**YEAR 5**

The fifth and final year (from September 2020 to May 2021) focused on data collection, evaluation and planning for the continuation of several projects including the SCOS, CVE, EPM and MMTPA.

**Challenges**

Throughout the five-year program, there were successes and failures, and many lessons learned.

The original 15 projects were trimmed and combined to a more manageable eight projects. Some projects were removed when it was discovered that there were other solutions being developed that did not require a “smart cities” approach.

Others were lost due to difficulties in developing legal or other agreements within the project timeframe – not surprising when dealing with projects that had few if any precedents.

The scopes of other projects such as CVE changed due to the readiness of the technology and the need to ensure that project implementation goals were achievable given the available time and resources.

### Adapting from application to reality:
Cities need flexibility in moving plans forward when working with developing technologies

- Managing and incorporating partner expectations because they do not always align with user needs or program policies
- The ability engage quickly and start strong begins with identifying and solidifying resources

### Be flexible and adaptive when applying traditional systems engineering to emerging technology projects

### Expect the unexpected: Unanticipated events will always be encountered, and the following two stand out for the Smart Columbus Program:

- The Federal Communications Commission Notice of Proposed Rulemaking regarding the 5.9GHz safety spectrum, which delayed implementation of the CVE project
- The COVID-19 pandemic, which affected the implementation, use and even the performance assessments of every project
FIGURE 5: SMART COLUMBUS PROGRAM HIGHLIGHTS

Kickoff meeting Sept. 2016
PMO Restructuring (new PgM and CINO in charge)
Working groups and initiation of stakeholder engagement
Finding the right people, right seats
Program re-set Sept. 2017
DC meeting Sept. 2017
15 to 9 projects
OS Procurement (Q2)
Initiation of SE documentation
Operating System MVP Dec. 2017
Acceptance of Program Plans and SEMP
Final Comms Plan Oct. 2018
Draft SMP & PfMP Feb. 2019
CEAV Vendor May Mobility Procurement and award
CVE Scope Reduced: April 2019
Launch of Operating System 2.0 Apr. 2019
CEAV Testing and launch April 2019
PTA Recruiting and Launch June 2019
EPM Vendor on-board and development begin Oct. 2019
Procurement & Development
 CVE Installation Nov. 2019 to July 2020
CVE Recruiting Launch July 2020
CVE Installations April 2020
CVE Testing Oct. 2020
SMH Construction and Installation Aug. 2019 to Jan. 2020
SMH Testing Jan to Feb. 2020
CEAV Linden LEAP Launch Feb. 2020
CEAV Food Pantry launch July 2020
Conclusion of MAPCD Mar. 2020
Planning for sustainability CVE, EPM, OS, Pivot, SMH
Testing & Demonstration
Data Collection & Evaluation

CEAV = Connected, Electric, Autonomous Vehicle
CINO = Chief Innovation Officer
CPS = Common Payment System
CVE = Connected Vehicle Environment
DMP = Data Management Plan
DPP = Data Privacy Plan
EPM = Event Parking Management
LEAP = Linden Empowers All People
MAPCD = Mobility Assistance for People with Cognitive Disabilities
MMTPA = Multimodal Trip Planning Application
MVP = Minimal Viable Product
OS = Operating System
PfMP = Performance Measurement Plan
PgM = Program Manager
PMO = Program Management Office
PTA = Prenatal Trip Assistance
SAH = Stay-At-Home
SASP = System Architecture and Standards Plan
SE = Systems Engineering
SEMP = Systems Engineering Management Program
SMH = Smart Mobility Hubs
SMP = Safety Management Plan
Program Summary

YEAR 1: Aug 2016 to Aug 2017
YEAR 2: Sept 2017 to Aug 2018
YEAR 3: Sept 2018 to Aug 2019
YEAR 4: Sept 2019 to Aug 2020
YEAR 5: Sept 2020 to May 2021

Program re-set Sept. 2017

OPERATING SYSTEM MVP Dec. 2017
Launch of Operating System 2.0 Apr. 2019

OS Procurement (Q2)
DC meeting Sept. 2017
15 to 9 projects Kickoff meeting Sept. 2016
Working groups and initiation of stakeholder engagement
Finding the right people, right seats
PMO Restructuring (new PgM and CINO in charge)

CEAV Vendor May Mobility Procurement and award
Launched service December 2018

Hackathon May 2018
Program documents; DMP & DPP
Draft SMP Dec. 2018
Final Comms Plan Oct. 2018

Truck Platooning removed May 2019
CVE Scope Reduced: April 2019
Initiation of SE documentation

Procurement & Development
Acceptance of Program Plans and SEMP
Draft SASP & PfMP Feb. 2019

MAPCD testing and launch Apr. 2019
PTA Recruiting and Launch June 2019
EasyMile Factory Testing July 2019

SMH Construction and Installation Aug. 2019 to Jan. 2020
SMH Testing Jan. to Feb. 2020
CEAV Food Pantry launch July 2020
Launch of CVE

COVID 19 SAH orders Mar. 2020 to June 2020
Testing & Demonstration
Launch of SMH July 2020

Data Collection & Evaluation
PIMP update Aug. 2020

Launch of SMH

Conclusion of SE documentation
Procurement & Development

Acceptance of Program Plans and SEMP
Draft SASP & PfMP

CPS removed Aug. 2020

Launch of CVE

Planning for sustainability CVE, EPM, OS, Pivot, SMH

SUMMARY

CEAV = Connected, Electric, Autonomous Vehicle
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SMP = Safety Management Plan
Deployment Approach
Throughout the challenges, the City relied on comprehensive stakeholder collaboration to ensure the Smart Columbus Program remained focused on its end users – the residents of Columbus. From the start, the City applied the following five guiding principles to designing, deploying, and operating the projects:

**HUMAN-CENTERED**
Intended use cases and end-user engagement such as surveys, interviews, working groups, beta testing and community liaison participation guided every deployment. This enabled the teams to solve real-world community challenges; for example, personal preferences stated within the Pivot app informed route design, and the mobility needs of specific groups guided design of the PTA project, which provided NEMT for pregnant individuals, and the MAPCD project, which empowered individuals with cognitive disabilities to travel independently via public transit.

**REPLICABLE**
The Smart Columbus Program established governance and standards for the projects, so that other cities could replicate the technology solutions. For example, the code developed for the SCOS – a scalable data-management platform designed to serve the needs of public agencies, researchers, entrepreneurs and the private sector – is open source and accessible on GitHub.com. Similarly, MMTPA uses proven software (Open Trip Planner) that other cities such as Portland, Oregon, have already implemented.

**COLLABORATIVE**
Partners from throughout the community including COTA, DriveOhio, MORPC, OSU and private-sector companies advised the development, implementation and sustainment of the projects. Coordination with efforts and projects taking place elsewhere in the region, or through other funding sources, were leveraged and brought together for the benefit of all stakeholders and projects. As an example, the CVE project continuously coordinated with DriveOhio and the 33 Smart Mobility Corridor project, which allowed the City to use existing software components that DriveOhio had already procured.

**HOLISTIC**
A holistic technology approach – with common goals, providers and solutions – is important when advancing multiple technology and mobility projects, especially those integrating various transportation modes. Sometimes, this meant partnerships did not materialize as expected. Consistent coordination with other City efforts and projects, and with additional funding sources, helped successfully leverage certain partnerships for the benefit of all stakeholders and projects. For example, the SMH leveraged both a grant from American Electric Power (AEP) for electric vehicle (EV) equipment and an existing agreement between Experience Columbus and Orange Barrel Media to install IKE Smart City kiosks free of charge.

**AGILE**
The tenets of Agile systems engineering – small, incremental (“thin slice”) delivery and failing fast to allow for fast improvement – were crucial in managing the inherent uncertainties surrounding emerging technology. It enabled the PMO to dare greatly, learn from failure, know when to move forward and when to call it quits. This approach was key in managing risk and accommodating changes, while still completing documentation for user needs, system requirements and testing for all projects. The City is now better equipped to take risks in the future, to embrace technology, to deploy innovative solutions and integrate them into its infrastructure and operations.

