
# Standardizing Data for Mobility Management

**DETAILS**

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**AUTHORS**

þÿO Neill, Suzanne M.; and Teal, Roger F.

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# SUMMARY

## Project Description

This research was conducted to assess the exchange of (computer based) data between transportation providers, brokers, customers and human service agencies for successful mobility management undertakings.

For decades, communities have been pursuing mobility management to improve transportation options for older adults, individuals with disabilities, individuals with low incomes, and, more recently, veterans. The success of mobility management requires effective exchange of information among transportation providers, service brokers, customers, and agencies that provide health, social, education, and other services.

Events have converged in the last decade resulting in a need to examine how technology can be used to enhance mobility management and coordination activities. The goal of this research is to identify opportunities for the standardization of data relevant to mobility management systems, focusing on realistically achievable objectives that can be attained in the near-term, including possible specifications, and which can also contribute to more ambitious outcomes over a longer time frame.

Data standards will provide a foundation for important advancements including:

- enabling transportation brokers or providers to efficiently share trip records regardless of the brand of scheduling software they use,
- developing a means for customers (whether individuals, mobility managers, or human service agencies) to obtain information on trip availability and cost, and
- allowing software developers to build applications that use the data for both transportation agency use and customer use. (For example, we are now seeing applications using the fixed route data available for transit systems that have put their data into General Transit Feed Specifications format, including applications to assist people with disabilities. As the availability of standardized data becomes widespread, the benefits of such standardization will be increasingly manifest.)

While there are challenges to developing data standards in such a diverse industry, the expected advancements illustrate how the public sector can benefit from improved communications between software programs and the investment of private sector industries, whether large companies or individual software developers. The federal commitment to improving mobility management, as demonstrated programs such as United We Ride (UWR), Mobility Services for All American (MSAA), and The Veterans Transportation and Community Living Initiative (VTCLI), provides further impetus for moving forward. Leadership and a clear vision will be needed to establish data standards.

This research examined the types of data that are used in technologies that are part of mobility management systems as well as the environment in which these software systems function. The recommendations address:

- Where data standards will provide value for mobility managers;
- The specific data and related protocols needed for improved functionality; and,
- Guidelines for procurement specifications for agencies purchasing new technology for mobility management.

This report presents the research findings and conclusions. It includes a survey of both private vendors of scheduling and dispatch software and a range of transportation agencies considered to be on the advance edge of standardized data and/or are Veterans Transportation and Community Living Initiative (VTCLI) grantees.

## Audience of This Report

This report is intended to be read both by individuals with a technical background and by planners and managers with more limited understanding of technology, but whose organizations make use of the technologies that are relevant for mobility management initiatives. While data standards and the specifications that implement them of necessity involve technical elements, in this context the purpose of standardized data is to improve the feasibility of achieving organizational objectives. Planners and managers need to understand how the absence of data standards is constraining their ability to develop effective mobility management systems. At the same time, those whose focus is on software systems need to understand the data relevant to mobility management and the data standardization needed for interoperability to become feasible. Both audiences need to understand the process necessary to advance data standards for mobility management services.

## Problem Understanding

As the research team explored the problem, we found that it contained multiple components. There are two basic aspects to consider:

- The functional aspect of understanding what data needs to be transferred among different organizations and software applications to improve ease of use and enhance productivity
- The context in which the software vendors and transportation providers conduct their businesses.

Developing a clear understanding of the problem and its components is critical for identifying potential solutions. We found a useful framework to be consideration of two different activities, that of information **discovery** and that of service **transactions**, each with its own characteristics and data requirements.

The **discovery** tasks have a customer focus, and cover both fixed route and demand response transportation. How does the customer find out what service options exist? Discovery data is of primary concern to information and referral centers, individual passengers, one-call, one-click transportation centers, or mobility managers concerned with assisting passengers with finding the most appropriate and cost-effective means of transportation. Trip planners that may be found on transit agency or 5-1-1 websites are an important tool in the discovery phase.

The **transactional** activities are the primary content of scheduling and dispatch software, although such software is generally focused on an individual transportation provider's trips and not on how such data is exchanged among multiple transportation providers. Transactional data is of primary concern to transportation providers. The transaction phase occurs not with the end-user or passenger, but rather with the transportation providers involved in delivering a trip on a demand responsive service. The transactional data is that which is needed to schedule a particular trip on a vehicle, provide the trip or job it out to another transportation provider, and verify the trip was made.

The problems that need to be addressed are oriented around two topics:

- Standardizing data for both the *discovery data*, as used both by transit systems and information and referral services and *transactional data* for demand response services to promote the efficient exchange of information among service providers.
- Developing a means to engage software vendors and the entire industry of transportation providers in developing and maintaining data standards for mobility management, and providing a mechanism to support their evolution over time.

## Current Environment

At present there are less than a dozen companies that provide reservations and scheduling software for demand response transportation providers, with two or three major firms and a variety of other firms with smaller market share. Some scheduling software products are part of a complete suite that can address all modes; others are directed at demand response transportation services. Some are best suited for small or medium-sized systems; others are suitable for large systems as well. When transportation providers who are purchasing such software request that it be able to exchange data with a transportation provider using a different brand of scheduling software, vendors typically create a "translator" that is specific to the two programs. This includes a data dictionary for the software programs and a user-friendly interface for the schedulers.

For the discovery data, trip planners are the primary relevant type of software used in the information and referral (I&R) function. Today most medium-to-large size transit systems include trip planners on their web pages. Trip planners have become more effective over time,

especially in improving the accuracy of identifying both desired origin and destination locations. They may have the flexibility to provide alternate itineraries, provide directions and/or a map, and print the itinerary in reverse for the return trip.

Fortunately for I&R services who need information on public transit services, a common format for fixed route transit data does exist, courtesy of Google, which developed the General Transit Feed Specification (GTFS) for its Google Transit product. With the GTFS data specification, trip planners and other web applications are able to use standards-based data and display map-based user interfaces that show transit routes and stops and service timetables. These applications thus enable potential transit users to discover their travel options and to plan their trips.

## Survey of Software Vendors and Transportation Providers

The research team canvassed two key stakeholder groups: software vendors and transportation providers. We contacted all of the demand response software vendors with a significant market share to determine their perspective on data standardization for mobility management systems. In addition, the team contacted transportation providers and others, focusing on those: (1) actively exploring the issues around how to exchange data, and (2) VTCLI grantees using this particular funding opportunity to advance the exchange of data related to either discovery or transactional functions. Both groups were contacted by telephone and/or email and requested to participate in an interview and almost all participated.

These interviews helped to develop the problem understanding, illuminated the context within which the software vendors and transportation providers function, and helped to identify the types of solutions that would be viable.

*Interest in Standardized Data*

Among both the software vendors and transportation providers whom the research team interviewed for this project there was general consensus that standardized data for demand response scheduling software is desirable. Transportation providers have a different perspective on this than private software vendors.

**Transportation providers** are aware of how exchanging data with other transportation providers is key to sharing trips among transportation providers, opening up opportunities to operate service more efficiently and provide more mobility. At the same time, only a few transportation providers have enough experience to understand the impact of data standards on what they do (or wish to do) or to have opinions on different approaches.

Although transportation providers express the desire to be able to have their software applications communicate with those of other transportation providers, across varied software systems, there is considerable distance between their vision and the reality of what must occur in

order to make possible the easy and reliable exchange of data. Individual transit providers can request that software vendors create a means for them to share data with another system, and the result is a unique software solution that enables these two particular systems to communicate electronically. However, the solution is not transferrable and may need adjustment anytime either of the software applications go through an upgrade. There is not yet a unified approach to creating data standards.

**Software vendors** expressed varied opinions, but with an overall consensus of support for standardized data. At present, when vendors respond to a Request for Proposals that specifies interoperability between two or more transportation systems, a unique software solution using some form of "translator" and "data dictionary" is created for that application. The more data that follows agreed upon standards, the less translation is needed. There was also a general consensus that the approach of starting small, with a minimum number of data elements, is preferred. The minimum data set can be expanded over time based on what is most useful. It is important to note that some degree of translation will continue to be needed, especially until the set of standardized data is robust. Having a base set of standardized data would allow software vendors to focus on enhancements to the basic data, in the translation process, to distinguish their products.

Some concerns noted by software vendors included:

- The competition among software vendors is an important aspect of the market economy. Therefore, it is important that standards be neutral, not giving an advantage to any vendor.
- The process of establishing and maintaining standards. Who will be responsible? What will be the role of software vendors?
- Who is going to take a lead role in this process? What if only some software vendors participate?

*Lessons Learned from Transportation Providers*

Interviews with transportation providers converged around the following points.

- ***Customer knowledge is limited.*** Customers often have a clear picture of the outcomes desired, however they do not have the sufficient expertise to assure that the software products they purchase will achieve these results.
- ***Mismatch with Technical Knowledge of Software Vendors***. Transportation providers are not on even footing with private software vendors when they go to purchase scheduling and dispatching software and related products. Few transportation providers have sufficient IT knowledge to ask all the right questions and evaluate the responses.
- ***RFPs are Often Generated by Consultants***. The use of consultants is effective at bringing together two complex fields: technology and the delivery of demand

responsive transportation. However, much of the expertise for defining how technology can be used to address these complex transportation problems is not being developed by transportation providers.

- ***Early Adopters Have Few Models.*** As in most industries, there are a few individuals who are seeking to make the most of available technology to meet the needs of their region. These efforts have resulted in the development of useful approaches, and are leading the way. The TCRP IDEA Project 50 report, "Developing Regional Mobility Management Centers", identifies how TransPro of Tacoma, Washington has used a translator and the value of this approach. Ride Connections in Portland, Oregon is developing open-source software that uses a "trip ticket" approach to exchanging data.

## Framework for Data Standards

Effective mobility management requires the efficient exchange of information among the multiple parties who are involved in organizing, providing, consuming, and financing local transportation services when the process of obtaining and delivering such transportation crosses organizational boundaries. The recommended framework is organized into **discovery** and **transactional** data. The type of data needed for each facet is different, although related. There are significant differences in discovery and transactional data, so the approach to and process of standardization will be quite different for each set of data. The problems associated with standardizing such data also vary as discovery and transactional processes have developed in different contexts.

*Approaches to Standardized Exchange of Transactional Data*

Many industries or vertical business segments have a need for the major software systems that organizations use to exchange data with other organizations. In the past decade, three major approaches to standardized data exchange have become commonplace.

1. ***Explicit data standards***, whereby a core set of data is designated.
2. ***Data hubs,*** which provide a mechanism for applications to exchange data without directly communicating with one another.
3. ***Application programming interface (API) mechanisms***, which are essentially a bi-lateral mechanism that enables collaborating systems to exchange data.

Each of these approaches has advantages and disadvantages, and all are potentially relevant for mobility management activities. The focus in this project is on the first approach, in which an "industry" group of some type agrees on data formats and a mechanism for data communication and publishes these as the standards for data exchange.

*Processes for Developing Specifications and Standards*

When the public and private sectors develop standards, there are several commonalities. All such processes take time and are iterative in nature. Leadership is a key element although these processes are essentially collaborative activities. The individuals who work on the effort may be volunteers or employees of companies that believe it is valuable to invest their employees' time in the development of standards.

*Proposed Approach and Core Elements*

Achieving any level of data standardization, particularly for service transactions, is likely to be a challenging process that will probably occur incrementally and iteratively. This suggests that a "walk before we run" approach to agreeing on standardized data is more likely to be successful than trying to obtain agreement on comprehensive data standards and data exchange protocols as the initial objective. Accordingly, the research team's assessment of the **core** data elements that need to be included in the **initial** data standards follow.

Data Elements for Service Transactions

The data needed to support service transactions include:

1. Trip data
2. Passenger data
3. Organization data
4. Financial data
5. Vehicle data

The two primary data records are the: (1) passenger record, consisting of 16 data elements, eight of which are mandatory; (2) the trip record, consisting of 18 data elements, 16 of which are mandatory. The other record types—organization, financial, and vehicle—have a total of 17 data elements, of which 14 are mandatory. Overall, there are a total of 51 data elements, of which 38 are mandatory.

It is our understanding that all of the data fields specified are present in the software applications currently being used for demand response services. They may have different names than those used in this study, but the data itself are present in the databases used by the existing applications.

Data Elements for Service Discovery

The data elements needed for service discovery are of a different character than those necessary to support transactions. Information and referral systems need data that describes fixed route transit, demand response and other flexible transit services that operate within the service area of the I&R system. As discussed previously, the GTFS specification has successfully standardized the data that are used to describe fixed-route transit services, but no such standards currently exist for demand responsive services. The proposed core data elements for service discovery for demand responsive services are also presented in the report.

## Conclusion

There are concrete benefits to developing data specifications for mobility management functions. These include direct cost benefits as (1) agencies with different demand response scheduling systems are able to save staff time daily by transferring data electronically between systems rather than re-entering it; (2) States or regions will be able to avoid locking-in with one vendor, allowing individual DRT providers to purchase scheduling software that best suits their size and type of organization rather than a program that is more than they need; and (3) informed purchasers of software will be more likely to purchase the appropriate product for their agency, including specifications for interoperability across technology platforms.

