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Abstract

This Smart Columbus Data Management Plan provides operational information for the use of data within the Smart Columbus Operating System (Operating System). The Operating System is the central data store for all relevant program data within the Smart Columbus demonstration and provides users data through an open data portal web interface as well as Application Programming Interfaces. Smart Columbus uses this plan as a guide to perform the necessary operations for optimum program functionality in addition to properly securing, backing up, maintaining, and sharing the data. The Smart Columbus team also utilizes this plan to support proper privacy procedures and guidelines as defined in the Smart Columbus Data Privacy Plan.
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Chapter 1. Introduction

1.1. PURPOSE OF THE PLAN

The purpose of the Data Management Plan (DMP) is to document how the data within the Operating System is added, made accessible, and/or stored within the Operating System. The DMP also details how the data is created, captured, transmitted, maintained, accessed, shared, secured, and archived. The DMP provides oversight for all eight Smart Columbus projects. Project-level data management development teams have used and will continue to use the guidance of this plan to resolve project-level designs.

Due to the dynamic nature of the Operating System (datasets can be added while operating), some documentation and processes may not be applicable to specific datasets. These will be reviewed and addressed during data curation, when a dataset is initially being evaluated for addition to the Operating System. Additionally, the Operating System may contain dataset metadata for datasets that are hosted on other publicly available systems. In this case, some information and procedures may not be applicable to those datasets.

The DMP is an operational guide for managing the data within the program. The DMP details how and where data is shared, subject to applicable privacy, security, and other safeguards, and how the data is made available to others to enable performance measurement and support independent evaluation.

The Operating System does not collect or store personally identifiable information (PII). While this is the case today, Smart Columbus built out the Smart Columbus Data Privacy Plan (DPP) to include data curation processes detailing how to de-identify a dataset that contains PII or other restrictions.

This DMP satisfies the requirements of Cooperative Agreement No. DTFH6116H00013 between the USDOT and the City of Columbus. It follows the USDOT guidance for creating Data Management Plans provided at https://ntl.bts.gov/public-access/creating-data-management-plans-extramural-research.

As mentioned above, this DMP will be updated regularly as the Operating System continues to mature and offer more features, functionality, and datasets.

1.2. ORGANIZATION OF THE PLAN

This DMP is organized into the following chapters:

- Chapter 1. Introduction
- Chapter 2. References
- Chapter 3. Data Description and Management
- Chapter 4. Standards Used
- Chapter 5. Sharing and Protecting Data
- Chapter 6. Re-Use, Redistribution, and Derivative Products Policies
- Chapter 7. Archiving and Preservation Plans
- Appendix A. Acronyms and Definitions
- Appendix B. Glossary
1.3. PROGRAM DESCRIPTION

In 2016, the U.S. Department of Transportation (USDOT) awarded $40 million to the City of Columbus, Ohio, as the winner of the Smart City Challenge. With this funding, Columbus intends to address the most pressing community-centric transportation problems by integrating an ecosystem of advanced and innovative technologies, applications, and services to bridge the sociotechnical gap and meet the needs of residents of all ages and abilities.

With the award, the City established a strategic Smart Columbus program with the following vision and mission:

- **Smart Columbus Vision**: Empower residents to live their best lives through responsive, innovative, and safe mobility solutions.

- **Smart Columbus Mission**: Demonstrate how Intelligent Transportation Systems (ITS) and equitable access to transportation can have positive impacts on every day challenges faced by cities.

To enable these new capabilities, the Smart Columbus program is organized into three focus areas addressing unique user needs; enabling technologies, emerging technologies, and enhanced human services. This portfolio of technical concepts was divided into eight projects as shown in Figure 1: Smart Columbus Framework.

![Figure 1: Smart Columbus Framework](source: City of Columbus)

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1 While the City of Columbus Smart Columbus Program Office has grown to oversee many innovation initiatives, the scope of this document is any data that is in the Operating System or that is in any of the other USDOT-funded projects. The City of Columbus USDOT-funded Smart Columbus program will be known throughout this document as Smart Columbus.
The Columbus Smart City Demonstration Projects are:

- **The Smart Columbus Operating System (Operating System)**
  
  The Operating System is the essence of Smart Columbus – it brings to life the innovation. The Operating System is designed and built to collect data from a variety of inputs; including public, nonprofit, education-based, and private sector contributors. These inputs may come from other systems, devices, and people. All of which are a critical part of building this ecosystem of innovation. Data is available for analytics and visualization as well as for artificial intelligence required by various smart city applications. The Operating System is a platform designed for big data, analytics, and complex data exchange. It captures the data and provides a means for multitenant access to aggregate, fuse, and consume data.

  Datasets housed in the Operating System include the Smart Columbus demonstration projects, traditional transportation data, and data from other community partners, such as food pantries and medical services. The Operating System is scalable and demonstrates the potential for serving city and private sector needs well beyond the life of the Smart City Challenge award period.

- **Connected Vehicle Environment (CVE)**
  
  Cars, trucks, and buses will talk to the infrastructure and talk to one another to reduce traffic congestion and increase safety. The CVE will connect up to 1,500 vehicles and over 90 smart intersections across the region. Safety applications are intended to be installed on multiple vehicle types including transit buses, first responder vehicles, city and partner fleet vehicles, and private vehicles. Applications will be deployed to ensure emergency vehicles and the Central Ohio Transit Agency (COTA) Bus Rapid Transit (BRT) fleet can utilize signal prioritization when needed to ensure safety and efficiency.