THE SMART COLUMBUS PROJECT SNAPSHOTs

The Smart Columbus deployments were not “demonstrations of tech for tech’s sake”; they delivered quantifiable outcomes that sought to serve the community. While the COVID-19 pandemic presented challenges to implementing the final portfolio of eight projects, these deployments still delivered measurable progress against all the City of Columbus’ six intended outcomes. Behind the outcomes are the stories of Columbus residents who benefited from the projects firsthand. These residents experienced the potential of intelligent transportation systems: an easier way to get to work or entertainment; access to food services; investments in their local tech or automotive businesses; hands-on job skills training. Their stories are presented throughout the following pages.
The SCOS provides the key functionality needed to develop and explore new concepts in data-driven transportation infrastructure by sending, receiving and visualizing real-time data from public and private organizations.

Data is the heartbeat of a smart city, but Columbus – and cities like it nationwide – lacked a centralized data delivery platform.

The SCOS is a cloud-agnostic, open-source data platform that houses all the Smart Columbus Program performance indicator data and uniquely generated project data, and it integrates all the program’s projects into a central data platform. It provides the key functionality needed to develop and explore new concepts in data-driven transportation infrastructure by sending, receiving and visualizing real-time data from public and private organizations.

The goal of the SCOS project was to create a replicable and sustainable data platform that enables cities, researchers, nonprofits, and businesses to better make decisions and solve problems.

The SCOS features a first-of-its-kind visual data ingestion interface for internal and public use, allowing the input and integration of data from a wide variety of sources. It provides streaming data services, ingesting the real-time project data from the CVE and program partners such as COTA.

Other features include browser-based data querying and visualization tools, and machine learning and hosting (specifically the EPM project’s parking predictive availability model).
The SCOS is built upon the principle of microservices architecture, where a series of processes communicates over a network to fulfill the goal of storing and retrieving data.

All SCOS components had to meet the following criteria:
- Open-source
- Widely used in the development community
- Well-documented support for implementation and maintenance

These essential criteria ensure that Columbus, and any future city that implements a similar system in the future, can easily find the development resources and support it needs.

While open technologies are less common in the public sector, leading technologists in innovative organizations often favor them. This approach brought these innovative engineering capabilities to the SCOS and ensured that the system could be migrated across technology platforms without vendor lock-in – reducing licensing costs for software, and providing public access to the SCOS technology.

Operating System Features and Functions Put Columbus a Step Ahead

“A major hurdle for cities and municipalities to adopting more smart city technologies is the ability to process and manage the incredible amount of data generated by the Internet of Things like sensors. The Connected Vehicle Environment showed the Smart Columbus Operating System has the capability to not only store, but process and manage 65 million new records each day. This functionality puts the City of Columbus ahead of many other U.S. cities and we’re excited to see how that functionality will move the region forward in the future.”

Aaron Schill, Director, Data & Mapping, Mid-Ohio Regional Planning Commission
**KEY FINDINGS**

- The SCOS was the only project to be completely developed using an Agile systems engineering methodology, and it reflects constant and consistent engagement from stakeholders and the user community.
- This implementation approach supports the project by increasing awareness of the City’s open-data efforts, engaging more individuals and organizations with the SCOS, and encouraging use and feedback of the system features.

Community involvement surrounding the SCOS include the following notable examples:

- Engagement with data enthusiast meetups and conferences including the Smart Columbus Open Data Enthusiast and Code for America groups, which hosted monthly meetups at the Smart Columbus Experience Center to connect with the SCOS delivery and development teams and PMO.
- Two Hackathons in 2018 and 2019 promoted by The Columbus Partnership.
- Close contact with five Technical Working Group segments, meeting monthly in person with frequent followup and collaboration via email newsletters and public Slack channels. All these working groups sought to develop datasets, user stories, data management and privacy policies, and ideas related to the development and sustainability the SCOS.
- The SCOS demonstrates the criticality and priority of privacy and security to both the program and the City. The protection of personally identifiable information (PII) was identified as an early priority in the program, and from that point forward, affected the development of the Data Privacy Plan and the Data Management Plan and their implementation. As a result, the SCOS does not collect or store any PII, which minimizes privacy and security risks, reducing requirements in product and operations, and strengthening public trust.

- The SCOS was a project that successfully leveraged partnership opportunities – Amazon provided hosting services throughout the Cooperative Agreement, and Battelle provided data curation services for a majority of the program.
- The replicability and scalability of the SCOS has been demonstrated. The SCOS codebase does not rely on the architecture of any one cloud provider and has been implemented successfully on the three major providers – AWS, Azure and Google. Likewise, demonstrations have validated that with the available documentation and guidance provided by the development team on Github, an instance of the SCOS can be implemented in as little as two to four weeks by two developers.1

**WHAT’S NEXT?**

The City is exploring two paths for near-term support to operate and maintain the SCOS: simply paying to support the SCOS through January 2022; and potentially engaging with private entities to explore strategic partnerships.
The CVE project deployed secure, high-speed, wireless, communication technology and accompanying software, both at intersections and in vehicles, to exchange critical situational data between the vehicles (V2V) and between the vehicles and connected infrastructure (V2I). The CVE project deployed secure, high-speed, wireless, communication technology and accompanying software, both at intersections and in vehicles, to exchange critical situational data between the vehicles (V2V) and between the vehicles and connected infrastructure (V2I). The software applications use data to alert drivers of potential safety issues.

The City also collaborated with public agencies and private companies to support improved mobility for public safety, transit, and freight operators. Finally, the CVE is a source of high-quality data for traffic management, safety

SUSTAINABILITY

The City of Columbus will operate and maintain the CVE with the support of its vendor teams. The City will also continue working with DriveOhio and the City of Dublin on interoperability and expansion efforts.
analyses, and other transportation-related research purposes.

The CVE is enabled by a communications network that allows the City to connect the region’s signalized intersections using a secure, high-speed fiber network backbone called the Columbus Traffic Signal System. Roadside units (RSUs) installed at 85 signalized intersections along four corridors (see Figure 9) broadcast current traffic signal states and the presence of school zones.

Onboard units (OBUs), which receive and report critical warnings from the CVE infrastructure and from other technology-equipped vehicles, were installed in over 1,000 vehicles. A total 11 CV alerts and other applications were deployed in various combinations, depending on vehicle class.

Many vehicle installations included a heads-up display that showed various alerts to drivers. While the alerts on the display are formatted simply, Figure 10 summarizes the scenarios that the applications developed for the CVE project address.

The CVE created rich safety and mobility data, sending almost 1 billion basic safety messages through March 2021. A CV transmitted a basic safety message such as vehicle location and speed 10 times per second.

The deployment of RSUs and applications geared toward transportation operators at the City and COTA have expanded Columbus’ intelligent infrastructure. This infrastructure increases the traffic-related data collected by the City, and the applications – particularly Vehicle Data for Transportation Operations and Transit

![FIGURE 9: CONNECTED VEHICLE ENVIRONMENT STUDY AREA](image)

![FIGURE 10: CONNECTED VEHICLE ENVIRONMENT APPLICATIONS](image)

Source: Siemens Mobility
Vehicle Interaction Event Recording – demonstrate how stakeholders can integrate this data into their existing operations, creating a more robust data source and identifying areas for improvement. This data enabled a better understanding of traffic management metrics around the City.

• The project engaged local automotive shops for CV equipment installations, creating a workforce development opportunity beyond the technology demonstration. Educating and training staff about CV technology, capabilities and benefits also contributed to the overall advancement and acceptance of the CVE project.

For long-term sustainability, CVs will require a workforce that is trained in the technology, and the CVE project tackled this challenge directly.

• Partnership and coordination with DriveOhio, whose position correction and security credentials were leveraged for deployment, were key to the success of the project. The CVE team regularly coordinated with DriveOhio on its deployments in Marysville and Dublin, Ohio, helping establish the statewide architecture upon which all CV deployment is expected to follow.

WHAT’S NEXT?

The City, with the support of its RSU and OBU vendors, will operate and maintain the CVE for at least 15 months after the Cooperative Agreement ends.

Grandmother Uses CV Technology to Keep Her and Her Granddaughter Safe on Trips to Dance Class

“I quickly adapted to getting the alerts in my vehicle. There were occasions when it made me aware of things I wouldn’t have noticed otherwise. I particularly liked the red light warning alert. My granddaughter is always amused when I’m driving her to dance and we get an alert; she laughs. I take that opportunity to talk to her about driver safety, which I hope she takes with her when she becomes driving age.”

Tonie, CVE Study Participant, Reynoldsburg

Tonie lives in Reynoldsburg, an eastern suburb of Columbus, and travels the Connected Vehicle Environment corridor to take her granddaughter to competitive dance lessons daily. She joined the study because she was interested in driver safety technology after experiencing a few costly fender benders.