More importantly, such data specifications will enable transportation providers to adapt to current technology and continue to innovate as technology changes and improves. It will enable transportation agencies to easily subcontract with smaller service providers who may have available capacity, reducing the cost of service and improving productivity.

The recommended approach is to actively involve transportation providers and scheduling software developers in a collaborative process to define specifications. Both bring important perspectives to the process. Further, it is recommended that the effort start small with a minimal set of data items, growing over time.

# I. INTRODUCTION

## Project Description

The Transit Cooperative Research Program has funded a "Quick Response" project (TCRP J-6/Task 82, *Standardizing Data for Mobility Management*) to assess the exchange of (computer based) data among transportation providers, brokers, customers and human service agencies for successful mobility management undertakings. The goal of this research is to identify opportunities for the standardization of data relevant to mobility management, focusing on realistically achievable objectives that can be achieved in the near-term, including possible specifications, and which can also contribute to more ambitious outcomes over a longer time frame.

This research examined the types of data that are used in technologies that are part of mobility management systems as well as the environment in which these software systems function. The recommendations address:

- Where data standards will provide value for mobility managers;
- The specific data and related protocols needed for improved functionality; and,
- Guidelines for procurement specifications for agencies purchasing new technology for mobility management.

## This Report

This report presents the research findings and conclusions from TCRP J-06/Task 82. It includes a survey of both private vendors of scheduling and dispatch software and a range of transportation agencies judged to be on the advance edge of standardized data and/or are Veterans Transportation and Community Living Initiative (VTCLI) grantees. The survey was conducted using telephone interviews with written questions provided in advance to the participating individuals. A description of the survey and those contacted is contained in Appendix A.

This report is organized as follows:

- *Chapter I: Introduction* presents background information.
- *Chapter II: Context* provides a context for understanding the problem, providing both a functional description and various perspectives on the problem.
- *Chapter III: Data Framework and State of the Practice* begins with an in-depth look at the data requirements for discovery and transactional data. It then describes the current state of practice.

- *Chapter IV: Data Exchange Standards* identifies common approaches to data exchange, illustrates practices in other industries, and provides examples of the development of standards in related situations.
- *Chapter V: Advancing Data Standards* identifies considerations in advancing data standards, proposes a core set of data standards for the mobility management community to consider, and outlines work to be completed to advance data standards.

A glossary is included at the end of the report with definitions of many terms used in the report.

As used in this report, the terms “data standards” or “standardization of data” are used in the generic context to refer to commonly defined data. The term “specifications” refers to the descriptions of such standardized data in a manner that can be used by software developers.

## Background

For decades, communities have been pursuing mobility management to improve transportation options for older adults, individuals with disabilities, individuals with low incomes, and, more recently, veterans. The success of mobility management requires effective exchange of information among transportation providers, service brokers, customers, and agencies that provide health, social, education, and other services.

Events have converged in the last decade resulting in a need to examine how technology can be used to enhance mobility management and coordination activities. Key events are:

- Some transportation providers have been working to electronically share passenger trip records with subcontractors or other providers with the potential to provide some trips more efficiently. This builds on the system of faxing a driver’s manifest, or record of trips that each vehicle will operate, to a subcontractor and having the subcontractor fax back, at the end of the day, a report on the disposition of these trips.
- The demand response transportation industry has begun to perceive the need for some level of interoperability between multiple software systems. Vendors of scheduling and dispatch software have developed, generally on a unique or one-off basis, data dictionaries and the software to translate data from one software system to another, enabling this to happen electronically, minimizing the data entry. Some individual transportation providers have experimented in developing software that will meet their needs, helping to define the functions where standardized data will be valuable.
- Google has developed specifications now known as the General Transit Feed Specifications (GTFS), enabling transit providers to enter fixed-route information into the Google mapping system. These specifications have become widely used

in the Google mapping software and in public transit trip planners, essentially becoming *de facto* standards for describing fixed route data spatially and temporally. The address standards in the Google Trip Planner are also widely used.

- Customers, human service agencies, and transportation providers have become very aware of the need to make it easier to access transportation services, particularly for groups such as the elderly, veterans, and low-income individuals. The concept of a "One-call, One-click" or other information and referral system is gaining in popularity.
- The Veterans Transportation for Community Living Initiative (VTCLI) has allocated tens of millions of dollars of federal funds to initiatives that are primarily of two types: (1) Information and referral (I&R) systems, which may have as their ultimate objective a One Call/One Click system which enables veterans to be able to obtain information on all relevant transportation options via a single phone call or web site; (2) Transportation "coordination" systems in which the focus is on multiple organizations concerting their activities so that vehicle capacity can be shared among the participants.

While there is a growing awareness of the desirability of standardized data and system inter-operability for mobility management, it is also clear that most participants in the demand response transportation industry have at most a rudimentary understanding of the advantages and challenges of developing such standards and accomplishing interoperability. The issue of data standards is considered to be a "technical" issue—or even more specifically, an "information technology (IT)" issue. Most system managers or program administrators perceive it to be outside of their functional comfort zone. In reality, data standards are as much about business/organizational processes as they are about technology, but this is not yet widely understood within the industry. This study, in fact, is in part motivated by the need to bring greater visibility to and understanding of this topic to a non-technical audience. It is important to build an understanding of how the absence of data standards and data interoperability is constraining the ability to develop effective mobility management systems.

# II. CONTEXT

There are several important aspects to the problem context; each will be discussed in this section. They are:

- A functional understanding of the problem
- Perspectives of software vendors and developers
- Perspectives of transportation providers and human service agencies

In addition to understanding the perspectives of these key groups, it is useful to understand the environment in which they function. This is discussed in the individual sections on perspectives. In addition, the last part of this section describes the data used in information and referral applications and the unique impact of Google Transit.

## A Functional Understanding of the Problem

The consulting team began by gaining an understanding of the research problem from the perspective of the end users – transportation providers, human service agencies, and the clientele or community residents they serve. We view the research problem as having two facets:

- An operational focus, concentrating on data that helps two or more agencies arrange the delivery and payment for trips
- A customer focus, concentrating on data that helps customers to access information about how to meet their mobility needs.

Figure 1 on the following page is a schematic developed to describe these two perspectives. Begin with the customer focus. A customer (individuals or a case worker for a human service agency or other representative) needing to arrange transportation may use a call center or information and referral service, a web-based trip planner, or simply a set of bus schedules to figure out how a particular trip can be made. If the trip can be made using a fixed route bus, the passenger will have enough information from these sources to make the trip. If the trip will be made using a demand response service, additional steps will be needed to assure the rider is eligible (except for general public demand response services) and to schedule the trip.

The operational focus takes place once passengers who are eligible for trips schedule the trip. At this point, data that supports reserving a trip, scheduling it on a vehicle, reporting on trips taken, and the billing and payment related to the trip are needed. Demand responsive transit (DRT) services typically utilize software for reservations and automated scheduling of trip requests. There are several different software applications that command a significant market share among providers of DRT services and these applications do not currently have common data structures nor are they capable of true interoperability. Even relatively basic data sharing among such scheduling systems has proven to be difficult to achieve. This makes it difficult for transportation providers to communicate with each other or with their subcontractors.

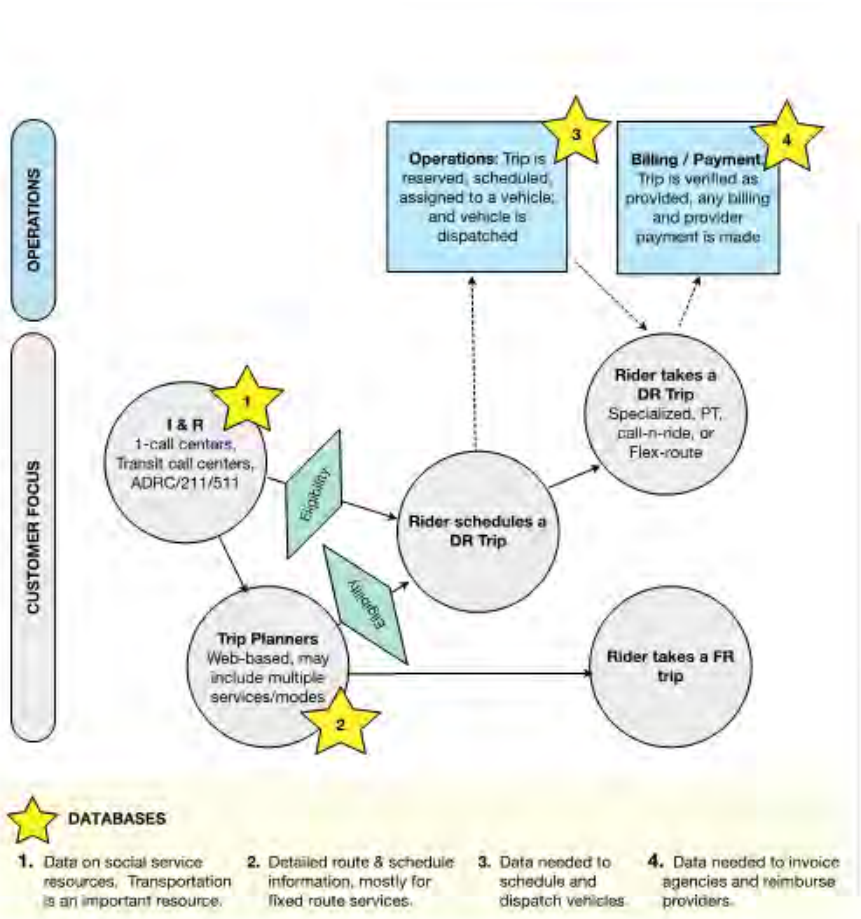



**Figure 1: Schematic of Transportation Agency and Customer Functions as Related to Data**

*Discovery and Transactional Data*

As the research continued, we found a useful framework to be breaking the trip down into two different phases, each with its own characteristics and data requirements. The first is the **discovery** phase and this relates to the customer focus common to mobility management activities. How does the customer find out what options exist? Is there fixed route or demand response service available at the time the trip is needed? Does it go between the origin and destination? Are transfers needed? Can it accommodate the passenger's wheelchair, service animal, or other needs? What is the cost? Is there space available? The customer may need to have a variety of questions answered in order to make the trip. Many riders of demand response services could use fixed route services for all or part of their trip, so discovery data that links the two is valuable. Discovery tasks cover both fixed route and demand responsive services, including those services for persons with disabilities.

Discovery data is of primary concern to information and referral centers, individual passengers, one-call/one-click transportation centers, or mobility managers concerned with assisting passengers with finding the most appropriate and cost-effective means of transportation for a particular trip. Computerized trip planners that may be found on transit agency websites or 5-1-1 websites are an important tool in the discovery phase.


**Service Discovery Tools**

The VTCLI project in San Bernardino County, CA has a strong focus on the available fixed route services that Veterans can use to access the VA Medical Center. The *2-1-1* system, an information and referral agency, is a key partner. Key tools are:

- the **trip planning software** to enable Veterans and *2-1-1* information and referral staff to identify available services and
- a listing of transportation services by facility

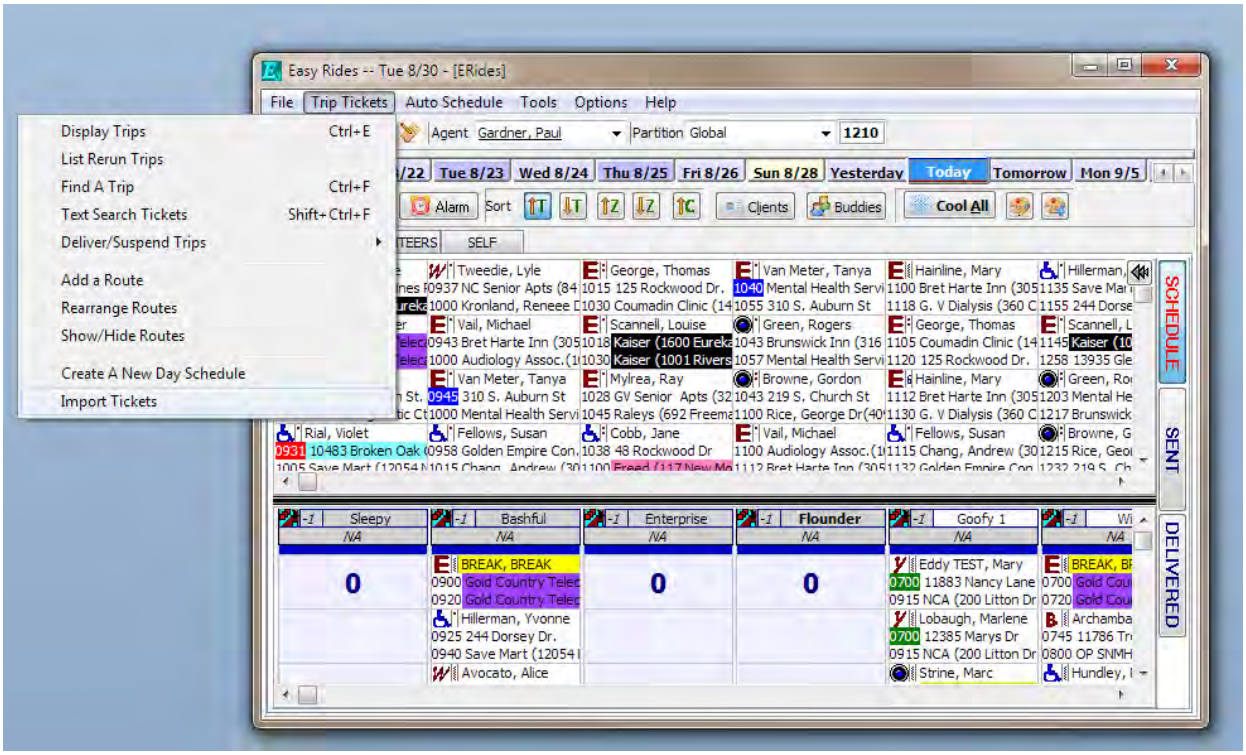
The website can be fouind at:

http://www.ie511.org/veterans-transportation.aspx

The second type of data is **transactional data.** This is the primary content of scheduling and dispatch software, although such software is generally focused on an individual transportation agency's trips and not on how such data is exchanged between multiple transportation agencies.