- **Multimodal Trip Planning Application (MMTPA)**
  
  The MMTPA provides a robust set of transit and alternative transportation options including routes, schedules, and dispatching possibilities. The application, named Pivot, allows travelers to request and view multiple trip itineraries and make reservations for shared-use transportation options such as bike-sharing, ride-hailing and scooter-sharing. Users will be able to compare travel options across modes, and plan and pay for their travel based upon current traffic conditions and availability of services.

- **Smart Mobility Hubs (SMH)**
  
  Smart Mobility Hubs have been deployed to serve travelers' needs more effectively by expanding transportation resources and offering access to comprehensive trip planning tools at designated locations. SMH sites are primarily located adjacent to existing COTA CMAX and transit center facilities and help bridge the first-mile/last-mile gap between transit and destination by providing physical space for the consolidation of services such as bike/scooter share, car share, and ride-hailing. Interactive kiosks and public Wi-Fi will be made available to the traveler to view real-time travel information and to book multimodal trip plans via the Pivot app.

- **Mobility Assistance for People with Cognitive Disabilities (MAPCD)**
  
  The City deployed an innovative smartphone application for people with cognitive disabilities to transition off costly paratransit services and increase independent travel on the fixed-route bus system. The application was piloted with 20 individuals in the Columbus region in partnership with the COTA and The Ohio State University (OSU). The application included a highly accurate, turn-by-turn navigator designed to be sufficiently intuitive such that older adults and groups with disabilities including the cognitively disabled could travel independently.
• **Prenatal Trip Assistance (PTA)**
  The City developed a system for providing flexible, reliable, two-way transportation to expectant mothers through a smartphone application, website and call center. The project uses Medicaid Managed Care Organization brokered non-emergency medical transportation services.

• **Event Parking Management (EPM)**
  The City will integrate parking information from City owned parking meters and multiple parking facilities into a single availability and reservation services solution. This will allow travelers to search for and reserve parking in advance or on the go. More direct routing of travelers during large events is expected to reduce congestion during those times.

• **Connected Electric Autonomous Vehicles (CEAVs)**
  CEAVs that operate in a mixed-traffic environment interacting with other vehicles, bicyclists, and pedestrians have been deployed. The project provides an accessible and easily expandable first-mile/last-mile transportation solution to the region by deploying a fleet of multi-passenger CEAVs that leverage the enhanced connectivity provided by the CVE and MMTPA.

### 1.4. **CORE FUNCTIONS OF THE OPERATING SYSTEM**

Figure 2: Core Functions of the Smart Columbus Operating System depicts high-level system elements of the Operating System.

![Figure 2: Core Functions of the Smart Columbus Operating System](image)

*Source: City of Columbus*

The Operating System is a platform for smart cities development and operation. It consists of several core functions, which can be leveraged across the Smart Columbus program, as well as other functions (defined below) that will specifically enhance and support the “Smart Applications.” The Operating System has the following core functions:

• **Data Environment**: The orderly ingestion and tagging of many forms of data from real-time, to slow-moving, or manually uploaded data.
• **Data Lake**: A storage repository that holds a massive amount of raw data in a secure way and makes it available to all the other supported operations in the system.

• **Security and Privacy**: To ensure trust, it is imperative that the Operating System manage the users and systems that have access to it.

• **Scalable Capacity**: The Operating System is “scalable” and “elastic” which means that it can grow and shrink to meet the demand of the system at any given time.

• **Shared Services Environment**: Application components can be housed and made available to any number of applications connected to the Operating System.

• **Data Research Environment**: Agencies will be supported with user dashboards and visualizations to help improve their data-driven decision making.

• **Analytics**: The ability to query and combine datasets made available through Application Programming Interfaces (APIs), visualization tools within the Operating System and integrating with tools external to the Operating System.

### 1.5. SYSTEM OF SYSTEMS OVERVIEW

The Smart Columbus program has many interrelated systems that work together to provide a System of Systems (SoS). Information from these systems is shared in the Operating System. Both real-time and archived data is maintained in the Operating System for use by other Smart Columbus projects and future applications. The SoS provides Smart Applications, Smart Vehicles, and Smart Infrastructure to travelers in the Columbus area. The Operating System enables the SoS to share data with many other external systems to provide the framework for the services provided.

**Figure 3: System of Systems External Context Diagram** shows the relationship of the SoS to the external travelers and systems.

![Figure 3: System of Systems External Context Diagram](source: City of Columbus)
The Smart Infrastructure element contains the Roadside Units, Smart Mobility Hubs, and corresponding network that enable interactions between these items and the Operating System. Smart Vehicles include the Onboard Units that will be installed in vehicles and include various vehicle types. Smart Applications include the software-oriented solutions that will deliver other Smart Columbus project capabilities such as multimodal trip planning and prenatal trip assistance. The Operating System is the repository for all Smart Infrastructure and Smart Vehicles performance data as well as the shared services platform; allowing the Smart Applications to be directly integrated.
Chapter 2. References

Table 1: References lists documents and literature referenced during the development and update of this document.

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Source: City of Columbus
Chapter 3. Data Description and Management

Data within the Operating System will be made available in different formats such as Comma-Separated Values (CSV), Extensible Markup Language (XML), JavaScript Object Notation (JSON), GeoJSON, Shapefiles and many others. Datasets are added by the Operating System product team through a data curation process.

Due to the dynamic and ongoing nature of the data curation process, the number of datasets and resources managed and made available by the Operating System will constantly change. When adding data to the Operating System, datasets need a description and other metadata from both the dataset and the elements that make up the data. Metadata adds important value to data to allow humans and machines to properly understand what information the dataset holds and to improve the usefulness of data. In addition to the metadata, a data dictionary provides column-level details about a dataset and provides guidance on its interpretation, accepted meanings, and representation. The metadata included in a data dictionary can assist in defining the context, scope, and characteristics of data elements, as well as the rules for its usage and application; helping humans and machines better understand a given dataset.

