SYSTEM ARCHITECTURE AND STANDARDS PLAN WEBINAR
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PURPOSE OF THIS WEBINAR
• Share concept development activities from Smart Columbus with stakeholders

WEBINAR CONTENT
• Smart Columbus program overview
• Document purpose and overview
• Development process and tools
• High-level system architecture for Smart Columbus
• Standards
• Lessons learned
• How to stay connected
• Stakeholder Q&A

WEBINAR PROTOCOL
• All participant lines have been muted during the webinar in order to reduce background noise
• Questions are welcome via chatbox during the Q&A Section
• The webinar recording and presentation materials will be posted on the Smart Columbus website

TODAY’S AGENDA
SMART COLUMBUS
OVERVIEW
$40 MILLION
78 APPLIED • COLUMBUS WON

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

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

OUTCOMES:
- SAFETY
- MOBILITY
- OPPORTUNITY
- ENVIRONMENT
- AGENCY EFFICIENCY
- CUSTOMER SATISFACTION

THE CITY OF COLUMBUS
ANDREW J. GINThER, MAYOR

U.S. Department of Transportation
USDOT PORTFOLIO

ENABLING TECHNOLOGIES
- CONNECTED VEHICLE ENVIRONMENT

ENHANCED HUMAN SERVICES
- MULTIMODAL TRIP PLANNING/
  COMMON PAYMENT SYSTEM
  - SMART MOBILITY HUBS
  - MOBILITY ASSISTANCE
  - PREGNATAL TRIP ASSISTANCE
  - EVENT PARKING MANAGEMENT

EMERGING TECHNOLOGIES
- CONNECTED ELECTRIC AUTONOMOUS VEHICLES
USDOT PORTFOLIO

Connected Vehicle Environment
- 100+ roadside units
- 1,500-1,800 on-board units
- 1,240 light duty vehicles
  - 430 transit vehicles
  - 110 emergency vehicles
  - 12 freight vehicles

Connected Electric Autonomous Vehicles
- Scioto Mile Deployment (May Mobility)
  - December 2018-September 2019
  - 6 vehicles
- Linden Deployment (EasyMile)
  - January 2020-January 2021
  - 2-3 vehicles

Smart Mobility Hubs
- 6 locations to facilitate first-mile/last-mile connections
  - 2 of the 6 locations are also CEAV stops
- Anchored by an interactive kiosk
Operating System
- Big data and complex data exchange
- Analytics and visualization
- Data aggregation, fusion and consumption
- Replicable and scalable

Multimodal Trip Planning App
- Publicly available app (Pivot)
- Backed by Common Payment System

Prenatal Trip Assistance
- Research study to improve transportation for moms-to-be
- Up to 500 participants

Mobility Assistance
- Research study with app for turn-by-turn navigation
- Increase independence
- Up to 30 participants

Event Parking Management
- Publicly available app (ParkColumbus)
- Probability of on-street parking
- Reserve private lot/garage spaces
SYSTEM ARCHITECTURE AND STANDARDS PLAN: DOCUMENT PURPOSE & OVERVIEW
Define System Architecture

Identify associated standards

Document the lessons learned
OVERVIEW

- This plan presents the following views for each of the projects:
  - Physical View
  - Enterprise View
  - Communications View
  - Functional Viewments

- Standards:
  - Identifies information exchange needs between systems that are supported by standards
  - Documents applicable standards that will be used to ensure interoperability
  - Identifies needs for new standards in emerging areas

Source: USDOT Architecture Reference for Cooperative and Intelligent Transportation
• The systems engineering methodology for each project varied
• Architecture development began during the procurement and/or requirements phase for each project
  ◦ Draft followed requirements
  ◦ Final followed vendor selection and aligned with system design/development

<table>
<thead>
<tr>
<th>Project</th>
<th>V-Model</th>
<th>Agile</th>
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<tbody>
<tr>
<td>Smart Columbus Operating System</td>
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<td>Connected Vehicle Environment</td>
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<td>Multimodal Trip Planning Application</td>
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<td>Common Payment System</td>
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<td>Mobility Assistance for People with Cognitive Disabilities</td>
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<td>Prenatal Trip Assistance</td>
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<td>Smart Mobility Hubs</td>
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<td>Event Parking Management</td>
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<td>Connected Electric Autonomous Vehicles</td>
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</table>
ARCHITECTURE VIEWS AND PURPOSE

Source: USDOT Architecture Reference for Cooperative and Intelligent Transportation
BY THE NUMBERS

• Eight Projects:
  o Four architectures per project
    ▪ Multiple figures and tables for each architecture

