MOBILITY DATA SPECIFICATION
ARCHITECTURAL LANDSCAPE

July 2020 - BOARD APPROVED

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Introduction/How to Use this Document

This Architectural Landscape is intended to guide the growth and evolution of the Mobility Data Specification (MDS) under the stewardship of the Open Mobility Foundation (OMF) and to help OMF prioritize the time and resources of its committees and working groups. This document is intended to inform and shape the direction of MDS and the processes that support it, but does not address the OMF's work in areas of policy, advocacy, and education. In addition to the technical work described here, the OMF will continue to engage in the larger conversations about the future of mobility and related public policy issues.

The architectural landscape is structured in the following four sections:

- The **Product Strategy** outlines high level vision and objectives for MDS, identifies priorities for how OMF manages the specification, and what types of additional resources should be provisioned to best support the range of stakeholders working with MDS and related mobility data.

- The **Technology Architecture** outlines the current architecture of the MDS APIs, situates MDS within the broader mobility data and technology landscape and identifies the technical considerations and design guidelines that OMF working groups and other developers contributing to the MDS codebase should follow in working on the new features necessary for the specification to evolve.

- The **Development Process** introduces best practices and governance strategies for the working groups managing the MDS codebase, reference implementations, and surrounding resources. This includes code management guidelines, privacy principles, and change approval processes.

- The **Project and Deliverable Roadmap** lays out an action plan for the OMF working groups, describing upcoming deliverables including both releases of MDS and reference implementations as well as supporting resources.

The Architectural Landscape includes technical terminology related to transportation, software, and data. To ensure that all readers share a common understanding of the definition for these terms and acronyms, a "Terms, Definitions, and Acronyms" appendix is provided at end of the document.

This Architectural Landscape was developed through a process designed to capture the vision and priorities of the Foundation, its members, and the broader MDS community. Extensive stakeholder outreach was performed to solicit input from OMF board members, public- and private-sector members, as well as non-member MDS stakeholders.

This Architectural Landscape is intended to be a living document, and will be updated at least annually to reflect the evolving priorities and target deliverables of the Foundation.

A Note about COVID-19

The writing of this Architectural Landscape was largely done before the outbreak of the COVID-19 pandemic. While much remains uncertain about the future, it is clear that there will be major impacts on cities and our transportation system. The temporary halt to non-essential movement, implementation of social distancing, and dramatic slowing of the global economy will have substantial effects on consumer behavior, the financial health of mobility companies and cities, and our collective priorities for the months and years ahead.

We believe that people are best served when local governments can operate with agility and use data to drive decisions about the transportation system. The technology we build lowers the barrier for policy experimentation, iteration, and learning. It is tough to predict the future in such a unique moment, but we know that adaptability, nimbleness, and rapid learning are what allow organizations to respond effectively in a time of crisis. By helping to enable an agile approach, we believe that MDS and the OMF will have an important role in helping cities and mobility companies respond to and rebuild from this pandemic.

The OMF stands with cities to help them adapt to new and unprecedented challenges in the months and years ahead.

About the Open Mobility Foundation

The Open Mobility Foundation (OMF) is an open-source software foundation that creates a governance structure around open-source mobility tools, beginning with a focus on the Mobility Data Specification (MDS). As an open source foundation led by cities, the OMF is designed to understand and take on technical issues surrounding emerging mobility technology in communities. By bringing together stakeholders including municipalities, private companies, technical specialists, privacy and policy experts, and the public, the Foundation will shape urban mobility management tools that help people move safely, efficiently, and effectively.

What is the mission of the OMF?

The Open Mobility Foundation's mission is to transform the way cities manage transportation infrastructure in the modern era using well-designed, open-source technology.

Technology Design Principles

- **Open-Source and Open Standards** – Use open-source code and open standards APIs to promote the formation of an ecosystem of private companies and public agencies who come together around these open source tools as the basis for products that manage and use the public right-of-way.
- **Competition** – Encourage the creation of competitive markets for products and services based on the open-source projects within the Open Mobility Foundation.
- **Data and Privacy** – Enable public agencies to use data generated by Mobility Service Providers while protecting individual privacy, adhering to privacy and data security standards, and promoting equitable community outcomes
- **Compatibility** – Encourage interoperability across products and borders to encourage a marketplace of shared tools and common regulatory patterns.
- **Sustainability** – Promote business models that ensure sustainable transportation networks for generations to come.
- **Modularity** – Create a flexible kit of parts and framework that public agencies may utilize to fit their needs and regulatory approach.

Partnership with OASIS

The Open Mobility Foundation is hosted by OASIS, an established leader in the open-source and software standards industry. OASIS is a nonprofit consortium that drives the development, convergence, and adoption of open standards for the global information society.

A global 5,000+ member-driven standards body that represents the marketplace of public and private sector technology leaders, users and influencers, OASIS promotes industry consensus and produces worldwide standards for security, Internet of Things, cloud computing, energy, content technologies, emergency management, mobility, and other areas.

Product Strategy

The **Product Strategy** outlines high level vision and objectives for MDS, identifies priorities for how OMF manages the specification, and what types of additional resources should be provisioned to best support the range of stakeholders working with MDS and related mobility data.

Key Takeaways

- The MDS ecosystem includes a wide spectrum of organizations and roles working with MDS APIs and datasets. OMF is well positioned to recognize the needs of these stakeholders and help develop tools and other resources to support their work with MDS.
- OMF creates a forum for cities to collaborate with private entities and to provide clarity around city needs as the stewards of the public right-of-way
- Understanding and working with MDS requires technical capacity. OMF can provide capacity building resources such as offering simplified documentation, publishing best practices, and acting as a forum for dialog between technical and non-technical stakeholders.
- OMF effort will need to be prioritized between maintaining/evolving MDS for the current micromobility mode and adapting/expanding the scope of MDS to cover emerging modes currently in the development pipeline.

Open Questions

- Will OMF stakeholder enthusiasm and working group effort align with the development timelines of “emerging modes” so that MDS APIs are ready to be implemented for these modes as they are deployed for commercial use in the public right of way?
- How can OMF and other MDS stakeholders best interact and/or collaborate with related organizations?

Vision for the Mobility Data Specification

Our transportation system is changing. In recent years, new modes and services have emerged on city streets fueled by smartphones, new technologies, and a surge of investor interest. Apps and data have altered the way we use traditional forms of transportation, from walking to public transit to driving. And our travel and purchasing behaviors have shifted in response to this new environment. This rapid pace of change shows little sign of slowing.

Despite this transformation, the public policy goals of local governments are remarkably consistent. Cities want transportation systems that are safe, equitable, efficient, accessible, and sustainable, and that protect the individual freedom and privacy of the traveling public. Achieving these goals in an environment of rapid change requires new tools and approaches, and it necessitates that governments adopt some of the digital, data-driven, dynamic approaches that undergird much of the evolution we are experiencing.

Core to the future of mobility is the development of a set of digital tools for public entities (city departments of transportation, metropolitan planning organizations, state departments of transportation, etc.) to manage the public right of way through data, APIs, and the dynamic application of policy. The Mobility Data Specification (MDS) meets this need by serving as a widely-adopted, standardized means of digital communication between the public entities that manage the right of way and the organizations that use it to provide transportation services. As the steward of MDS, the OMF can support cities in the transition from analog to digital management of the public right of way.

The OMF vision for MDS encompasses many modes of transportation (micromobility, passenger services, aerial urban systems, freight and logistics, and autonomous vehicles) and multiple functions of government (policy, asset planning, enforcement, and operations). OMF imagines MDS as a digital kit of parts similar to how the Federal Highway Administration's Manual on Uniform Traffic Control Devices (MUTCD) defines standards for the physical assets and tools (stop lights, road signs, etc) used to manage the public right of way. MDS provides a specification for a digital set of interconnected technologies that each can serve specific public policy purposes, while connecting together to create an interoperable digital framework for understanding and

managing a city's transportation system. This vision of MDS seeks to enable cities to use data and technology to effectively manage and steward the public right of way.

Cities may share many of the same policy goals, but they may take different approaches to how they achieve these goals. MDS does not encode a singular view of how cities operate. It is instead a basic language in which policy, management, operations, and other needs can be described and expressed. It is a toolkit from which city governments can pick the right tools for their local context and apply them to advance their goals for their communities.

Key Goals

The following goals have been identified as key steps/focus areas necessary to achieve the Vision for the continued development of MDS as a set of digital tools for managing the public right of way through data, APIs, and the dynamic application of policy.