Data is categorized upon ingestion as either restricted or public data. As noted above, neither categorization includes data with PII. Public data is defined as data that is available for public consumption. Restricted data is any data that is held for performance measure evaluation per the USDOT Cooperative Agreement or is held based on a private entity’s contract with the City of Columbus. If the Operating System is further developed to ingest PII, PII data would be categorized as restricted.

Smart Columbus created an inventory of the data that is or will be collected through the Smart Columbus program. The inventory contains the following information about each dataset: name, type, source, responsible party for maintenance, collection approach, frequency and period of collection, expected users, value of the data, whether the data contains PII and where the data is located. All projects are not live so this inventory will continue to be updated as projects go live and start actively collecting data.

3.1. METADATA

The Operating System has been built to conform with the Federal Project Open Data Metadata Schema v 1.1. While this metadata schema is widely adopted and based upon Data Catalog (DCAT) standards, the Operating System has the capability of extending the metadata to contain additional fields that may be enforced on a per-dataset basis, on a dataset level, or on a system level. Metadata can be applied at the dataset, resource, and data element levels. A resource is part of a specific dataset that can be consumed and made available in multiple formats (CSV, JSON, XML, etc.). A resource is comprised of one or more data elements. This represents the minimum capability of the system; over the course of the program additional metadata standards may be supported.

Metadata related to the dataset shall, at a minimum, include the following fields in addition to other system-level metadata (ID numbers, etc.):

2 https://project-open-data.cio.gov/v1.1/schema/
3 https://www.w3.org/TR/vocab-dcat/
• Dataset Project Open Data Fields
  ○ Title
  ○ Description
  ○ Tags (keywords)
  ○ Modified date
  ○ Publishing organization
  ○ Point of contact name and email address
  ○ Public access level
  ○ License
  ○ Rights – detailed information if access level is not “public”
  ○ Spatial applicability of the dataset
  ○ Temporal range of the dataset (start and end dates)
  ○ Distributions (details of the resources)
  ○ Frequency – how often the dataset is published
  ○ Data standard – Uniform Resource Locator (URL) to a format the dataset would conform to
  ○ Data dictionary – URL to a data dictionary
  ○ Data dictionary type – file format of the data dictionary
  ○ Collection – if the dataset is part of a collection
  ○ Release date – date of formal issuance
  ○ Language – language of the dataset
  ○ Homepage URL – URL of a page related to the dataset
  ○ Related documents – URLs to documents that are related
  ○ Category

• Resource Metadata
  ○ Date last updated
  ○ Date metadata updated
  ○ Created date
  ○ Format (CSV, JSON, XML, etc.)
  ○ License

The Operating System project team is responsible for populating the metadata fields for datasets and every effort will be made to ensure that they are populated and correct during the data curation process. To comply with the Project Open Data metadata standards, the Operating System will provide a JSON formatted catalog of all datasets and resources in the data.json file located on the root directory of the Operating System website: https://www.smartcolumbusos.com/data.json.
3.2. DATA DICTIONARY

A data dictionary provides machine-readable detailed information for a dataset and its columns. For data shared with the Operating System, it is preferred that a data dictionary be provided by the source data provider in a machine-readable form such as CSV. The Operating System houses many datasets from many diverse sources, each with its own data dictionary, for which the URL is provided in the metadata of the resource. If a data dictionary exists for a dataset, the URL will be in the “describedBy” field of the dataset metadata if accessed through the API and displayed in the “Data Dictionary” field if viewing through the Operating System website (as prescribed by the Federal Project Open Data Metadata Schema).

During the initial data curation process for datasets in which a data dictionary is unable to be provided, a data curator will work with the source data provider to develop a data dictionary. This will entail methods around creating data dictionaries such as defining business terms and relating them to column names, detailing the values of any codes, and providing detailed information on what each column represents. For example, if columns from different tables are address_1, one_address, first_line_address, user_address, and company_address, and if they all are used the same way with the exact same definition, the business term might be “Company Address.” Using the same column names, if the data constituted a person instead of a company, “Personal Address” would be a business term for user_address and the rest would remain the under the Company Address classification.

To ensure consistency in data dictionary fields, mapping to a standard such as the National Information Exchange Model\(^4\) will be performed upon ingestion if there is an appropriate standard that would apply to the data. This will help support the data communities’ development within the Operating System.

3.3. SIZE AND SCALE OF DATA

Because the number of datasets located in the Operating System will continually grow as more Smart Columbus projects are brought online and additional datasets are identified, determining the size and scale of the data will be an ongoing effort. The Operating System project team will evaluate current usage statistics monthly and make determinations regarding whether cloud data storage space needs to be scaled up. The cloud-based architecture of the Operating System allows storage space to remain flexible as necessary.

Additionally, when a new project is ready to come online and provide data into the Operating System, an initial analysis will be performed by the Operating System project team that will estimate the amount of data by estimating the number of data points, the data frequency, and individual entry sizes. The Operating System product team will work closely with the other project teams to ensure all data sizing and velocity needs are met so that the Operating System remains stable and can ingest the amount of data necessary to meet program goals.

Data that is continuously streamed into the Operating System is added to the data storage for that project and continually monitored for total space usage. During ingestion, the data size is reviewed and a decision is made whether to control the size of the data. For example, instead of saving all events, it may be decided to only keep the latest event. Also, policies will be established to decide whether to purge everything older than a set number of days in compliance with Ohio public records law. As the Operating System includes a data tracking and grading system, datasets that go unused or receive low performance scores will be considered for deletion. This decision will be made on a dataset by dataset basis depending upon the use cases supported and in compliance with Ohio public records law.

