ROCKY MOUNTAIN INSTITUTE

MOBILITY TRANSFORMATION

A CONSORTIUM APPROACH TO TRANSIT DATA INTEROPERABILITY

BY JACKSON CRANE AND GREG RUCKS

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ABOUT US

ABOUT ROCKY MOUNTAIN INSTITUTE

Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. In 2014, RMI merged with Carbon War Room (CWR), whose business-led market interventions advance a low-carbon economy. The combined organization has offices in Basalt and Boulder, Colorado; New York City; Washington, D.C.; and Beijing.

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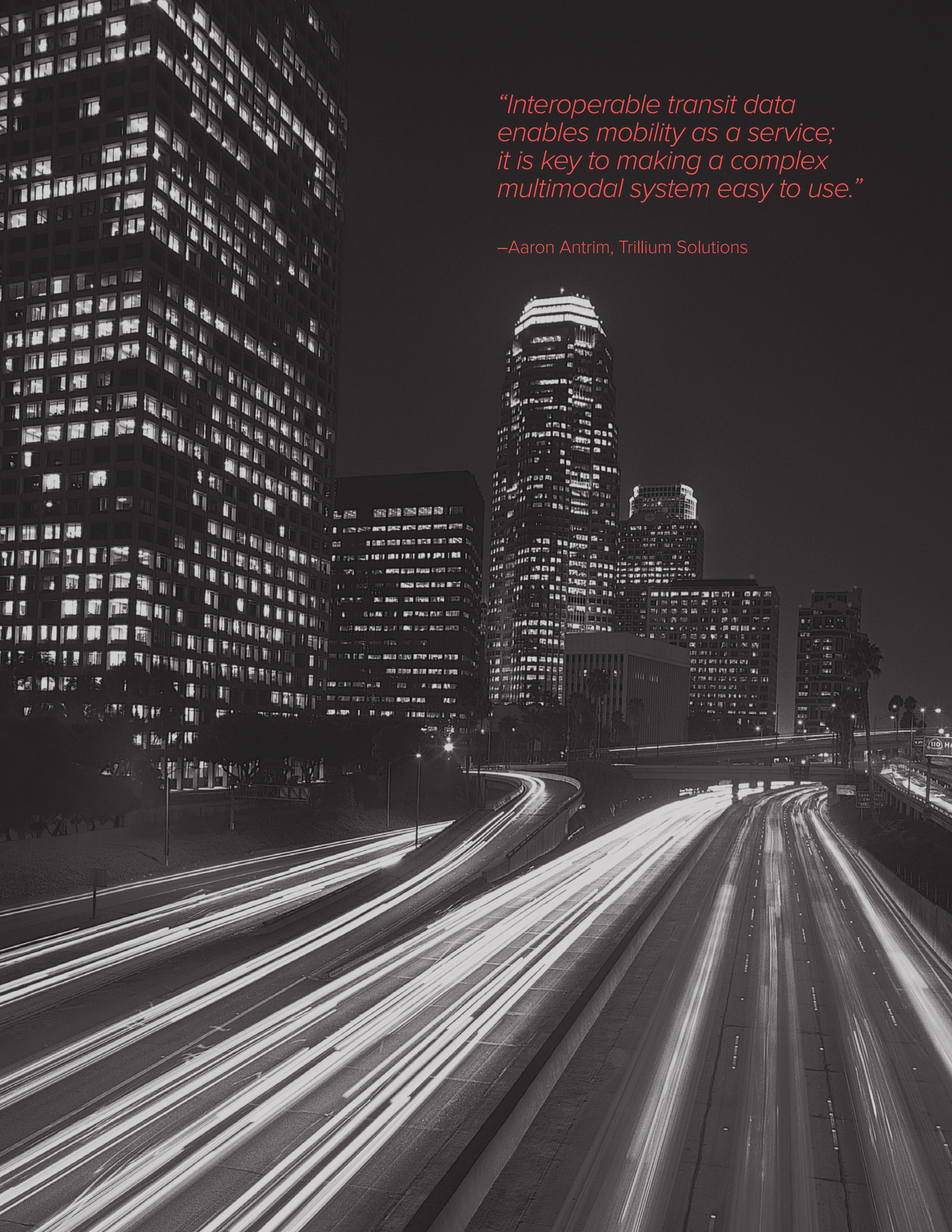


"Interoperable transit data enables mobility as a service; it is key to making a complex multimodal system easy to use."

–Aaron Antrim, Trillium Solutions

01 KEY FINDINGS

KEY FINDINGS

- The U.S. market potential for data interoperability is estimated at upward of $6 billion and is shown to drive ridership of alternative transportation modes.
- The primary barriers to data interoperability are identified as poor quality and incomplete data, a lack of data standardization, still-nascent technology and design, misaligned incentives, and inadequate public engagement.
- This paper presents a set of data requirements that addresses poor quality and incomplete data and data standardization barriers and thus helps deliver a complete user experience across all modes of alternative transportation.
- A cross-industry consortium can develop and maintain data standards, define best practices to address poor quality and incomplete data, and innovate in technology and design.
- This paper also presents near-term opportunities for transit providers and municipalities to overcome poor quality and incomplete data and public engagement barriers without the development of a consortium.

02 INTRODUCTION

INTRODUCTION

Today's transportation system is characterized largely by privately owned, individually driven, gas-powered vehicles that sit unused 95 percent of the time, cost over $1 trillion annually, and emit 1 gigaton of emissions each year. Present societal and governmental trends, emerging technologies, and new tech-enabled transit businesses suggest that the current system can change dramatically. Rather than using a personally owned vehicle, imagine a scenario in which people can travel via a wide variety of mobility options that seamlessly get them where they want, when they want, and how they want, at a lower cost to both them and the environment. We call this "mobility as a service" (MaaS).