Increase the Utility of MDS for Micromobility

From its initial development, through its rapid and widespread adoption by cities around the world, MDS has significant momentum as the accepted standard for the exchange of data between city transportation departments and micromobility providers, serving regulatory, operational, planning, and analysis use cases. OMF must capitalize on this momentum to solidify the use of MDS to meet micromobility business needs by helping cities implement MDS to support planning, analysis, operational, and regulatory needs, educating members on the opportunities and challenges of working with mobility data, and continuing to evolve MDS as business models and services evolve.

Expand the Scope of MDS

Micromobility has served as a testing ground for a new model of API-enabled right of way management. The MDS model allows local and/or regional government to more effectively steward transportation in the public right of way for the public good, while enabling new business models, modes, and technologies to deploy and scale. The OMF is well positioned to extend MDS to serve use cases beyond micromobility. The interest and energy of members, especially cities, will guide the Foundation in this expansion. In the sections below, this document explores areas of

future investigation for how the scope of MDS might expand, including both new mode use cases as well as policy innovations that can leverage MDS.

Increase Ease of Non-Technical Staff Working with MDS

The MDS APIs and the data exchanged via the MDS APIs can be difficult to understand for users without a background in software development, data analytics, technical transportation planning and engineering, or related fields. In part, this is because the MDS is housed on GitHub, designed primarily for software developers managing complex codebases, and not typically used by planners, policymakers and other roles within transportation departments. This creates barriers to adoption for cities that do not have dedicated technical staff to work with MDS internally or the resources to contract with consultants. A direct link between policy and technology implementation will be critical to the long term success of MDS. As departments of transportation transition towards relying on digital tools for managing the public right of way, MDS must become more accessible to policy-oriented staff, and those people will need to develop skills to better engage with these tools. Decisions made in the implementation of technical systems can have profound implications on policy, and it is important that software and data skills not become a barrier for policymakers responsible for shaping outcomes.

Increase Ease of Developers/Data Staff Working with MDS

Changes to make working with MDS APIs and data more accessible to non-technical staff will also benefit the software developers and data analysts working directly with the MDS codebase or MDS data, making documentation and examples easier to find and reference in their work. In addition, the unevenness in the technical capacity for MDS code and data within cities can create challenges for translating city policy and regulations into MDS data, to understand how to implement MDS to meet a city's policy goals.

In addition, when cities who may interpret the same type of data differently and often with insufficient context, MSPs are required to develop additional tools or reports to meet each city's requirements. This in turn leads to increased distrust between stakeholders producing and consuming the data. These issues can be addressed by OMF efforts to increase the ease of working with MDS APIs for developers and data specialists. In addition to the development of reference implementations, OMF could make it easier for developers to familiarize themselves with MDS via

more robust documentation moved from the Github code repository into a purpose-built documentation site, with clear examples.

Gather and Share Best Practices

MDS has a broad stakeholder base that includes both the public and private sectors and users with a range of technical skills and different ways of engaging with MDS (as described in the User Personas below). OMF is well positioned to learn from the experience of its members, as well as other stakeholders, and develop a set of best practices for working with MDS. This includes technical considerations such as setting up and managing MDS API endpoints, as well as policy considerations such as how to best write MDS requirements into a mobility operating permit. By gathering and sharing these best practices, OMF can help the MDS community learn from each other, and grow and strengthen the MDS user base.

Ecosystem

This section defines a typology of the organizations currently engaged in the development, maintenance and implementation of MDS, and other data and technology systems used for the stewardship of the public right of way. We anticipate this ecosystem evolving as different types of players recognize the utility of MDS to meet their business needs.

Local & Regional Governments

Local and Regional governments are the legal entities responsible for regulation planning, operations, enforcement, investment, implementation, and/or analysis of mobility on their public rights of way. As stewards of the public right of way, local and regional governments need to understand patterns of movement in relation to the infrastructure they manage and operate. To accomplish these tasks, they use physical and digital tools. There are a number of ways in which local and regional governments are already using digital tools to support right of way management. For example, adaptive algorithms for traffic signals change based on real time traffic data and dynamic parking pricing programs raise and lower prices based on demand. Transportation planners and engineers will need to develop new processes and workflows to use MDS, and the capabilities for digital policy that MDS enables, in combination with existing spatial data like right of way maps, parking inventories, etc. Data about how communities are using and

being served by existing and future mobility services can inform policy to create more equitable, safe, and sustainable outcomes.

Mobility Service Providers

Private organizations providing mobility service for the movement of people and/or goods in the public right of way, MSPs include Ridehail/Transportation Network Companies (TNCs), taxis, micromobility providers (bikeshare/e-scooters), carshare companies, freight and other delivery providers. Future MSPs could also include autonomous vehicle fleets and urban aerial transport providers. MSPs rely on MDS and other data exchange mechanisms to fulfill the data sharing agreements included in operational permits required by many cities and to communicate a city's operating restrictions to their customers through their mobile applications.

Software and Technical Infrastructure Providers

Cities often rely on vendors and consultants for a number of software and technology functions within the "MDS stack" including data storage, data visualization and analysis, cloud hosting and computing resources. These technical functions may each require different contract provisions and protections, which some cities address by separating them. This includes consideration of data stewardship and data ownership. OMF wants to enable a variety of successful business models for companies, not by offering a singular vision for the role of private companies in supporting management of public rights of way, but rather by creating the conditions where market competition and creative experimentation can offer local and regional governments a broad selection of tools and technical approaches to achieve their public policy goals. Cities must manage this carefully and proactively, especially since regulatory data frequently belongs to the city under standard vendor contracts and most cities disallow monetization of data

Data Intermediaries

Private companies sometimes act as an intermediary between local/regional governments and mobility service providers. Data intermediaries and tool providers may ingest, store, and aggregate mobility data for local governments to serve regulatory and analysis purposes. In this intermediary role, data intermediaries and tool providers may be responsible for ensuring data security and privacy to protect personally identifiable or commercially sensitive information in the raw, disaggregated data.

Analysis Tool Providers

Cities often rely on data visualization and analysis tools provided by a vendor as the primary interface point between city staff and MDS, allowing for non-technical staff to easily work with MDS for regulatory, analysis and planning purposes, translating data into actionable insights. In some cases, data aggregators, as described above, provide the user interface/data visualization dashboard for non-technical staff to interact with realtime and historical mobility data to meet their business needs, but cities may choose to separate these functions, and select different vendors for each.

MDS as a Service Providers

Cities or MSPs looking to implement the OMF's reference implementation of MDS, may seek a vendor who offers the MDS reference implementation as a software-as-a service solution. This model would provide cities and/or MSPs with a production ready, turn key instance of MDS, and handle all hosting and maintenance for that instance of the MDS software. These vendors may provide standalone MDS APIs or also offer the data intermediary and analysis tools described above.

Other Software and Technical Infrastructure Providers

Cities may also rely on a range of other software or technical infrastructure vendors to meet the needs of their unique MDS stack. This includes cloud hosting for MDS software or data storage, cloud computing resources for data processing and analytics, and analysis and visualization tools for working with MDS in combination with other sources of data and digital policy. As the MDS community grows and matures, we anticipate the ecosystem of software and technology vendors will also evolve, providing a range of tools to meet the changing needs of cities working with MDS.

Universities and Other Research Organizations

Universities and other research organizations rely on new sources of mobility data to support research efforts to better understand how a city's public right of way is being used by individuals as well as mobility service providers. The range of this research includes developing more nimble and dynamic travel demand modeling, behavioral economics investigations into how and why

individuals make the mobility decisions they do, evaluation of the effectiveness of novel management strategies and policies, study of the climate impacts of transportation, and multiple other applications studying the public right of way.

Members of the Public/MSP Customers

Mobility customers interact with mobile applications developed by mobility service providers to support their use of shared mobility services. These applications frequently convey information about regulations concerning the proper use and storage of vehicles, such as parking and speed restrictions. Users enter into agreements with mobility providers that govern the types of data that will be collected about them and their travel behavior and how that data will be used. These agreements are often based on an understanding that their privacy and data will be protected and the uses of that data will be limited. Beyond complying with applicable law, however, the mobility industry has not adopted a standardized set of practices and rules regarding its collection and use of data.

MDS User Personas

This section establishes a typology of users of MDS and associated mobility data to ground product development in an understanding of the current use cases for MDS. These personas are not intended as an exhaustive list, but rather as a set of notional representations that help OMF identify the spectrum of tools or resources that would help users best leverage MDS to meet their organization's needs. We envision these roles evolving as the MDS ecosystem evolves, and recognize that OMF will need to respond to new users and needs.

