

Open Mobility Foundation White Paper

From: APPENDIX A OPEN MOBILITY FOUNDATION OPEN MOBILITY DESIGN PRINCIPLES

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DESIGN PRINCIPLES

1. The work of the Foundation will incorporate, develop, and expand on the contribution by the City of Los Angeles of the ***Mobility Data Services (“MDS”) specification***, at <https://github.com/CityOfLosAngeles/mobility-data-specification>. The Foundation is open to contributions from all sources, recognizing that all contributions may require adaptation to meet these principles.
2. Much of the work of the Foundation will be based on the ***“digital twin” model*** described in the appended white paper, which specifies that ***municipalities own and control*** a definitive digital data model of urban mobility. This model represents the real-time and historic state of vehicles and other devices operating within the right-of-way managed by the city.
3. All technical Foundation work will support a service mesh of interoperable microservices using ***standardized APIs and data models***, which can be hosted locally or in the cloud, and is designed to be ***cloud vendor-agnostic***. All Foundation work will support federated identity services, role-based access control (RBAC), authentication and authorization based on ***open standards***.
4. The Foundation will support the prime importance of ***privacy and security*** within the MDS architecture. Considering the varying laws and regulations in each jurisdiction where MDS is deployed, and the significant and ongoing benefits offered by different data protection research, frameworks and standards, Cities will require a range of options for privacy protective measures. The Foundation and its committees will not seek to impose a single, mandated standard. Rather, the MDS architecture enables each city to specify appropriate policies for privacy, security and elevation of public trust. Contributions to the Foundation must identify the relevant privacy and security standards, if any, that have been incorporated.
5. The Foundation will develop and release ***working reference code that fulfills each role and function*** needed for those results, which will be articulated in the ***MDS architectural landscape statement*** developed and approved by the Foundation.
6. All Foundation ***code will be issued under open source licenses***. It will be penetration tested, assessed for software supply chain vulnerabilities, and certified in an appropriate manner. Systems and applications which manage vehicles, devices and infrastructure will be assessed for conformance by successful interaction with the APIs implemented by the reference code. However, some vendors may choose to implement their own code in support of the MDS APIs.

WHITE PAPER

Transportation Administration History

For over 120 years, public agencies have adopted and enforced laws and rules governing the movement and pricing of people and goods on the sidewalks, streets, highways, bikeways and other public infrastructure to minimize the occurrences of crashes, ensure safety, and support overall city commerce.

This has traditionally been accomplished through a combination of:

- Enforcement of vehicle condition, vehicle speed, and vehicle operation
- Traffic control and curb management through signs and signals
- Establishment of “rules of the road” and training
- Dynamic changes in street availability (events, crashes, emergencies, etc.)
- Defined and enforced methods of interaction between people driving and walking, emergency vehicles, and infrastructure

These functions have had two important temporal aspects: 1) planning, which is asynchronous (speed limits, signage, rules of the road), and 2) operational, or real-time (pedestrian/driver interactions, enforcement, road closures, emergencies).

A New World for Departments of Transportation

After decades of relative stability, agencies which govern the public realm are facing unprecedented disruption to their responsibility and authority. Four changes are occurring simultaneously that require cities to expand the range of mechanisms and technologies that they apply to planning and operations.

- The number and types of vehicles using the public right-of-way is increasing dramatically. To a relatively simple world of automobiles, trucks, bicycles and mass transit, there are now: electric micromobility vehicles, autonomous vehicles, drones, and aerial taxis.
- New business models have emerged that fundamentally complicate the interface between the city’s infrastructure and vehicles. Examples include Transportation Network Companies (“TNCs”), advertising-based map and routing services, dockless micromobility, and a massive shift to online shopping which drives both delivery vehicle activity and eventually drone use.

There has been an exponential increase in the capability of technologies applied to transportation. Some of these include: mobile applications, batteries, communications, sensing through LIDAR and video, autonomous vehicle (AV) software and analytics, drones and mapping. Public agencies must understand, manage, and regulate these technologies.

- Our expectations of the public realm include requirements for tackling congestion, reducing traffic deaths to zero, ensuring environmental sustainability, enabling economic development, providing equitable transportation services and building a long term, sustainable business model for city transportation services.

The confluence of this change has had a measurable, negative impact on the quality of life in cities. Congestion has increased, transit ridership is down, and traffic deaths are increasing. Finally, since most of this technological change has been driven by individual, for-profit companies, there are no standards for interaction or operation between any of these transportation modalities or even between cities.