• Standards:
  o Communications
  o Connected Vehicle
  o Privacy
  o Quality
  o Vehicles
GUIDANCE

• National ITS Architecture

• ARC-IT:
  o ISO/IEC/Institute of Electrical and Electronics Engineers (IEEE) 42010:2011
  o Defines data and messages and the full environment in which stakeholder concerns are satisfied
  o Four Views:
    ▪ Physical, Enterprise, Communication and Functional

• SET-IT:
  o Service packages: describe portions of each of the four views that the Architecture needs to implement a service.
  o Not intended to tie to specific technology

• Regional ITS Architecture:
  o Ohio Statewide ITS Architecture (Mid-Ohio Regional Planning Commission)
PROCESS

**INPUTS**

- SET-IT (service packages) – ARC-IT 8.2
- Regional ITS Architecture
- Concept of Operations
- Requirements

**CUSTOMIZATION**

- City and engineering teams
- Stakeholders

**PROGRAM**

- Overlaps
- Interfaces

**INPUTS**

- USDOT Comments
- ARC-IT 8.3
- Interface Control Document
- System Design Document
- Architecture Changes and Updates (Agile)

**CUSTOMIZATION**

- City and engineering teams
- Stakeholders
- Vendor teams

**PROGRAM**

- Overlaps
- Interfaces
## SCHEDULE

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<td>Final Smart Columbus architecture</td>
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**Milestones**

- [ ] Indicates milestone completion.
SYSTEM ARCHITECTURE FOR SMART COLUMBUS DEMONSTRATION
## PHYSICAL LEGEND

### Flow Time Context
1. Now
2. Recent
3. Historical
4. Static

### Flow Spatial Context
- A - Adjacent
- B - Local
- C - Regional
- D - National
- E - Continental

### Flow Routing
- (d) - Routed through a Data Distribution System
- Abbr
- Terminal
- Project

### Elements
- Center
- Field
- Vehicle
- Traveler
- Support
- People
- System Boundary
- Site Amenities

### Flow Status
- Existing
- Project
- Out of Scope

### Flow Cardinality
- Unicast
- Multicast
- Broadcast

### Flow Control
- Transaction initiated by left-hand party
- Receipt acknowledged

### Flow Security
- Clear text, No Authent
- Encrypted, No Authent
- Clear text, Authent
- Encrypted, Authent

### Functional Objects
- Existing
- Project
## Communications Profile Architecture View

### Layers of ARC-IT Communications Model
- **Source Physical Object**
- **ITS Standard**
- **Communications Profile Name**
- **Protocols**
- **Information Flow**
- **Destination Physical Object**

### World Wide Web Browser / JSON / Wide Area Wireless FLOWS

<table>
<thead>
<tr>
<th>ITS Application Information Layer</th>
<th>Information-Layer-Standard</th>
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<tbody>
<tr>
<td>Application Layer</td>
<td>IETF HTTPS, IETF SFTP, IETF WebSockets</td>
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<tr>
<td>Presentation Layer</td>
<td>W3C XML, W3C HTML5, IETF JSON, IETF GZIP, W3C CSS, IETF CSV</td>
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<tr>
<td>Session Layer</td>
<td>IETF TLS, Docker*</td>
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<tr>
<td>Transport Layer</td>
<td>IETF TCP</td>
</tr>
<tr>
<td>Network Layer</td>
<td>IETF IPv4, IETF IPv6</td>
</tr>
<tr>
<td>Data Link Layer</td>
<td>Wide Area Wireless WAN</td>
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<tr>
<td>Physical Layer</td>
<td>Wide Area Wireless WAN</td>
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</table>

<table>
<thead>
<tr>
<th>Security Plane</th>
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<tbody>
<tr>
<td>IETF HTTP Auth, IETF TLS</td>
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<tr>
<td>Name</td>
<td>Source</td>
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<td>Intersection geometry</td>
<td>RSE</td>
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**Information Flow**
- Source Physical Object
- Destination Physical Object
- Standard
- Profile
## FUNCTIONAL VIEW - EXAMPLE