Developer, Data Specialist, or IT Specialist at City

This person is tasked with building systems capable of ingesting and processing raw MDS data. This role usually requires a high level of technical expertise in working with APIs and data structures. Many cities do not have someone in this role working with mobility data and instead rely on consultants or outside companies. The person is often responsible for designing systems to maintain the safety and privacy of the data and developing methodologies for converting raw MDS data into aggregate vehicle and ride counts that are accessible to other stakeholders. Due to the high level of technical expertise, this person usually resides within a city or organization's

Information Technology or similar department and holds a degree or specialization in computer science or data analytics. Compared to the parallel role in the private sector, city data/IT specialists may have more rigid funding requirements, be subject to increased methodological transparency expectations through open records requests and public scrutiny, are subject to IT/technology policies and regulations, and may have requirements to publish open data or data as open records.

Developer at Software or Technical Infrastructure Vendor

The person in this role designs systems to ingest and process raw MDS data and process it into data that is easily accessible to cities and sometimes mobility service providers. Like their public sector technologist counterparts, this role usually requires a high level of technical expertise in working with APIs and data structures. The person is often responsible for designing systems to maintain the safety and privacy of this data, and developing methodologies for converting raw MDS data into vehicle and ride counts that are accessible to non-technical audiences and secondary consumption.

Private companies have a responsibility to maintain financial sustainability and generate profits. Companies operating as MDS data intermediaries and tool providers today derive their revenue primarily from fees paid by city customers, but may also see revenue opportunities in the use or sale of aggregated data.Compared to the parallel role in the public sector, vendors and consultants may be able to use a more flexible technology stack, and have access to extra funding to develop technology solutions and hire additional developers.

City Transportation Policymaker and/or Regulator

This person typically resides in a city's transportation or public works department and is responsible for determining the data-sharing and operational requirements for mobility providers who have applied for an operating permit within the city or other jurisdictional boundary. This person may be responsible for implementing compliance/conformance programs for mobility providers, which can include tracking performance metrics such as the number of vehicles, collisions, or the state of vehicle repair responding to public complaints of improperly operating/parked vehicles, collecting fees, and reporting about the program to elected officials and the public. In some cities, these are separate functions, and the person or team who operates

the program and regulates companies may be different from the team or policymaking body that sets the requirements. Generally, this person or team is in contact with technical resources either through developing system requirements for internal staff or managing a contract with a third-party data intermediary.

City Transportation Data Auditor

This person is responsible for conducting data audits in the city. Auditors may use visual observation, monitored test rides, tooling based on MDS endpoints, and other data sources to verify the accuracy and validity of data. This role enables cities to be confident when making planning decisions that involve investment of public dollars, issuing policy compliance reports, or taking enforcement actions on regulated entities.

Transportation Planner (City/MPO)

This person is responsible for planning, managing and maintaining multimodal transportation infrastructure within a city. This could include a combination of roads, bridges, sidewalks, bike infrastructure, and sidewalk furniture. This planner or group of planners typically interacts with aggregated data to understand demand patterns, service usage, and safety or parking concerns. This data may be used to direct investments to maintain the safety and access of all right-of-way users, including protected bike lanes to reduce collisions and managing the installation of bike racks or other hard infrastructure to respond to increased micromobiltiy usage. MDS data may also inform their overall understanding of travel demand, modal share, and changing patterns across the transportation system. Planners may operate at a citywide or regional level, and may collaborate or share data/methodologies with their local peers.

Data Product Manager at Mobility Provider

This person is responsible for the implementation of MDS at the mobility provider. This role leads the design of software systems that translate the streams of data being generated by that provider's fleet of vehicles and backend systems to be made available to cities via MDS. This role is responsible for mapping MSP specific vehicle states and events to the appropriate expression in MDS. This person may also be responsible for the design and architecture of systems to pull regulation data (such as slow zones or dynamic fleet caps) from a city's Policy API endpoint and operationalize those policy requirements through the provider's backend systems, user-facing

app, and fleet of vehicles in the public right of way. They are typically responsible for planning the implementation of new versions of MDS and accommodating other data sharing requirements that cities may impose beyond MDS.

Developer/Data Analyst at Mobility Provider

This person is responsible for the development and maintenance of a mobility provider's MDS-related software and tools, including the implementation of Provider API endpoints and systems to interact with a city's Agency or Policy API endpoints. This person may also be responsible for building and maintaining processes to collect and deliver additional mobility data to cities through ad-hoc reports and visualizations. They likely work closely with the mobility provider's product managers, as well as the policy and government relations team.

Ecosystem of MDS Resources

To grow the MDS user base and deliver maximum value to the full spectrum of stakeholders, the OMF should support and grow the existing ecosystem of resources surrounding MDS. As the curator/manager of MDS resource, OMF can do this by:

- Gathering and disseminating best practices, both technical best practices for working with MDS and derivative data, as well as policy best practices.
- Documenting and sharing case studies for city and mobility provider use cases for MDS highlighting "minimum viable products", easy to build/manage approaches, etc. to help new/small cities understand barriers to entry to working with MDS.
- Vetting and publicizing tools, methodologies, and other resources produced by members of the MDS community.
- Serving as a clearinghouse for methods to promote data privacy and security, such as data minimization, anonymization, and aggregation
- Identifying and producing tools, methodologies, or other resources that would be useful to the MDS community, but are not yet provided by existing firms or organizations.

Of the following categories of resources to support working with MDS APIs and data, some may be produced by OMF, others may be produced by members of the community and then curated/shared by OMF.

Documentation

OMF should develop and share MDS documentation catering to the full range of technical expertise of those working with MDS APIs and data. This includes a version of documentation comprehensible to individuals without a background in computer engineering focusing on the key concepts of MDS architecture and functionality, as well as definitions of the technical terms necessary to understand those key concepts. In addition, clear documentation helps all stakeholders better understand the use cases for particular endpoints included in the MDS APIs. Making documentation more approachable could be accomplished by maintaining the specification and documentation on GitHub, but also presenting it on the OMF website, synced to GitHub to ensure content stays up to date.

Tools

There are several categories of tools that would help cities, mobility providers, consultants and others work with MDS data in a consistent and reliable way. Standardized verification/validation methodologies and software would help ensure trust between cities and the mobility providers producing data exchanged via MDS. "Off the shelf" data processing and/or visualization tools can help reduce the technical burden and overhead cost of working with MDS data to support analysis and planning. Members of the MDS community are already working on developing tools in these categories. It may not make sense for OMF to directly produce tools for working with MDS, but rather to gather, evaluate, and then share effective tools with the MDS community.

Policy and Permitting

OMF should gather, evaluate, and share best practices and examples of city policy referencing the use of MDS. Currently, operating permit language around MDS requirements is often either overly general, such as "provide MDS data", or overly specific, such as "provide data via Provider API v0.4.1", leading to inconsistency in how providers must meet MDS requirements from city to city. By providing sample language for cities to use, OMF can help facilitate consistency across cities while also ensuring that cities and providers are using the most recent, supported versions of MDS.

Standardized Analytical Methodologies and Metrics

OMF, itself or in partnership with other organizations, can lead the development and implementation of standardized analysis methodologies and metrics to support business uses of MDS. This is important because using data to measure or enforce policies requires converting raw data into metrics or applying analytic logic (e.g. how many vehicles are in a given place at a given time). This is complicated and requires a strong understanding of both policy goals and provider operations. The lack of standardized metrics results in many cities going through this learning process on their own and continually re-inventing the wheel. Standardized metrics create a shared understanding between regulator and regulated, and shortens the path to getting public value from data.

System Architecture and Reference Implementation

Many cities and mobility providers that are interested in working with MDS require technical capacity building before they are ready to implement one or more of the MDS API services. By gathering and sharing best practices for how other producers and consumers of MDS data are architecting their systems or by offering a reference implementation, OMF can help cities and providers build technical capacity without starting from scratch on their own as they set up their MDS APIs.

Data Handling and Privacy Procedures

Data produced and exchanged through MDS APIs includes privacy sensitive or commercially sensitive information. Because of this, OMF takes concerns around data handling, security, and privacy very seriously. The OMF Privacy, Security, and Transparency Committee is developing a range of materials regarding data privacy and security, which will be incorporated into future iterations of this Architectural Landscape document, offered as guidance for cities and companies implementing MDS, and used to inform decisions about what and how we build within the OMF

Survey of Related Organizations and Standards

In the table below, we outline some of the organizations and data standards with an overlapping or adjacent scope to that of OMF and MDS. For each organization, there is an overview of their work, and summary of what data standards or products they work with or develop.