Digital Twins, a Technology Solution

The massive increase in the number of vehicles, the varying types of vehicles operating with different business models and the explosive increase in the technical capabilities of vehicles create huge challenges for DOTs. Managing the complexity of this transportation ecosystem in a way that can scale for the next 120 years requires a new approach – a revolutionary change.

The emerging technology of “Digital Twins” represents such an innovation. A Digital Twin is a digital replica of a physical system. By exchanging information between the physical and virtual worlds, it can provide an accurate digital representation of the state of the physical world, which can analyze and manage physical systems. Over time each city is able to build a virtual model of all of the critical elements of their city. By applying simulation and machine learning to this increasingly accurate virtual world, DOTs will be able to manage transportation environments of arbitrary complexity and size. Bringing the virtual and physical worlds together in this way will lead to better, less risky decision making, while acting as a medium for citizen engagement.

DOT operations are shaped by the interpretation of policy through governance, and virtual analogs of these concepts exist in the Digital Twin. Virtual operations and simulations must be able to query policy and apply governance to take the correct – virtual – course of action.

As an example, an emergency vehicle must respond to a crash by traveling from the local fire house to the crash location. Immediately, a routing simulation is run on the virtual city with its representation of current traffic. Once the optimized route is determined, the vehicle can be directed through both the real and virtual world. In the virtual world, intersection signals are notified just in time for the emergency vehicle to advance through the route and each signal’s real-world counterpart is then set to green. In the future, digital proxies for autonomous vehicles will be notified of the changing context so that their physical twins can take appropriate action.

As a virtual, ‘living’ equivalent of the city’s many systems, a Digital Twin allows a DOT to model possible strategies to plan for and mitigate problems before and as they occur, and to implement a solution which has been virtually tested in many simulated scenarios to minimize risk. For instance, if a stadium lets out 20,000 patrons at 9:30pm after a given event, what is the best temporary, one-way street configuration? And for how long should the temporary configuration remain in effect? City planners and operators can use dashboards which provide

access to different planes of the physical and virtual worlds to gain the insights needed for effective decision making.

Building out these virtual city worlds with the appropriate levels of security and privacy will take years. However, by starting with an extensible framework for data gathering, analysis and simulation, emerging transportation technologies can be plugged in as they arrive. A modern Digital Twin framework is based on a set of digital, interoperable services using standardized interfaces and data models.

Unfortunately, many of the newer mobility businesses have been built on very incomplete, and proprietary, Digital Twins (for example, a TNC's database of locations of available drivers). These systems represent partial, private and conflicting views of the world that are at odds with the needs and priorities of the city and its residents (and may contradict or attempt to countermand each other as well). Going forward, each city must manage its own Digital Twin, which will provide the ground truth on which mobility services depend.

Privacy and Security

While most functionality of the Digital Twin will be a duplicate of the physical version, data privacy and security are topics that gain significant prominence in the virtual twin model far beyond what is required and expected in the physical environment. (Of course, this risk exists whether a city adopts an official Digital Twin model, or simply tolerates or suffers the existence of multiple, partial private models.) A safe and constructive virtual model of the city's transportation activity requires comprehensive privacy protections underpinned by robust security measures, as data flows among vehicles, operators, third party service providers, individuals (like riders) and city agencies.

Privacy and security are different sets of goals and address different concerns. For purposes of this document, we are generally referring to a combined set of data protection features to describe the importance of addressing both strong privacy protections and robust security measures. In practice, each of these concepts must be fully addressed, designed and implemented at the outset in very targeted and granular ways. Each layer of the virtual twin, including policy, enforcement, communication or infrastructure must consider the type, timing and duration of data exchange requirements to meet the specific needs of each service.

For certain management and operational tasks, the Digital Twin must exchange data with vehicles and infrastructure in real time. For other applications, such as planning and retrospective analysis, it may be sufficient to rely on aggregated time-series data.

One of the great strengths of a holistic approach such as the Digital Twin is the ability to apply clear, consistent public policies for managing and securing data. These policies will address the types and sources of data; why it is needed; how it is transformed, aggregated, and analyzed; who can access it for what purposes; and how and why it is retained. Such policies are of great concern for city residents and mobility users, because of the personally identifiable elements in such data, but they are critically important for many other stakeholders, from commercial operators of mobility solutions to the agencies responsible for the safe and secure operation of city infrastructure.

Such data protection measures must be enforced with a high degree of accountability mandated upon all players in the virtual ecosystem. Just as cities expect robust, accurate, seamless data from providers and other partners, they must demand strict protections and compliance on the use of data with those with whom the data is shared.

Generalized Digital Twin Plan

Development of a scalable Digital Twin world is a complex task that would usually be taken on by a large commercial entity over years. However, this would result in a large, vertically integrated solution that represents a particular city from the perspective of one vendor, and which could create multi-decade lock-in for that city. Assuming that no one company would win the business of all cities, there would be incompatibilities between cities.