Public transit agencies, private transit providers, and commuters create and use enormous stockpiles of transit data. Currently, however, this data is largely siloed. The momentum of software and mobile business is quickly making this data more interconnected and available. This opens up new possibilities for multimodal transportation that highlight the value of transit options to travelers, increase revenue potential for transit agencies and entrepreneurs, and give granular data to cities to inform city planning. The data that enables these opportunities is called interoperable transit data.

The purpose of this report is threefold: (1) to describe the current industry barriers and opportunities; (2) to establish a set of minimum data requirements for transportation service providers (TSPs) geared toward enabling mobility as a service; and (3) to propose a set of both immediate and long-term next steps for the industry to achieve greater data interoperability.

DATA LANDSCAPE

A few data standards have been established to facilitate the organization and dissemination of transit information. Most notably, the General Transit Feed Specification (GTFS), established in 2006 in a collaboration between Google and Portland's TriMet, aims to standardize fixed-route public transit information for import into transit-routing applications such as Google Maps. GTFS has been adopted by most large U.S. transit agencies and many smaller agencies for easy integration with user-facing applications. As technology has advanced, newer data specifications have emerged to accommodate new technologies. Notably, with real-time location information on buses and rail lines, GTFS Realtime (or GTFS-RT) was developed to facilitate real-time vehicle location and service alert information.

As other transit modes emerged, such as digital ridehail, carshare, and bikeshare, other data dissemination methods were adopted. Specifically, digital ride-hailing companies, also known as transportation network companies (TNCs), notably Uber and Lyft, use custom application program interfaces (APIs) to share a limited amount of data with external parties for integration with their applications. Carshare companies, such as Zipcar and Car2Go, have similar capabilities wherein, in some cases, APIs allow a user to book and pay for a vehicle directly through a third-party app. With the greater penetration of bikeshare throughout U.S. cities, the NABSA (North American Bikeshare Association), in collaboration with bikeshare operators, developed the General Bikeshare Feed Specification (GBFS). GBFS has been adopted by most bikeshare programs and allows the simple and scaled integration of bikeshare data with user-facing applications.

Image: Wikimedia, the Google driverless car at intersection

INDUSTRY BARRIERS

A few major barriers exist today that prevent transit authorities, TSPs, and user-facing application developers from displaying complete multimodal trip-related information to users, and to allow users to book and pay for multimodal trips in a single place.

POOR QUALITY AND INCOMPLETE DATA: Often the quality of data published is poor or incomplete. For example, real-time location data is often inaccurate, published infrequently, or missing for certain services. In other cases, certain transit authorities or TSPs do not publish data elements critical for users to make informed transit choices, such as vehicle location, fare data, or park-and-ride information, or they are inconsistent about stop and route identifiers, challenging data consumers to provide a consistent experience.

DATA STANDARDIZATION: Well-utilized data standards for certain modes don't exist, such as digital ridehail and carshare, whereas for other modes, such as fixed-route transit, the data standards are incomplete. Nonexistent standards and a lack of industry consensus prevent the simple and scaled integration of TSPs into user-facing applications. Incomplete standards prevent certain organizations from publishing all data that they may internally collect that would provide value to users. Furthermore, TSPs lack access to a set of industry best practices for data publishing, causing fragmented and inconsistent data feeds.

TECHNOLOGY AND DESIGN: Certain technological or design barriers exist that prevent complete functionality. Integrated booking and payment processing technology, although it already exists, is not accessible and simple to adopt for all authorities and TSPs. For example, for a public transit authority to allow mobile ticketing today, costly contracts with mobile-ticketing service providers are used, which often hinder integration with other transit pass systems (such as contactless smart cards), public transit systems, and other private TSPs. Multimodal routing and user-interface design is a complex and still-developing technology and design problem.

INCENTIVES: In some cases, TSPs and/or their technology vendors face a disincentive to make interoperable transit data available. For example, some TNCs disallow real-time information about pick-up times and costs to be shown alongside that of competitors, limiting a robust marketplace facilitated by innovative apps. Another example is that large transit vendors often have no incentive to share data openly with their transit authority clients, because doing so would impede their chances of winning future contracts.

PUBLIC ENGAGEMENT: Often, tools and capabilities exist to bring transit information to users, but current or potential users do not know how to use them, or even that they exist. One example of an effort to gather applications for users is City-Go-Round (citygoround.org), but it has not remained an active effort.

IN SUMMARY

Generally, the poor quality and incomplete data and public engagement barriers are distributed issues that are best overcome on a local scale. The Near-Term Solutions section of this paper speaks to overcoming these barriers.

Conversely, the data standardization and technology and design barriers are global-scale challenges that will affect the entire industry, and, as such, might best be tackled on an industry-wide basis instead of by isolated stakeholders. The Consortium as a Solution section aims to overcome these barriers.

MARKET IMPACT

Qualitatively, it is understood among TSPs that improving transit information and discoverability is beneficial for ridership for both public and private transit. Quantifying the market potential of improved data sharing, however, remains difficult. Data interoperability can be thought of in terms of tiered opportunities, where the tiers are:

Tier 1: **STATIC INFORMATION:** Standard public transit timetables and stop locations, taxi stand locations, carshare parking spaces or zones, etc.

Tier 2: **REAL-TIME INFORMATION:** Real-time bus and rail location and arrival times, wait times for taxis/ TNCs, carshare/bikeshare vehicle/bike locations, exception information (e.g., service advisories, detours), etc.