Tonie plans to keep the CV equipment installed in her vehicle and hopes the technology becomes more widely available.
The City will continue to operate and maintain the Pivot application going forward. The product roadmap will continue to evolve and grow as mobility behaviors affected by COVID-19 resume, and as the transportation needs of the region change.

**SUSTAINABILITY**

The City will continue to operate and maintain the Pivot application going forward. The product roadmap will continue to evolve and grow as mobility behaviors affected by COVID-19 resume, and as the transportation needs of the region change.

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**MULTIMODAL TRIP PLANNING APPLICATION**

Central Ohio residents rely heavily on their own cars to travel, contributing to traffic congestion that will only get worse as the population grows. The MMTPA project’s Pivot app makes it easy to find and pay for the best way to get to a destination using more than one mode of transportation, such as bus, bike, scooter and ride-hailing service.

The app suggests routes based on preferences such as schedule, budget and preferred transportation options. It is powered by real-time data from mobility partners, optimized by the SCOS. The goal was to improve mobility by reducing traffic and increasing access to jobs, education, and services for all Central Ohio residents.

The MMTPA project was designed to allow travelers throughout Columbus and outlying communities to create multimodal trips and pay for services using a single, account-based system linked to different payment media and modes of transportation. The resulting application was branded “Pivot,” as Columbus sought to become a facilitator for Mobility as a Service (MaaS) by providing a platform that integrates end-to-end trip planning, booking, electronic ticketing, and payment services across all modes of transportation, public or private. Pivot makes multimodal travel options easily accessible by providing a robust set of transportation and payment options. Multimodal trip options include

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**MULTIMODAL TRIP CONFIRMED**

**BICYCLE PICK-UP 30 FEET**

**PAYMENT RECEIVED**

**MULTIMODAL TRIP CONFRONED**

**FIGURE 11: MULTIMODAL TRIP PLANNING APPLICATION AT A GLANCE**

<table>
<thead>
<tr>
<th>COST</th>
<th>DEMONSTRATION</th>
<th>PEOPLE SERVED</th>
<th>OUTCOMES</th>
</tr>
</thead>
</table>
| $2.3 MILLION | DECEMBER 2020 - TO - MARCH 2021 | DOWNLOADS 1,103 | MOBILITY
| TRIPS TAKEN 447 | MOBILITY PROVIDERS 8 | • Pivot users reported easier transfers between modes than those who did not use Pivot |
| MILES TRAVELED 1,700 | | OPPORTUNITY
| | | • Pivot users had easier access to health care and entertainment than those who did not use Pivot |
| | | CUSTOMER SATISFACTION
| | | • Pivot users were more satisfied with their transportation options, travel time, distance and flexibility |

MMTPA’s Pivot app makes travel easy by offering users a way to plan and pay for trips that include multiple modes including public transit, walking, bike-sharing, scooters and ride-hailing services, as well as personal bikes and vehicles.
walking, public transit (COTA and Campus Area Bus Service (CABS)), ride-sharing (Gohio Commute), bike-sharing (CoGo), scooters (Bird, Lime), ride-hailing (Yellow Cab, Uber, Lyft), and personal bikes and vehicles. Pivot allows travelers to request and view multiple trip itineraries from within a single app, and book and pay for services through deep linking with various mobility provider apps. Users can compare travel options across modes, and plan and pay for their travel based upon current traffic conditions and availability of services.

The Pivot app was conceptualized in 2017 and 2018, and local technology firm ETCH GIS was selected in 2018 as the vendor for app development. The beta version launched in early 2019, and the time after the beta launch was intended to develop and integrate a common payment system to the application. Challenges and delays related to mobility provider participation and the COVID-19 pandemic resulted in that functionality not being deployed. The public version of Pivot was launched in December 2020.

Pivot uses open-source and proven technologies without dependence on subscription services, proprietary code, or commercially licensed data. The platform is made of containerized microservices comprise the platform, allowing for interoperability with the SCOS or a future host environment. The MMTPA project’s custom code is replicable because it can be entirely redistributed as Massachusetts Institute of Technology.

WHAT MAKES PIVOT UNIQUE?

» Pivot aggregates data from bike- and scooter-sharing services, ride-hailing services and public transportation to deliver customized, multi- or single-mode trips

» Pivot provides a seamless trip plan based on the user’s preferences

» Pivot is an open-source platform flexible enough to accommodate the needs of various agencies, and state and local governments

Essential Worker Uses Pivot for All Transportation Needs

“Information, route information, and voice navigation in Pivot, I’m a convert. I even share it with my fellow bus riders so they don’t have to guess which bus to take or what stop to get off at. One day my daughter got out of practice early. I wasn’t able to pick her up but through Pivot I was able to book her a cab ride home.”

Morgan, Essential Worker, Linden

Morgan is a mom of four who works in the hospitality industry in the Short North Arts District. She owns a vehicle but chooses to take the bus to work because it’s easier than finding and paying for parking. Pivot helps with the transportation needs of her whole family.
of Technology-licensed, open-source software. The platform includes a distributed ledger (“blockchain”) that offers redundancy, transparency, shared governance, and long-term viability for Columbus and other cities who may decide to deploy the platform to address similar mobility gaps.

**KEY FINDINGS**

- User adoption is significant and has been steadily growing. Since the beta version launched, over 3,000 multimodal trips have been taken with Pivot, 447 of those during the demonstration period (from December 2020 through March 31, 2021), with over 1,000 downloads and over 600 registrations. Since September 2019 when trips first began, over 5,000 miles have been traveled by Pivot users, with more than 1,700 of those miles since public launch in December 2020.

- Low-cost, secure, efficient and resilient options for trip planning are available to cities. Pivot was developed to be a low-cost solution using the following integrated, open-source technologies:
  - OpenTripPlanner
  - OpenStreetMap
  - Pelias GeoCoder
  - Blockchain Hyperledger

**FIGURE 12: PIVOT TRIPS DURING DEMONSTRATION**

**FIGURE 13: PIVOT METHODOLOGY**
All data that Pivot stores are encrypted in transit (HTTPS) and at rest (Amazon’s Encrypted Elastic Block Store (EBS) or Relational Database Service (RDS)).

User data are stored in a cryptographic ledger, which helps ensure their integrity. Individual data records cannot be tampered with without changing the entire cryptographic hash chain. All data including logs are stored either on EBS or RDS.

- Data were a key driver and priority in Pivot. Trip data from Pivot (stored on the Pivot Hyperledger Blockchain) are transmitted to the SCOS through a secure Application Programming Interface (API), allowing access to traveler patterns and behavior that previously was inaccessible to the City through mobility providers.
- Data are aggregated and de-identified to protect the identities of individual travelers and mobility providers. The Pivot routing engine uses machine learning to make recommendations based on traveler behavior and preferences, and to provide trip optimization based on current and historical conditions.
- Seamless integration of payment remains an opportunity. Pivot demonstrates that a MaaS platform is achievable, although links to third party apps for payment may be an interim solution to payment. True MaaS cannot be achieved without the seamless ability to pay for any combination of transportation services. Solidifying the enterprise architecture and gaining stakeholder consensus for the payment coordination is key to implementing all potential policies and agreements that are necessary for full integration.
- To achieve MaaS, transit agencies should continue to serve in a key role. Cities often have regulatory/permitting mechanisms for mobility providers, but public transit agencies are better positioned to build relationships to encourage connection to transit and building a MaaS system. This process can and will take time, but may be mitigated by incremental development and integration, a strong project champion/owner, and incentivizing mobility provider participation.

**WHAT’S NEXT?**

The City will continue to operate and maintain Pivot going forward. Basic features and functionalities will be enhanced, building upon the existing metrics to include “gamification” and rewards. Trip history will be used to suggest alternate modes based on traveler activity, as well as using gamification to reward users with badges for using cost-effective and environmentally friendly modes of transportation. Pivot will integrate with COTA’s new fare product, incorporate booking with COTA Mainstream and COTA Plus services, and additional mobility providers will be added as needed. The product roadmap will continue to evolve and grow as mobility behaviors return to normal post-pandemic, and as the transportation needs of the region change.