Organization	Description	Products/ Data Standards
MobilityData	Mobility Data began as a project of the Rocky Mountain Institute focused on Best Practices for the GTFS static data standard before becoming an independent non-profit organization. MobilityData is currently the custodian of several open data standards which currently supplement or are closely aligned in purpose with MDS.	● GTFS / GTFS-realtime ● GBFS
SAE/ Mobility Data Collaborative (MDC)	SAE recently formed the Consortium focused on developing micro mobility standards with a primary focus on recommendations regarding the privacy/data licensing practices and performance metrics for shared bikes, scooters, and cars providers.	● TBD
SharedStreets	SharedStreets is a nonprofit organization focused on open data standards for transportation. CurbLR product is a data structure for mapping curb regulations and restrictions.	● CurbLR ● Mobility Metrics
US Dept. of Transportation	The U.S. Department of Transportation is responsible for managing existing, new and emerging modes of transportation nationally, as well as funding the majority of the infrastructure and maintenance of national highways.	● Workzone Data Standard
Oregon Department of Transportation and Oregon State University	ODOT and OSU developed GTFS-ride, an open data standard designed to track transit ridership. As currently constructed by Oregon State University, the standard incorporates a multi-tiered data structure for representing transit ridership in a standardized format	● GTFS-ride (Transit Ridership Data Standard)
TCRP G-18 Stakeholders	TCRP G-18 is a Federal Transit Administration (FTA) Transit Cooperative Research Program (TCRP) project to develop new data formats/standards for data collected by automatic vehicle location (AVL), automatic passenger counter (APC), and automatic fare collection (AFC) systems.	● TBD
NUMO	NUMO is developing a set of mobility metrics that link common public policy goals with specific measurement approaches.	● TBD
Alliance for Parking Data Standards	APDS is an international coalition of parking providers focused on developing data standards to allow greater interoperability between parking, transportation, and mobility industries.	● Parking Data Standard

What's Next for MDS?

In the sections above, we have identified key goals for the growth and evolution of MDS, developed typologies of the organizations and roles working with MDS, identified opportunities for developing resources to support those working with MDS, and surveyed the range of other organizations and standards adjacent to MDS. Looking forward, the sections below outline focus areas for investigation into how OMF might steward the future evolution of MDS. In addition, we establish a framework to help OMF identify and prioritize new streams of work within these focus areas.

Additional Data for Micromobility

While MDS is widely used today for the regulation, management, and analysis of privately provided micromobility fleets (e-scooters and bikeshare), modifications and extensions to the specification could support additional business needs of both cities and mobility service providers. Both cities and mobility providers have raised concerns that operating permits for micromobiltiy providers often require the collection/provision of significant amounts of data that are not currently covered by features of the MDS API. These include information regarding number of unique riders, complaint and response reporting, maintenance and status reporting, and incident reporting for cases such as stolen/missing vehicles or collisions involving a micromobility vehicle.

While incorporating some of these types of data into MDS could lessen the need for providers to produce custom reports and data extracts on a city by city basis, care should be taken to avoid jeopardizing privacy or creating reporting mechanisms based around city-specific systems rather than common standards. As these extra reports are often provided in PDF or CSV format, it's important to understand whether replacing them with MDS might pose a technology barrier for the consumers of these reports.

Emerging Modes

While MDS has been most commonly adopted by cities and mobility providers to serve themicromobility mode, cities are increasingly interested in applying MDS to other modes in the public right of way. This includes both existing modes currently in operation as well as new modes currently under research and development that are expected to be ready for commercial

use in the near future. In the tables below, we describe the services and business models for emerging modes, including the phase of development (whether a mode is in commercial use or under development), as well as define the current phase of MDS implementation for each mode into the following phases knowing that they can change rapidly:

- **Refinement**: MDS has been widely used by cities and mobility service providers to gather and track data related to full-scale commercial deployments of these modes, and cities and mobility service providers are beginning to refine the ways in which they use MDS to manage specific, potentially unique use cases.
- **Implementation:** Cities and/or mobility service providers are starting to use MDS data to implement policies and manage data exchange with mobility service providers, potentially as part of a pilot program or initial service rollout.
- **Exploration:** Cities and mobility providers are exploring the ways in which MDS could be applied to these modes in the future. This includes modes that are currently in development or modes whose viability is still being tested.

These tables also describe key policy considerations for OMF

	Micromobility
Description	Private companies provisioning fleets of lightweight vehicles in the public right of way for short term rental, including bikeshare and e-scooters
Mode Development Status	In Commercial Use
Phase of MDS Development Status	Refinement
Policy Considerations	Conditions of existing operating permits may make it difficult to require use of new MDS API functionality. This can be addressed via a "model permit" to guide cities to use common language allowing for the evolution of MDS technical features.

	Mopeds
Description	Private companies provisioning fleets of electric mopeds in the public right of way for short term rental.
Mode Development Status	In Commercial Use

Phase of MDS Development Status	Implementation
Policy Considerations	New permitting process and may require a different permitting scheme to require MDS than what was used for scooters

	Carshare
Description	Private or public entities making passenger vehicles available for short-term (hourly) rental, either roundtrip (car must be returned to pickup location, or point to point (trip may be ended in any legal parking space within a designated service area) by which users reserve and rent vehicles owned by private citizens (GetAround, Turo) or by carshare company (Reachnow, Lime Pods, Zipcar)
Mode Development Status	In Commercial Use
Phase of MDS Development Status	Implementation
Policy Considerations	● Carshare fleets have already been operating in commercial use in some cities for years. ● Updating operating permits to require MDS could lead to pushback from providers. ● The Carshare market has recently undergone major restructuring, the results of which are unclear.

	Carpool/Vanpool/Paratransit/Mass Transit
Description	Private or public entities that coordinate shared (typically commute) rides in private automobiles (carshare), public or privately owned vans (vanpool), or accessible vehicles operated by specially trained drivers (paratransit). Traditional mass transit such as bus, rail, or ferry service
Mode Development Status	In Commercial Use
Phase of MDS Development Status	Exploration

Policy Considerations	• Vanpool/paratransit fleets have already been operating in commercial use in some cities for years. • Travel behavior is already tracked/managed by transit agencies

	Ridehail/Transportation Network Companies/ Taxis
Description	Demand-Responsive ride services, currently operated by drivers, but potentially served by fleets of AVs in the future
Mode Development Status	In Commercial Use
Phase of MDS Development Status	Exploration
Policy Considerations	• Ridehail companies have already been operating in commercial use in some cities for years. • Most local jurisdictions have limited regulatory authority and may not be able to require data sharing. • Responsibility for regulatory oversight of taxis and ridehail may or may not be in the same department depending on the city. • Some cities have the ability to determine data sharing requirements for taxis, but not ridehail.

	Urban Freight
Description	Existing urban freight uses include commercial and residential deliveries, delivered primarily via automobile mode (e.g. passenger or larger)., e-commerce deliveries. Emerging urban freight modes include delivery drones, delivery robots, and e-bike deliveries.
Mode Development Status	In Commercial Use
Phase of MDS Development Status	Exploration
Policy Considerations	• Existing users of public right of way may be

	resistant to new reporting requirements via MDS

	Autonomous Vehicle Fleets
Description	Fleets of autonomous vehicles providing on-demand services for passengers and/or delivery of goods.
Mode Development Status	In Development
Phase of MDS Development Status	Exploration
Policy Considerations	● Data sharing needs will be different in testing phases than during eventual commercial use. ● Regulatory frameworks enabling AV testing may preempt local jurisdictions from collecting data and existing uses of public right of way may be resistant to new MDS reporting requirements. ● Use of MDS in ridehail and taxi context could help define the role of MDS for AV fleets as well.

	Urban Aerial Vehicles
Description	Small urban aerial vehicles capable of takeoff and landing in an urban environment including package/freight delivery drones, as well as passenger vehicles (i.e., flying taxis)
Mode Development Status	In Development
Phase of MDS Development Status	Exploration
Policy Considerations	● Uncertainty regarding what types of vehicles and services will make it to commercial use. ● Unsettled jurisdiction between cities and FAA regarding regulation of urban air space. ● FAA/NASA acknowledge the role of the city in urban air stewardship, and are aware of OMF/MDS.