Transactional data is of primary concern to transportation providers and service sponsors. The transaction phase occurs not with the end-user or passenger, but rather with the transportation providers (and non-provider service sponsors) involved in delivering a trip on a demand responsive service. The transactional data is that which is needed to schedule a particular trip on a vehicle, provide the trip or subcontract it out to another transportation provider, and verify the trip was made. In the process of delivering the trip, information such as time of pick-up, delivery, and drop-off; trip mileage; and fare paid, trip cost, and other billing information is gathered and becomes a part of the trip record.

Figure 2 illustrates a typical screen showing the use of transactional data for a DRT system. Discovery and transactional data will be explored in more detail later in the report.




*Source: Transportation Research Board Transit IDEA Project 50 Final Report "Developing Regional Mobility Management Centers"; original screen shot courtesy of Mobilitat Software.*

**Figure 2: Typical Scheduling Software – Use of Transactional Data within a System**

### *Software Used for Discovery and Transactional Data*

The software used for discovery and transactional functions are fundamentally different from each other. It is useful to begin with a description of each.

#### Scheduling and Dispatch Software (Transactions)

There are a small number of private firms that have developed scheduling and dispatch software for DRT providers. These various products are differentiated on a variety of factors; some are geared towards small systems and others towards larger more complex systems; they may have different levels of emphasis on developing a suite of related products, customer service, or specific features; and they developed out of different backgrounds and this is reflected in their structure. The backgrounds from which these systems developed include community transportation, fixed route transportation, human service transportation and even the taxi industry.

In other industries, such as the airline industry, the airline companies themselves initially developed and maintained ownership of the primary software used for transactional data. In

contrast, the vast majority of DRT providers (or non-provider service sponsors) do not own the software they depend on for transacting business. This is largely a consequence of the size of the individual businesses needing such software as most could not justify the information technology staff to develop or maintain the software. As a result, most DRT providers have not gained the desirable levels of experience that would make them informed purchasers of software. Another result of this situation is that a partnership between the private software vendors and the transportation providers is needed. The involvement of DRT providers is needed to define what is needed to support efficient business activities; the involvement of the private software vendors is needed to develop products that meet the needs of the market.

It is worth noting that there are some examples of transportation agencies that have developed their own software platforms (typically via contracts with software development companies or by hiring software developers for this purpose). In the state of Oregon, considerable work has occurred in this area. Tri-County Metropolitan Transportation District of Oregon (TriMet) has been actively involved in developing and maintaining open source software both for transactional data for DRT systems and for their fixed route trip planner. The Oregon Department of Human Services has long worked with transportation brokers for scheduling Non-emergency Medical Transportation trips (NEMT) under the Medicaid program and its state-level counterpart. Oregon's software is the basis for this open source scheduling and dispatch software. Ride Connection in Portland is at the forefront of developing software using open source formats. In addition, Lane Transit District in Eugene, OR has developed its own software platform that supports order taking, scheduling, service brokerage, billing, and other functions for multiple types of DRT services in its area of jurisdiction, including DRT services operated by other (human service) organizations. The Denver RTD is another example of an organization that developed its own technology platform, in this case for its general public DRT services.

Information and Referral Software Used for Discovery Data

There are three basic relevant types of software used in the information and referral function:

- Trip planners (an application that shows a user how to get from point A to point B at a specified time by using public transit, often via a map-based interface).
- Databases that provide standard information about a wide range of social services, and transportation, through the 2-1-1 networks or long-term care options (through Aging and Disability Resource Centers).
- Databases that are client-focused and provide broad information about the needs of clients in a community, such as that developed through the Robert Woods Johnson Foundation and used in community-based volunteer programs.

While the latter two are important to be aware of, the focus at this point is on trip planning software applications.

Transit networks of bus and rail services are complex; they have many routes, each with different schedules that vary by the time of day or day of the week. Efficient networks are often fine-tuned, with limited stop service on busy routes or in peak periods, deviations at certain times, and frequency of service based on demand. Some transit systems include general public demand response services (DRT) in areas of low demand. In small cities and semi-rural areas, DRT may be the only form of transit service available. The extensive data makes it challenging for an information and referral staff person to provide the variety of data needed to persons calling in for travel information. Rather than trying to answer such questions, callers may be simply referred to a transit system call center. If a trip requires more than one transit system, not uncommon in urbanized areas, additional calls are needed.

Years ago, riders primarily obtained information on services through schedules and a system map. Using these tools it is possible to figure out the options that exist using different routes or at different times of day, but this can be challenging for many people. Telephone information lines grew in popularity, with prospective riders calling for information on how to make a particular trip. Agents ask callers for trip origin, destination, and the time of day the trip will be made; they tell the caller where to catch the bus and at what time, often giving information on the next bus (20, 30 or 60-minutes later). As web sites were developed over the past decade, it became possible for riders to either look up schedules and maps online or to use a trip planner to obtain the needed route and schedule information.

Today most medium-to-large size transit systems include trip planners on their web sites. Web sites for 5-1-1 include trip planners, or may connect directly to the transit system trip planner. These trip planners function much like the telephone information lines: users enter the origin, destination, and desired time of travel. The trip planner application responds with information on how to make the trip using transit including specific bus route, location of stop, time the bus will arrive at the stop, and time scheduled to arrive at the destination.

Trip planners have become more effective over time, especially in improving the accuracy of identifying both desired origin and destination locations. They often have the flexibility to provide alternate itineraries, provide directions and/or a map, and print the itinerary in reverse for the return trip. A rider may be able to choose between multiple trip planner applications, and use a help function for hints on how to use it or to troubleshoot. There are trip planners available through Google Transit, Open Source platforms, and, in large metropolitan areas, also through a variety of private software vendors.

## Perspectives of Software Vendors and Developers

The project team contacted DRT software vendors with a significant U.S. market share to determine their perspective on data standardization for mobility management systems. The software companies were contacted by telephone and/or email and requested to participate in an interview with one or more members of the project team. A total of seven companies were

contacted; six agreed to participate in an interview. The interviews were conducted by telephone and typically lasted 60 to 90 minutes. While the project team had developed questions and topics to guide the interviews, the actual interviews tended to be wide-ranging as the subject of data standards was not something that many of these organizations had given a great deal of attention or thought to.

The DRT software companies come in two distinct categories. There are three relatively large companies (one quite large) and several smaller competitors. The larger companies have many installations of their software or at least a number of very large installations. The smaller companies are focused on smaller demand response systems and may have a limited number of installations as well. In addition, whereas the larger companies have many technical staff, the smaller companies may have only a few technical staff, and possibly no more than a single senior software developer, who is often a key executive of the organization. As a result, both the situations these organizations have been exposed to in terms of needs/desires for data exchange, and the level of resources available to modify their core software applications in response to any data standards, are quite different between the two classes of software providers.

*Major Software Vendors Perspective*

Two of the three major software vendors have considerable understanding of mobility management systems and some level of involvement with such systems. One was selected to provide the software for some of the FTA-funded United We Ride demonstration projects for mobility management. The other's software applications have been used in several multiple organization systems that bear some resemblance to mobility management systems, and the company has experience with a number of transportation brokerage systems. In contrast, the third major vendor has not been as involved in mobility management or brokerage systems, although its software does have some integration with fixed route trip planning software to be able to determine fixed route transit ride times as part of the ADA Complementary Paratransit trip scheduling process.

All three of these software companies expressed a willingness to participate in a process that could lead to data standards for DRT software applications. At the same time, two of the firms have developed - and continue to develop - products that represent proprietary approaches to data standardization.

One company has developed a product that enables different organizations that are using its core demand response software application to exchange trips and service capacity; transportation agencies can post trips that they do not have the capacity or other resources to provide themselves and would like to have other transportation agencies provide, and transportation providers can view and select the trips from this "white board" that they wish to transport. While this product contains functionality that is core to the needs of mobility management systems, it works only with the company's own software applications, and not applications from other DRT

scheduling software vendors. This product currently does not include “connectors” or “adaptors” that would enable other software applications to post trips to or select trips from the white board.

The other major company has also recently developed a new product that promises data integration and data exchange, and appears to have a number of features that are central to a mobility management system. In contrast to the system described in the paragraph above, this other application contains a mechanism for third party software systems to connect to the vendor’s hub application and includes a dictionary-type mechanism to facilitate data translation. But while this other major company is currently promoting this product, and the data dictionary approach to data translation embedded in it, as a mobility management system solution, it has also indicated to this study’s researchers that it supports the development of data standards for application interoperability. It has further indicated, moreover, that it would prefer the standards-based approach to its current data dictionary approach as the mechanism for enabling multiple applications to interoperate and exchange data.

*Other Software Vendors Perspective*

The software vendors with smaller market shares have much less experience with situations involving some form of mobility management initiative, and in some cases essentially none. Only one of these vendors interviewed appears to have given much consideration to data standards or application interoperability. As one of the contributors to the TCRP IDEA-50 study, this firm has also developed a software tool that enables data to be translated from a source system’s format into a format where it is compatible with its own software. The larger vendors also have developed such translators.

These vendors view data standards as a generally good thing and are supportive of efforts to develop such standards. They would be willing to participate in a standards-setting exercise, but may have little conception of what that would mean in practice. Whether they have the internal resources to develop additions to their own software to produce standardized data to the external world, and to create adaptors/connectors that would facilitate data exchange between running software systems is a question not easily answered in advance. The level of effort needed to enable real-time data exchange - using standardized data - among these vendors’ applications and those of another vendor or a central data hub is likely to be significant, measured in person months. This will include the planning, design, and implementation work, including participating in some measure in demand response industry-focused planning as well as the design of the standards and approaches.

*The Influence of Market Dynamics on Software Vendors Potential Responses*

The current situation in the DRT software industry, where 2 companies have the dominant market share and the other software companies are smaller and mostly focused on smaller systems (although two of the smaller firms have recently been awarded a contracts by two different states--Pennsylvania and Illinois--that makes their software available to most of the

small-medium demand response systems in the state), poses challenges to incentivizing collaboration on data standards by industry participants. The two largest software companies do not have strong incentives to support data standards or non-proprietary data exchange approaches. They are likely to derive limited value from data standards and standards-based data exchange mechanisms, since an alternative is for all of the providers in the mobility management system to use these large companies own software, which can now support multiple separate operating entities with nominally separate fleets but with the capability of automated or at least semi-automated trip exchange.

For the large software companies, supporting data standards and application interoperability probably means providing a more even playing field for their smaller competitors vis-a-vis the initial structuring of a mobility management system. The two software companies with the largest installed base understand that there is potential benefit to them as well from data standards, since they may facilitate the development of mobility management systems in which there is a need for the products developed by these companies specifically for this market. But it is also clear that neither of these companies currently perceives that a non-proprietary approach to data standards/application interoperability is essential for expanding their business.

In the course of this study, one of the two largest software companies moved from a position of lukewarm support for data standards to one in which they indicated they are now prepared to assume a leading role in helping move data standards forward. Like all of the software companies, they were not sure how that process might unfold, but it is significant that this company, which by all indications has the largest installed base, expressed a willingness to take an active leadership role a data standards development process for mobility management.

## Perspectives of Transportation Providers and Human Service Agencies

The project team contacted a range of transportation providers with an emphasis on those either exploring the issues around how to exchange data and/or are VTCLI grantees using this particular funding opportunity to advance the exchange of data related to either discovery or transactional functions. Interviewees were identified by panel members, by other interviewees, by the project team's knowledge in the field, and through a review of VTCLI grantees conducted for TCRP Project B-42. The transportation providers were contacted by telephone and/or email and requested to participate in an interview with one or more members of the research team. Four of these transportation agencies were contacted and participated in an interview. The interviews were conducted by telephone and typically lasted 60 to 90 minutes. As with the interviews of software vendors, these were guided by prepared questions and topics, again the actual interviews tended to be wide-ranging as each transportation provider had some unique perspectives on the issues.