Since the launch of the Pivot app’s beta version, **over 3,000 multimodal trips have been taken with the app, with over 1,000 downloads and over 600 registrations.**

Trip data from Pivot are transmitted to the SCOS through a secure API, allowing access to traveler patterns and behavior that previously was inaccessible to the City through mobility providers.
FIGURE 14: MOBILITY ASSISTANCE FOR PEOPLE WITH COGNITIVE DISABILITIES

MOBILITY ASSISTANCE FOR PEOPLE WITH COGNITIVE DISABILITIES

People with cognitive disabilities rely on caregivers or paratransit transportation services, which limits a person’s ability to travel independently. The goal of the MAPCD project was to give people with cognitive disabilities the freedom to use public transit to travel. The app provides easy to understand, highly detailed turn-by-turn instructions for riding fixed-route bus service, with trips developed and monitored by caregivers.

Individuals with disabilities comprise nearly 20% of the U.S. population (and will continue to include an increasing number of older Americans), and many studies reflect the need to remove barriers to transportation options for people with visual, hearing, cognitive and mobility disabilities. The goal of the MAPCD project was to enable individuals with cognitive disabilities to travel more independently on the fixed-route bus service, many of whom relied on caregivers for transportation in privately-owned vehicles. To do this, the MAPCD project provided a solution from AbleLink (WayFinder) that offered accurate, customized turn-by-turn navigation with other support features ensuring that users with cognitive disabilities can safely and confidently complete a trip using the fixed-route bus service.

The project team decided upon a “caregiver response model” to assist users, in
which the traveler’s caregiver monitors the trip and intervenes as necessary.

The MAPCD project was conducted in partnership with OSU, which played a critical role assessing the existing applications, conducting an evaluation of the technology, and completing a field study of wayfinding applications through the Pre-Vocational Integrated Education and Campus Experience (PIECE) program, a partnership between the Nisonger Center at OSU and Franklin County Board of Developmental Disabilities Adult Services. The project launched in 2017 with initial research and definition of the user needs, and AbleLink was selected as the vendor in 2018. Application development and participant recruitment took place from late 2018 into early 2019, with 27 participants and their caregivers joining the study.

After application enhancements and testing in the first quarter of 2019, the study launched in April 2019 with travelers and caregivers using the solution. OSU regularly engaged with participants for a 12-month demonstration via interviews and surveys to gather findings and results.

KEY FINDINGS

- The project specifically addressed barriers that traveling individuals with cognitive disabilities encounter such as missed announcements of upcoming bus stops; malfunctioning automated stop notifications on fixed-route bus systems; and the inability to navigate public transit systems.

- Initially, the project team envisioned cost savings for COTA’s paratransit services; however, the results indicate that the benefits of increased independence, community participation,

WayFinder App Helps People with Vision Impairment Explore Central Ohio

“It was a great experience because it provides directions and listening to the audio; it tells me what bus to get on and what stop to get off to go places like the North Market. You get to taste all different foods from different parts of the world like I’d never had before. It can help, not just me, but everyone, get around Columbus faster, more directly, and get to know the city to make it more fun and have good experiences.”

José, Mobility Assistance for People with Cognitive Disabilities participant, Clintonville

Before joining the MAPCD study, José relied on his family, caregivers, or the paratransit system to help him get around. After going through training on how to ride the bus and how to use the WayFinder app, Columbus is José’s oyster.”
and autonomy comprise the project’s biggest value. Therefore, local, regional and state organizations that focus on vocational opportunities for individuals with cognitive disabilities – particularly individuals with developmental disabilities – might realize most the value of the project. This was recognized in the Franklin County Board of Developmental Disabilities’ project involvement, and the implementation of similar programs throughout the nation, including the Cuyahoga County Board of Developmental Disabilities.

- Technology solutions such as the WayFinder product are one aspect of implementation. While the MAPCD project demonstrated individual cases of success and satisfaction in terms of improving access, mobility and independence, widespread adoption (and, therefore, sustainability) requires coordination with transit agencies and community service organizations. Transit agencies ensure that access to General Transit Feed Specification (GTFS) is integrated into the solution and that travel training facilities are available, while community service organizations ensure access to the resources and personnel that are necessary for successful implementation.

- Two facets of participant satisfaction were assessed because the MAPCD project involved both the traveler and a caregiver. The project findings indicated that these two sides are not always aligned in terms of satisfaction and perceived benefits: travelers were extremely satisfied with the increased independence, while caregivers were less satisfied by the time to build routes. This industry should continue to explore indicators that can accurately describe success from both sides. Mobility independence is key in connections to jobs and opportunity – which is critical to the economic vitality of these travelers. Mobility independence can be achieved, but it requires commitment from all stakeholders who contribute to the individual’s care and well-being to achieve it. This can be a difficult trade-off in terms of convenience.

- A robust and flexible training plan improves success and satisfaction and may enable more independence. Modifications may be needed to the training protocol to make the training as effective as possible for each individual.

**WHAT’S NEXT?**

The City, OSU and COTA are engaging with agencies and organizations that support those with cognitive disabilities to identify champions to maintain and support the program after the demonstration period ends. To assist in this transition, OSU has developed a detailed training plan and COTA will provide its training facilities to assist the champion agencies/organizations moving forward. AbleLink Smart Living Technologies will provide ongoing support for the WayFinder app after the demonstration period.

**FIGURE 15: WAYFINDER APPLICATION**

Source: AbleLink

91% of MAPCD project participants said the app and/or training enabled them to travel at least one time per week

76% of participants showed a high level of independence after using the WayFinder app*

* Independence evaluated by participants’ test scores when rated against their ability to complete a specific set of travel skills.
Pregnant individuals face transportation barriers to receiving necessary medical care, which in turn, impact a city’s infant mortality rate. The City of Columbus worked to make it easier for these individuals to get to their doctor appointments by connecting them with StepOne’s care connectors who can ensure they are getting all they can out of the transportation benefit provided by their CareSource or Molina Medicaid insurance. The goal of the PTA project was to improve one of the factors that can impact preterm birth: transportation. As far back as the initial SCC application, Columbus identified that there could be a link between reliable and safe transportation and medical outcomes, especially when it comes to Columbus’ most vulnerable populations. Columbus has identified improved birth outcomes as an important goal, and Mayor Andrew Ginther previously created an initiative called CelebrateOne to combat infant mortality, because every baby deserves to celebrate their first birthday, regardless of race, address or family income.

The PTA project’s website, app and call center system gave pregnant individuals a convenient way to schedule flexible, reliable, two-way transportation to non-emergency medical and related services, and provided high-quality data to agencies researching the prenatal care of Columbus Medicaid recipients.

The City is expanding programs to reduce infant mortality and improve birth outcomes with CelebrateOne. At the state level, in late 2020, a task force was created to eliminate racial disparities in infant mortality.
to study whether changes in NEMT services can impact premature birth and thereby lower the rate of infant mortality."

The PTA project developed a solution for a technologically advanced NEMT service. This project enhanced mobility and increased opportunity, efficiency, and customer service for pregnant individuals who used Medicaid-provided NEMT. PTA also provided sources of high-quality data for the Ohio Department of Medicaid, MCOs, and others researching prenatal care of Columbus Medicaid recipients.

Project participants could schedule their rides through three flexible, on-demand options: a call center, website or smartphone app (Rides4Baby). The PTA system connected NEMT service providers with the participant, enabling multiple transportation reminder texts, emails or calls, and real-time driver location information, so participants were ready for pickup and avoided long waits. The system also transferred driver information directly to the participants, giving them the extra security of knowing what type of vehicle to expect.

The PTA project team started recruiting participants on May 31, 2019, and the last data for the project were collected on Jan. 12, 2021. Because this project targeted a specific use case to test transportation technology, an experienced research partner was imperative. Researchers from the OSU Wexner Medical Center provided the background, expertise and passion required to execute the PTA project. The OSU researchers provided complete oversight of the study including creation and implementation of the research protocol, and communication and interaction with participants.

**KEY FINDINGS**

- While a standalone intervention such as the provision of smart NEMT services are unlikely to meaningfully reduce adverse birth outcomes, preliminary work suggests that it may be a valuable contribution to providing individuals the wrap-around care needed during the pregnancy and postpartum periods.
- Participants assigned to the usual care group (for whom NEMT trips are available through MCO-based call centers) took fewer trips than those in the intervention group. Over the study period, participants in the usual care group took a median of two trips; those in the intervention group took a median of 19 trips. More participants in the usual care group – 44% compared with the intervention group’s 18% – took no trips at all during the study period.
- There was a strong suggestion of increased satisfaction in the intervention group compared with the usual care group, with 90% and 79% reporting being “satisfied” or “very satisfied,” respectively.
- Among participants randomly assigned to the intervention group who used the mobile app to schedule a ride, 82.8% said that they would “definitely recommend,” and 13.8% indicated that they would “probably recommend” the Rides4Baby mobile app to other pregnant individuals.
- Of the participants assigned to the intervention group, 93.1% reported being very satisfied or somewhat
satisfied with the mobile app. Regarding the ease of learning the mobile app, 98.3% were very satisfied or somewhat satisfied.