Policy Innovations

MDS has the potential to support new types of policy making and implementation. Cities are increasingly turning to data to manage the public right of way, from operations, regulatory and planning perspectives. Below are some topics that OMF stakeholders have identified as opportunities for policy innovation where MDS could play a significant role. In most cases, MDS would likely need to be extended or modified to support these use cases.

Curb Management

Urban curb is a valuable, limited, and often under-managed part of the public right of way. Curb demand comes from passenger pickup/drop off, traditional and on-demand delivery services, transit priority, active mobility (e.g walking, biking and micromobility), and parking for personal vehicles and micromobility devices. While cities have made some progress in digitizing their curb and other physical assets, technology and data offer new tools to proactively manage curbs and sidewalks, and in doing so deliver more public value from this scarce resource. Cities often lack a digital index or map of curb regulations, relying instead on signs and paint in the right of way. Curb data standards could provide a mechanism for expressing static and dynamic regulations for curb use. New approaches to curb usage fees could enable more goal-driven management strategies. OMF is well positioned to help cities use dynamic digital curb regulations, which could allow cities to manage the curb and adjacent infrastructure on sidewalks within the public right of way in real time and communicate the evolving restrictions, permissions, and pricing via a data feed or API.

OMF could support this type of policy innovation by building APIs within MDS to support policy approaches such as:

- Dynamic ridehail pick-up/drop off spaces during special events
- Conversion of on-street vehicle parking spaces into designated micromobilty parking
- Time restricted freight/delivery zoned to increase efficiency of urban logistics
- Curb access fees, static or demand-responsive
- Dynamic or flexible curb use regulations that respond to changing use patterns

Equitable Access

MDS could evolve to allow cities to collect and communicate data to increase equitable access to mobility services provisioned in the public right of way. Relevant metrics may include:

- Geographic access to vehicles in communities of concern and underserved areas.
- Access to mobility services for individuals with disabilities.
- Usage of low income/reduced price programs or incentives.

In considering these potential applications of MDS for equity analysis, OMF should also consider that equity-related data has the potential to be more sensitive as it is likely to require measuring or inferring "who" is using vehicles, not just where they're located/used. OMF's approach to privacy and data management must ensure that new capabilities intended to enhance equity don't result in compromising the privacy or safety of marginalized communities or the public at large. Quantifying and measuring equity is an evolving policy area for cities. As city approaches to equity develop and evolve, OMF will need to find ways to support these goals through existing or new MDS functionality.

Road Pricing

Road pricing can be a powerful tool for managing a scarce public asset and ensuring that private beneficiaries of a public resource pay for the use of that resource. Road pricing could be applied to a variety of modes, services, and activities within the public right of way. Multiple cities across the US are experimenting with road pricing programs. The most common of these, dynamic street parking fees, allows cities to adjust on-street parking rates in real-time to respond to fluctuations in parking demand. Some North American cities, such as New York City and Chicago, are charging ridehail congestion fees in certain areas. Dynamic pricing for on-street parking could serve as a test case for expanded curb access pricing for a range of curb uses including freight, ridehail drop-off, parking, etc. MDS has the potential to support road pricing by:

- Providing data to inform road pricing policies
- Conveying dynamic pricing information to users
- Tracking chargeable actions on the road
- Facilitating transaction processing/clearing

The MDS Policy API is evolving to gain limited pricing capabilities, but MDS would require significant new development to support more sophisticated pricing schemes.

How to Prioritize Future Work

With such a broad spectrum of areas for exploration and investigation, OMF will need to prioritize how the attention of working groups and committees is applied. For an evolving MDS to be successful in the long-term, it is critical that OMF's priorities are driven by the public interest, as expressed by the policy goals of local governments and the OMF Board of Directors. As we guide the evolution of MDS, OMF will need to balance the potentially conflicting priorities of:

- Maintaining and refining MDS to best meet the demands of micromobility as the current primary use case.
- Implementing MDS for modes currently operating in the public right of way, but not yet covered by MDS such as ridehail and carhare/vanshare.
- Exploring emerging use cases aggressively enough to be prepared to incorporate modes currently in development, such as autonomous vehicles or urban aerial vehicles.

The distinction between "sanctioned" and "unsanctioned" work by OMF's working groups, committees, and broader membership is important for balancing these objectives. Sanctioned work represents the work streams within the policy goals and priorities set by OMF's Board of Directors and filtered down through the Technology Council to the working groups and committees. This includes on-going maintenance or updates of existing MDS features, or the development of new features already prioritized by the Board of Directors and Technology Council. Unsanctioned work covers any efforts outside of that formalized process outlined in OMF's bylaws, such as the experimental or speculative development of new MDS features. These may be undertaken by a single contributor (or a small group of contributors) interested in pushing new ideas forward through experimental or locally-focused development. OMF needs to develop a process for transitioning successful unsanctioned work efforts to sanctioned features of MDS.

The OMF should establish "exploratory committees" made up of members to further articulate use cases and opportunities for new projects under consideration. These committees will raise potential focus areas and priorities to the Board of Directors and Technology Council for their consideration in directing the future focus of the organization's sanctioned work, and may offer a path to integrate unsanctioned work into the larger canon of the OMF.

Technology Architecture

The **Technology Architecture** outlines the current architecture of the MDS APIs, situates MDS within the broader mobility data and technology ecosystem, and identifies the technical considerations and design guidelines that OMF working groups and other developers contributing to the MDS codebase should follow in working on the new features necessary for the specification to evolve.

Key Takeaways

- Design of MDS API features should be useful and feasible for both producers and consumers of data
- Design of MDS API services and reference implementations should allow for a flexible technology stack and should not require the use of paid or proprietary services or platforms for implementation
- The API specifications shall be the primary "source of truth" for API definitions. Reference implementations can clarify correct behavior in situations where aspects of the specification are ambiguous or undefined.

Open Questions

- What are the respective roles for the MDS Agency and Policy APIs?
- When and how should the OMF enable extensibility and modularization of the MDS specification and reference implementations?
- What is the timeline for deprecating older versions of the MDS APIs and what resources and documentation does OMF need to provide to facilitate cities moving from one version to another?
- What should the scope and scale be for MDS reference implementations supported by the OMF?

- How will the work of the Privacy, Security, and Transparency Committee influence the design of MDS API services and reference implementations?

The OMF's technical mission is to nurture a contributor community that builds, maintains and evolves technology that enables cities to manage the public right of way. In this role, the OMF is responsible for the MDS APIs, as well as development of tools and resources to help cities and private companies implement and work with MDS. OMF does not directly implement or host software and does not collect, process, or otherwise handle MDS-derived data.

MDS allows for the dynamic communication of policy and data between cities and mobility providers, which supports the regulation, planning and analysis of use cases necessary to manage companies operating in the public right of way. New APIs to exchange other types of data will support broader efforts by local governments to steward the public right of way. These new features and APIs must be interoperable with each other and with other commonly used technologies (maps, transaction processing, etc.). While the MDS APIs have been designed around a broad vision of mobility management, implementation thus far has been primarily focused on the micromobility use case.

MDS Architecture Overview

The Mobility Data Specification comprises three primary Application Programming Interfaces (APIs): **Agency**, **Provider**, and **Policy**.

Agency and Provider APIs

Both the **Agency** and **Provider** APIs allow agencies to gather data about vehicles and trips from a Mobility Service Provider (MSP). Although the design of the APIs differ, they allow for similar types of data gathering. A city can adopt one or both of these APIs depending on their goals, tools, and resources. Additional information on the architecture and features of the Agency and Provider APIs can be found in the "Understanding MDS APIs" page of the MDS GitHub repository (https://github.com/openmobilityfoundation/mobility-data-specification/wiki/Understanding-MDS-APIs).

The agency and provider APIs were developed in alignment with each other, with shared terminology and a similar data model. While the APIs will likely stay aligned at a high-level, they are part of an open source development process and it is possible that their features and functionality may diverge further in the future.

Public agencies should consider their goals and use cases when selecting software to ingest and analyze MDS data. Some software packages and vendors may only support Agency or Provider. Data sharing requirements in permits and regulations should specify which MDS API(s) the public agency intends to use.