<table>
<thead>
<tr>
<th>Physical Object</th>
<th>Functional Object</th>
<th>Process</th>
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<tbody>
<tr>
<td>MMTPA</td>
<td>MMTPA API</td>
<td>Receive Requests and Send Responses</td>
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<td></td>
<td>TIC Data Collection</td>
<td>Collect Misc. Traveler Information</td>
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<tr>
<td></td>
<td></td>
<td>Collect Transit Operations Data</td>
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<td></td>
<td></td>
<td>Collect Multimodal Data</td>
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<td></td>
<td></td>
<td>Process and Send Data (to Operating System)</td>
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<td></td>
<td>TIC Trip Planning</td>
<td>Provide Interface for IK</td>
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<td>Provide Interface for Mobility Providers</td>
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<td>Provide Interface for COTA Back Office</td>
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<td></td>
<td>Provide Trip Planning Information to Traveler</td>
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<td></td>
<td>Confirm Traveler's Trip Plan</td>
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<td></td>
<td></td>
<td>Provide Operator Interface for Trip Planning Parameters</td>
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<td></td>
<td></td>
<td>Manage Traveler Profiles</td>
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<td></td>
<td>Process Travel Services Provider Data</td>
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<tr>
<td></td>
<td></td>
<td>Provide Traveler Alert Interface</td>
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<td></td>
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<td>Provide Vehicle Route Calculation Data</td>
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<td>Provide Operator Interface for Route Parameters</td>
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<tr>
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<td></td>
<td>Manage Trip History</td>
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<td>Collect Feedback</td>
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<tr>
<td>Trip Optimization</td>
<td>Provide Multimodal Route Selection</td>
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<td>Collect Traffic Data</td>
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<td></td>
<td>Calculate Vehicle Route</td>
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<td>Select Transit Route</td>
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<td></td>
<td>Select Other Routes</td>
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<tr>
<td></td>
<td>Provide Traveler With Optimized Trip Route</td>
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</table>
What we will present today:
  o Physical Architecture View – Layer 0
  o Enterprise Architecture View – Diagram

What is not discussed (but is in the document):
  o Physical Architecture View Tables
    ▪ Elements
    ▪ Information Flows
    ▪ Functional Objects
  o Functional Architecture View
  o Communication Architecture View
  o Enterprise Architecture View
    ▪ Table of Agreement and Status
    ▪ Roles and Responsibilities by Phase
SMART COLUMBUS: ARCHITECTURE BY PROJECT
Note: USDOT ITS Data Hub, OSU Researchers, MCOs, 3rd Party Data Sources are part of Data Consumers and Data Producers.
CVE – PHYSICAL VIEW

V2V Basic Safety

Transit Signal Priority

Freight Signal Priority

Emergency Vehicle Preemption

Security and Credentials Management

Vehicle-Based Traffic Surveillance

Intersection Safety Warning and Collision Avoidance

Curve Speed Warning

Vehicle Maintenance

CV System Monitoring and Management
CVE – ENTERPRISE VIEW

Note: Individual Vehicles/Vehicle Systems are not shown for clarity. Vehicles include Vehicle Systems and Vehicle OBEs. Vehicle Owner owns the vehicles and Drivers operate the vehicles and vehicle OBE. Vehicle Usage Agreement may exist between the Driver and Vehicle Owner.

City of Columbus

- Information Exchange Agreement
- Employment Agreement
- Service Agreement
- Agreement for RSU Installation
- Agreement for RSU Installation for County Project

City COTA

- Employment Agreement

Brandmonitor

- Application Usage Agreement

City Public Agency

- OBE Usage Agreement

City Private Vehicle

- OBE Usage Agreement

City COTA

- Employment Agreement

COTA

- Staff Employment Agreement

CORS

- Network Time Source

ODOT

- Maintenance Field Personnel
- Field Maintenance Equipment

SCMS Provider

- OBE Usage Agreement

RSE Supplier

- OBE Usage Agreement

OBE Installer

- OBE Usage Agreement

Vehicle OBE

- OBE Usage Agreement

Emergency Vehicle OBE

Light Duty Vehicle OBE

Heavy Duty Vehicle OBE

Garages

- Agreement for Space Use and Installation

Customer Relations Manager

- Agreement

Public Agency Vehicle Owners

- Agreement for Space Use and Installation

Construction Contractor

- Agreement for RSU Installation
MMTPA – PHYSICAL VIEW

SMART COLUMBUS MULTI-MODAL TRIP PLANNING APPLICATION

LAYER 0: MMTPA

- COTA Back Office
- CEAV Fleet Management System
- 3rd Party Data Sources
- Mobility Provider Central System (MPCS)
- Smart Columbus Operating System (OS)
- Common Payment System (CPS) Back Office

(2C) Center to Center
(2B-C) Wide Area Wireless
(2C) Wide Area Wireless

(2C) Center to Center

Infrastructure Provided
Trip Planning and Route Guidance

MMTPA SYSTEM BOUNDARY

SET-IT

MMTPA

Personal/Wireless Devices (PWD)