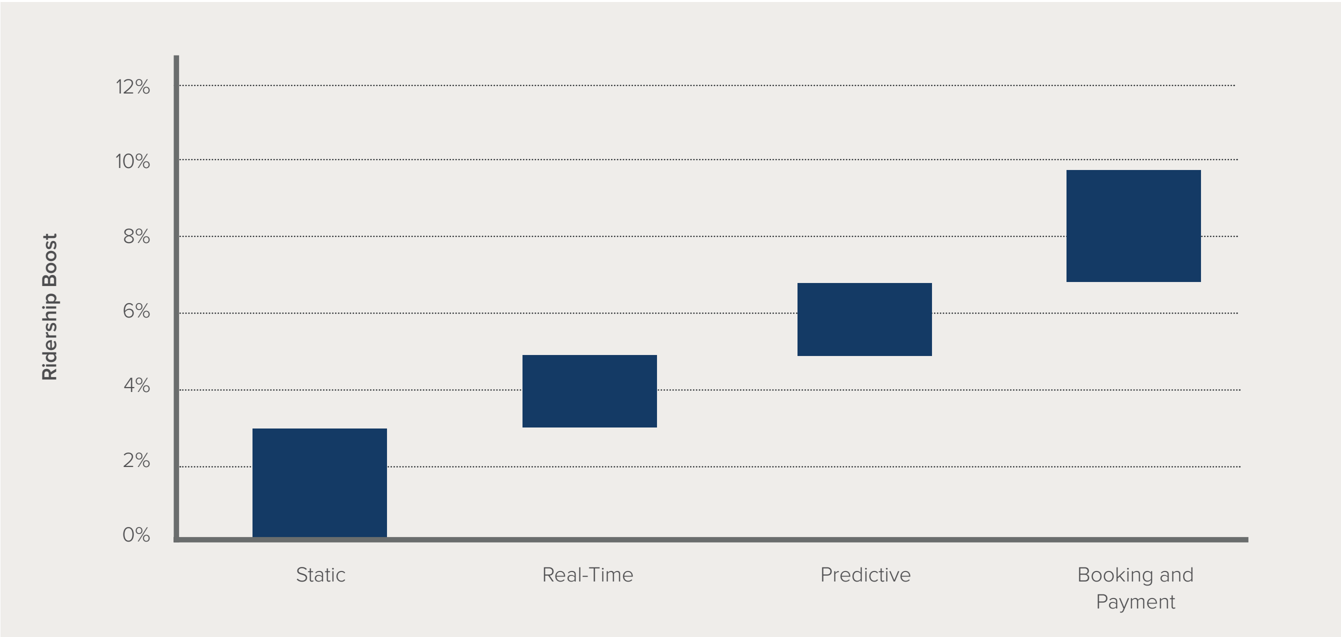
Tier 3: **PREDICTIVE INFORMATION:** Probability of on-time departures, predicted wait times or availability for taxis/TNCs, predicted carshare/ bikeshare locations, etc. This data can be based on past performance and modeling of future service.

Tier 4: **INTEGRATED BOOKING AND PAYMENT:** Ability to buy a ticket for public transit, or book a carshare vehicle or TNC ride from a single integrated interface.

A large survey-based study found that the effect of improved public transit information was a 5 to 10 percent increase in ridership.[1] Because not all of this effect can be achieved through data sharing (improved signage, public engagement, etc., are also important), we conservatively assume here that high-quality static data produces a 3 percent improvement in ridership. There are a few results that quantify the effect of real-time data in public transportation ridership, which is the second tier of data opportunities. Specifically, Chicago[2] and New York[3] both found a 2 percent improvement in ridership directly attributable to real-time information on bus lines (and the simple payback associated with these improvements is estimated to be three months). Little research has been done on the effect of predictive information (Tier 3), but we can assume it is 1 to 2 percent, similar to real-time information. With a well-executed integration with Uber, Transit App was able to achieve thousands of sign-ups and rides on the Uber platform.[4] TriMet has seen a rapid growth of mobile-ticketing penetration, already over 10 percent of total tickets in two years.[5] The same survey-based study cited above found that e-ticketing caused an additional 5 to 10 percent boost in ridership. Here, we assume that the effect of integrated booking and payment (Tier 4) is a 3 percent increase in ridership. We conservatively assume—once we account for these effects not necessarily being additive and the lack of solid evidence that predictive information boosts ridership—that the potential boost in ridership is between 5 and 10 percent.

FIGURE 1

ESTIMATED RIDERSHIP IMPACT BASED ON DATA INTEROPERABILITY TIERS



With 59 billion personal miles traveled (PMT) on public and private transit it 2013[6]—an estimated 1 billion PMT from carshare, 10 million PMT from bikeshare, and 30 billion PMT from TNCs and taxis[7]—the opportunity associated with an estimated 5 to 10 percent boost in ridership is large. Although many of these tiers have already been achieved by both public and private TSPs, we estimate that the total remaining opportunity is between \$3 billion and \$6 billion. As MaaS gains more market share over privately owned vehicles, the business opportunity for improved transit data is expected to commensurately rise.

The generation and publication of this data has further impact beyond user discoverability and integrated booking and payment. As higher-quality data is incorporated into public and private transit systems, the operations and offerings of the TSPs can be optimized. Notably, rider behavior and usage analytics is a developing functionality that has strong implications for public and private transit system optimization, city planning, and marketing. Many notable companies and projects are engaged in understanding traveler behavior using new transit data.

03 TRENDS, BARRIERS, AND SOLUTIONS

TRENDS, BARRIERS, AND SOLUTIONS

MINIMUM DATA REQUIREMENTS

To overcome barriers around poor quality, incomplete data, and standardization, this paper defines a set of minimum data requirements for transit agencies and TSPs. The data outlined here, with elegant representation in a user-facing application, will allow a current or potential user to make an informed decision about transit routing and usage. A full table of the minimum data requirements can be found in the Appendix to this paper.