Policy API

The **Policy** API allows agencies to clearly and understandably express various types of regulations through an API and can be used in tandem with the Agency or Provider APIs. This allows for the consistent communication of regulations across all cities using the MDS Policy API, reducing the burden on MSPs to interpret and enforce regulations in each city in which they operate. Because of the potential complexity of Policy API implementations, the OMF shall manage the Policy API to promote a sustainable regulatory landscape for both cities to manage and MSPs to interpret and enact.

Guiding Principles for Technology Architecture

The table below outlines a number of principles that provide a framework to guide the development of MDS in a way that works deliberately towards implementing the vision for MDS that we establish in the Product Strategy section above.

Guideline	Description
Design must be function-driven	All new features must respond to a distinct business need of MDS that is not adequately met by existing features.
Ensure each feature/endpoint has a clear purpose	To the extent possible, each feature should serve a specific purpose or business need, exchanging the minimum amount of data possible to meet that need.

Design for consistency and interoperability across features	Build modular components that share consistent formats and identifiers to serve as a "kit of parts", allowing for flexibility in how sets of features can be implemented to meet the needs of a specific context.
APIs must be usable for both producers and consumers of MDS data alike	Features must meet the needs and technical capabilities/resources of both producers and consumers or they will likely go unused and become "orphan" features within the specification.
New features should be discussed by community before formal inclusion in specification	To ensure that new features are meeting the needs of the broad MDS stakeholder community and aligned with our principles, it is important for new ideas to be discussed and refined before being added to the specification.
Allow for experimentation and incremental design	Provide ability for experimental features, informal extensions, in addition to formal releases. All extensions and experimental features should be published and discoverable, allowing them to be auditable by the MDS community. The Technology Council shall develop and publish criteria for vetting potential speculative features. At a minimum, the addition of a new feature or the modification or deletion of an existing feature must be co-sponsored by both a producer and consumer of data via that API.
Design for future expansion and flexible application	We aim to build features that meet the needs of today while supporting the larger vision for MDS. We prefer design patterns that work for multiple modes of transportation and support a variety of policy implementations that cities may want to pursue.
Allow for flexibility in technology stack	MDS will be implemented in a variety of contexts and technology environments. Any code managed by OMF should be implementable in a variety of software ecosystems and be minimally prescriptive about the technology stacks that end users choose to implement MDS code. MDS specification should be machine-readable in a way that can be interoperable in a variety of programming languages and tools.
Support low/no-cost deployment environments	The design of new MDS functionality should not require paid or private services or platforms to function. For example, OMF should not pick a cloud-provider and build software features that can only be implemented on that provider.

Design for individual privacy	MDS should be designed to protect individual privacy while enabling digital right of way management. Where appropriate, the specification should incorporate features that support data minimization, aggregation, anonymization, and other approaches to privacy protection.
Plan for privacy and security at every stage of development	Because mobility data is often sensitive, privacy and security considerations should be reviewed throughout the development lifecycle. Privacy and security considerations should be incorporated in both technical implementations and any accompanying documentation and guidance.

Versioning and Backwards Compatibility

OMF's currently supports the two most recent major release versions of MDS, along with all associated minor releases. Older versions are considered "deprecated" and are not supported. This policy was intended to encourage upgrading as versions are released and to reduce the implementation complexity for API implementers who may be asked to support multiple versions.

As the specification matures and evolves into new areas, OMF will need to develop a clear policy around support for prior versions to balance backwards compatibility with a pace of evolution that supports the rapidly changing mobility landscape. The Technology Council should investigate how well the current approach meets the needs of MDS users. Moving to a time threshold (i.e. - a major release version shall be supported for an additional six months after it is no longer one of the two most recent major release versions) may be necessary to allow time for users to adapt.

As the MDS APIs evolve and new features are developed, consideration of versioning and backwards compatibility requires the consideration of the following trade-offs:

- Multiple actively used versions increases cost and complexity for MSPs, consultants, vendors, academics, and cities.
- Cities and mobility providers have limited capacity to rapidly transition to new versions.
- In their operating permit conditions, cities may require different major or minor versions of MDS than those actively supported by OMF. While OMF can share "best practice"

language for cities to use/adapt in their operating permits, it is likely that some cities will continue to require unsupported/deprecated versions of MDS.

- Incompatible versions and breaking changes undercut the scalability benefits of data standards.

Guiding Principles for Reference Implementations

Reference implementations of MDS can act as an on-ramp for developers and users, and foster the adoption of interoperable implementations of OMF-approved APIs and data models. They provide a starting point for organizations implementing MDS or integrating it into another product. They can also serve as a tool for testing software, verifying data feeds, and refining API implementations. While reference implementations are an important part of MDS, the official specifications shall always stand as the "source of truth" for API definitions. Reference implementations can clarify correct behavior in situations where the specification is ambiguous or undefined, but are not intended to replace or supersede standard definition process.

Within the broad category of reference implementation, a wide spectrum of tools may be built, ranging from blocks of sample code to fully-functional software packages. Currently, the only reference implementation managed by OMF is the "mds-core". As OMF considers what type of reference implementation it could or should build for each MDS API service, it will be necessary to first articulate the intent of that reference implementation, and then match the level of investment and effort to that intent and need.

Full scale reference implementations should be designed for extensibility through the development of plug-ins. These plug-ins can serve as a proving ground for new capabilities which may become official stand-alone applications or be integrated into future versions of the reference implementation, based on their use case and utility to the wider community.

Certification and Conformance

MDS is a new, evolving open standard with a wide spectrum of users. At times, this has led to inconsistencies in different implementations of MDS, due to ambiguities in the specification itself or different assumptions on the part of implementers. Certification and conformance testing can

ensure that implementations of MDS are producing data that is consistent, interoperable, and reliable. The goal of any certification effort should be to make it easier for cities and MSPs to implement, procure, and extend vetted, fully-compliant software. The OMF is well positioned to coordinate MDS stakeholders in the development of certification/conformance standards, tools and implementation of best practices.

Conformance standards should offer unambiguous testing procedures for API implementations. Confirming software would also be expected to comply with any documented best practices related to data quality, user experience, security, privacy, and interoperability with other systems. In addition to supporting testing, these standards should inform OMF Working Groups on ways to improve the clarity of the MDS documentation.

We anticipate that the development of certification and conformance standard, and the expectation of compliant software will support a market of companies offering consulting services to MDS implementers to assist in the validation and auditing of data quality, and the identification of strategies for improving compliance.

When cities implement MDS for micromobility or other use cases within their stewardship of the public right of way, they can rely on Service Level Agreements (SLAs) as an enforcement mechanism for conformance and compliance. SLAs are contractual mechanisms for defining the behavior (in the use of MDS) that a city expects of a provider, and/or the behavior a city commits to a provider. Over time, as cities learn from each other's experiences, OMF may serve as a place where cities harmonize their MDS SLAs. OMF might synthesize best practices into a sample "Master MDS SLA" for cities to use as a starting point when drafting their own SLAs.

The OMF should consider offering a formal program to test and label code as "OMF Certified." With such a program in place, any code released by the OMF would undergo a formal testing and certification process. The OMF may also choose to offer certification services for software written by third parties. Certified software will give cities and mobility providers confidence that they are using software which is fully conformant to specifications and best practices. Cities may require certification when procuring from vendors and/or permitting MSPs.

Data Privacy and Security

Data privacy and security are primary considerations for OMF and its membership. Cities working with MDS face a range of data privacy and security considerations. When cities require MSPs to provide disaggregated data it is important for there to be clear policies and practices for how that data is to be used, stored, and shared. Vendors acting as data intermediaries and tool providers may be helpful as stewards of disaggregate MDS data. There may also be an important role for objective intermediaries who conduct audits of the raw data to ensure its accuracy and aggregate the data so that it is still useful for cities for enforcement and planning purposes, while also protecting the security and privacy of individual user data.

Privacy is not just a matter of policies and practices, but also of technology design. MDS contributors have proposed a number of changes that can help reduce the need to store privacy-sensitive data while still preserving data verifiability and support for a full range of use cases. Some of these changes have been released while others are still under review. The OMF should continue to build "by design" privacy features into MDS without compromising the purpose or utility of the standard.

As established in the OMF Bylaws, the Privacy, Security, and Transparency Committee is responsible for the review and development of policy, guidance, and best practices for transparency and data protection measures, including privacy, data retention, anonymization, and technical security practices. Anticipated work products of the Privacy, Security, and Transparency Committee will be incorporated by reference into future versions of this Architectural Landscape. Information about the committee's work can be found in the OMF GitHub (https://github.com/openmobilityfoundation/privacy-committee).