- In examining the adequacy of prenatal care that participants received, there was no notable difference in prenatal care use between the groups, with 66% receiving adequate or adequate plus prenatal care in the usual care group versus 69% in the intervention group. Prenatal care information was missing for 12 members, or 8%, of the study cohort due to miscarriage or missing vital records data.

- No meaningful difference was observed in preterm delivery between the usual care and intervention groups, with term birth proportions of 77% and 69%, respectively.

During the PTA project study period, participants in the usual care group took a median 2 trips; however, the intervention group participants – who had access to Rides4Baby – took a median 19 trips.

Final infant mortality data will be available, at the soonest, in January 2022; however, investigators have not reported any infant deaths among the study population to date.

- While the City does not operate NEMT, the MCOs’ changes to NEMT during the COVID-19 pandemic demonstrate that the PTA project gave the organizations the information they need to think innovatively as they negotiate new transportation contracts.

WHAT’S NEXT?

CelebrateOne and the City continue to advocate for additional programs focused on reducing infant mortality and improving birth outcomes. In late 2020, the State of Ohio created a task force to eliminate racial disparities in infant mortality. PTA project data is expected to be helpful in developing solutions as the task force includes representatives from the City and from the MCOs that participated in the PTA project.

Rides4Baby Partner Expands Transportation Benefits

“Caresource is always looking for innovative ways to improve health outcomes for pregnant women. We’ve gained valuable insight from Rides4Baby and are now expanding same-day transportation benefits to better serve our clients.”

Donna Gabbard MSN, RN, MHA, CCM, Director, Women & Children’s Health, Caresource
The SMH project was designed to improve the availability of transportation options for people living in areas with limited connectivity. The Linden neighborhood was identified as the focus area for the project, as its residents face numerous socio-economic challenges, including low household income, lack of major employers, and high infant mortality rates. These problems are compounded by the lack of access to transportation options, as there are numerous job centers throughout the Columbus region, including some a short drive from this neighborhood. Easton is a high-traffic retail destination and office center in the northeast part of Columbus, just a
few miles from Linden. Although Easton is a major employment center, the jobs in this area have a high turnover rate. Research shows that a major contributor to this type of job instability is lack of reliable transportation, including first-mile/last-mile issues related to safety and mobility.

Six SMHs were deployed to give travelers consolidated transportation amenities such as the IKE kiosks with Wi-Fi and emergency call buttons, modal transfers between a variety of transportation options, and access to comprehensive trip-planning tools such as Pivot. Taken together, these services made it easier and more convenient to make multimodal trips, including coordinating first-mile/last-mile connections. Project construction was completed in January 2020, but the hubs did not officially open to the public until July 2020 due to the COVID-19 pandemic. The deployment of the SMHs was inexpensive, as significant construction was not required, with expenses of about $250,000 for infrastructure (concrete, signage, pavement markings) and bike-share stations and bikes to deploy the hubs.

KEY FINDINGS

- Once a vision for the project concept, user needs, and participating mobility providers are identified, the construction of the sites can be accomplished quickly. In the case of the SMH, site survey, design, permitting, and construction can be accomplished in months, if using in-house resources (City employees) to construct.
- Most of the CoGo bike users who began their rental at an SMH returned the bicycle to that same hub.
- The introduction of the electric pedal-assist bicycles at the SMHs was successful, and the option became a very popular choice, accounting for 46% of bike-share trips at the SMHs since their launch.
- The Linden Transit Center had the most foot traffic and St. Stephen’s Community House had the least amount of traffic. Due to COVID-19, St. Stephen’s had reduced programming, limited guests in the building, and was closed to visitors for some time during the demonstration period. The project team noted that
because the kiosk was located inside the building, interactions with the IKEs were drastically limited.

WHAT'S NEXT?

The City of Columbus Department of Public Service will take ownership of the SMH project after the demonstration period and coordinate further implementation.

Additional neighborhoods and mobility corridors are being studied as part of the City’s mobility plan, LinkUS. Opportunities to include SMHs in LinkUS will be identified and prioritized for implemented using the framework developed by the Smart Columbus Program and COTA’s mobility hub program.

The existing SMH sites have agreements with the private property owners to ensure they continue beyond the Smart Columbus project.
EVENT PARKING MANAGEMENT

Finding parking is difficult in Columbus’ busy Downtown and Short North Arts District areas. The City expanded the features of its ParkColumbus app to be a one-stop-shop to easily find and pay for parking in garages, surface lots, and streets. The app is powered by real-time data from parking management operators and predictive analytics flowing from the SCOS.

The goal of the EPM project was for people to be encouraged to eat, shop, and play in the Short North Arts District and Downtown due to the ease of parking, while congestion and emissions are reduced by fewer drivers circling for parking.

The EPM project is the future of smart parking in Columbus. The project implemented new features in the ParkColumbus app and created a website to integrate parking information from City-owned parking meters and multiple parking facilities into a single availability and reservation services solution.

EPM expanded the City’s ParkColumbus app features and created a website to integrate parking information from City-owned parking meters and multiple parking facilities into a single availability and reservation services solution.

The City’s Division of Parking Services and established vendor will continue to operate and maintain ParkColumbus including the predicted availability model. An expanded curb management program is planned, building on this partnership.

SUSTAINABILITY

The City’s Division of Parking Services and established vendor will continue to operate and maintain ParkColumbus including the predicted availability model. An expanded curb management program is planned, building on this partnership.

EVENT PARKING MANAGEMENT

The City’s Division of Parking Services and established vendor will continue to operate and maintain ParkColumbus including the predicted availability model. An expanded curb management program is planned, building on this partnership.
Program Summary

includes gains in tourism and business travel in the urban core during regular business days as well as events such as festivals, conventions, sporting events and marathons.

The geographic scope of the EPM project focused on providing parking availability information for parking garages, surface lots, parking meters, and loading zones in Downtown Columbus and the Short North Arts District.

The project also enabled sharing of location and restriction information on the City’s loading zones, and provides the location of on-street EV-charging and handicap accessible parking spaces citywide. Real-time and historic parking meter data is collected and sent to the SCOS to be run in an in-house, custom produced, open-source algorithm, built by the SCOS team, that calculates and predicts the availability of parking.

New registrations have remained steady since the new ParkColumbus app features were announced in December 2019, with over 4,500 new registrations each month (January and February of 2021 were over 5,400).

KEY FINDINGS

• Since the launch of the ParkColumbus app, the share of credit card payments made within the app has grown rapidly to be greater than the credit card payments made at the meters: 52% versus 47% respectively, essentially reversing this allocation in the time since ParkColumbus originally launched in 2019 (prior to the addition of new features developed through the EPM project).

• Leveraging existing relationships and projects enabled the team to work with a vendor that had established trust with the project team while still developing and integrating innovative and customized components into the system:
  › ParkMobile previously worked with the City’s Division of Parking Services as a subcontractor to Conduent on its mobile payment project. This created development efficiencies in procurement while also providing a built-in user base from ParkColumbus and an established connection to the parking operators, easing the completion of necessary agreements to solidify their participation.
  › The parking prediction model was developed in-house within the contract for the Operating System team. Similar models were not ready to be tested or were cost-prohibitive and proprietary. The Operating System team’s solution was less expensive, customized to Columbus (since it used data from the City and ParkMobile in the model) and open source, making it accessible to other cities.

WHAT’S NEXT?

While the EPM project was one of the smaller projects in terms of size, the strong project champion from the City’s Division of Parking Services and an established vendor ensured success - despite the COVID-19 pandemic. The City will operate and maintain ParkColumbus including the parking prediction model going forward.
Young Professional Uses ParkColumbus for Work and Play

“When I’m headed to the Short North for dinner or drinks, I check the on-street parking availability to see how busy it is to decide if I attempt to find a spot or head to a garage or further out parking spot directly. My partner and I are avid Columbus Blue Jacket fans and now that games have started up again, I can use ParkColumbus to reserve a spot in advance so I’m not stranded by the bus after hours or paying surge pricing for a ride-hail home.”