**Customer and Other Perspectives**. Interviews with transportation providers illustrate the knowledge and awareness among those who depend on the exchange of data to improve mobility, or to provide more—or more efficient-- service to their constituents. A limited number of providers were interviewed, but the results converged around the following points.

*Customer knowledge is limited.* While customers often have a clear picture of the outcomes desired, they do not have the level of knowledge needed to assure that the products they buy will achieve these results, much less do so in a way that considers the unique situation in their region or positions them for the future.

*Mismatch with Technical Knowledge of Software Vendors*. Transportation providers are not on even footing with private software vendors when they embark on the process of purchasing scheduling and dispatching software and related products. Few transportation providers have enough IT knowledge to ask all the right questions much less evaluate the responses. This is compounded by the fact that the product(s) needed to meet their vision is quite possibly not available.

*RFPs are Often Generated by Consultants.* Because of the transportation providers' limited knowledge of information technology, they often rely on consultants to prepare both minor and major RFPs for software and related equipment. In major procurements, the vendor may be a third party IT developer or consultant in the IT field. However, much of the expertise for defining how technology can be used to address these complex transportation problems is not being developed among transportation providers – the organizations and individuals who often best understand the idiosyncrasies of delivering trips and managing mobility – and who must live with the results.

*Early Adopters Have Few Models*. As in most industries, there are a few organizations who are seeking to make the most of available technology to meet the needs of their region. Those organizations who wish to try work with an existing vendor to exchange data efficiently with other transportation providers have few models of how to achieve this. Nonetheless, such efforts have often resulted in the development of useful approaches, and provide potentially replicable examples. Examples of what has been tried include various "translators" or development of "data dictionaries" to import, export, and use data generated by other systems in an efficient manner. The TCRP IDEA-50 report identifies how TransPro of Tacoma, Washington has used a translator and the value of this approach. Ride Connections in Portland, OR is developing open-source software that uses a "trip ticket" approach to exchanging data.

*No Industry Standards to Drive Project Objectives*. Industry standards that could set expectations for various functions and products do not currently exist. Such standards would support transportation providers in building a common understanding of their options for addressing the question of "How can I efficiently share data with the small providers in my

region who operate with different or manual scheduling systems?" Knowing the available options would help to drive project objectives and assist in measuring success.

*Challenges and Opportunities*

While contemporary information technologies clearly enable the development of potentially powerful mobility management systems, a key potential barrier to the realization of such systems is the current absence of data standardization among the various software applications and systems used by organizations and individuals that will be part of such initiatives. The different software applications that command a significant market share among providers of DRT services do not currently have common data structures nor are they capable of true interoperability. Even relatively basic data sharing among such systems has proven to be difficult to achieve in practice.

Standard data definitions and protocols that guide the exchange of data are core requirements for software applications to achieve higher levels of functionality and interoperability. Without such data and protocol standardization, applications and systems from different software providers cannot "talk" to one another, restricting opportunities to construct more comprehensive systems than are provided by any one software vendor or type of application.

Mobility management initiatives will clearly be facilitated by data standardization. For example, in the airline industry there is a standard format for an electronic record of an airline ticket (the "passenger name record" or "PNR") that allows multiple airlines to exchange information when a passenger travels on 2 or more airlines in the course of an itinerary. This enables each airline to extract the information relevant to its portion of the itinerary—including how much of the total fare it should receive. If a comparable standard "trip ticket" existed for local transportation as part of a mobility management system, then each organization involved in the process of arranging for and delivering the transportation of the passenger—service provider, funding agency, service organizer, service broker, call center, etc.—would be able to obtain the information it needed from this trip ticket without concern about which reservation and scheduling system was used to book and manage the trip, or which funding source was paying for the trip. Such data standardization would remove an important technological impediment to the establishment of mobility management systems that involve multiple organizations and diverse software applications used by those organizations.

## Information and Referral Systems and the Google Transit Situation

A substantial portion of the VTCLI projects do not plan to go beyond information provision in their initial program implementations. According to an analysis of VTCLI grant information performed as part of TCRP Project B-42, over 60% of the grant recipients intend to focus on information and referral systems initially. While some of these grantees may eventually evolve to a more transactionally-oriented mobility management system, many may not move beyond information and referral functionality.

Information and referral (I&R) systems generally (and most One-Call/One-Click services) are in their essence service discovery applications. A client contacts an information resource and that resource provides information specific to the client's needs about the services that are available, including helping the client navigate through whatever organizations and their processes that they must interface with in order to obtain the needed service. I&R systems for mobility management must inform the client of what transportation services are available, and then provide them with information that will enable them to make use of these services for one or more specific trips that the client needs to take. This may include information about fixed route transit routes and schedules and information about demand responsive services, including where and when DRT services are available and their eligibility requirements and fares. It may also include information about services provided via human service agencies, including those that may rely on volunteer drivers or other semi-formal arrangements. A trip planner application may assist the client in showing them how to get from their origin to their destination, particularly useful for trips on fixed route transit that involve multiple transit routes. By using the I&R system the client "discovers" their transportation service options and how well they fit with their trip needs, and can then make a choice as to which service(s) to utilize.

For service discovery applications to work effectively, it is very useful for the data that describes the different available services to be in a common format. Otherwise, the organization that provides the I&R service faces the daunting problem of sourcing data in many different formats from many different organizations, and then transforming it into a consistent, comprehensive data set. Without common data standards, the result is likely to be inconsistent and incomplete information on the services available.

Fortunately for those organizations sponsoring I&R services who need information on public transit services, a common format for fixed route transit data does exist, courtesy of Google, which developed the General Transit Feed Specification (GTFS) for its Google Transit product (which works in the context of its Google Maps product). The GTFS is a published data specification for fixed route transit initially developed by Google, but now open to input for modifications and extensions from a larger community of interested parties who use GTFS data. As a result of the GTFS data specification, which has become the industry standard for the public transportation industry, web applications, including trip planning applications, are able to "consume" standards-based data that describe the fixed route transit services in an area and use those data to display map-based user interfaces that show transit routes and stops and service timetables. These applications thus enable potential transit users to discover their travel options and to plan their trips.

The GTFS specification is the key to the usefulness of Google Transit, trip planning applications, and other web-based applications that provide information on fixed route transit services. Since data about transit services is "published" in a common, consistent format, applications can be developed with the assurance that the data they "consume"—which is published by another organization—will be in a known format and hence will have the same

meaning from service to service and from system to system. This has led to the development of many applications, including mobile applications running on smartphones, for transit users in a number of large cities.

The GTFS specification has essentially solved the problem of service discovery for fixed route transit services, but this specification does not currently encompass demand responsive services and other forms of flexible transit. An initiative is now under way, stimulated in part by this study, to develop initial GTFS specifications for DRT and other flexible transit services. It is conceivable that the flexible transit specification will be added to GTFS within the next several months, which would be extremely valuable for mobility management I&R systems.

If a DRT/flexible transit specification is indeed added to the GTFS in the near future, the data will be quite different than for fixed route transit. Because some flexible transit services include features similar to fixed route transit, such as points that are visited regularly on a schedule, there will be some overlap between the fixed route data elements and those for DRT/flexible transit. Nonetheless, many of the data elements for the flexible transit specification will have no counterpart in the fixed route specification. The data elements that appear to be most important to include in a DRT/flexible transit extension to the GTFS are set forth later in this report.

# III. DATA FRAMEWORK AND STATE OF THE PRACTICE

## Framework

Effective mobility management requires a system that facilitates the efficient exchange of information among the multiple parties who are involved in organizing, providing, consuming, and financing local transportation services when the process of obtaining and delivering such transportation crosses organizational boundaries. A useful mobility management system in today's world will be one that is based on information technology and which takes full advantage of the inter-connectedness made possible by web-based technologies and data flows. The scope of such a mobility management system can encompass some or all of the following functional areas:

- Trip information—including origin to destination trip planning for fixed route and demand response services
- Trip booking—actually securing a seat on a vehicle trip when a reservation or other pre-arrangement is required
- Service planning—determining what types of services need to be provided, including when and where
- Scheduling and routing of vehicles to meet traveler requirements
- Real-time vehicle tracking (using GPS-based AVL) to assist in dispatching, routing and operational control of vehicles delivering services
- Fare payment via electronic (non-cash) methods
- Financial management of the flows of funds among travelers, service providers, and funding sources

## Discovery and Transactional Data

This framework discussion is organized into **discovery** and **transactional** data, as described in Chapter II. The type of data needed for each facet is different, although related. Table 1 identifies and illustrates some of the key differences between discovery and transactional data. Because of these differences, the approach to and process of standardization will be quite different for these two types of data. The problems associated with standardizing such data also vary, inasmuch as discovery and transactional processes have developed in different contexts.

**TABLE 1: Characteristics of Service Discovery and Transactional Data**

| Discovery Data | Transactional Data |
|---|---|
| **Where Used:**<br>Transit websites, 2-1-1 and 5-1-1 services, other information and referral services | **Where Used:**<br>Providers of demand response services, either within a single organization or among brokers or providers |
| **Tasks:**<br>• *Service type and characteristics*: what type of service is available for a given trip; accessibility, and if reservations are taken/needed (fixed route or some form of demand response)<br>• *Temporal factors*: when service is offered, how long a trip takes, the timing of transfer connections<br>• *Eligibility factors*: General public or some subgroup (seniors, Veterans, etc.)<br>• *Cost factors*: Fares, how to purchase tickets | **Tasks for demand response services:**<br>• Passenger record data<br>• Trip origin, destination, time of travel, and return trip information<br>• Eligibility and fare information<br>• Special conditions: accessibility equipment, service animals, aides, special instructions for pick-up or drop-off<br>• No show or changes in reservation<br>• Verification of trip completion (time, date, mileage, etc.)<br>• Program billing information |
| **Development:**<br>2-1-1 Social Service information and 5-1-1 Traveler information services started as telephone only services, later transitioning to web pages.<br>• *2-1-1 services* generally use summary level information, not adequate for the detail needed for individual trip planning activities. A comprehensive taxonomy and set of procedures have developed to enable these services to provide broad-based and accurate information. Some have developed more extensive services in particular areas (child care, Veterans, etc.)<br>• *5-1-1 services* in many states are limited to roadway information. As they transitioned to web services and mobile applications, more extensive services could be provided. The San Francisco Bay area was a pioneer in providing ridesharing, fixed route and demand response transit, and bicycle information. San Diego is another example of comprehensive services.<br>http://511.org<br>http://transit.511sd.com | **Development:**<br>The primary work in this area has been through private software developers. Some products evolved from:<br>• Companies that were also involved with fixed route services (primarily run cutting software).<br>• Individuals involved in the community transportation sector, with a strong focus on demand response services, developed others.<br>• Software for taxi dispatching has developed at the same time, with some cross.<br>There are examples where extensive software systems have been developed largely in-house. An important example is in Oregon where TriMet has significant investment in the development of open source software.<br>Size, complexity, and cost are one set of the differentiators between products. Some are designed and priced for small providers – often less than 10 vehicles. Others are suited to providers with hundreds of vehicles. |

| Discovery Data | Transactional Data |
|---|---|
| • A variety of trip planners have been developed over the past decade, with substantial improvements over time. The 5-1-1 websites tend towards more comprehensive trip planners oriented to the diversity of services they provide.<br>• The General Transit Feed Specifications (GTFS) allow transit services to be included in its general mapping software.<br>• A variety of mobile applications have been developed to provide information on access to and from transit stops or for individuals with disabilities. | Transportation providers began sharing data with other providers, either because they were vendors or they found that coordination improved their ability to provide mobility.<br>• Early-on transactions were accomplished via faxes<br>• Email was the next step<br>As providers requested vendors to develop an electronic means of sharing data, a variety of on-off solutions have developed. Generally these are based on some form of "translator" that uses a "data dictionary".<br>There is interest in web or cloud based systems as many small providers do not have the IT staff capacity to maintain a complex system. |
| **Business Context:**<br>State Departments of Transportation and Metropolitan Planning Organizations have been leaders in the traveler information systems and have been responsible for a good deal of the development of software solutions. | **Business Context:**<br>Transportation providers generally do not own the systems they use. They rely on the private firms to make changes or adapt the system.<br>The interest of private firms in investing is such changes is based on customer demand. |
| **Data Standardization:**<br>GTFS has provided a promising approach to standardizing data for service discovery.<br>• *GTFS* may prove to be useful in establishing standards for addressing in the demand response side.<br>• *Google* has shown interest in developing base data for demand response services. | **Data Standardization:**<br>Standardized data for service transactions represents a more challenging situation.<br>• There are many data elements in use, but it is important to start small and then build up.<br>• Translators will continue to be needed until a high level of standardization is achieved.<br>• Leadership and education will be key elements in a process to begin standardizing data. |

**Discovery Data.** For I&R systems, there is a need to devise and implement systems which provide customers with the ability to "discover" transportation services in a consistent format, and to provide as much useful information as possible about the services. For fixed route transit services, this need has essentially been fulfilled by the Google Transit standard for data which "describes" fixed route services, GTFS. GTFS-based data can be used by trip planning applications (most notably Google Transit itself) and other software applications to present information to consumers interested in taking trips on transit. Regional 2-1-1 systems can consolidate information about all transit services in a metropolitan region on a single web site

using GTFS-based data from the transit agencies in the region, and as such offer a highly relevant model for I&R systems targeted at veterans. However, as discussed previously, there is currently no analogous GTFS data for DRT services, which leaves a major gap in what I&R systems are able to accomplish without special data generation activities aimed at remedying this deficiency.