\(^4\) National Information Exchange Model, or NIEM, [https://www.niem.gov/](https://www.niem.gov/)
3.4. DATA ACQUISITION/CREATION

There are three primary methods of data acquisition within the Operating System:

1. A manual request submittal through the Operating System website at https://www.smartcolumbusos.com/share-your-data, or

2. The Operating System project team and data curators identify datasets that would be beneficial to the program, or

3. Other Smart Columbus project team(s) identify data needs or data to share and bring to the attention of the Operating System project team.

After a data-sharing request has been made, a formal data curation process (see Figure 4: Data Ingestion Workflow) is conducted by the Operating System project team. This process involves working with the source provider to determine what data can be shared, validating if the data contains any PII, what formats would be best suitable, what metadata is available, and identifying any additional resources such as data dictionaries or web pages that would help users better understand the data. Special consideration is given to the risk that a dataset may represent as a method of re-identifying persons through the combining of the ingested dataset with other datasets in the system.

The Operating System project team then determines and develops the method of ingestion for the data and metadata. Data is initially processed within an isolated environment to be validated and approved. Once validated, the process continues, and data is moved to the production website where the data is made available to users of the Operating System.

Data-sharing requests are prioritized based on various factors during the data curation process:

- Value and relativity of data to Smart Columbus projects
- Current availability of data
- Complexity of ingestion into the Operating System, including de-identifying any PII data
- Size of data
Figure 4: Data Ingestion Workflow

Source: City of Columbus
3.5. PERFORMANCE MEASUREMENT DATA

Smart Columbus has a Performance Measurement Plan (PfMP) that details out how the Operating System and each project will measure their performance. Specifically, the Operating System is conducting user surveys to identify the use and usability of the data.

The Operating System is used to house, publish, and distribute Smart Columbus program performance measure data and categorizes the data as public or restricted. Authorized users from OSU who are conducting project evaluations require access to data collected specifically pursuant to the PfMP. The data that is categorized as public or restricted is available to OSU project evaluators through the Operating System user interface and through an API to query the data. Data that is not ingested by the Operating System due to it containing PII is collected directly by project evaluators.

3.6. EXTERNAL INGESTION INTERFACES

External interfaces provide a method for other projects within the Smart Columbus demonstration to interface with the Operating System to send data to the Operating System. The Operating System contains multiple external interfaces for data ingestion: the API, secure file transfer protocol (SFTP) and batch upload.

- **API**: The Operating System ingests data through PUSH and PULL API services.
  - **PULL APIs**: An external vendor creates an API and feeds the project data into it. The Operating System PULLS the project data from this API.
  - **PUSH APIs**: The Operating System creates an API. External vendor PUSHES the project data into this API.
- **SFTP**: An external vendor creates an SFTP and provides credentials (Username, password, IP address, and File Location) to the Operating System. The Operating System sets up a Cron job and pulls data from this site.
- **Batch upload**: An external vendor sends batches of data through an email, SFTP or other data sharing mechanism. The Operating System manually ingests this data. (This is not used for project data but for acquiring key performance indicators.)

3.7. FREQUENCY OF DATA COLLECTION

During the data curation and discovery process, the Operating System data curator works with the source data provider to determine how often the data is collected, updated, and published. This information determines what methods are used to get the data and metadata into the Operating System. This can be defined down to near real-time. A metadata field, frequency, describes how often the data is updated. The metadata fields identified in Table 2: Data Collection Frequency Metadata Fields provide detailed information about the frequency of data collection.
Table 2: Data Collection Frequency Metadata Fields

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>How often the dataset is published</td>
</tr>
<tr>
<td>Last Updated</td>
<td>Date/Time that the data was last updated. ISO-8601(^5) repeating duration</td>
</tr>
<tr>
<td>Temporal</td>
<td>Start and end date for data</td>
</tr>
<tr>
<td>Release Date</td>
<td>Date of issuance</td>
</tr>
</tbody>
</table>

Source: City of Columbus

3.8. RELATIONSHIP OF NEW DATA TO EXISTING DATA

The Operating System is configured such that data updating strategies can be defined by the data curator. Common strategies include file replacement and merge and rolling sync. The action taken on a dataset may be recorded in the metadata.

3.9. CONCEPT OF ORGANIZATIONS

The Operating System uses the concept of Organizations as a key concept to group datasets to an entity that provides the dataset. This enables users of the Operating System to use the source entity’s name as a filter when querying for datasets. The Operating System project team can add new Organizations through the data curation process and group datasets together from that source entity so that related entity metadata is automatically provided with the data. This allows the data, although similar, to be managed separately when coming from various sources. The Operating System and API allows users to query similar data across multiple Organizations to create a “mash-up” of diversely sourced data. While the concept of Organizations within the Operating System will stay constant, the implementation and definition of it may change as future requirements are defined and the projects mature.

Examples of Organizations within the Operating System include:
- Ohio Geographically Referenced Information Program (OGRIP)
- Mid America Association of State Transportation Officials (MAASTO)
- City of Columbus
- COTA
- Ohio Department of Transportation (ODOT)

3.10. DATA USERS

Users of the Operating System are diverse; users include community members, technology developers, researchers, companies, government entities, and others. The Operating System has been designed to allow all types of users easier and better access to data for use and analysis. After users have access to the data and APIs, they can use the data to create web applications, or import into many different data analysis and/or visualization tools. The usage pattern varies from data source and metadata discovery to flat file downloads and on-demand API requests.