TSP TRENDS AND BARRIERS

MASS TRANSIT: Public transportation such as bus and rail service has a widely used data standard to publish its data: GTFS. More than 6,000 official GTFS feeds exist internationally today,[8] which are used by a number of mapping and routing applications, such as Google Maps and Apple Maps. The GTFS Realtime extension publishes the location of vehicles, service alerts, and trip updates. An estimated 35 agencies around the world publish real-time information in a GTFS-RT feed, while other agencies publish some real-time data in other formats (including the other popular API format, NextBus). Notably, there is no comprehensive directory of GTFS-RT feeds, though transitfeeds.com does show selected real-time data feeds for transit providers. The quality and completeness of the data in GTFS-RT and other real-time feeds are variable. In 2014, about 70 percent of agencies in an APTA survey provided real-time information, but less than half provided data through an API for third-party developers.[9]

The first major barrier in public transit data interoperability is the overall cost and complexity of generating high-quality real-time feeds. Both hardware and software solutions are traditionally expensive to roll out to transit authorities. These costs include outfitting fleets of vehicles with GPS transponders and upgrading transit authority software to utilize real-time information. Newer technology companies are aiming to remedy this barrier with integrated low-cost infrastructure and software. In addition to making new third-party transportation apps for customer end-users possible, standardized and interoperable transit data also helps transit agencies and transportation providers readily integrate products from multiple vendors into a single system. This creates a more dynamic marketplace of flexible and responsive products and vendors.

The next barrier is the comprehensiveness of existing data standards. GTFS and GTFS-RT fall short of the complete minimum data requirements to which industry believes TSPs must adhere to enable MaaS. For example, GTFS-RT does not have a field for remaining transit vehicle capacity, particularly important information for users riding during peak times on busy routes. The treatment of fares is another example. Often transit agencies have complex and unintuitive fare systems that cannot be described by current data standards; conversely, GTFS cannot always incorporate all of the intricacies of public transit fare systems necessary to serve the diverse set of customers and services that a transit authority handles. The GTFS and GTFS-RT data standards continue to evolve, but inadequate community collaboration and tools for monitoring specification usage have slowed the pace of this evolution. Beyond the public transportation mode covered by GTFS and GTFS-RT, more data and specifications are needed for complementary modes (see below).

TNCS AND TAXIS: As technology-led businesses, TNCs collect a vast amount of information and are able to display nonprivate information such as wait times, service availability, and pricing to users through their native apps, as well as through APIs. As TNCs have become more established in the transit space, they have been more willing to offer information, and even offer integrated booking and payment through their APIs. The Uber API, for example, allows developers to integrate Uber into apps, so that it is possible to request and pay for Uber rides directly in a third-party app, and never leave the original application.

The principal barrier to TNC data interoperability is the competitive landscape of the industry. As TNCs are engaged in building market share, they are often loath to share any data that would give competitors visibility into their operations. As the Appendix shows, it is possible for TNCs to share data that enables a robust mobility marketplace without giving competitors direct visibility into their operations.

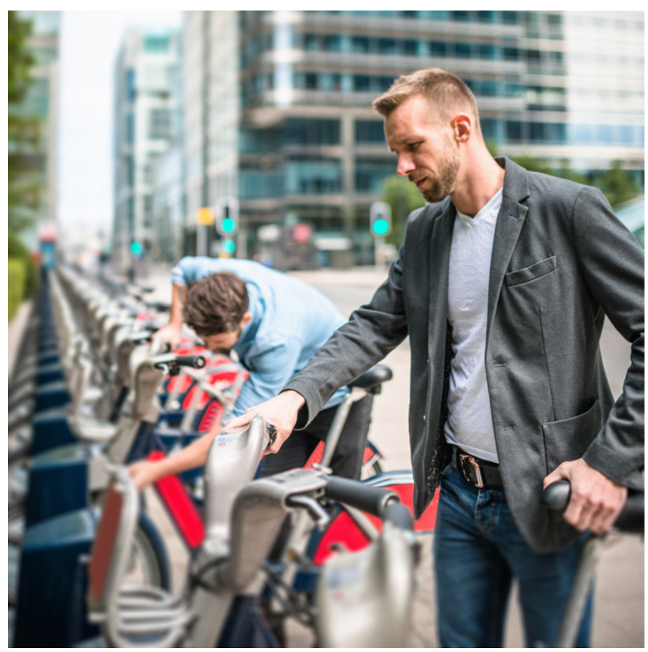
Taxis have been slower to adopt the smartphone-based hailing and payment approach than their TNC counterparts, but are adapting, and several taxi applications are emerging that connect travelers to taxis in TNC-like ways. Technology adoption presents the main barrier to parity with TNCs, and to integration with other third-party applications.

BIKESHARE: As bikeshare becomes more popular in urban areas across the nation, NABSA, in partnership with the major bikeshare suppliers (8D Technologies, PBSC Urban Solutions, Social Bicycles, BCycle, Smoove, and Motivate)[10], published the General Bikeshare Feed Specification (GBFS) in late 2015. This data standard allows bikeshare organizations to publish bikeshare station locations and real-time capacity and availability of bikes, and also provides a standard for free-floating bikeshare systems. GBFS has been adopted by many of the major bikeshare systems, and third-party multimodal transit app developers are able to integrate a greater number of bikeshare systems more quickly than they were before the standard existed.