Within trip planners, the addressing function is important. It has evolved in response to common ways in which people put in addresses, at the same time that users have learned how to identify addresses in a way machines can read accurately. Many trip planners now allow one to put in an address, pick a location from a list of landmarks by type (schools, office buildings, etc.), or indicate an intersection.

The adoption of widely used mapping software applications has been an important part of the transition in trip planners. GTFS is used by many transit systems to code routes and stops so they are available in online maps, not just the transit system map. They link bus routes and stops to other points or businesses on area maps. They also enable people to plan trips across more than one transit system, if each provides its data using the GTFS. The success of the GTFS, as measured by its widespread use, has resulted in de facto standards for fixed route bus information, including routing, stops, and trip time. Virtually all third party trip planner software applications use this specification. Some large transit agencies still continue to promote their own trip planner software, but even they typically provide data in the GTFS format.

Because of the development of trip planners and the GTFS, the development of standards for discovery data is proceeding apace. The inclusion of DRT service information, currently lacking in these standards, is clearly desirable, but as indicated previously there are signs that this lack may be remedied to at least some extent in the near future.

**Transactional Data.** There is an even greater gap between the needs for standardized data and current reality for transactional data. As noted previously, there are several different software packages used by providers of DRT services for the core functions of reservations and scheduling, and currently none of these software applications share common data definitions or data structures or are interoperable with each other. The only way a mobility management system could currently guarantee that all service providers would be able to share data is if they all use the same software package, and that package enables different providers to “see” each other’s data and to work against a common database.

In a situation where there are several different software packages used by service providers, however, data exchange is only possible if additional software is developed specifically for this purpose. This is typically an expensive, time consuming task which acts as a major barrier to the realization of any significant interoperability for the different software packages. While standardized data would not itself solve this problem—the software producers would still need to

develop external interfaces to their products that would enable such standardized data to be exchanged with other applications—it is an essential pre-requisite to true data interoperability.

As a result, those transportation providers intending to implement interoperable scheduling and dispatch systems are currently confronted by a choice between adopting a single software package for all participants—in a situation where there may already be a multiplicity of software packages used by the participating organizations—or commissioning the relatively expensive unique or "one-off" development of customized software to enable data exchanges among the different software applications.

The process of developing standards for transactional data will need to bring together individuals from private sector software development firms and the end users, the transportation providers.

## Current State of Practice in Data Standards

**Standards.** At the present time, almost no data standards exist for DRT software. This lack of data standards encompasses both service "discovery"—such as data needed for I&R systems—and service operation, where the need is for software systems to exchange "transactional" data.

To the extent that any data standards do exist, it is for information that must be collected for Medicaid reimbursement of non-emergency medical transportation trips. There are both federal standards and specific state implementation of standards for the data that service sponsors must submit to a state in order to receive financial reimbursement for trips provided to Medicaid recipients. But these standards bear only minimally on the data standardization and exchange needs of software applications that would be the centerpiece of mobility management systems.

**Translators.** Several DRT software companies have developed data translators which enable passenger and trip records to be transformed from the format used by their software application to that of another demand response software application. While such translators are clearly useful tools, a translator does not represent a data standard, nor does it appear to be usable for real-time data exchange. A translator does not have the durability that data standards provide. Translators may require adjustments each time either vendor does an upgrade.

One major demand response software company has developed a product, targeted in part at mobility management systems, which features multiple "dictionaries" to enable data to move between their own software application and other software applications (from other software providers) that may be part of a larger, multi-organizational system. These dictionaries, depending on how well they are accepted by other software vendors for use as to system to system data interfaces, could serve as a substitute for data standards. At the same time, an important issue is that these dictionaries represent a proprietary approach to developing a data exchange mechanism. In most industries, data standards emerge from a proprietary application

only if that application has dominant market share, and no single demand response software vendor appears to have that level of dominance. In addition, without more in-depth understanding of this specific dictionary approach, it is not clear that it encompasses all of the desirable functionality for data exchange standards.

The TCRP IDEA-50 project proposed the need for universal "translator" software that would enable data to be exchangeable among different software applications, albeit not necessarily in real-time with running systems. In a small number of projects, sponsors have requested software vendors to develop unique software modules that would enable two software packages to exchange data so that they can both be used in a larger "coordination" system that encompasses multiple service providers who are concerting their activities. For example, in the Longmont area of the Denver region, the Denver RTD and a large human services transportation provider, Via Mobility Services, have been progressively implementing a coordinated service project that enables both RTD and Via operated vehicles to be used by customers of either system, even as different software applications are used to accomplish reservations and scheduling for each agency's fleet. In north central Massachusetts, two large regional service sponsors in adjacent regions are in the early stages of implementing data interoperability between the—different—software systems used to operate their DRT systems, which collectively manage scores of vehicles.

**Inclusion of DRT in GTFS.** A notable area of deficiency in data standards is the absence of any coverage of DRT services in the GTFS. Google Transit appears open to extending GTFS to DRT services. This would largely address data standardization for service discovery purposes for mobility management initiatives or information and referral services. It also would be helpful for transit systems operating general public dial-a-ride services as part of their service network. While the time during which service is available is similar for fixed route and demand response services, discovery data for demand response services must address the area where service is available as a polygon rather than a line. It must also identify if reservations are required. Capacity is quite different for demand response service than fixed route service as additional vehicles must be assigned once the fairly low capacity limits are reached on the demand response vehicle. Additional pick-ups and drop-offs affect travel time, so the itinerary information would be less certain.

**Software Development Initiative**. While no data standards currently exist for transactional data, at least one organization has taken the initiative to develop software that could help motivate the development of common data elements for data exchange in mobility management systems. RideConnection, an organization based in Portland, OR, chartered the development of an open source trip exchange software application that is based on the concept of "trip tickets". The Ride Connection software enables organizations to establish a "hub" or "clearinghouse" which permits software applications to exchange data on trip requests and available trip capacity. The clearinghouse enables software applications to both post requests for service and to offer to provide rides in response to trip requests. In order for this functionality to work well, the

clearinghouse defines certain data that both service requesters and service producers must provide. This includes information about the trip itself, the passenger, and the costs of the service. The software used by service requesters and producers will need to develop "connectors" to the Ride Connection clearinghouse software in order to exchange data and inter-operate in real-time. Initially, the software will rely primarily on users to complete transactions via its user interface—both requests and offers can be viewed, and matching accomplished manually. But eventually automated processes could handle many transactions, although that might require additional data exchange.

As this brief review indicates, there has been limited progress toward data standards for mobility management, but much ground remains to be covered until data exchange among different software systems can become routine. The absence of service description data standards for DRT services is a notable deficiency, although there is the definite possibility that the GTFS process may develop data specifications in this area in the near future.

# IV. DATA EXCHANGE STANDARDS

This chapter covers the related topics of how data is exchanged, the use of data exchange standards in other industries and common processes for developing data standards.

## Approaches to Standardized Data Exchange

Many industries need major software systems to exchange data with other organizations. In the past decade, three key approaches to standardized data exchange have become commonplace.

1. *Explicit data standards*, whereby a core set of data is designated, including specifying data formats and meanings, that conforming software applications will be able to exchange with another application of the same type; such data standards often include consideration of how the data transmission process itself will occur (the Internet is typically the medium for data communications).
2. *Data hubs*, which provide a mechanism for software applications to exchange data without directly communicating with one another; the hub typically uses a proprietary approach to specifying data format and meaning, and while the hub is responsible for the actual data exchange process, each conforming software application must implement an "adaptor" (or "connector") that translates data from its native format to that specified by the hub for the different data elements included.
3. *Application programming interface (API) mechanisms*, which are essentially a bi-lateral mechanism that enables collaborating systems to exchange data, in which one system "publishes" an API specification that enables another system to obtain data from—or submit data to—the host system using the data formats (and meanings) specified in the API document; the Internet is typically used as a communications medium.

Each of these approaches has advantages and disadvantages, all are potentially relevant for mobility management systems, and they may be used in combination with each other. The focus in this section is on the first approach, in which an "industry" group of some type agrees on data formats and communication protocols and publishes these as the standards for data exchange. It bears emphasizing, however, that the other two approaches may represent a more rapid means of achieving data exchange among systems when no data standards exist and there is no existing industry framework for establishing standards.

## Data Exchange Standards in Other Industries

*Air Travel Industry*

Since the 1960's, the air travel industry has made use of a standardized means of structuring data about airline flights—and eventually, much more—in order to enable computer reservations system to share information about airline reservations/tickets. The need for data standards arose due to inter-lining requirements, in which a passenger's travel itinerary involved one or more airlines other than the airline that the itinerary was booked on and which was used for the initial flight. There was a need to transmit the data for the flights on the other airline(s) to the computer reservations systems of those airlines, where a new record could be created in the other airline's system which included a reference to—and all of the data of—the original record. This record could then be retrieved in the second airline's computer system just as if the ticket had been originally booked on that second airline.

The "solution" was the Passenger Name Record (PNR) system that continues to exist today in the airline travel industry, and which has been extended as well to hotel and rental car reservations booked in conjunction with airline travel. The PNR message system is far from ideal, as it was begun when teletype machines were used to transmit data and includes many features that are undesirable in a contemporary data standards system. It is quite complex, and there is a nearly 500-page manual that specifies the rules for message construction and transmission. While the syntax in that manual is now implemented in the computer systems used by the air travel industry, human beings using airline and global distribution system (GDS) computer systems nonetheless need to know how to "read" PNR data messages. Despite these shortcomings, the air travel industry continues to rely on these data standards and it is unlikely they will be superseded anytime soon.

The basic PNR consists of the following information:

1. Record identifier—a 6 character value
2. Passenger name
3. Origin airport
4. Airline and flight number
5. Destination airport
6. Scheduled arrival and departure times
7. Additional data elements as in (3) thru (6) for other flight segments on the itinerary

There are many optional data elements that can be included in the PNR, including bi-lateral data (defined just for the two systems exchanging the data). While there are very detailed rules about many of the data fields, others are somewhat flexible, such as the passenger name field,

which can contain multiple types of formats, particularly when multiple passengers are traveling on the same record locator number.

By contemporary standards, the PNR system is undesirable as an approach to data standards. It suffers from numerous limitations and deficiencies. Nonetheless, it underpins data exchange among very large computer systems in a huge industry, and illustrates that what is most important in data standards is not technical elegance, but the simple act of the key organizations agreeing to use a common scheme to format and exchange data among systems.

*Electronic Health Records and Health Information Exchange*

The development of electronic health records (EHR, also commonly referred to as electronic medical records, EMR) systems began over a decade ago. Numerous large and small software vendors have developed EHR systems, and they have been implemented by thousands of health care organizations ranging from small medical practices to national scale health care giants with huge medical centers. It quickly became apparent that for EHR systems to have the greatest value, they needed to be able to exchange data. Consumers frequently change health service providers, and the data that has been generated for them in one EHR system needs to be transferred to the system of their new provider. Or a patient may receive treatment from medical practitioners in different health care organizations in the course of a medical episode, and the different practitioners need data from an EHR system other than their own.

The federal government has played the key role in facilitating data standards for EHR systems, its leverage attributable to the magnitude of funding of health care services that occurs via the Medicare and Medicaid programs. Several years ago a certification program for EHR systems was developed, and most producers of these systems have had their products certified—which in important part means they must meet data standards, including 32 required data elements. The certification process is focused on EHR Modules, hence some EHR systems may have only some of their modules certified and others their entire product. The certification process and the accreditation of certification organizations is the subject of federal rules and quite detailed.

Moreover, while certification of EHR systems is the key mechanism, the ultimate objective is actually health information exchange (HIE). That is, the movement of data between EHR systems to support the health care a consumer receives. The federal government has published other rules that are intended to encourage this objective, although they do not focus on specific data standards.

The requirements for data standards for EHR systems are among the most rigorous for any industry, and are not a recommended model for mobility management systems. Nonetheless, this indicates that in a situation where the stakes are high, standards for data formats and data exchange are perceived as fundamentally important for driving positive change in an industry and for creating consumer benefits.