\(^5\) International Organization for Standardization
Each type of user has different habits and use cases with the Operating System. For example:

- **Community members**: General interest and browsing available datasets for short periods of time using online visualization tools
- **Technology developers**: Targeted interest in specific datasets, continued or repetitive use of the same datasets through APIs or download links
- **Researchers and project evaluators**: Downloading datasets or querying through the provided API for either local analysis or analysis in the online analytics environment

### 3.11. VALUE OF THE DATA

The Operating System is focused on providing datasets that are valuable to users. While Smart Columbus surveys users on their personal value of the data and also track the usage numbers for each dataset, Smart Columbus understands that value is a subjective measure for each user of the Operating System. Therefore, Smart Columbus focuses on creating valuable data by focusing on ensuring that the data is as usable as possible.

During the data curation process, the data curator works with the source entity to provide as much information as possible along with the dataset so that it has value to users.

### 3.12. ROLES RESPONSIBLE FOR DATA MANAGEMENT

The Operating System has five roles that are responsible for the management of the data. During project development and operation, all roles except data provider will be performed by members of the Operating System project team. Data providers are members of the entities providing the data to the Operating System. Below are some of the roles that will be responsible for data management.

- **System Administrators**: Responsible for the upkeep, configuration, and reliable operation of the Operating System to maintain the integrity and availability of the data.
- **Data Curators**: Involved with the design and integration between the Operating System and entities that contribute data. Ongoing efforts to validate data and usage and improve datasets and relationships with providers.
- **Data/System Architects**: Responsible for the design and integration of all system back-end components used to ingest data.
- **Data Providers**: Responsible for working with the Operating System to ensure their entities’ data is valid and compliant.
- **Privacy and Security Board**: Advise Smart Columbus on privacy and security issues.

The Organizations concept within the Operating System will allow authorized users of an entity to act as the data provider for the data the entity provides. Authorized users will be able to manage datasets, metadata, and the data hosted within the Operating System.
3.13. MANAGEMENT AND AUDIT CONTROLS

Data management and audit controls are important aspects of the Operating System. Data curators and administrators are primarily responsible for the management of datasets. The governance of the inbound content of remotely sourced datasets will be done by signed agreement. The Operating System logs each action to configure datasets or load data. The Operating System will store logs in a separate read-only data store to control the integrity and validity of the logs. These factors provide integrity controls for the data and metadata.

For datasets on the Operating System that are remotely linked to the data provider source, the provider of the data carries the sole responsibility of ensuring compliance with data privacy and de-identification. For the purposes of this document, remotely linked datasets are referred to as datasets that are not hosted on the Operating System but are linked to the source location of the data.

When a dataset underperforms, the dataset statistics maintained by the OS can be used to initiate further investigation. The data provider will be contacted and asked to remediate any anomalies detected. In the event of persistent underperformance or irresponsible inclusion of private data, datasets may be removed from access or deleted.
Chapter 4. Standards Used

4.1. DATA FORMATS

The Operating System uses only platform-independent and nonproprietary formats to focus on machine-readability of the data. To accomplish this, it is preferred that any data source that is in a non-machine-readable format be converted to a different format during the data ingestion design process. A sample, non-comprehensive, list of machine-readable and non-machine-readable formats is provided in Table 3: Sample File Types.

Table 3: Sample File Types

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

Source: City of Columbus

In addition to the data provided, metadata must be provided that complies with the metadata standards defined in Section 4.3.

Datasets that are available in other publicly available systems can be read into the Operating System if the system publishes a metadata catalog that is compliant with one of the following formats: Comprehensive Knowledge Archive Network (CKAN), DCAT Vocabulary, DCAT Resource Description Framework (RDF), or Project Open Data. The Operating System will have data “harvesting” functionality that will allow consumption of another system’s data.json per https://project-open-data.cio.gov.

Due to the variety of projects that are being deployed under the demonstration, there may be many data standards and formats that are ingested into the Operating System. Correspondingly, multiple formats have been and will be used for data ingestion and the workflow of data ingestion is tailored to the required data type and elements. During ingestion, prioritization may be given to automated processes, specific data sources, and/or validated files. Since data from various sources and formats are anticipated, coordination across projects is recommended. Data providers register with the Operating System and after approval and agreement to terms of service (or other required documentation), submit prepared datasets. No data is accepted anonymously. Ingestion may be manual or API, which is decided by the Operating System project team during the design phase of the data ingestion process.

4.2. COMMUNICATING ABOUT THE DATA

The main method of describing datasets is through the dataset’s associated data dictionary and related documents. The two fields in the metadata that describe these are “Data Dictionary” and “Related Documents.” These two metadata fields can contain hyperlinks to resources that help define and describe
the data and any other useful resources that are available to users. These resources are discovered or
defined during the data curation process.

In addition to the metadata fields, data stories can be published on the Operating System website that
contain information about a dataset, a potential problem or need that might be solved, and information on
how to consume the data using the Operating System API. It is the intention that these data stories help
spark discovery of data services within the Operating System to support applications to help respond to
specific community needs.

4.3. METADATA SCHEMA, STORAGE, AND MANAGEMENT

Datasets within the Operating System will comply with the Project Open Data Metadata Schema v1.1. This
schema is a standard defined and used by the U.S. Government and is extensible to include other
necessary fields. The Operating System complies with all Project Open Data requirements for its catalog
and datasets. The Operating System extends the metadata to include other common metadata fields that
are populated when the dataset is first scheduled for ingestion.