Open Data and Open Records Policy

City and regional governments have a responsibility to manage the data produced and used in the governance and management of public assets. As part of this data management responsibility, Open Data and Open Records policies encourage or obligate cities to release, to the greatest extent possible, this data to the general public via open data portals or through public records requests.

Given that disaggregated MDS-derived data may include privacy-sensitive information about location and/or commercially sensitive information, it is important for cities to consider and mitigate these concerns before releasing MDS-derived data for public consumption.

Across the country, cities using MDS are developing policy documents to highlight the privacy implications of mobility data, as well as methodologies and tools to ingest, aggregate and anonymize MDS data to be appropriate for sharing externally as open data. OMF, led by its Privacy, Security and Transparency Committee, is well positioned to collect and share best practices so that cities can learn from each other's experience handling MDS datasets for release as open data.

In addition, public sector MDS users will need to evaluate their collection, storage, and retention policies in the context of applicable sunshine / public records laws to ensure they are not compelled to release information which could pose a privacy risk.

Development Process

The **Development Process** introduces best practices and governance strategies for the working groups managing the MDS codebase, reference implementations, and surrounding resources. This includes code management guidelines, privacy principles, and change approval processes.

Key Takeaways

- Technical changes to MDS APIs and reference implementations are to be made via consensus and communicated openly via GitHub and/or other forums.
- To the extent possible, code changes should be considered in a granular fashion, and bulk pull requests should be avoided.

Open Questions

- What is the process and threshold for elevating technical issues with policy implications to the Technology Council and OMF Board of Directors for further consideration?
- What are the acceptance criteria for a major code contribution to the MDS APIs or reference implementations from a single organization?
- What is the process or structure for coordination and collaboration across working groups and committees?
- What is the process for funnelling the interests & specializations of working groups upwards to influence the technical agenda or to prioritize tasks?
- What is the strategy for long term recruitment, retention and succession to ensure the continuity and productivity of the working groups?

Defining Roles in the Development Process

The development process for data standards, software tools, and documentation managed by OMF is intended to be hierarchical. The Board of Directors provides general direction/agenda, the Technology Council translates the agenda into high level priorities for the architecture and design of MDS, and the working groups handle the detailed technical implementation of those designs. It is also expected that ideas will bubble up from working groups as people with deep on-the-ground experience identify opportunities for improvements to MDS. These roles and responsibilities are detailed below.

Role of the Board of Directors

The Board of Directors is responsible for setting the broad agenda for OMF. This includes:

- What public policy challenges to address?
- What standards, tools, documentation to focus on?
- What business models to encourage and enable?

The Board is also charged with ensuring that OMF deliverables ultimately serve the interests and needs of cities, by providing input before, during, and after development. The Board members shall also serve as a source of expertise on how technology would be applied in real world government environments.

Role of the Technology Council

The Technology Council is responsible for translating the public policy priorities defined by the Board of Directors into high level technology architecture to be implemented by the appropriate Working Group. In addition, the members of the Technology Council are expected to provide their perspective as senior technologists to all aspects of OMF. In this role, Technology Council members act as a reviewer of deliverables and as an advisor/escalation point for Working Groups. The Technology Council has the domain expertise to discuss new policy considerations as they arise throughout the development process.

Role of the Working Group

The Working Groups are responsible for the implementation and evolution of all of OMF's technical products, including API specifications, reference implementation, and accompanying documentation. The Working Groups are guided by the policy and architecture decisions made by the Board of Directors and Technology Council, and the scope of the Working Groups will focus on the technical details of the products under their stewardship. In the event that these technical decisions have policy implications, Working Groups are to elevate these issues to the Technology Council and/or the Board of Directors for further consideration. Working Group participation is open to any contributor, regardless of OMF membership.

Role of the Working Group Steering Committee

Within the Working Group, the Working Group Steering Committee (WGSC) shall serve the role of "direction setter", outlining priorities for the Working Group's efforts and release roadmap, following the vision and policy directions articulated by the OMF Board of Directors and the Technology Council. The WGSC is responsible for assigning code maintainer and reviewer roles from members of the working group for each product for which that working group is responsible. The WGSC shall act as the decision maker of last resort, on the occasion that the broader working group is not able to reach consensus on a particular technical decision. The WGSC is composed of representatives of OMF member organizations.

Working Group Development Process

The following general development process guidelines provide a framework for the process by which changes are made to MDS or other technical deliverables.

Guideline	Description
Proposed changes are to be discussed openly.	Working groups should provide members and other MDS stakeholders with a range of ways to engage in the development process following a process oriented towards a consensus decision.This discussion should occur during working group meetings and as an issue thread in the relevant GitHub repository.

All technical decisions are to be made in the public domain	To allow for maximum transparency and traceability, discussion of a proposed technical change, including the outcomes of working group calls, should be tracked as an issue thread in the relevant GitHub repository.
Design/development decisions are to be made by consensus	Approval of new features or major modifications to existing features of MDS will benefit from the detailed consideration and discussion required to reach a consensus decision. In the rare case when consensus is not feasible, the WGSC has authority to act as the decision maker of last resort.
Code changes are proposed and discussed in granular fashion	Working Groups should avoid bulk pull requests as much as possible to focus discussion on individual features, with an exception for new module development.

Detailed guidelines specific to either the API development process or the Reference implementation process are described in subsections below.

Contributions of Major Changes

From time-to-time, the OMF may want to consider significant large code contributions from a single organization. For example, an OMF member implements a major new extension to MDS or contributes source code for a significant new tool for working with MDS data. The OMF could also choose to partner with another organization to take over stewardship of an existing specification or codebase. Any such work completed outside of the Working Group process formalized in the OMF Bylaws constitutes “unsanctioned” work. If OMF accepts a contribution, it then becomes “sanctioned”.

Such major contributions are a valuable way for the OMF to expand its offerings. However, the OMF needs to consider the risks of bypassing working group-led development and/or giving an outsized influence to a single contributor. Decisions about if and how to move major code contributions from “unsanctioned” to “sanctioned” should be reviewed by the Board of Directors and the Technology Council to make sure they’re aligned with the vision and objectives of OMF. While contributors of major changes may continue to be heavily involved in development once the code is accepted by the OMF, it is expected that future work will happen through the working group structure with ample opportunity for other contributors to shape the direction of future

changes. Relevant working groups (and their steering committees) should be involved in the code acceptance process to ensure this is a smooth transition).

Reference Implementation Process

The OMF should strive to keep its specifications and reference implementations in sync. Given the limited resources and time of working group members, it may sometimes be necessary for reference implementations (such as mds-core) to slightly lag behind release of new versions of API specifications. It is essential that reference implementations be clearly documented to indicate what versions of a specification they are built to support. Any reference implementation functionality built against unreleased/draft API specifications shall be clearly tagged as "EXPERIMENTAL" or "CANDIDATE".

Publishing Data Standard/API Specifications

Currently all three MDS APIs (policy, agency, and provider) are stored within the mobility-data-specification repository. Versioned MDS releases include all three APIs under a single version number. This offers simplicity, but may become unwieldy as additional APIs are added (for example, the audit and compliance APIs currently in draft). An area for future exploration if it makes sense to continue to have multiple APIs coupled together in a single repository and version. An alternative approach would be to decouple each individual API and allow them to evolve at their own pace and with their own version numbers. The disadvantage of this approach is that it may create complex dependency trees (e[.g. Audit v1.2 can only work with data from Agency v0.4.2).

The question of how to organize APIs across repositories and versions doesn't have a simple answer and will require continued evaluation as MDS grows and evolves.

Applying Privacy Principles in the Development Lifecycle

As the OMF Privacy, Security, and Transparency Committee develops more specific guidance and principles, it will be important to update our process documentation and this Architectural Landscape to ensure our development practices put these principles into action.

Project and Deliverable Roadmap

The **Project and Deliverable Roadmap** provides an action plan for the OMF working groups, describing upcoming deliverables including both releases of MDS and reference implementations as well as supporting resources.

Key Takeaways

- Minor releases during 2020 will expand scope of covered vehicle types within micromobility.
- MDS v1.0.0 will reconcile data structures, terminology, and state between the Provider and Agency APIs
- mds-core v0.1 will be the first OMF-managed release of a reference implementation, serving as a starting point for community-driven development

Open Questions

- How can we establish a release cadence for reference implementations that keeps pace with the evolution of the MDS API specification?
- What role will the Strategy Committee play and how will their work influence the design and development process?