## Data Exchange Standards in the Public Transit Industry

The "Transit Communications Interface Profiles" (TCIP) standards are a major initiative organized by APTA, working in partnership with the US Department of Transportation Research and Innovative Technology Administration, to implement the U.S. ITS program within the transit industry. As stated by the key TCIP document:

> *"TCIP is an interface standard. Its primary purpose is to define standardized mechanisms for the exchange of information in the form of data among transit business systems, subsystems, components and devices. The standardization of these interfaces is intended to reduce the cost of future procurements of transit computer based systems, and to facilitate a greater degree of automation and integration of those systems.*
>
> *TCIP recognizes that transit agencies operate differently, and have different internal architectures for their business systems, vehicles, and field systems. As a result TCIP does not mandate a single agency operating paradigm or any agency ITS architecture. Instead TCIP provides a rich vocabulary of possible information exchanges that agencies can use on an a-la-carte basis according to their specific business needs."*[1]

The TCIP standards are broad and flexible, containing a very large number of data elements. To date the TCIP data standards have been primarily focused on data communications between components and systems within vehicles. As such, the TCIP documents are focused on the so-called "connected vehicle" for transit systems. The TCIP standards define data and messages, and have a strong focus on data dialogs, which are exchanges of data via messages. The content of the messages is specified, including required data elements. The scope is relatively broad, encompassing much of the data on scheduling, passenger information display, vehicle positioning, real-time operations, fare collection, dispatching messages, etc. that occurs in the course of day to day transit operations. At the same time, the TCIP document is explicit in stating that these standards apply only to data exchange, and do not have any relevance to how data is internally stored, manipulated, displayed, etc. within the software systems internally used by a transit agency.

The TCIP data standards represent potentially relevant guidance about how to approach the development of core data standards for mobility management systems. The focus on core data, minimum essential functionality, and data dialogs all seem to be important guidance for the development of first generation data standards for mobility management. The TCIP standards were developed within the "National ITS Architecture"[2], a framework for ITS activities. The

[1] American Public Transit Association, "APTA Standard for Transit Communications Interface Profiles", Version 4.0.0, Vol. 1, p.1.

[2] A summary from the paper "Key Concepts of the National ITS Architecture" states "The National ITS Architecture provides a common structure for the design of ITS. It defines the functions that must be performed

FTA maintains a policy that ITS projects be consistent with the National ITS Architecture. The National ITS Architecture identifies the services required by users (who could be the public or a systems operator) and then defining more detailed requirements for users. One of the service categories is Public Transportation, and within this are more specific requirements in areas such as Fixed Route Transit Operations, Demand Response Transit Operations and Transit Traveler Information. It is under the Public Transportation area that the USDOT has partnered with APTA in developing the Transit Communications Interface Profiles (TCIP), the transit component of the ITS family of standards.

While this general policy provides support for the concept of interoperable systems, significant work is needed to assure that investments are made in systems that have the capability to easily exchange data with one another. The recommendations in this report provide a framework for such work.

A brief on interoperability[3] prepared by Community Transportation Association of America (CTAA) and provides sample language that can be used in current Requests for Proposals to obtain scheduling software systems with access to the information needed for the scheduling system to interoperate with other scheduling systems. Such systems will likely rely on translators that will require updating to reflect changes to the system such as a new provider or a new release of one of the software systems. Over time, as the data definitions are standardized and the means to exchange data are developed, more elegant methods of achieving this will be possible. The suggested language follows:

*"The Provider considers broad freedom of access to Provider data residing on the selected system to be of paramount importance. Proposers should describe how the Provider will be assured of complete, unfettered, direct, and perpetual access to Provider data and all associated information that renders the data useable and human-readable. This includes the following: full rights to create, read, update, and delete provider data as it resides on the proposed solution via SQL (structured query language) and common interfaces such as the Open Database Connectivity (ODC) standard, access to metadata-related documentation such as data schemas and data dictionaries that facilitate understanding of the solution's data structures, and complete documentation of all application programming interfaces that the proposed solution exposes either via a network interface or to other applications residing on the same server."*

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by components or subsystems, where these functions reside (e.g., field, traffic management center, or in-vehicle), the interfaces and information flows between subsystems, and the communications requirements for the information flows in order to address the underlying user service requirements. Since the National ITS Architecture is also the foundation for much of the ongoing ITS standards work, consideration of the interface and information exchange requirements established by the Architecture today will likely facilitate or ease the transition to incorporating standards-compliant interfaces in the future." Source accessed on August 2, 2013: http://www.iteris.com/itsarch/documents/keyconcepts/keyconcepts.pdf

[3] The Interoperability Brief was prepared under a cooperative agreement with the Federal Transit Administration (FTA) for technical assistance to the Veteran's Transportation and Community Living Initiative (VTCLI).

## Processes for Developing Data Exchange Standards

In the case of the airline industry, standards were developed internally as the industries saw a business advantage in working together to create mechanisms to exchange data. This is common in many industries, particularly where the industry owns the software. In contrast, in the transit industry the scheduling software is purchased through third party vendors. In the development of electronic health records, the federal government played a significant role in facilitating the development of standards across diverse industries in which the government is a major purchaser of services. Similarly, the government and industry associations had a significant role in developing the TCIP data standards. Common to all processes are that it takes time and is an evolutionary process.

Following are four examples of ways in which specifications have been developed to illustrate different processes:

- General Transit Feed Specifications
- Joint Council on Transit Wireless Communications
- Alliance of Information and Referral Systems
- 5-1-1 Data Exchange

The private sector took a lead in the first example while the remaining examples illustrate how public sector and private non-profit sector groups have advanced standards.

**General Transit Feed Specifications** (GTFS) provide an example of a mature process of developing standards. The GTFS evolved out of the original Google Transit initiative, in which Google developed a standardized method of describing fixed route transit services for use in its Google Maps platform to describe transit options for travelers. The Google Transit application is essentially a trip planner application with a map-based interface. Initially the system focused on a few big city transit systems. Google then informed the transit industry that if transit agencies submitted their fixed route system data to Google using these data formats, Google would enable Google Transit for that transit system. Many transit agencies took advantage of this offer, and within a few years the Google Transit application was available for most of the larger transit systems in the country.

Because Google Transit's data formats for fixed route service had in this manner become a de facto industry standard, Google decided to develop a formal specification for these data formats. This was named the General Transit Feed Specification (GTFS), although for all practical purposes this remains a Google standard. The Google Transit group within Google is responsible for managing the GTFS process of maintaining and extending the data specification (which is essentially a standard, despite the difference in terminology). There are a number of major data elements that comprise the specification, e.g., routes, stops, shapes, etc., each including many data sub-elements that must conform to a specific format. Google published the

initial GTFS document, and then created a process whereby a "community" of GTFS users could extend and modify the specification. Transit agencies and individual software developers—or the Google Transit manager themselves—propose modifications to the specification, comments are generated, participants engage in discussion and debate about the merits of the proposals, and eventually the Google Transit manager makes a decision about changes to the specification. There have been many relatively minor changes made to the specification in this manner, and there is an active community of users who participate in this process. It bears emphasizing that even though GTFS has had a major impact on how public transit agencies format their data for use on the Web, there is no official public sector direction of the GTFS process—it is entirely a voluntary effort with Google itself the ultimate decision maker of how the specification evolves.

**The Joint Council on Transit Wireless Communications.** According to their website, the organization "was established in 2009 in response to results developed under the National Academies, Transportation Research Board (TRB), Transit Research Cooperative Program (TCRP) Project, *C-18 Strategic Plan for Meeting Transit Industry Wireless Communications Needs*. Under this project, a strategic plan for transit industry wireless communications was developed through a collaborative effort with the American Public Transportation Association (APTA), the Community Transportation Association of America (CTAA), and other industry representatives. One of the transit industry goals identified in the resulting strategic plan is the creation of a joint council to implement the strategic plan."

> *"The vision of the Joint Council on Transit Wireless Communications is to be the collective voice committed to addressing transit industry wireless communications needs. Transit industry wireless communications needs have too often been not adequately represented in the Federal Communications Commission (FCC) regulatory process, Federal Transit Administration (FTA) funding, Department of Homeland Security (DHS) emergency planning, and equipment standards.*
>
> *Our mission is to assure that the transit industry wireless communications needs are continuously met through information sharing. This sharing of information is in both directions — to and from transportation providers and other groups, including government, manufacturers, and service providers."*

The Joint Council on Transit Wireless Communications was established as a voluntary (non-membership) transit organization to capture all aspects of the passenger transportation industry, to provide a place to address interests, and to engage crucial partner organizations. (Source: www.transitwireless.org) The American Public Transit Association and Community Transportation Association are national partners supporting this initiative, and the members represent a wide range of private industry and public transit interests.

Initial funding was received under the National Academies through TRB and TCRP, with these organizations receiving their funding from the Federal Transit Administration.

**Alliance for Information and Referral Systems** is a professional member association serving over 1,200 information and referral services. Their mission is to "To provide leadership and support to its members and Affiliates to advance the capacity of a Standards-driven information and referral industry that brings people and services together." AIRS works in partnership with a variety of national associations and:

- Supports a taxonomy for organizing *2-1-1* social service information,
- Establishes processes and standards to provide quality control, and
- Provides training, and certification.

One of the unique characteristics of this organization is the massive amount of volunteer time that went into the development of the taxonomy, led by a Los Angeles County librarian. The website describes this taxonomy as follows:

> *"The AIRS/211 LA County Taxonomy is the North American standard for indexing and accessing human services resource databases. The Taxonomy is a hierarchical system that contains more than 9,000 fully-defined terms that cover the complete range of human services….*
>
> *The Taxonomy is an intellectual property copyrighted by 211 LA County[4] and available only to licensed subscribers. Vendors who create I&R software that incorporates the Taxonomy and I&R services that use the software to maintain a resource database employing the Taxonomy, are required to maintain a valid license.*
>
> *The Taxonomy serves as a common language that facilitates interoperability between different I&R resource databases. It represents a tremendous gift to the I&R movement that has evolved over 20 years thanks to the commitment of 211 LA County and the Taxonomy's editor, Georgia Sales. The cost of developing and maintaining anything comparable from scratch today is almost inconceivable."*

Both the Joint Council on Transit Wireless Communications and AIRS have dealt with issues of developing standards and informing a wide range of participants. Both bridge issues that cross between traditional organizations. These are characteristics that are also common to developing data standards for specialized transportation.

A key difference is that the Joint Council on Transit Wireless Communications received substantial funding through research organizations and the Federal Transit Administration while AIRS undertook much of its technical work on a volunteer basis. It is notable that AIRs recognizes the value of the taxonomy and the benefits to the I & R sector in having the taxonomy.

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[4] http://www.airs.org/i4a/pages/index.cfm?pageid=3386 211 LA County has provided licensing to the human service taxonomy for over a decade at www.211taxonomy.org.

**5-1-1 Data Exchange**. A third example of developing common standards is for transportation information through 5-1-1 centers. A group working through the Metropolitan Transportation Commission in California's Bay Area and Open North is developing a 5-1-1 Data Exchange that includes a proposed Open511 Protocol.

Their working paper draft version 1.0 describes the Open511 Protocol and notes the reasons for a 511 Data Exchange, *"Open511 is a newly designed open standard that defines a set of data interfaces in order to facilitate access to 511 data. These interfaces are intended to benefit both internal and external traveller application development…..511 systems host a wealth of traveller information that can be a valuable resource for innovative application development by external parties if the data can be exposed through a data exchange standard. In addition to sharing data with developers, adoption of standard based data exchange would also help share data between a 511 system and other data sources, a transit agency for example, as well as neighbouring 511 systems, facilitating traveller information across neighbouring 511 jurisdictions. Each 511 system has developed its own mechanism to collect data and disseminate information. An open standard for disseminating data would help 511 data consumers easily access data and develop their products based on a set of known interfaces."*

Often the software used by 5-1-1 systems is developed internally and owned by the 5-1-1 organization, although portions may be purchased from vendors. This is in contrast to scheduling software for demand response transportation. The ownership of the software provides the entities with the flexibility to determine the auxiliary components they find to be useful.

## Application to Data Standards for Mobility Management

Characteristics of mobility management include:

- It is a diverse industry that includes public sector, private non-profit agencies, and private for-profit agencies of all sizes.
- Activities range from the discovery functions of one-call, one-click centers to the transactional functions involved in scheduling, dispatching, and billing for DRT trips.
- Software is primarily provided by for-profit vendors, although in some areas open-source software is used.
- It is important to bridge to data used for fixed route trip planning software and the communications platforms used in the transit industry, so building upon existing specifications (GTFS, TCIP) will be useful.

Any process for advancing data standards will need to be consensus-based and include the software vendors and the consumers. Ideally it will have the support of both major associations, APTA and CTAA, and will be supported by federal agencies with a vested interest in the outcomes.

# V. ADVANCING DATA STANDARDS

## Existing Foundation

Important foundational pieces are in place for advancing data standards, including policies, processes, and specifications. On the policy side, a framework exists in support of this activity. The Research and Innovation Technology Administration (RITA) ITS Joint Program Office is responsible for the National ITS Architecture. This program is grounded in policy, standards development, and technology transfer activities and is guided by a five-year plan that reflects current priorities. RITA is in the process of developing a new strategic plan. FTA's overall policy is that ITS projects be consistent with the National ITS Architecture. The FTA has integrated this into their grant administration activities.