4.4. DATA CONSUMPTION METHODS

Users of the Operating System will consume data in multiple ways:

- Downloading a file that contains the dataset (various formats will be available depending on the
dataset)
- Viewing structured data with an in-browser previewer/viewer
- Consuming the API to query the data
- Analyzing/visualizing data through analysis tools like the embedded plotly functionality, or via
external tools such as JupyterHub and Tableau

Because all data is desired to be in a non-proprietary format, once retrieved, data can be used within many
different tools as needed. Users do not need to register a user account to interact with the data or API.
However, if users register for a user account, SQL queries and visualizations can be saved and shared with
others.

At this time, no limit exists on the amount of data a given user can request through the website. The
Operating System has set a public use standard that everyone complies with unless under separate
contractual agreement with the City. The Operating System manages by exception with contracts.

Metadata consumption is subject to the same controls as the content of the dataset.

4.5. QUALITY CONTROL MEASURES

All data providers, including project and Operating System data providers, are responsible for their own
quality controls which, when applicable, are expected to conform with relevant industry standards, such as
the American Society for Testing and Materials’ (ASTM) Quality Control Standards.6

Specifically, submitted project and Operating System data should possess or undergo the following:

- An identified, authenticated submitting entity
- All available metadata about the dataset

6 https://www.astm.org/Standards/quality-control-standards.html
• A provenance plan based upon Service Level Agreements (SLAs)
• Initial ingestion process that identifies any high-risk data, such as PII, Payment Card Industry (PCI), or Personal Health Information (PHI)

The Operating System determines freshness, completeness and validity of the data initially and periodically as defined in the associated SLA. This provides a score that is appended to the data page. Usage statistics are also generated automatically. Validation rules may be used to flag unusual entries. Should outliers, missing or otherwise anomalous entries be found, the data providers may be contacted for verification. Flagged data may be changed to show null value or may be rejected in whole.
Chapter 5. Sharing and Protecting Data

5.1. SHARING DATA
Public data that has been vetted through the Operating System project team and undergone the data curation, design, and ingestion processes is shared publicly and available to all users. Once data is identified that needs access control and authorization mechanisms, the appropriate controls are put into place – specifically when other Smart Columbus projects are ready to begin sharing data through the Operating System. The Operating System has a concept of restricted datasets with built in authentication which can be used. To access restricted datasets, authentication and authorization are required for the user interface and the API.

5.2. USER AUTHENTICATION
Data within the Operating System is categorized as restricted or public. These concepts are defined in the introduction in Chapter 3.

If a dataset is marked as restricted, a user must authenticate and have privileges to gain access to read the data.

The classes of users within the Operating System define what datasets they have access to as described below. As additional datasets are brought into the Operating System, additional user classes may be defined to meet requirements.

- **Unauthenticated User**: Access to all public datasets
- **Authenticated User**: Access to all public datasets, enhanced datasets, and restricted datasets to which organization administrators have provided access through role-based access control

5.3. CONCERNS WITH SHARING
The Operating System is built with a foundation of sharing – sharing data within the system – from sending links to datasets, to building proof of concept applications, to analyzing data for a research paper or article. This open nature of the Operating System means that the risk of sharing the data is minimized because of the thorough process during data curation to limit confidential information from being ingested. This does not eliminate the risk of private person re-identification as the complexity of assessing all datasets against one another for the presence of a re-identification risk is difficult to nearly impossible given the systems and processes currently available. The operation relies upon the curation process to maintain an active oversight of such risks.

5.4. DE-IDENTIFYING DATA
During data curation of datasets, data is evaluated to see whether it contains PII. If a dataset is found to contain PII, the dataset is rejected and sent back to the data provider for de-identification based on the Smart Columbus De-identification Policy which is located on the Operating System website.
6.1. PERMISSIONS TO MANAGE DATA

The data within the Operating System is generally collected outside of the Operating System before being ingested into the Operating System. Therefore, in most cases, the right to manage the data belongs to the source entity contributing the data. During data curation and with the acknowledgement and review of the data provider, the Operating System project team can manipulate the data only if the data does not change the meaning of the data – for example to remove duplicate entries, to change file formats, to de-identify, or add proper geotags to the data. The Operating System project team functions purely in an administrative role and they can move, archive, index, or perform other maintenance on the data to promote accessibility, performance, security, or reliability of the data.

6.2. INTELLECTUAL PROPERTY OWNER OF DATA

The Operating System data complies with Ohio Revised Code section 149. In general, the Operating System and the City of Columbus serve as data providers for the Operating System data. Any entity submitting public data must agree to release any claim of ownership or fees when providing data to the Operating System. Private entities may retain ownership of the data by contractual agreement.

In Ohio, public records are governed by Ohio Revised Code section 149.011 (G):

"...any document, device, or item, regardless of physical form or characteristic, including an electronic record as defined in section 1306.017 of the Revised Code, created or received by or coming under the jurisdiction of any public office of the state or its political subdivisions, which serves to document the organization, functions, policies, decisions, procedures, operations, or other activities of the office."

Data provided from governments, businesses, and agencies may not be records that serve “to document the organization, functions, policies, decisions, procedures, operations, or other activities of the” City of Columbus. Therefore, that data is not held to the same public records disclosure and retention standards of the City of Columbus.

For data contained in the Operating System provided by the City of Columbus, the City department who shares the information serves as the owner of that public record and therefore has all duties under Ohio law to maintain, retain, and disclose those documents per Ohio law. Users of the Operating System are able to access the owning department and contact information in the dataset’s metadata under the “Publisher”, “Contact Name”, and “Contact Email” fields.

6.3. COPYRIGHTS TO DATA

Providers of public data certify that all data provided is free of any copyright or other obligation by indicating the data can be published under an open license. All public data within the Operating System will remain free of copyright. Private entities may retain copyrights of the data by contractual agreement.