CARSHARE: Similarly to TNCs, carshare vehicles are technologically equipped, and the carshare companies collect large amounts of data, primarily for internal tracking and operational reasons. Much of this data is shared with potential users through carshare providers' web or mobile applications. Increasingly, carshare providers are delivering information to third parties through APIs. ZipCar, one of the incumbents in the carsharing space, provides static discovery data (static car home location and car type) through an API, but to get real-time information, or to book or pay for a vehicle, interfacing directly with the ZipCar platform is required. Car2Go, another carshare incumbent in various dense metropolitan areas, allows integrated booking through APIs, which has allowed integration with various third-party applications such as Transit App.[11]

RIDESHARE/CARPOOL: We speculate that the barrier to the proliferation of carpool apps and abundance of carpool options is the difficulty of consolidating a critical mass of drivers and riders on one platform. Interoperable transit data for rideshare could break down these silos. The Metropolitan Transportation Commission (MTC) of the San Francisco Bay Area has investigated creating a kayak.com-like site for ride-matching, but is still in scoping phases. There have been a number of efforts to create rideshare/carpool APIs, but none have gained traction and widespread use. Privacy issues are one of the challenges to rideshare APIs. Here are three example APIs:

1. Carma API[12]
2. Carpoolworld API[13]
3. OpenTrip (a.k.a. TripML)[14]—No longer in development, but was briefly implemented in 511.org (run by MTC) in 2009



NEAR-TERM SOLUTIONS

Several near-term opportunities exist for public and private transit service providers to improve transit data interoperability and capture additional ridership (at an attractive ROI) that don't involve multistakeholder efforts. The solutions recommended below have been shown to have a quick payback period, and have been successfully implemented in many peer agencies and companies.

MASS TRANSIT: Most public transit authorities publish static data, but ensuring that the data is properly formatted into the GTFS standard, with as many fields populated as are available, and with stable and consistent identifiers, will continue to improve information availability for, and thus ridership of, public transportation. Publishing a high-quality static GTFS feed generally offers a quick payback for any agency. Some transit agencies currently do not generate real-time data. Technology providers are now able to equip agencies with real-time data capability (hardware and software) with an attractive ROI. Some transit agencies have real-time capability and generate the data, but do not publish it in GTFS-RT. A GTFS-RT feed allows third-party applications such as Google Maps to report real-time information to users, which has been shown to improve ridership beyond the increase imparted by static data alone.

Continually improving the quality and accuracy of transit data is also important for cultivating travelers' trust in system reliability. Data quality includes frequency of real-time location publication, accuracy and resolution of GPS data, complete bus route information, and complete and useful station information and context.

BIKESHARE: If a bikeshare organization is not publishing its data in GBFS, a high-impact opportunity for data interoperability is to publish all data in GBFS. Any deficiencies in GBFS that emerge from wide-scale adoption of the standard can be iterated on in collaboration with the NABSA and other partner companies.

TNCS, TAXIS, AND CARSHARE: As third-party multimodal routing apps become more sophisticated and popular, it will be advantageous for TNC, taxi, and carshare companies to continue to develop APIs (and other open-interface approaches) in order to enhance discoverability of their services and integration with other modes, such as public transit, which can in turn increase their market share.

MUNICIPALITIES: A sophisticated suite of tools is available to travelers in many cities, including real-time alerts of public transit deviations, advanced routing, and mobile ticketing. However, only a fraction of alternative transportation users, and an even smaller fraction of the general public, are aware of the full suite of available tools. Municipalities, including city and county governments, transportation management associations (TMAs), and other organizations, have an important role to play in promoting these tools, including educating users on how best to use them. Some transit authorities and municipalities have found success by creating a central resource for all tools and user-facing applications that are available for travelers. A good example of this is TriMet's App Center (http://trimet.org/apps/). City-go-round.org (no longer maintained) provides an example of a central transit app directory. Municipalities can also help overcome barriers involving investment, incentives, and public engagement by aligning incentives among TSPs and vendors and facilitating public engagement through policy and public projects.

CONSORTIUM AS A SOLUTION

Overcoming many of the barriers described in this paper requires an approach reflecting broad and varied understanding of the space combined with deep technical knowledge, as well as buy-in and ownership from a critical mass of adopters. We think the best way to bring this expertise together and to build critical mass to overcome the barriers presented here is to build a multistakeholder consortium that brings together perspectives and provides resources to develop solutions without putting the onus of development on one particular party.

Two principal barriers to data interoperability, as listed above, are data standardization and technology and design. These two barriers are particularly challenging to solve in a single-stakeholder context, and instead are most appropriate for a crosscutting group of industry experts to shoulder. This is the case for two reasons: (1) a single stakeholder is not necessarily incentivized to solve problems with solutions of benefit to the entire industry; and (2) a single stakeholder may not have the expertise or perspective to create the optimal solution.

Individual companies and organizations can benefit from such a consortium because they can contribute their resources and expertise and enjoy the benefit of robust and far-reaching standardization, best practices, and other insights. Reaching these outcomes individually would otherwise cost an organization significant development time and risk.

CASE STUDY: FIX TRADING COMMUNITY

As financial markets transitioned to electronic trading, there was need for a transactional standard between stock exchanges, banks, and financial information firms. In 1992, the FIX standard was formed, and by 1994, a committee with key stakeholders was assembled to govern and manage the standard moving forward. This trading protocol is now used internationally, with more than 275 financial service companies backing the nonprofit organization that maintains the standard. These companies participate in the continued improvement of the standard, as well as the dissemination and development of best practices for the protocol.

Member companies pay between $8,000 and $25,000 for membership, which allows them to take part in technical committees, participate in an annual conference, collaborate with other member firms, and advertise participation in the community. Governance is controlled by a steering committee and directors, who all hold positions at member companies. The FIX Trading Community is recognized as an effective, well-respected, and efficient group that controls an important, if niche, aspect of the financial industry.