The current federal transportation legislation, known as MAP-21, includes specific funding to continue the process of standards development. Section 5314 provides for technical assistance and standards development, to support the effective and efficient delivery of public transportation service. Eligible activities may include "technical assistance and the development of voluntary and consensus-based standards and best practices by the public transportation industry".

The most notable example of the development of specifications is the General Transit Feed Specifications (GTFS), which have been so widely adopted that they have become a de facto standard for fixed route transit information. With Google Transit considering the extension of GTFS to flexible transit (which includes DRT), another key part of the foundation will be underway. Specifications developed for 2-1-1 and 5-1-1 systems also form an important part of the foundation. The RITA ITS Joint Program Office and the American Public Transit Association (APTA) have partnered in developing the Transit Communications Interface Profiles (TCIP). While the TCIP is focused on data communications between components and systems within vehicles, the existence of the TCIP suggest that there is an overall structure within public transit broad enough to encompass the development of standards for the scheduling, dispatch, and billing needed to coordinate DRT services.

While the considerable work that has been completed forms a solid foundation for the next steps towards data standards, work still remains to develop the specifications necessary for one-call, one-click and other mobility management services that are based on data standards. Such specifications will also increase the ability of transportation providers to more effectively utilize ITS to reach mobility management goals.

## Process and Data Elements

To advance data standardization, consideration needs to be given to both process and data elements. Key points in advancing standards through a consensus-based process include:

- An understanding that this is a heterogeneous industry with many actors who do not routinely communicate with one another.
- An industry group will need to organize the process, as no software vendor has sufficiently dominant market presence to set standards.
- The willingness of most software vendors, and all major software vendors, to cooperatively participate is key to a successful outcome.

*Process*

Paratransit software vendors will have a key role in developing the standards: their support of the use of standardized data is critical. While most software vendors agreed that standardized data is desirable, there exists inertia around the existing business models. Factors that could provide an impetus to move forwards towards standardized data include:

- Hearing from customers that they want to buy products based on standardized data.
- A clear message that the FTA wants to obtain full value from this investment by enabling systems to easily communicate with each other.
- Addressing the issue of who will be responsible for creating the mechanisms to enable effective data transfers.

Transportation providers also have an important role in the development of standards for transactional data. Transportation providers are the end users. Collectively, they understand the unique characteristics of a wide range of human service programs and the idiosyncratic nature of how they are implemented in different regions and states. They know the capacity of the partners with whom they would like to exchange data, from similar systems to very small Medicaid providers to volunteer driver programs. Only a limited number of specialized transportation providers have an information technology staff with sufficient knowledge to be full participants in such a process, but finding these individuals and inducing their involvement is very important to develop balanced data standards.

A successful process will most likely be led by a neutral industry group and include both software vendors and transportation providers and result in a consensus-based set of specifications with the potential to be expanded over time. Leadership provided by a national organization will be critical, and the Community Transportation Association of America (CTAA) and/or American Public Transit Association (APTA) are logical choices for this role. CTAA represents many of the community transportation providers involved with delivering DRT services; APTA represents more of the larger public transit agencies and has a standards development process. Such a process might be structured as a “special interest group” or other voluntary association.

As one result of this study, a core group of individuals in the transit industry and among vendors has indicated a willingness to participate in a leadership role to develop specifications. It is recommended that such a group be convened approximately twice a year at transit industry conferences with intermediate meetings via web and video conferencing. Work products can be developed by participants and circulated among the group for comment, as they begin to both define the process and initial data elements. It bears re-emphasizing that development of standardized data that can be easily exchanged is a process, not a one-time event.

## Data Elements

*Approach*

In discussions with software and transportation industry representatives, there was concurrence that starting small is a key to establishing data standards. Standards can develop from a basic starting point in response to transportation industry needs. While it is likely that a wide-ranging effort will be needed over time, it is important that the broader issues are not allowed to distract participants from meeting the objective of getting agreement on an initial set of data standards or specifications. It is feasible that an initial set of specifications could be in place within 12 months for a base set of data, given the appropriate process and incentives.

It is useful to distinguish here between the development of standards and the development of specifications. The term “standards” has been used throughout this report to describe an outcome: data elements each having an agreed upon definition, described so they can be exchanged in an electronic format. However, the term ‘standards’ can also be used to reflect a set of standards (such as safety standards) that are developed in a top-down process and must be met as minimums. The recommendation of this report is that specifications be developed, using a consensus-based process that involves both private and public sector stakeholders. Such specifications should be rigorously defined using a review process so that the specifications will meet the needs of the users of the data and the software while also achieving certain technical requirements of the software and its interfaces.

*Proposed Core Data Elements*

We have made a distinction throughout this study between data needed for service transactions and that needed for service discovery for mobility management initiatives. Consequently, we have divided our proposals for core data elements into those for service transactions and those for service discovery.

We also recognize that achieving any level of data standardization, particularly for service transactions, is likely to be a challenging process that will probably occur incrementally and iteratively. This suggests that a “walk before we run” approach to agreeing on standardized data is more likely to be successful than trying to obtain agreement on comprehensive data standards

and data exchange protocols as the initial objective. Accordingly, the research team's assessment of the **core** data elements that need to be included in the **initial** data standards follow.

*Data Elements for Service Transactions*

The data needed to support service transactions is of 5 types:

1. Trip data
2. Passenger data
3. Organization data
4. Financial data
5. Vehicle data

The table on the following pages shows the proposed data elements for an initial standard.

**Table 2. Proposed Data Elements for an Initial Standard**

| Category and Data Item | Required Input? | Required Output? | Comments |
|---|---|---|---|
| **Passenger Header Record** | | | |
| Passenger ID | Y | | |
| First name | Y | | |
| Last name | Y | | |
| Street address | | | |
| City | | | |
| Zip code | | | |
| Telephone number | Y | | |
| Ambulatory status | Y | | Ambulatory or uses mobility aids |
| Mobility aids indicator | | | List of mobility aids if indicator present, null acceptable and means no aids needed |
| Companion flag | Y | | Number of companions could be substituted for flag |
| Service animal indicator | Y | | Type of service animal if indicator present |
| Disability indicator | | | List of disabilities if indicator present |
| Extra boarding time indicator | Y | | Amount of extra time needed if indicator present |
| Medicaid eligible flag | | | Depends on application whether required |
| ADA eligible flag | | | Depends on application whether required |
| Agency affiliation | | | Depends on application whether required, list of 0 to N agencies |
| **Trip Record** | | | |

| Category and Data Item | Required Input? | Required Output? | Comments |
|---|---|---|---|
| Trip ID | Y | | |
| Vehicle ID | | Y | |
| Passenger ID | Y | | |
| Origin street address | Y | | |
| Origin city | Y | | |
| Origin zip code | Y | | |
| Destination street address | Y | | |
| Destination city | Y | | |
| Destination zip code | Y | | |
| Requested pick-up time | Y | | |
| Promised pick-up time | | Y | |
| Pick-up time min | | Y | |
| Pick-up time max | | Y | |
| Requested delivery time | | | Nullable if P/U time requested |
| Estimated delivery time | | Y (?) | Nullable if P/U time requested? |
| Space type required | Y | | Seat, wheelchair space |
| Vehicle entry type needed | Y | | Lift, ramp, driver assistance, etc. |
| Trip fare | Y | | Fare paid by passenger |
| Trip distance | Y | | O-D distance in miles (from GIS) |
| **Organization Record** | | | |
| Agency ID | Y | | |
| Agency type | Y | | Sponsoring agency or service provider organization or both |
| Agency name | Y | | |
| Agency street address | | | |
| Agency city | | | |
| Agency zip code | | | |
| Agency phone number | Y | | |
| **Financial Record** | | | |
| Trip ID | Y | | |
| Sponsoring Agency ID | Y | | Need convention for when no sponsoring agency, as in general public service |
| Provider Agency ID | Y | | |
| Trip Price Bid | Y | | Price agency willing to pay for trip |
| Trip Price Offered | Y | | Price at which provider willing to provide trip |
| Trip Price Final | | Y | Price at which parties agree to transact for trip transportation |
| **Vehicle Record** | | | |

| Category and Data Item | Required Input? | Required Output? | Comments |
|---|---|---|---|
| Vehicle ID | Y | | |
| Agency ID | Y | | Agency ID for service provider |
| WC space type capacity | Y (?) | | Needed only by service provider |
| Seat space type capacity | Y (?) | | Needed only by service provider |

The two primary data records are the: (1) passenger record, consisting of 16 data elements, eight of which are mandatory; (2) the trip record, consisting of 18 data elements, 16 of which are mandatory. The other record types—organization, financial, and vehicle—have a total of 17 data elements, of which 14 are mandatory. Overall, there are a total of 51 data elements, of which 38 are mandatory, and it is possible that three of the mandatory fields are not essential for all parties to the transaction, as noted in the table.

It is our understanding that all of the data fields specified above are present in the software applications currently being used for DRT services. They may have different names than those used in this report, but the data itself is present in the databases used by these applications.

*Data Elements for Service Discovery*

The data elements needed for service discovery are of a different character than those necessary to support transactions. Information and referral systems need data that describes fixed route transit, DRT, and other flexible services that operate within the service area of the I&R system. As discussed previously, the GTFS specification has successfully standardized the data that is used to describe fixed route transit services, but no such standards currently exist for DRT services. The proposed core data elements for service discovery for DRT services are presented in Table 3.

**Table 3: Proposed Data Elements for an Initial Standard for Discovery Data**

| Data Element | Required? | Comment |
|---|---|---|
| Service name | Y | |
| Service sponsor | Y | |
| Service phone number | Y | For trip reservations |
| Service Web URL | | Only relevant if Web booking possible |
| Service area boundaries | Y | GIS shape file |
| Service operating hours | Y | By day of week |
| Ridership restrictions | Y | General public, ADA restricted, agency affiliation, etc. |
| Service fare structure | Y | Listing of fares and applicability |
| Reservation policies | Y | Advance notice requirements, subscription availability |
| Cancellation policies | | Hours in advance of trip to avoid penalty |
| Service accessibility | Y | Wheelchair accessible vehicles, other accessible options |
| Scheduled points served | Y | Variation on GTFS-fixed route |
| Timetables for scheduled stops | Y | Variation on GTFS-fixed route |

## Vendor Comments

In addition to the initial survey comments, a variety of comments were received from vendors and stakeholders through follow-up communication and a presentation and discussion of material at the 2013 CTAA EXPO conference. Key comments are summarized here and incorporated into the body of the document and recommendations.

- Interest in pursuing data specifications has increased significantly over the course of the project. This appears to be from a combination of increased awareness of the available options and increased understanding of the importance of systems that can exchange data as systems continue to address the need for increased mobility at affordable costs. The research projects and the Veterans Technology Cooperatives at conferences have been important in raising awareness. Vendors' interest has increased over the course of the project, and some have expressed an interest in taking more of a leadership role. Reasons for this may include their customers expressing the need for scheduling solutions with more flexibility across platforms, a realization that this is the direction of the future with interconnectivity between not just scheduling systems but a wide range of mobility management solutions, and learning firsthand the challenges of keeping track of many different data dictionaries and translators.
- Specifications versus standards: this should be a consensus-based process resulting in data specifications rather than imposing standards on the industry.

The process should include software vendors and purchasers of scheduling and dispatch systems. It would be useful to broaden the process so that connections and opportunities with related data can be identified.

- Consider the longevity of the current software applications, and include how specifications will evolve as part of the process.
- Identify the education issues and needs of the vendors and providers. Recognizing that this is as much a business problem as a technology problem, it will be important to include the tools to help the providers and funding agencies in a region reach agreement and to build capacity among decision-makers.
- Discuss the funding and responsibility for creating the interfaces and communication tools that will be needed to exchange this standardized data.
- Follow existing standards in other industries and processes that have proven effective. At a minimum this would include 2-1-1, 5-1-1, GTFS, and basic computer language and system standards.
- Organize another meeting of leaders and individuals with enough interest to pursue this initiative in the interim until it can be appropriately funded. Invite interested parties to address the problem of identifying what the paratransit and human services transportation community needs from the emerging data standards.
- Consider the overall framework – scope and depth of effort that will be needed – even though the approach is to start small within that framework.

## A Scope of Work for Moving Forward

A suggested scope of work has been drafted to describe the types of activities needed to move forward.

**Task 1.** Create a forum of stakeholders for DRT to (1) guide the development of initial data specifications, standards and related business protocols, and (2) develop a strategic plan for the expansion of data specifications, standards and protocols.

**Task 2.** Identify the scope and reach of the data specifications, standards and business protocols that will be addressed for DRT. This includes determining the appropriate relationship between activities, specifications, and standardization occurring in other ITS areas, such as with trip planners and the Open 511 Protocols, Transit Communications Interface Protocols (TCIP), and the various Federal requirements within the Regional ITS Architecture for software systems that are interoperable and provide purchasers with access to data. Define a consensus-based process for initial data specification definitions and how these data would be used.