[http://codes.ohio.gov/orc/1306.01v1](http://codes.ohio.gov/orc/1306.01v1)
6.4. TRANSFER OF RIGHTS

Data rights will not be transferrable.

6.5. DATA LICENSING AND REDISTRIBUTION

The Operating System is able to retain public and restricted data. Public data housed within the Operating System is required to be under an “Open License” which, in general, requires the following conditions:

- **Re-use**: Allow for reproductions, modifications, and derivative works
- **Redistribution**: No restriction on selling or giving away
- **No Discrimination**: Must not discriminate against any person or group of persons

Examples of open licenses that can be used on the Operating System are:

- Creative Commons Attribution\(^8\)
- Creative Commons Attribution Share-Alike\(^9\)
- Creative Commons CCZero\(^10\)
- GNU Free Documentation\(^11\)

The license that applies to a specific dataset is within that dataset’s metadata under the “license” field, which contains a URL to the description and terms of the license. Private entities may choose to license their data in any fashion agreed upon by contract.

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\(^8\) [http://opendatacommons.org/licenses/by/1.0/](http://opendatacommons.org/licenses/by/1.0/)

\(^9\) [https://creativecommons.org/licenses/by-sa/4.0/](https://creativecommons.org/licenses/by-sa/4.0/)

\(^10\) [https://creativecommons.org/publicdomain/zero/1.0/](https://creativecommons.org/publicdomain/zero/1.0/)

\(^11\) [http://www.gnu.org/licenses/fdl-1.3.en.html](http://www.gnu.org/licenses/fdl-1.3.en.html)
Chapter 7. Archiving and Preservation Plans

7.1. ARCHIVING STRATEGY
The Operating System has a data archive component. The Operating System uses readily available and redundant services for all its data storage and archives. The cloud infrastructure of the Operating System provides multiple redundant copies of both static files and structured data through their respective services. The cloud environment services provide managed backup services, which are customizable and configurable. High-value datasets are enabled to take advantage of this feature. In the event of data corruption, a valid copy of the data may be retrieved from a backup copy and applied to the corrupt copy to correct any corruption.

Digital preservation practices, including auto-recovery, integrity monitoring, and redundancy are incorporated to support data integrity.

All long-term preservation efforts endeavor to comply with the ISO Technical Report (ISO/TR) 18492:2005 standard (long-term preservation of electronic-document-based information). The success of any long-term preservation efforts will be dependent on the entity that owns the project post-grant. For data that does not have a contractual archival requirement, the decision to retain a dataset is primarily at the discretion of the data curator. As the Operating System matures, the data usage statistics and user ratings will determine the desire for the Data Curator to retain a given dataset.

7.2. TIME BETWEEN COLLECTION AND SUBMISSION TO ARCHIVE
The timeliness of availability of data modifications differ slightly between two cloud-based products that store data, but they both operate on the same principle. The Operating System cloud environment keeps multiple copies of any data within a single region. The cloud environment relies upon back-end processes that asynchronously copy changes to replicas. Although the time to consistency is not readily available and can vary, it is typically close to real-time.

7.3. BACKUP AND DISASTER RECOVERY
The Operating System relies on the geographically redundant and distributed nature of the cloud-based data storage repository. Whenever a change or update occurs, a copy of the original data will move asynchronously to a data archive assuming this remains feasible given storage costs. The Operating System administrators will work with the defined cloud-based data storage provider to retrieve an archive should core data become corrupt or require a restore. The Operating System uses AWS S3 Stores which have built-in replication.

7.4. PROTECTION FROM MODIFICATION OR DELETION
Operations that require write access require user registration and an access key. Any party submitting data must register, gain submission approval, and remain in good standing. Team members with administrative privileges in the cloud-based host web interface must be an authorized user and use multifactor authentication. The Operating System uses auth0 as a single sign-on for authentication for end users. For system administrators, the Operating System uses a multi-factor authentication system consisting of VPN and AWS credentials.
7.5. DATA RETENTION

As the volume of the data that the Operating System houses increases over time, the Data Curator will evaluate applying expiration policies to datasets or data within a dataset. This may include the moving of infrequently accessed data to other, less expensive storage or to make a recommendation to purge it in accordance to Ohio public records law requirements.
# Appendix A. Acronyms and Definitions

Table 4: Acronym List contains program level acronyms used throughout this document.