Robert, ParkColumbus User, Merion Village

Robert is a young professional that works in Downtown Columbus. He prefers to ride the bus or bike to work but depending on the weather or his work that day, he sometimes opts to drive. He uses ParkColumbus to find a long-term parking spot during his work day. Robert lives in Merion Village, south of Downtown, but finds himself frequently in the Downtown or Short North Arts District areas.
Columbus demonstrated two CEAV deployments through the Smart Columbus Program. The technology was originally envisioned to serve multiple routes in the City’s Easton area, connecting existing transit routes to jobs and businesses; however, technology readiness was a barrier to deployment. So, the City worked with partners and stakeholders to determine new routes in Downtown and the Linden area to serve the public during the demonstration period.

The first autonomous shuttle deployment, with May Mobility in December 2018, traveled the Scioto Mile and served attractions and cultural resources like the Center for Science and Industry, Veteran’s Memorial and the Smart Columbus Experience Center. The service operated until September 2019.

The second shuttle deployment with EasyMile provided a first-mile/last-mile connection to transit in Linden. The Linden LEAP - short for “Linden Empowers All People” - launched February 2020 and operated for about two weeks before an on-board incident paused passenger operations.

When the COVID-19 pandemic impacted the ability to return to passenger service, the City reimagined the mission of the vehicles, launching a food pantry delivery service in July 2020, concluding in April 2021.

Smart Columbus deployed autonomous shuttles that operated in mixed traffic, interacting with other vehicles, bicyclists and pedestrians. The project conducted two demonstrations: one in Downtown and one in the Linden community.
Linden Leads Neighborhood Innovation
to Serve Residents Now and in the Future

Ms. Peg is a grandmother and woman of faith who lives on Cleveland Avenue in Linden. While the Linden LEAP was providing passenger service, she walked 0.3 miles to the stop at Douglas Recreation Center to pick up the LEAP to get to St. Stephen’s for services and community events or to Maloney Park to walk the paths. When Ms. Peg’s car was totaled during the pandemic, she didn’t see a need to replace it right away. Usually, she would pick up a food pantry box once every two weeks from St. Stephen’s, but without a vehicle, she would have had to depend on others to take her. When the Linden LEAP expanded the service of the food pantry to the Rosewind Community Center, Ms. Peg was able to continue getting food without having a car.

“It was nice to have Linden noticed for something positive. And now Linden is a leader in this space and has the infrastructure, data, and experience to be prepared for future innovations. It’s also a plus that what was learned here will shape pilots in other communities that look like Linden so they’re on the forefront of innovation as well.”

Ms. Peg, Linden LEAP participant, Linden
SMART CIRCUIT: MAKING HISTORY IN OHIO

Smart Circuit became the first AV deployment in Ohio when it launched for passenger service on December 10, 2018.

» During its 10-month operation, Smart Circuit carried 16,062 passengers, carrying an average of 59 riders per day.

» The six shuttles drove 19,118 miles during the demonstration.

» The Smart Columbus Experience Center stop was the most popular among Smart Circuit riders, with 55% of ridership using that stop.

KEY FINDINGS

- A vehicle operator (driver) was on board all CEAV vehicles at all times to ensure safety, and small parts of some routes, such as crowded parking lots and stop-sign-controlled intersections, were designated for nonautomated operation.

- Autonomy was found to be affected by weather and other variables. This can impact service reliability if operations are regularly suspended or slowed.

  Operating in light rain, mild fog and light snow events seemed a reasonable expectation when developing the procurement documents, based on other AV demonstrations in Norway and Minnesota. The reality is that most precipitation hindered the operation of the vehicles in autonomous mode. There are other variables, such as the exhaust from gasoline-powered vehicles in colder months, which can cause the vehicle to stop suddenly, or sun glare at certain times of the year that can cause the vehicle to slow down.

- An unexpected result of the Scioto Mile service was its regular use by some commuters who parked on the west side of the river, where parking was cheaper and used the service to travel into Downtown.

- During its initial two weeks of operation of the Linden LEAP passenger service, 50 passengers took rides on the Linden LEAP, with the vehicles operating at greater than 70% automated mode on a challenging route.

- The Linden LEAP food pantry service averaged 100 boxes per week throughout the project and saw strong and steady distribution throughout the project.

  » More than 80% of patrons said they were satisfied with the convenience of the service.

  » Almost 9% of the food pantry service patrons walked to the shuttle and did not drive, so bringing the food into the community eased the two-mile walk to and from the food pantry with a 30-40 pound box.

  » With each box containing 36 meals (three meals per day for
EasyMile contracted EmpowerBus, a local operator that hired local residents to operate the shuttles and greet passengers. After EmpowerBus went out of business due to the pandemic, EasyMile directly hired the operators to continue the service and distribute food into the community.

- Without flexibility, the project team may not have been able to deliver a successful project in Linden due to the sudden stop incident and pandemic as confounding factors. Rethinking the mission of the vehicles to still meet the needs of the community allowed for a successful transformation of the deployment, despite the circumstances.

WHAT'S NEXT?

The vehicle demonstrations ended with the conclusion of this project; however, the City is continuing food pantry delivery from St. Stephen's to Rosewind using a traditional vehicle.

The lessons learned and deployment playbook developed as a result of the CEAV project are already aiding new deployments through DriveOhio and other states.
PROGRAM RESULTS

Summarizing the results from a program of this size, scope and duration was considered from various perspectives. The performance measurement results provide a quantitative assessment of the program and each project against a defined set of indicators that tie directly to the six outcomes identified in the original program vision.

The City has continually kept the USDOT’s 12 Vision Elements for the Smart City Demonstration (as identified in USDOT’s SCC) at the forefront of project development and implementation efforts.

Performance Measures Results
The primary objective of the Smart Columbus Program was to demonstrate, quantify, and evaluate the impact of advanced technologies, strategies, and applications toward addressing urban mobility challenges. The performance measurement findings help clarify the impact of the integrated Smart City solutions on the six program outcomes:

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

After almost five years, the Smart Columbus Program was found to have successfully or partially achieved 22 of the 29 objectives identified for the program.

Performance on the remaining seven objectives was inconclusive primarily due to small sample size or COVID-19 impacts, not project or application failures:

• The CVE Safety outcomes were 100% successful in all three objectives.
• Opportunity objectives, assessed for the program and individually as part of the MMTPA, MAPCD, PTA and CEAV projects, were also found to be 100% successful for the five objectives.
• The Mobility and Customer Satisfaction outcomes were successful in the majority of objectives but produced inconclusive results for some objectives.
• The impact of COVID made it especially difficult to gather the necessary data for mobility objectives.
• The Environmental objective was also inconclusive due to the small amount of data and limited length of demonstration of the contributing projects (CVE, MMTPA and EPM).
• The Agency Efficiency outcome was successful or partially successful in four out of five objectives, with inconclusive results for one objective. This was a result of the MAPCD project not recruiting participants who had previously used paratransit.

After almost five years, the Smart Columbus Program was found to have successfully or partially achieved

22 of the 29 objectives the program identified.

Resident Impacts
Outside the scope of the six outcomes defined in the Performance Measurement Results, OSU also evaluated the economic and accessibility impacts of the program:

• The economic analysis calculated a short-term impact of $147.86 million in gross metropolitan product (GMP), $51.05 million from direct investments by the program, and $96.82 million in indirect effects, through impacts on the supply chain and increased household spending. And investments by the program are likely to generate an increase of 4,220 jobs, with approximately 719 jobs generated as a direct effect of the expenditure from the program-related staffing, with the remaining 3,501 attributable to the indirect effect on affected sectors through the supply chain.

The long-term projected impacts have more uncertainty, due to the difficulty in projecting future effects of the program. However, assuming the successful deployment of the Smart Columbus Program projects, utilization of the services is likely to generate a $671.28 million or 0.5% increase in GMP, and 7,039 jobs (an employment increase of 0.3%).

Overall, the multiplier of the Smart Columbus Program investment was found to range between 1.71 and 2.09, indicating that each dollar invested in the Smart Columbus Program is associated with an increase of between $1.71 and $2.09 in value added to the local economy.