CASE STUDY: SUTI

SUTI, a Scandinavian transportation data standard, which is an acronym for a phrase that means "standardized exchange of transport information" in English, is a widespread data protocol for taxis and other on-demand ride options. The standard has been widely adopted throughout Nordic countries, including Sweden, Norway, and Denmark. The SUTI standard is used on more than 30 million taxi and related orders annually, which constitute up to 80 percent of all taxi orders in these countries.

The standard is maintained by a nonprofit organization that has 39 members, which contribute an annual fee (€1,500) to the organization. The SUTI organization creates technical committees from the member companies and organizes industry conferences. Generally, technical members of the SUTI community spend 10 percent or less of their professional time advancing SUTI.

OTHER CASE STUDIES:

Numerous other compelling case studies serve as models for the formation of a consortium or working group. These include:

- OPENTRAVEL: OpenTravel is a not-for-profit trade association that facilitates communication within the global travel industry.
- NORTH AMERICAN BIKESHARE ASSOCIATION: A nonprofit corporation responsible for, among other things, creating GBFS, a widely used and successful bikeshare data specification.
- TRANSXCHANGE: A U.K. national data standard for bus transportation data. The specification is supported and maintained by all main U.K. suppliers.[15]
- TRANSMODEL AND SIRI: A real-time information specification for public transportation. The European Committee for Standardization (CEN) maintains this standard.

A CONSORTIUM TO SOLVE BARRIERS

DATA STANDARDIZATION: A consortium can use its expertise and governance to create effective standards, which application developers can utilize and to which TSPs can adhere. With broad participation among TSPs, an industry consensus can emerge that would drive the utilization of a single standard (or suite of standards). The consortium could also play an important role by continuing to update the standards and by developing best practices for data publishing in the standards. The Appendix offers a first step in the development of these best practices. Findings could be published online and disseminated through consortium-led conferences or workshops.

TECHNOLOGY: Leading research and development in algorithms, cost-effective data generation and collection, user experience, and other data-related technologies and approaches could be shared through the consortium structure. In areas where collaboration and knowledge sharing is beneficial, technical committees from both academia and industry can pursue projects to advance technology and design challenges. Such projects could include technical research projects and pilot projects in member cities and organizations. All of these projects will include a strong dissemination platform through the consortium.

NEXT STEPS FOR THE CONSORTIUM

Rocky Mountain Institute recommends that interested industry, municipal, and academic partners pursue the formation of a consortium, possibly through a workshop. The next steps would be:

1. Define the scope of the consortium. This could include the development and maintenance of standards, and technology and design innovation.

2. Identify consortium members. This could include members present at a workshop, as well as members key to the success of the working group who are absent. Members would define their goals, objectives, and problems, as well as identify potential barriers, associated with collaboration on interoperable data specifications.

3. Define the governance structure and operational details of the consortium. This can include membership details, technical committees, and a steering committee.

CONCLUSION

As mobility as a service captures greater market share in urban areas, a rich ecosystem of transit data is needed. Transportation providers, application developers, and municipalities all have a part to play and value to gain in the development and dissemination of high-quality, sharable data. Simple and well-understood opportunities exist for some organizations, while the industry can move forward together by establishing a consortium to develop and maintain standards, innovate in technology and design, and develop consensus.

04

ENDNOTES

ENDNOTES

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05 APPENDIX

APPENDIX

DEFINITIONS

Platform: A user-facing service with mobile and web capabilities to provide multimodal trip planning, service updates, travel advisories, and, ideally, integrated booking and payment

Private transit: Transportation provided by private companies, including bikeshare, carshare, TNC, for-hire and taxis, and dynamic mass-transit providers (e.g., Bridj, SuperShuttle)

Public transit: Transportation requested by and/or operated by public agencies, typically bus and rail

Station: A specific vehicle pick-up location (including bus/rail stops) or rental/parking spot

Transit: Synonymous and used interchangeably with transportation to denote any mode of vehicle travel other than that provided by privately owned means (including private car, bike, scooter, walking, etc.)

Transportation network company (TNC): Connects paying passengers via websites and mobile apps with drivers who provide transportation in noncommercial vehicles (e.g., Lyft, Uber, Sidecar, Wingz, Summon, Taxify, Haxi, and Didi Chuxing)

Transportation provider: Generic phrase meant to include both public and private companies that deliver transportation service

DATA LIST AND TABLE OF CONTENTS

The list below is divided according to six major data type categories:

1. Location
2. Service
3. Station
4. Payment
5. Booking
6. Identification

Each category contains data elements that are universal to all transportation providers and some that may be only partially applicable to certain travel modes, in which case we try to provide more detail in the comment column.

We hope that this delineation will aid in understanding and improving this list, but also help transportation providers quickly find the data elements requested of them.