<table>
<thead>
<tr>
<th>Acronym/Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>API</td>
<td>Application Programming Interface</td>
</tr>
<tr>
<td>ASTM</td>
<td>American Society for Testing and Materials</td>
</tr>
<tr>
<td>BRT</td>
<td>Bus Rapid Transit</td>
</tr>
<tr>
<td>CEAV</td>
<td>Connected Electric Autonomous Vehicle</td>
</tr>
<tr>
<td>CMAX</td>
<td>COTA’s brand name for its BRT line</td>
</tr>
<tr>
<td>COTA</td>
<td>Central Ohio Transit Authority</td>
</tr>
<tr>
<td>CSV</td>
<td>Comma Separated Value</td>
</tr>
<tr>
<td>CV</td>
<td>Connected Vehicle</td>
</tr>
<tr>
<td>CVE</td>
<td>Connected Vehicle Environment</td>
</tr>
<tr>
<td>DCAT</td>
<td>Data Catalog</td>
</tr>
<tr>
<td>DMP</td>
<td>Data Management Plan</td>
</tr>
<tr>
<td>DPP</td>
<td>Data Privacy Plan</td>
</tr>
<tr>
<td>DSS</td>
<td>Data Security Standards</td>
</tr>
<tr>
<td>EPM</td>
<td>Event Parking Management</td>
</tr>
<tr>
<td>GNSS</td>
<td>Global Network Satellite System</td>
</tr>
<tr>
<td>IE</td>
<td>Independent Evaluator</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organization for Standardization</td>
</tr>
<tr>
<td>ITS</td>
<td>Intelligent Transportation Systems</td>
</tr>
<tr>
<td>JSON</td>
<td>JavaScript Object Notation</td>
</tr>
<tr>
<td>MAASTO</td>
<td>Mid America Association of State Transportation Officials</td>
</tr>
<tr>
<td>MAPCD</td>
<td>Mobility Assistance for People with Cognitive Disabilities</td>
</tr>
<tr>
<td>MMTPA</td>
<td>Multimodal Trip Planning Application</td>
</tr>
<tr>
<td>ODOT</td>
<td>Ohio Department of Transportation</td>
</tr>
<tr>
<td>OGRIP</td>
<td>Ohio Geographically Referenced Information Program</td>
</tr>
<tr>
<td>OS</td>
<td>Operating System</td>
</tr>
<tr>
<td>Acronym/Abbreviation</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>OSU</td>
<td>The Ohio State University</td>
</tr>
<tr>
<td>PCI</td>
<td>Payment Card Industry</td>
</tr>
<tr>
<td>PDF</td>
<td>Portable Document Format</td>
</tr>
<tr>
<td>PiMP</td>
<td>Performance Measurement Plan</td>
</tr>
<tr>
<td>PHI</td>
<td>Personal Health Information</td>
</tr>
<tr>
<td>PII</td>
<td>Personally Identifiable Information</td>
</tr>
<tr>
<td>PTA</td>
<td>Prenatal Trip Assistance</td>
</tr>
<tr>
<td>RDF</td>
<td>Resource Description Framework</td>
</tr>
<tr>
<td>SAE</td>
<td>Society of Automotive Engineers</td>
</tr>
<tr>
<td>SLA</td>
<td>Service Level Agreement</td>
</tr>
<tr>
<td>SMH</td>
<td>Smart Mobility Hub</td>
</tr>
<tr>
<td>SoS</td>
<td>System of Systems</td>
</tr>
<tr>
<td>SSN</td>
<td>Social Security Number</td>
</tr>
<tr>
<td>TNC</td>
<td>Transportation Network Companies</td>
</tr>
<tr>
<td>URL</td>
<td>Uniform Resource Locator</td>
</tr>
<tr>
<td>XML</td>
<td>Extensible Markup Language</td>
</tr>
<tr>
<td>USDOT</td>
<td>U.S. Department of Transportation</td>
</tr>
</tbody>
</table>

*Source: City of Columbus*
# Appendix B. Glossary

Table 5: Glossary contains project specific terms used throughout this document.

## Table 5: Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authentication</td>
<td>The testing or reconciliation of evidence of a user’s identity. It establishes and verifies that a user is who they say they are.</td>
</tr>
<tr>
<td>Authorization</td>
<td>The rights and privileges granted to a person or process.</td>
</tr>
<tr>
<td>Data</td>
<td>Data is raw (unorganized and unprocessed) digital messages sent between components. From Society of Automotive Engineers (SAE) Standard J2735: Representations of static or dynamic entities in a formalized manner suitable for communication, interpretation, or processing by humans or by machines.</td>
</tr>
<tr>
<td>Dataset</td>
<td>A collection of related sets of resources to include metadata that defines dataset and its contents.</td>
</tr>
<tr>
<td>Data Element</td>
<td>It is a component of a dataset that makes up its resources. This could be a file, a record, row, cell, or column.</td>
</tr>
<tr>
<td>Data Ingestion</td>
<td>Obtaining and importing data for use or storage.</td>
</tr>
<tr>
<td>Dedupe</td>
<td>Process to eliminate duplicate data.</td>
</tr>
<tr>
<td>Information</td>
<td>Processed data that is organized, structured, or presented in a given context to make it useful.</td>
</tr>
<tr>
<td>PII</td>
<td>The information that can be used to distinguish or trace an individual's identity, such as their name, Social Security Number (SSN), biometric records, etc., alone, or when combined with other personal or identifying information, which is linked or linkable to a specific individual, such as date, place of birth, and mother's birth name. The definition of PII is not anchored to any single category of information or technology. Rather, it requires a case-by-case assessment of the specific risk that an individual can be identified by examining the context of use and combination of data elements. Non-PII can become PII whenever additional information is made publicly available. This applies to any medium and any source that, when combined with other available information, could be used to identify an individual.</td>
</tr>
<tr>
<td>Privacy</td>
<td>Defined as control over the extent, timing, and circumstances of sharing oneself (physically, behaviorally, or intellectually) with others.</td>
</tr>
<tr>
<td>Pull Interface</td>
<td>Defined as the interface from which the data will be pulled from the Operating System.</td>
</tr>
<tr>
<td>Push/Self-Service Interface</td>
<td>Defined as the interface through which the data will be pushed into the Operating System.</td>
</tr>
<tr>
<td>Requirements</td>
<td>Set of information necessary to accomplish one action.</td>
</tr>
</tbody>
</table>
## Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource</td>
<td>A resource is part of a specific dataset that can be consumed and made available in multiple formats (CSV, JSON, XML, etc.).</td>
</tr>
<tr>
<td>Transmit</td>
<td>Sharing data directed to a specific receiver. In the case of transmission between systems, all transmitted data is signed and encrypted where required based on SAE J2945/1.</td>
</tr>
<tr>
<td>Upsert</td>
<td>Method of adding/updating data. If the specific entry exists the data is updated, if it does not exist it is added.</td>
</tr>
</tbody>
</table>

*Source: City of Columbus*