• The accessibility analysis evaluated the improvement in potential mobility provided by the application of...
**FIGURE 25: HIGHLIGHTS OF PERFORMANCE MEASURES RESULTS**

<table>
<thead>
<tr>
<th>OUTCOMES</th>
<th>SAFETY</th>
<th>MOBILITY</th>
<th>OPPORTUNITY</th>
<th>ENVIRONMENT</th>
<th>AGENCY EFFICIENCY</th>
<th>CUSTOMER SATISFACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVE</td>
<td>• CVE</td>
<td>• SMART COLUMBUS PROGRAM</td>
<td>• SMART COLUMBUS PROGRAM</td>
<td>• SMART COLUMBUS PROGRAM</td>
<td>• SCOS</td>
<td>• SCOS</td>
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<tr>
<td></td>
<td>• CVE</td>
<td>• MMTPA</td>
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<td>• SMH</td>
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<td></td>
<td>• MAPCD</td>
<td>• MAPCD</td>
<td>• CEAV</td>
<td>• CEAV</td>
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<td>• CEAV</td>
</tr>
</tbody>
</table>

**CONTRIBUTING PROJECTS**

<table>
<thead>
<tr>
<th>PROGRAM FINDINGS</th>
<th>OUTCOMES ENVIRONMENT</th>
<th>AGENCY EFFICIENCY</th>
<th>CUSTOMER SATISFACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not applicable; only CVE project evaluated for safety benefits</td>
<td>Improved ease of transferring modes</td>
<td>Projects assessed as a group:</td>
<td>Not applicable; only SCOS and MAPCD projects evaluated for agency efficiency benefits.</td>
</tr>
<tr>
<td>Modest reduction in traffic delays and traffic volume observed during peak weekday hours</td>
<td>Significantly easier trip planning post-Smart Columbus</td>
<td>Projects assessed as a group:</td>
<td>Not applicable; customer satisfaction evaluated only at project level</td>
</tr>
<tr>
<td>Accessibility area expanded by 30 minutes from Linden Transit Center</td>
<td>Inconclusive due to small sample sizes and impact of COVID-19 pandemic on travel behavior</td>
<td>Projects assessed as a group:</td>
<td></td>
</tr>
<tr>
<td>Established access to 20,000 more jobs and 3,000 more health care services</td>
<td></td>
<td>Projects assessed as a group:</td>
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</table>

**HIGHLIGHTS OF PROJECT OBJECTIVES ACHIEVED**

<table>
<thead>
<tr>
<th>CVE:</th>
<th>EPM:</th>
<th>MMTPA:</th>
<th>MAPCD:</th>
<th>PTA:</th>
<th>CEAV:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Emergency response times improved by average of 1.64% when signal preemption granted; improvement of up to 5.2% noted</td>
<td>• Significant improvement in mean response time taken to find parking for leisure activities</td>
<td>• Significant increase in access to health care and entertainment</td>
<td>• Shifted 82 trips from the personal vehicles of caregivers to public transit</td>
<td>• Percentage of participants who did not take NEMT trips decreased from 44% to 19%</td>
<td>• 265 walkups at the Rosewind stop</td>
</tr>
<tr>
<td>• Vehicle speeds reduced by average of 2.3 mph when approaching red light</td>
<td>• 914 charging ports installed</td>
<td>• Participants reported sense of greater independence</td>
<td>• Projects assessed as a group:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• School zone speed limit compliance improved from 18% to 56%</td>
<td>• 18.6 million people educated about Smart Columbus Program</td>
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</tr>
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**SCOS:**

- Over 800 agency-related datasets
- 222,685 downloads
- 67,156 queries
- 59% of users rated their experience of finding intended data as good to very good
- Agency users cited improved data-sharing ability
- Over 60% of users said experience accessing and using data was good to very good

**MAPCD:**

- 97% found Pivot easy or very easy to use

**PTA and CEAV:**

- 90% were satisfied, very satisfied or extremely satisfied

**EPM:**

- Over 30,000 app downloads; 82% users say they will use new app features
Smart Columbus Program investments are likely to generate an increase of **4,220 JOBS**

About **719** jobs would result directly from program-related staffing expenditures

The remaining **3,501** jobs would result from the program’s overall indirect effect on affected sectors.

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Smart Columbus projects to access employment and community services. The analysis used the Linden Transit Center as a representative starting location, and examined public transit routes and schedules, sidewalk networks, the location and availability of docked and dockless micromobility options, and other information to compute the area that could be reached within a set travel time (30 minutes), both with and without the Smart Columbus project improvements. The analysis then computed the number of job and health care locations that could be reached within the set travel time with and without the improvements. The accessibility area (defined as the area a traveler could reach within 30 minutes) expanded regardless of the time of day assessed (9 a.m., 1 p.m., or 6 p.m.), as illustrated in Figure 26.

- As a result of the expansion, travelers would be able to reach at least 20,000 additional jobs and 3,000 additional health care services than they would using the trip planning tools that existed prior to the introduction of the Smart Columbus projects. The increase in accessibility was even greater for certain classes of jobs and services and at certain times of day.
  - These accessibility improvements can provide benefits to those living close to or interacting with the SMHs. Specifically, OSU’s housing assessment analyzed SMH-adjacent neighborhoods to determine if they displayed new housing market activity relative to similar neighborhoods. The housing analysis results provide context for how neighborhoods may evolve in the future:
    - A sizable effect of SMHs on short-run market activity was found that implies a 33.5% increase in sales likelihood for residential parcels.
    - However, evidence was inconclusive regarding any change in housing prices due to proximity to SMHs.

**Achievement of USDOT Vision Elements**

Figure 27 on Page 42 depicts the Smart Columbus projects that demonstrate the 12 Vision Elements identified by the USDOT in the SCC. Applicants were encouraged to consider these 12 elements in developing ideas for their smart city demonstration to address real-world issues and challenges that citizens and cities face.

Aligning Columbus’ goals with USDOT’s Vision Elements required a holistic approach to addressing the City’s transportation challenges. Each project addressed multiple USDOT Vision Elements, as described in each project chapter. The specific achievement and example of how each project satisfied these elements was not always what was originally anticipated but demonstrates the importance of keeping this vision at the forefront of the planning and deployment efforts.

**Local Legacy and Enduring Outcomes**

While the performance measurement results contain the tangible scientific results of the program when measured against the defined indicators of the plan, there are many examples (both quantitative and qualitative) that also speak to what the City of Columbus achieved through the implementation of the program.
USDOT identified 12 Vision Elements (see Figure 27) that SCC applicants were encouraged to consider when developing ideas for their smart city demonstration to address real-world issues and challenges that residents and cities face.

Aligning Columbus’ goals with USDOT’s Vision Elements required a holistic approach to addressing the City’s transportation challenges. Each project addressed multiple USDOT Vision Elements. The specific achievement and how each project satisfied the elements was not always what was originally anticipated; however, the City’s commitment to keeping USDOT’s vision was always at the forefront of the Smart Columbus planning and deployment efforts.

FIGURE 27: SMART COLUMBUS PROGRAM ALIGNMENT WITH USDOT SMART CITY VISION ELEMENTS
SUSTAINABILITY

The SCC sought projects that would be sustainable, and the City worked closely with stakeholders to establish projects that could take hold and continue beyond the Cooperative Agreement. Working together as a region ensured there was adequate investment from public, private, and institutional sources to sustain the Smart Columbus Program vision both during the demonstration and beyond. With the study phase largely completed, Columbus is continuing to support the advancement of the SCOS, EPM, CVE, SMH and MMTPA projects. The City’s Department of Public Service has taken ownership of these projects and identified funding for operations, maintenance, and enhancements.

- The City will own the SCOS, continuing to provide data-driven analytics to evaluate mobility and transportation investments and help City departments optimize safety and efficiency. The Operating System will continue to serve the needs of the City by collecting data and providing analytics tools for use by the City and the general public.
- EPM provided important enhancements to the ParkColumbus app, which will continue to be one of the key solutions used by the City’s Division of Parking Services to provide accessible, equitable and predictable mobility and parking options for all residents, guests and visitors.
- CVE, RSU and OBU vendors are funded to operate and maintain their assets for a period of 15 months after the demonstration; the City is also continuing coordination with DriveOhio and the City of Dublin to test interoperability with other CV deployments managed by DriveOhio.
- The City’s Department of Public Service will take over the six SMHs, and, as part of its mobility plan, the City is studying neighborhoods and corridors for additional hub locations.
- The City will sustain the MMTPA “Pivot” app through January 2022. Basic features and functionalities will be enhanced, and the app will be improved to include gamification and rewards for using cost-effective and environmentally friendly modes of transportation, as well as accommodating the ever-changing landscape of mobility providers.