Interactive Kiosk

Human Interface

Traveler

Based on ARC-IT Physical Diagram r6 Jan 17 2020 VBV
CPS – PHYSICAL VIEW

SMART COLUMBUS COMMON PAYMENT SYSTEM

LAYER 0: CPS

Common Payment System (CPS) Back Office

COTA Back Office
Mobility Provider Central Systems (MPCS)
NMTPA
EPM Central System (EPMCS)

Financial Centers (FIN)

CPS Web Portal
Service Provider Web Portal
Personal/Wireless Devices (PWD)
Interactive Kiosk

COTA On-Board Payment Equipment (FBO)
Mobility Provider Payment Equipment

CPS SYSTEM BOUNDARY

Laer 0: CPS

Layer 1A-C Center to Center
Layer 2B Center to Center
Layer 2C Wide Area Wireless
Layer 2B Center to Field
Layer 2B Center to Center
Layer 2C Center to Field

Based on ARC-IT Physical Diagram v11 Jan 3, 2020 V0
MAPCD – PHYSICAL VIEW

Layer 0: MAPCD

- Smart Columbus Operating System (OS)
- MAPCD
- Caregiver Personal/Wireless Devices
- Traveler Personal/Wireless Devices
- COTA Back Office
- Infrastructure

Set-IT
Infrastructure-Provided Trip Planning and Route Guidance

Based on ARC-IT Physical Diagram r6 Jan 3 2020
PTA – PHYSICAL VIEW

SMART COLUMBUS
PRENATAL TRIP
ASSISTANCE

LAYER 0: PTA

PTA SYSTEM BOUNDARY

PHYSICAL VIEW

Based on ARC-IT Physical Diagram r6 Jan 10 2020

Infrastructure-
Provided Trip
Planning and
Route Guidance

SET-IT
PTA – ENTERPRISE VIEW

SMART COLUMBUS
PRENATAL TRIP
ASSISTANCE

PTA Central System
PTA Technology Vendor
Traveler Personal/Wireless Devices
Prenatal Traveler
R4B NEMT Mobility Provider System

Managed Care Organizations
Expectation of Data Provision
OSU-MCOs Data Sharing Agreement

City of Columbus
City-MCOs Data Sharing Agreement
City-MCOs Reimbursement Agreement

OS Vendor
PTA Technology Vendor
MCOs-PTA Technology Vendor Service Agreement
MCOs-PTA Technology Vendor Business Associate Agreement

OSU Researchers
OSU-Prenatal Traveler Information Provision Agreement

Personal/Wireless Devices
PTA Central System

OSU
Expectation of Data Provision

MCOs
Expectation of Data Provision

NEMT Mobility Provider
NEMT Mobility Provider-PTA Technology Vendor Service Usage Agreement

NEMT Driver
Driver Personal Information Device

Prenatal Traveler
Expectation of Data Provision

NEMT Mobility Provider
NEMT Mobility Provider-Driver Service Usage Agreement

SMART COLUMBUS
PRENATAL TRIP
ASSISTANCE

PTA Central System
PTA Technology Vendor
Traveler Personal/Wireless Devices
Prenatal Traveler
R4B NEMT Mobility Provider System

Managed Care Organizations
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NEMT Driver
Driver Personal Information Device

Prenatal Traveler
Expectation of Data Provision

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SMART COLUMBUS
PRENATAL TRIP
ASSISTANCE

PTA Central System
PTA Technology Vendor
Traveler Personal/Wireless Devices
Prenatal Traveler
R4B NEMT Mobility Provider System

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Personal/Wireless Devices
PTA Central System

OSU
Expectation of Data Provision

MCOs
Expectation of Data Provision

NEMT Mobility Provider
NEMT Mobility Provider-PTA Technology Vendor Service Usage Agreement

NEMT Driver
Driver Personal Information Device

Prenatal Traveler
Expectation of Data Provision

NEMT Mobility Provider
NEMT Mobility Provider-Driver Service Usage Agreement
CEAV – PHYSICAL VIEW

SMART COLUMBUS
CONNECTED ELECTRIC AUTONOMOUS VEHICLES

CEAV SYSTEM BOUNDARY

CEAV OPERATOR

Other Vehicle OBEs

[1-2A] Short Range Wireless

RSE

MMTPA

(2C) Center to Center

CEAV Fleet Management System

[1-2A] Short Range Wireless

CEAV Passenger

Human Interface

Human Interface

Human Interface

COTA Back Office

[2C] Center to Center

Smart Columbus Operating System (OS)