**Task 3**. Review current efforts at Federal and state levels to provide for technology systems for DRT that provide the maximum interoperability, access to data, and building the capacity of staff to understand technology that impacts their jobs. Document how data flows between various software systems including the modes represented on web-based 5-1-1 services.

**Task 4.** Prepare strategic plan that addresses (a) the development of additional data specifications, standards and protocols for DRT, (b) the ongoing maintenance of data specifications, standards and protocols, and (c) the migration from current DRT scheduling systems based on non-standard data to specified or standardized data. Identify how to assess the readiness and capacity of regions to pilot projects where communication between scheduling software systems is needed. Identify stakeholder roles in facilitating necessary transitions and specific steps to assure that specifications and standards across various applications are integrated and provide a solid foundation for ongoing development activities.

**Task 5.** Develop and pilot a curriculum to train transit professionals, mobility managers, community transportation providers, and human service or non-profit agency staff as well as consultants to these agencies. The training should (a) strengthen understanding of the available choices, (b) explain how various options meet differing objectives or provide differing functionalities, and (c) assure that the procurement process reflects the choices and priorities made by the procuring agency and meets specific requirements for interoperability. This task could be initiated early in the work scope.

## Conclusion

The development of data specifications for mobility management functions aligns with the strategic research goals and priorities of FTA and the US Department of Transportation Research and Innovative Technology Administration. Data specifications will enable the FTA to leverage their considerable investment in technology.

Common standards providing for readily interoperable demand response scheduling systems will promote scheduling efficiency and increase productivity. One way it will do this is by supporting subcontracting, making it easier for agencies with empty seats on their vehicles to fill the seats with passengers needing service. More importantly, such data specifications will enable transportation providers to adapt to current technology and continue to innovate as technology changes and improves.

The recommended approach is to actively involve transportation providers and scheduling software developers in a joint process to define specifications. Both bring important perspectives

to the process. Further, it is recommended that the effort start small with a minimal set of data items, growing over time.

# BIBLIOGRAPHY

Burkhardt, J.E. “Developing Regional Mobility Management Centers”, Final Report of the Transit Innovations Deserving Exploratory Analysis (IDEA) Project 50, Transportation Research Board of the National Academies, June, 2012. Can be accessed at: http://www.trb.org/Main/Blurbs/168118.aspx

National ITS Architecture, accessed on August 16, 2013 at: http://www.iteris.com/itsarch/

FTA National ITS Architecture Consistency Policy for Transit Projects, Additional Grantee Guidance, 2003, Number C-01-03, 1/2/2003, http://www.fta.dot.gov/newsroom_511.html .

# GLOSSARY

The lack of common definitions in this field hampers the conversation about standardizing data. At present there exist different definitions for common terms. This glossary identifies the most commonly used definitions and the definitions used in this report.

***Application Programming Interface – API***. A protocol intended to be used as an interface by software components to communicate with each other. An API is a library that may include specification for routines, data structures, object classes, and variables. (Source: Wikipedia, http://en.wikipedia.org/wiki/API)

***Coordination.*** This term is often used interchangeably with the term "mobility management" and usage of these terms vary in different parts of the country. In the context of this report, "coordination" will serve as an umbrella term meaning all of the activities various transportation providers and human service agencies engage in to use resources wisely and to refer to the specific activities transportation providers and human service agencies engage in to enable the desired outcome. This might be an exchange of data, development of a cost-sharing agreement, or development of common driver or service quality standards. In this sense, the term coordination is focused on agency activities. *(see Mobility Management)*

***Demand Response Transportation.*** This term includes all types of demand response transportation services, including route deviation, flexible route services, taxi, and jitney services. Demand response transportation may be referred to as "call-and-ride" or "specialized transportation". It may be for the general population or for persons with specialized transportation needs; rides are generally shared, but in the case of taxi services only one passenger or party is carried at a time (unless it is identified as a shared ride service). ADA Complementary Paratransit services are a particular type of demand response services.

***General Transit Feed Specifications***. Known by the acronym GTFS, these are the data specifications, originally developed and known as Google Transit Feed Specifications. They are used in all Google Transit applications, from the trip planner to Google mapping functions. Transportation providers agree to provide their route data in this format in order to be included in Google Transit applications.

***Information and Referral Service (I & R***). Information and referral services provide information to callers about available services. These include 2-1-1 or 5-1-1 services, local Area Agencies on Aging, or transportation call centers. There are standards in place for how such entities organize, update, and deliver information, developed under the auspices of the Alliance of Information and Referral Services (AIRS). AIRS (www.airs.org) is an international professional society for groups involved in community information and referral services. Within the aging community, the phrase "information, referral, and assistance" is often used to denote the effort that is often needed to make sure individuals are able to use the available services.

***Mobility Management***. This term is often used interchangeably with the term "coordination" and usage of these terms vary in different parts of the country. In the context of this report, "mobility management" will primarily mean the activities in various regions or communities geared toward identifying the mobility options available for individuals and matching individuals to the lowest cost mobility options that best suit their abilities and travel needs. Mobility management may occur in a "One-call, One-click" center or other information and referral agency, through an Aging and Disability Resource Center, through a broker of demand response transportation services, or through a regional or county agency that provides mobility and/or transportation services. Many mobility management activities are focused on making it easier for customers to access available transportation services. Typical activities include information and referral, streamlined eligibility or a single eligibility system, trip planners, or providing access to a wide range of options including gas vouchers, ridesharing, or emergency car repairs. In this report, the term mobility management has a customer focus. (See Coordination)

***National ITS Architecture***. A common, established framework for developing integrated transportation systems. The National ITS Architecture is comprised of the logical architecture and the physical architecture, which satisfy a defined set of user service requirements. The National ITS Architecture is maintained by the United States Department of Transportation (USDOT). (Source: http://www.iteris.com/itsarch/ )

***One Call/One Click Center.*** A location where customers can obtain information on all relevant transportation options via a single phone call or web site. These centers may be limited to information and referral or may also schedule trips. (See Information and Referral)

***Open Source Software (OSS)***. Computer software with its source code made available and licensed with an open-source license in which the copyright holder provides the rights to study, change and distribute the software for free to anyone and for any purpose. Open-source software is very often developed in a public, collaborative manner.

(Source: http://en.wikipedia.org/wiki/Open-source_software#The_Open_Source_Definition)

***Passenger Name Record (PNR) -*** A standard format for an electronic record of an airline ticket that allows multiple airlines to exchange information when a passenger travels on 2 or more airlines in the course of an itinerary. This enables each airline to extract the information relevant to its portion of the itinerary—including how much of the total fare it should receive.

***Private Software Vendors***. Companies that develop and sell software are generically referred to as private software vendors. In this document, this phrase specifically refers to those companies that develop and sell software for scheduling transportation services. Developers of open source software are not included in this definition as the structure of their enterprise is quite different.

***Transit Communications Interface Profiles (TCIP).*** The TCIP standards are a major initiative organized by APTA in partnership with the US Department of Transportation's Research and

Innovative Technology Administration ITS Joint Program Office to implement the U.S. ITS program within the transit industry. As stated by the key TCIP document: *"TCIP is an interface standard. Its primary purpose is to define standardized mechanisms for the exchange of information in the form of data among transit business systems, subsystems, components and devices. The standardization of these interfaces is intended to reduce the cost of future procurements of transit computer based systems, and to facilitate a greater degree of automation and integration of those systems."*

***Transportation Brokers.*** A transportation broker is an entity that brokers trips between multiple providers. Generally these organizations are either publicly funded or private non-profit entities. A transportation provider (see below) may also broker some or many trips.

***Transportation Providers or Transportation Agencies***. These are the organizations that deliver transportation services, whether demand response or fixed route. They may be publicly funded, private for-profit, or private non-profit organizations. They may be a single purpose agency or part of a multi-purpose agency that provides transportation as one aspect of their services. A taxi company is a private for-profit transportation provider. A Regional Transportation Authority is a public transportation provider, and may commonly be referred to as a transportation agency or a public transit agency.

***Web Portal***. A web portal presents the user with a single web page that brings together or aggregates content from a number of other systems or servers. Most often it is a specially-designed Web page bringing information together from diverse sources in a uniform way. A portal may use a search engine API to permit users to search intranet content by defining which domains may be searched. (Source: http://en.wikipedia.org/wiki/Web_portal)

# APPENDIX A: SURVEYS

Guided interviews were arranged with participants to explore the problem from the perspective of software vendors/developers, trip planning software, and those public and human service transportation agencies defined as having "emerging applications". This wide focus provides a context to assure that data standards and protocols for such systems consider the broader world of mobility management and the directions these systems are taking in the future.

The overall purpose of this activity was to canvas the key software programs that use similar data sets to (a) provide a conceptual framework of the relationships between these applications; (b) build an understanding of the data sets and protocols used in each; (c) identify the directions each is headed; and (d) the role, potential, and value of data standards for these systems.

The basic systems were grouped into Information and Referral, Scheduling & Dispatch software, and Trip Planning software. These related functions use separate databases that contain overlapping information. In addition to these categories, an examination of ***Emerging Applications*** is included as a fourth category to highlight new approaches taken by organizations on the forefront of developing mobility management applications.

## Scheduling / Dispatch Software Vendors

The participants were:

- RouteMatch
- Trapeze
- Mobilitat
- Stratagen
- EnGraph
- EcoLane
- HB Software Solutions

In addition, Shah Software was contacted but did not participate. Some of the above and additional vendors were spoken to at the CTAA EXPO Trade Show (CTS, PC Trans, Enghouse Transportation)

The questions listed below were used to guide the interviews. The interviews were conducted via telephone, with one or both members of the project team on the line. They generally lasted for 60-90 minutes. The discussions turned out to be deeper and more wide-ranging that originally anticipated. They often led to recommendations to speak with others, and these leads were followed up.

*Initial Contact Questions: Structured Interview*

- Describe J-6/82 project, trend to interoperability, and vision of private sector in developing standardized data
- Assess interest

- Identify how to work with them on detailed questions. Range of topics:
  - Description of products and how their products work together and with others
  - The impact of / interest in interoperability on these products
  - Ways in which interoperability could be achieved
  - Challenges and barriers / successes and benefits
  - Future plans for new technology (cloud based; mobile apps; etc.)
  - How we can work with them in this project

### Trip Planning Applications and Information and Referral Services

The purpose of these interviews was to understand the structure of the programs used in trip planning applications, their underlying data sets, and the potential interfaces between these and information and referral programs. Trip planning applications were initially web-based, but recently some mobile apps have been developed.

These two categories are closely related and were combined. Trip planning systems are imbedded in web sites for fixed route transit services; advanced 5-1-1 systems also provide trip planning applications for consumer use.

The participants were:
**Trillium** (Aaron Antrim) for existing and future General Transit Feed Specifications and to seek out information on systems with advanced technology
**Google Transit** regarding potential demand response specifications.
**San Bernardino VTCLI Project**: I & R with 211, 511, and Veterans focus

Denver RTD was contacted but their long-time IT manager was retiring so no participation was obtained.

The websites for the San Francisco Bay Area, San Diego, and Atlanta 511 interfaces for transit AND demand response or other services (PT, DAR, Amtrak, Air, ICB) were investigated, as well as those for the National 2-1-1 Initiative and Aging and Disability Resource Center. While this provided useful background, it did not appear that individual contacts would be fruitful so these were not pursued.

The Google Transit contact resulted in a conference call with a variety of interested participants, which in turn has led to the creation of a GTFS initiative to develop a specification for flexible transit services, which includes DRT.

*Initial Contact: Structured Interview (Task 3)*

- Describe J-6 / 82 project, investigation of interoperability, and roles of the private sector and public sector in developing standardized data.
- Ask for a description of their approach to trip planning and how it differs from other trip planning systems. For I & R systems, ask for a description of their system.
- Ask them to identify:
  - Primary data sets used
  - Standards that apply to these data sets
  - Where do these data sets reside? How are they updated?
- Ask them to identify the primary protocols used, and any standards that apply to these protocols.
- Is the orientation to directly to consumers (via phone, internet, mobile), through agency staff, or both?
- How is their system used in navigation between systems, if at all? (Various transport systems, navigation for first and last mile, pedestrian interfaces, mapping software)
- Do they have or are they developing mobile applications?
- Describe the strengths of their system and ways in which it is most effective.
- Describe the challenges and what they see as next steps in improving the functionality.
- Ask them to discuss interoperability of data with other systems.
  - Where do they see the interfaces with the most potential and the value of these?

### Emerging Applications

The participants were:

- Ride Connection
- New England Open Data Exchange group:
  - Montachusetts RTA, West Metro RTA, and HB Software Solutions were on the call.
- Rogue Valley Transportation District
- Denver RTD

In addition, the team followed up with Tri-Met to gain a better understanding of their open-source software. The questions asked of the software vendors were used to guide the interviews, but with an emphasis on the provider's perspective, the particular application that the provider is developing, and the relationship of the provider to the existing software vendors: What software have they and other providers in their region used? Why did they decide to do some of their own development?