Table 1: **Location-related Data**

	OPERATOR TYPE					
Data Point	**Station-based Mass**	**Flexible Mass**	**Station-based Shared**	**Free-floating Shared**	**TNC/Taxi**	**What this means and/or Why it is important**
Network area boundary	✓	✓	✓*	✓*	✓	Area of operations (e.g., carpooling zone of availability, TNC or taxi pick-up and drop-off zones, shared vehicle travel boundaries, extent of public transit agency routes, or authorized operation area). * Shared vehicle boundaries may simply be defined by the extent of the network of stations. Or it could be allowed zone of travel.
Vehicle route	✓	✓				Route a vehicle is expected to travel.
Timestamp of last reported data update	✓	✓	✓	✓	✓	Helps data consumers report most accurate information.
Real-time vehicle location	✓ >20 sec. refresh rate*	✓ >20 sec. refresh rate*	✓ >1 minute refresh rate	✓ >1 minute refresh rate		Accurate current location of vehicle (e.g., GPS). Likelihood of vehicle being available and likely wait time. * Consistent real-time location for station-based vehicles while in transit is nice to have. However, data about real-time vehicle arrivals at a station is necessary so journey planning can account for appropriate departure possibilities/routing.
Future/predicted vehicle location	✓	✓	✓	✓	✓*	Probabilistic vehicle location based on historical data and any forecasted events. Important for end-to-end journey planning to construct an itinerary based on likely available services. * For TNCs, this could be the likely wait time for a vehicle to arrive/ be available. Alternatively, this could be a heat map of predicted wait times without showing actual vehicle numbers.
Real-time parking dock status			✓	✓		Availability *and* number of parking spots or docks.
Future/predicted parking dock status			✓	✓		Useful to ensure journey planners can construct an entire itinerary based on likely ability to dock vehicle close to destination.
Real-time vehicle status			✓ >1 minute refresh rate	✓ >1 minute refresh rate		Status of vehicle (e.g., reserved, disabled, available).
Real-time vehicle availability			✓ >1 minute refresh rate	✓ >1 minute refresh rate		Availability of vehicle based on current rentals and reservations.
Future/predicted vehicle availability			✓	✓		Availability of vehicle based on existing rentals and historical usage for a given time of year and day.

Table 2: **Service- and Schedule-related Data (Part 1)**

	OPERATOR TYPE					
Data Point	**Station-based Mass**	**Flexible Mass**	**Station-based Shared**	**Free-floating Shared**	**TNC/Taxi**	**What this means and/or Why it is important**
Connection monitoring	✓	✓				Inter-/intra-transportation connection timing for planned service. An update to let travelers know that two mode arrival and departure schedules have been designed to allow for transfer between them without missing the connection. For example, an airport train departure is designed to accommodate the arrival of buses at a train station that connect to that train.
Real-time connection monitoring	✓	✓				Real-time inter/intra-transportation connection timing. For example, coordinating timing to holding the bus for a late train.
Service message	✓	✓	✓	✓	✓	An advisory service consisting of update messages between transportation providers and to subscribed users, including operational advice, travel news, or traffic incidents.
Service availability	✓	✓	✓	✓	✓	• Dates *and* hours of service, including day of the week, start/end date • Traveler status-specific service availability (e.g., member and nonmember values)
Service exception	✓	✓	✓	✓	✓	Service exception type (e.g., delay, cancellation, etc.) and exception description (e.g., shuttle needed to reach new stop location or revised route).
Vehicle type	✓	✓	✓	✓	✓	Vehicle type providing a particular service (e.g., bus, train, sedan, SUV, bicycle, etc.). Allows journey planning app to provide a simple notation of vehicles used within a route for travelers who may be unfamiliar with available services.
Vehicle identification information	✓	✓	✓	✓	✓	Vehicle make and model to allow travelers to correctly identify their vehicle (e.g., route number, license plate, vehicle color, vehicle model, vehicle picture).
Driver identification information					✓	Ways travelers can be sure they are traveling with the correct driver (e.g., a profile picture).
Driver contact information					✓	Provide ability to contact driver to coordinate pick-up locations as needed. Actual contact information does not need to be visible, only the ability to be routed to them (e.g., ability to call or text a driver without needing to see their actual number).
Vehicle amenities	✓	✓	✓	✓	✓	Expected vehicle capabilities (e.g., luggage/roof racks, able to carry bikes, wheelchair accessibility [has ramp, can carry a chair], 4WD/AWD, storage capacity, front/rear fenders, smoking allowed or not, environmentally friendly vehicle, vehicle can attach a trailer, can deliver packages).

Table 2: **Service- and Schedule-related Data (Part 2)**

	OPERATOR TYPE					
Data Point	**Station-based Mass**	**Flexible Mass**	**Station-based Shared**	**Free-floating Shared**	**TNC/Taxi**	**What this means and/or Why it is important**
Driver services	✓	✓			✓	Information on services provided by driver. For example, driver can help carry luggage, can help lift a passenger, is willing to transport an animal, is ADA certified; familiarity with city (e.g., certified tour guide, not familiar, moderately familiar, very familiar/local); smoker/nonsmoker.
Designed vehicle capacity	✓	✓	✓	✓	✓	Passenger carrying capacity of vehicle when empty.
Current vehicle capacity	✓	✓			✓	Current number of seats open on vehicle; could be a quantitative or a qualitative description (e.g., "standing room only," "many seats available," "few seats available," "full").
Vehicle comfort	✓	✓	✓	✓	✓	Description of seat size/comfort (e.g., long legroom, normal legroom, tight legroom).
Planned timetable (arrival and departure for each station)	✓	✓*				Details of published operations for a period within the current day, including applicable deviations. *Any scheduled stops around which the flexible route operates.
Route information	✓	✓*				• Route long name (e.g., Airport Flyer) • Route short name (e.g., AF) • Route URL to allow someone to look-up website for more information * As applicable for named routes