[2-3C] Center to Center

(1A) Position Location Interface

Location and Time Data Source

V2V Basic Safety

Autonomous Vehicle Safety Systems

Transit Vehicle Tracking

Transit Traveler Information

Transit Security

Transit Passenger Counting

Transit Fleet Operations

Transit Fixed Route Operations

SET-IT

SET-IT

SET-IT

SET-IT

SET-IT
RELATIONSHIPS BETWEEN PROJECTS
OS POINTS OF INTERFACE

Smart Columbus Operating System

CEAV Project
- CEAV Fleet Management System
  - Real-Time Location
  - CEAV Route
  - CEAV Archive Data

CVE Project
- Transit CV Management System
- Traffic CV Management System
  - Data Archive Coordination
  - road network conditions + Data Archive Coordination

MMTPA Project
- MMTPA
  - traveler archive data

EPM Project
- EPM Central System (EPMCS)
  - EPM Archive Data
    - user profile
    - Parking Availability Probability
  - User Feedback
    - Parking Payment Archival Data

Personal/Wireless Devices (PWD)

SMH Project
- Interactive Kiosk (IK) Central Management System
  - Data Feeds
    - SMH Archive Data
    - Administrative, Health, Usage and Monitoring

MAPCD Project

PTA Project
- PTA Central System
  - Trip Data
  - MAPCD
  - SMH Archive Data

PTA Central System

EPM Central System (EPMCS)

MMTPA Project

EPM Project

CEAV Project

CVE Project

SMART COLUMBUS

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MMTPA/CPS – SMH – CEAV POINTS OF INTERFACE
CVE POINTS OF INTERFACE

• Internal
  ◦ Smart Columbus Operating System

• External
  ◦ Vehicle systems
  ◦ School zone management system
  ◦ Traffic signal controller
  ◦ SCMS
  ◦ CORS
  ◦ Network time source
  ◦ Location and time data source

• Interfaces were previously presented in the CVE ICD webinar:
COTA POINTS OF INTERFACE

CEAV Project
- CEAV Fleet Management System
  - transit traveler information coordination

MMTPA Project
- MMTPA
  - transit and fare schedules + transit schedule adherence information
  - transit trip request
  - transit trip plan
  - trip confirmation

CPS Project
- Common Payment System (CPS) Back Office
  - Request Barcode
  - Barcode
  - user profile
  - Request User Profile

OS Project
- Smart Columbus Operating System
  - transit schedule information + Real-Time Arrivals

MAPCD Project
- Trip Updates
APPLICATION OF ITS AND OTHER STANDARDS
## ITS STANDARDS

### Connected Vehicle
- IEEE 1609.2/CAMP SCMS
- ISO 19091
- SAE J2735-2016
- SAE J2945/1
- USDOT RSU 4.1

### Service Positioning
- GTFS/GTFS-Realtime
- SMART Wayfinding Specification

### Signal Controller
- NTCIP 1202-ASC

### Time and Location
- NMEA 0183
- NTP
- NTRIP
## OTHER STANDARDS/REGULATIONS

### Vehicle Standards/Regulations
- USDOT Autonomous Vehicle-Related Standardization Activities
- FMVSS
- Transit Safety Standards
- LADOT Mobility Data Specifications

### Privacy Standards/Regulations
- HIPAA
- PCI-DSS 3.2
- SOC 2

### Quality Standards/Regulations
- AWS Framework
- ISO 9001 QMS
• Multi-modal transportation:
  ◦ Applicability of existing transit standards
  ◦ Mobility Data
    ▪ Los Angeles Mobility Data Specification

• Common payment:
  ◦ Certain standards were applied: PCI-DSS
  ◦ Use of agreements to solidify partnerships, data exchange, payment flow/process
  ◦ Opportunities to expand ITS standards in this area
LESSONS LEARNED
LESSONS LEARNED

• Individual project versus program level
• Time management
• Application of SET-IT
  o Creating awareness of established services packages and associated elements
  o Standard vs. Personalization vs. Customization
• Consistency between projects
  o Clarity in terminology and definitions
• Application of standards
Public comment period open for the System Architecture and Standards Plan:

- March 3 to March 17

Where to find it:

1. View the System Architecture and Standards Plan at:

How to comment:

1. Please email comments to: kldepenhart@columbus.gov
2. Subject line: SASP Comments
3. Include your contact information
4. State whether or not you represent a vendor interest
HOW TO STAY CONNECTED

SMART COLUMBUS INQUIRIES:
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Upcoming Smart Columbus Webinars:

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Webinar recording and materials will be available at ite.org and smart.columbus.gov
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