Beyond the term of the Cooperative Agreement, the Smart Columbus initiative will continue as a public-private partnership co-led by the City of Columbus and The Columbus Partnership, with a charge that extends beyond mobility, and positions the organization as an agile, collaborative innovation lab for the city of the future. As such, Smart Columbus will serve to accelerate and advance what’s next at the intersection of technology and community good. Projects already underway at Smart Columbus include a broadband pilot that will help to close the local digital divide, an app that will facilitate the criminal record sealing process to create pathways to the middle class for those who have served their time, and a corporate renewable energy buying program that will improve local air quality and fight climate change.

SMART CITY PROGRESS AND OTHER REGIONAL COLLABORATIONS

The Smart Columbus Program was part of a wide range of inspired and invigorated community initiatives that are exploring what’s next in urban mobility and technology. With the USDOT SCC complete and other efforts from the City, COTA, DriveOhio, The Columbus Partnership, MORPC and others established and gaining momentum, regional leaders continue to embrace new concepts and innovation. Community leaders have rallied around Columbus’ emergence as a smart city. Policymakers have been inspired to create further change and new collaborative initiatives have emerged. The following sections summarize the exciting initiatives underway throughout the region.

Autonomous Vehicles

- Automated Driving System (ADS) and Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) Grants – Since the deployment of Smart Circuit and the Linden LEAP, DriveOhio won two grants to advance vehicle automation in the state and region: an 2019 ADS grant for DATA – or “Deploying Automated Technologies Anywhere” – which focused on rural environments and cooperative automation; and a 2020 grant award for truck automation on I-70 between Indiana and Ohio.
- SMARTCenter – In July 2019, the Transportation Research Center (TRC) in East Liberty, Ohio, opened its SMARTCenter (Smart Mobility Advanced Research Test Center), a dedicated 540-acre AV and CV test area within the immense 4,500-acre TRC proving grounds. This new $45 million investment established TRC as North America’s largest AV test facility.

Connected Vehicles

- 33 Smart Mobility Corridor – A $5.9 million demonstration grant from USDOT helped initiate this project, which was led by DriveOhio, Union County and the cities of Marysville and Dublin, Ohio. This project created a 35-mile corridor with redundant fiber network and more than 100 dedicated short-range communications (DSRC) devices along US-33 through Marysville and Dublin. Both Columbus and Dublin are planning on extending the fiber network and DSRC installations to the point where they meet in Northwest Columbus to create an expanded, interoperable CVE.
The 33 Smart Mobility Corridor partners were selected for an opportunity with the Institute of Transportation Engineers to conduct interoperability testing among these deployments.

- **Vision Zero** – Joining a national road safety initiative, Columbus’ Vision Zero Columbus Action Plan lays out a strategy to pursue the goal of zero fatalities and serious injuries from crashes on city streets. The Action Plan identifies a High Injury Network of city streets that have a higher density of fatal or serious crashes where injuries and fatalities frequently involve vulnerable road users such as pedestrians, bicyclists and motorcyclists. With the current CVE infrastructure remaining in operation (and licensed by the Federal Communications Commission for the foreseeable future), this infrastructure and potential future expansion of the CVE network can help reduce crashes and improve safety for all roadway users.

**Shared Mobility**

- **LinkUS** – LinkUS is Central Ohio’s transformational and comprehensive mobility initiative unveiled in June 2020, and is jointly led by the City, COTA, MORPC and Franklin County, with private sector and neighborhood partners.

LinkUS is intended to serve as an umbrella program for all mobility implementation efforts in the region. The innovative approach will include high capacity and advanced rapid transit, bikeways, green space, pedestrian improvements, and focusing land development along major roadway corridors throughout Central Ohio.

The initiative is actively seeking solutions to address traffic congestion, provide new mobility options, expand access to opportunities, and promote equity and economic vitality along key regional growth corridors.

Projects such as SMH, MMTPA and CVE provide examples for such solutions and hold potential to contribute to what will be deployed through this promising initiative.

- **Growth of the Shared Mobility Ecosystem** – The number of mobility providers serving Columbus has expanded greatly during the past five years. Through active attraction efforts, Columbus introduced Zipcar, Chariot, Bird, Lime, Spin scooter- and bike-sharing services to the market and fostered the foundation of homegrown startups EmpowerBus and SHARE Mobility.

**Electric Vehicles**

- **Statewide Charging Strategy** – In 2020, DriveOhio developed a statewide approach to EV charging and published a strategic plan to assess needs for EV charging, primarily along Ohio’s highway corridors. The report identifies DC Fast Charging gaps in Interstate, U.S. highway and state route corridors, and identifies options to fill them.

**Intelligent Mobility**

- **COTA Fare Management System Upgrade** – In summer 2020, COTA initiated procurement of a new fare management system. In working on the MMTPA and CPS project requirements at the start of the Smart Columbus Program, COTA’s existing fare system was a constraint that was difficult to accommodate into the user needs and requirements. However, the COVID-19 pandemic placed an increased priority on contactless payment for COTA.

With this concern, as well as a desire for other improvements to fare management, COTA approved a contract with Masabi in October 2020, which is expected to be completed in 2021, and integrated with Pivot. This new solution will be account-based, multimodal, and will use an open architecture that is scalable to support growth, and capable of accepting a variety of payment types, in alignment with the original concept for the MMTPA.

- **COTA Traffic Management and Predictive Analytics Artificial Intelligence System** – In December 2020, COTA announced this first-of-its-kind project, which will improve traffic safety and reduce travel time for transit users across 13 central Ohio counties through a cloud-based connected mobility platform owned and operated by Waycare Technologies. The project is made possible by a $1.7 million Integrated Mobility Innovation Demonstration Research Grant awarded by USDOT to COTA and 13 additional partners.

The system will be the largest of its kind in the country and the first involving public transit agencies.
CONCLUSION

A key tenet of the Smart Columbus Program was managing in an agile and adaptable way, which allowed the program to plan and react to changing staff, partners, priorities and technology capabilities. A majority of the eight projects will move ahead in some form or fashion. The City is proud that, even though projects were removed from the original portfolio, many were implemented through other means. Even for projects that are not continuing, the knowledge and lessons that were learned have helped to increase awareness of emerging technologies and their benefits to all residents in Columbus.

Managing stakeholder expectations and understanding the importance of communications was a key activity in Columbus’ ability to mitigate risk and improve both awareness and technology adoption.

Ultimately the City used the Smart Columbus Program as a springboard to innovation. More importantly, the program empowered residents to live their best lives, as demonstrated by several important and quantifiable results. A few of the many great examples are the MAPCD project empowering individuals to travel independently for the first time; making mobility options more accessible for the Linden community through the construction of the SMHs in the neighborhood; enabling residents to reserve and pay for parking in advance (and check the likelihood of finding an on-street space) through the ParkColumbus app; and the CVE project training local automotive shops on the installation, use and operation of connected vehicle technology.

These examples are among many that reveal the community impacts of the program, both big and small.

Projects from this portfolio will be sustained to continue to serve the mobility needs of Columbus residents, and the partnerships and project management methodologies honed through the program will benefit the community for years to come. Through implementation of the SCC, the projects have created short- and long-term impacts for the Columbus community and created a replicable playbook that other cities may build upon to have similar effects across the nation. The Smart Columbus Program has also added to the knowledge base for smart cities projects, advancing the development of multimodal and MAPCD-type projects, spurring research into the benefits of prenatal trip assistance, and helping advance AV and CV technology.

Smart is just the START.

ENDNOTES

1 Source: Accenture

2 Paratransit is a subsidized transit service that provides pickup and drop-off for individuals who are unable to use regular fixed-route transit services (for example, because of a developmental disability). Paratransit is expensive for transit agencies to provide, and high demand often means that trips need to be scheduled well in advance, limiting mobility.

3 https://www.its.dot.gov/research_archives/attri/index.htm

4 Infant mortality is defined as the death of an infant before age 1 and is a global indicator for population well-being.

5 Even in communities with high rates of infant mortality, most individuals have access to a smartphone and can navigate a mobile app to schedule a ride. The PTA project’s provisions of on-demand transportation and flexibility in available destinations (e.g., the food bank or grocery store) increases users’ satisfaction, which makes them more likely to use the available NEMT services.

6 Grant regulation 2 CFR §200.313(c)(2) allows the federal government to approve temporary use of grant equipment for non-federally funded programs or projects, provided that such use will not interfere with the work on the projects or program for which the grant equipment was originally acquired.

7 The Linden-McKinley STEM Academy is a public Middle School and High School with a curriculum that focuses on science, technology, engineering, and math (STEM).