Table 3: **Station- and Stop-related Data**

	OPERATOR TYPE					
Data Point	**Station-based Mass**	**Flexible Mass**	**Station-based Shared**	**Free-floating Shared**	**TNC/Taxi**	**What this means and/or Why it is important**
Accurate stop and station location	✓ within 20 feet		✓ within 20 feet			Detailed location of stops/station (e.g., GPS coordinates, latitude and longitude, cross-street, landmark vicinity, postal code of station).
Pick-up locations		✓ within 20 feet		✓ within 20 feet	✓ within 20 feet*	Dedicated locations to find vehicle. * Pick-up locations where vehicles may be waiting (e.g., airport, taxi stand).
Station/stop identifier	✓	✓*				Includes both: • Unique station/stop identifier code • Unique station/stop description (a name people will understand) * As applicable for any scheduled/regular stops.
Station/stop sequence number	✓	✓*				This numbering allows for appropriate ordering of stops and representation on a map. * As applicable for any scheduled/regular stops.
Station/stop description	✓	✓*				Written description of where a stop can be found. For example, where on the platform, near what airport door, gate number, etc. * As applicable for any scheduled/regular stops.
Parking availability	✓[1]	✓[1]	✓[1]	✓[1]		Flag denoting whether parking is available or not near a station or stop.
Parking facility description	✓[1]	✓[1]	✓[1]	✓[1]		Simple description of type of parking facility. For example, pay station, underground, garage, etc.
Parking cost	✓[1]	✓[1]	✓[1]	✓[1]		Price for parking at various time increments (e.g., hourly, daily, etc.).
Parking capacity	✓[1]	✓[1]	✓[1]	✓[1]		Parking capacity ideally in real-time, or probabilistic based on past usage/analysis of parking capacity data.
Facility access information	✓[1]	✓[1]	✓[1]	✓[1]		Information to help passengers comfortably and appropriately plan travel choices: • Elevator availability • Escalatory availability • Stairs available and how many
Handicapped facility information	✓[1]	✓[1]	✓[1]	✓[1]		Description of handicapped accessibility modifications (e.g., lifts) or concerns (e.g., confined spaces).

[1] Parking and facility information is necessary to provide comprehensive travel planning. It is in the applicable operator's best interest to ensure this information is made available.

Table 4: **Pricing-related Data**

	OPERATOR TYPE					
Data Point	**Station-based Mass**	**Flexible Mass**	**Station-based Shared**	**Free-floating Shared**	**TNC/Taxi**	**What this means and/or Why it is important**
Fare chart/service charges	✓	✓	✓	✓	✓	Details regarding various fare charges and under what circumstances they are assessed. For example, ¼-mile charges, per ride charges, additional fees, rental fees, etc.
Fare class names	✓	✓	✓	✓	✓	Categories of fare classes supported (e.g., senior, employee pass, etc.).
Fare discounts	✓	✓	✓	✓	✓	Quantify impact of specific discount categories (e.g., military, senior, employer pass discounts).
Fare transfer prices	✓	✓	✓	✓	✓	Instantaneous prices for transfers between and within modes/ operators as applicable.
Transfer rules	✓	✓	✓	✓	✓	Price integration/fare rules to handle transition between modes/ operators (e.g., discounted transfers available when transferring within a certain time and between specific modes). • Transfers accepted (yes or no) • Transfer eligibility duration • Transfer fare boundaries (e.g., whether a transfer may only be used within certain network boundaries) • How to show proof of transfer eligibility
Payment currency	✓	✓	✓	✓	✓	Currency accepted for payment.
Payment methods	✓	✓	✓	✓	✓	Payment methods accepted (e.g., cash, card, PayPal, ApplePay, AndroidPay, Transit Card, account number, operator issued key fob/card, etc.).
Payment profiles	✓	✓	✓	✓	✓	Ability to set up multiple payment accounts, for example business and personal accounts with different payment mechanisms.
Peak/off-peak status	✓	✓	✓	✓	✓	Flag denoting whether peak pricing is in effect and if a price multiplier applies (e.g., surge pricing).
Payment system access	✓	✓	✓	✓	✓	Provide access to payment system to facilitate proof of payment and transfer of funds.
Instantaneous trip price or estimate	✓	✓				Instantaneous actual price or estimate for a selected trip of any length within operating boundary, including transfers and fees.

Table 5: **Trip Booking and Reservation-related Data**

	OPERATOR TYPE					
Data Point	**Station-based Mass**	**Flexible Mass**	**Station-based Shared**	**Free-floating Shared**	**TNC/Taxi**	**What this means and/or Why it is important**
Booking time window	✓	✓	✓	✓	✓	Earliest and latest times booking is available for a trip; could include how far in the future a booking may be made. Helpful information to allow for end-to-end journey planning that includes reserved vehicles.
Ticket reservation	✓	✓	✓	✓	✓	Capability to purchase tickets from a third-party application or site (i.e., ability to purchase tickets outside operator-specific portal).
Vehicle reservation		✓	✓	✓	✓	Ability to prebook and real-time reserve a vehicle/ride from a third-party application or site (i.e., ability to make a reservation outside operator-specific portal).
Parking reservation			✓	✓		Ability to reserve a designated (branded) parking spot/dock for trip destination. As application to operators that offer parking for their vehicles.

Table 6: **Operator Identification-related Data**

	OPERATOR TYPE					
Data Point	**Station-based Mass**	**Flexible Mass**	**Station-based Shared**	**Free-floating Shared**	**TNC/Taxi**	**What this means and/or Why it is important**
Operator name	✓	✓	✓	✓	✓	Agency or business long name.
Operator URL	✓	✓	✓	✓	✓	Agency or business website.
Operator time zone	✓	✓	✓	✓	✓	Time zone used in specific network area boundary.
Operator language	✓	✓	✓	✓	✓	Language used to interact with operator business and drivers in specific network area boundary.
Operator contact information	✓	✓	✓	✓	✓	Contact methods (e.g., phone, email) to allow customers to reach operator and for data users to contact appropriate department.
Operator description	✓	✓	✓	✓	✓	Specific description to communicate the type of service in each market. For example, if a company named electroGO offered free-floating electric carshare, the operator name would be electroGO and the description "free-floating electric carshare in Denver."

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