There is another solution. By adhering to three key principles, a Digital Twin framework and a real-world implementation can be built that truly meets the needs of cities:

1. Cities specify the underlying framework of digital, interoperable services using standardized interfaces and data models for the virtual world. The specific implementation details can be designed and offered by commercial vendors.
2. The entire system is implemented in freely available Open Source code, so that any city can implement the system at minimal cost, creating an open marketplace for vendors to compete.
3. Modular elements of the code allow cities to start small. While initially the entire virtual architecture is defined at a high level, the first implementations are focused on solving immediate problems that allow cities and industry to learn and iterate.

The intent is to promote the emerge of a marketplace of provably interoperable components from many entities while maintaining the highest degree of security and efficiency, and to encourage the creation of open source implementations for all components. This is the only way that a complex technology like Digital Twins can be realized for cities, by cities.

MDS Digital Twin Path

The Mobility Data Services (MDS) meets the needs of entities today. While cities initially developed MDS to help manage dockless scooters, the MDS framework maps the real world into the long-term Digital Twin world.

The architecture of MDS rests on a service mesh of interoperable microservices using standardized APIs and data models. The architecture supports several types of composition:

- Application APIs, which provide applications with access to the data and functionality managed by MDS
- Managed service APIs, which mediate data interchange and workflows between MDS and services that manage mobility and infrastructure
- Lateral service APIs, which allow MDS microservices to exchange data for delivery of composite services and share common mechanisms such as mapping and policy engines.
- Platform services, which are used to ensure that all MDS microservices adhere to standards for identity management, API security, and compliance.

The status of the real world is ingested through two groups of APIs: the Provider and Agency APIs.

- The Provider API is a set of data export APIs to facilitate the gathering of historical data from providers.
- The Agency API is a set of bi-directional APIs that support ingesting status information from providers and sending notifications back to the providers. In the long-term, Agency will evolve into a framework for synchronizing physical systems with their Digital Twins.

The Digital Twin world must support transaction rates for 100,000's of vehicles operating simultaneously. It will be capable of operating on historical data, for analytics and planning, and in real time, when the physical systems and infrastructure require it. It must integrate into any public or private cloud or data center, in a vendor-agnostic manner, based on an open, component-based architecture so that each city can configure the services and policies to its needs.

For enhanced security, MDS supports Federated Identity Services, Role Based Access Control (RBAC), and fine-grained authentication and authorization. The system is designed to be deployed in configurations which will support both FISMA and FedRAMP compliance audits.

The design of the Application APIs encourages active development by many companies with rich experience in transportation planning, parking, mapping, and traffic flow control. Extending these APIs and introducing new interoperable service components to support new APIs will support new applications, such as those required for autonomous vehicles and drones. The Digital Twin system services will ensure that all APIs comply with consistent access control and privacy policies.

The key to establishing a universal, extensible framework for city Digital Twins is its availability as Open Source code. The establishment of a non-profit foundation governed by cities, with a role for technology vendors, will make the Digital Twin architecture available as reference

software source code. This will ensure that cities will shape the vision of a City Digital Twin made available to all.

An open community will develop Foundation reference software, including the APIs and rigorously test them for interoperability and security. Cities and vendors may deploy the software from the Foundation, or implement their own code, verifying interoperability through compliance tests the Foundation develops. This will allow cities to run their own MDS Digital Twin systems, or contract them out to Software-as-a-Service vendors.

Summary

To support the plethora of new digital transportation services, cities need a common set of technology to allow them to continue to fulfill their multiple responsibilities, including: safety, tackling congestion, reducing traffic deaths to zero, ensuring environmental sustainability, enabling economic development, providing equitable transportation services and building a long term, sustainable business model for city transportation services. The emerging technology of Digital Twins is a solid paradigm for how cities will manage their transportation systems for the future.

Cities have a long history of addressing commercial vendors who use proprietary systems to limit market competition. A vibrant, non-profit, open source community around MDS provides a sound, scalable solution. In addition, the MDS Application APIs can enable a rich ecosystem of companies offering thousands of solutions to transportation challenges. Within this community, privacy and security must remain at the forefront of the MDS architecture and must continue to evolve over time in ways that meet the needs of both cities and their citizens.

Cities will contribute the initial architecture and initial implementations of the MDS system to support management of dockless scooters. Cities and entities that have a role in managing the public realm will govern the non-profit organization supporting MDS assisted by technology members, so that the evolution of MDS will support the needs of cities while taking advantage of innovative technology.