Overview of Existing/Anticipated Deliverables

This section provides an overview of the scope (adapted from the working group and committee charters) and technical deliverables already planned for completion by OMF's working groups and committees. The Project and Deliverable Roadmap section of this document expands upon these existing planned deliverables and includes a speculative roadmap for additional deliverables under the proposed Product Strategy, which will become part of the Working Groups' and Committees' work plans.

Working Groups

The Provider Services and City Services Working Groups are responsible for the management and evolution of the MDS API services, as well as tools and documentation to support the implementation and use of those services. Additional information regarding each working group's scope and anticipated deliverables can be found below.

Provider Services Working Group

Scope

The Provider Services Working Group is responsible for the development of APIs and services hosted by mobility providers. These APIs are typically accessed by cities or other regulators. This WG manages the MDS Provider API, which is currently the most widely deployed API within MDS. Other APIs, which are hosted by cities, are overseen by the City Services Working Group.

Anticipated Deliverables

A set of **Mobility Data Specification Provider APIs,** which defines a RESTful API used to share data from mobility providers with the agencies that regulate or license them.

City Services Working Group

Scope

The City Services Working Group is responsible for the development of APIs and services hosted by cities or other regulators. These APIs are typically accessed by mobility providers. This Working Group manages the MDS Agency and Policy APIs. It is also responsible for the creation of a vendor-neutral reference implementation (known as mds-core), will facilitate testing and interoperability, and will provide sufficient structure and extensibility to support new services created by future OMF Working Groups. MDS services which are hosted by mobility providers are overseen by the Provider Services Working Group.

Anticipated Deliverables

A set of **Mobility Data Specification Agency and Policy APIs**, which define RESTful APIs used to specify the digital relationship between mobility-as-a-service providers and the agencies that regulate or license them.

One or more **reference implementations** of the City Services APIs which support interoperability verification for the above APIs, and comply with the Open Mobility Design Principles. One of the main goals of the Foundation is to foster the creation of interoperable implementations of standard approved Foundation APIs and data models.

Committees

Privacy, Security, and Transparency Committee

Scope

Privacy, Security and Transparency Committee (PSTC) will review and develop policy for appropriate transparency and data protection measures, including privacy, data retention and anonymization features, technical security practices related to mobility data including but not limited to encryption, role-based access control, and penetration testing. These policies shall support responsible and trustworthy data management practices that serve individual privacy, security, transparency and safety.

Anticipated Deliverables in 2020

- **Inventory of the State of Practice** - a catalog of current principles, policies, methods, and technologies applicable to location data privacy and anonymization.

- **Privacy and Security Guide** - a guide for public sector mobility data users that identifies key questions and considerations when making technology and policy decisions.

- **Privacy Principles** - a set of principles related to data privacy that can guide the OMF in its development of technologies and users of MDS in how they work with mobility data.

OMF is partnering with NABSA and NUMO in an attempt to develop industry-wide principles which can apply to all users of mobility data.

Future Deliverables

PSTC will recommend data privacy enhancements as part of future MDS releases.

Strategy Committee

While the Committee is defined in OMF's bylaws and has a committee charter, it has not yet gotten off the ground as an active committee, and additional work is needed to clarify its purpose and anticipated deliverables. The strategy committee could act as the product manager for OMF, producing the detailed roadmaps for OMF initiatives. They also could serve as advisors to the Board of Directors, helping inform key decisions and helping bridge the technical and policy communities within the OMF.

Scope

The Strategy Committee enables public agencies and regulatory representatives to review and consider alignment of their policies and programs in support of urban mobility and Mobility-as-a-Service, and to assist in identifying current and future Foundation projects that support these policies. This may include creating functional requirements for automated systems to monitor and manage policies using historical or real-time data.

Anticipated Deliverables

TBD

Next Steps for the Architectural Landscape

The process of developing this first iteration of the Architectural Landscape surfaced a number of open questions for further consideration by OMF leadership. With the completion of this first version, we must now build a deliberate process to reach consensus on these open issues and capture the outcome in successive drafts of the Architectural Landscape.

MDS is still a relatively new data specification and OMF is a young organization. As MDS matures and OMF grows in membership and develops new priorities and processes, this Architectural Landscape document will need to evolve in parallel. The Product Strategy shall be revisited as the mobility data and technology landscape changes. The Technology Architecture will require updates as new and changing uses for MDS are developed. The Development Process shall need to adapt based upon the experiences of OMF's working groups and committees. The Project and Deliverable Roadmap will need to reflect OMF's upcoming technical and policy priorities.

The structure of OMF as an organization and the varied backgrounds and skill sets of its membership enable a culture of experimentation. As these experiments lead to better workflows, ideas for new projects, or insights on how to work better together, we will update the Architectural Landscape to reflect that.

Appendix A - Terms, Definitions, and Acronyms

- **API Endpoint –** A point at which an API connects with a software application or service.
- **Application Programming Interface (API) -** A function or set of functions that allow one software application to access or communicate with features of a different software application or service.
- **Backwards Compatibility –** A software, product, or technology that allows use with other older or legacy software, product, or technologies.
- **Commercially Sensitive Information (CSI)** – Information that must be protected from unauthorized access that could pose a risk to the company or entity if discovered by competitors or the general public.
- **Curb Management –** a form of demand response used to manage curb space for passenger pickup/drop off, on-demand delivery, transit priority, active mobility (walking, biking and micro mobility), traditional freight delivery and personal vehicle parking.
- **Data Aggregators –** Companies that compile information from regulated entities with intent to prepare combined datasets for data processing.
- **Disaggregate/Aggregated Data -** Disaggregate data refers to datasets comprised of individual observations (ex- a single e-scooter trip), while aggregated data refers to datasets in which observations have been summarized according to a variety of criteria such as time, category, or location (ex- # of trips by zip code by week).
- **Git –** a distributed version control system to track changes made to source code during software development.
- **GitHub –** A US based global company that provides hosting for software development version control using Git. (Note: Github is owned by Microsoft, an OMF commercial member)
- **Interoperable –** a software, system, or service that can create, exchange and consume data and work with other products or systems at present or in the future.
- **Metropolitan Planning Organization** – a policy board of an organization created and designated to carry out the metropolitan transportation planning process.
- **Micromobility –** a mode of transportation which consists of lightweight, shared vehicles, such as electric scooters, docked and undocked bicycles. Fleets of micromobility vehicles

are often provided by private companies under permit to operate in the public right of way.

- **Minimum Viable Product-** the simplest design of a software feature, featureset, or program in order to meet a baseline set of functional requirements.
- **Mobility Data Specification (MDS) –** a set of APIs and code projects that enable standard communications between cities and for-profit vehicle fleets operating within the public right-of-way (i.e. e-scooters or delivery drones) to improve safety and protect residents.
- **Mobility Service Provider (MSP) –** A private company operating a mobility service within the public right of way.
- **Personally Identifiable Information (PII) –** information that alone or in conjunction with additional information can be used to uniquely identify an individual person.
- **Public Right Of Way –** the physical infrastructure reserved for transportation purposes, examples include sidewalks, curbs, bike lanes, transit lanes and stations, traffic lanes and signals, and public parking.
- **Reference Implementation –** Software or pieces of software code that can act as a resource for cities and/or MSPs working with MDS APIs. Reference implementations can be implemented directly, used as a baseline for custom software or serve as examples for organizations looking to develop their own implementations of MDS APIs.
- **Road Pricing –** Direct charges for use of roads, including toll roads, distance or time based fees, and congestion charges used to influence travel behavior.
- **Shared Mobility Services (SMS) –** SMS are transportation services and resources that are shared among users, either concurrently or one after another, providing mobility without requiring private ownership. SMS providers include micromobility service providers, carshare and TNCs. While SMS are often thought of as only services provided by a private company, we expand that definition to also include traditional fixed-route and demand-responsive transit service.
- **Technology Council –** Executes the general technical direction of the Open Mobility Foundation's endeavors and guiding principles, established by the Board of Directors. Prioritizes the efforts of the working groups.
- **Transportation Network Company (TNC) –** A private company providing a digital platform for ridehail services.

- **User Persona –** An abstract representation of the goals and behaviors of a typical type of user of MDS or MDS-derived data. Assists in understanding user needs, experiences, behaviors and goals.
- **Working Group –** Working Groups are responsible for technical deliverables, including API service specifications, reference implementations, software tools, and documentation. Members of the working groups include both OMF members and non-member stakeholders contributing to the MDS project, but voting members of the Working Group Steering Committees must be OMF members.